MODELLING, SIMULATION AND PERFORMANCE ANALYSIS OF PV ARRAY UNDER DIFFERENT SHADING CONDITIONS

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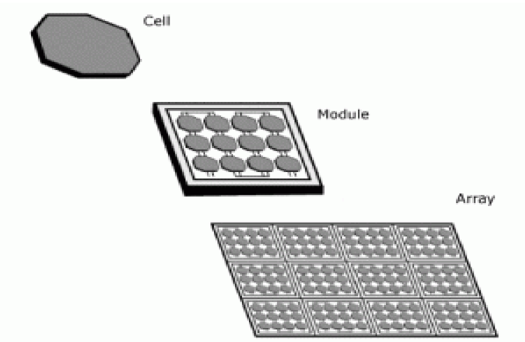
ABSTRACT

In this project we have done the analysis of several DC-DC converters to find the most stabilised converter on the basis of efficiency, voltage ripple, current ripple. We have been checked through different converters like Boost Converter, Bride Boost Converter and Soft Switched Interleaved Boost Converter. Power losses and their consequences have the negative effect of decreasing the power density and the efficiency. The proposed soft switching interleaved boost converter module. DC-DC boost converters are connected in parallel which leads to reduction of the size of components especially inductors. The total power is divided in paralleled converters there by reducing the stress among the individual converters Soft Switching Techniques Ensure proper design and operation of the SSIBC's soft-switching mechanism (ZVS and ZCS) to minimize switching losses. The interleaving technique ensures the reduction of ripple currents in both input and output circuits. This is crucial for high efficiency. we can reduce power density with high frequency operation.so we find Soft Switched Interleaved Boost Converter as an efficient one. In partial shading conditions uneven sunlight distribution due to shading creates varying power outputs across PV modules in a series-parallel array. There by higher efficiency is realized. The MOSFETs with appreciable on-state current-carrying capability and off-state blocking voltage capability is obtained.

I. INTRODUCTION:

The basic ingredients of PV cells are semiconductor materials, such as silicon. For solar cells, a thin semiconductor wafer creates an electric field, on one side positive and negative on the other. When light energy hits the solar cell, electrons are knocked loose from the atoms in the semiconductor material. When electrical conductors are connected to the positive and negative sides an electrical circuit is formed and electrons are captured in the form of electricity. This electricity is used to power a load. A PV cell can either be circular or square in construction. In a PV module because of the low voltage generation in a PV cell (around 0.5V), several PV cells are connected in series (for high voltage) and in parallel (for high current) to form a PV module for desired output. In case of partial or total shading, and at night there may be requirement of separate diodes to avoid reverse currents The p-n junctions of mono-crystalline silicon cells may have adequate reverse current characteristics and these are not necessary. There is wastage of power because of reverse currents which directs to overheating of shaded cells. At higher temperatures solar cells provide less efficiency and installers aim to offer good ventilation behind solar panel. Usually there are of 36 or 72 cells in general PV modules. The modules consist of transparent front side, encapsulated PV cell and back side. The front side is usually made up of low-iron and tempered glass material. The efficiency of a PV module is less than a PV cell. This is because of some radiation is reflected by the glass cover and frame shadowing. A photovoltaic array (PV system) is an interconnection of modules which in turn is made up of many PV cells in series or parallel. The power produced by single module is not enough to meet the requirements of commercial applications, so modules are connected to form array to supply the load. In an array the connection of the modules is same as that of cells in a module. The modules in a PV array are usually first connected in series to obtain the desired voltages; the individual modules are then connected in parallel to allow the system to produce more current. In urban uses, generally the arrays are mounted on a rooftop. PV array output can directly feed to a DC motor in agricultural applications. The basic principle behind the operation of a PV cell is photoelectric effect. In this effect electron gets ejected from the conduction band as a result of the absorption of sunlight of a certain wavelength by the matter (metallic or non-metallic solids, liquids or gases). So, in a photovoltaic cell, when sunlight hits its surface, some portion of the solar energy is absorbed in the semiconductor material.



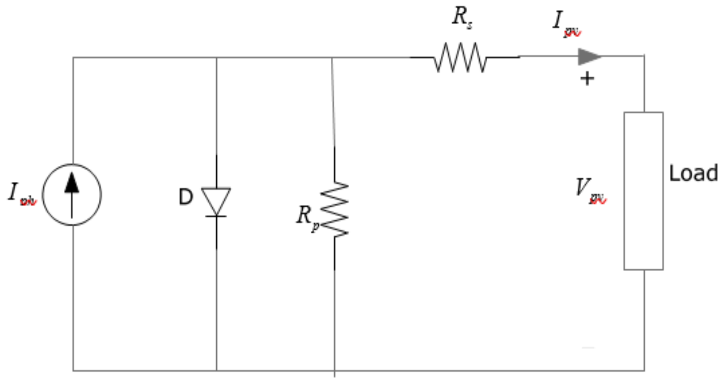


Fig 2.4. Equivalent circuit of a solar cell

The electron from valence band jumps to the conduction band when absorbed energy is greater than the band gap energy of the semiconductor. By these hole-electrons pairs are created in the illuminated region of the semiconductor. The electrons created in the conduction band are now free to move. These free electrons are enforced to move in a particular direction by the action of electric field present in the PV cells. These electrons flowing comprise current and can be drawn for external use by connecting a metal plate on top and bottom of PV cell. This current and the voltage produces required power. The photovoltaic system can generate direct current electricity without environmental impact when is exposed to sunlight. The basic building block of PV arrays is the solar cell, which is basically a p-n junction that directly converts light energy into electricity. The output characteristic of PV module depends on the cell temperature, solar irradiation, and output voltage of the module. The figure shows the equivalent circuit of a PV array with a load. This article explains about the attaining of better efficiency and low voltage ripple and current ripples values by analysing different DC-DC converters. The information comes from a verified user. Different DC-DC converters are widely used in:

- Portable electronics
- LED Lighting
- Solar panels
- Electric Vehicles (EVs)

The proposed PV based boost converter utilizes a soft switching method using an auxiliary circuit with a resonant inductor and capacitor, auxiliary switch, and diodes. The soft switching techniques reduce the switching losses enabling high frequency operation and consequently reducing the overall system size and hence to increase the power density. The passive snubber circuits can be added to the converter to reduce the stresses to safe levels by limiting the rate of rise (di/dt) of currents through devices at device turn on Limiting the rate of rise (dv/dt) of voltages across devices during reapplied forward blocking voltages and shaping of the switching trajectory of the. device as it turn on and off. The interleaved boost converter design involves selection of duty cycle, boost inductances L1 and L2, the values of coupling coefficient k, the values of snubber capacitances C1 and C2.

II. RELATED WORK:

The proposed system E-Circular is to overcome the existing problems. It is to display that the Buck Boost converter able to give the efficiency based on the switching technique like ZVS and ZCS. The input of DC/DC converters is an unregulated DC voltage, which is obtained by PV array and therefore it will be fluctuated due to changes in intensity and temperature. In these converters the average DC output voltage must be controlled to be equated to the desired value although the input voltage is changing. From the energy point of view, output voltage regulation in the DC/DC converter is achieved by constantly adjusting the amount of energy absorbed from the source and that injected into the load, which is in turn controlled by the relative durations of the absorption and injection intervals. These two processes of energy absorption and injection constitute a switching cycle. On the other way, if the energy storage capacity of the converter is too small or the switching period is relatively too long, then the converter will transmitted all the stored energy to the load before the next cycle begins.

1. Analysis and Implementation of a perfect DC-DC boost converter

We have been analysed and go through different DC-DC boost converters but it is to find that SSIBC is the most suitable converter. Energy efficiency can make a major contribution to meeting the global energy demand. A boost converter is a particular type of power converter with an output DC voltage greater than the input. This type of circuit is used to 'step-up' a source voltage to a higher, regulated voltage, allowing one power supply to provide different driving voltages.In recent years, interleaved boost converter is well suited for high performance applications. The switching losses pre-dominate causing junction temperature to rise which is a major drawback of PWM switching. The soft switching phenomena known as zero-voltage switching (ZVS) and zero current switching (ZCS) can reduce switching losses. For zero-voltage switching (ZVS), the transistor will be turned on at zero Vds voltage to reduce the turn on switching loss. For zero-current switching (ZCS), the transistor will be turned off at zero Id current to reduce the turn off switching loss. The soft switching techniques reduce the switching losses enabling high frequency operation and consequently reducing the overall system size and hence to increase the power density

2. Using of an MPPT Technique

In solar power systems, MPPT is an essential technique that optimizes the power output from photovoltaic (PV) modules. It continuously adjusts the operating voltage of the PV modules to ensure they operate at the Maximum Power Point (MPP), where they produce the most electrical power under the prevailing environmental conditions. The MPPT of a PV module is not constant but varies depending on solar irradiance (sunlight intensity), Higher irradiance levels generally shift the MPP to a higher voltage. Module temperature as temperature rises, the MPP typically moves to a lower voltage.

3.Series-parallel configuration

Partial shading is a common occurrence in photovoltaic (PV) systems, where some solar panels receive less sunlight than others due to clouds, buildings, or other obstructions. This uneven exposure can significantly impact the array's overall power output.

This is the most widely used configuration for connecting PV modules in a solar array. Here's a breakdown of how it works and its behaviour under partial shading:

- ✓ **Series Connection:** Multiple modules are linked positive to negative, forming a string. The current remains constant throughout the string, but the voltage is additive (voltage of each module adds up).
- ✓ **Parallel Connection:** Multiple strings are connected positive to positive and negative to negative. The voltage across each string remains constant, but the current is additive (current from each string adds up).
- ✓ **Impact of Partial Shading:**

When a module in a series connection is shaded, its current output drops. Since the current is constant throughout the series, the entire string operates at the current level of the shaded module. This significantly reduces the power output of the entire string compared to unshaded strings

III. RESEARCH METHODOLOGY

This proposed system described by thoroughly reviewing existing research on SSIBCs, MPPT techniques, and their application in mitigating the effects of partial shading on PV systems. Focus on recent advancements in SSIBC topologies, control strategies, and MPPT algorithms specifically designed for handling shading. Identify research gaps and areas for potential improvement in efficiency, dynamic response, and effectiveness under complex shading scenarios. And the system design and simulation are done through

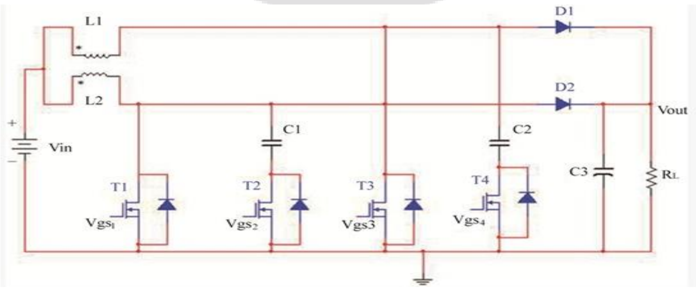


figure shows the circuit diagram of the SSIBC.

- ➢ Designing the SSIBC circuit based on your chosen topology. Consider factors like switching frequency, component ratings, and inductor selection for optimal performance.

- Utilizing simulation software like MATLAB/Simulink, PSIM, or PLECS to model the complete system, including the PV array, SSIBC, MPPT controller, and load.
- Developing a detailed simulation model incorporating the following aspects:
  - PV module characteristics with temperature and irradiance dependency.
  - SSIBC model with accurate switching behaviour and soft-switching analysis.
  - MPPT algorithm implementation (e.g., Perturb and Observe, Incremental Conductance, Fuzzy Logic Control).
  - Shading patterns with the ability to simulate various shading scenarios (partial shading, rapid shading changes, etc.).
  - Load model reflecting your project's specific load requirements.
- Appliances conveniently and securely through voice commands By following these steps, you can collect and preprocess the data needed for a voice-controlled notice board system that accurately recognizes voice commands and provides the desired information.

IV. METHODOLOGY:

- The main objective of this paper is to increase the efficiency, voltage ripple and current ripple of our proposed sytem.It is a modern and innovative project that utilizes the advanced features with soft switching technique and scrum's iterative approach allows us to break down the project into smaller phases focused on specific shading conditions. This enables us to test and refine our model as we progress through different shading scenarios.
- **Adaptability to changing requirements:** As we analyze the performance of the PV array under various shading conditions, we might discover new factors to consider or refine our modeling approach. Scrum's flexibility allows us to incorporate these adjustments into our workflow seamlessly.
- **Focus on results:** At the end of each sprint (short cycle), we'll have a concrete deliverable, such as a simulation result for a particular shading condition. This facilitates progress tracking and ensures we're meeting our project goals.

Here's how we implementd Scrum for our project:

1. Define Sprints**:** Divided our project into sprints, each focusing on a specific shading condition (e.g., partial shading, uniform shading, etc.).
2. Sprint Planning**:** At the beginning of each sprint, planing the tasks required to model, simulate, and analyze the PV array's performance under the designated shading condition.
3. Daily Scrum Meetings**:** Conduct brief daily meetings to discuss progress, identify challenges, and make adjustments as needed.
4. Sprint Review**:** At the end of the sprint, presenting our findings from the simulation and discuss them with the team. This is a chance to get feedback and identify areas for improvement.
5. Sprint Retrospective**:** Hold a retrospective meeting to discuss what went well during the sprint and what could be improved in the next one.

Scrum emphasizes collaboration and continuous improvement. By using this methodology, you can ensure your project progresses efficiently while adapting to new learnings and discoveries throughout the modeling and simulation process.

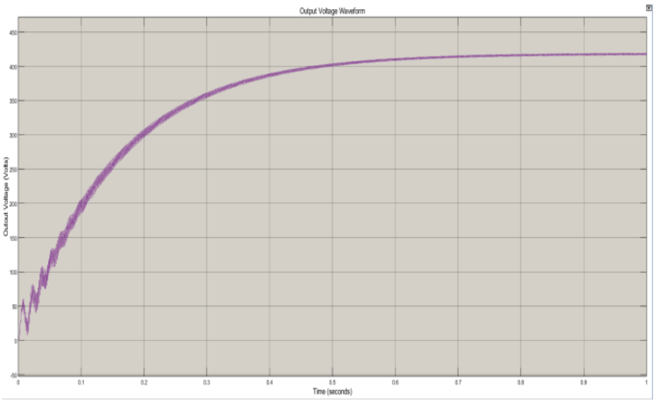
V. RESULT:

Testing and Evaluation

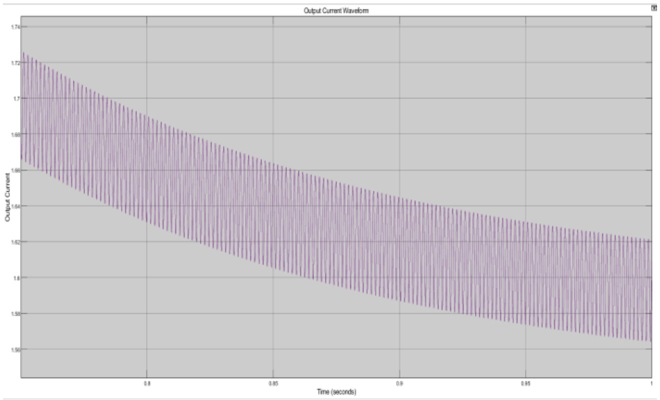
Testing and evaluation can be done through simulating the Simulink model of PV array connected with 20 modules

Under different shading conditions.In this process we obtain the voltage and current characteristics shown below

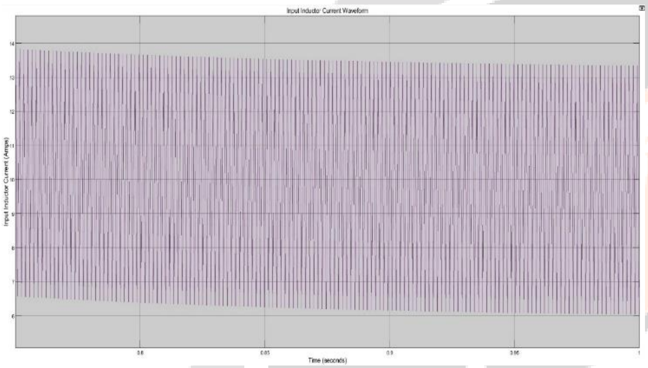
OUTPUT VOLTAGE



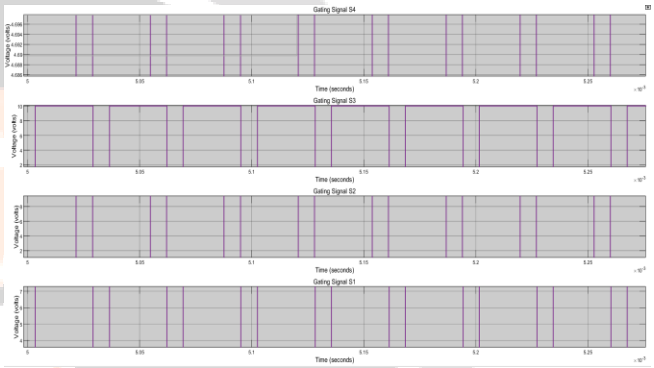
OUTPUT CURRENT



INDUCTOR INPUT CURRENT



PWM PULSE WAVEFORM



PROPOSED SYSTEM CALCULATIONS:

%inductor current ripple

= (Max input Current - Minimum i/p Current / Mean Value current)

=13.9-6.1/6.836=1.14%

% output current ripple

= (Max output Current - Minimum o/p Current / Mean Value current)

= 1.73-1.57/1.6123=0.099 %

% output voltage ripple

= (Max output Voltage - Minimum o/p Voltage/Mean Value voltage)

=419.03-419.00/419.02-0.415%

POWER =V*I

% Efficiency = (OUTPUT POWER/INPUT POWER) * 100

= (419x1.6123)/(100 x 6.836)*100=98.8%

VI. CONCLUSION:

In this project, we embarked on a comprehensive journey to investigate the modelling, simulation, and performance analysis of photovoltaic (PV) arrays under various shading conditions, with a particular focus on the utilization of a soft-switched boost converter. Through rigorous simulation studies and analysis, we aimed to address the challenges posed by partial shading scenarios and devise strategies to enhance the overall efficiency and reliability of PV systems. By employing sophisticated modelling techniques and simulation tools, we were able to capture the dynamic responses of PV systems to shading events, facilitating a deeper understanding of the underlying phenomena. The integration of a soft-switched boost converter emerged as a promising solution to mitigate the adverse impacts of shading on PV array performance. Through its advanced topology and control strategies, the soft-switched boost converter offers improved efficiency, reduced losses, and enhanced power extraction capabilities, even under challenging shading scenarios. Our simulation results demonstrated notable improvements in power output and system stability when employing this converter, reaffirming its efficacy in real-world applications. In conclusion, our investigation into the modelling, simulation, and performance analysis of PV arrays under different shading conditions, coupled with the utilization of a soft-switched boost converter, has yielded valuable insights and practical solutions for enhancing the efficiency, reliability, and sustainability of solar energy systems. By advancing our understanding of PV system behaviour and leveraging innovative technologies, we are poised to unlock the full potential of solar energy and accelerate the transition towards a greener and more sustainable future.!

VIII. REFERENCES:

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