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Adaptive Noise Reduction Control Technique For Power Quality Enhancement Of Grid Integrated Solar PV System

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ABSTRACT

This paper presents execution of a two phase three stage PV-network interfaced framework with a three stage VSC which has been used as a multifunctional gadget. Versatile commotion lessening method is utilized to control multifunctional VSC which exchanges the dynamic power from PV framework to the matrix and furthermore acts as a dynamic power filter (APF) to enhance control quality at AC mains. The control calculation exhibited here has a quick and exact dynamic reaction. The proposed SPV vitality framework has been executed with straight and non-direct load to indicate consonant end, stack adjusting and control factor amendment.

1.INTRODUCTION

With an expansion in the request of sustainable power sources, matrix associated sun based photovoltaic (PV) framework is developing as a noteworthy research region nowadays. Additionally, a sharp decline in cost and increment in efficiency of PV boards alongside the coming of less expensive and inventive inverter configurations are making the lattice associated PV framework substantially more appealing [1]. Be that as it may, combination of PV into the network brings many difficulties, for example, accomplishing most extreme power point following (MPPT), stack administration and power quality at interface of PV with the lattice i.e. music end, stack adjusting and so forth.

In this paper, a two phase PV framework is proposed in which a three stage matrix is interfaced with the PV framework utilizing a 3 leg voltage source converter (VSC). Up until this point, a sensible measure of research has been done on single stage PV-matrix interface , however two phase frameworks have not been examined much yet. Be that as it may, it is imperative to actualize two phase topology if our goal is to enhance control quality at PV-framework interface. A two phase framework is more efficient in accomplishing MPPT, DC interface voltage security, dynamic power filtering and receptive power pay. Somewhere in the range of two phase PV-matrix frameworks are accounted for in the writing ,however their significant concentration is to utilize inverter as a dynamic power sustaining gadget from PV to the lattice, not as a receptive power compensator gadget. Some of them talk about the power quality change of the framework yet they are constrained to reenactment study and equipment points of interest are not given.

In this Project, we propose a control which has following targets:

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- To abuse responsive power pay ability of the inverter alongside exchange of sun based power in a framework coordinated sunlight based PV framework.
- To improve control nature of the framework at AC mains.

For the most part, the inverter stays sit out of gear when there is no sun oriented power era yet a shrewd inverter with responsive power capability can be used constantly. Such multi functional inverter will diminish the general cost of sunlight based PV establishment. Alongside multi-usefulness of the inverter, the proposed framework is additionally equipped for different capacities, for example, sun oriented power exchange to the matrix and burdens, MPPT following, consonant pay at AC mains, Power factor redress and load adjusting with both straight and non-direct load. Besides, the control strategy introduced here is exceptionally powerful, simple to execute in programming and equipment and gives quick and precise dynamic reaction.

2. MODELING OF PV CELL

The photovoltaic framework changes over sun oriented vitality specifically to power without having any terrible impact on our condition. The fundamental section of PV exhibit is PV cell, which is only a basic p-n intersection gadget. The fig.2.1 shows the equal circuit of PV cell.Equal circuit has a present source (photocurrent), a diode parallel to it, a resistor in arrangement demonstrating an inbuilt imperviousness to the stream of current and a shunt resistance which communicates a spillage current. The current conveyed to the heap can be given as.

$$I\text{--}\{(V+I/a)-1\}(+I) \qquad (2.1)$$

Where

I_{PV}–Photo voltaic current

I_O–diode's Reverse saturation current

V–Voltage across the diode

a– Ideality factor

V_T–Thermal voltage

R_s– Series resistance R_p–Shunt resistance

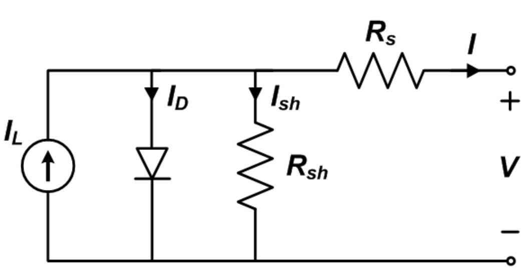

Fig.2.1 Equivalent Circuit Of PV Cell

I_{SC_STC} - short circuit current at standard test condition

V_{OC_STC} - short circuit voltage at standard test condition

K_V - temperature coefficient of open circuit voltage

3. SHADING EFFECT

At the point when a module or a piece of it is shaded it begins creating less voltage or present when contrasted with unshaded one. At the point when modules are associated in arrangement, same current will stream in whole circuit however shaded segment can't ready to create same current yet need to enable a similar current to stream, so shaded part begins carrying on like load and begins expending power. At the point when shaded segment begins to go about as load this condition is known as problem area issue. Without proper insurance, issue of problem area may emerge and, in serious cases, the framework may get harmed .To decrease the harm in this condition we for the most part us a side step diode . Square outline of PV cluster in shaded

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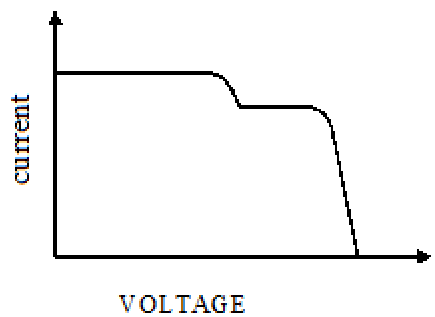
Due to partial shading or total shading PV characteristic become more non-linear, having more than one maximum power point . So for this condition tracking of the maximum power point become very tedious. We can easily see the effect of shading on PV characteristics in the fig shown below.



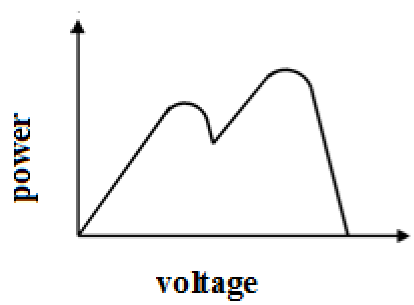


Fig.3.2 Effect of partial shading on I-V & P-V characteristics

4. MAXIMUM POWER POINT TRACKING

Maximum power point tracing (MPPT) system is an electronic control system that can be able to coerce the maximum power from a PV system. It does not involve a single mechanical component that results in the movement of the modules changing their direction and make them face straight towards the sun. MPPT control system is a completely electronic system which can deliver maximum allowable power by varying the operating point of the modules electrically .

4.1 NECESSITY OF MAXIMUM POWER POINT TRACKING

In the Power Vs Voltage normal for a PV module appeared in fig 2.8 we can see that there exist single maxima i.e. a greatest power point related with a particular voltage and current that are provided. The general proficiency of a module is low around 12%. So it is important to work it at the pinnacle control point with the goal that the most extreme power can be given to the heap independent of persistently changing ecological conditions. This expanded power improves it for the utilization of the sun oriented PV module. A DC/DC converter is associated by the PV module separates most extreme power by coordinating the impedance of the circuit to the impedance of the PV module and exchanges the extricated energy to the heap. Impedance coordinating should be possible by fluctuating the obligation cycle of the exchanging components.

4.2 MPPT algorithm

There are many algorithms which help in tracing the maximum power point of the PV module. They are following:

a. P&O algorithm
b. IC algorithm
c. Parasitic capacitance
d. Voltage based peak power tracking
e. Current Based peak power tracking

4.3. Perturb and observe

Every single MPPT calculation has its own points of interest and burdens. Irritate and watch (P&O) strategy is broadly utilized due its straightforwardness. In this calculation we present a bother in the running voltage of the board. Irritation in voltage should be possible by changing the estimation of obligation cycle of dc-dc converter.

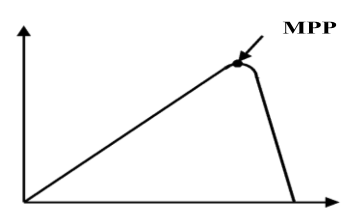


Fig. 4.1 P-V characteristics (basic idea of P&O algorithm).

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Fig 4.1 show the p-v curves of a photovoltaic system, by analyzing the p- v characteristics we can observe that on right side of MPP as the voltage decreases the power increases but on left side of MPP increasing voltage will increase power. This is the main idea we have used in the P&O algorithm to track the MPP. The flow chart of P&O algorithm is manifested in figure.4.2.

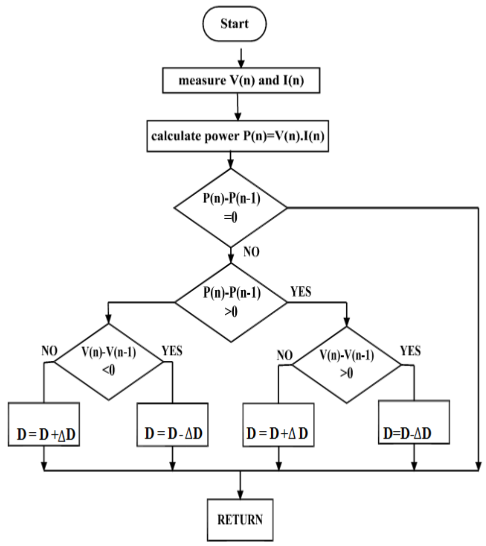

FIG.4.2 Flow Chart Of P&O Algorithm

As should be obvious from the stream diagram above all else we measure voltage and current, by utilizing these qualities we compute control, ascertained power is contrasted and past one and as needs be we increment or decline the voltage to find the Maximum Power Point by modifying the obligation cycle of converter.

5. CONTROL ALGORITHM

Two stage control algorithms are used in the proposed system as shown in Fig.6 First stage is maximum power point tracking (MPPT) which is used to control DC-DC boost converter whereas the second stage is to control VSC switching. For VSC control, a new control algorithm called adaptive noise reduction (ANR) has been used in this work as shown in Fig 6.2. Detailed control systems are

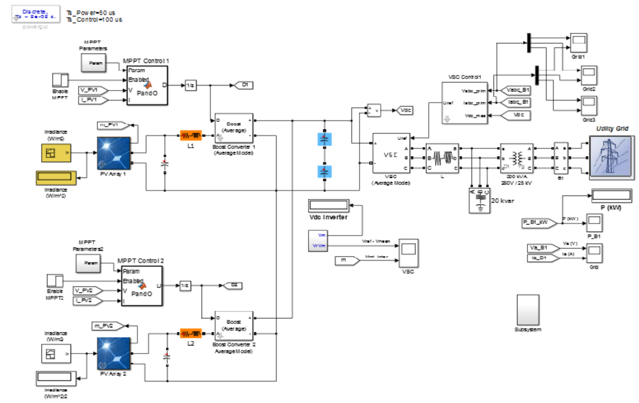

Fig. 5.1 Schematic of grid interfaced SPV energy system

Several MPPT algorithms have been presented and analyzed in the literature . The InCond method, which is popular among them, has been used here. The In Cond control is based on the fact that the slope of the PV array power curve is zero at the maximum power point (MPP). In this method, PV array voltage (V_{pv}) and current (I_{pv}) are sensed and fed to the MPPT controller to track the MPP where change in voltage and current is estimated as,

$$dVpv = Vpv(k) - Vpv(k - 1) \quad (1)$$

$$dIpv = Ipv(k) - Ipv(k - 1) \quad (2)$$

B. Stage 2 - Control of Three Phase VSC

This control algorithm consists of three main blocks as shown in Fig. 2. The first and most important block is for extracting fundamental load current quickly and accurately i.e. harmonic detection, the second one is for estimating active component of load currents and whereas the last one is for estimating source reference current signals. The basic steps for estimation of different control variables are explained below.

Fundamental Extraction of Load Currents (ANR):

In this control technique, the fundamental component of all the three-phase source currents are extracted independently to generate reference source current. A set of non-linear differential equations governs the dynamics

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of the algorithm which are shown below [9]. Any signal can be represented as,

X(t)=t +)+n(t) _(3)

where, n(t) is the noise and A_i, $w_i t + \theta_i$ are amplitudes and phases of harmonically related sinusoid.

denotes the vector of estimated parameters. So the desired sinusoidal component is

Y(t(t),(t)(t))=(t)(t)dt+(t)) _(4)

To extract Y, estimated parameters should be optimum which minimize the distance between X (t) and Y(t(t),(t)(t)), So, the obtained set of differential equations are,

d(t)/dt=2e(t)(t) _(5)

d)/dt=2e(t) (t) _(6)

d(t)/dx=(t)+(d(t))/dx _(7)

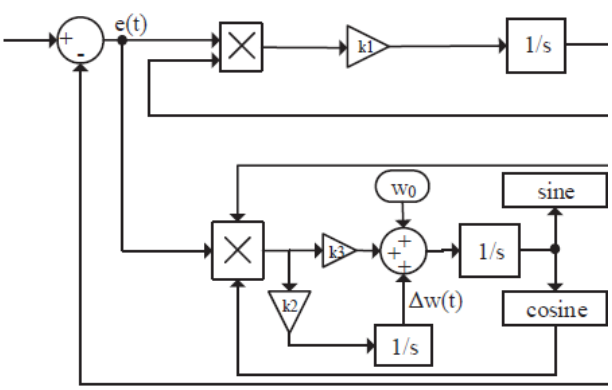

Fig. 5.2. Adaptive Noise Reduction (ANR) Control scheme block for currents fundamental current extraction

where,

e(t)=X(t)-)(t) _(8)

A block diagram of the adaptive noise filter technique has been shown in Fig.5.2. The sinusoidal tracking algorithm presented above is highly efficient for the extraction of non-stationary sinusoidal signal and estimation of their parameters namely amplitude, phase and frequency. This algorithm provides a high degree of noise immunity and robustness and it can get adjusted adaptively according to the variation in grid frequency. It is observed in simulation that both the amplitude and phase of fundamentals of load currents are tracked accurately as shown . Advantages of the algorithm are low computational time and high estimation accuracy which are necessary in most of the practical applications.

Estimation of Source Reference Currents and Generation of Gating Pulses: Sum of estimated three-phase active current components I_{Lp} is divided equally in all the three phases to get balance reference current. It should be noted that I_{dc} is also added into it as shown . I_{dc} is the precise amount of

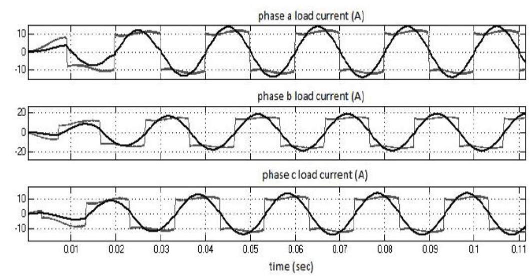

Fig.5.3. Fundamental extraction of 3 phase non-linear currents

EXPERIMENTAL RESULTS AND DISCUSSION

A prototype of grid connected SPV system is developed in laboratory using an IGBT-based three-leg VSC. ANR based control algorithm is implemented using a DSP (dSPACE1103 real time controller). To simulate solar PV characteristics in the laboratory, an AMETEK make TerraSAS PV simulator is used. Experimental results for unbalanced linear and balanced non-linear loads are discussed below. The results are discussed for harmonic elimination, load balancing, power factor correction and solar power transfer.

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A.Performance under Linear Unbalanced Load Condition

In this case phase c is removed to create unbalance in the load (I_{Lc} is almost zero). But it can be observed that the supply currents have same amplitudes in all the three phases which validates the load balancing feature of the system. Fig.7(g)-(i) show total harmonic distortion (THD) for supply, load and inverter current respectively. Since these results are for linear loads, the load currents do not have harmonic contents. Their THD is under 5% which is acceptable according to IEEE 519 standards. So, harmonic elimination feature does not apply here. We will see this feature with non-linear loads in next section show grid power, load power and solar power respectively. Since the available solar power (6.28 kW) is more than the

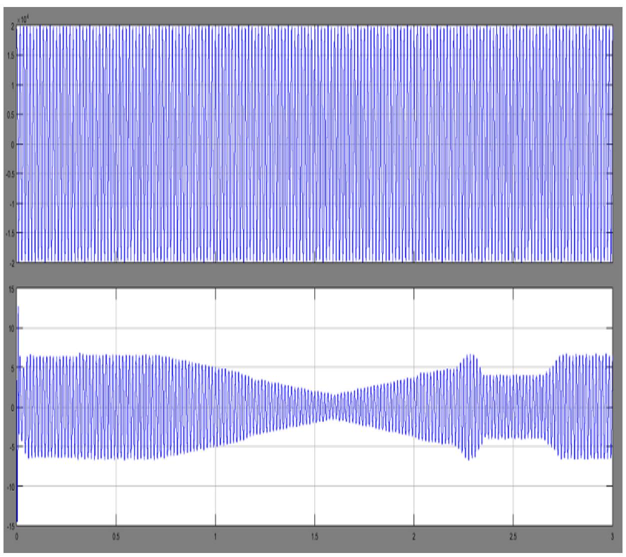

Fig. Supply currents with reference voltage(Vsabc)

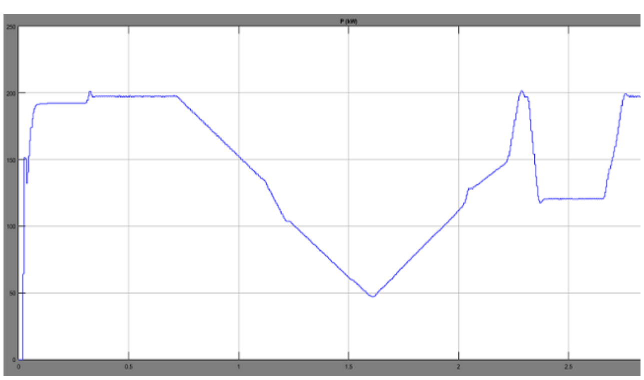

Fig. Output power(load power)

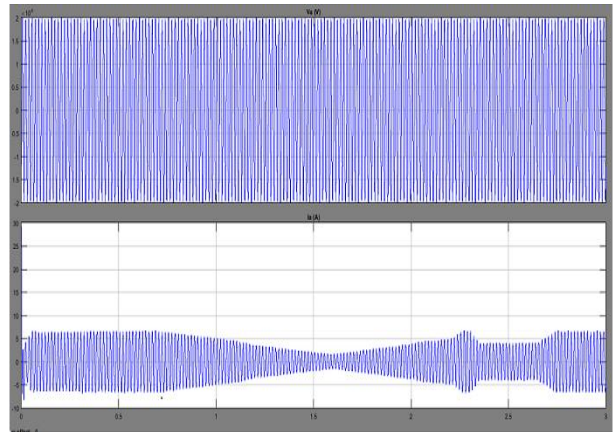

Fig. Load currents with reference voltage(Vabc)

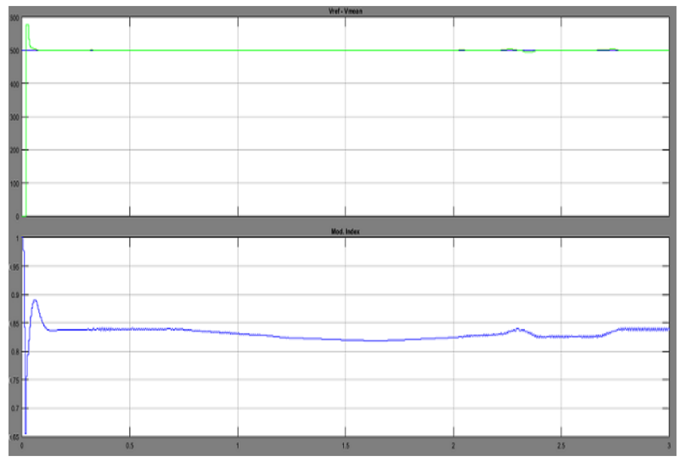

Fig. Modular index (Vref – Vmean)

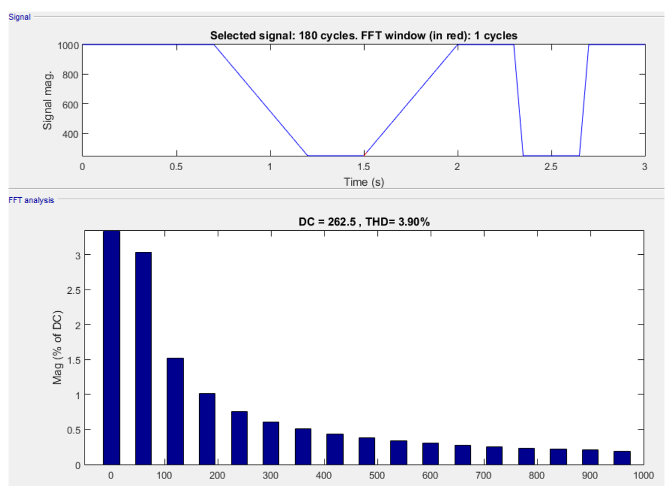

Fig. THD of Irradiance(Ir)

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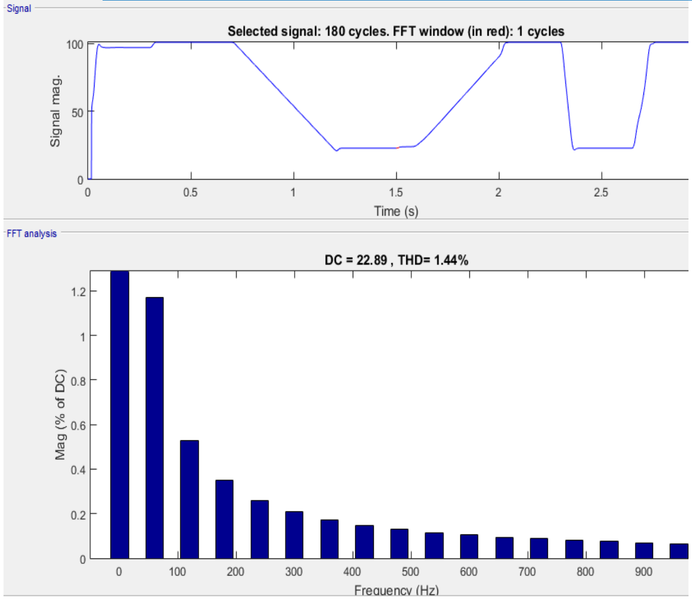

Fig. THD of Grid, load and solar power

load power (0.91 kW), most of the solar power is being fed to the grid as visible from negative value of grid power. Almost zero reactive power component in supply power shows the unity power factor condition at PCC which demonstrates power factor correction feature of VSC. These test results show satisfactory performance of the proposed system for load balancing, power factor correction and solar power transfer under linear unbalanced load condition.

B. Performance under Non-Linear Balanced Load Condition

Since it is non-linear load, this case validates the harmonics elimination feature of VSC. Harmonic compensation can be observed from the THD analysis. THD of load current is around 27.6% but supply current has only 4%THD which is under 5% and acceptable according to IEEE 519 standard. Since the available solar power is more than the required load power, most of the solar power is being fed to the grid as visible from waveforms. Negative sign of supply power depicts the direction of power flow i.e. feeding back to the grid. Zero reactive power component in supply power shows the unity power factor condition at PCC. Since the loads are balanced, we do not require load balancing feature in this case. Load balancing has been verified with unbalanced load in the last section. These test results show satisfactory.

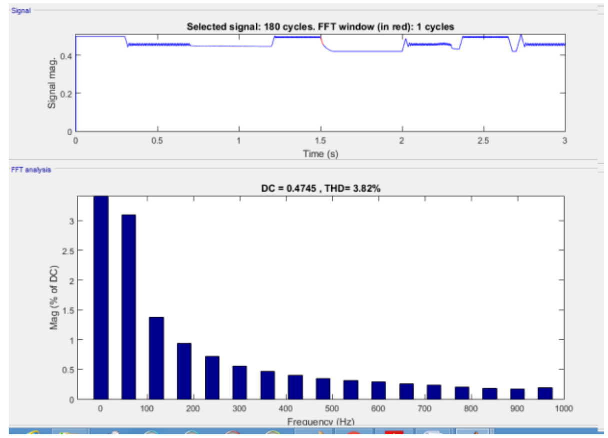

Fig. THD of diode current (inverter current)

performance of the proposed system for harmonic elimination at PCC and solar power transfer under linear balanced load condition.

7.CONCLUSION

A three-stage two phase SPV vitality transformation framework has been executed on equipment. Another ANR control procedure has been proposed and executed for estimation of reference supply current to produce the exchanging beats for VSC. The actualized control calculation has been found to give adequate qualities in every one of the circumstances. The execution of the multifunctional VSC has been shown for symphonious disposal, control factor amendment, stack adjusting, receptive power remuneration and exchange of sunlight based power adjusted and unbalanced load condition for both straight and non-direct loads. unlight based power from the sun based test system has been effectively bolstered to the network and general execution of the proposed matrix interfaced SPV vitality framework has been discovered acceptable under various working conditions. The responsive power pay ability of the inverter has been shown notwithstanding sunlight based power exchange. This makes it conceivable to use inverter at near time when there is sunlight based power era. This will definitely bring about enhanced efficiency and decreased cost of sun powered PV framework.

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