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Control and Simulation of A Standalone Solar Photo-Voltaic Hybrid System

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***Abstract*:- In this system we used A Control Algorithm. It deals with the nature of energy generated by PV array and provides power quality improvement. A wind-solar hybrid power generator system consisting of photovoltaic modules controlled by MPPT method and connected to a DC-DC boost converter, a grid-connected wind turbine coupled with a permanent magnet synchronous generator (PMSG). Battery energy storage system is integrated to DG set for coordinate load management and power flow in the system. There are some algorithm which we used like harmonic elimination, load balancing, reactive power compensation this algorithm are used under three phase linear and non-linear loads. A four leg VSC provides neutral current compensation with battery energy storage system. This system is analyzed under different loading conditions using MATLAB/SIMULINK and it is validated to a prototype of the system. The aim of this paper is to review the current state of the design, operation and control requirement of the standalone PV solar-wind hybrid energy systems with conventional backup source i.e. diesel or grid. This paper also highlights the future developments, which have the potential to increase the economic attractiveness of such systems and their acceptance by the user.**

Index Terms :- Admittance based control algorithm, BESS, DG Set, Four Leg VSC, Neutral current compensation, Power quality, solar photovoltaic array, Standalone system.

I. INTRODUCTION:

Solar energy is a renewable energy source. There is a rapid increase in the use of non linear loads like refrigerators, computers, any electronic appliances, medical equipments etc. and it concerns the stress for power quality in the distribution system. Three phase-four wire loads are also known to suffer the problems of neutral current due to non linearity and unbalance present in the system. This types of loads are produce large amount of neutral current which consists triple harmonics. A four-leg VSC is used for neutral current compensation. Due to over-loading of the distribution system and caused additional heat losses which may be damage the connected equipment. This controller responds faster under steady and dynamic conditions. A four-leg VSC with admittance control algorithm is realized in the control implementation. Operation of the system is depends upon the implementation of control strategies have been applied for controlling like FLC control method, sliding mode control method, multi loop strategy and phase locked technique. The control of solar photovoltaic system has recently attracted a lot of attention.

The penturbation and observation (P&O) MPPT algorithm is commonly used , due to its ease of implementation. It is based on the observation that if the operating voltage of the PV array is perturbed, in a given direction and the power drawn from the PV array increases, which means the operating point is moving towards the MPP, so the operating voltage must be perturbed in the same direction. A small wind generation system for wind-speed estimation and PI control for maximum wind-power extraction. The controller moves the operating power of the PV system to its maximum power by shifting the PV terminal voltage to its identified optimal value. The admittance of the load is estimated using the active and reactive powers of the load. The conductance and susceptance are extracted from the estimated active power and reactive power of the three phase four-wire loads respectively. The control strategy is based on the Lagrange's multiplier method and the fundamental principle of the Clarke's transformation is eliminated. The control implementation is realized using a four-leg VSC with admittance control algorithm. The compensation allows balanced source currents to be drawn from the network. As well as a grid connected system can be highly beneficial too. There are many remote places, especially in under-developed and developing countries, where grid supply has not reached yet but with the availability of solar-wind hybrid system. When there is enough energy from the sun, a portion of the DC load demand can be supplied from the wind turbine and the PV array system. Whenever there is an excess supply from the system, the energy storage bank stores energy from the wind-turbine and the PV arrays which will be fed to DC loads at times when there are insufficient supplies from the wind-solar systems.

➢ SYSTEM DESIGN

MPPT reception system is attached in between PV system and boost converter for which MPPT is providing solar as input and its output is going to converter which converts DC-DC converter as shown in fig or schematic diagram. Its input is going through solar to measures the various quantities of voltage and current and it converts in power to know the maximum point of it. If we calculate the maximum point in a particular time period like morning 7am – 8am then it shows the maximum time at 8am because its sun rays and radiations are maximum than 7am. That means, at 8am whatever the voltage generate in solar plate, that voltage generation makes it maximize like that we calculate MPPT reception.

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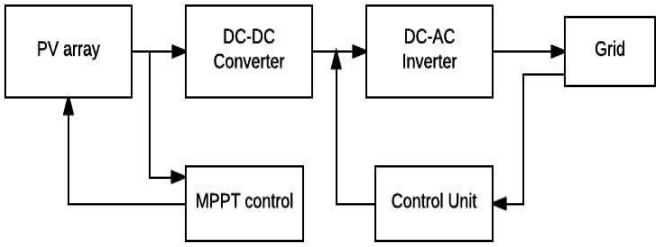

Now, its output is coming to converter in PWM signal and converts MPPT signal into input and current to calculate one output generate and that output is PWM output and it provides to converter. If voltage is less then it maximize that voltage and if voltage is high then it minimize that voltage because we use battery bank and it's a floating/charging voltage and it needs constant voltage & if we fluctuate the voltage like 5v & 20v then the life of battery is too short that's why we need a constant voltage battery of 12v, 11v, 13v it absorbs randomly. That's the reason we used buck boost converter. When the power of solar is less that time it boosts and when its power is high that period it generates because at that time its density, temperature are high and that time it bucks to decrease the solar power. Now, we connect, Inverter and it converts AC-DC. It is used for non linear loads because this is a three phase system and it has many chances of fluctuations. It generates DC link, and if link is not proper then whatever the distortion is created to remove the ripple filters, rl filters, rfl filters with the combination of this we cleared the line. It totally depends on load that the output is measures if its maximize or minimize. If we used any kind of transformers like step-up, step-down, linear transformer as we saw there is an transformer attached in the system.

➢ METHODOLODY AND SIMULATION

In the proposed system, the wind turbine first converts the kinetic energy of the wind to mechanical energy of the turbine blades and finally converts this to electricity. The kinetic energy of the wind is connected to the mechanical energy in the rotor, and then transmitted to the PMSG where the rotor shaft speed is accelerated without the need

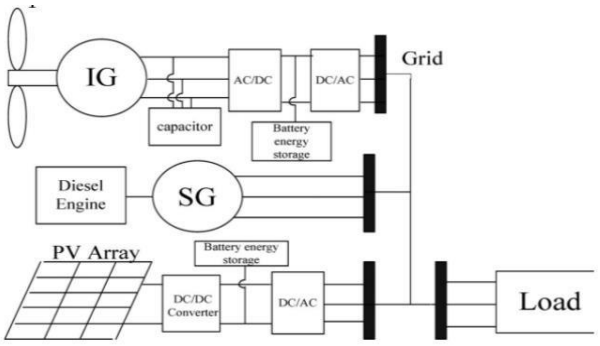

Fig 3 hybrid system

for a gearbox. The electricity that comes from the PMSG goes to a bidirectional DC-DC converter, and can then get stored in the batteries, or sent to the grid through an inverter. The solar panels in the system convert solar radiation directly to electricity.

➢ PV SYSTEM

It is a power system designed to supply usable solar power by means of photovoltaic. It consists of an arrangement of several components, including solar panels to absorb and convert sunlight into electricity, a solar inverter to convert the output from direct to alternating current as well as mounting, cabling, and other electrical accessories to set up a working system.

Due to growth of photovoltaic, prices for PV systems have rapidly declined. The PV systems should be designed to operate at their maximum output power for any temperature and solar radiation level. Solar energy is the most readily available and free source of energy since prehistoric times. It is estimated that solar energy equivalent to over 15,000 times the world's annual commercial energy consumption reaches the earth every year.

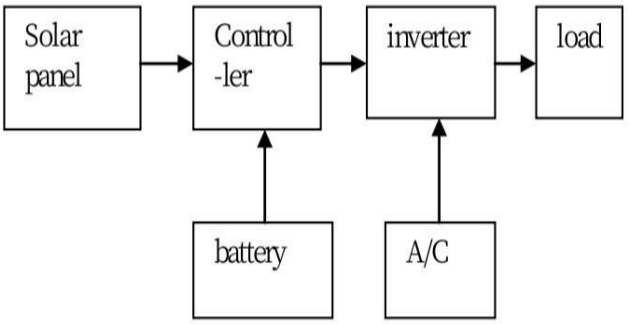

Fig 1 pv system

➢ HYBRID SYSTEM

One of the primary needs for socio-economic development in any nation in the world is the provision of reliable electricity supply systems. Here, electric DC energies produced from photovoltaic and wind turbine systems are transported to a DC disconnect energy mix controller. It can be used to reduce energy storage requirements. The influence of the deficiency of power supply probability, relative excess power generated, energy to load ratio, fraction of PV and wind energy, and coverage of PV and wind energy against the system size and performance were analyzed. For all load demands the levelized energy cost for PV-wind hybrid system is always lower than that of standalone solar PV or wind system. The PV – wind hybrid option is techno-economically viable for rural electrification. Usually storage systems is expensive and the size has to be reduced to a minimum possible for the renewable energy system to be cost effective. Hybrid power systems can be used to reduce energy storage requirements.

➢ WIND ENERGY SYSTEM

Wind power is energy extracted from wind, passing through a machine known as the windmill. Electrical energy can be generated from the wind energy. This is

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done by using the energy from wind to run a windmill, which in turn drives a generator to produce electricity. The windmill in this case is usually called a wind turbine. This turbine transforms the wind generator, wind turbine, aero generators is known as a wind energy conversion system (WECS).

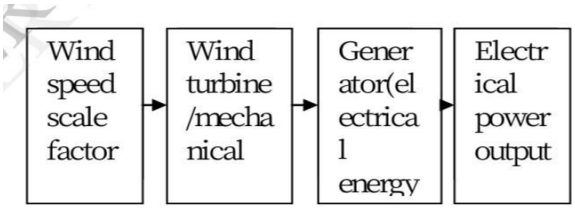

Fig 2 wind energy conversion system

➢ MPPT CONTROL ALGORITHM OF THE PV SYSTEM

With the cost of solar cell, it is necessary to implement MPPT to have the voltage operating close to the maximum power point under the changing environment. MPPT is also used to provide a constant voltage to the required load. This system is developed by combining the models of established solar module and DC-DC buck – boost converter with the algorithms. According to the comparisons of the simulation results, it can be observed that the photovoltaic simulation system can track the maximum power accurately using the three MPPT algorithms possesses fast dynamic response and well regulated PV output voltage than hill climbing algorithm.

A. RBFN CONTROLLER DESIGN

A three-layer RBFN NN with a boost converter shown in fig. is adopted to implement the controller where the control law VMPPT is generated.

Basic Nodes Operation :

Layer 1: Input Layer

The nodes in this layer are used to directly transmit the numerical inputs to the next layer.

Layer 2 : Hidden Layer

Every node performs a Gaussian function. The Gaussian function, a particular example of radial basic functions, is used here as a membership function.

Layer 3 : Output Layer

The signal node K in this layer is denoted by ∑, which computes the overall output as the summation of all incoming inputs.

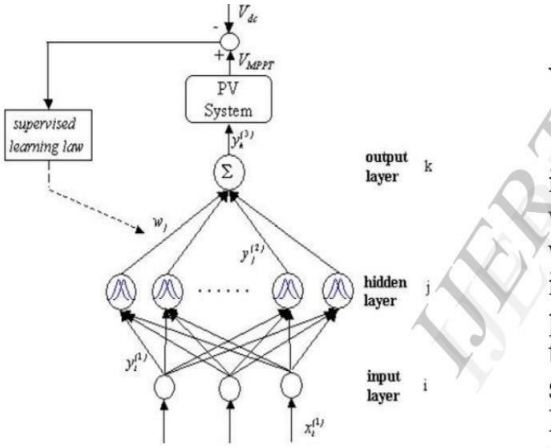

Fig 5 Radial basis function

RBFN are artificial neural networks for application to problems of supervised learning:

- ❖ Regression
- ❖ Classification
- ❖ Time series prediction

➢ **MPPT CONTROL ALGORITHM OF THE WIND ENERGY SYSTEM**

A. WIND ENERGY CONTROLLER DESIGN

The wind power generation system studied in this paper composed of an induction generator, a current control PWM ac/dc converter, a field-orientation mechanism including the coordinate translator, a current controlled dc/ac inverter, and the MPPT controller, where the PI and

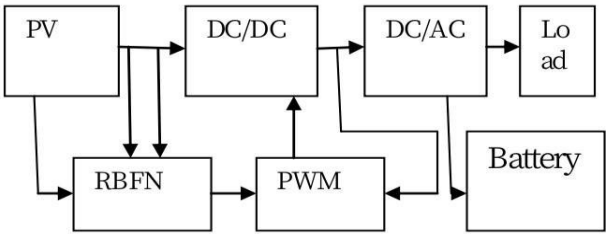

Fig 4 mppt controller using RBFN

ENN were studied in this paper. The dc-bus voltage is regulated at a constant value so the real power from the wind turbine can pass to the grid. The derivation is the same as that of the back-propagation algorithm. It is employed to adjust Wrj, Wjo, Wrj of the ENN by using training parameters. The purpose of supervised learning is to minimize the error function E expressed as

E = 1/2 (Pout –Pref)2 = ½ (e)2

Where, Pout = Actual Power , Pref = Reference Power , e = Tracking response

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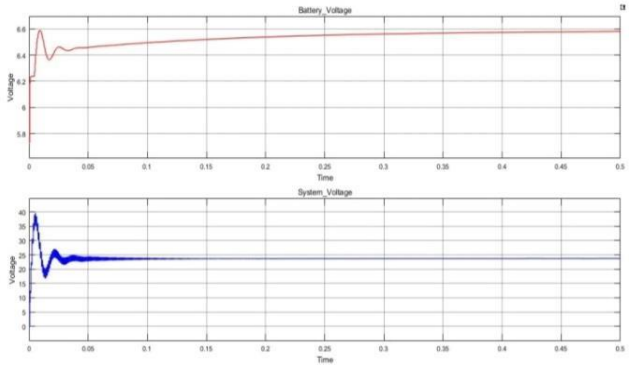
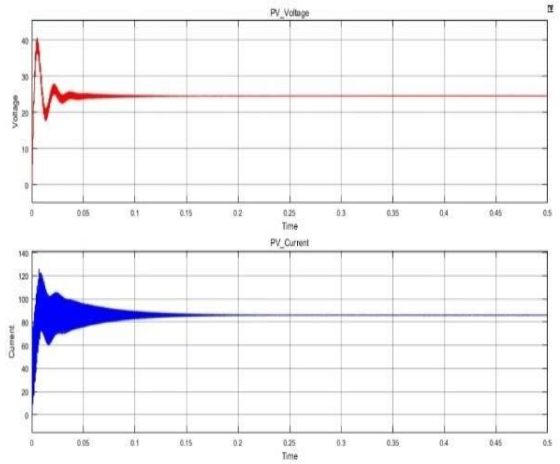
II. SIMULATION RESULTS

The response of a standalone system is analyzed under nonlinear load using sim-power system (SPS) toolbox in MATLAB/SIMULINK. The performance of the system is observed during line outage in one of the three phases at time t
= 1.5s to 1.56s. it is observed that for a subjected load unbalance in the system , the four-leg VSC has the capability of harmonics elimination as the source current.

This scope are show that each IGBT gate signal are provide from PWM control system to generate the each PWM signal for given to IGBT with zero to one amplitude.



This waveform shows the battery parameter. The battery is connected to the bidirectional converter that means battery are two dimensional work it has a load as well as source. This waveform shows that the charging of the battery and system voltage shown to output of the bidirectional converter are near about this constant voltage.



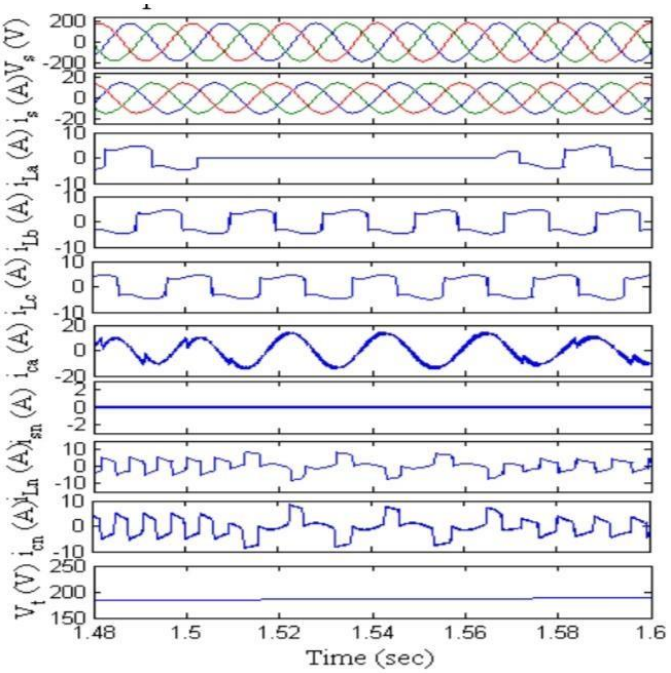
This graph is shown in the output of the photovoltaic system to measure the voltage and current waveform with respect to time. This graph shows that the voltage is near about load 25v and current is near about 85amp, it means irradiance and temperature are maximum generated to the photovoltaic plate. This voltage and current are fed back is given to the converter as well as MPPT.

III. HARDWARE IMPLEMENTATION

A prototype of a standalone PV-DG-BESS system is developed in the laboratory. The system is configured according to available equipments and conditions. The proposed system configuration consists of VSC , interfacing inductors , ripple filter, battery, parameter magnet synchronous generator and its drive system, solar array simulator. This photovoltaic emulator is used to emulate a solar PV array. The MPPT is obtained at 99.7%. The diesel engine driven generator is realized by using a 3.7 kW, 4 pole permanent magnet synchronous generator coupled to an AC motor drive. The voltages and currents are sensed by Hall- Effect voltage sensors (LV25) and current sensors (LA55p) respectively. The line voltages vab and vbc are sensed as feedback signals. These signals are used to determine the phase voltages Va, Vb and Vc.

The source currents are sensed (isa, isb, isc) which are further used in the control approach. The Hall-Effect sensors are used for sensing the three phase load currents (iLa, iLb, iLc). These current sensors can sense up to 50A without saturation. A scaling circuit is required for scaling of the sensed signals according to the DSP-dSPACE 1104 controller. The control strategy is realized using to deliver the gate pulses to amplification and isolation circuit for switching of the voltage source converter(VSC) for which input/output pins is used.

The energy storage system provides the load leveling. The DG set is made to operate at the pre-set rated current limit.



Performance of proposed system under unbalance nonlinear load

A. Test Performance of System under Linear Load

The steady state operation under a linear load is analyzed using the obtained test results. The source currents (iSa,

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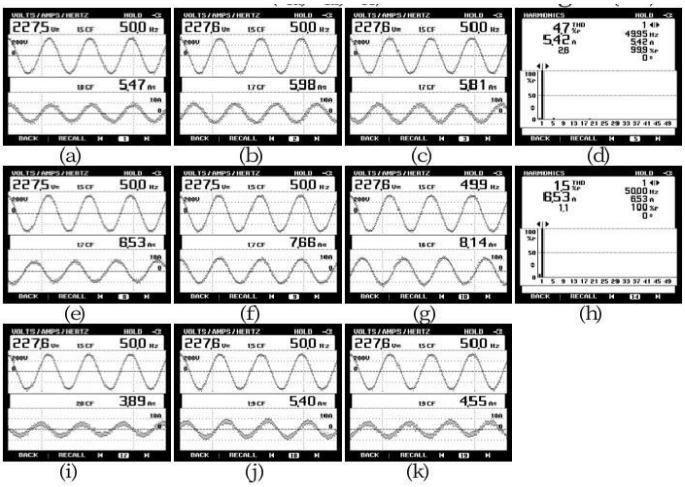
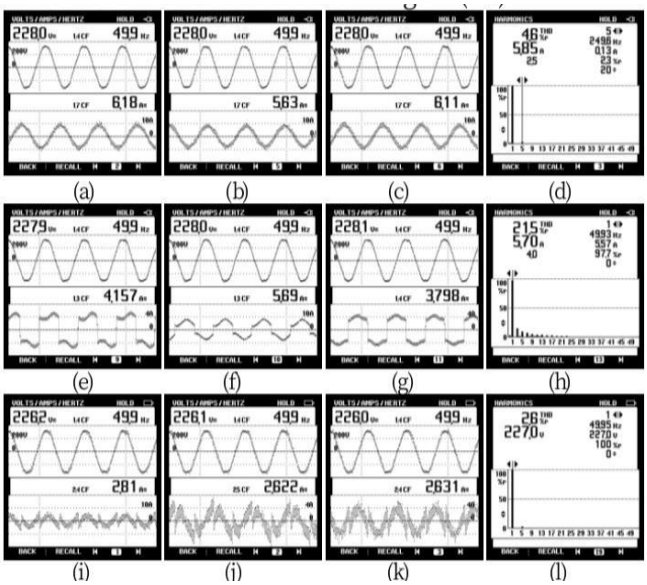
iSb, iSc) are maintained sinusoidal as shown in fig.below. The THD of the source currents is 4.7%. The load currents (iLa, iLb, iLc) also shown. The THD of the load current is 1.5% under linear load. The steady state operation is maintained by the suitable reactive power compensation provided by the four leg VSC. The VSC currents (ica, icb, icc) are shown in fig.



A. Test Performance of system under Nonlinear Load

Test results for the steady state operation under nonlinear load are also evaluated. The source currents (isa, isb, isc) are maintained sinusoidal as obsedved in fig.



B. Test Performance of System under Transient Condition

Test results of the dynamic response of the system under change in the load and isolation level are examined. Fig shoes the sudden removal of phase a load current (iLa). It is observed that with the compensation provided by the VSC, the current (iCa) becomes sinusoidal for maintaining the PCC voltage (vsa) maintained sinusoidal. Further, it is realized that even under sudden load removal, the source neutral current (isn) is almost zero due to the neutral current compensation provided by the four leg VSC. In case of decrease in the insolation, the output power of the PV is reduced and vice versa.

IV. CONCLUSION

The admittance based control technique has been used for a PV-diesel-battery hybrid system for an uninterrupted power supply and power quality improvement. The incremental based MPPT algorithm has delivered maximum solar array power under varying conditions of temperature and isolation radiation. The technique has been demonstrated to eliminate harmonics, load balancing and to provide neutral current compensation by incorporating four leg VSC in the system. The PCC voltage and frequency have been maintained constant. Satisfactory performance of the system has been observed through test results obtained for steady state and dynamic conditions under both linear/nonlinear loads.

➢ APPENDIX

PV Array and Boost Converter : Pmax = 4.5 Kw, Vmp = 165V, Imp = 27A, Isc = 30A, Voc = 205V, L= 4Mh ;
PMSG: 3.7Kw, 1500rpm, 230V, 50Hz ; Battery : Voc= 400v, Cb = 12000F, Rb = 10000Ω, Rin = 0.1Ω, Cdc = 6000µF;
Ripple filter: Rf = 5Ω, Cf =10µf; Load R = 30Ω, L = 150Mh

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