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Renewable Energy Based Power Generation Systems

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Abstract- **The microgrid has shown to be a promising solution for the integration and management of intermittent renewable energy generation. This paper looks at critical issues surrounding microgrid control and protection. It proposes an integrated control and protection system with a hierarchical coordination control strategy consisting of a stand-alone operation mode, a grid-connected operation mode, and transitions between these two modes for a microgrid. To enhance the fault ride-through capability of the system, a comprehensive three-layer hierarchical protection system is also proposed, which fully adopts different protection schemes, such as relay protection, a hybrid energy storage system (HESS) regulation, and an emergency control. The effectiveness, feasibility, and practicality of the proposed systems are validated on a practical photovoltaic (PV) microgrid. This study is expected to provide some theoretical guidance and engineering construction experience for microgrids in general.**

Keywords- Solar energy ,Solar hybrid, battery , Hybrid energy storage system (HESS).

I. INTRODUCTION

PV technologies years owing have received to their ability to reduce fossil energy use and provide positive impacts to the environment. Photovoltaic generation in the form of distributed photovoltaic microgrids that are integrated into the power system rely on efficient use of solar energy. When compared to traditional distribution networks, photovoltaic microgrids are distinctly different in terms of their control strategies and protection methods. Specifically, when PV microgrids are being operated in isolated mode, improving peer-to-peer control strategies are considered as critical factors for supporting islanded microgrid operations. In the authors have presented a coordinated voltage/frequency (V/F) and active power and reactive power (PQ) control system for both islanded and grid-connected mode in a PV microgrid that shows effective coordination between inverter V/F (or PQ) controls.

Several other strategies have been proposed for seamless transfer between different microgrid operation modes. They include a seamless control methodology for a PV-diesel generator microgrid that can operate both in the grid-connected and islanded modes, and at the same time does not require any islanding detection mechanism. Similarly, in, a control strategy has been proposed that contains the control state/reference compensation algorithm to effectively reduce the impact caused by microgrid operation mode transitions on critical loads and distributed generators (DGs). The control strategies mentioned above provide excellent solutions for microgrid operational control. However, these strategies are relatively independent having poor flexibility and weak expansibility, which may lead to collapse when the microgrid contains multiple distributed generators. Therefore, there is a need to integrate microgrid operational control technologies at steady and transient states in more practical ways. In addition to advanced control technologies, microgrids also require effective protection systems.

The maximum short-circuit current in a microgrid is generally limited to less than two times the rated current because of a large number of DGs configured with power electronic interface devices. Power flow and short-circuit capacity changes are significant under different microgrid operation modes. As a consequence, conventional protection methods in large-scale power grids are not able to effectively meet the needs of an inverter-dominated microgrid. A range of advanced methodologies is available in the literature for microgrid protection. They include a simple three-phase four-wire system with differential current and zero sequence current used to detect faults in a microgrid; a protection scheme that uses both modes of operation for optimally setting direction over current relays; as well as other protection schemes with voltage restraint algorithms or inverse time characteristics.

All these systems can be adapted to address the frequent changes in a microgrid. However, the main focus of these aforementioned methods is on relay protection, and they tend to neglect regulation resources and means available in the microgrid, e.g., energy storage systems. As a result, there is a need to further explore and develop integrated microgrid protection systems

II. LITERATURE SURVEY

Integrating solar PV energy into marine power system provides a new way to deal with the rapid growth of fossil fuels consumed by traditional ships in improving the energy efficiency and reducing the greenhouse-gas emissions. In this study, one practical PV/SC hybrid power system integrated into a 2240 pure car and truck carrier ro-ro ship is utilized as a case to carry out the techno-economic analysis. Taking into account the navigation route of the target ship, the amount of electricity generated by the PV/SC hybrid system is calculated based on the solar irradiation data of the seven port cities on the route. The analysis results show that (i) the levelized cost of energy of the PV/SC hybrid power system reduces to 0.53 USD/kWh from 3.89 USD/kWh over the life cycle; (ii) the discounted payback time of the PV/SC hybrid power system is 5.49 year. Yuanchao Qiu et.al (2019).

In recent time, researchers are aiming to integrate renewable energy with nuclear energy to utilize the energy infrastructure at its best or to meet the local energy demand, especially for the remote places. In this paper, the feasibility analysis of the nuclear-renewable energy system is conducted by HOMER (Hybrid Optimization Models for Energy Resources) software. This paper considers three modes of power supply; only renewable energy, only Nuclear Power Plant (NPP), and integration of both nuclear-renewable energy; to meet the electric demand The simulation results show that the grid-connected Nuclear-Renewable Micro Hybrid Energy System (N-R MHES) is the most feasible option to meet the sizeable electrical power demand. The paper also sets the analysis guidance and criteria for the three power supply mode depending on the annual load profile of a facility. (Hossam A. Gabbar) (2019)

III. PROPOSED WORK

Grid-connected and stand-alone operations are the two typical operation modes in a microgrid. The requirements of PV microgrid operation modes include: The microgrid voltage and frequency should be stable and the power flow should be balanced, so as to realize the independent operation in different modes. The two modes can transfer smoothly from one to the other, which can help avoid transient surge in the microgrid. The P&O based MPPT technique is a most popular technique because of its simplicity and is implemented by using easy mathematical equations. It is based on a slope of power (Ppv) vs. voltage (Vpv) curves of a PV array. For achieving MPP, derivative of slope of PV curve is zero. In P&O based MPPT algorithm, the power change is observed when an operating point is moved in a single direction. If change in its power, is positive then the perturbation direction is true otherwise it has to be reversed to generate reference DC link voltage V*dc. The proposed MINF based adaptive control algorithm is used to estimate reference grid currents, which generates switching pulses for VSC as shown. The MINF control algorithm is described as follows.

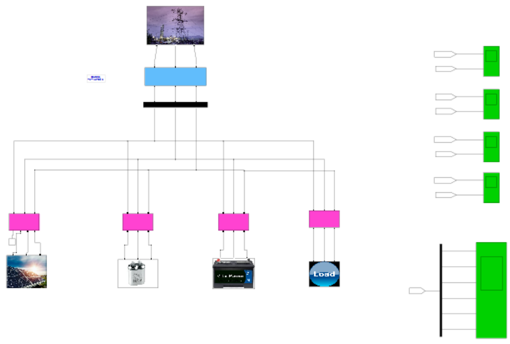

Fig 1 proposed block diagram.

Modules Description

- Solar panel
- Maximum power point tracking (MPPT)
- DC-AC converter
- Battery storage system(HESS)
- Ac grid
- Non-linear load
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MTTP ALGORITHM: Maximum power point tracking (MPPT) is an algorithm implemented in photovoltaic (PV) inverters to continuously adjust the impedance seen by the solar array to keep the PV system operating at, or close to, the peak power point of the PV panel under varying conditions, like changing solar irradiance, temperature, and load. Engineers developing solar inverters implement MPPT algorithms to maximize the power generated by PV systems. The algorithms control the voltage to ensure that the system operates at “maximum power point” (or peak voltage) on the power voltage curve, as shown below. MPPT algorithms are typically used in the controller designs for PV systems.

The algorithms account for factors such as variable irradiance (sunlight) and temperature to ensure that the PV system generates maximum power at all times. Maximum power point tracking is a technique used commonly with wind turbines and photovoltaic (PV) solar systems to maximize power extraction under all conditions. Although solar power is mainly covered, the principle applies generally to sources with variable power: for example, optical power transmission and thermo photo voltaics. PV solar systems exist in many different configurations with regard to their relationship to inverter systems, external grids, battery banks, or other electrical loads. Regardless of the ultimate destination of the solar power, though, the central problem addressed by MPPT is that the efficiency of power transfer from the solar cell depends on both the amount of sunlight falling on the solar panels and the electrical characteristics of the load. As the amount of sunlight varies, the load characteristic that gives the highest power transfer efficiency changes, so that the efficiency of the system is optimized when the load characteristic changes to keep the power transfer at highest efficiency.

This load characteristic is called the maximum power point and MPPT is the process of finding this point and keeping the load characteristic there. Electrical circuits can be designed to present arbitrary loads to the photovoltaic cells and then convert the voltage, current, or frequency to suit other devices or systems, and MPPT solves the problem of choosing the best load to be presented to the cells in order to get the most usable power out. Solar cells have a complex relationship between temperature and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve. It is the purpose of the MPPT system to sample the output of the PV cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions. MPPT devices are typically integrated into an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors.

- Solar inverters convert the DC power to AC power and may incorporate MPPT: such inverters sample the output power (I-V curve) from the solar modules and apply the proper resistance (load) so as to obtain maximum power.
- The power at the MPP (Pmpp) is the product of the MPP voltage(Vmpp) and MPP current(Impp).

AC GRID : An electrical grid is an interconnected network for delivering electricity from producers to consumers. It consists of generating stations that produce electrical power, high voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers. An AC-AC converter with approximately sinusoidal input currents and bidirectional power flow can be realized by coupling a pulse-width modulation (PWM) rectifier and a PWM inverter to the DC-link. The DC-link quantity is then impressed by an energy storage element that is common to both stages, which is a capacitor C for the voltage DC-link or an inductor L for the current DC-link. The PWM rectifier is controlled in a way that a sinusoidal AC line current is drawn, which is in phase or anti-phase (for energy feedback) with the corresponding AC line phase voltage.

DC-AC CONVERTER - This chapter gives a description and overview of power electronic technologies including a description of the fundamental systems that are the building blocks of power electronic systems. Technologies that are described include: power semiconductor switching devices, converter circuits that process energy from one DC level to another DC level, converters that produce variable frequency from DC sources, principles of rectifying AC input voltage in uncontrolled DC output voltage and their extension to controlled rectifiers, converters that convert to AC from DC (inverters) or from AC with fixed or variable output frequency (AC controllers, DC–DC–AC converters, matrix converters, or cycloconverters). The chapter also covers control of power converters with focus on pulse width modulation (PWM) control techniques.

Power electronic circuits are used to control the power conversion from one or more AC or DC sources to one or more AC or DC loads, and sometimes with bidirectional capabilities. In most power electronics systems, this conversion is accomplished with two functional modules called the control stage and the power stage. The topology for a single source and single load converter application that includes a power processor (the power stage) and a controller (the control stage). The converter, handles the power transfer from the input to output, or vice versa, and is constituted of power semiconductor devices acting as switches, plus passive devices (inductor and capacitor). The controller is responsible for operating the switches according to specific algorithms monitoring physical quantities (usually voltages and currents) measured at the system input and or output.

The Insulated Gate Bipolar Transistor (IGBT) The IGBT is a hybrid or also known as double mechanism device. Its control port resembles a MOSFET and its output or power port resembles a BJT. Therefore, an IGBT combines the fast switching of a MOSFET and the low power conduction loss of a BJT. shows a circuit symbol that is used for an IGBT, which is slightly different from the MOSFET with similar terminal labels. The control terminal is labeled as gate (G) and the power terminals are labeled as collector (C) and emitter (E). The i-v characteristics of a real IGBT are shown, which shows that the device operates in quadrants I and III.

The ideal characteristics of the device are shown. The device can block bidirectional voltage and conduct unidirectional current. An IGBT can change to the ON-state very fast but is slower than a MOSFET device. Discharging the gate capacitance completes control of the IGBT to the OFF-state. IGBT's are typically used for high power switching applications such as motor controls and for medium power PV and wind PE.

DC/AC Converter: Also described as ''Inverter'' is a circuit that converts a DC source into a sinusoidal AC voltage to supply AC loads, control AC motors, or even connect DC devices that are connected to the grid. Similar to a DC/DC converter, the input to an inverter can be a stiff source such as battery, solar cell, or fuel cell or can be from an intermediate DC link that can be supplied from an AC source.

BATTERY STORAGE SYSTEM (HESS) : Battery Batteries.jpg Various cells and batteries (top-left to bottom-right): two AA, one D, one handheld ham radio battery, two 9-volt (PP3), two AAA, one C, one camcorder battery, one cordless phone battery Type Power source Working principle Electrochemical reactions, Electromotive force First production 1800s Electronic symbol Battery symbol2.svg The symbol for a battery in a circuit diagram. It originated as a schematic drawing of the earliest type of battery, a voltaic pile. A battery is a device consisting of one or more electrochemical cells with external connections provided to power electrical devices such as flashlights, smartphones, and electric cars.

NON-LINEAR LOAD: Harmonic distortion needs to be defined as either 'current distortion' or 'voltage distortion.' Non-linear loads, unlike linear loads, draw a non-sinusoidal current from a sinusoidal voltage supply. The distortion to the normal incoming sinusoidal current wave can be considered to result from the load emitting harmonic currents that distort the incoming current. These emitted harmonic currents, like any generated current, will circulate via available paths and return to the other pole of the non-linear load. In doing so, they cause harmonic voltage drops in all the impedances through which they pass which distort the normal supply sinusoidal voltage.

Maximum power point tracking (MPPT) is an algorithm implemented in photovoltaic (PV) inverters to continuously adjust the impedance seen by the solar array to keep the PV system operating at, or close to, the peak power point of the PV panel under varying conditions, like changing solar irradiance, temperature, and load. Engineers developing solar inverters implement MPPT algorithms to maximize the power generated by PV systems. The algorithms control the voltage to ensure that the system operates at "maximum power point" (or peak voltage) on the power voltage curve, as shown below. MPPT algorithms are typically used in the controller designs for PV systems.

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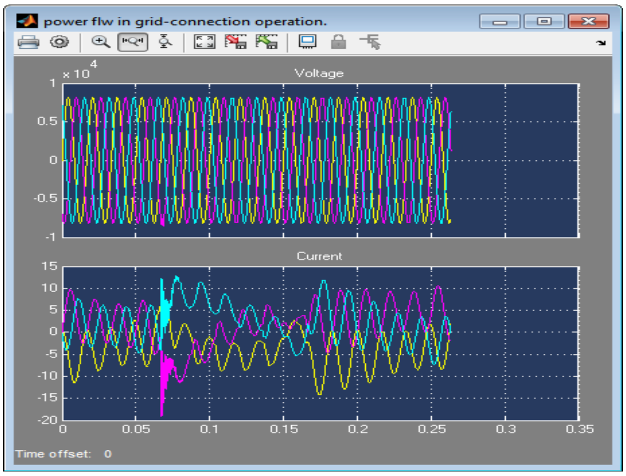

Fig.2 power flow in grid connection operation

The battery system is less active, but when the PV system is not utilizing the majority of the inverter capacity (i.e. at night) it is able to actively participate in fast response frequency regulation. PV generation first, then the remainder is utilized for frequency regulation participation. In full sun the PV system will normally require approximately 325 kW of AC capacity, leaving 175 kW of inversion capacity available for participation in the frequency regulation market. When there is a grid outage the microgrid system senses the loss of grid and signals the isolation breaker to open and convert to Islanded mode. The system adjusts automatically from a grid-tied current source to an islanded voltage source in a few cycles

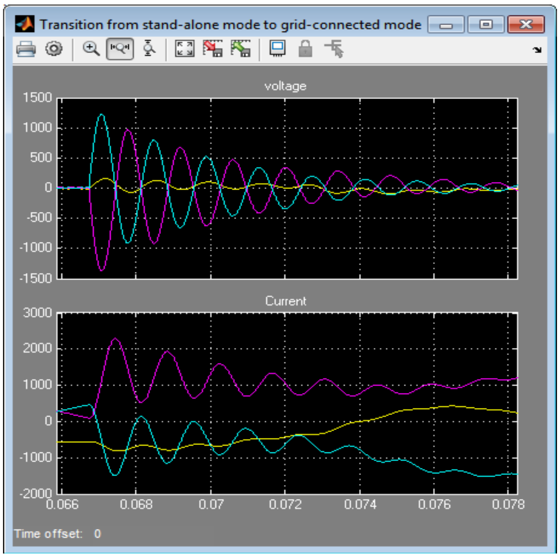

Fig .4 3power flow in grid connection operation

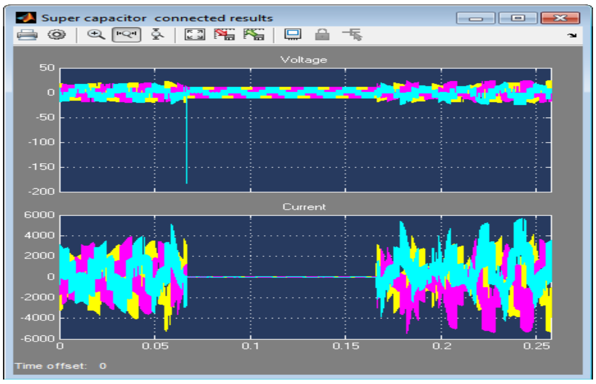

Fig 4 super capacitor voltage and current.

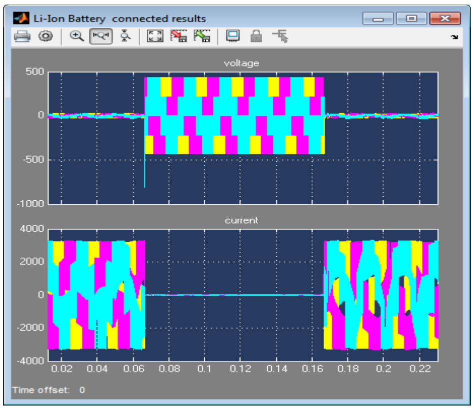

Fig .5 power flow in grid connection operation

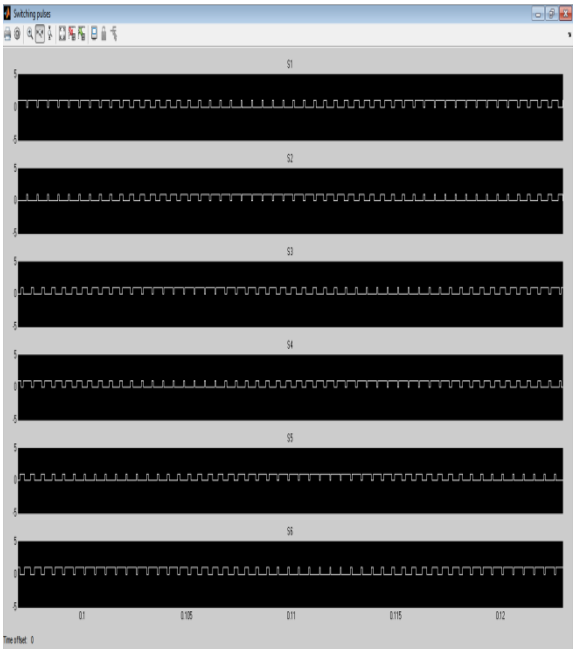

Fig.6 power flow in grid connection operation

IV.CONCLSUION AND FUTURE WORK

In this Research an integrated protection and control system with a hierarchical structure is proposed and a 100 kWp photovoltaic Microgrid is built to validate the effectiveness and feasibility of the proposed strategy. Test results show that stable and flexible transition between different operation modes of the PV microgrid are achieved and the viability of the micro-grid under severe fault is greatly improved. At the design stage of the microgrid ESS it is necessary to compare energy efficiency indicators before and after its implementation. The specification of the energy efficiency indicators estimation is based on comparison of daily profiles of loading and of solar insolation in the course of the calendar year. The implementation of microgrid with solar power plants allows to increase the efficiency of the ESS. The reserve for increasing the efficiency through the implementation of microgrid has two components, the first one is related to the normalization of the power consumption mode, and the second one to the optimization of the structure of the network, when the distances between energy sources and consumers are reduced, and the density of the network energy flow and trunk line decreases. Moreover, the second component makes a more significant contribution to increasing the efficiency of the energy supply system.

In solar energy sector, many large projects have been proposed in India. Thar Desert has some of India's best solar power projects, estimated to generate 700 to 2,100 GW. On March 1st, 2014, the then Chief Minister of Gujarat, Narendra Modi, 27 Proceedings of International Seminar on Sources of Planet Energy, Environmental & Disaster Science: Challenges and Strategies (SPEEDS-2015) inaugurated at Diken in Neemuch district of Madhya Pradesh, India's biggest solar power plant.

The Jawaharlal Nehru National Solar Mission (JNNSM) launched by the Centre is targeting 20,000 MW of solar energy power by 2022 Gujarat's pioneering solar power policym aims at 1,000 MW of solar energy generation. In July 2009, a $19 billion solar power plan was unveiled, which projected to produce 20 GW of solar power by 2020. About 66 MW is installed for various applications in the rural area, amounting to be used in solar lanterns, street lighting systems and solar water pumps, etc

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