
ISSN: 2319-345X
IJMRBS
International Journal of
Management Research and
Business Strategy
www.ijmrbs.org
E-mail
editor@ijmrbs.org
editor.ijmrbs@gmail.com

ISSN 2319-345X www.ijmrbs.com

Vol. 10, Issuse. 2, June 2022

CHARGE CONTROL OF BATTERIES IN A STANDALONE SOLARPHOTO-VOLTAICHYBRID SYSTEM

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ABSTRACT

An efficient battery charge controller employing a standalone solar photovoltaic (PV)-diesel battery hybrid system is implemented in the model's suggested Standalone Photovoltaic (PV) system. Using the proposed approach, the intermittent nature of the PV array's output is addressed, as well as the improvement in power quality A DC-DC boost converter and a maximum Power Point Tracking (MPPT) algorithm are used to optimize the PV array's output under a wide range of operating conditions. The diesel engine generator (DG) set is connected with the battery energy storage system (BESS) to provide load management and powerflow coordination within the system.

IndexTerms—Neutral current compensation, Admittance-based control algorithm BESS, DG set Four-leg VSC Array of solar cells, stand-alone system.

INTRODUCTION

Remote areas that lack grid and transportation infrastructure benefit from a global shift to renewable energy resources. As global warming is a serious environmental concern, the usage of renewable energy resources is on the rise as an alternative for future energy supply. Among the available renewable energy resources, solar photovoltaic (PV) power generation is gaining significant recognition, and it is used for many applications such as domestic appliances, distant missions, data communications, telecommunication systems, hospitals, electric airplanes, and solar autos . Using photovoltaic (PV) power generation has several advantages, including providing clean detection-based control technique is shown in to operate a stand-alone DC/DC converter with battery energy storage (BES). There is an example of a four-wire stand-alone distribution system controlled by a character triangle function (CTF). Three enhanced phase-locked loops (EPLLs) are utilized to extract the fundamental active and reactive power components of load currents in this control strategy based on EPLLs. However, only computer simulations are discussed in this publication. Standalone PV-DG systems are controlled using a composite observer-based technique. The authors have, however, produced experimental data, but the control strategy is difficult and necessitates fine-tuning of internal parameters. They have. In contrast to the control method used in

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The suggested system employs a simple conductance-based control technique. In addition, all of the system's features are demonstrated by a thorough experimental investigation.

PMSG, PV array, and BES are the components of the proposed system. Diesel-engine-driven permanent magnet synchronous generator An example of a typical rural hospital power supply system, this microgrid must maintain a continuous power supply 24 hours a day, seven days a week. As a result, the PMSG powered by a diesel engine provides a stable supply of power. The DG set is built to run at 80–100% of its full capacity in order to preserve efficiency and save maintenance costs.

This is because the DG set's efficiency decreases and its maintenance costs rise as carbon accumulates on it during periods of low load. It is common practice to avoid these issues by utilizing battery charging to maintain a minimum loading level of 80 percent or by programming the DG to turn ON/OFF according on its current loading level. However, switching the DG set on and off is generally not suggested for safety reasons.

1) The load may vary frequently. Therefore, theThe mechanical maintenance on DG grows with each ON/OFF cycle.

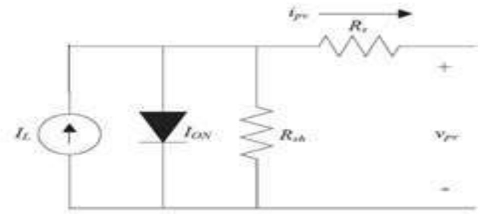
2)During brief times of high discharge current, the battery's life expectancy decreases.

3)Excitation control for the PMSG operated by the diesel engine is unnecessary. There are no moving parts, therefore it is more durable and requires less maintenance than a brushless motor-driven machine. Variations in the output power from the PV array necessitate a battery energy storage system (BESS). Compressed air, super capacitors, flywheels, pumped hydro, and superconducting magnetic storage are all alternatives to the BESS when it comes to stand-alone systems for storing electrical energy. To meet the following specifications, a stand-alone system of PV array, DG set, and BESS will be implemented.

4)It's possible to regulate solar irradiance, load fluctuations, and unbalances to alter the voltage at the point of common coupling (PCC). 2) Load measurement is not required to turn on or off DG. Reduced harmonic distortion (THD) of PCC voltages and DG set currents under the IEEE-519 standard improves the system's power quality. To 4)control the flow of electricity between the power source and the load. Residual power correction and balanced DG currents are provided by BESS' voltage-source converter (VSC). As a result of this, machine overheating and shaft vibrations are reduced.

5)6) It is possible to compensate for neutral current with a four-legged VSC. Power quality in the electrical distribution system is becoming increasingly important as nonlinear loads such as computers, electronics appliances, medical equipment and refrigerators become more prevalent.

6)Poor power quality is a result of the harmonics injected by these loads and the distortion of the current and voltage waveforms. Incorporating custom power devices while yet adhering to IEEE-519 could help alleviate the power difficulties with quality. Additionally, three-phase four-wire loads have been known to have issues with neutral current due to their nonlinearity and imbalance. Neutral current, which includes harmonics with three levels of repeating frequency, can be generated from this. When the system is overloaded, neutral currents can produce dangerous and even catastrophic heat losses.posesaseriousthreattotheconnectedequipment.Afour-legVSCisusedforneutralcurrentcompensationinadditiontomitigatethecurrentharmonicswith otherreportedadvantages.Additionally, the flexible operation of the systemdependsuponimplementationofthevariouscontrol strategies. Some of the control algorithmsthathavebeenappliedforcontrolling aremultiloop strategy , sliding-mode control , P controllerbased techniqueFLC-based control methodandenhancedphaselockedtechnique.Theauthorshavefailedtodiscussthepowerquality andreactivepowercompensation.Theresponse ofthesecontrollerstotheunbalanceanddynamic conditions is slow.In this paper,an admittancebasedcontrolalgorithmisappliedfortheevaluation of reference power component of sourcecurrentsinthePV-DGhybridsystem.Theadmittance of the load is estimated using the activeand reactive powers of the load. The conductance(GL) and susceptance (BL) are extracted from theestimated active power and reactive power of thethree-phasefour-wireloads,respectively.Itisasimplemathematicalformulationbasedonsinusoidal Fryzecurrentcontrol.ThiscontrolstrategyisbasedontheLagrange'smultipliermethod and the fundamental principle of the PQtheory where the computation through the Clarke'stransformation is eliminated. Therefore, it providesan improvement in the mathematical calculations.Here,theinputsaretheloadcurrents(iLa,iLb,iLc) and load voltages (va ,vb ,vc), which are furtherusedfortheestimationoftheactive(p)andreactive (q) power components using the formulamentioned in this paper. The



oscillating componentof power is eliminated as it is passed through thelow-pass filter (LPF) to obtain Pdc and Qdc . Theseareusedfortheestimationofthereference conductance and susceptance, thus giving the valueforthereferenceactiveandreactivepower components. This method facilitates the extractionof the fundamental components and compensatesindependently for the active and reactive powerseven when the system comprises of harmonics andunbalances at the PCC. The compensation allowsbalancedsourcecurrentstobedrawnfrom thenetwork. The controller responds faster under thesteady-state and dynamic conditions. The controlimplementation is realized using afour-leg VSCwithadmittancecontrolalgorithm.Theperformanceisverifiedexperimentalstudyusing digitalsignalprocessor(DSP-dSPACE)underbothlinear andnonlinearloads.

I. **PHOTOVOLTAICINVERTER**

II. The following are the primary components of a photovoltaic power generation system:

III. Photovoltaic power station

IV. 2. Inverter

V. 3. Grid

4. MPPT

VI. Analysis of dynamic performance, robustness, and stability requires the use of mathematical models. Analytical modeling is vital. The mathematical model of a three-phase grid-connected PV system is needed to study these properties. The suggested system's modeling comprises the following:

VII. Modeling of Photovoltaic Arrays and Cells 2.Model of inverter with three phases

VIII. Three-step modeling of fundamental changes

Each of these components will be presented in detail, along with a mathematical model, in this chapter.

Fig.1EquivalentcircuitdiagramofthePVcell

Next time an injection is made, it will be made with an opposing effect.

According to this algorithm's description: "The Perturb and observe algorithm operates by varying the array terminal voltage and then monitoring its effect on energy production," as well as comparing its results with those of earlier perturbation cycles.

PV array operating points are shifted in one of two directions: one direction if the operating voltage and power of the PV array are changing, and the other direction if the operating voltage and power are staying the same.

The process repeats itself in the following perturbation cycle. In Fig.2.2, the algorithm's logic is depicted. Every MPPT cycle, the array's terminal voltage is disrupted; this causes the output power to wobble near its maximum, resulting in PV system losses.

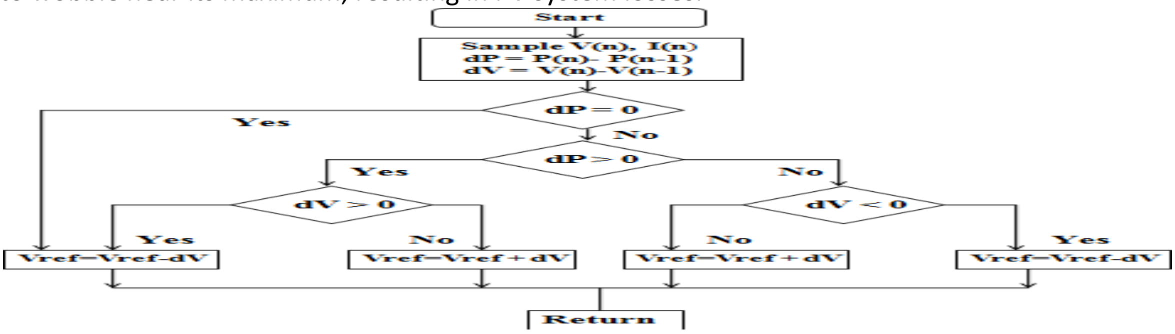


Fig.2Flowchartofperturb andobserve

i ▯ I▯ I[exp▯ [(v ▯ Ri)]▯ 1]▯ vpv▯ Rsipv

pv L s

pv sPV

Rsh

IX. **DC-DCConverterBasics**

ADC-to-DCconverterisagadgetthatacknowledgesaDCinfovoltageandproducesa

6.1

MPPT:(MaximumPowerPointTracking)

The P&O algorithm requires few mathematicalcalculationswhichmakestheimplementationofthisalgorithmfairlysimplecomparedtoothertechniques. For this reason, P&O method is heavilyused inrenewableenergysystems.

PerturbandObservealgorithm

The perturb and observe MPPT approach is currently the most prevalent in PV systems. It is possible to use this method by first injecting a little perturbation, and if it results in an increase in output power, it is then followed by injecting an even smaller perturbation, and so on until a rise in output power is achieved. Voltage can be generated from DC. In most cases, the yield given is at a different voltage level than the information it is intended to replace. DC-to-DC converters can also be used for noise reduction, force transmission control, and other similar functions. The following is a brief overview of some of the most common DC-to-DC converter designs.

The PV cell's maximum output voltage is quite low, making it unsuitable for this purpose. The combination of series and parallel also fails to meet the desired output. In order to make advantage of the low voltage PV array, a boost converter is required. Capacitors are also used to reduce harmonics between the

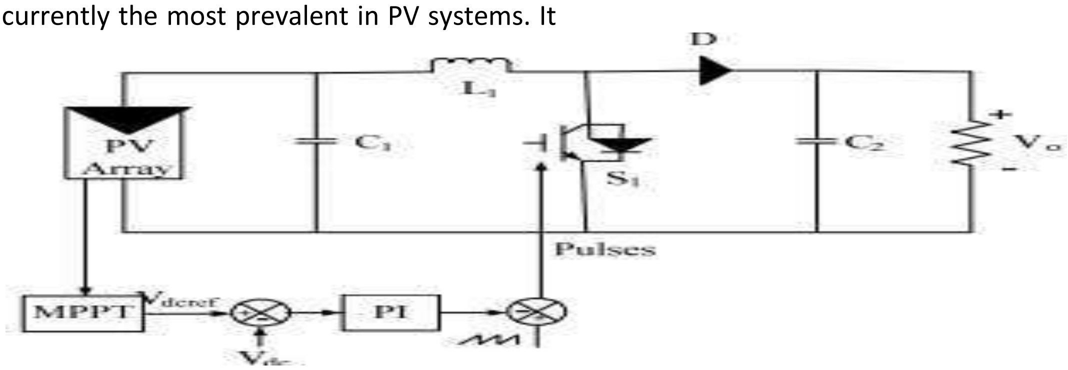


Fig..3.Closedloop controllerfor boostconverter

Voltage (V8) generated by the PV array charges the inductor L1 and discharges the capacitor C1 when switch S1 is turned on. The duty cycle D is 9: and T " ;.. It's a CCM boost converter (Continuous Conducting mode).

The output RC circuit receives intermittent current. As a result, the output voltage ripple is reduced using a large filter capacitor, percent C='. When diode D is turned off, the output dc current to the load must come from the filter capacitor.The PWM signal is used to control the boost converter. It is compared to the reference voltage, which is the output of the filter. The PI controller adjusts the process control inputs in an effort to reduce the error. The PWM signal, which is used as a gate signal by the IGBT switch, is then generated by comparing it to the saw-tooth waveform. Regulating the reference voltage Vdcref, derived using the MPPT techniques, in the control circuit As a result, the duty ratio for operating at the maximum power point can be used to control the PV array.

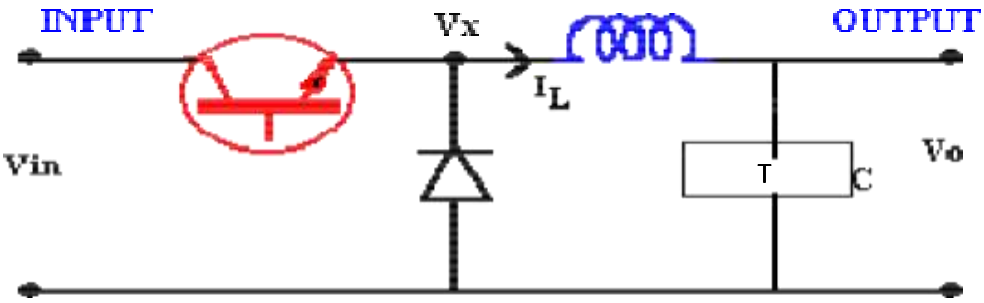
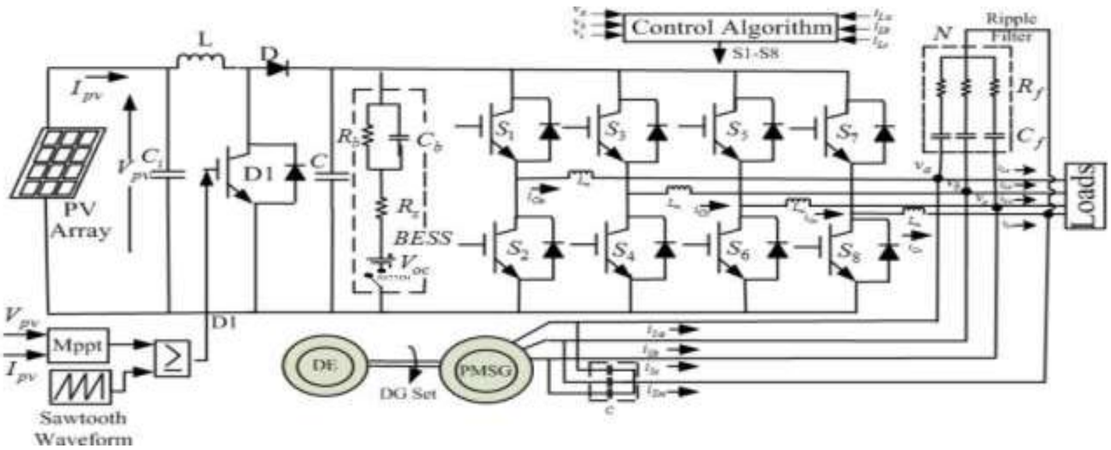


Fig4 BuckConverter

X. PROPOSED CONVERTERDESIGN&OPERATION

4.1 Systemdesign :

Solar panels, an MPPT controller (maximum power point tracking), an engine-driven PMSG, and



three-phase four-wire AC loads make up the standalone system seen in Fig. 1. Reactive power is coordinated via VSC control to restore the PCC's voltage. BESS can charge during the daytime when the insolation is high and the load is low, depending on the parameters of generation and load. In order to make up for any shortfalls, the battery drains. The DG set is able to maintain the system's frequency despite variable generation and demand. When there is no load on the terminal capacitor, the rated terminal voltage remains constant. A four-legged VSC and its dc bus are connected. In order to avoid switching harmonics, ripple filters and interface inductors are employed.

Fig.5.Schematicdiagramoftheproposedsystem.

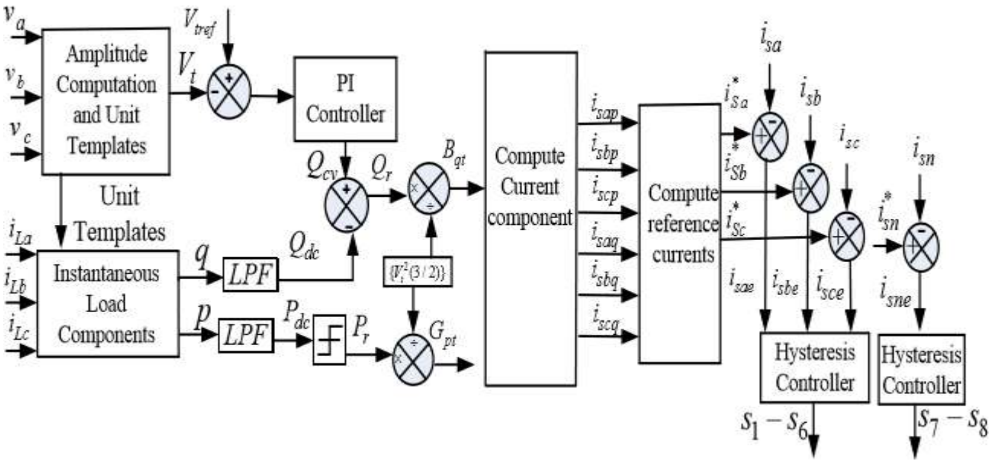
4.2 Controlalgorithm:

Admission control is used to extract the load's core component using the control algorithm. In addition, the load currents' active and reactive power components are identified. Reactive power (Qcv) is generated in the proportional integral (PI) control loop to

compensate for voltage variations caused by changes in reactive power. From the three-phase load reactive power, the reference susceptance (Bqt) for the reactive component of source current is calculated (Qdc)
based on the output of the PI controller (Qcv). The active power of the reference load is used to estimate the reference conductance (Gpt) (Pr). With VSC-BESS load leveling, the active power component of the load can operate the DG set at 80–100% of its full load capability. Fig. 3 depicts the control technique's block diagram. The control algorithm's resilience and relatively fast reaction have been demonstrated by its evaluation. The quality of computation is enhanced because it is a straightforward calculation of the active and reactive power components.. As a result, there is no delay in getting the findings, and there is less chance of a system fault occurring as well. As a result, this control algorithm enhances the system's performance.

Fig.6.Admittance-basedcontrolalgorithm.

XI. BATTERYCHARGECONTROLLERSINPV SYSTEMS



In a stand-alone PV system, the primary job of the charge controller is to prevent the battery from overcharging by the array and overdischarging by the loads while maintaining the greatest possible level of charge. It is possible to build a solar power system that does not require a battery charge controller but this is usually not the case for a system with unpredictable loads, user intervention, or undersized batteries (to decrease initial cost). Controlling a battery charge controller's algorithm and PV array utilization is critical to ensuring that the system can satisfy its load requirements at a given time. Charge controllers with additional features like temperature correction and alerts, meters, remote voltage sensor leads, and special algorithms can improve their ability to maintain a constant voltage.the health and extend the lifetime of a battery, as wellas providing an indication of operational status to thesystemcaretaker.

Important functions of battery charge controllersandsystemcontrolsare:

•PreventBatteryOvercharge:tolimittheenergysuppliedtothebatterybythePVarraywhenthebatterybecomesfullycharged.

•Prevent Battery Overdischarge: to disconnectthe battery from electrical loads when the batteryreacheslowstateofcharge.

•ProvideLoadControlFunctions:toautomatically connect and disconnect an electricalload at a specified time, for example operating alightingload fromsunsettosunrise.

OverchargeProtection :For the month of the year with the lowest insolation-to-load To address the system's power needs, a remote stand-alone solar system with battery storage is constructed. It's common for the array's energy production to exceed the demand for electricity during the summer months. A battery that has been overcharged is no longer viable thanks to the use of a charge controller. No matter how big or small the system is, a charge controller should be used to prevent overcharging, independent of the load profile, operating temperatures and solar insolation..

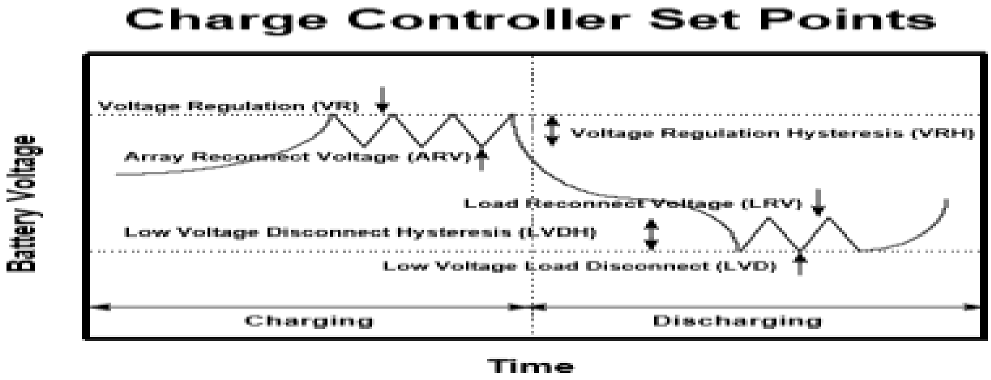


fig.7.chargecontrollersetpoints

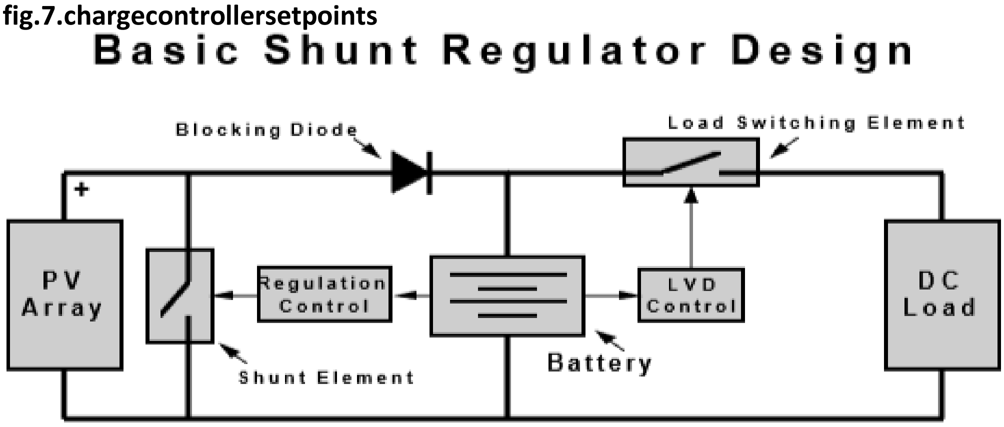


Fig8.shuntcontroller

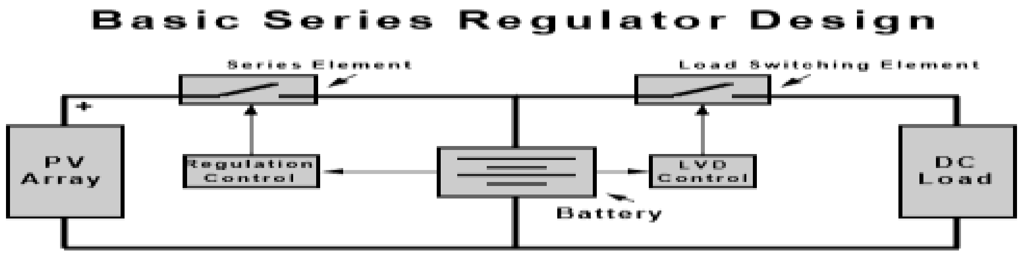


Fig.9.seriescontroller

XII. SIMULATIONRESULTS:

PROPOSED SYSTEM MATLAB BLOCKDIAGRAM:

Fig10:Performanceofproposedsystem undernonlinearloads:
Thelinevoltageofthesystemas below
Fig11:Theproposedsystemlinecurrentsundernonlinearloadsare below:

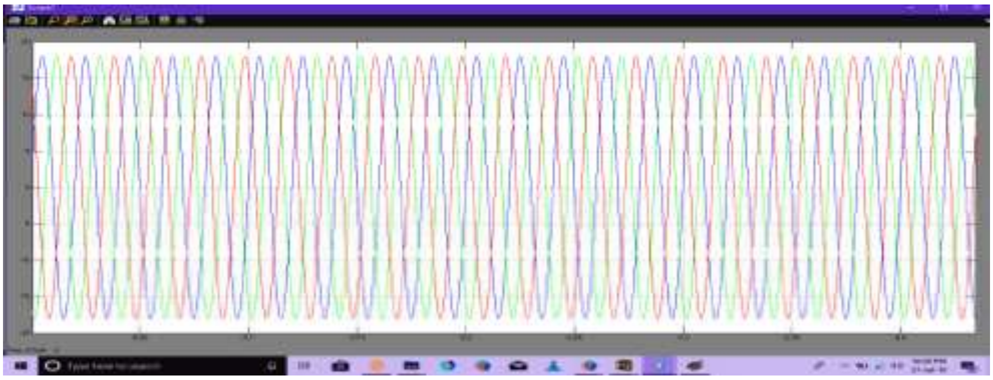
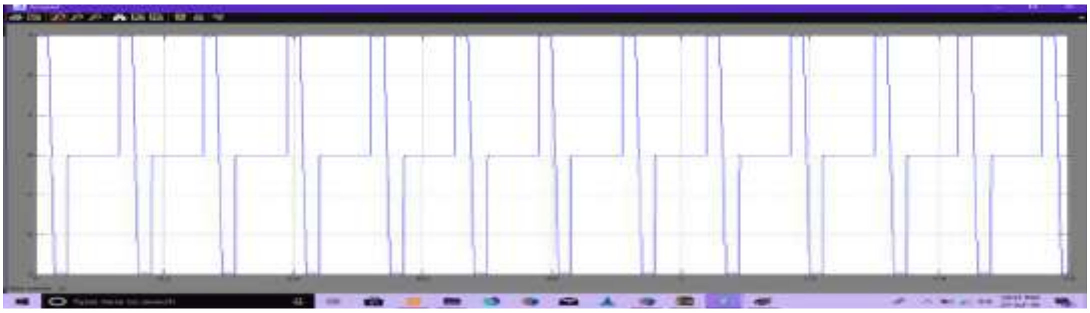


Fig12:Theloadcurrentsareasbelow:iLa



XIII. **CONCLUSION**

A PV-diesel-battery hybrid system has been implemented using the admittance-based control technique for uninterrupted power supply and improved power quality. When temperature and insolation radiation were both changing, the incremental-based MPPT algorithm produced the highest possible output from the solar array. Incorporating four-leg VSC into the system has been shown to remove harmonics, balance loads, and offer neutral current compensation. The frequency and voltage of the PCC have been kept constant. The system's steady-state and dynamic performance under both linear and nonlinear loads has been shown to be satisfactory. Overcharging and overdischarging of the battery can be prevented with the use of a battery charge controller.

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