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Maximum Power Point Tracking Powered Solar PV Grid Integrated System Using DSTATCOM

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Abstract: The energy crisis has arisen as a consequence of rapid depletion of fossil fuels and a growing awareness of the need of environmental preservation. As a result, scientists are attempting to develop new methods for harvesting renewable energy sources. Maintaining usage efficiency is essential for conserving resources for future generations. Due to the availability of renewable energy sources, the goal of this study is to explore, assess, and underline the importance of a PV system that is linked to the grid and as a consequence the description of PV systems in connection to grid regulation is examined. The micro grid concept decreases the number of reversals in a single AC or DC grid, making it easier to connect variable renewable AC and DC sources and loads to energy systems. Energy storage systems (ESS) are one way to improve the quality of a power supply while also assuring its stability. The distributed static synchronous compensator (D-STATCOM) is used to adjust if the AC network is unable to supply the power requirement. The suggested model was simulated in MATLAB R2020a simulink programme to see if it was feasible using an Intel core Pentium(R) dual core processor running at 2G.20GHz and 3GB RAM in a 64 bit configuration.
Keywords: Micro-grids, DSTATCOM, Energy Storage Systems, PV systems, Synchronous Reference Frame Theory (SRF).

I. INTRODUCTION

Micro-grids combine a variety of energy sources in the most efficient manner possible to fulfil growing needs, and they can work in conjunction with or independently of the grid system. They may be regarded of as a regulated component that produces energy from mostly sustainable Distributed Energy Resources (DER).

Extensive amount has a variety of drawbacks, including constraints on the use of non-renewable energy sources, network expansion, capacity reduction on existing lines, and threats from hostile parties.[9-11]

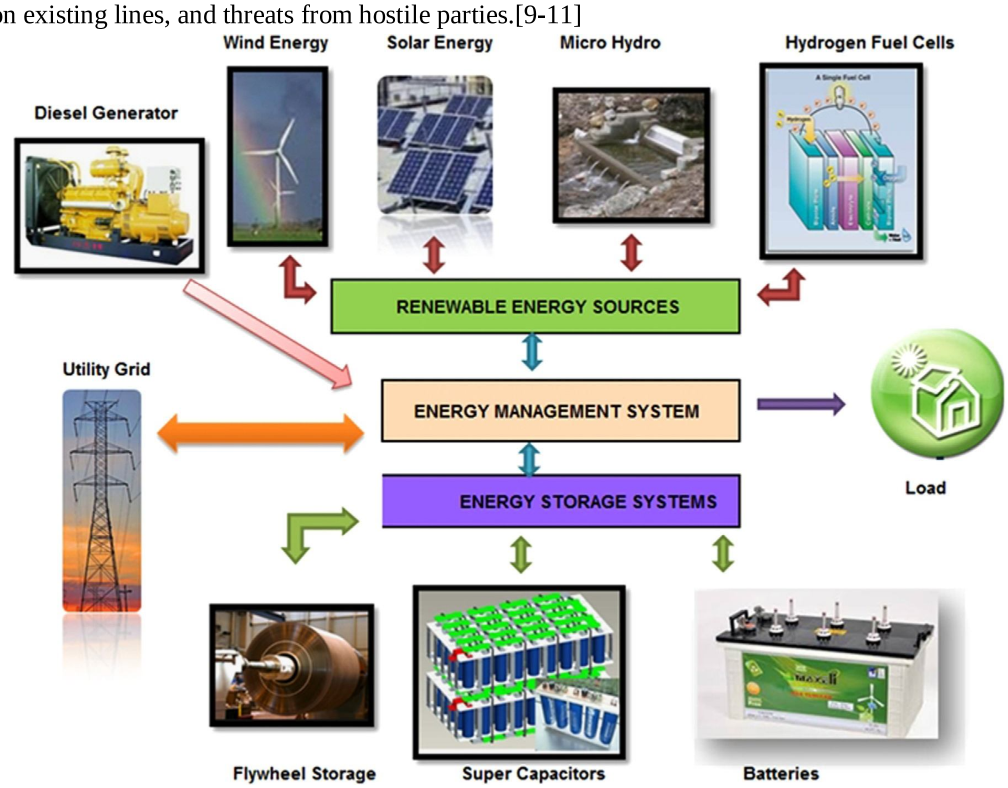

Fig. 1 Hybrid renewable energy systems(HRES)

Certain sources' electricity is erratic or of poor quality because of their stochastic nature. As a result, a full transition from fossil fuels to renewable energy would demand a diverse mix of alternative energy sources.

Biofuels including hydro, geothermal, biomass, wind, solar, hydrogen, nuclear, and fossil fuels should be made to work as a single unit in varied configurations to meet a common demand zone. The term "Hybrid Renewable Energy System" (HRES) refers to a system that integrates many DGs to satisfy the needs of a client.

As shown in Fig. 1, HRES can be a mix of traditional resources like generating units and/or renewable energy sources like photovoltaics (PV) and wind turbines (WT) combined with reserve systems and advanced configurations.

Light photons are converted into electrons and then collected. Energy from the sun is now extensively generated, thanks to the efforts of several energy investment organizations.

When light photons reach the photovoltaic array, it converts them to electrons. This generates a DC current, which may then be increased using DC–DC converters before being reversed to deliver AC power to the loads.

The bulk of PV cells are made of semiconductor polycrystalline materials. Mono-crystalline, poly-crystalline, and thin-film PV cells are available in a range of sizes and forms. [12]

Titanium-oxide clad PV cells have emerged as a result of new improvements in cellular production procedures, greatly increasing output efficiency.

PV cells are assembled into modules, which are then connected in series and/or parallel to create larger units with greater values and outcomes. An MPPT system is needed for effective solar energy reception in order to increase the conversion process performance.

II. POWER QUALITY

Harmonics are a type of power quality problem that predominantly impacts the distribution system. According to the IEEE vocabulary, harmonics are "a sinusoidal element of a wave shape or value having a pace that is an integral function of frequency." [1]. Communication interference, solid-state equipment failures, and overheating can all generate overtones in the power grid.

When non-sinusoidal current interfaces with the distribution system, voltage characteristic fluctuation occurs, affecting the distribution network significantly. [2]. In distribution networks, power conditioning devices such as DSTATCOM and quality management strategies improve power quality [3,4,5]. To save money and increase efficiency, it's vital to place them in the best available area and execute them effectively [6].

A. DSTATCOM

The D-STATCOM technology is used to improve the quality of power when voltage quality issues develop, such as network redundancy, poor power factor, improper voltage regulation, aberrant neutral current, and so on. [8]

One of the main reasons D-STATCOM is so widely used nowadays is the introduction of fast, self-commuting material components. STATCOM, also known as distribution STATCOM, is a FACTS component that balances out voltage variations and flickers induced by distribution line disruptions by injecting reactive power into the network.

There are two ways to control the D STATCOM: voltage mode control and current mode control.

In voltage mode control, the output dc voltage is produced sinusoidally, regardless of whether the power is coming from the demand or the supply. In continuous current mode, the input current has to be symmetrical sinusoids. [7]

The functioning of D STATCOM is based on SVPWM (Space Vector Pulse Width Modulation) methodology, that may be utilised for sinusoids and non-sinusoids, controlled and imbalanced three-phase power systems both with and without zero sequence elements.

B. Principle Of Operation Of Dstatcom

In the subspace domain, sine triangle variation has been utilized, and in the d-q stationary reference frame, space vector propagation has been used. In every sense, sine-triangle and space vector modulation are the same.

The triangle form and sine wave overtones are two examples of characteristics of the space vector architecture that are connected to the sine-triangle scheme.

The synchronous reference frame idea is employed to regulate the APF's three-phase three-leg VSC. A block diagram of the control scheme is shown in Figure 2.

To isolate the Dc offset of iLd and iLq from d–q current elements, low-pass filters (LPFs) are utilised.

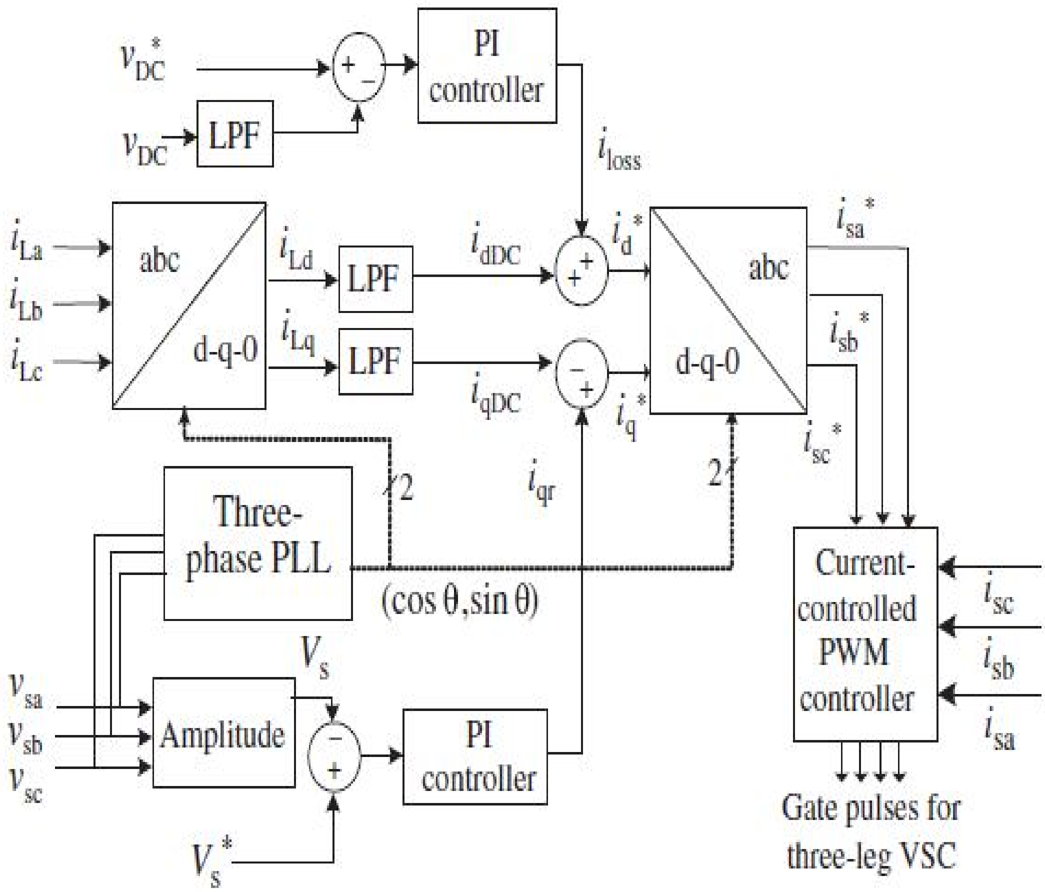

Fig. 2 Synchronous Reference Frame theory based control algorithm

$$\begin{pmatrix} i_{Ld} \\ i_{Lq} \\ i_{L0} \end{pmatrix} = \frac{2}{3} \begin{pmatrix} \cos\theta & -\sin\theta & \frac{1}{2} \\ \cos\left(\theta - \frac{2\pi}{3}\right) & -\sin\left(\theta - \frac{2\pi}{3}\right) & \frac{1}{2} \\ \cos\left(\theta + \frac{2\pi}{3}\right) & -\sin\left(\theta + \frac{2\pi}{3}\right) & \frac{1}{2} \end{pmatrix} \begin{pmatrix} i_{La} \\ i_{Lb} \\ i_{Lc} \end{pmatrix}$$

C. Principle Of Space Vector Pulse Width Modulation Of DSTATCOM

$$\begin{pmatrix} v_d \\ v_q \end{pmatrix} = \frac{2}{3} \begin{pmatrix} 1 & -\frac{1}{2} & -\frac{1}{2} \\ 0 & \frac{\sqrt{3}}{2} & -\frac{\sqrt{3}}{2} \end{pmatrix} \begin{pmatrix} v_{an} \\ v_{bn} \\ v_{cn} \end{pmatrix}$$

1) The sinusoidal voltage may be thought of as a constant amplitude variation revolving at a given frequency.
2) This PWM approach determines the set reference voltage Vref by altering the eight switching phases V0 to V7 (From abc reference point to the d-q reference point)
3) Dimensions Transformation: A three-phase voltage array is converted into a vector that specifies the three-phase voltage's coordinate sum of matrices in the steady d-q point of reference.

III. SIMULATION RESULTS

Fig 3 depicts the overall MATLAB Simulink diagram of system. Current at the bus has been seen changing accordingly with the change in pattern of irradiance provided

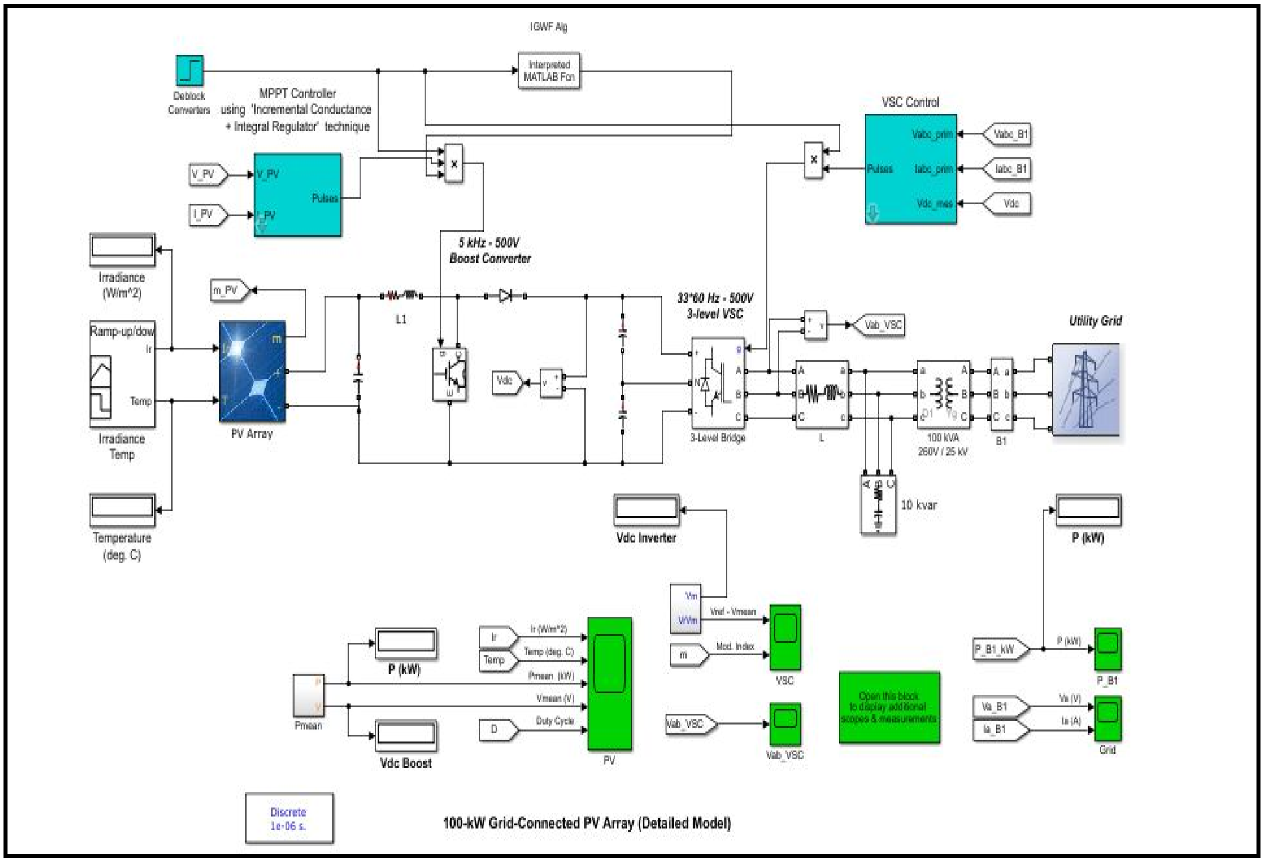

Fig. 3 Simulink diagram of the system

The switching frequency applied to a converter with a maximum value of 0.5 is shown in Figure 4. At t=0.4s, the Control scheme is active, and it begins adjusting the duty cycle of the converter in order to harvest the most power from the PV panel.

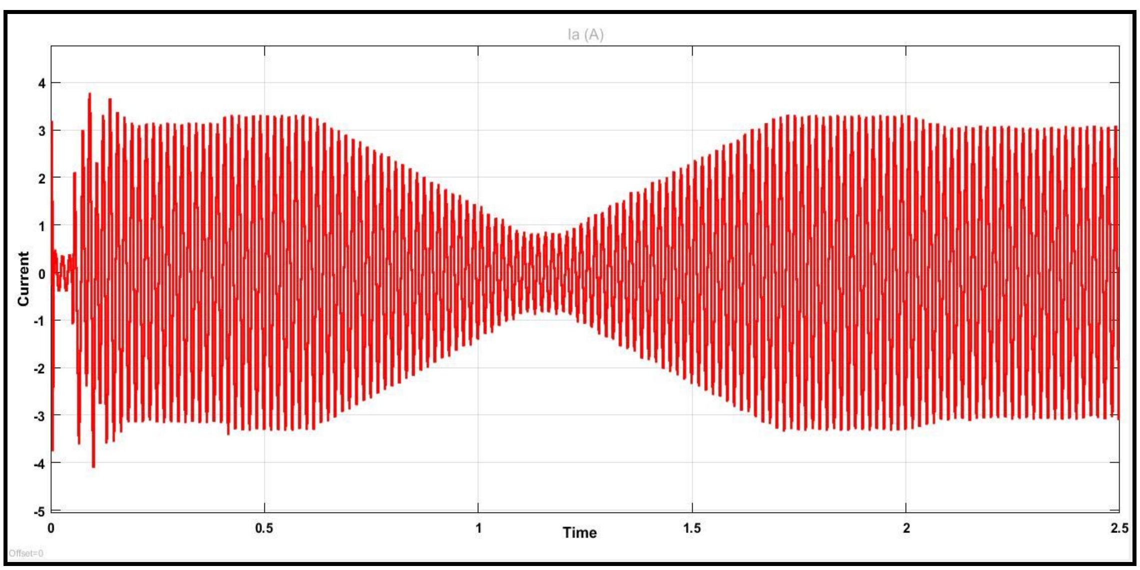

Fig. 4 Duty Cycle

The modulation index for the PV module is depicted in fig 5.

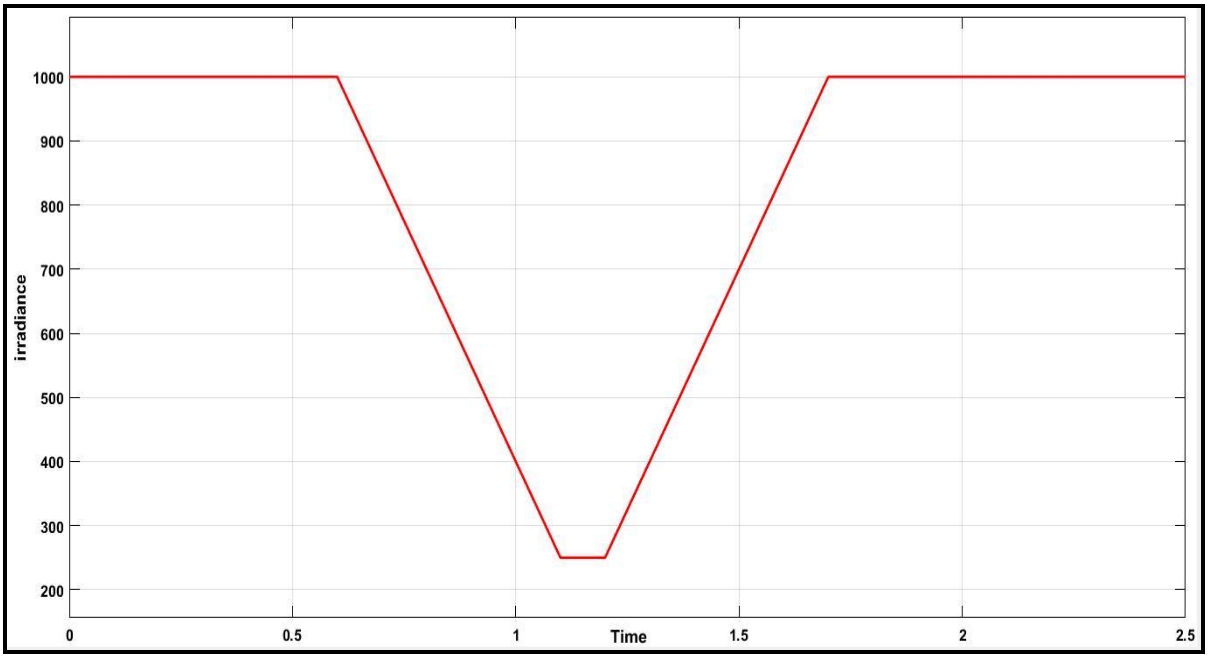

Fig. 5 Modulation Index

Figure 6 depicts the thermal variation applied as a Photovoltaic modules input. The temperature is 25 degrees Celsius until t=2 seconds and then it rises to 50 degrees Celsius. That is, we are just increasing the temperature to double to see how it affects the amount of energy created.

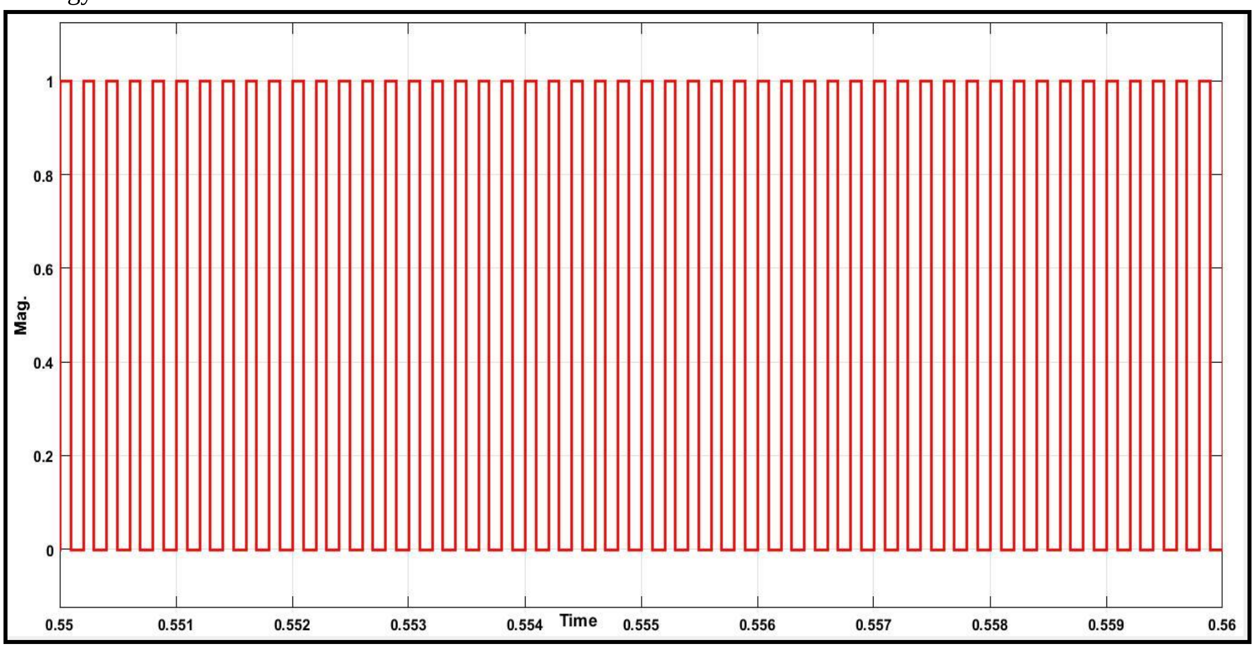

Fig. 6 Temperature

The maximum power point of a photovoltaic array denotes the highest usage of a Photovoltaic modules. The peak power point voltage and current dimensions are [7.9A, 26V]. It is tracking maximum power or, in other words, it is pulling maximum power from the PV Board at this specialist area. Climate, device deterioration, and solar irradiance accessibility at a given location can all cause the maximum power point voltage to fluctuate.

The average value for a converter is depicted here in fig 7, with the standard value system at 500V and the average value rising from 0 to 508V in a fraction of a second.

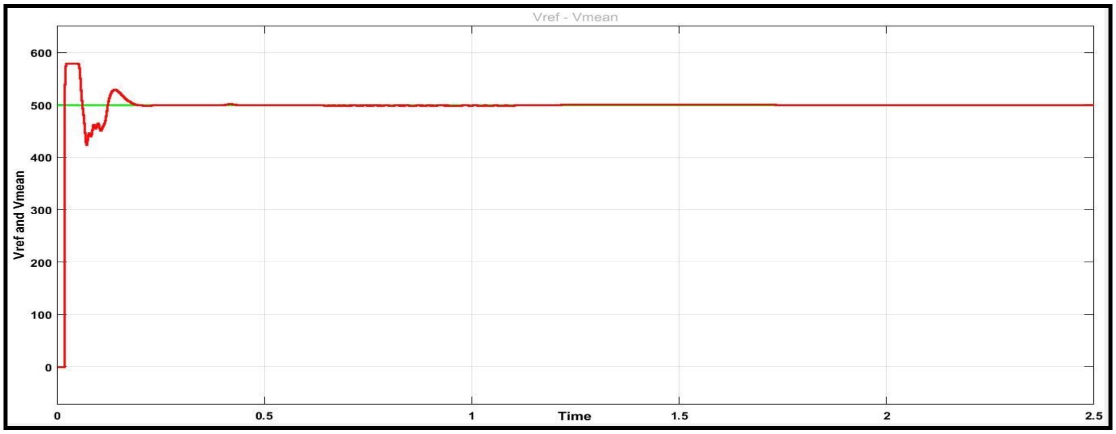

Fig. 7 Mean Value of the converter

IV. CONCLUSIONS

It's vital to remember that various storage technologies offer various benefits, so picking the right one for your requirements is crucial. Power conditioning technologies such as DSTATCOM and quality control methodologies can be used in distribution systems to enhance power quality and fulfill load demand. Utilizing a FACTS control device like DSTATCOM, active and reactive power may be regulated. Further research will assist in power quality improvement from HRES and overcoming the drawbacks of the current scenario.

A standardized approach of solar grid - connected power system with enhance features of MPPT and controllers is utilized to simulate the hybrid microgrid for power system design in the MATLAB/SIMULINK environment. This solar PV with grid modeling satisfies demand side requirements due to its non-disturbing supply. The most contemporary research focuses on grid-connected service in the mixed grid mode. Both converters' architectures, as well as the control technique, are geared to sustain a reliable unit under changeable loads and resource restrictions.

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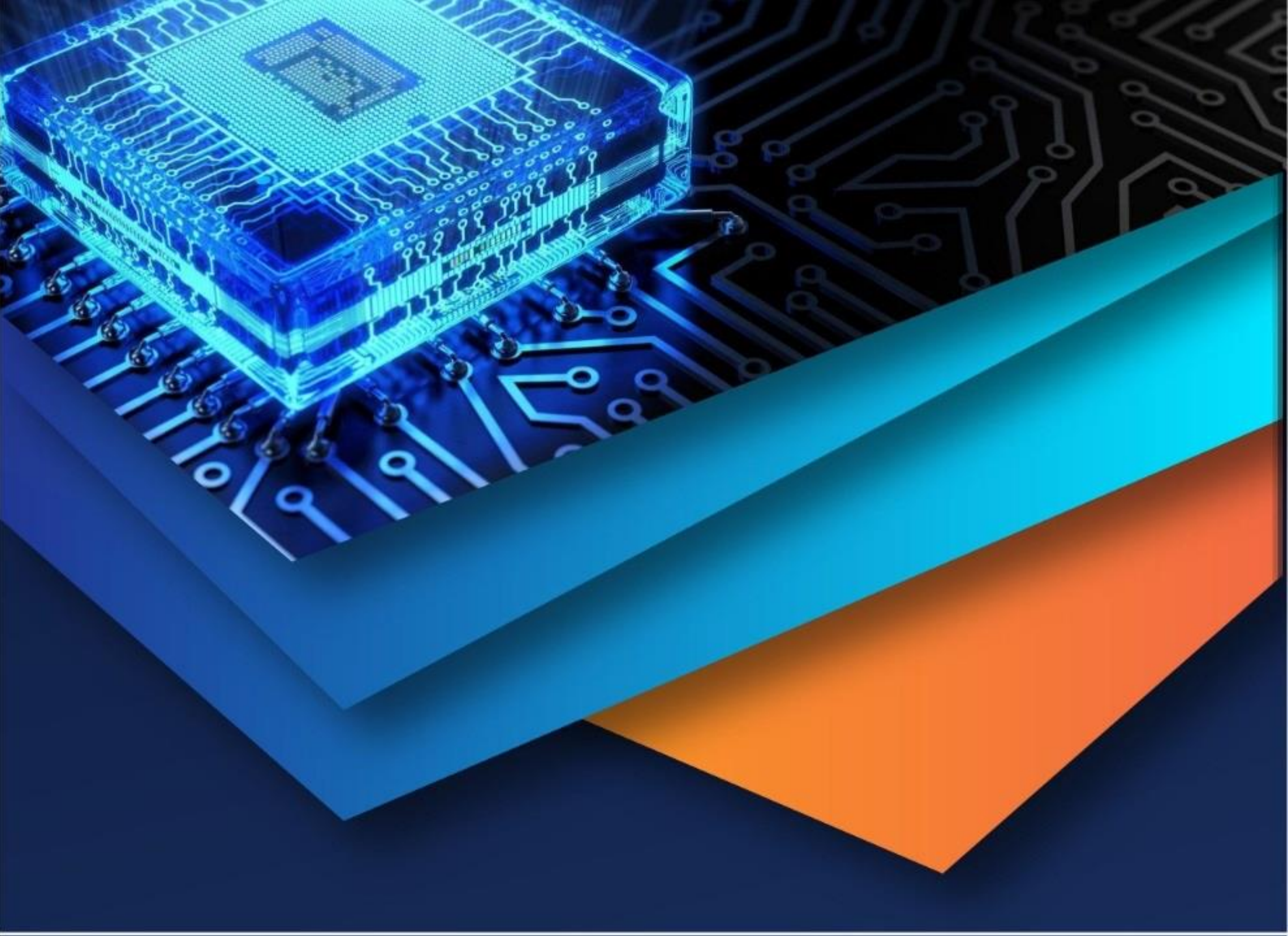

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