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HYSTERESIS CURRENT CONTROLLED 3 PHASE GRID CONNECTED P V SYSTEM

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Abstract -The integration of distributed generation, like sun and wind power, is increasing because of the reduction of fossil fuels and the need to lower carbon emissions. This integration, particularly of Solar PV, can cause power quality issues in distribution networks, notably higher Total Harmonic Distortion (THD). This study investigates the impact of varying levels of solar power penetration on grid power quality Using analysis of the Fast Fourier transform to measure THD. The research focuses on developing controllers for boost converters and grid-tied inverters to minimize harmonics in grid-connected PV systems. In particular, tracking maximum power points (MPPT) is designed for the boost converter, and Hysteresis Current Control (HCC) is implemented for the inverter to reduce THD, ensuring compliance with IEEE519-1992 standards. Simulations using MATLAB 2024a demonstrate The efficiency of these controllers. Comparative analysis shows that incorporating the hysteresis current controller significantly improves power quality by reducing THD, thus enhancing the overall functionality of the grid-connected PV system.

Key Words: Harmonic distortion, Hysteresis, Maximum power point tracking.

1.INTRODUCTION

Solar power is an extremely functionality of the grid-connected accessible and clean renewable energy source. India, receiving around 200 MW/km² of solar power as opposed to its 3.827 million km² area, has an annual potential of approximately 657.4 million MW. With 2,300-3,200 hours of daylight per year, India has a great deal of potential for solar energy generation. With 34.404 GW of installed solar capacity, the country has the lowest capital cost per megawatt for solar power plant establishment. However, harnessing power from renewable sources involves multiple conversion stages, which can cause performance distortions. To maximize the effectiveness and dependability of solar power systems, these distortions might have a detrimental effect on power electronic components.

2. STRUCTURE OF GRID- TIED PV SYSTEM

The grid-connected PV system includes a PV array, a boost converter with MPPT control, a Hysteresis Current Controller-equipped inverter (HCC), utility grid, linear and non-linear loads, and active filters. The PV module voltage is increased by the boost converter, and power extraction is optimized by MPPT. The inverter converts DC to AC for grid integration. The HCC manages inverter switching by comparing grid-side feedback current with reference current, maintaining it within a hysteresis band, thereby reducing current harmonics. This ensures efficient and stable power delivery to the grid under varying conditions.

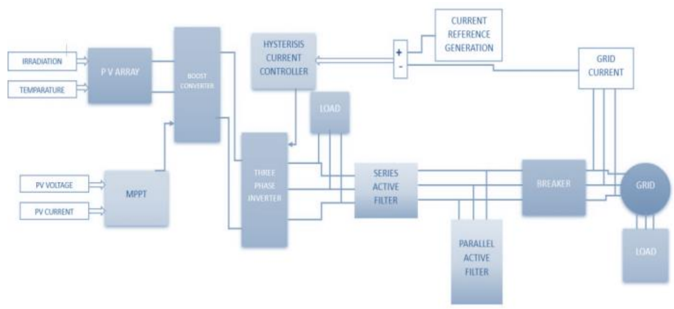

Figure 1 Schematic diagram for Grid–tied Solar PV system

3.GRID CONNECTED PV SYSTEM MODELING

3.1. PV Array Modeling

Figure 2 depicts the solar PV cell's equivalent circuit, and Figure 3 shows the matching PV and IV properties.

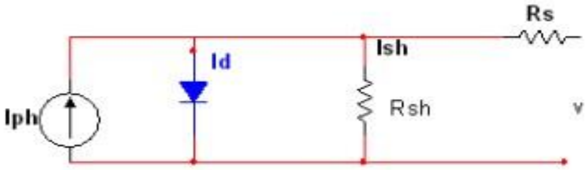

Figure 2. Equivalent of solar cell

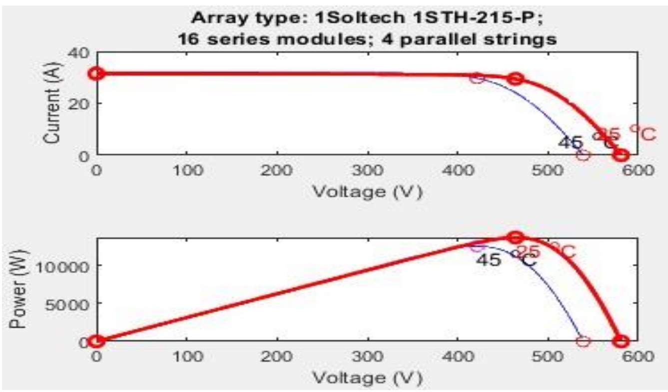

Figure 3 PV cell characteristic curve

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3.2. Boost Converter Model

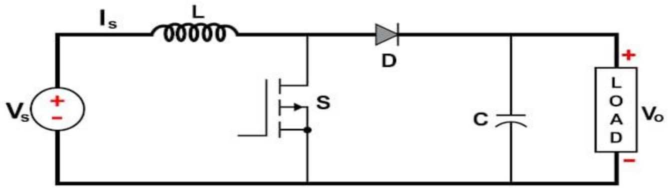

Figure 4 DC-DC booster converter

The inverter and PV panel are connected to the boost converter. A capacitor is always given after PV panel when it is connected with a grid system since it reduces the ripple current.

Duty cycle, $D = 1 - (\frac{Vout}{Vin})$ (1)

Inductance, $L = \frac{(Vin*(Vout-Vin))}{\Delta Il*fs*Vout}$ (2)

$\Delta Il = (0.2\ to\ 0.4) * Iout * (\frac{Vout}{Vin})$ (3)

Capacitance, $C = \frac{(Iout*D)}{fs*\Delta Vout}$ (4)

Where,

Vin = Input Voltage

$Vout$ = Desired Output voltage

fs = Switching frequency

ΔIl = Change in ripple current

$Iout$ = Output current / boost current

C =Capacitor

D = Duty cycle

3.3. Voltage source inverter (VSI) model for three phase

An inverter is used to transform the boost converter's DC electricity into AC power. The three-phase inverter of the system uses six MOSFET switches. The gate pulses for the MOSFET are provided by the hysteresis controller, which controls the switching of the inverter switches to minimize distortions in the output AC waveform. Referring to figure 5, the inverter terminals' VDD and -VDD represent the boost converter's output terminals. In this case, the hysteresis current controller's output from the inverter controller is represented by the gate pulses G1, G2, and G3. The top switches, Q1, Q3, and Q5, receive gate pulses; the bottom switches, Q2, Q4, and Q6, do not receive gate pulses. The inverter switches can be turned on and off successively to produce a clean, minimally distorted sinusoidal AC waveform by using inverter control.

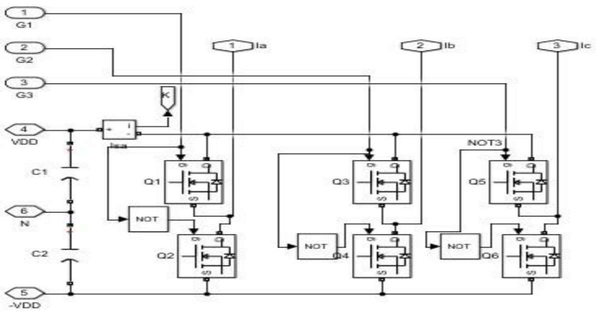

Figure 5 Three phase VSI

3.4. Design of Filter

Two filters are used before feeding power to grid. One series active filter is used and one parallel active filter is used. The series active filter injects voltage which is produced in series with the supply. It controls or makes up for grid and load-side voltage sags and swells. The power quality is improved by this. The model for the series filter uses an RL filter. Reactive power adjustment for the system's nonlinear loads is accomplished by the parallel active filter. It offers a reduction in current harmonics. For a parallel active filter, use an RC filter.

RL=1.5e^{-3}. Pbase (5)

L= $\frac{0.15*Pbase}{2*pi*f}$ (6)

Where P_{base}=$Vbase^2/P$ (7)

The voltage for which the grid is intended is expressed as Vbase.

Qc=0.1 x P (8)

Pc= $\frac{Qc}{50}$ (9)

where P is the system's actual power in watts.

4. DESIGN OF CONTROLLER

4.1. MPPT Controller (Maximum Power Point Tracker)

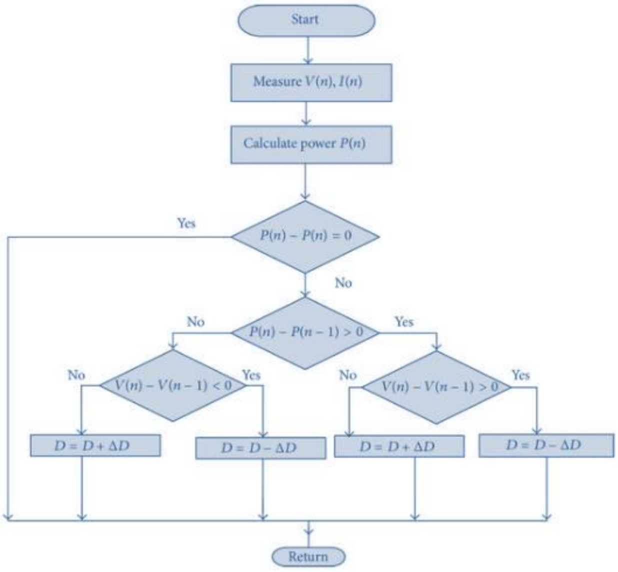

Figure 6 Flowchart of MPPT

MPPT verifies the kind of PV module being used and examines its specifications. It attempts to acquire the MPP of the curve by substituting dP/dV = 0 from the PV curve of the module. By calculating the derivative, one may determine the maximum power and maximum voltage of the curve. A duty cycle range is provided to MPPT, which aids in adjusting the converter's output voltage to the provided reference value. The PV system's maximum power can be reached using a variety of strategies. By examining the features, this algorithm calculates the PV module's V and I. It makes an effort to ascertain the module's MPP using its PV curve.

4.2. Hysteresis Controller Design

The generated reference current and the feedback current—that is, the current delivered to the grid—are compared by the Hysteresis Current Controller. . A relay that defines the Upper Hysteresis Bound (UHB) and Lower Hysteresis Bound (LHB) of the band of hysteresis receives the comparison's output. The feedback current is forced to follow the current of reference waveform by the controller. The inverter switches' gate terminal receives the relay's output. Pulses for switching or gating are generated by the HCC. When the current error reaches or crosses the upper limit, the VSI applies a voltage to the grid that is negative, or less than zero. At the grid side, this causes the current to drop. When the current error gets close to or exceeds the lower limit, a voltage is produced.

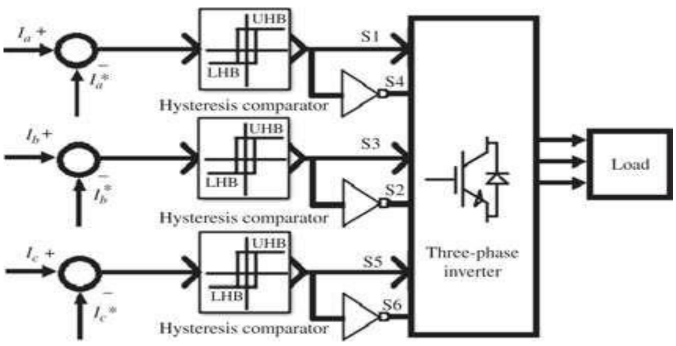

Figure 7 Hysteresis Current Controller

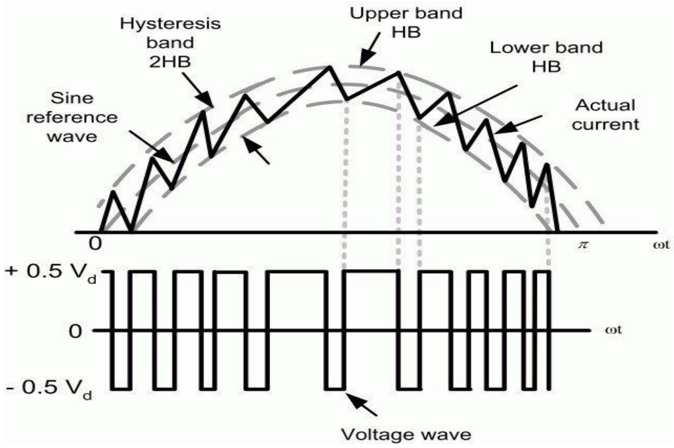

Figure 8 Hysteresis Band (HB)

Table 1 Inverter Switching Logic based on HB

Status of the comparator	Status of the switch
> =Upper HB	ON - Upper Leg OFF- Lower Leg
>= Lower HB	OFF - Upper Leg ON- Lower Leg

4.2.1. Current Reference Extraction

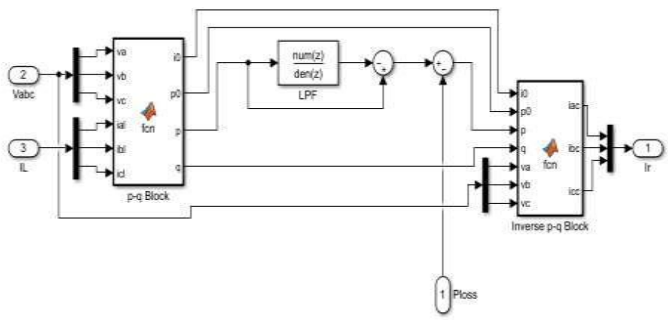

Figure 9 Simulink of Current Reference Extraction

After being compared to a reference voltage, the VSI input voltage is fed into the proportional integral controller. Since obtaining zero steady state error is useful, there are PI controllers in use. The current compensating block receives the PI controller's output. Using the compensating current block, reference current is generated. It is essential to the hysteresis control method. The time domain method is less complicated than the frequency domain method. The p-q conversion to frame is called the Clarke Transformation. It changes the current and voltage of the "abc" (3-phase) system into a

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stationary reference frame. We apply a Low Pass Filter (LPF) to eliminate all high frequency disturbances after executing Clarke's transformation, and then we execute.

5. Conceptual Framework

In the proposed concept, reactive power is balanced by connecting two loads at the grid side. Reactive power control is defined as reactive power compensation, which enhances the performance of the AC system. The load support mechanism is used within the suggested framework to compensate for reactive power. In the load support technique, load balancing is done to raise the system's power factor, which balances the real power at the inverter side and enhances voltage regulation. System stability is improved via reactive power adjustment, which raises the power delivered to the grid and loads. Considering that reactive power is required to maintain system voltage, increased reactive power consumption.

6. END RESULTS AND TALK

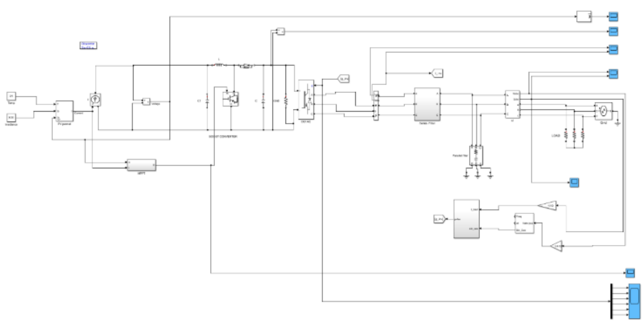
Using MATLAB/SIMULINK 2024a, the whole grid-connected photovoltaic system model has been constructed and simulated. Table 2 displays the PV module's specifications.

Table 2 Specification of PV System

Parameters	Specifications
Module	1Soltech 1STH-215-P
Parallel String	4
Series-connected module per string	16
Open circuit voltage (V)	36.3
Short circuit current (A)	7.84
Maximum Power (W)	213.15

The system is connected to the PV grid and runs at 13.5 KW. At 25 °C, a variable 800 W/m2 irradiance is established.

4.2. Simulation



4.4. Output values

Parameters	Case
PV Voltage	440V
PV Power	13.5KW
voltage of the DC link	700V
Inverter voltage	460V
Inverter current	35A
THD	3.64%

Table 3: Case at 800W/m^2 and 25^o Tempatarure0f 13.5KW system

4.5. Output wave forms

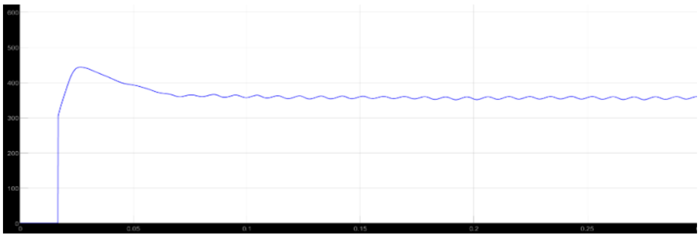


Figure 10. PV Voltage

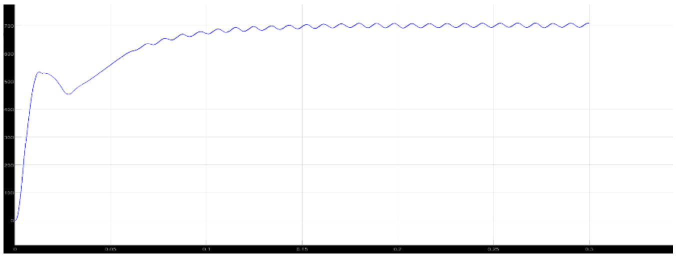


Figure 11. Boost Voltage

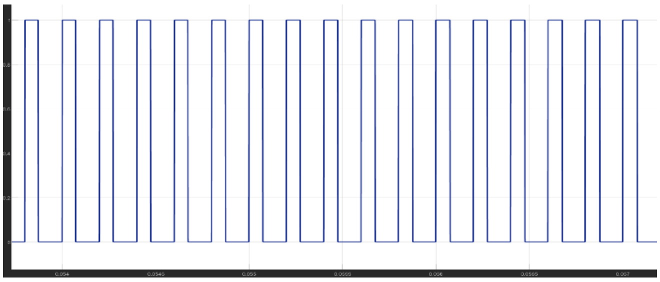


Figure 12. MPPT Gate Pulses

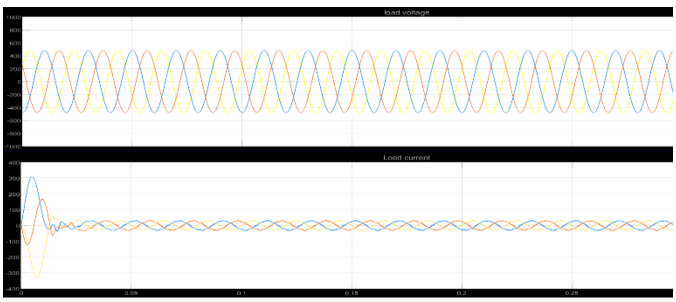


Figure 13. Inverter Voltage, Inverter Current

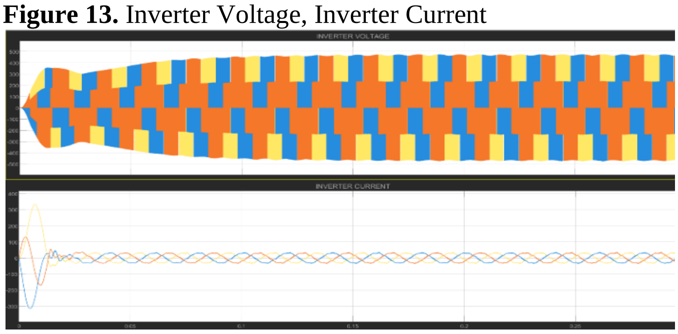


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Figure 14. Load Voltage, Load Current

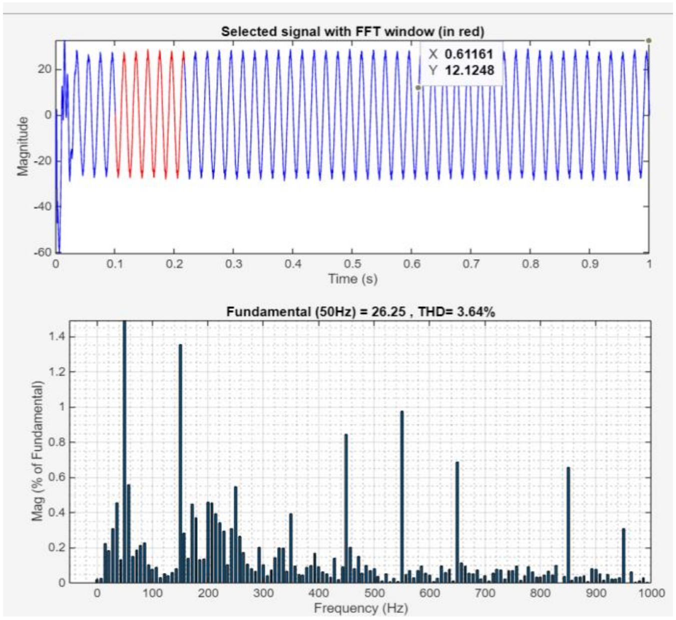

Figure 15. THD

5. CONCLUSION

By designing and implementing the Hysteresis current controller and MPPT controller, better power quality has been achieved. The PV array modelling, boost converter, inverter, filters, Study has been done on control algorithms and analyzed in detail and designed as per the system requirement. The analysis concludes that with the proposed algorithm, The problems with the power quality have been fixed.

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