Novel Algorithm for Inverter Control in Single Phase Grid Connected PV System

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***Abstract* - The single-phase voltage-source inverter, which is used in photovoltaic (PV) electricity generating systems, is the subject of this paper. Time-variant systems are more difficult to control than time-invariant systems, as we all know. Time-variant systems can, however, be modelled as time-invariant systems using appropriate transformation methods. Control signals that are normally time-variant (often varying sinusoidally in time) become time-invariant at the fundamental frequency after the transformations, making them much easier to deal with.**

The design of a single-phase inverter controller based on a novel algorithm is proposed. The aim of this research is to find new ways to improve single-phase voltage-source inverters. The primary goal is to address the issues associated with single-phase designs. As a result, the focus of this research is on a novel controller approach for obtaining a more reliable and flexible single-phase inverter. Simulation using the MATLAB/SIMULINK environment is used to demonstrate the efficiency of the methods suggested in this paper.

***Index Terms* - Renewable Energy Sources, Single-Phase Voltage-Source Inverters, Maximum Power Point Tracking (MPPT).**

IINTRODUCTION

Importance of renewable energy sources

One of our society's most basic needs is energy. Fossil fuels have been used to generate electricity since the beginning of the industrial revolution. Scientists have been looking forward to developing more sustainable forms of energy production for decades due to the growing population, limited fossil fuel resources, and polluting energy production. [1] One of the best renewable energy sources is solar energy.

The solar energy source is vast and has the potential to meet humanity's inexhaustible needs. On the earth's surface, the sun provides approximately 885 million terawatt-hours of energy per year, which is 6,200 timesthe commercial and primary energy consumed by humanity in2008. Figure 1 depicts the amount of energy consumed by humans in comparison to the estimated total fossil fuel reserve remaining on the planet and the annual energy provided by the sun. [2]

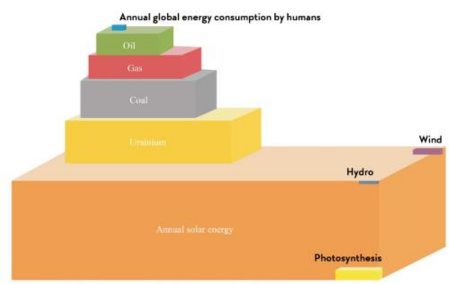

Figure 1. Global energy consumption compared with different resources. For oil, gas, coal and uranium the estimated reserves are shown. The renewable sources are shown for one year.

Given these figures, solar energy will undoubtedly become more important in the future than it is now. PV modules have always been less expensive since their inception. Solar energy has become more affordable to a larger number of people in the last decade or so. [3] With increased PV power production, calculations of traditional distribution grids with centralized power production are no longer completely valid. These grids are designed for a single-direction power flow. The possibility of current flowing in both directions will result in overvoltage far from a transformer. This study takes into account a number of variables that will have an impact on the phenomenon. [4]

The main objective was to develop new methodologies for inverter current control.

II. METHODS FOR INVERTER CURRENT CONTROL

Current control is critical in power electronic circuits, especially in DC-to-AC inverters, where the goal is to produce a sinusoidal AC output whose magnitude and frequency can both be controlled.

A. Linear Regulator Based Method:

Carrier-based PWM (also known as the carrier-based method) is used to control the inverter output current. Several studies have adapted this technique to minimise the THD of the inverter output current. The carrier-based control approach is depicted in Figure 2 as a simplified diagram Due to steady-state error at frequencies other than DC, proportional+integral control (PI) has poor performance when tracking a sinusoidal reference. Furthermore, this controller is incapable of minimising current signal noise. This is due to the integral phrase, which is more responsive to previous errors and less responsive to actual (nonnoise) and relatively quick changes in state. As a result, the system takes longer to reach the set point and respond to perturbations. As a result, it's possible that the current values will exceed the set point values.

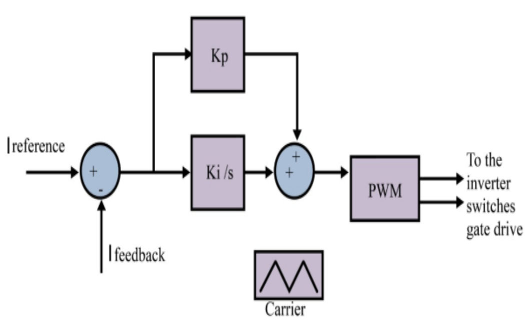

Fig 2 Carrier-based current control method

B. Hysteresis Control Method:

This technique is called direct control, because the current is regulated in a hysteresis loop and is based on the switch status.The inverter output current is obliged to obey the current references in this technique. The upper and lower bands in the hysteresis loop limit the difference between references and output currents (see Figure 3). This also ensures that peak current limiting is possible.

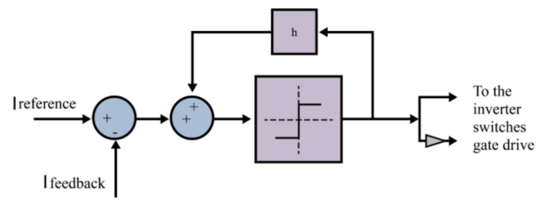

Fig 3 Hysteresis current controller scheme

Because of the controller's variable switching frequency, it has a high THD.

C. The Peak Current Control Method:

Peak current control technique is commonly implemented with digital or analogue DC-to-DC converters. Peak current mode control works by comparing the current waveform of the inductor to the current reference level. The following is a description of it: The peak inductor current control works by comparing the inductor current (or switch current) up-slope to a current level determined by the reference value. The power switching device is switched on at a predetermined interval. The switching gate drive turns off the power switching device when the instantaneous inductor current exceeds the reference value. Figure 4 shows how this technique produces a constant switching frequency.

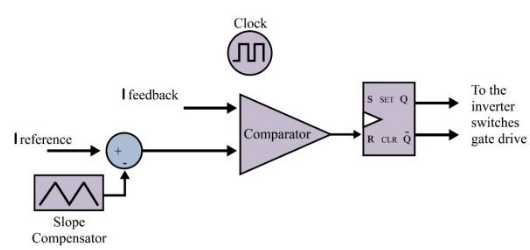

Fig 4 Analog peak current mode control scheme

D. Proportional-Resonant current controller:

Although PI controllers are widely used in DC-to-DC converters, they perform poorly in inverter applications. This is due to the fact that tracking a sine wave signal is not as simple or easy as tracking a DC signal. The time-variant steady-state error produced while tracking the sinusoidal reference is the cause. Furthermore, this controller is incapable of rejecting the current signal's noise. As a result, the Proportional-Resonant (PR) current controller was developed. The classic PI DC-compensator is converted into an equivalent AC compensator with the same frequency response characteristics in the bandwidth of interest using this method.

E.Synchronous Rotating Frame Controller:

A current-error compensation scheme's design is critical, particularly in grid-connected single-phase inverter applications. [6-10], which uses current control techniques based on a separate current controller (current error compensation) and a PWM function that can exploit more benefits in an independently developed overall controller structure, are among the earlier innovations of current controllers and making use of the experience with the three-phase inverter.

III. NOVEL ALGORITHM FOR INVERTER CONTROL

A. Working principle

Figure 5 represents a simplified diagram to describe the novel algorithm for inverter current Control.

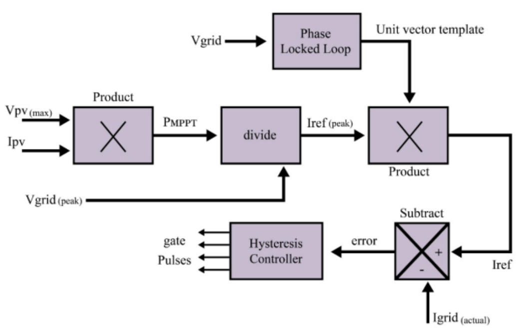

Fig 5 Novel algorithm for inverter control

To begin, multiply the PV voltage (Vpv) at the maximum power point by the PV current (Ipv). The product provides the solar panel's maximum power output. The algorithm perturb and observe is used to track the maximum PowerPoint. The maximum power is divided by the grid voltage's peak value (Vpeak). It specifies the maximum value of grid current (Iref-peak) that must be injected into the grid in order to provide the maximum amount of power to the grid. Second, to extract the unit template vector (isn't), V grid is fed into the synchronous frame phase-locked loop (PLL). Then (Iref peak) is multiplied by the unit vector template to inject current into the grid in phase with the voltage, resulting in a power factor of one. Finally, their reference current (Iref-peak)multiplied by (sinωt) is compared to real grid current, and the error is fed into the hysteresis current controller. Hysteresis current controller gives the gating pulse for the inverter.

IV. SIMULINK MODEL

The models that have been used to achieve the results will be discussed here.

A. PV installation and load:

Each location that represents a home or a housing block, as shown in the models in the following section, consists of a modelling block that represents the PV installation and a household load. PV array, inverter, inverter control, and load are the four major components of the model.

B. PVarray:

The PV array can receive two inputs, as shown in Figure 6. The temperature can be set as a constant during the simulation. Second, the PV array's irradiance can be set to a fixed value or to different values that change during the simulation.

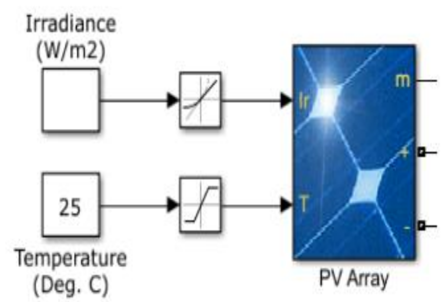

Fig 6 PV Array in Simulink

C. Inverter

The inverter is shown in Figure 7. Solar energy generates direct current (DC) power. Because the distribution grid runs on AC, the DC should be inverted to AC. The AC power connections are A and B on the diagram, while the inverter controller input is g.

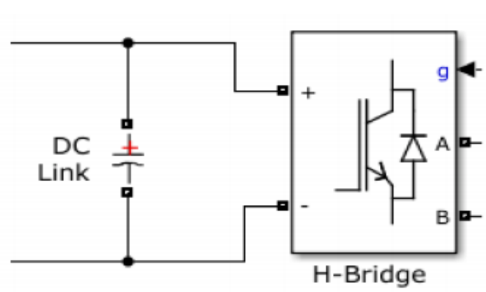

Fig 7 H-Bridge in Simulink

D. Modeling in the work

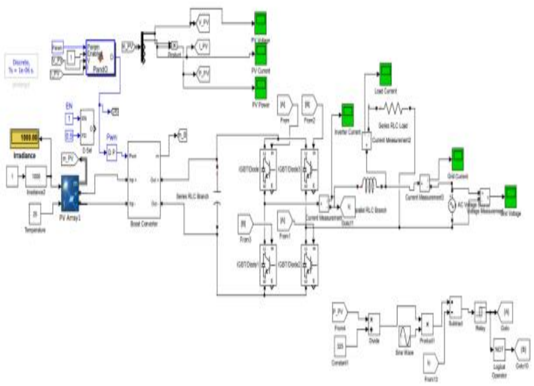

Fig 8Modeling in the work

V. SIMULATION RESULTS

Current control by novel algorithm:

Simulations are carried out in MATLAB/Simulink software for inverter control in single phase grid connected photovoltaic system with proposed novel algorithm scheme.

The system parameters are:

Irradiance: 1000 W/m^2

Temperature: 25 C$^\circ$

PV Panel: 250 W each 15 PV arrays in series

DC Link Capacitor: 1100 µF

AC Voltage source: 220 RMS Voltage

Load: 10 Ω

MPPT Algorithm: perturb and observe (P&O) method

Waveform 1: The waveform of PV voltage is shown in fig. The study state value of PV voltage is around 488 V.

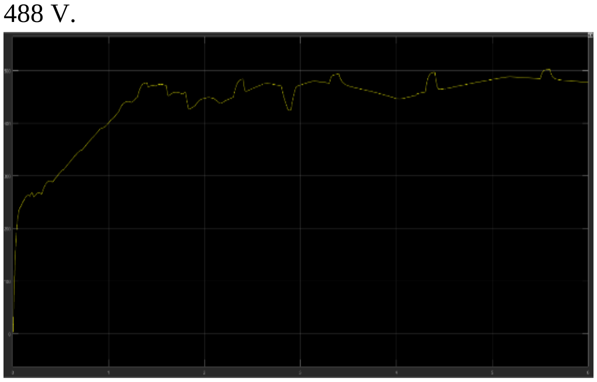

Fig 9. PV voltage

Waveform 2: The waveform of PV current is shown in fig. The study state value of PV current is around 6.73 amp.

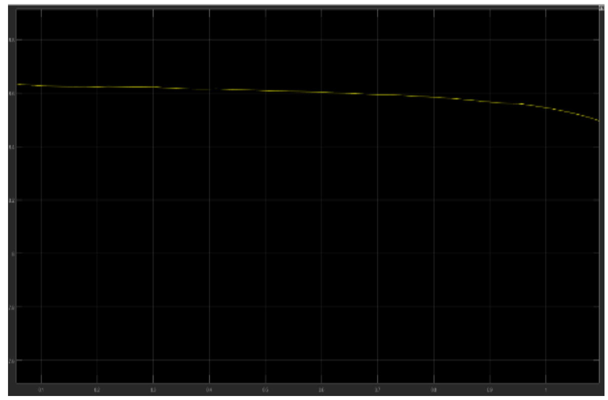

Fig 10.PV current

Waveform 3:The waveform of PV power is shown in fig. The study state value of PV power is around 3500 watts.

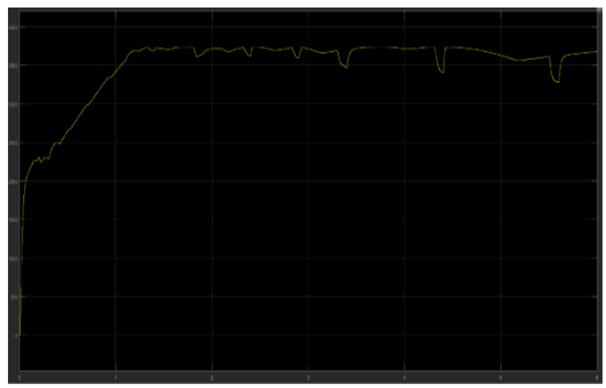

Fig 11.PV power

Waveform 4:The waveform of inverter current is shown in fig. The study state value of inverter current is around 8.42 amp.

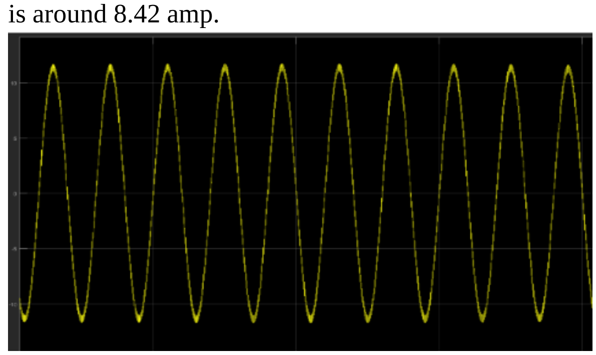

Fig 12. Inverter current

Waveform 5: The waveform of load current is shown in fig. The study state value of load current is around 8.84 amp.

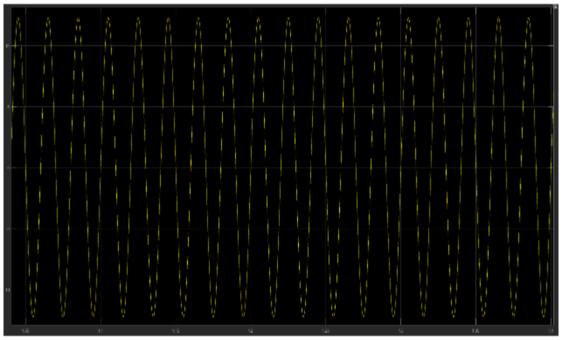

Fig 13.Load current

Waveform 6:The waveform of Grid Voltage is shown in fig. The study state value of grid voltage is around 330 voltage.

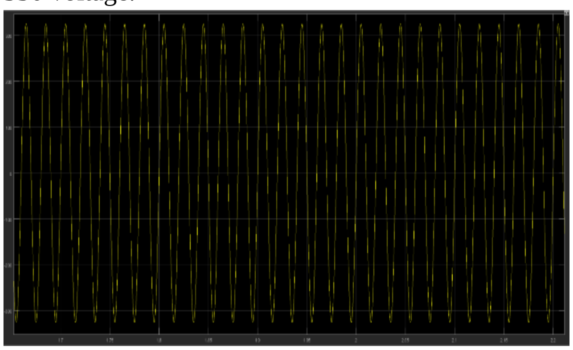

Fig 14.Grid voltage

(A) Conclusion

This paper provides an analysis and development of a Grid-connected PV system using a novel inverter current control algorithm.

A grid-connected converter and an energy storage capacitor module are used in the H Bridge topology for the Grid-connected system. A complete design process for a novel control algorithm is also presented, with the goal of lowering the THD of the grid current introduced into the system. In addition, the inverter is triggered using the original Hysteresis-based current controller.

(B) Future Scope

The paper, according to the author, will be helpful in the design of a single-phase grid-connected PV system. The topologies presented, as well as energy storage, are suitable for constructing a grid-connected PV system. Furthermore, the results are adaptable to the majority of grid-connected converters, primarily renewable energy sources, and primarily grid-connected PV system interfaces. In a distributed environment, the proposed solution can be incorporated into smart Grid systems to reduce pollution and increase reliability. Future research will focus on how distributed energy sources and distributed storage systems can work together.Cooperation of these systems can significantly enhance operation of future distribution network by:

- Energy balancing
- Active power management
- Power quality improvement.

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