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Designand Testing of MPPT Based Solar PV Grid System

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Abstract –Enhancing the performance of Solar PV system based on MPPT based tracker is an open field of research in recent days. This paper aimed to validate the parametric performance of the Grid based solar PV system. The paper has examined the model in Simulink for an MPPT-based solar PV system. An extensive survey on the pertinent literature is offered. The controlled PWM waveforms are shown for 0.2 seconds of simulation time in order to successfully validate the models. The paper also helped to discover the many design parameters that can improve the efficiency of solar power systems. Performance is measured in terms of Hysteresis curve to represent the stability of system. The basic MPPT based control system is represented as model. The validation is based on the 3pulse based PWM generators system.

Key Words: Solar PV system, MPPT, Inverter, PWM control, Renewable Energy, IGBT, Hysteresis curves,

I INTRODUCTION

Maximum Power Point Tracking, or MPPT, is an essential part of solar PV systems since it has a big impact on their overall effectiveness. The following summarizes the way an MPPT system improves the functioning of any solar PV plants.Studies have indicated that efficient tracking system (MPPT) can improve the power outcomes or performance of the Solar based renewable energy systems. By understanding and addressing MMPT, we can ensure optimal performance and efficiency in solar PV systems with multiple panels.

Numerous algorithms and control techniques have been researched in an effort to improve the effectiveness of MPPT-based solar power plants. When it comes to gradient values as well as overall efficiency, studies have compared algorithms such as Levenberg–Marquardt (LM), and Bayesian regularization (BR) gradient descent the momentum (GDM), along with scaled conjugate a gradient (SCG) [1]. LM as well BFGS has demonstrated superior outcomes in MPPT accuracy than constants current (CC) approaches [2]. In comparison to more conventional approaches like P&O, technologies including fuzzy shifting mode controllers (FSMC) along with proportional-integral (PI) control were recently proposed to improve MPPT under partial shade situations, demonstrating increased stability and reduced errors [3]. Additionally, techniques based on Artificial Neural Networks (ANN) and the Fuzzy FIS System (ANFIS) have been examined when handling training datasets [4]. Ultimately, quick transient behavior and increased efficiency of boost converter PV systems are provided by a model predictive control (MPC) dependent MPPT technique.However, most of these solutions are not practical for real-time applications. The major factors affecting the performance are shown in Figure 1.

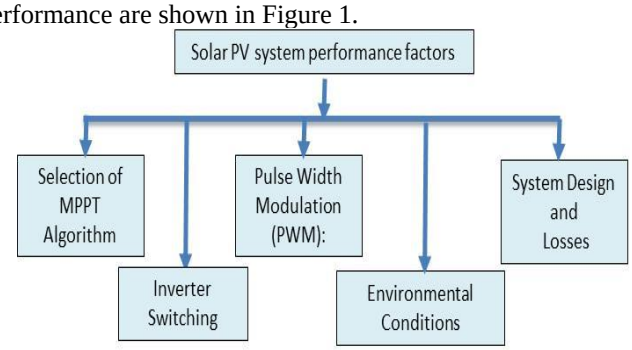

Figure 1 Major Factors affecting Solar PV system performances

The efficiency and reaction times of various algorithms (such as Progressive Conductance, Perturb as well as Observe,(P&O) etc.) differ. The technique that is selected may have an effect on how well the system tracks the MPP. in terms of environment the temperature and irradiance have a big influence on where the MPP is on the solar panels' I-V curve. The ability of MPPT to follow the altering MPP under different circumstances determines its performance.

The overall efficiency of the MPPT system may be lowered by losses in conversion within the system itself, such as in the DC-DC converter. It is critical that system design minimize these losses.

All things considered, MPPT is essential for optimizing the power and effectiveness of solar PV systems. MPPT systems increase the amount of solar energy harvested and boost a return from investments for solar arrays by guaranteeing operation at the MPP.

.The major advantage of suing Solar PV systems are as follows;

- **Power increase**: Solar PV cells output power changes with operational voltage and current. MPPT guarantees that the system works at its maximum power point (MPP), which is when power output is highest. This equates to optimizing the energy derived from sunshine.
- **Gain Efficiency:** In order to minimize energy waste, MPPT keeps an eye on its maximum power point (MPP) in order to prevent running at sub-optimal places. The solar PV system's overall effectiveness gain is raised by this modification.
- When temperature and irradiance (the amount of sunshine) change, MPPT algorithms can respond quickly. In spite of

variations, this guarantees that the system adjusts to changing circumstances and keeps its maximum power output.

- These DC-DC converters are mounted at a panel level and provide the ability to modify current as well as voltage in order to lessen the consequences of mismatch. Compared to MLMPPT, they provide a cost-performance balance.

2 Research Problems

Achieving MMPT is a special problem encountered in solar PV systems with several panels connected in series or parallel. While MPPT optimizes the power output of any one solar panel, MMPT addresses the circumstance in which distinct panels across a string or array suffer varying operating conditions. The validation and testing of the Solar PV system is an open research area.

The major challenges for MPPT based Solar PV system is:

- **Mismatches**: Individual panels across a string may have varying I-V curves as well as MPPs because to minor manufacturing variances, dust, shadowing, and possibly temperature differences.
- Mismatch between underperforming panels causes power loss.
- It is an open field of research to design efficient PWM generator for Solar PV systems for achieving better control.
- It is required to evaluate the performance using different inverter switching options.
- The Hysteresis curves evaluation may be carried out for the analysis of the stability of system.

3. Applications of Grid Connected Inverters

Solar PV systems offer an extensive variety of uses, from powering homes to generating massive amounts of electricity. Here's a look at the various uses of solar PV systems. The most frequent applications of the Solar PV systems are shown in the Figure 3.

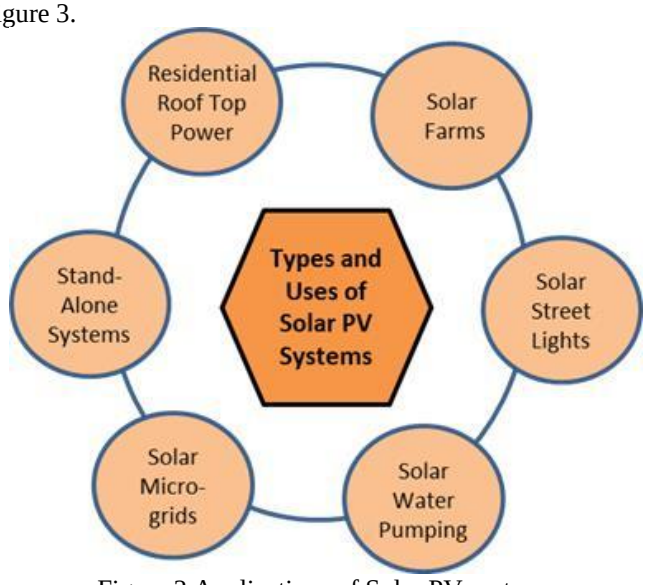

Figure 2 Applications of Solar PV systems

The solar PV systems may be installed as standalone system for roof tops, may be designed for commercial energy saving for grid connected system as micro grids or MPEV grid lines. Solar panels are a popular application that is installed on the roofs of homes, companies, and factories. This can simply and fulfills the daily needs of the individuals and may also distribute remaking uses to grid if connected.

Contribution of Work

The major contribution of this paper is to improve the performance of a solar PV system using an MPPT-based tracker has recently been an active study area. This article sought to validate the parametric effectiveness of a grid-based solar PV system. The article tested the Simulink model for MPPT based Solar PV system. The extended survey of the relevant literature is presented. The control PWM waveforms are plotted for the 0.2 sec simulation time to just validate the models successfully. Paper also contributed to identify the various design parameters which may enhance the performance of Solar PV systems.

4.Review of Telecom Inverters

There is huge research available in the field of solar PV system recently. This paper is to primarily review the MPPT based system designs. Boubaker, O. et al have objective of this systematic evaluation is to highlight the most significant recent developments and emerging trends in the industry. In relation to survey and research publications released during the three years prior (2019–2022), a "Scopus" bibliographical survey is carried out. Different MPPT, technique taxonomy is contained in the selected studies. Along with establishing the list of related benchmarks, the field's issues, future prospects, and present developments are all clearly defined. Researchers and businesses interested in the goals of sustainable development (GSD) for the environment and renewable energy generation could discover this survey study to be a helpful resource.

Abbadi, A. et al have addressed the fuzzy logic controller-based electrical current comparison control approach of an electrical converter. A converter is used to link a PV array to a household system. Three processors are used by the inverter's system of control. A MPPT (Maximal Power Point Tracking) microcontroller is the first one. This MPPT system adjusts the converter's VDC regulator's VDC standard signals according to fuzzy logic architecture to determine the DC voltage that will maximize the PV string's power output. The third computer controls both active and reactionary grid current elements, while the subsequent computer sets the voltage at the DC connection to its baseline value.

Akhtar, Iram et al stated that to meet worldwide demands, additional sources of energy must be developed. The photovoltaic system is a reliable and safe method of supplying electricity to the rural region. The world's carbon emissions from traditional sources of energy are increasing, which raises concerns about climate change. To supply steady energy, an appropriate energy producing system is required. In this study, we construct an efficient connected to the grid solar array with a

12-kW capacity to power Chennai, India India's rural areas and mitigate the negative effects of climate change.

Anang, Nurhazwani et al had an objective of the research's presentation of the electrical quality problem is how total distortion from harmonics, or THD, affects grid-dependent photovoltaic systems. First, a one-phase, single-stage grid-dependent photovoltaic system has been built to track outputs electricity and voltage levels as well as the patterns of distortion due to harmonics. Since the use of MPPT has been shown to be the initial phase in reducing total harmonic distortion (THD), it has been put into practice. MPPT allows for the greatest amount of electricity, voltage, & present of the photovoltaic system without fluctuating, which lowers THD. This is additionally; using a high-quality filter lowers the PV method'stotal harmonic distortion (THD) level.

Ahsan SM et al have worked to investigate THD and network voltages are impacted on the low-voltage (LV) distributing feeders by the widespread use of network-connected photo-voltaic (PVs) in conjunction with dynamic loads & electrical power flows. This study assessed LV power quality problems at the threshold of common coupling, also called PCC, with large non-linear loads. To assess the total distortion of harmonics in the present situation (THD-i) and voltages (THD-v) at PCC in conjunction with seasonal fluctuations, a radial adapted IEEE-34 bus system was utilized to examine several scenarios of solar power utilization (0 to 100%) for actual feeder information in a weak electrical grid setting.

YacineDjeghader et al have studied a three-phase converter that supplies the line is controlled by PWM in the present research, and the boost converter's operation is controlled by an MPPT controller of the perturbed and observed kind. We employ simple and several filters as part of a passive filtering strategy to reduce the sinusoidal currents that the nonlinear load generates. The findings collected suggest the total frequency distortion (THD) rate in the first instance, when the combined system is by them-selves are below the accepted range. However, the THD levels exceed the applied norm when the not linear load is present. When applying a calibrated filter on the 5th harmonics using our suggested approach, the THD values produced are within the norm; however, utilizing multiple filters (number five and seven) yields superior results.

MeghaKhatri et al. look at the existence of electrical and voltage harmonic caused by reactionary energy transfer among the plant, the electrical system, and the equipment in use as well as both linear and nonlinear loads. In order to service the load, the system maintains digital electricity analyzer that determines the amount of energy imported and exported among the facility and network. A power character regulator connects at the point with common interaction, and a device to compensate is integrated into the phases locking loop inside the inverters to regulate the influence of aberrations.it is required to evaluate the THD for converting blocks of the systems.

Ben Saïd-Romdhane et al have study's primary goal is to provide a method for evaluating the effectiveness of various architectures for domestic solar power plants that have three phases and four wires. This article looks at two of the most common topologies for solar systems. Concerning the wire that serves as the neutral, both of these solar topologies are designed differently. A DC-link neutralizer is a part of the first structure, while a Delta/Star grounding converter is a part of the following one. The work was limited to converter in system.

Atsu, D et al concluded thatsystem converters play a vital role in supplying the grid with electricity from various locations. As network-tied photovoltaic (PV) panels (both rooftops and massive amounts) proliferate, there is a growing recognition of reliability concerns and the need for new rules and guidelines to maintain grid stability. In accordance with the recognized standards for solar PV integrating, the electrical performance of micro inverters has been studied in both real-world outside situations and constant sun radiation solar PV energy source. The overall harmonic distortion (THD) of the micro inverter in examination under the outdoors was found to be much higher than that of the research conducted under stable inside illnesses and it also surpassed the established requirement.

Zaghba, L et al enhances the grid-dependent solar energy systems' effectiveness in areas with fluctuating temperatures, this research suggests a novel strategy. Conventional control techniques are hampered by the unpredictable nature of climatic conditions, which lowers the effectiveness and dependability of PV systems. We provide a unique approach that combines the control of sliding modes with fuzzy logic to handle this problem. By utilizing fuzzier logic, the PV system can manage inaccurate and unpredictable meteorological information and make decisions based on expert expertise and subjective input. Despite changing climatic circumstances, shifting control—which is well-known for its resilience to ambiguities and disturbances—maintains reactivity and consistency. Our suggested strategy provides a thorough response to the challenges presented by actual weather dynamics by integrating various approaches.

Shareef, H et al have presented a lightning search method (LSA), a unique meta-heuristic optimizations technique, as a solution to the trial-and-error process of acquiring member functions (MFs) utilized in the standard FLCs. The lightning natural phenomenon is simulated by the LSA. The generalization of the step lead dissemination technique is made. The idea of missiles, which are quick fragments, is taken into account by the suggested optimization technique. Various randomization models are used to describe the stochastic and convoluted nature of lightning releases, which vary depending on the kind of particle. The LSA is initially evaluated using ten benchmarking units with different properties required for evaluating an entirely novel algorithm in order to assess the efficacy and reliability of the suggested method. After that, it is applied to the best FLC design for a single PV converter.

Gupta, A. et al have designed a single-stage grid-dependent solar energy production system featuring both reactive and active energy regulation is presented in this study. It is transformer-less. The grid-tied supply of voltage conversion (VSC) runs in reactive power production mode when there is no passive power supply available. This ensures a controlled DC power supply to the VSC and feeds its control electronics. In accordance with IEEE-519/1547 norms, a data-driven MPPT (maximum power point tracking) management system is put

into place to manage power quality at the highest possible level by lowering the level of total harmonic distortion (THD) in meter injection power. The supply sided converter is controlled during a one-phase ground fault using a DVR (dynamic voltage restorer) controlling technique employing a proportional-integral (PI) microcontroller. Together with the accompanying fluctuation in reactive as well as active electricity throughout the problem situation, the study additionally includes the current through the grid THD.

Zhao, Y et al stated that inaccurate tracking may also result in poor agility and incorrect judgments. This research suggests a novel fractional controller set models anticipatory current management (FCS-MPCC) of an inverter and a model for forecasting control (MPC) of PV modules as a solution to these problems. The modular-based MPC microcontroller is constructed using the PV array identifying model, and optimum power generation is attained by combining the ideal pair of spectral wavelengths and modular temperatures. Next, an FCS-MPCC method is created to forecast the inverter present over various value vectors. The associated optimum shifting condition is subsequently applied to the converter's semiconductor components, and the perfect voltage vector is chosen based on the most suitable functions.

Atsu, D. et al have attempted to create a model anticipatory control system for grid-connected photovoltaic power generation that takes into account the best MPPT control for PV modules.Sunil Kumar et al have designed the PWM based on PLLL and control for the better MPPT based system design.

Eltamaly, A. M etal.have unlikely scenario that the PSC modifications, this research proposes a novel way for recognizing the most recent location of the GP without requiring re-initialization. In the suggested approach, a small particle is sent to the expected locations of peaks in order to look for any point that has more power as the present GP. Once it finds such a maximum, the PSO components are sent immediately to the newly established GP. In contrast to the time needed for the standard PSO technique's randomized re-initialization, our solution slashed the re-initialization duration by 650%. Furthermore, this suggested approach totally eliminates the early divergence linked to traditional PSO methods. The summary of the survey is given in Table 1.

Table 1 Summary of the review works

Authors	Methodology	Parameters
Km, Charu et al.	Performance analysis of MPPT solar PV system.	V-i Curves, Power output,
Boubaker, O et al	MPPT techniques for UICs and MPPT techniques for PSCs.	MPPT parameters for PV systems
Abbadi, A. et al [2]	Fuzzy logic controller for MPPT Three controllers: MPPT, DC link voltage, grid current	The active current reference is the output of the DC voltage controller.
Akhtar, Iram et al [3]	Designing a 12 kW grid-connected solar system Using a PV system model to analyze carbon emission reduction	Reduction of fossil fuel reserves Decrease in carbon emission level
Anang, Nurhazwani et al [4]	Maximum power point tracking (MPPT) algorithm Implementation of a low pass LCL filter	Parameters include solar irradiance, current, voltage, and harmonic distortion. THD value must comply with utility grid standard (<5).
Ahsan SM et al [5]	The total harmonics ratio to the fundamental frequency component is defined as the THD of the system.	The specific parameters such as power rating (W),
Yacine DJEGHADER et al [6]	Perturb and observe type MPPT controller for the boost converter PWM control for the three-phase inverter	Power electronic devices degrade power quality and generate harmonic currents. .Presence of non-linear load increases total harmonic distortion (THD) values.
MeghaKhatri et al [7]	Methods which characterize solar radiations are solar irradiance and solar isolation.	sinusoidal in nature and in phase with the grid electrical parameters.

4.Proposed MPPT based SystemDesigns

The proposed system diagram is illustrated as shown in the Figure 3. The proposed system is validated in this paper for accurate performance. The respective Simulink model is shown in the Figure 4. The model is just tested for small 0.2 sec duration to validate the same.

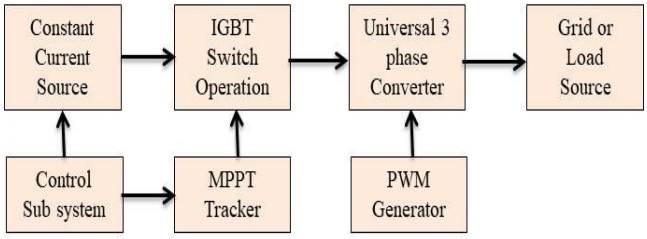

Figure 3The proposed block diagram of the MPPT based solar PV system

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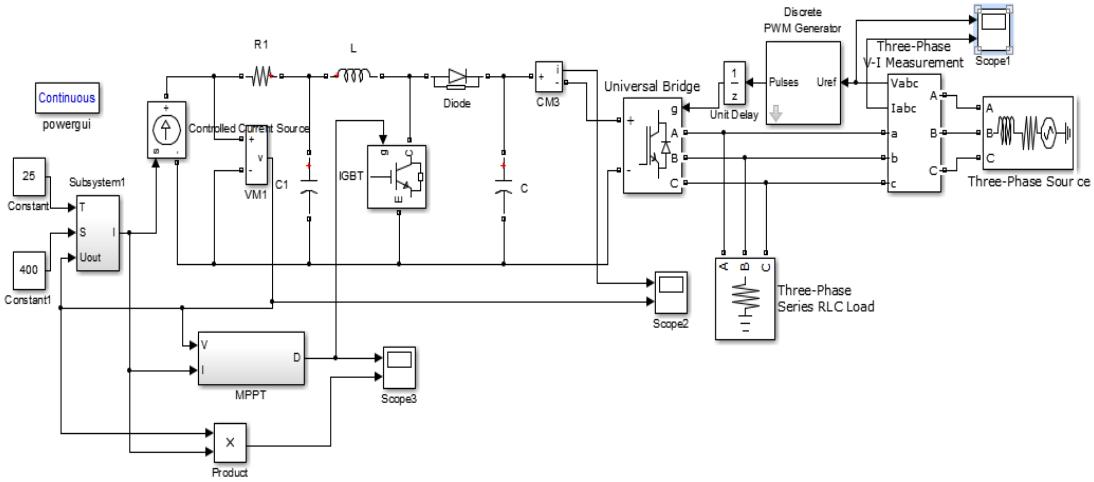

Figure 4 Proposed models for MPPT based Solar PV system modeling.

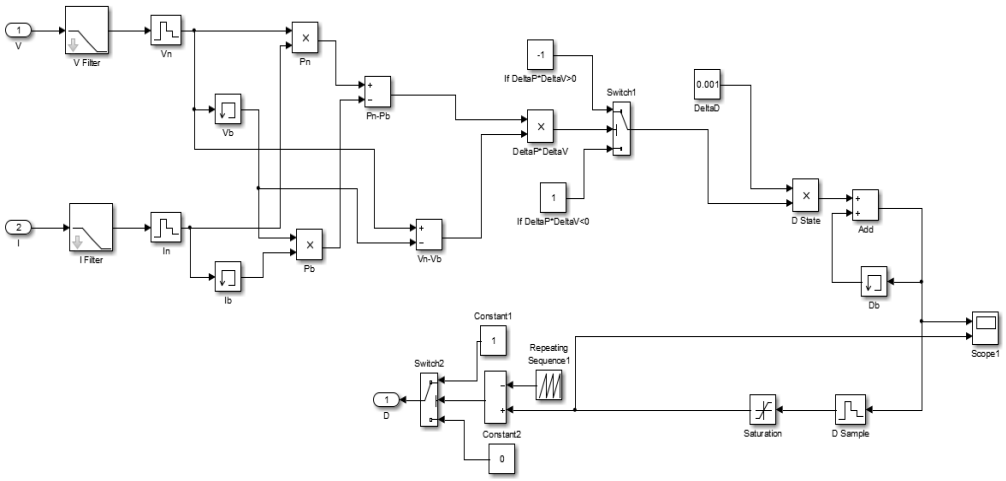

Figure 5 MPPT based Tracking and control system using PWM Repairing pulses.

In this paper the solar system is modeled using the MPPT based controlled design method. The system is consisting of the PWM for the controlling the inverting operation. The MMPT model of system is illustrated in the Figure 5.

The IGBts switching is used in the three-phase architecture of the universal inverter to facilitate solar operations.

5. Results and Discussion

The performance is evaluated and validated based on output waveforms analysis of solar PV system.

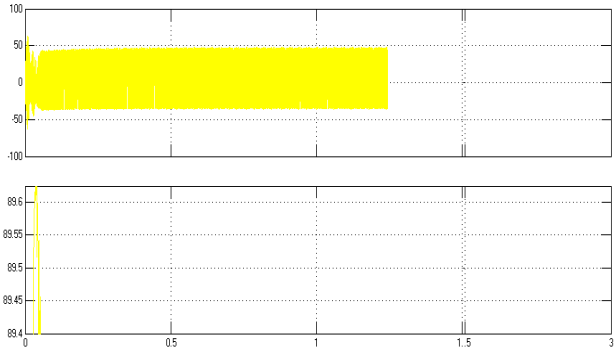

Figure 6The validation of the voltage measurement of MPPT control and post are presented for 3 arm generator PWM.

The voltage measurement waveform of MPPT control systemas shown in Figure 6.

The validated three phase controlled PWM waveform and logic signals are illustrated in the Figure 7.

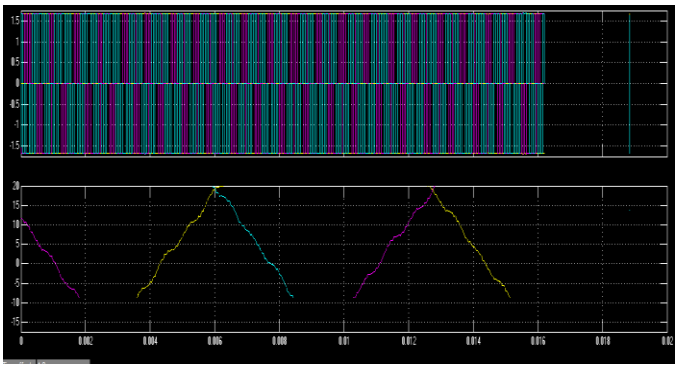

Figure 7three phase voltages random control signals

In order to quantify and evaluate the systems stability the Hysteresis curves are plotted as shown in Figure 8The respective design parameters for analysis are shown in numeric values in the Figure 8. It is highly required to minimize the area of curve and increases the slope of curve for better stability.

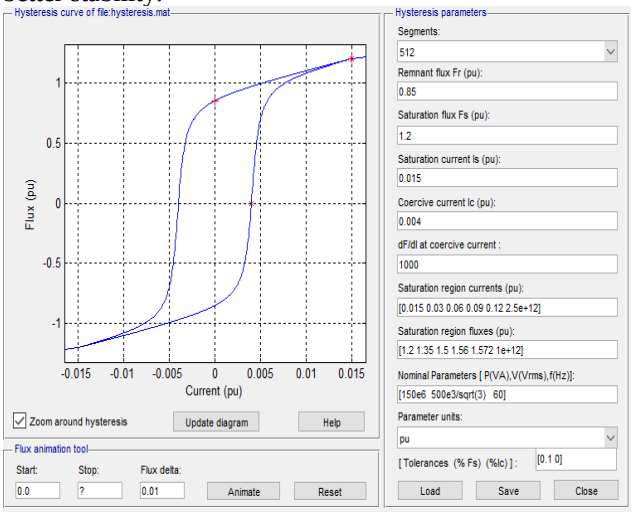

Figure 8 Hysteresis curve analysis for the PV system validated with 3 arm 6 pulse bridge PWM generators.

VII CONCLUSIONS

The purpose of this work was to validate the grid-based solar PV system's parametric performance. The Simulink model for an MPPT-based solar PV system has been studied in this study. A thorough analysis of the relevant literature is provided. To effectively validate the models, the regulated PWM waveforms are displayed for 0.2 seconds of simulation time.The main contribution of the paper is to evaluate the Hysteresis a curve allows one to measure and assess the stability of the system. The resonant flux is found to be 0,35pu. And saturation flux is 1.2 pu. The validation of the voltage measurement of MPPT control and post are presented for 3 arm generator PWM

It is concluded that for the better performance of system the accurate PWM generation is necessary. The inquiry may consider both the total comorbid THD in the future.

It has been discovered that increasing the switching control can lower harmonic distortions and increase PV equipment's voltage efficiency.

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