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DESIGN OF INVERTER-LESS SOLAR DC OFF-GRID SYSTEM FOR INDIAN HOMES

Mr. Vrushabh S. Waghmare[1], Mr. Anup P. Rautkar[2], Prof. Mangesh J. Nemade[3]

[1,2]UG Scholar, Electrical Engineering (E&P), DESCOET, Dhamangaon (Rly.), Maharashtra, India,
[3]Assistant Professor, Electrical Engineering (E&P), DESCOET, Dhamangaon (Rly.), Maharashtra, India,

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Abstract - *This seminar presents an innovative approach to tackle the crisis of electrification of off-grid and near off-grid homes by using the innovative inverter-less solar DC system. Improved efficiency, lower cost and robust design makes it a very attractive solution. Inverter-less system is not only cost effective to power off-grid homes but as and when grid becomes available, it can be seamlessly integrated. For homes which are connected to the grid but face load shedding, this system provides uninterrupted power. This seminar presents the technical design details of this system. India may be a power deficit country and one third of its homes square measure off-grid or close to off-grid. This seminar presents an efficient and affordable solar DC solution for powering such homes. Though many solutions have emerged within the past for powering these homes, those have been expensive and energy inefficient.*

Key Words: Efficiency, Near Off-Grid Homes, Off-Grid Homes, Remote Monitoring, Solar-DC, Solar Power.

1. INTRODUCTION

There are over 300 million people in India that are yet to have access to quality electricity. Primarily due to the fact that it is not economical to provide grid connectivity to many of these homes due to the lack of affordability on the consumer side and the huge expenditure needed to reach the last mile. A decentralized mechanism is needed to generate the required power at affordable costs. Prices of solar PV have been coming down rapidly, the flexibility in deploying with varying power levels from few watts to several megawatts and the fact that India receives almost 300 days of sun make it an ideal renewable source. For rural India decentralized rooftop solar would be an ideal fit. Typical rooftop solar systems deployed are of few kilowatts, primarily to augment a stable grid. But the rural homes in India would need only a few hundred watts of power. At these power levels with Solar and battery being DC, supporting traditional AC loads would be highly inefficient with losses up to 45%. Furthermore, the instability of the grid adds to the complexity of the system, making them not only inefficient but also expensive. Therefore, a different solution is needed to enable these large scale solar deployments.

A commonplace Indian home's base necessity to meet the power needs is several fans, lights and a versatile charging point which together will normally expend 250W. So as to oblige this heap through a traditional sun oriented AC framework, one would require a 500W sun oriented board and a 4kWh battery. A similar investigation of different galaxies which are accessible in the market was finished. It was discovered that they were very wasteful in changing over sun oriented power accessible to control the home burdens. One reason for such high wastefulness was the way that they were inadequately structured and so as to defeat this poor plan, these frameworks upheld up power utilizing lead corrosive batteries which were larger than usual and costly however the heaps were low. These frameworks were problematic and did not work under different experiments. It was seen that a large portion of these frameworks utilized power converters which were to a great degree wasteful. An extensive number of the Indian homes (about 70 million) are off-matrix and presumably another 30-40 million are close off-lattice (those with power outages for over 12 hours per day). In spite of the fact that sun sparkles brilliantly for over 300 days a year for just about 10-12 hours every day in many parts of the nation, the capability of decentralized sun based vitality has not been enough investigated. With most places having in excess of 1400 identical pinnacle long stretches of daylight every year, sun oriented vitality turns into an appealing decision for crossing over the power-lack. Administration of India understands the way that empowering the utilization of sustainable power source assets, particularly the sunlight based vitality, can help connect the present interest supply hole of controlling homes across the country. Consequently, applicable approaches have been confined for advancing sun oriented power use. The nation propelled a Solar Mission named Jawaharlal Nehru National Solar Mission (JNNSM) in 2010 focusing to introduce 20 GW sun powered power establishments by 2022. Energized with 3GW introduced in 4 years, it has now expanded the objective to 100 GW by 2022 with 40 GW of this focused through sunlight based housetops. Ensuing to the dispatch of JNNSM, a few states additionally propelled particular Solar Polices. In Tamil Nadu (TN), one of the Indian states, TN Solar Energy Policy was propelled in 2012 focusing on 3GW. The TN Vision 2023 has in this way expanded the sun based focus to 5GW by 2023. Understanding the significance of housetop Solar, Tamil Nadu Government has allowed matrix tied net metered sun oriented housetops, commanded roofs on all administration structures and gave an impetus of INR 20,000 for every KW to every single residential roof notwithstanding 30% sponsorship given by legislature of India. TN is likewise introducing free sun oriented housetops on 300,000 houses, and changing over 100,000 streetlights to Solar. TN is driving the sunlight based rooftop top unrest in the nation with 50.3 MW housetops introduced out of 285 MW the

nation over. While the Indian Government is making strides and confining strategies to advance sun oriented power utilization, the innovation must help effective, maintainable, prudent and adaptable arrangements. With existing sunlight based arrangements in India utilizing numerous AC to DC and DC to AC converters, the frameworks will in general lose a lot of produced sun oriented vitality. This wastage gets additionally intensified as burdens turn out to be progressively DC (most electronic contraptions use DC) adding up to another AC to DC transformation at the gadgets. The at present utilized methodology makes the frameworks profoundly vitality wasteful. An Inverter-less DC UPS structured at IIT Madras called (OGH), is proposed to give a far unrivaled arrangement, which is intended to ideally utilize the sun powered power straightforwardly in DC frame limiting the misfortunes because of changes. This power is straightforwardly nourished to the DC loads which are undeniably more vitality effective when contrasted with the regular AC loads. The planned highlights of OGH make this framework more vitality effective and conservative when contrasted with the current arrangements.

1.1 Modularity of Inverter-less System

Inverter-less system has been designed as a scalable solution by allowing solar and battery capacity to be added incrementally and modularly as and when the users want. Solar capacity can be increased from 125W- 500W, battery capacity can be increased from 1kWh to 5kWh. This system also supports incremental addition of grid capacity of 150W or 500W as and when it becomes available. Each inverter-less system can be used to support 4 individual homes. Every home is connected through a Inverter-less Remote Unit (IRU) and is independently metered. Each of the 4 homes which can be connected will continue to have a normal line and an emergency line. Each of these homes is monitored and load is controlled by the inverter-less system. All communication between IRU and inverter-less is done on the power line using DTMF. This eliminates the need of laying communication cable between the inverter-less system and rest of the homes which are powered through it. Communication cable between the Inverter-less system and rest of the homes which are powered through it.

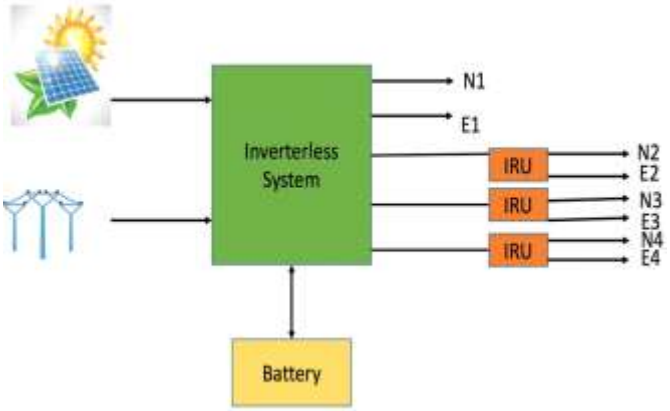

Fig. 1.1: 4 Home Modularity Inverter-less System

1.2 Block Diagram

This system combines solar PV, battery and grid (in DC form) in a highly efficient manner and delivers power to the load. It does so by operating both the source voltages and load voltages at almost the same voltage. In order to efficiently charge the battery as well as cater to loads an innovative mechanism is implemented by means of a delta adder circuit which can maintain the required difference between input and output. This enables the system to have lower losses as power conversion is required only for the additional voltage which is added thereby eliminating losses incurred in conventional power conversion. Fig. 1.2 shows the block diagram of the inverter-less solar DC controller developed at IITM which provides a decentralized DC micro grid solution which generates DC power and drives DC loads bringing down the solar panel and battery sizing to a third.

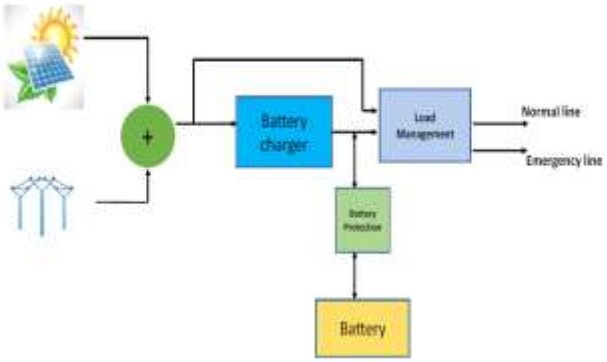

Fig. 1.2.1: Block Diagram of Inverter-less System

A priority algorithm ensures maximum power is drawn from solar followed by battery and is lastly augmented by grid whenever it is available. It also ensures that during the day maximum solar power is utilized, in order to do so, battery is discharged from time to time when solar is not available. This reduces the dependency on grid and thereby reducing costs for the user. Health of the battery and improved longevity is an important factor to be considered when designing such systems as they involve huge costs.

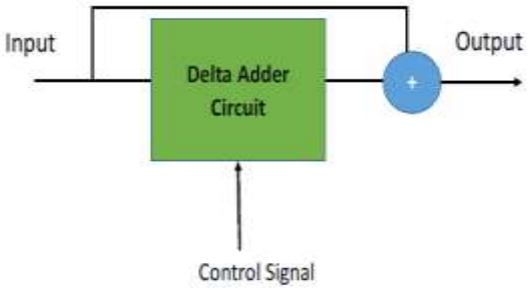

Fig. 1.2.2: Block Diagram of Battery Charger

2. Load Management

Inverter-less framework utilizes astute load the board framework which guarantees that the battery does not release past a specific limit. This guarantees an appropriate charge release cycle for the battery which helps in broadening the battery life. Load line is isolated into typical and crisis separately. This is done as such to guarantee that some lighting or versatile charging point is accessible for a more extended span contrasted with alternate burdens. Commonly, the heap on the crisis line is a globule. Furthermore, the heap states are partitioned into low state and crisis state for demonstrating that the battery is getting released. Signs are given through bell signals and by utilizing LED signs. Contingent upon the condition of charge of the hitter change between the states is made.

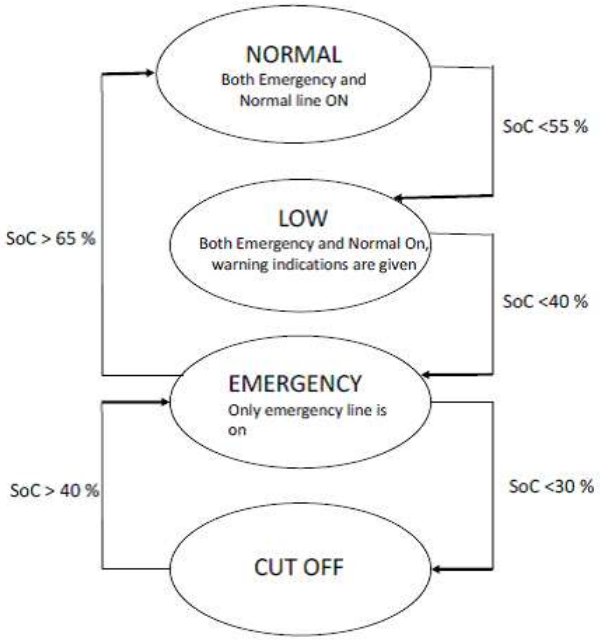

Fig. 2: Load Management State Machine

Both the typical line and the crisis line work when the SoC of the battery is more noteworthy than 65%.

At the point when the SoC of the battery falls underneath 40% the typical line gets cut off permitting the crisis line to work until the SoC of the battery goes beneath 30%. Past this, the battery isn't permitted to release and along these lines the crisis line is likewise cut off. As and when the battery charges the heap lines will walk out on. Additionally, in light of client criticism where it was recommended that the inverter-less framework bolster an old AC machine which the client does not which to change to DC. Inverter-less framework gives an inverter yield control constrained to 125W which is empowered just when the lattice comes up short. In the event that matrix is accessible, the AC apparatus under thought is straightforwardly fueled through it and the inverter in the Inverter-less framework is skirted.

3. Efficiency Details

Based on the source and load management mechanisms discussed before, we have achieved the following efficiency details for the inverter-less Solar DC system. Solar to battery is through the delta adder as shown in source management section is very high. There is almost a direct path from solar to load likewise for the battery to load. The grid is converted to DC with a highly efficient AC-DC converter. This also has a direct path to load and through the delta adder to the battery. Table No. 1, summarizes the efficiency numbers achieved by this system in various paths.

Table -1: Efficiency Details

Sr. No.	Path	Efficiency
1	Solar to Battery	95%
2	Solar to Load	97%
3	Grid to Battery	89%
4	Grid to Load	92%
5	Battery to Load	97%

4. System Monitoring and Management

The greater part of the off-matrix and close off-framework homes in India are situated in the midst of troublesome landscapes. These spots are remotely found and not actually available for individuals to go and attempt support. Thus so as to comprehend if the framework is acting accurately or not, subtleties of over use, under use, altering ends up vital. Inverter-less framework ceaselessly screens sunlight based power, lattice control, control going into the battery and power releasing out of the battery, the power utilization on the heap lines and SoC of the battery.

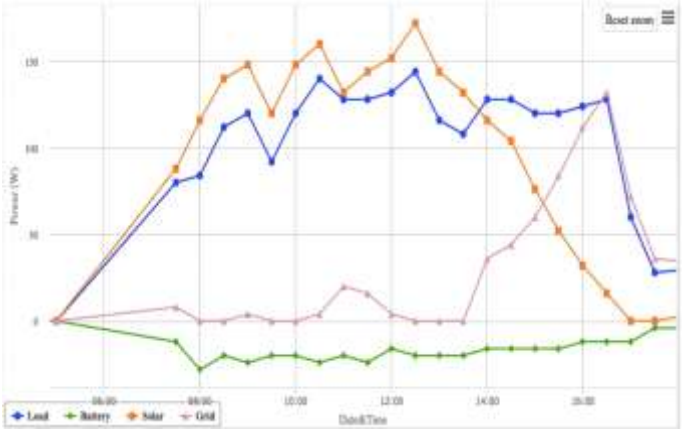

Fig. 4: Remote Monitoring Graph

This data is locally stored on the system which can be accessed once every month by a person who goes around for billing purpose. This data can then be sent to the cloud which can be extremely useful for the system user as well as the designer, for this purpose, Inverter-less system is designed with a BLE interface which is cost effective as providing a

GSM module for every system will be expensive. This enables the system to talk to any external device like a mobile phone / tablet which can support BLE which in turn can connect to cloud as and when data connection is available. This monitoring of data enables the user or system designer to understand the health of the system and also system behavior under field conditions which might not have been tested in lab environment. Fig. 3.6 shows data from one such system installed in the field. Based on the data available from the installed systems in the field, modifications to existing algorithms were done which has improved the system behavior under different conditions. Also, most of the decisions in the algorithm are taken based on certain values which can be change from place to place where the system is deployed and can impact its behavior. Hence, this BLE interface enables the system provider to set the system parameters accordingly using the mobile app.

5. CONCLUSION

The Inverter-less solution through its efficient implementation of solar DC has enabled a powerful mechanism providing electricity to all homes in India, literally removing the need for grid connectivity at much lower costs. By using inverter-less solar dc system the efficiency of the system get improved and also the overall cost of the system get reduced, this system provides uninterrupted power and the robust designe makes it very attractive solution, from above theory conclude that the inverter-less system is not only cost effective to power off-grid homes but as and when grid becomes available, it can be seamlessly integrated.

REFERENCES

[1] Anusha Ramachandran, Sairam Mannar, Ashok Jhunjhunwala, "Inverter-less Solar- DC System Design for Off-Grid and Near Off-Grid Indian Homes", IEEE Transaction, 2016.

[2] Ashok Jhunjhunwala, Krishna Vasudevan, Lakshmi Narasamma & Bhaskar Ramamurthi, "Technological and Deployment Challenges and User-Response to Uninterrupted DC (UDC) deployment in Indian homes", IEEE First International conference on DC Microgrids, June, 2015.

[3] Ashok Jhunjhunwala, Prabjhot Kaur, Aditya Lolla "Solar-DC Microgrid for Indian Homes: Transforming Power Scenario", IEEE Electrification Magazine, Vol. 4, Issue 2, pp: 10-19. June 2016.

[4] Venkat Rajaraman, Uma Rajesh, Prabhjot Kaur, Ashok Jhunjhunwala, "Economic Analysis of deployment of DC power and Appliances along with Solar in urban multi-storied buildings", IEEE First International conference on DC Microgrids, June, 2015.