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PV Integrated Battery System for Power Balance using ANN Technique

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ABSTRACT

Battery storage is usually employed in Photovoltaic (PV) system to mitigate the power fluctuations due to the characteristics of PV panels and solar irradiance. Control schemes for PV-battery systems must be able to stabilize the bus voltages as well as to control the power flows flexibly. This paper proposes a comprehensive control and power management system (CAPMS) for PV-battery-based hybrid micro grids with both AC and DC buses, for both grid-connected and islanded modes. The proposed work compares PI controller with Artificial neural networks (ANN). The power balance and ripples are regulated. The work was carried out using Matlab simulink software.

KEYWORDS: Battery storage, Artificial Neural Network, PV-battery systems, PI Controller.

INTRODUCTION

A microgrid is a group of interconnected loads and distributed energy resources within clearlydefined electrical boundaries that acts as a single controllable entity with respect to the grid. Amicrogrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.

To meet the electricity demands of its users, a microgrid must have a generation source. Giventhat microgrids are an older concept, the electricity supplied to microgrids has historically been from "behind the meter"fossilfuelgeneratorsgas-poweredgenerators,forexample.However, with the falling cost of solar, not to mention the environmental benefits of switchingfrom fossil fuel generation to solar power, many of the microgrids being designed today supply electricity with a combination of solar plus battery storage.

First, this is a form of local energy, meaning it creates energy for nearby customers.Thisdistinguishes microgrids from the kind of large centralized grids that have provided most of ourelectricity for the last century. Central grids push electricity from power plants over longdistances via transmission and distribution lines. Delivering power from afar is inefficientbecause some of the electricity – as much as eight to fifteen percent– dissipates in transit. A microgrid overcomes this in efficiency by generating power closeto thoseit serves the generators are near or within the building, or in the case of solar panels, on the roof.

2. SOLAR ENERGY

A.Introduction

Solar cell is one way of producing electricity that includes converting solar radiation into direct current electricity using photovoltaic semiconductors. Solar panels with a number of cells containing a photovoltaic material are used in photovoltaic power generation. Monocrystalline silicon, polycrystalline silicon, amorphous silicon, cadmium telluride, and copper indium selenide/sulfide are currently employed in photovoltaic's [1]. Solar cell and photovoltaic array production has evolved significantly in recent years as a result of the increased need for renewable energy sources.

Solar photovoltaic generates electricity in over 100 nations as of 2010, and is the world's fastest growing power-generation technology, but accounting for only a small portion of the 4800 GW total global power-generating capacity from all sources. Grid-connected PV System capacity expanded by 60% of annually average of 2004 to 2009 is 21GW. Building Combined Photovoltaics or BIPV for short are installations that are either ground-mounted or sometimes integrated with farming and grazing embedded into the roof or walls of a building. An extra 3–4 GW comes from off-grid PV.

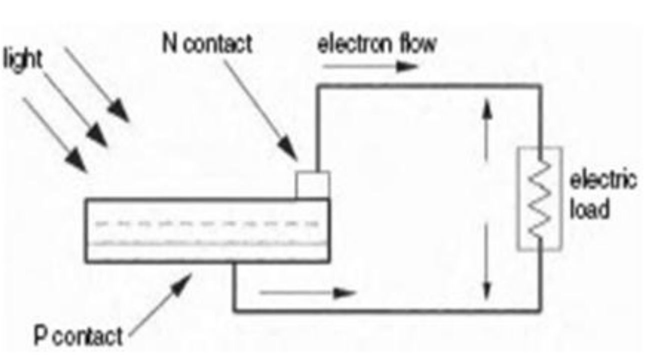

Fig 2.1: PV converts the photon energy into voltage across the p-n junction

Since the first solar cells were developed, the cost of photovoltaic has gradually decreased due to breakthroughs in technology and increases in manufacturing scale and sophistication. Solar PV installations have been aided by net metering and financial incentives such as favorable feed-in prices for solar-generated electricity in various nations.

The photovoltaic effect occurs when a substance is exposed to light and generates a voltage (or a corresponding electric current). Though the photovoltaic and photoelectric effects are related, the two processes are distinct and should be differentiated. Electrons are ejected from a material's surface when it is exposed to sufficient energy radiation in the photoelectric effect. The photovoltaic effect differs in that the produced electrons are moved across various bands inside the material (i.e., from the valence to conduction bands), leading in a voltage buildup between two electrodes. The radiation used in most photovoltaic applications is sunshine, which is why the devices are called solar cells. In the case of a p-n junction solar cell, illumination causes the generation of an electric current as excited electrons and the remaining holes are swept in various directions by the depletion region's built-in electric field, as seen in figure 2.1. Alexandre-Edmond Becquerel discovered the photovoltaic phenomenon in 1839. The largest photovoltaic (PV) power plants in the world as of October 2010 are the Sarnia Photovoltaic Power Plant (Canada, 80 MW), the Olmedilla Photovoltaic Park (Spain, 60 MW), the Strasskirchen Solar Park (Germany, 54 MW), the Lieberose Photovoltaic Park (Germany, 53 MW), the Puertollano Photovoltaic Park (Spain, 50 MW), the Moura Photovolta (Germany, 40 MW).

2.1.1 In Buildings:

Buildings are frequently associated with photovoltaic arrays, which are integrated into them, placed on them, or mounted close on the ground. Arrays are frequently retrofitted into existing structures, either on top of the existing roof structure or on the existing walls. Alternatively, an array can be positioned outside of the building but connected to it by cable to provide electricity to the structure. More over four-fifths of Germany's 9,000 MW of solar PV capacity was installed on rooftops in 2010.

2.1.2 In Transport:

PV has long been used in space for electric power generation. PV is rarely utilized to generate motive power in transportation applications, but it is becoming more common in boats and cars as an auxiliary power source. A self-contained solar car would have limited power and utility, however a solar-charged vehicle would allow transportation using solar power. There have been demonstrations of solar-powered automobiles.

2.1.3 2.1.3 Standalone Devices:

PV was widely used to power calculators and other novelty devices until about a decade ago. Improvements in integrated circuits and low-power LCD displays allow such gadgets to operate for several years between battery changes, making PV less prevalent. Solar-powered remote fixed devices, on the other hand, have recently gained popularity in areas where grid electricity is prohibitively expensive due to high connection costs. Water pumps, parking meters, emergency telephones, trash compactors, temporary traffic signs, and remote guard posts and signals are only a few examples of such uses.

2.1.4Rural Electrification:

Photovoltaics have been popular in developing countries because many communities are more than five kilometers from grid power. A rural lighting programme in India has been delivering solar-powered LED illumination to replace kerosene lamps in distant regions. The solar lamps were offered for roughly the same price as a few months' worth of kerosene. Cuba is aiming to deliver solar power to off-grid locations. These are regions where the societal costs and benefits make a strong case for going solar, however the lack of profitability may limit such efforts to humanitarian purposes.

2.1.5 Solar Roadways:

A 45 mi (72 km) section of roadway in Idaho is being used to test the possibility of installing solar panels into the road surface, as roads are generally unobstructed to the sun and represent about the percentage of land area needed to replace other energy sources with solar power. Now total technology was mainly on solar system because it is pollution free, easy maintenance. Recent days in roadways solar system is implementing for better utilizing of power.

2.1.6 Solar Power Satellites:

Large solar power collection satellites have been the subject of design research for decades. The concept was first presented by Peter Glaser, then of Arthur D. Little Inc; NASA performed a long series of engineering and economic feasibility studies in the 1970s, and interest has recently resurfaced in the early years of the twenty-first century. The launch cost appears to be the most important issue for such satellites from a practical economic standpoint. Development of space-based assembly techniques will be another factor, but they appear to be less of a barrier than the capital cost. These will be lowered as the cost of solar cells falls or the efficiency of the cells rises.

2.2 Performance:

2.2.1Optimum Orientation of Solar Panels:
Terrestrial PV systems strive to spend as much time as possible facing the sun for optimal performance. Solar trackers work towards this goal by shifting PV panels to follow the sun. In the winter, the rise can be as high as 20%, and in the summer, it can be as much as 50%. The Sun path can be used to optimize static mounted systems. Although most panels are set at a latitude tilt or an angle equal to the latitude, performance can be enhanced by altering the angle for summer or winter.

2.2.2 Irradiation:

Irradiation is the process of exposing something to radiation. The exposure might be planned, sometimes for a specific goal, or it can happen by chance. In general usage, the word refers to ionizing radiation and a dose of radiation that will serve that specific function, rather than radiation exposure to typical levels of background radiation or abnormal levels of radiation as a result of an accident. Non-ionizing radiation such as microwaves or low frequency (50/60 Hz power supply) and high frequency (50/60 Hz power supply) are also included in this category (as cellular phones, radio and TV transmissions).

2.2.3 Insolation:

Solar radiation energy received on a given surface area in a given period is measured as insolation. Average irradiance is often given in watts per square meter (W/m2) or kilowatt-hours per square meter per day (kW·h/ (m2•day)) (or hours/day). In Photovoltaics, it is often expressed as kWh/(year/KW) (kilowatt hours per year per kilowatt peak rating).A planet, a terrestrial object inside a planet's atmosphere, or any object exposed to sun rays outside of an atmosphere, including spacecraft, could be the specified surface. The sun's rays will be absorbed to some extent, while the rest will be reflected.

2.3 Solar cell:

A solar cell is a solid-state device that uses the photovoltaic effect to turn sunlight directly into electricity. Solar modules, commonly known as solar panels, are made up of cell assemblies. Solar power, or the energy created by these solar modules, is an example of solar energy.

The difference in the chemical potential, known as the Fermi level, of the electrons in the two isolated materials is the source of the PV potential. The junction approaches a new thermodynamic equilibrium when they are linked. Only when the Fermi levels in the two materials are equal can such equilibrium be achieved This is accomplished via the flow of electrons from one material to the next until a voltage difference between them is produced, with a potential just equal to the Fermi level's initial difference. The photocurrent in the PV circuit is driven by this potential.

Though term is commonly used exclusively to refer to the generation of energy from sunshine, Photovoltaics is the subject of science and study connected to the practical application of photovoltaic cells in creating power from light. When the light source isn't necessarily sunshine, cells are classified as photovoltaic cells. These are used to detect light or other electromagnetic radiation in the visible range, such as infrared detectors, or to measure light intensity.

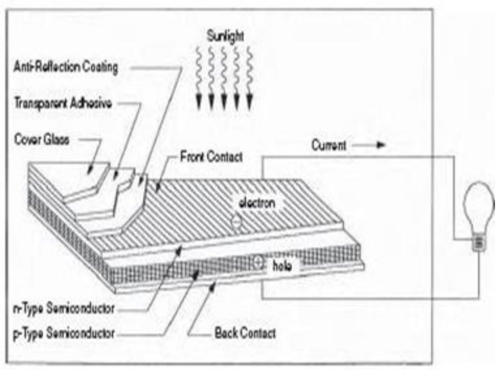

Fig 2.2: Basic construction of PV cell

2.4. Equivalent electrical circuit of a Battery:

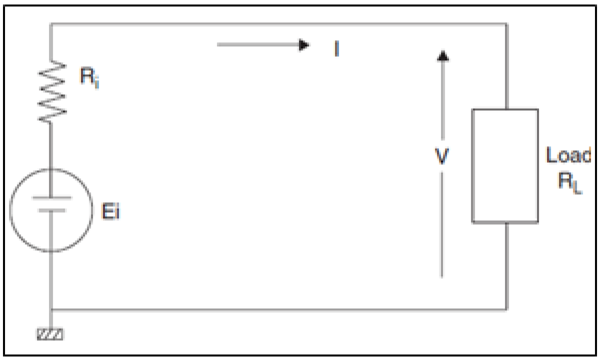

Fig 2.3: Equivalent electrical circuit of a Battery

3. PI CONTROLLER

In control engineering, a PI Controller (proportional-integral controller) is a feedback controller which drives the plant to be controlled by a weighted sum of the error (difference between the output and desired set-point) and the integral of that value. It is a special case of the PID controller in which the derivative (D) part of the error is not used.

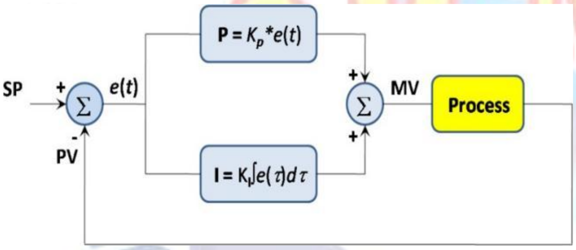

Fig.3.1: Block diagram of a PI controller

Integral control action added to the proportional controller converts the original system into high order. Hence the control system may become unstable for a large value of K_p since roots of the characteristic eqn. may have positive real part. In this control, proportional control action tends to stabilize the system, while the integral control action tends to eliminate or reduce steady-state error in response to various inputs. As the value of T_i is increased,

- Overshoot tends to be smaller
- Speed of the response tends to be slower.

4. ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks are relatively crude electronic models based on the neural structure of the brain. The brain basically learns from experiences. It is natural proof that are beyond the scope of current computers are indeed solvable by small energy efficient packages. This brain modeling also promises a less technical way to develop machine solutions. These biologically inspired methods of computing are thought to be the next major advancement in the computing industry. Even simple animal brains are capable of functions that are currently impossible for computers. Computers do rote things well, like keeping ledgers or performing complex math. But computers have trouble recognizing even simple patterns much less generalizing those patterns of the past into action of the future.

Now, advance in biological research promise an initial understanding of the natural thinking mechanism. This research shows that brain stores information, as patterns. Some of these patterns are very complicated and allow us the ability to recognize individual faces from any different angles. This process of storing information as patterns, utilizing those patterns, and then solving problems encompasses a new field in computing. This field does not utilize traditional programming but involves the creation of massively parallel networks and the training of those networks to solve specific problems. This field also utilizes words very different from traditional computing, words like behave, react, self-organize, learn, generalize, and forgot. An artificial neural network (ANN), often just called a "neural network" (NN), is a mathematical model or computational model based on biological neural networks. It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system that changes its structure based on external or internal information that flows through the network during the learning phase. In more practical terms neural networks are non-linear statistical data modeling tools. They can be used to model complex relationships between inputs and outputs or to find patterns in data. A neural network is an interconnected group of nodes, akin to the vast network of neurons in the human brain.

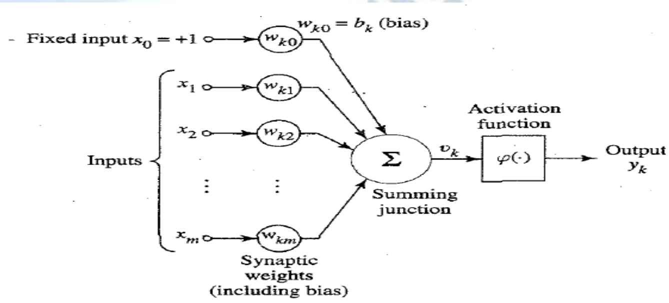

Fig 4.1: Artificial Neural Networks

5. SIMULATION RESULTS

- Project Background
- In this project PV array is interfaced with the DC bus

by a DC/DC boost converter.

- Battery bank uses a bidirectional DC/DC converter to control the changing and discharging processes.
- A centralized inverter is installed to interconnect the DC and AC networks.
- DC load block generally represents the loads that are connecting at the DC bus, which can be multiple types of loads.
- Depending on the PV output power, state of charge and power limit of battery, AC loads, CAPMS decides the operation modes of PV array & battery (charging, discharge mode) & provides proper reference values to controllers. CAPMS select specific control schemes to be applied to the converters to ensure a reliably power environment.

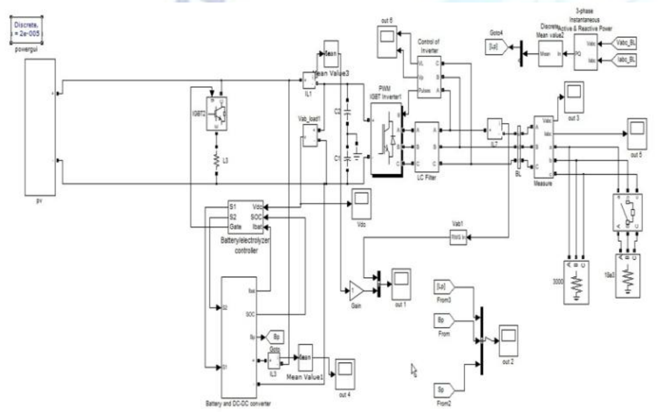

Fig.7.1Proposed Model

a) Case1:

Initialload -10000watt

Extraload - 4000watt

Battery Specifications:

1. 200volts,
2. 6.5AH
3. Nickel-Metal Hydrate Battery

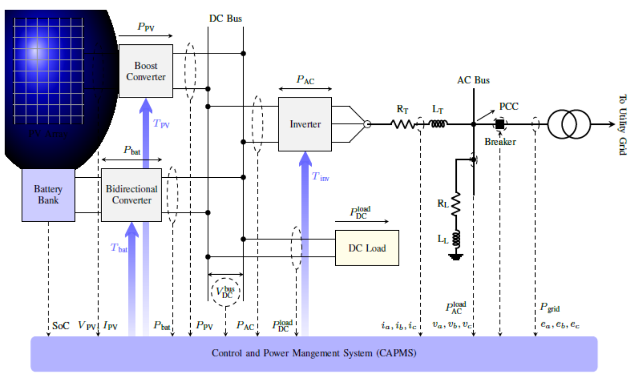

Fig 7.2 Simulation Model of CAPMS

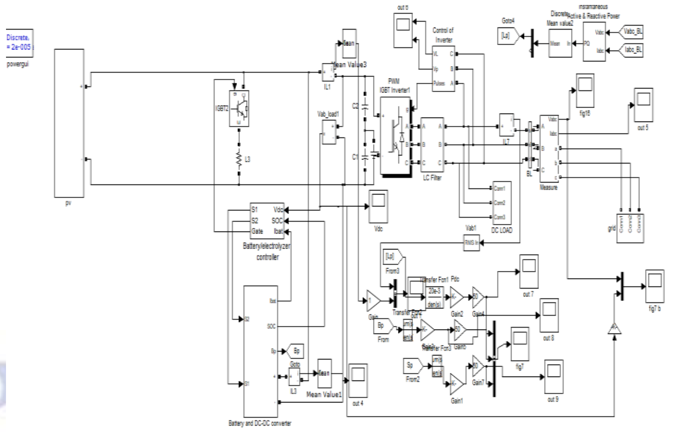

Fig 7.3 Simulation Model of Proposed System with ANN

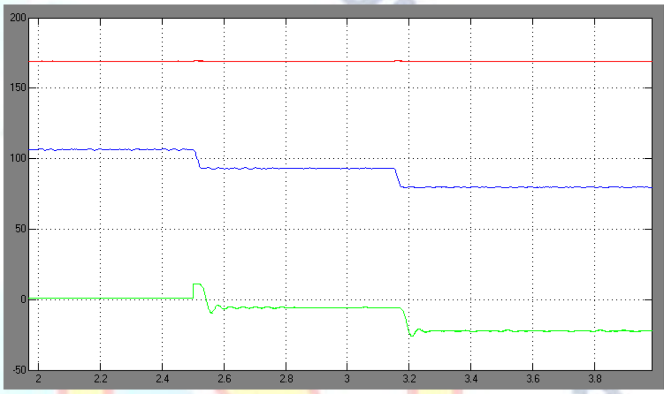

Fig 7.4 Simulation result with PWM (PI) control

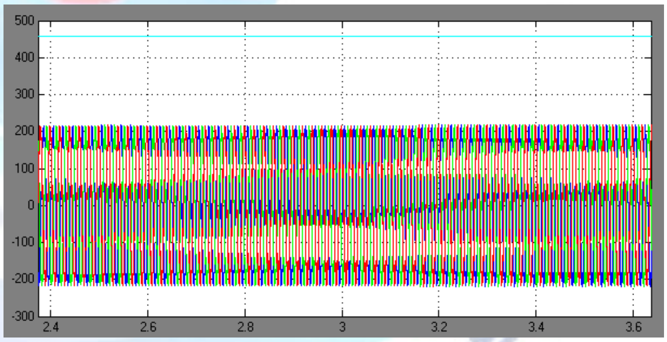

Fig 7.5 AC Line Voltage and Phase Voltage given by the inverter

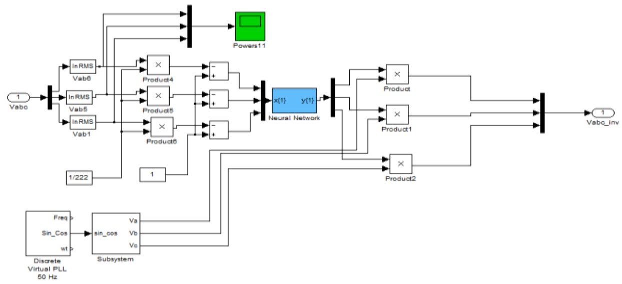

Fig 7.6 Inverter control with ANN control

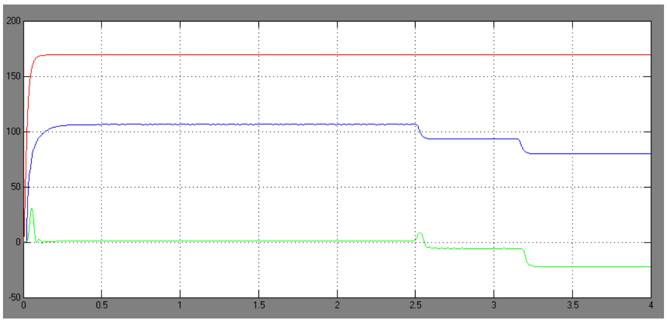

Fig 7.7 Simulation result with ANN control

7. CONCLUSION

This paper proposes a control and power management system for PV Battery system with both DC and AC buses in islanded mode. Therefore, DC and AC buses are under full control by the CAPMS in islanded mode. The presented CAPMS is able to manage the power flows in converters of all units flexibly and effectively. Furthermore, CAPMS ensures a reliable power supply to the system when PV power fluctuations due to the unstable irradiance or whenever PV array shutdowns due to the faults. The CAPMS optimizes the reference values for each unit and sends the PWM (pulse width modulation) signals to the inverter and converter to control the power flow in the hybrid system and voltages of DC and AC buses. Proposed CAPMS employs one of the most popular methods with PI and ANN controllers. ANN controllers give better results when compared with conventional methods.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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