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A Novel Hybrid Solar Power System with MPPT Technology for Commercial Application

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Abstract
A hybrid design of a battery charging system and its implementation has been explained in this paper. The system has been designed based on a novel algorithm to couple existing solar PV charging and utility supply charging systems. The algorithm has been programmed in a Microcontroller that senses the battery voltage and generates appropriate commands to operate a relay that controls the utility grid supply availability by connecting or disconnecting it to the Uninterrupted Power Supply (UPS) system through which the battery is charged. Besides the utility grid supply charging, solar PV also charges the battery whenever it is available through a charge controller. This system ensures continuous power supply and faster charging of the battery. Residential backup UPS systems serve as an alternate power source for utility grid supply where storage system plays a vital role. These storage systems need a minimum of two hours of uninterrupted power supply from the utility grid for charging. As this is a rare possibility, solar energy is used to charge these systems. Existing methods are based on charging systems which use either solar power or utility grid supply as a source but an efficient hybrid system that can utilize both solar power and utility grid supply is a necessity when there is intermittent power supply. In this project the hybrid Solar Charging Power System simulation will be implemented and verified by MATLAB/SIMULINK.

Keywords - UPS, PV, UGS, SPS, SPVS

I .INTRODUCTION

India, a country which has one of the world's fastest growing energy markets, has been predominantly using fossil fuels in electricity generation. Almost 70% of India's energy generation capacity is made up of fossil fuels. Over the past few decades, though the fossil fuels have been powering the country, their diverse demerits such as green house gas emission, environmental pollution and their limited availability is forcing India to explore energy alternatives. Hence to meet the growing energy demands, India has planned to expand its renewable energy market. India currently has an installed generation capacity of 26GW and it has also proposed to generate approximately 41.8GW of power by 2017 from various renewable energy sources. This would also bring down the use of coal and petroleum to approximately 57% by 2022. This helped India's electricity sector hold a position among the world's most active players in renewable energy utilization. Despite India's efforts in attaining energy sufficiency, the country is still facing a significant amount of energy deficit. During the period

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2012-13, the total deficit of peak power in India was 9% of the total demand and the southern regional grid had a maximum deficit of 18.5%. Tamil Nadu, India, had a peak demand deficit of 13.2%. This is evident from the scheduled load shedding for at least 3 hours a day in urban and rural areas of the state and 40% load shedding for commercial consumers, leading to intermittent power supply throughout the state. As a measure to better the situation, the State Government of Tamil Nadu, India has enacted appropriate policies and has envisioned adding 3000MW of solar capacity by 2015. Residential backup UPS systems serve as an alternate power source for utility grid supply where storage system plays a vital role. These storage systems need a minimum of two hours of uninterrupted power supply from the utility grid for charging. As this is a rare possibility, solar energy is used to charge these systems. Existing methods are based on charging systems which use either solar power or utility grid supply as a source but an efficient hybrid system that can utilize both solar power and utility grid supply is a necessity when there is intermittent power supply.

II. HYBRID SOLAR POWER SYETRMS

A purely solar power solution for general lighting load is very expensive as far as initial investment is concerned. Also, due to frequent power failure, a regular battery backup UPS / INVERTER barely gets time to charge the battery from mains. The Hybrid Version combines solar energy and mains utility to give an excellent solution by providing the best of both worlds. Our hybrid solar inverters are designed with extreme flexibility so that you can add panels as and when required in the future to increase the percentage sharing of solar power.

You are assured of uninterrupted supply, even during frequent and long power failures. More importantly, you get to use Green Power and in turn help maintain a pollution-free environment. The Solar Inverter comes with the choice of charging of batteries by both solar as well as mains utility (Hybrid Solar Inverter), with automatic change over from mains to battery and from battery to mains like a regular inverter. It employs an inverter circuitry, two-level battery charging from mains, Solar Charge Controller ie. MPPT and fast change over mechanism during power failure and resumption.

III. PROPOSED HYBRID SOLAR POWER SYSTEMS

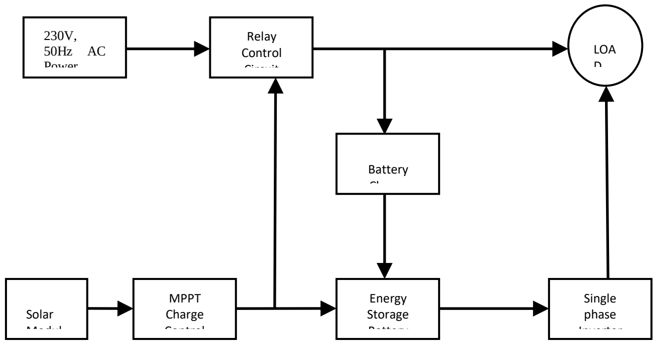

Fig 1: Functional Block Diagram

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The hybrid system makes use of both the solar power and utility grid supply to charge the battery. When these thresholds are met, appropriate commands to switch the relay accordingly, allowing solar power and/or utility grid supply to charge the battery. The threshold values are set in terms of the percentage of battery charge or the battery voltage levels. The 12V solar tubular battery used in this design can be charged to a maximum voltage level of 14.5V and can retain a voltage level of 10.5V when fully discharged. The threshold level has been set at 80% of the battery voltage for the range of 10.5V to 14.5V. The charging of the battery can be divided into two stages based on the preset threshold value.

Stage 1: 0% - 80%:

This stage denotes the charging of the battery to 80% of the maximum voltage level from the fully discharged state. The battery voltage level is constantly measured using a voltage sensing circuit has been programmed such that when the battery voltage level goes below 13.7V which corresponds to 80% of the maximum level, it generates a command to switch the relay from normally open state to normally closed state allowing the battery to charge from the solar PV and utility grid supply simultaneously.

Stage 2: 80% - 100%:

When the battery is charged up to 80% of its maximum voltage level, generates commands to switch the relay back to normally closed state and block the utility grid supply. At this stage, the battery is charged only from the solar PV. In the charging current - time characteristics, it can be seen that at around 11:30 am to 11:50 am, when the charging current reaches 1O.2A, it suddenly drops down to 3.5A indicating that the battery voltage level has reached I3.7V i.e., 80% of the maximum voltage level and the utility grid supply has been blocked. From here on only solar power is used till the battery charges up to 100% voltage level i.e., I4.5V.

OFFLINE UPS MODE:

During offline Ups mode they are using solar supply system it converts mechanical energy into electrical energy and it is connected to the mppt. Mppt as Maximum Power Point Tracking it is used to convert a higher voltage Dc output from solar panels down to the lower voltage needed to charged the battery means switch the relay3 from normally open state to normally closed state allowing the battery to charge from the solar PV supply simultaneously and it is supplied to the battery is charged as near 14.5v at that time switch the relay4 from normally open state to normally closed state allowing the battery Charge Voltage. The required supply voltage supplied to the inverter it converts dc supply to ac. The load running under inverter mode.

ONLINE UPS MODE:

During Online mode, they are using a normal Grid supply 230v ac. In this Mode, PV has no power so that battery getting charge from grid supply simultaneously R1 closed. Its voltage is reduced as 14.5v down to 8v it is not suitable to use the whole power supply. At this mode Battery getting charge from grid it is used to backup the some Required Voltage. At that time switch the relay4 from normally open state to normally closed state allowing the battery Charge Voltage. Now the Voltage level changed as 10.5v to 14.5v. Now it is comfortable to use the whole power supply with the help of online ups mode. Hence Power from the grid flows directly to the load.

IV. SOLAR HYBRID BATTERY CHARGING:

SOLAR CHARGING:

The output of the solar panel is fed to the charge controller. The charge controller then regulates the voltage and current to suit the requirements of the battery to charge and its output is fed directly to the battery. The MPPT charging is implemented in Solar Smart Charge Controller, which has additional option for battery sensing and based on the Battery Voltage level when the solar Power Not present and When the battery is reach under Voltage Set point, our Solar smart Charge Controller will Switch Grid utility power . to avoid to much Voltage drop we are using Voltage Drop Index methods

Voltage Drop Index:

Another way to size wires for a PV system uses an equation to calculate the voltage drop voltage drop index (VDI). With this equation and a VDI chart, you can calculate the wire size for any voltage drop and any nominal system voltage.

$$VDI = \frac{\text{Amps x feet}}{\text{\%Voltage drop x voltage}}$$

Where:

Amps = Maximum number f amps through circuit.

Feet = one way wire distance.

% voltage drop = Percentage of voltage drop desired (use 2 for 2%)

Voltage = Nominal system voltage.

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Voltage Drop Index Chart

Wire Size AWG	Copper Wire VDI	Copper Wire Ampacity	Aluminum Wire VDI	Aluminum Wire Ampacity
4/0	99	230	62	180
3/0	78	200	49	155
2/0	62	175	39	135
1/0	49	150	31	120
2	31	115	20	94
4	20	85	12	65
6	12	65		
8	8	50		
10	5	30		
12	3	20		
14	2	15		

Fig 2: Table 1: Voltage drop index

UTILITY GRID SUPPLY CHARGING:

The grid supply is utilized for charge the battery. To the power from Inverter supply is stepped down to 12V AC using a step down transformer. It is then rectified to DC supply and regulated which is then supplied to the microcontroller. To charge the battery, the supply is fed to an UPS through a solid-state relay.

V. SIMULATION RESULTS

GRID OPERATING MODE:

In this mode R1=1; R2=1 or 0; R3=0; R4=0(NOTE: 0 for open; 1 for closed) Here R1 closed so that power flows directly from grid to load, simultaneously R2 closed to charge the battery. When battery get fully charge R2 open so that it prevent overflow of power from the grid. Battery can be charged with the help of dc to dc converter which is connected to the grid. In this PV power becomes low.

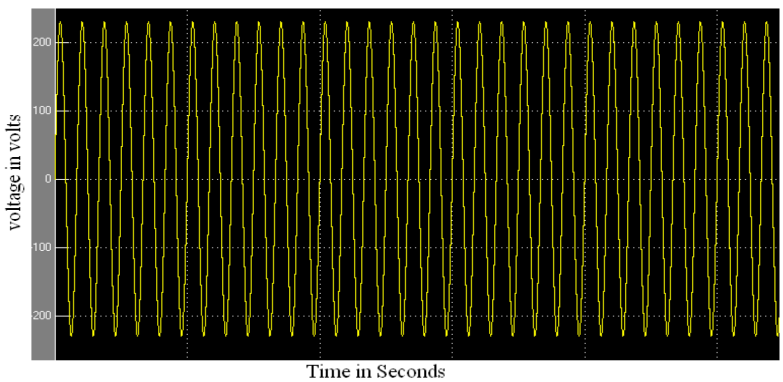

Fig 3: Grid Mode output waveform

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BATTERY OUTPUT WHEN > 10 VOLTAGE: CHARGING TIME

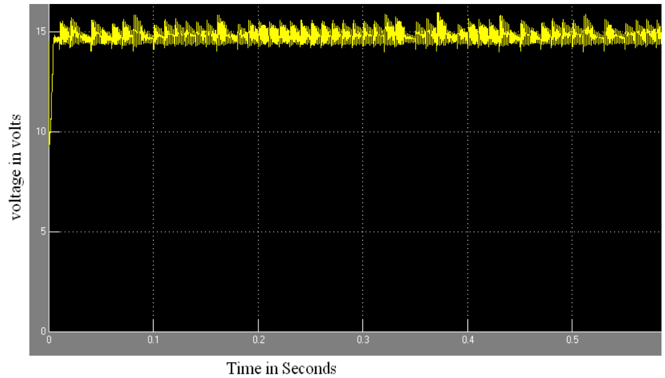

Fig 4: Battery charger output voltage waveform

BATTERY OUTPUT WHEN <10 VOLTAGE: Battery Under Voltage

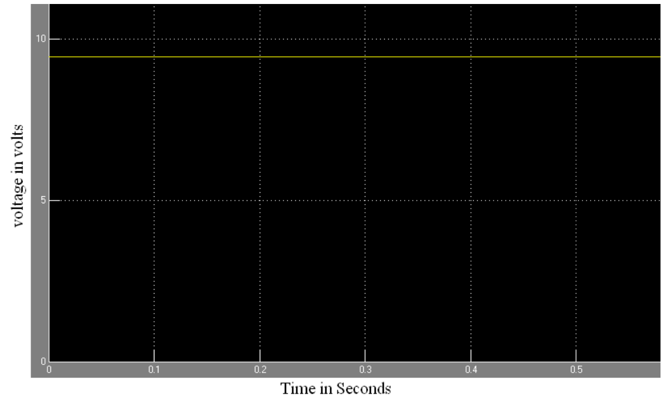

Fig 5: Battery Under voltage waveform

BATTERY FULLY CHARGED CONDITION:

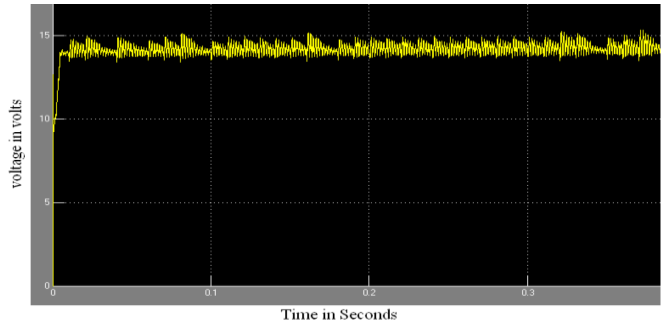

Fig 6: Battery charging voltage waveform at battery full

5.4 INVERTER OPERATING MODE:

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In this mode R1=0; R2=1 or 0; R3=1; R4=1; In this operating mode, PV supplies maximum power according climatic condition. PV power can be controlled by buck boost converter (i.e. it act as a MPPT controller). The output of the MPPT controller can be fed to the battery for charging (R3 closed). When battery gets fully charge automatically R3 open.

LOAD VOLTAGE AT INVERTER MODE:

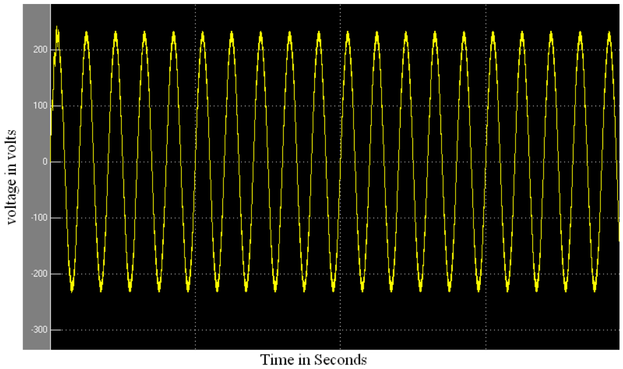

Fig 7: Inverter Mode output waveform

PV VOLTAGE:

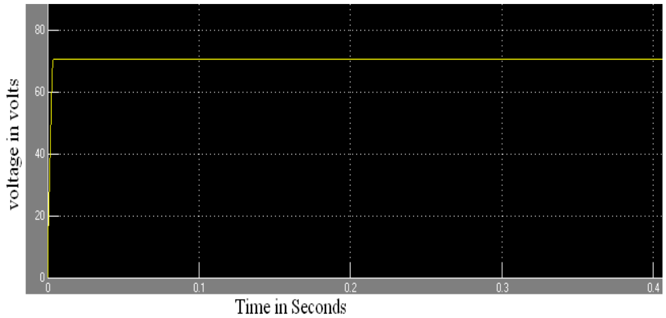

Fig 8: PV Input Voltage waveform

BUCK BOOST CONVERTER VOLTAGE (MPPT OUTPUT VOLTAGE):

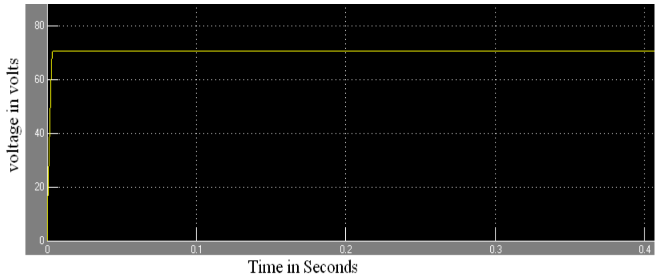

Fig 9: PV Input Voltage waveform

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BATTERY VOLTAGE UNDER INVERTER MODE

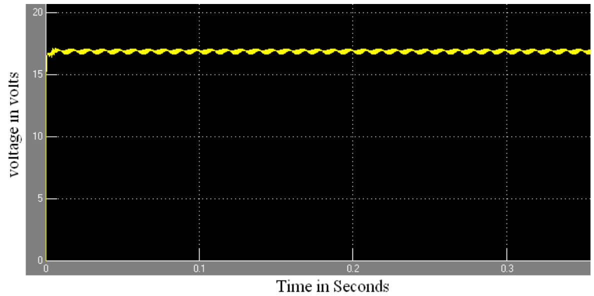

Fig 10: Battery Voltage under Inverter Mode Voltage Wave Form

VII. CONCLUSION

The hybrid system designed to charge a battery has been implemented utilizing both solar PV and utility grid supply suited to an Commercial Application as per Indian scenario. The simplified the control and enhanced the operational efficiency of the system. The prerequisite for varying the threshold setting has ensured enhanced flexibility of the system Battery voltage-based switching has simplified the operation, programming and control of the entire system. Using this entire system we are utilize maximum Solar Power. This Solar Power Inverter is act as Solar Hybrid off Grid Power systems; Both Grid based Inverter Output Wave form Voltage - Time characteristics have been plotted and Solar off Grid Power Inverter Output Wave form Voltage - Time characteristics have been plotted. The complete battery charging period has been monitored and Battery Voltage - Time characteristics have been plotted.

REFERENCES

[1] D. P. Hohm and M. E. Ropp, "Comparative study of maximum power point tracking algorithms using an experimental, programmable, maximum power point tracking test bed," in Proc. 28th IEEE Photovoltaic Spec. Conf., 2000, pp. 1699–1702.

[2] M. G. Wanzeller, R. N. C. Alves, J. V. da Fonseca Neto, and W. Ad. S. Fonseca, "Current control loop for tracking of maximum power point supplied for photovoltaic array," IEEE Trans. Instrum. Meas., vol. 53, no. 4, pp. 1304–1310, Aug. 2004.

[3] Koutroulis, E. and Kalaitzakis, K .. , "Novel battery charging regulation system for photovoltaic applications," Electric Power Applications, TEE Proceedings - , voU51 , no.2, pp. 1 9 1 , 1 97, Mar 2004

[4] S. B. Kjaer, J. K. Pedersen, and F. Blaabjerg, "A review of single-phase grid-connected inverters for photovoltaic modules," IEEE Trans. Ind.Appl., vol. 41, no. 5, pp. 1292–1306, Sep./Oct. 2005.

[5] D. C. Riawan and C. V. Nayar, "Analysis and design of a solar charge controller using Cuk converter," in Proc. Aust. Univ. Power Eng. Conf., 2007, pp. 1–6.

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[6] S. Jain, and V. Agarwal, “A New, Current Control Based, MPPT Technique for Single-Stage Grid Connected PV Systems, ” Elsevier Science Journal of Energy Conversion and Management,vol. 48, pp. 625-644, 2008.

[7] H. Dehbonei, S. R. Lee, and H. Nehrir, “Direct energy transfer for high efficiency photovoltaic energy systems. Part I: Concepts and hypothesis,” IEEE Trans. Aerosp. Electron. Syst., vol. 45, no. 1, pp. 31–45, Jan. 2009.

[8] Y. K Chan and J. C. Gu, “Modeling and control of stand-alone photovoltaic generation system” IEEE International Conference on Power System Technology (POWERCON), pp. 1-7, Oct. 2010.

[9] C. H. Lin, W. L. Hsieh, C. S. Chen, C. T. Hsu, T. T. Ku, and C. T. Tsai, “Financial analysis of a large-scale photovoltaic system and its impact on distribution feeders,” IEEE Trans. Ind. Appl., vol. 47, no. 4, pp. 1884– 1891, Jul./Aug. 2011.

[10] T. Hirose, H. Matsuo, "Standalone Hybrid Wind-Solar Power Generation System Applying Dump Power Control Without Dump Load," IEEE Transactions on Industrial Electronics, vol. 59, no. 2, pp . 988-997, Feb. 2012.

[11] Energy Department, Government of Tamil Nadu, India. (20 1 2). Tamil Nadu Solar Energy Policy 2012 (online Link avliable in TEDA Wesite) – 2012. http://www.teda.inlpdf/tamilnadu_solar_energyp0Iicy_201 2.pdf

[12] Hisham Mahmood, Dennis Michaelson and Jin Jiang: "Control Strategy for a Standalone PV/Battery Hybrid System", 38th Annual Conference of the IEEE Industrial Electronics Society (IECON20 1 2), Montreal, PQ, 25-28 October 201 2.

[13] M. P. Shreelakshmi, M. Das, and V. Agarwal, “High Gain and High Efficiency Bi-Directional DC-DC Converter for Battery Charging Applications in Stand-Alone Photo-Voltaic Systems, ” 39th IEEE Photovoltaic specialists conf., Tampa, Florida, USA, 16-21 June, 2013.

[14] Mohamed O. Badawy, Ahmet S. Yilmaz, Member, IEEE, Yilmaz Sozer, Member, IEEE, and Iqbal Husain, Fellow, IEEE “Parallel Power Processing Topology for Solar PV Applications” IEEE Transactions On Industry Applications, Vol. 50, No. 2, March/April 2014.