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Adaptive Noise Reduction Control Technique for Power Quality Enhancement of Grid Integrated Solar PV System

Yerrabelliprathapkumar
Assistant Professor Department Of Eee Khammam Institute Of Technology And Sciences
Khammam, Telangana 507170, India.

Abstract: *This paper presents execution of a two phase three phase PV-arrange interfaced system with a three phase VSC which has been utilized as a multifunctional device. Flexible tumult lessening strategy is used to control multifunctional VSC which trades the dynamic power from PV structure to the matrix and besides goes about as a dynamic power filter (APF) to improve control quality at AC mains. The control estimation showed here has a snappy and correct dynamic reaction.The proposed SPV imperativeness structure has been executed with straight and non-guide load to indicate consonant end, stack adjusting and control factor revision.*

Keywords: VSC, PV, APF.

I. INTRODUCTION

With an extension in the demand of sustainable power sources, matrix related sun based photovoltaic (PV) structure is developing as an imperative research district these days. Furthermore, a sharp decline in cost and increment in proficiency of PV sheets close by the coming of more affordable and inventive inverter setups are making the cross section related PV system significantly all the more appealing. Nevertheless, combination of PV into the system brings numerous troubles, for instance, accomplishing most outrageous power point following (MPPT), stack administration and power quality at interface of PV with the grid i.e. music end, stack adjusting et cetera. In this paper, a two phase PV system is proposed in which a three phase matrix is interfaced with the PV structure 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 structures have not been examined much yet. In any case, it is basic to realize two phase topology if we will probably improve control quality at PV-system interface. A two phase system is more effective in accomplishing MPPT, DC interface voltage security, dynamic power filtering and open power pay. Some place in the scope of two phase PV-matrix systems are represented in the writing, however their critical fixation is to use inverter as a dynamic power sustaining contraption from PV to the grid, not as an open power compensator device. Some of them discuss the power quality difference in the structure yet they are constrained to reenactment study and hardware points of interest are not given. In this Project, we propose a control which has following targets:

1. To manhandle responsive power pay capacity of the inverter close by trade of sun based power in a system coordinated daylight based PV structure.
2. To enhance control nature of the structure at AC mains.

Generally, the inverter stays sit out of apparatus when there is no sun arranged power period yet a sagacious inverter with responsive power capacity can be utilized always. Such multi practical inverter will diminish the general cost of daylight based PV foundation.

Furthermore, the control system introduced here is especially powerful, easy to execute in programming and gear and gives speedy and exact dynamic response.

II. MODELING OF PV CELL

The photovoltaic system changes over sun arranged imperativeness particularly to

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power without having any ghastly effect on our condition. The basic segment of PV show is PV cell, which is just an essential p-n intersection device. The fig.1 demonstrates the equivalent circuit of PV cell. Level with circuit has a present source (photocurrent), a diode parallel to it, a resistor in game plan demonstrating an inbuilt impenetrability to the flood of current and a shunt protection which imparts a spillage current. The current passed on to the stack can be given as.

$I = I_{PV} - I_O\{(V+IR_S/a\ V_T)-1\}(V_S+IR_P)$

Where

IPV–Photo voltaic current

IO–diode's Reverse saturation current

V–Voltage across the diode

a– Ideality factor

VT –Thermal voltage

Rs– Series resistance Rp–Shunt resistance

ISC_STC - short circuit current at standard test condition

VOC_STC - short circuit voltage at standard test condition

KV - temperature coefficient of open circuit voltage

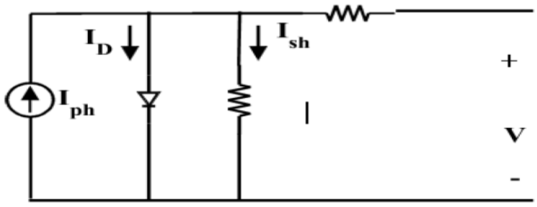

Fig 1. Equivalent Circuit of PV Cell.

III. SHADING EFFECT

Exactly when a module or a bit of it is shaded it begins creating less voltage or present when appeared differently in relation to unshaded one. Exactly when modules are related in course of action, same current will stream in entire circuit however shaded fragment can't prepared to make same current yet need to empower a comparative current to stream, so shaded part begins carrying on like load and begins expending power. Exactly when shaded fragment begins to go about as load this condition is known as issue zone issue. Without appropriate insurance, issue of issue territory may rise and, in genuine cases, the system may get hurt .To diminish the damage in this condition we generally us an evade diode. Square outline of PV group in shaded condition is exhibited as takes after.

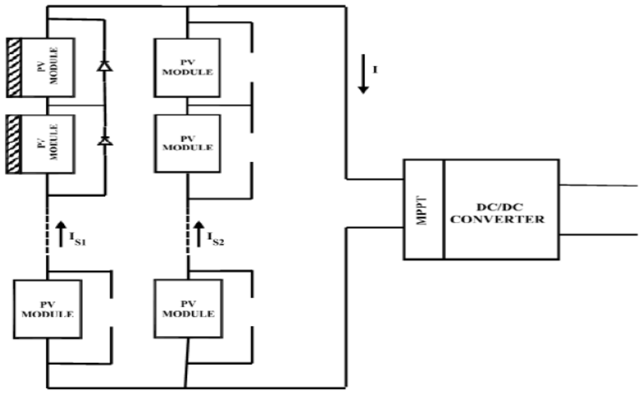

Fig 2. PV Array in Shaded condition.

Because of fractional shading or aggregate shading PV trademark turn out to be more non-linear, having more than one maximum power point. So for this condition tracking of the maximum power point turn out to be extremely monotonous. We can without much of a stretch see the impact of shading on PV attributes in the fig demonstrated as follows.

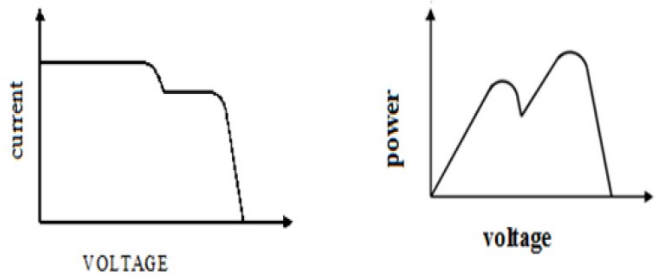

Fig3.Effect of partial shading on I-V & P-V characteristics.

IV. MAXIMUM POWER POINT TRACKING

Maximum power point tracing (MPPT) system is an electronic control system that can have the capacity to pressure the maximum power from a PV system. It doesn't involve a single mechanical part that outcomes in the development of the modules changing their heading and influence them to confront straight towards the sun. MPPT control system is a totally electronic system which can convey maximum passable power by varying the operating point of the

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modules electrically. A. Necessity of Maximum Power Point Tracking

In the Power Vs Voltage typical for a PV module showed up in fig. we can see that there exist single maxima i.e. a biggest power point related with a specific voltage and current that is given. The general capability of a module is low around 12%. So it is essential to work it at the pinnacle control point with the objective that the most outrageous power can be given to the store independent of tirelessly changing biological conditions. This extended power enhances it for the use of the sun arranged PV module. A DC/DC converter is related by the PV module isolates most outrageous power by coordinating the impedance of the circuit to the impedance of the PV module and trades the removed energy to the pile. Impedance coordinating ought to be conceivable by fluctuating the commitment cycle of the exchanging parts.

B. MPPT algorithm

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

1. P&O algorithm
2. IC algorithm
3. Parasitic capacitance
4. Voltage based peak power tracking
5. Current Based peak power tracking

C. Perturb and observe

Each and every MPPT computation has its own points of interest and weights. Bother and watch (P&O) procedure is comprehensively used due its straightforwardness. In this computation we show a trouble in the running voltage of the board. Bothering in voltage ought to be conceivable by changing the estimation of commitment cycle of dc-dc converter

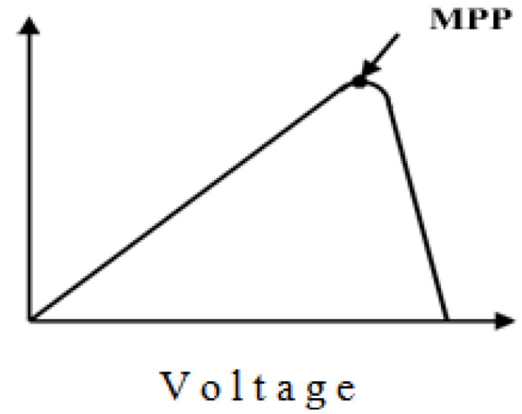

Fig 4. P-V characteristics (basic idea of P&O algorithm).

Fig 4 demonstrate the p-v bends of a photovoltaic system, by analyzing the p-v qualities we can watch that on right half of MPP as the voltage diminishes the power increases yet on left half of MPP increasing voltage will increase power. This is the main thought we have utilized as a part of the P&O algorithm to track the MPP. The stream diagram of P&O algorithm is showed in figure.5.

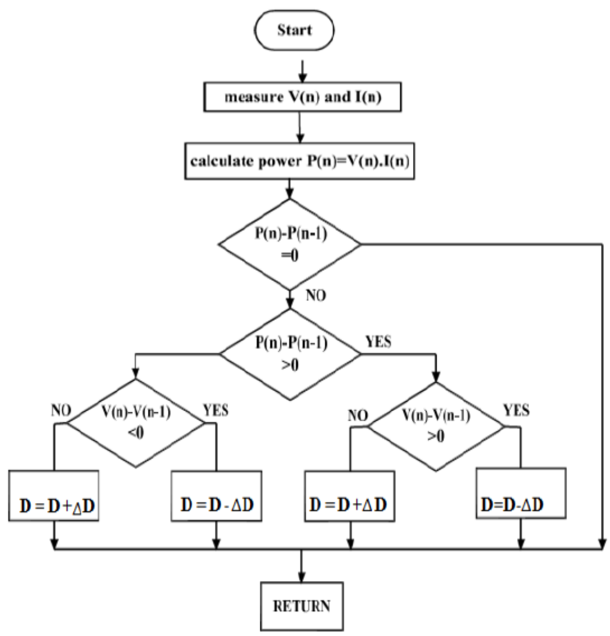

Fig 5. Flow Chart of P&O Algorithm.

As ought to be evident from the stream chart to the exclusion of everything else we measure voltage and current, by utilizing these qualities we process control,

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ascertained power is differentiated and past one and as requirements be we increment or decline the voltage to find the Maximum Power Point by modifying the commitment cycle of converter.

V. CONTROL ALGORITHM

Two phase control algorithms are utilized as a part of the proposed system as appeared in Fig.6First arrange is maximum power point tracking (MPPT) which is utilized to control DC-DC support converter though the second stage is to control VSC switching. For VSC control, another control algorithm called adaptive noise reduction (ANR) has been utilized as a part of this work as appeared in Fig 6. Definite control systems are Several MPPT algorithms have been displayed and dissected in the writing. The In Cond technique, which is well known among them, has been utilized here. The In Cond control depends on the way that the slant of the PV exhibit power bend is zero at the maximum power point (MPP). In this technique, PV exhibit voltage (Vpv) and current (Ipv) are detected and encouraged to the MPPT controller to track the MPP where change in voltage and current is assessed as,

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

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

This control algorithm comprises of three main pieces as appeared in Fig. The first and most vital square is for extracting central load current rapidly and precisely i.e. symphonious location, the second one is for estimating is for estimating source reference current signs. The essential strides for estimation of various control factors are explained underneath. Basic Extraction of Load Currents (ANR).

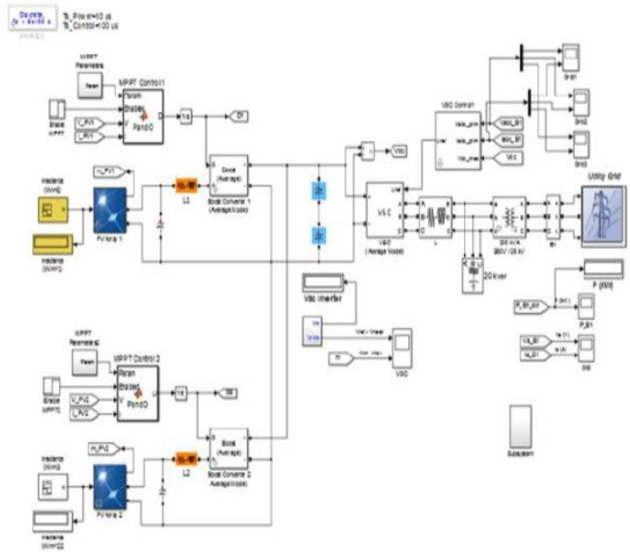

Fig 6. Schematic of grid interfaced SPV energy system.

In this control technique, the central part of all the three-phase source currents is extricated independently to create reference source current. An arrangement of non-linear differential conditions administers the dynamics of the algorithm which are demonstrated as follows. Any flag can be spoken to as,

$$X(t)=\sum A_i \sin (wW_i t +\Theta_i) +n(t) \quad (3)$$

Where, n(t) is the noise and Ai , wi t + θi are amplitudes and phases of harmonically related sinusoid.

$[\bar{A}(t), \bar{w}(t), \bar{\theta}(t)]^T$ denotes the vector of estimated parameters. So the desired sinusoidal component is

$$Y(t, \bar{A}(t), \bar{w}(t), \bar{\theta}(t)) = \bar{A}(t)\sin\left(\int_0^t \bar{w}(t)\,dt + \bar{\theta}(t)\right) \quad (4)$$

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,

$$d\hat{A}(t)/dt = 2k_1 e(t) \sin \hat{\emptyset}(t) \quad (5)$$

$$d\hat{w}(t)/dt = 2k_2 e(t)\, \hat{A}(t) \cos \hat{\emptyset}(t) \quad (6)$$

$$d\hat{\emptyset}(t)/dx = \hat{w}(t) + k_3 (d\hat{w}(t))/dx \quad (7)$$

Where,

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$$e(t)=X(t)-\hat{A}(t))\sin\hat{\phi}(t) \quad (8)$$

A square chart of the adaptive noise filter technique has been appeared in Fig.7. The sinusoidal tracking algorithm introduced above is exceptionally proficient for the extraction of non-stationary sinusoidal flag and estimation of their parameters specifically adequacy, phase and recurrence. This algorithm gives a high level of noise invulnerability and heartiness and it can get balanced adaptively according to the variety in grid recurrence. It is seen in reenactment that both the plentifulness and phase of basics of load currents are followed precisely as appeared. Preferences of the algorithm are low computational time and high estimation exactness which are vital in the greater part of the commonsense applications.

1. Using the removed central current sufficiency and phase, plentifulness of active part of load current is assessed which is talked about in next area.
2. Active Power Estimation using the In-phase and Quadrature Voltage Templates: In-phase (Usap) and Quadrature (Usaq) unit formats of PCC voltages are assessed as takes after

$$U_{Sap}=\frac{V_a}{V_t} \quad (9)$$

$$(\text{where}, V_t=\sqrt{\frac{2}{3}}(V_{Sa}^2+V_{Sb}^2+V_{Sc}^2)$$

$$U_{Sap}=\frac{-U_{Sbp}++U_{Scp}}{\sqrt{3}} \quad (10)$$

$$U_{Sbq}=\frac{3U_{Sap}+U_{Sbp}-U_{Scp}}{2\sqrt{3}} \quad (11)$$

$$U_{Scq}=\frac{-3U_{Sap}+U_{Sbp}-U_{Scp}}{2\sqrt{3}} \quad (12)$$

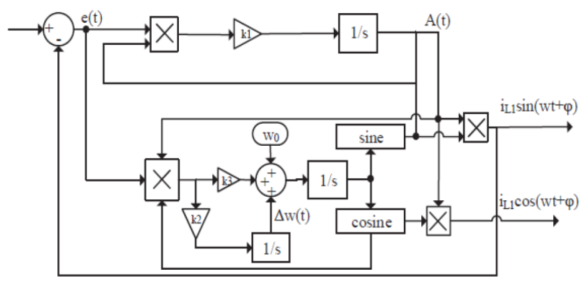

Fig 7. Adaptive Noise Reduction (ANR) Control scheme block for currents fundamental current extraction

Presently active segment of load current ILap can be figured using following trigonometric conditions for phase a. Likewise ILbp, ILcp can be ascertained for phase b and c. |ILa|f , |ILb|f , |ILc|f are the amplitudes of major segments of load currents a, b and c individually assessed by ANR in the past advance.

3. Estimation of Source Reference Currents and Generation of Gating Pulses: Sum of assessed three-phase active current parts ILp is isolated similarly in all the three phases to get adjust reference current. It ought to be noticed that Idc is additionally included into it as appeared.

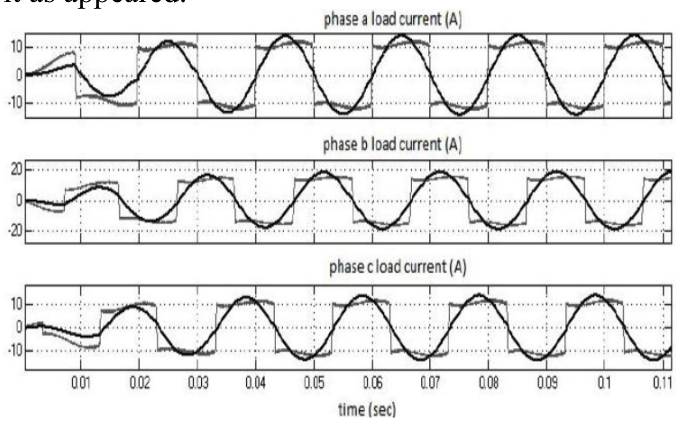

Fig8. Fundamental extraction of 3 phase non-linear currents.

I_{dc} is the exact measure of Per-phase active current that ought to be taken from the source keeping in mind the end goal to maintain the DC-link voltage at a coveted level. I_{dc} part includes misfortunes of converter and solar power accessible at DC-link. To obtain I_{dc} part, reference DC-link voltage is contrasted and the real DC-link voltage and the mistake is gone through a PI controller as appeared in Fig. Reference source current for each phase is assessed as,

$$I_{Sa}^*=(I_{nap})U_{Sap} \quad (13)$$

$$I_{Sb}^*=(I_{nbp})U_{Sap} \quad (14)$$

$$I_{Sc}^*=(I_{ncp})U_{Scp} \quad (15)$$

The estimated supply currents are given to current controller for generation of switching logic.

VI. EXPERIMENTAL RESULTS AND DISCUSSION

A model of grid associated SPV system is produced in research facility using an IGBT-based three-leg VSC. ANR based control algorithm is actualized using a DSP (dSPACE1103 ongoing controller). To reenact solar PV qualities in the research facility, an AMETEK make TerraSAS PV test system is utilized. Exploratory outcomes for unequal linear and adjusted non-linear loads are talked about beneath. The outcomes are talked about for consonant elimination, load balancing, power factor remedy and solar power exchange.

A.Performance under Linear Unbalanced Load Condition

For this situation phase c is evacuated to make unbalance in the load (ILc is just about zero). In any case, it can be watched that the supply currents have same amplitudes in all the three phases which approves the load balancing highlight of the system. Fig indicate add up to consonant mutilation (THD) for supply, load and inverter current separately. Since these outcomes are for linear loads, the load currents don't have consonant substance. Their THD is under 5% which is adequate according to IEEE 519 gauges. Along these lines, consonant elimination include does not have any significant bearing here. We will see this component with non-linear loads in next area indicate grid power, load power and solar power separately. Since the accessible solar power (6.28 kW) is more than the load power (0.91 kW), the greater part of the solar power is being bolstered to the grid as unmistakable from negative estimation of grid power.

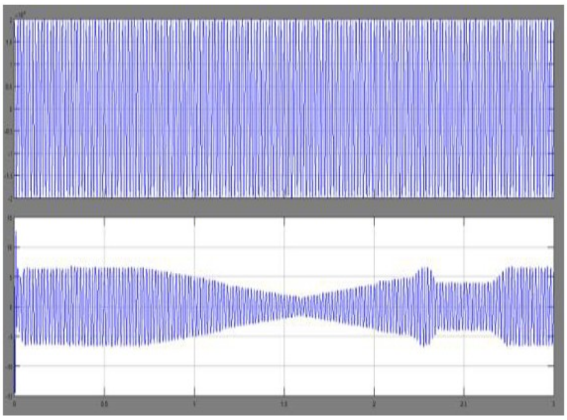

Fig 9. Supply currents with reference voltage(Vsabc).

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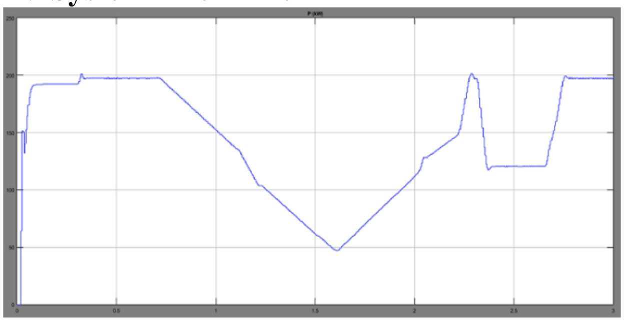

Fig 10. Output power(load power).

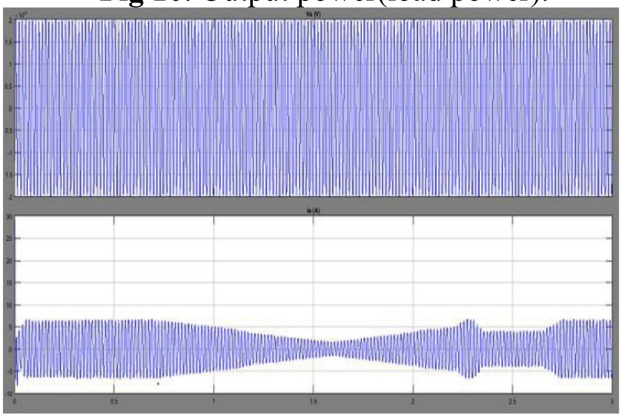

Fig 11. Load currents with reference voltage(Vabc).

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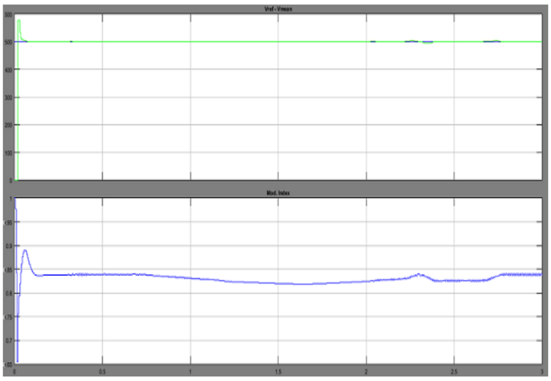
Fig 12. Modular index (Vref – Vmean).

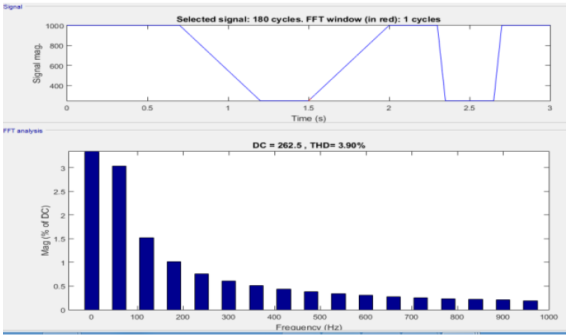

Fig 13. THD of Irradiance(Ir).

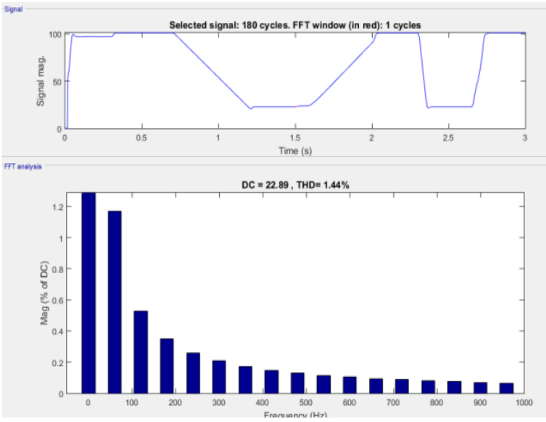

Fig 14. THD of Grid, load and solar power.

Just about zero reactive power segments in supply power demonstrate the solidarity power factor condition at PCC which shows power factor adjustment highlight of VSC. These test outcomes demonstrate satisfactory execution of the proposed system for load balancing, power factor remedy and solar power exchange under linear uneven load condition.

B. Performance under Non-Linear Balanced Load Condition

Since it is non-linear load, this case approves the sounds elimination highlight of VSC. Consonant remuneration can be seen from the THD investigation. THD of load current is around 27.6% yet supply current has just 4% THD which is under 5% and adequate according to IEEE 519 standard. Since the accessible solar power is more than the required load power, a large portion of the solar power is being sustained to the grid as unmistakable from waveforms.

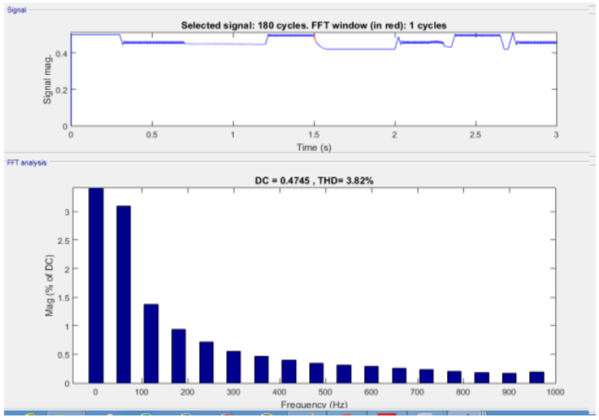

Fig 15. THD of diode current (inverter current).

Negative indication of supply power delineates the bearing of power stream i.e. feeding back to the grid. Zero reactive power parts in supply power demonstrate the solidarity power factor condition at PCC. Since the loads are adjusted, we don't require load balancing highlight for this situation. Load balancing has been confirmed with lopsided load in the last area. These test outcomes indicate satisfactory Performance of the proposed system for consonant elimination at PCC and solar power exchange under linear adjusted load condition.

VII. CONCLUSION

A three-organize two phase SPV essentialness change structure has been executed on gear. Another ANR control system has been proposed and executed for estimation of reference supply current to create the exchanging beats for VSC. The realized control count has been found to give sufficient qualities in each one of the conditions. The execution of the multifunctional VSC has been appeared for symphonious transfer, control factor correction, stack adjusting, open power compensation and trade of daylight based power balanced and uneven load condition for both straight and non-coordinate loads. unlight based power from the sun based test system has been viably reinforced to the system and general execution of the proposed matrix interfaced SPV imperativeness structure has been found adequate under different working conditions. The responsive power pay capacity of the inverter has been appeared notwithstanding daylight based power trade. This makes it possible to utilize inverter at close time when there is daylight based power time. This will definitely bring about improved proficiency and diminished cost of sun powered PV system.

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Author's Profile:

YERRABELLIPRATHAPKUMAR, he obtained his M.Tech in the stream of Power Electronics from JNT University Hyderabad in 2013.He obtained his B.Tech in the stream of Electrical and Electronics Engineering from JNT University Hyderabad in2010.He has the teaching experience of over 4 Years. He has also guided more than 4 M.Tech and 10 B.Tech Projects.His areas of interest are power systems and Analysis, HighVoltage Engineering, Electrical Machines and Electromagnetic field Theory