Performance Improvement of Induction Motor using a Single Stage Inverter in Comparison with Multilevel Inverter.

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Abstract

In this paper a three phase single stage DC to AC inverter in photovoltaic power conversion system is implemented for industrial applications and compared with conventional five level cascaded H-bridge multilevel inverter. The aim of proposed inverter is to reduce the requirement of PV sources, to reduce the power conversion stages from DC to AC hence number of switches minimum and total harmonic distortion will be less than 5%. The switching of proposed inverter is control by sliding variable structure control (SVSC) technique and in photovoltaic system maximum power is tracked by PO MPPT method. With this proposed single stage inverter the improvement in the performance of induction motor for industrial applications has been attained and also the performance is compared with that of a multilevel inverter with the help of simulation by using MATLAB.

Key words:MPPT controller, Sliding Variable Structure Control, Single stage power conversion, Total Harmonic Distortion, Induction motor, multi level inverter

Nomenclature:

SVSC- sliding variable structure control,H-bridge-MPPT,PO,THD,PV,SPWM -sinusoidal pulse width modulation.

I. Introduction:

The rising power interest and climb in oil costs has coordinated the explores to move for substitute sustainable power sources like sunlight based, wind . These sources are savvy, eco well disposed and plentifully accessible particularly sun oriented. As the traditional sources are exorbitant and discharges toxins, the other energy sources are required for the gathering customer energy prerequisites. Subsequently the investigates are presently zeroing in much on the same energy sources like sunlight based , wind. The sunlight based energy is which is bounteously accessible and contamination free can undoubtedly adapt up the cutting edge power converters to furnish the plentiful energy with high proficiency and minimal expense

The rising interest for substitute clean energy sources and the aim of climate insurance is quickly influencing the advancement of present day power converters with the extent of incorporating the sun based power into the framework. The sun oriented energy creation has turned into the pertinent part among the different substitute energy sources .This has brought about progress in energy transformation frameworks with regards to control quality, proficiency, heartiness and dependability.

In Modern human culture , electric power is the significant type of fuel source and it is utilized in practically every single angle and every where. Power hardware is related with sun based power converters for power reversal, controlling and molding according to the shopper prerequisites. The power hardware are at satisfying the specific

targets of successful and effective use of force with worked on quality. Power gadgets frames the muscle and human data hardware shapes the cerebrum of Modern innovation.

For blending a flight of stairs waveform and furthermore for power change , multilevel converters idea with a few low dc voltage sources has been created. Sustainable power sources in particular solar,wind,fuel cell and batteries or capacitors taxi be utilized as hotspots for the staggered converters. The voltage evaluations of force semiconductor switches relies upon the rating of the dc voltage sources associated with them. Traditional setup of PV source fed Induction motor is displayed in the Figure1 underneath.

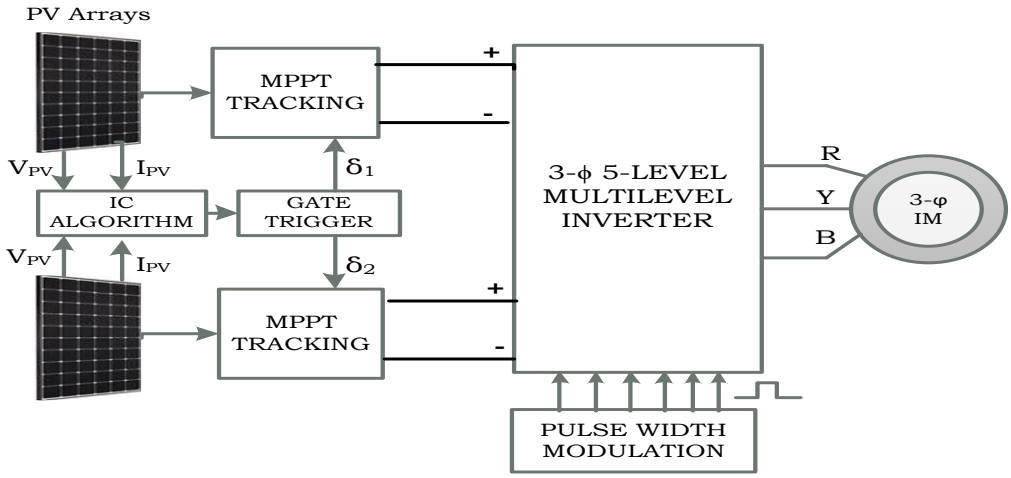


Figure:1 Conventional arrangement of PV source fed Induction Motor.

In Multilevel converters , countless semiconductor switches are required and this number expands The tragically, staggered converters truly do have a few impediments. One specific inconvenience is the more noteworthy number of force semiconductor switches required.

In spite of the fact that lower voltage evaluated switches can be used in a staggered converter, each switch requires a connected door drive circuit making the general framework to be more complicated and costly.

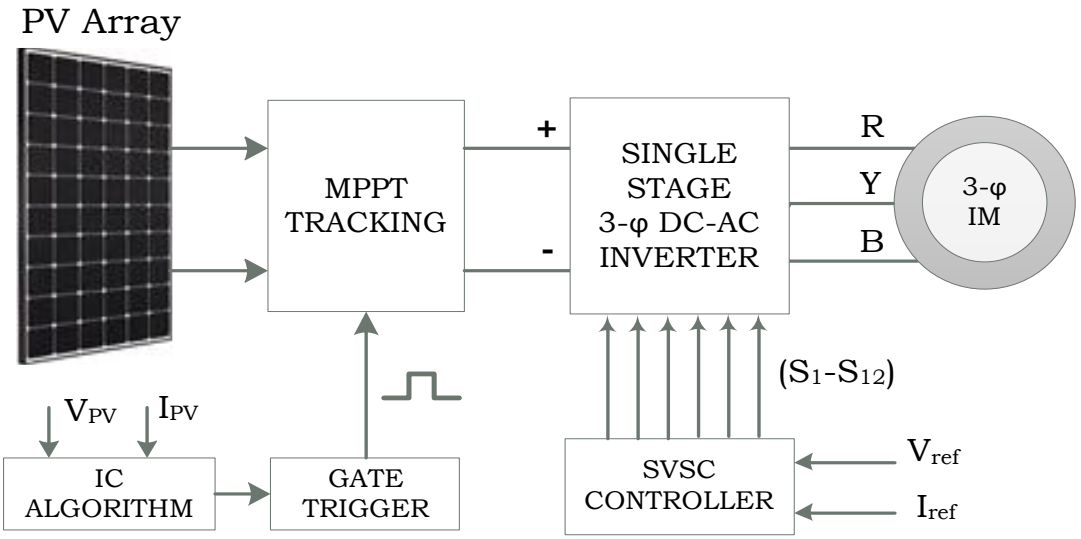


FIGURE 2.proposed configuration of PV source fed Induction Motor.

A 3-ϕ DC to AC Inverter is proposed in this paper which converts low dc voltage to high ac voltage with a basic recurrence in a solitary stage taking care of the electrical lattice organization or and business load as displayed in Fig. 1. In the proposed inverter the sun powered yield voltage accessible in DC structure is straightforwardly expanded and reversed to utility voltage. The inverter is taken care of from a sun oriented comprising of most extreme power point following (MPPT) sun based charger, single power transformation stage. MPPT [4] regulator.

The P&O calculation manages the variable dc result of photovoltaic (PV) modules [2] , giving a consistent DC which can be put away utilizing a battery.The helping and modifying of the voltage is gotten in a solitary stage utilizing regulators, for example, MPPT and SVSC.The MPPT based P&O calculation procedure [5] is carried out directing the result voltage of the sun powered and the steady DC yield voltage to meet the different burdens can be considered by utilizing SVSC controlling Technique.

The climatic varieties generally influences the presentation of the sunlight based cells bringing about factor voltage subsequently giving less proficiency [2]. Likewise, the DC battery acing as an energy stockpiling framework and prerequisite of more number of sunlight based cells will prompt a climb in venture of the sun oriented power plant.

In this paper a fair correlation between the proposed single stage double leg three stage inverter and staggered inverter is made demonstrating the viability as far as misfortunes, cost inverter, intricacy, execution of enlistment engine and generally proficiency of the proposed approach. The Matlab, Simulink climate has been considered for results approval..

In this paper at first the foundation subtleties are thought of and are referenced in Section-II. The regulator reason and its execution is made sense of in segment - III.The examination of proposed strategy with that of staggered inverter are talked about in Section-IV. The end is obviously advised in Section-V.

II. P&O MPPT ALGORITHM ANALYSIS AND IMPLEMENTATION

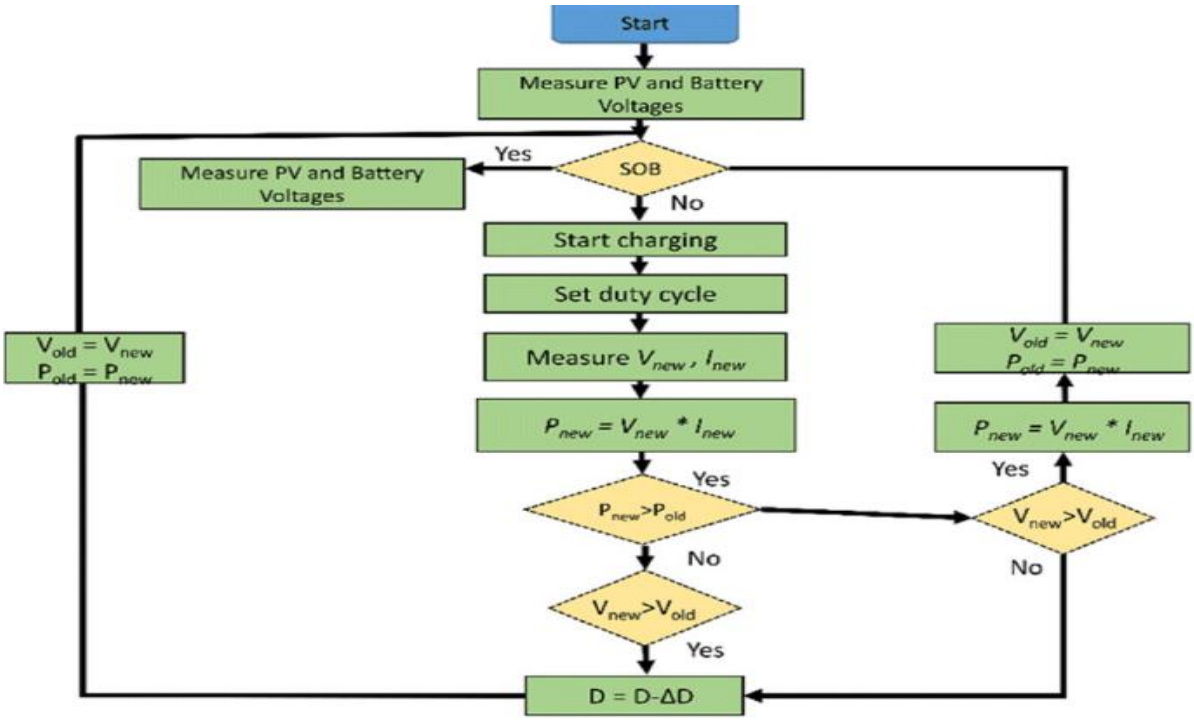
Most extreme power point following (MPPT) is a calculation for consistently changing the impedance saw by the sunlight based exhibit for the framework to run at greatest power point or near it under an assortment of conditions like changes in irradiance, temperature, or burden.

Engineers chipping away at sunlight based inverters should utilize MPPT calculations to amplify how much power created by PV systems.The calculations direct the voltage to keep the framework running at its "most powerful point" (or pinnacle voltage) on the power voltage bend.

MPPT calculations are usually used in PV framework regulator designs.To guarantee that the PV framework gives greatest power consistently, the calculations consider factors like fluctuating irradiance (daylight) and temperature.

The P&O calculation depends on the idea of bothering the framework's functional guide all together toward expand yield power.Small augmentations are added to the PV cluster until the most extreme power point is arrived at [7].P1 (power yield) is first registered by observing the sun based module's V1 and I1 values.Then, as V, a minor unsettling influence is added.The overhauled upsides of V2 and I2 are then used to decide P2.The framework will keep on irritating in a similar heading on the off chance that the P2 is positive. [7].

Whenever P2 is negative, the technique adds a negative augmentation to the result power worth to take it back to the most extreme power point [7].When the greatest power point is accomplished, the framework working point starts to waver about that most extreme power point indefinitely.The regulator will monitor this working point and endeavor to get the sun based module's V to perform at greatest power.[7]In this model, the regulator would be in a DC converter associated with the DC module yield.



The perturbation technique is very simple to use.The circuit models for the PV cell were made utilizing reasonable attributes gathered from Manufacturer;s information sheets and an insightful methodology depicted before [7].It's worth focusing on that the logical model depicted above is very valuable for PV framework simulation and modelling.It smoothes out solar powered module numerical calculations and plan without evolving notable actual qualities for solar cells [7].As an outcome, despite the fact that the boundaries are completely numerical (Figure 6), they precisely portray the normal actual way of behaviour of a PV module and array (Figure 7).

III. Induction Motor Modelling

Due for its different expected benefits, as negligible cost, essential, and sturdy turn of events, the polyphase selection motor is the most broadly used ac motor.Induction motor speed control is a sweeping topic.The acknowledgment motor (IM) has usually been used with steady repeat sources, and the squirrel-restrict machine is used in a wide extent of current applications, from compound plants to contort turbines to trains and electric vehicles.

Figure 1 depicts a delineation of a squirrel Cage IM construction.The mechanical and electrical straightforwardness and durability, the shortfall of pivoting contacts (brushes), and the ability to make force across the whole speed range are its key advantages.

IV. 5-Level H-Bridge Multilevel Inverter

Various H-Bridges are associated in grouping in a flowed H-Bridge staggered inverter.To give reversed ac yield, every H-Bridge has its own DC source, which can be provided from any normal sources, ultra capacitors, energy components, or batteries[7].

FIGURE 4.Five level staggered inverter(R-Phase)

The upside of this strategy is that it requires no capacitors or diodes for clipping, and the result waveform is sinusoidal in nature as the quantity of levels increments, regardless of whether we channel it.Multilevel inverters are used in environmentally friendly power sources like breeze, sunlight based, and energy components for both high and low power applications.For high-power applications, these application sources are effectively connected with staggered inverters.It can be utilized in an assortment of medium to high-control applications, including static VAR compensators, AC power supply, and drive frameworks [8].

Albeit a boundless number of levels can give a result wave zero consonant mutilation, the quantity of pf levels is confined because of voltage unbalance issues, circuit design, and pressing cutoff points.

The fundamental weakness of this framework is that each progression requires a singular DC power supply. Only one sets of switches worked at a transporter recurrence simultaneously for every H-span cell, while different matches worked at a reference recurrence.

V.MODELING OF PROPOSED SINGLE STAGE INVERTER

Each phase of the proposed DC-AC Converter has four switches, resulting in dc biassed sinusoidal voltage.Each converter's output voltage phase shift is angle, delivering the highest voltage differential across the load [4].Each converter's reference node should be connected together, and the load should be connected across the positive node of each converter.The 3-DC to AC modifier's circuit is depicted in Fig.2.The conversion of solar voltage capability voltage and the boost low level dc to high level ac voltage in a single power conversion stage delivers good DC-AC converter benefits with few power switches and no sine wave disruption.

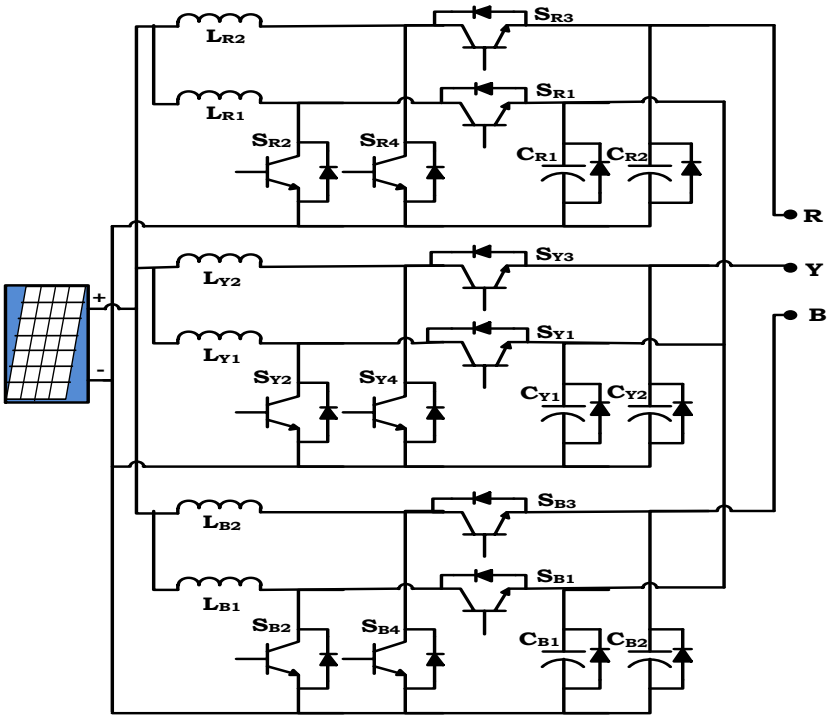


FIGURE 5.Single stage 3-ϕ dual leg DC-AC Inverter

A.WORKING PRINCIPLE OF SINGLE STAGE INVERTER

Figure.3,4 depicts the proposed R-Phase DC-AC Converter and its functioning in two modes.

1st (R-Phase) mode:When switch S_{R1} is open and S_{R2} is closed during the positive half cycle, the inductor L_{R2} is charged, increasing the loop current, but when S_{R2} is open and S_{R1} is closed, the capacitor C_{R1} provides electrical power to the load.

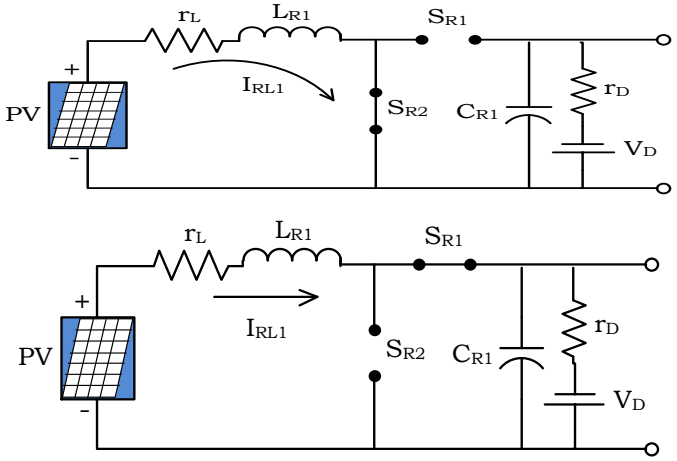


FIGURE .6. Operation of DC/AC Converter (R-Phase, Mode-1)

2nd Mode (R-Phase):

When S_{R3} is open and S_{R4} is closed during the negative half cycle, the inductor L_{R1} is charged, and when S_{R4} is open and S_{R3} is closed, the C_{R2} gives electric power to the load.

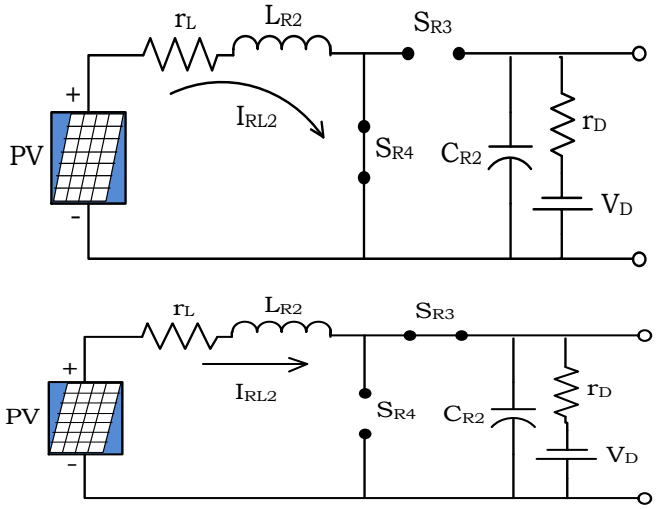


FIGURE.7. Operation of DC/AC Converter (R-Phase, Mode-2)

The Conduction mode of converter1

$$\frac{V_{CR1}}{V_{DC}} = \frac{1}{1-D} \qquad (1)$$

And the conduction mode of converter2 is

$$\frac{V_{CR2}}{V_{DC}} = \frac{1}{D} \qquad (2)$$

The functionality of the converter (R-Phase) can be easily evaluated with the equations given below

$$V_R = V_{CR1} - V_{CR2} = \frac{VDC}{1-D} - \frac{VDC}{D} \qquad (3)$$

$$\frac{V_R}{V_{DC}} = \frac{2D-1}{(1-D)\,D} \qquad (4)$$

$$\frac{\Delta i_{LRI}}{\Delta t} = \frac{VDC}{L_{R1}} - I\,\frac{r_{LR}}{L_{R1}} \qquad (5)$$

$$\frac{\Delta V_{CR1}}{\Delta t} = \frac{\Delta V_{CR2}}{r_{DCR}} - I\,\frac{r_{LR}}{L_{R1}} \qquad (6)$$

In the similar manner the converter for Y-Phase & B-Phase can be evaluated with 120 degree phase shift each.

VI.CONTROLLER DESIGN

The expression "variable construction framework" (VSS) was begat in Russia in the last part of the 1950s.VSS was first perceived as a subclass of nonlinear frameworks used to tackle an assortment of control difficulties in second-request straight and nonlinear systems.The most distinctive property of VSS, as per research, is that the shut circle framework is completely safe to framework vulnerabilities and outer disturbances.When heartiness turned into a conspicuous prerequisite in modem control applications after the 1980s, the control research local area turned out to be extremely keen on VSS.

The VSS standards have been developed into functional application in the field of control of DC servo, PM coordinated servomotors, enlistment engines, and mechanical controllers because of their high invariance and heartiness qualities.Sliding modes assume a significant part in VSS hypothesis, and the principal thought behind VSS control calculations is to uphold this sort of movement in unambiguous manifolds in framework state spaces.Sliding mode control in view of VSS stifles the vulnerabilities because of parametric varieties, outside aggravations and variable payloads .The sliding mode method gives prevalent execution, defeating the disadvantages of PI control, which is restricted by the inborn clash between consistent state exactness and dynamic reaction speed.

The sliding variable construction control (SVSC) is a high level nonlinear control approach that can change its design consequently when it arrives at a changing plane to accomplish wanted framework dynamic properties. It is a powerful control technique for managing framework boundary irritation and outside disturbance.SVSC hypothesis has been applied to discrete frameworks, time-defer frameworks, solitary frameworks, and other complex frameworks as of late. SMVSC has been utilized to deal with a wide scope of useful frameworks, including power models, satellite mentality control, and robot control.

By differentiating the variable construction approach with the direct state controller plan for a solitary information framework, the center way of thinking of the variable design approach might be effortlessly perceived.

$$I = A\,x + b\,u\,.$$

In the direct state controller plan, the construction of the state criticism is fixed as

$$u=kTx$$

Where the steady boundaries are chosen utilizing an assortment of plan procedures, for example, Eigen esteem situation or quadratic reduction].In variable construction frameworks, the control can change its design whenever, changing from one individual from a bunch of conceivable persistent state capacities to another.The variable design plan issue is then to choose the boundaries of every one of the designs and to characterize the exchanging rationale.

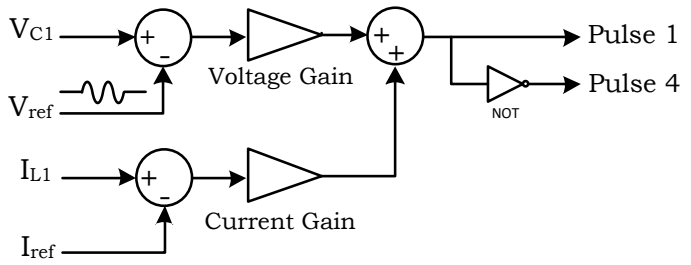


FIGURE.8. sliding variable structure control of mode1 operation

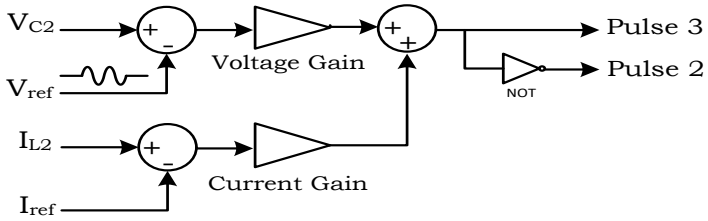


FIGURE.9. sliding variable structure control of mode2 operation

To manage the result of the single stage double leg dc-ac converter in Fig.5, a sliding variable construction control approach is proposed.The hysteresis current regulator is given the amount of the mistake upsides of the state factors of the proposed converter with sufficient increases [1].

In light of the wave of the mistake flags, the hysteresis current regulator structures two groups, the lower and upper band[1]. Cutting the waves on the edges of the lower and higher groups with a recurrence scope of up to 400kHz produces a nonstop heartbeat signal with inconsistent broadness.

VII. Simulation models

The exhibition of proposed single stage three stage double leg inverter and, level staggered inverters, PV module with MPPT and SVSC regulator are planned by utilizing the MATLAB/Simulink platform .

Simulation model of the proposed framework

The design and displaying of single stage three stage double leg DC-AC inverter for PV power and control procedures are created by MATLAB SIMULINK climate as displayed in Figure 6. Believeing the circuit boundaries to be an ideal. The parameters are: VDC = 100V, VO = 300sinωt (215VRMS), L1, L2 = 750µH each, C1, C2 = 20µF each fSW = 400KHz (Variable).

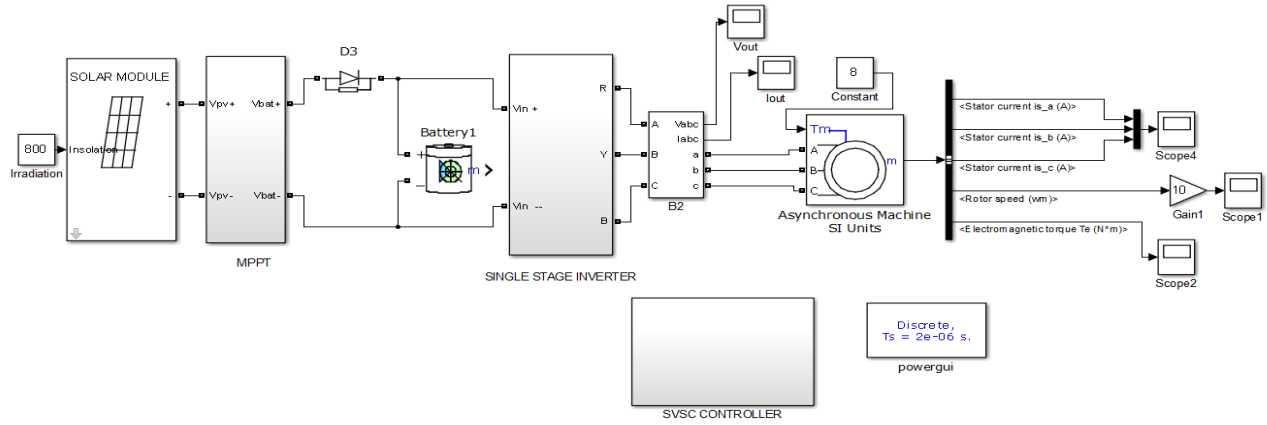


FIGURE.10. **Simulation model of the proposed system**

Simulation Model Of SVSC Controller

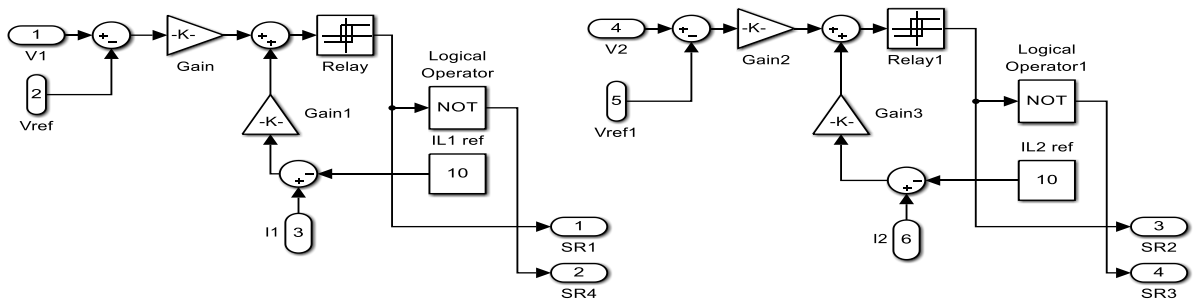


FIGURE.11. **Simulation model of SVSC Controller**

Simulatiom Model Of Five Level Multilevel Inverter

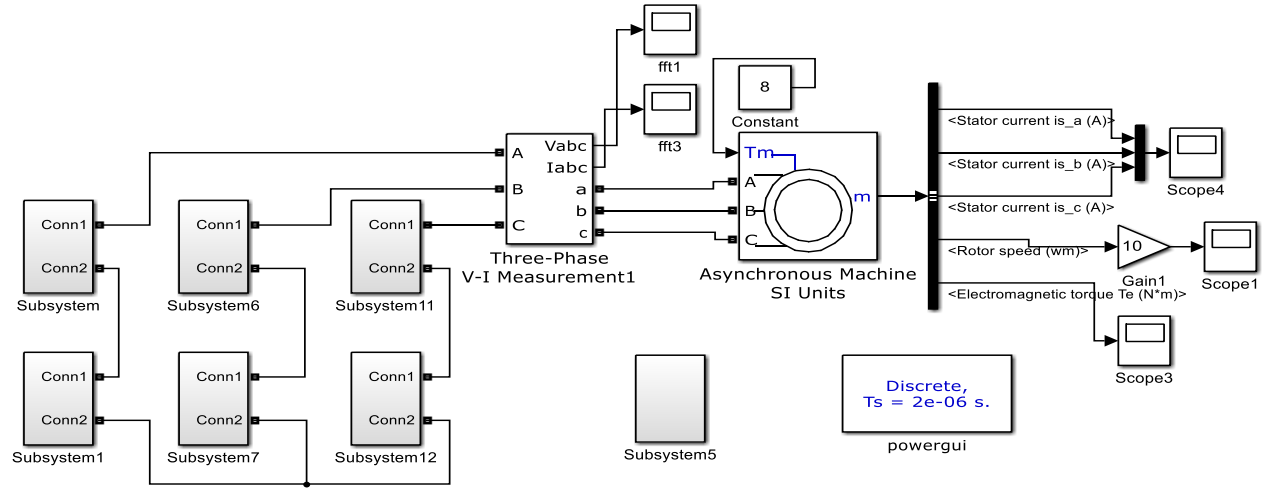


FIGURE.12. **Simulation model of five level multilevel inverter**

VI. Simulation and Results Comparison

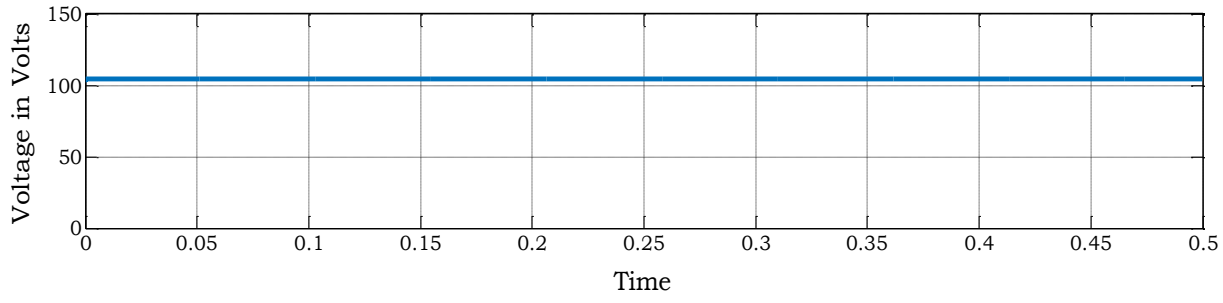


FIGURE.13.Solar panel output voltage

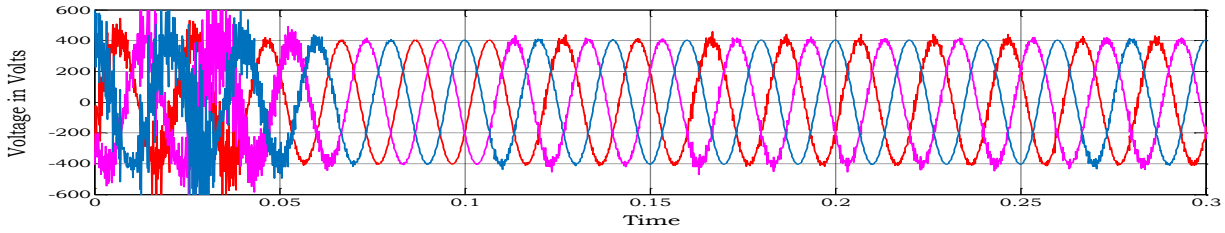


FIGURE.14.Single stage inverter output voltage

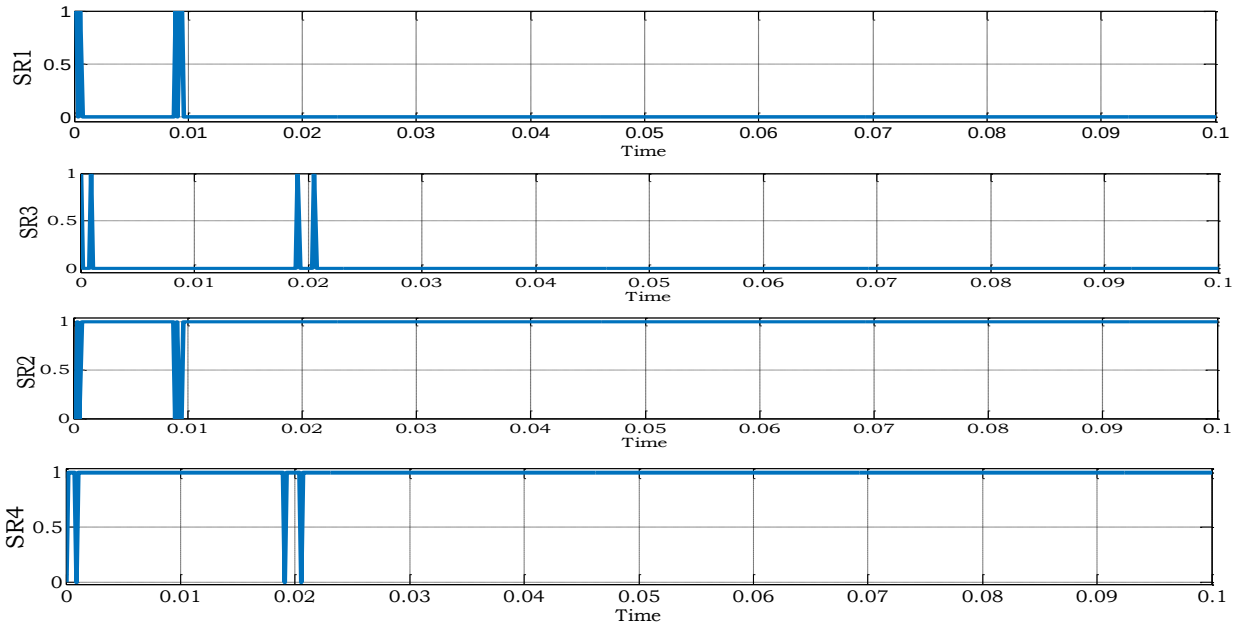


FIGURE.15. Switching pulses to single stage inverter (for R-Phase)

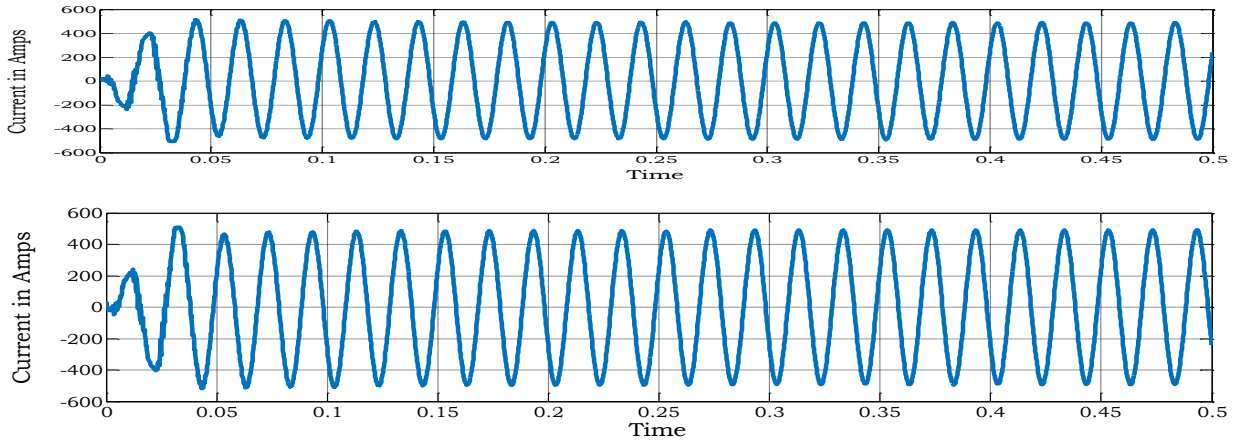


FIGURE.16. Inductor currents I_{LR1} and I_{LR2} in single stage inverter

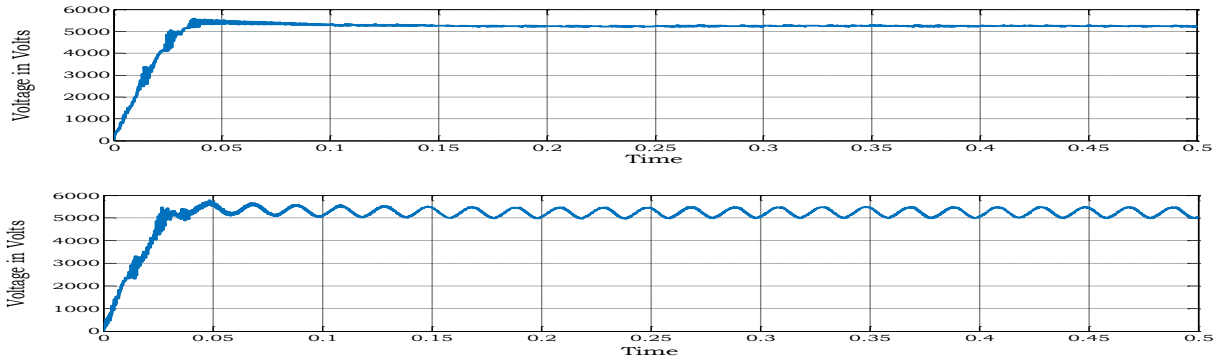


FIGURE.17.Capacitor voltages V_{CR1} and V_{CR2} in single stage inverter

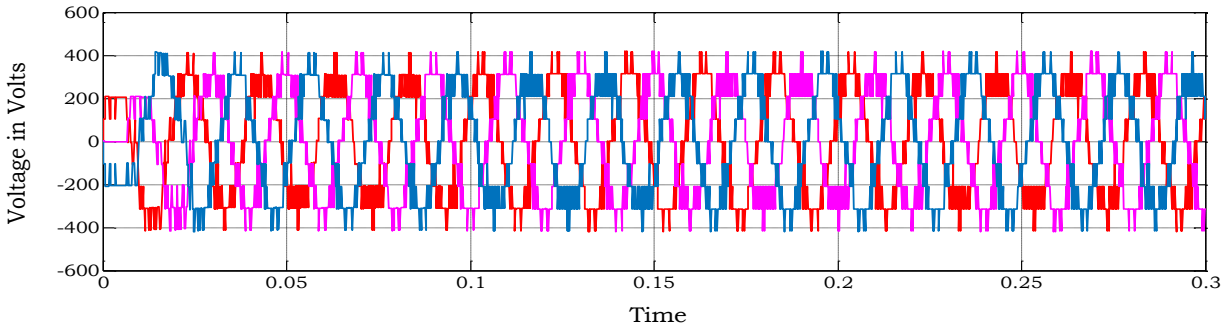


FIGURE.18.Five level inverter output voltage

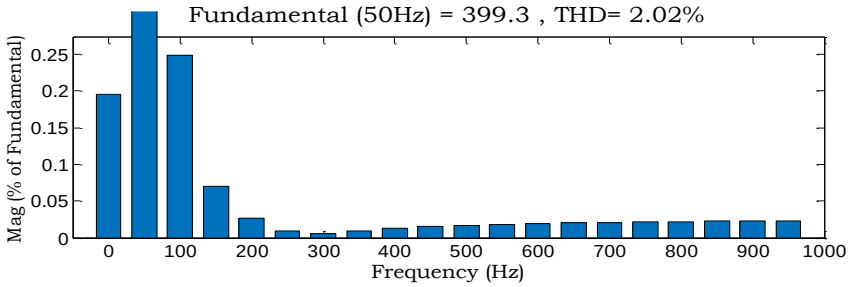


FIGURE.19. THD in output voltage with proposed inverter

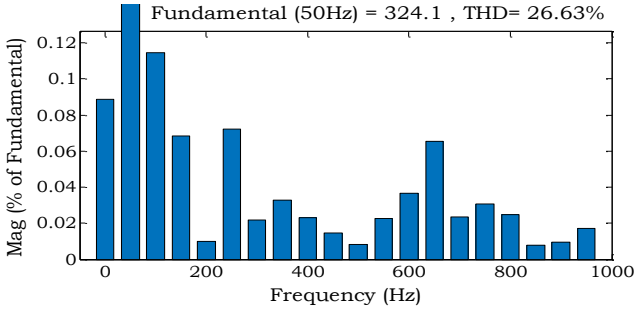


FIGURE.19. THD in output voltage with conventional inverter

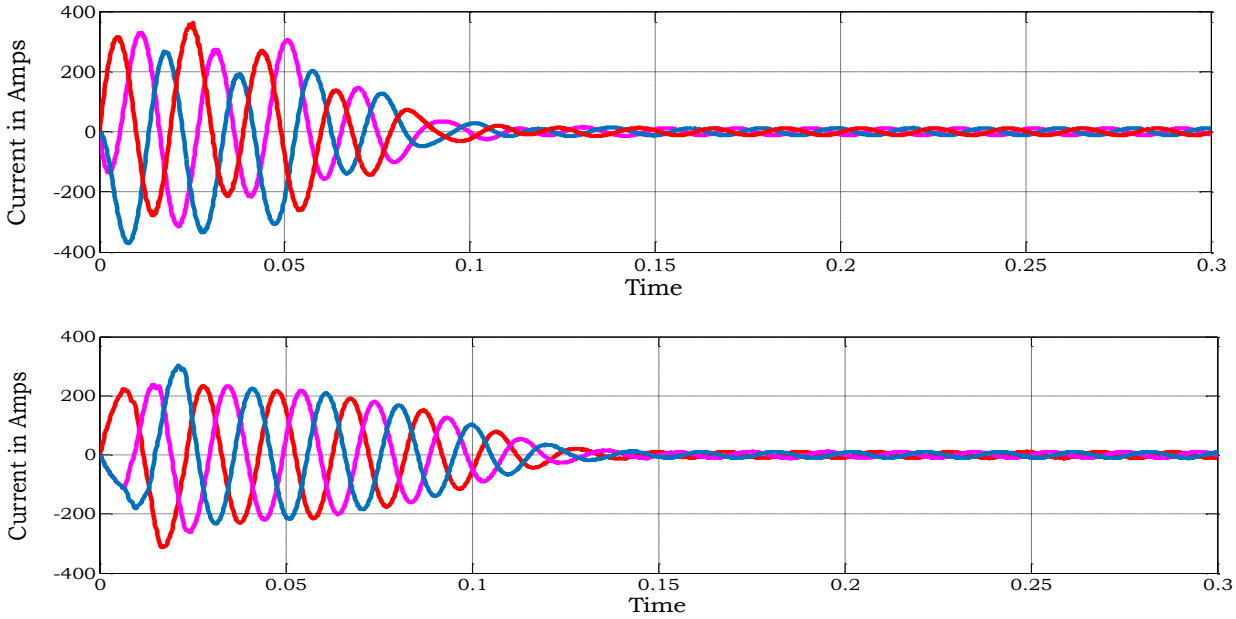


FIGURE.20.IM Stator Currents with proposed inverter and conventional Inverter

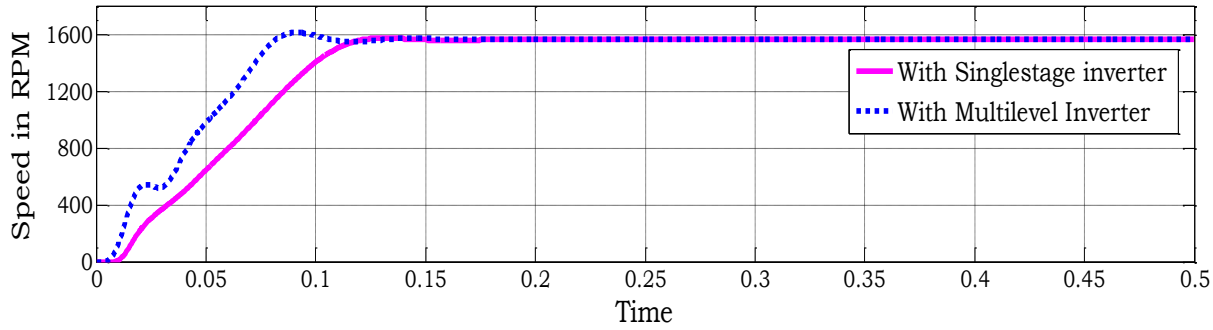


FIGURE.21. IM Speed with proposed inverter and conventional Inverter

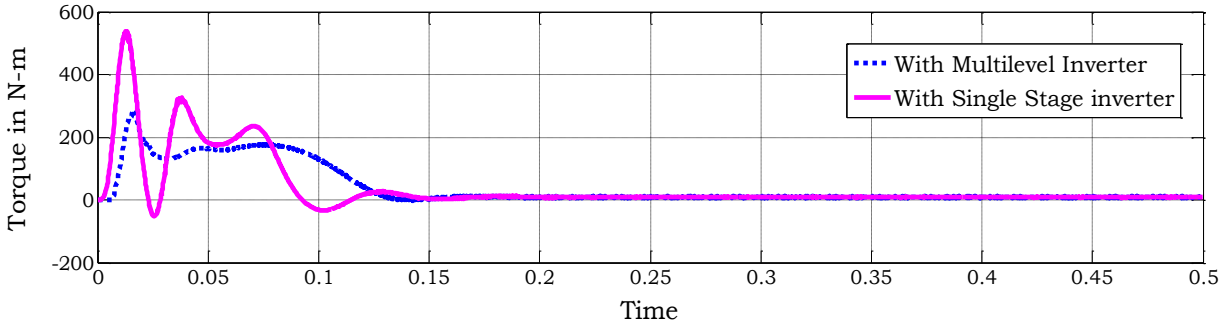


FIGURE.22. IM Torque with Proposed inverter and conventional inverter

TABLE.1.Comparison of single stage inverter and multilevel inverter

Parameter	Single stage inverter	Multilevel inverter
THD	2.02%	26.63%
Number of switches	12	24
Number of PV sources	One source	Two sources
Output voltage	415V	415V

TABLE.2 IM Performance Comparison with single stage inverter and with multilevel inverter

Parameter	With Single stage inverter	With Multilevel inverter
IM Maximum torque	536.7 N-m	282.8 N-m
IM speed	Oscillated with 3% peak overshoot	No oscillation
IM Stator current	327.4 A	222.5 A

VIII.Conclusion

The performance of Induction motor with hybrid energy system fed single stage inverter has been observed and has been compared with that of multilevel inverter.It can be concluded that single stage inverter fed IM has given better performance with maximum torque of 536.7N-M when compared with that of multilevel inverter with 282.8N-m only. Also the THD in output voltage is only 2.02% with SS Inverter and that with MLI is as high as 26.63%.

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