IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE)
e-ISSN: 2278-1676,p-ISSN: 2320-3331, Volume 13, Issue 4 Ver. I (Jul. – Aug. 2018), PP 14-19
www.iosrjournals.org

Hybrid Energy Storage Supported Backup For Photovoltaic Based Microgrid

Nandeesha BC [1], to Dr. W M Sivakumar [2], Anguraja R[3]
[1]*(Electrical and Electronics, DBIT, India)*
[2]*(Electrical and Electronics, DBIT, India)*
Corresponding author: Nandeesha BC
[3]*(Electrical and Electronics, DBIT, India)*
Corresponding Author: Nandeesha BC

Abstract: *The proposed operational strategy is mainly focused on using an appropriate energy management and control strategies toimprove the operation of an islanded microgrid, formed by photovoltaic (PV) system, SMES-batteries and loads. This control strategy is to achieve decentralized power management of a PV/battery/Fuel cell hybrid unit in a droop-controlled islanded microgrid. In contrast to the common approach of controlling the PV unit as a current source, in the proposed strategy, the PV unit is controlled as a voltage source that follows a multi-segment adaptive powercharacteristic curve. The proposed power characteristics, of the hybrid unit and of the whole microgrid, adapt autonomously to the microgrid operating conditions so that the hybrid unit may supply the maximum PV power, match the load, and/or charge the battery, while maintaining the power balance in the microgrid and respecting the battery state-of-charge limits. These features are achieved without relying on a central management system and communications, as most of the existing algorithms do. The simulations andcomparisons among the SMES-based, BES-based and HES-basedDVR schemes have demonstrated that the HES-based DVRscheme integrates the merits of fast response speed and highpower density from the SMES-based scheme and the merits of lowcapital cost and high energy density from the BES-based scheme.*

Keywords *- Point of common coupling (PCC), dynamic voltage restorer (DVR),superconducting magnetic energy storage (SMES), hybrid energy storage (HES).*

Date of Submission: 26-06-2018 Date of acceptance: 10-07-2018

I. Introduction

The introduction of the paper should explain the nature of the problem, previous work, purpose, and the contribution of the paper. The contents of each section may be provided to understand easily about the paper.

Distributed generation (DG) technologies such as wind

power generation, photo-voltaics and Micro-turbine are expectedto play a significant role in future electricity supply. However, the increase of DG penetration depth in the power system will bring a new challenge foroperating the power system safely and efficiently. Thischallenge can be partially addressed by MicroGrid which is defined as a cluster of DGs and loads interconnected to the distribution network [1]. The MicroGrid technologies will allow the grid to better adapt to the dynamics DGs, permitting them provide their full benefits.

Rechargeablebatteries are wildly used as energy source. However, the batteries are challenged with the limited lifecycles,sensitivity to high discharge current and low power densitywhich provided the impetus to develop additional solutionsHowever, such batteries have problems, such astheir limited current rate, low response time, limited powerdensity, and environmental hazards [2]. In addition, super-capacitors(SCs) and superconducting magnetic energy storage (SMES) systems are energy storage technologies with ahigh power density that are best suited for transient disturbance conditions [3][4].

Islanded microgrids share the same issue with DG systems, since the battery storage is needed to maintain the generation/load balance and to regulate the microgrid voltage and frequency[5]. In both cases, the power management strategy should consider the state-of-charge (SOC) limits and the power rating of the battery. However, unlike in PV systems, in microgrids, the battery storage can be connected to the microgrid bus as a separate unit, which might be in a different location than the PV unit. Furthermore, in microgrids, the PV unit is commonly controlled. As in grid-connected configurations, where the interfacing voltage sourced converter (VSC) is controlled as a current source to inject the available Photovoltaic(PV) power[6] into the grid/microgrid bus.Since this technique was developed originally for grid-connected configurations, it does not address the power balance problem in islanded microgrids. Therefore, the operation of the PV unit, the battery storage, and other units in the microgrid, such as droop-controlled units, must be coordinated to balance the power in the islanded microgrid[7] while respecting the battery storage limits. Accordingly, a supervisory power management strategy, which is usually implemented in a central energy management system (EMS), is required to coordinate the operation [8] of these units.

However, communication can still be used in the grid-connected mode as a part of the tertiary control layer to achieve certain objectives such as ensuring economic dispatch based on the electricity market and fuel prices. In this case, communications are not crucial to maintain the power balance in the microgrid, as it is achieved through the grid. Moreover the power management strategy is designed so that both the fuel cell and the battery use the droop control approach to share the peak load, when the power available from the PV unit and the micro turbine is inadequate to match the load. This might deplete the battery prematurely. Instead, it is recommended that the battery only be used during transients, and to supply the deficit power only after the load increases beyond the total capacity of the other generating units.

The proposed voltage characteristics, of the hybrid unit and of the whole microgrid, adapt autonomously to the operating conditions of the microgrid so that the hybrid unit may supply the maximum PV power, match the load, and/or charge the battery. This is accomplished while maintaining the power balance in the microgrid and respecting the battery SOC limits. In general, the battery module within the hybrid unit is controlled to offer the same operational functions that a separate storage unit can provide in an islanded microgrid, such as maintaining the microgrid power balance and regulating the voltage and frequency. Distributed generation (DG), also known as on-site generation generates electricity frommany small sources such as solar, tidal, natural gas (fuel cells), wind and small hydro. Due tocertain advantages like environmental friendliness (low or zero emission of pollutant gases), flexibility and expandability, DG's are considered as the best option to form modern electricalgrids by properly locating them. DG technology is decentralized and is gaining increasingattention due to various advantages offered by them. The advancement in power electronicstechnology makes it possible to integrate DG systems to the utility

II. System Description And Basic Principle

The Fig. 1 indicates the application of a SMES-battery in a photovoltaic-based microgrid, which is composed of two solar PV generators and two power loads. The SMES and the battery are independently controlled, and a fully active topology including two DC/DC and DC-AC converters is adopted [9].and corresponding MATLAB Simulink model is depicted in below figure 2 Which is modeled in MATLAB of version is 2014a.

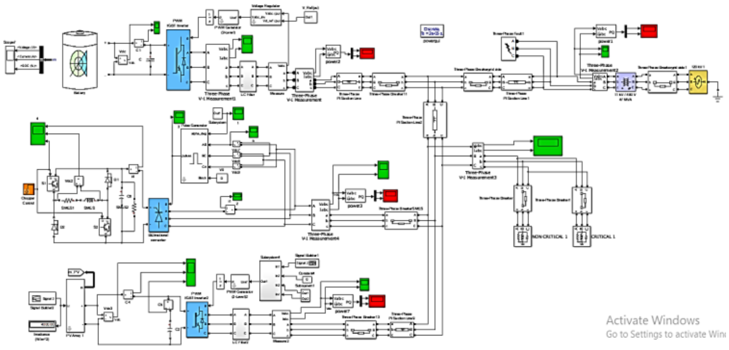

Fig. 2. Simulink model of a photovoltaic-based microgrid with a SMES-battery.

This whole system consists following blocks and they are explained briefly as fallow

- Pv Module Generation.
- Battery
- Dc To Dc Converter
- Dc To Ac Converter
- Smes

1)Pv Module Generation.

In Matlab Simulink have only solar array so we must create a PV module using that solar array.Fig. 3 indicates the photovoltaic-array of diode model, fig1 PV based microgridwhich is composed of two solar PV generators and two power loads. In this PV systemmodules consists solar arrays those are connected in series. When the irradiance value is given to the solar terminal solar cell converted generates DC power that is converted to AC and connected to AC 3phase grid. In a Grid-connected Solar power is sold to the electricity company. In this type of system the usual choice for energy storage is the lead-acid battery. The number and type of batteries is dependent on the amount of energy storage needed. Find out more about batteries here.PVPower is emerging as a major power resource, steadily becoming more affordable and proving to be more reliable than utilities. Photovoltaic power promises a brighter, cleaner future for our children. Using the technology we have today we could equal the entire electric production of the United States with photovoltaic power plants using only about 12,000 square miles. Originally this technology was a costly source of power for satellites but it has steadily come down in price making it affordable to all power homes and businesses.

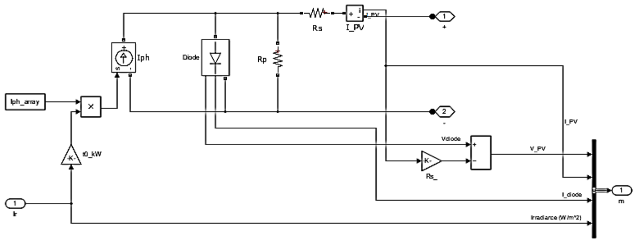

Fig. 3. Simulink model of a photovoltaic array

Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 320 watts. The efficiency of a module determines the area of a module given the same rated output - an 8% efficient 230 watt module will have twice the area of a 16% efficient 230 watt module. A single solar module can produce only a limited amount of power; most installations contain multiple modules. A photovoltaic system typically includes a panel or an array of solar modules, an inverter, and sometimes a battery and/or solar tracker and interconnection wiring. Solar panel refers either to a photovoltaic module, a solar thermal energy panel, or to a set of solar photovoltaic (PV) modules electrically connected and mounted on a supporting structure.

2)Battery And Dc-Dc Boost Converter

An electric battery is a device consisting of one or more electrochemical cellsWhen the microgrid operates normally, the battery storage is to restrain the long-term power fluctuation (low-frequency power component) in the PCC. For the faults, the battery storage will act as a backup support and with external connections provided to power electrical devices Fig 4 and 5 shows the MATLAB Simulink model of battery with DC-DC boost converter and their controller respectively.

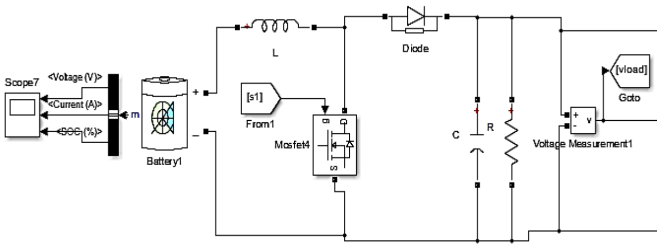

Fig. 4. Simulink model of a battery with DC-DC boost converter

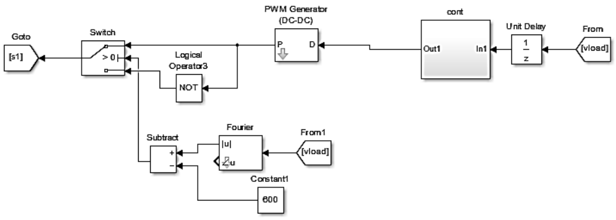

Fig. 5. Simulink model of a battery and boost converter control

Batteries come in many shapes and sizes, from miniature cells used to power hearing aids and wristwatches to small, thin cells used in smartphones, to large lead acid batteries used in cars and trucks, and at the largest extreme, huge battery banks the size of rooms that provide standby or emergency power for telephone exchanges and computer data centers. In this we are using SMES and Battery to supply the load.

A DC-to-DC boost converter is an electronic circuit or electromechanical device that converts a source of direct current (DC) from one voltage level to another Additionally, the battery voltage declines as its stored energy is drained. Switched DC to DC converters offer a method to increase voltage from a partially lowered battery voltage thereby saving space instead of using multiple batteries to accomplish the same thing[10]. Most DC to DC converter circuits also regulate the output voltage. Some exceptions include high-efficiency LED power sources, which are a kind of DC to DC converter that regulates the current through the LEDs, and simple charge pumps which double or triple the output voltage. DC to DC converters developed to maximize the energy harvest for photovoltaic systems and for wind turbines are called power optimizers. Transformers used for voltage conversion at mains frequencies of 50–60 Hz must be large and heavy for powers exceeding a few watts. This makes them expensive, and they are subject to energy losses in their windings and due to eddy currents in their cores. DC-to-DC techniques that use transformers or inductors work at much higher frequencies, requiring only much smaller, lighter, and cheaper wound components. Consequently these techniques are used even where a mains transformer could be used.

A bidirectional converter is useful, for example, in applications requiring regenerative braking of vehicles, where power is supplied to the wheels while driving, but supplied by the wheels when braking. Switching converters are electronically complex, although this is embodied in integrated circuits, with few components needed. They need careful design of the circuit and physical layout to reduce switching noise (EMI / RFI) to acceptable levels

3)Dc To Ac Converter

Most inverter applications require a means of voltage control. This control may be required because of variations in the inverter source voltage and regulation within the inverter. It can be grouped into three categories,

- Control of voltage supplied to the inverter
- Control of voltage within the inverter
- Control of voltage delivered by the inverter

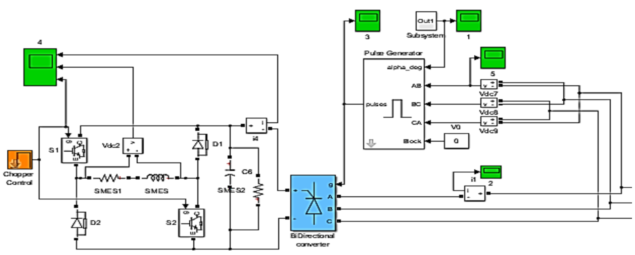

Fig. 6. Simulink model of SMES with DC-DC Chopper and DC-AC Inverter

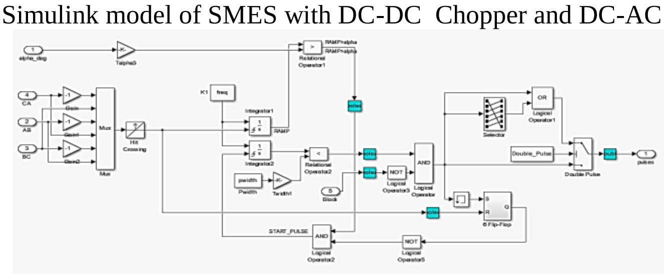

Fig. 7. Simulink model of DC-AC Inverter PWM Signal Generator

Fig 6 and 7 shows the MATLAB Simulink model of of SMES with DC-DC boost converter and DC-AC Inverter and DC-AC Inverter PWM Signal Generator respectively battery with boost converter and their controller respectively There are a number of well-known methods of controlling the d-c voltage supplied to an inverter or the a-c voltage delivered by an inverter. It includes the use of saturable reactor, magnetic amplifier, and induction regulator, phase controlled rectifiers and transistor series or shunt regulators. With the introduction of high speed, efficient and extremely reliable solid state switching devices, including transistor and silicon controlled rectifier, considerable effort has been put to develop new methods of voltage control. In

general, these improved controls involve switching techniques where the voltage control is achieved by some form of switching time-ratio control.

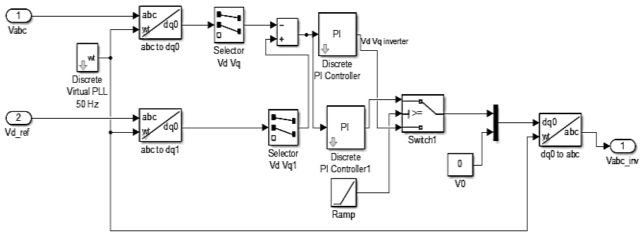

Fig. 8. Simulink model of PWM Signal Generator Controller

Fig. 8 shows the control Simulink model of PWM Signal Generator block diagram of the SMES for the microgrid. In light of Fig. 8 the output voltage of inverter control is to handle the internal fault as same as normal case voltage. Here, not only a voltage outer-loop regulator and a current inner-loop regulator are used, but also the voltage adjustment based open-loop control is applied[11]. It means that the voltage reference after an integral processing will be sent to the Pulse-Width Modulation (PWM) pulses, so as to make the SMES inverter's voltage outputs be controlled within a given frequency.

One of the most advantageous means of controlling inverter output voltage is to incorporate switching time-ratio controls within the inverter circuit. This basic form of inverter voltage control is the principal emphasis of this chapter. With implementation of this technique, it is often possible to include inverter output voltage control without significantly adding to the total number of circuit components. A single phase pulse width control technique is discussed here to illustrate the important principles of this means of controls. By properly gating the inverter controlled rectifying device it is possible to vary the amplitude of fundamental component of inverter output voltage.

III. Results

When grid meets fault between 0.05-0.15 second duration at same time circuit breaker isolates grid from supply then three-phase voltage and currents sag to 50% of nominal voltage and current occurs this is because same load supplying by only PV and battery which is depicted in figure8.

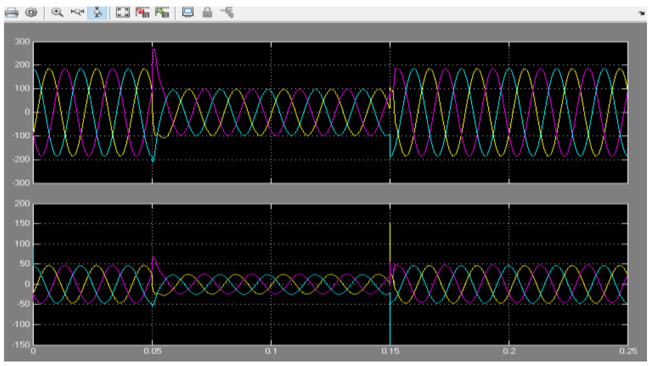

Fig. . Hybrid System Simulation results: Three phase sag to 50% of nominal voltage at load during faults in 0.05-0.15second

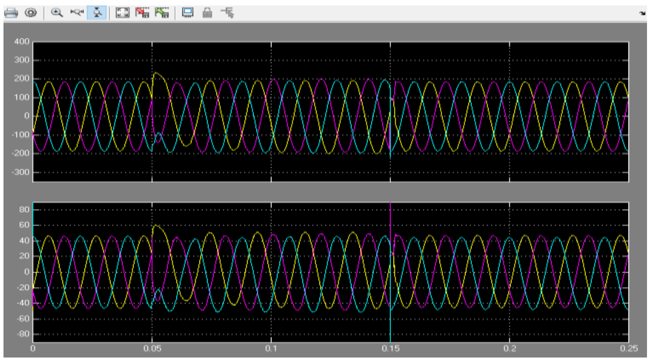

Fig. . Hybrid System Simulation results:

Three phase sag is cleared at load during faults in 0.05-0.15second lasting 100 ms was used to demonstrate the response of the DVR and energy storage systems. From Fig. 9 it can be seen that the hybrid

DVR system mitigates the voltage sag effectively during the sag event. The battery is discharged momentarily at−1.45 A at the end of the sag when the inductor energy has been depleted..from these it is confirmed that the SMES-battery is superior to the battery to ensure a seamless mode transition for the microgrid under the external fault, and reduce the fault current in the PCC to avoid an unnecessary off-grid under the fault.WhenSmes comes into existence Phase to phase sag are overcome.

IV. Conclusion

The operation and control of utility interactive microgrid consisting of PV and SMES system was simulated using Matlab/Simulink.Different fault conditions are created and Results are noted .From the simulation it is cleared that by the use of SMES in the microgrid Faults can be tolerated and if there is any absence in any source like PV Panel the SMES-Battery can supply for the load efficiently.Therefore, the proposed HES-based DVR concept integrated with fast-response high-power SMES unit and low-cost high-capacity BES unit can be well expected to apply in practical large-scale DVR developments and other similar applications.

Acknowledgements

The authors are thankful to Don Bosco Institute of Technology for providing necessary facilities & support and special thanks to Dr. W M Sivakumar and Mr. Anguraja R Associate professor and head of the department, Don Bosco instituet of technology, Bengaluru for support and suggetions

References

[1]. Mustafa Farhadi, and Osama Mohammed, “Energy Storage Technologies for High-Power Applications,” *IEEE Trans. Ind. Appl.*, vol. 52, no. 3, pp. 1953–1961, May 2016.

[2]. Xiao Yuan Chen, and JianXun Jin, “Energy Efficiency Analysis and Energy Management of a Superconducting LVDC Network,” *IEEE Trans. Appl. Superconduct.*, vol. 26, no. 7, Oct. 2016, Art.No. 5403205.

[3]. Jae Woong Shim, Youngho Cho, Seog-Joo Kim, Sang Won Min, and KyeonHur, “Synergistic Control of SMES and Battery Energy Storage for Enabling Dispatchability of Renewable Energy Sources,” *IEEE Trans. Appl. Superconduct.*, vol. 23, no. 3, June 2013, Art. No. 5701205.

[4]. ZanxiangNie, Xi Xiao, Qing Kang, Raj Aggarwal, Huiming Zhang, and Weijia Yuan, “SMES-Battery Energy Storage System for Conditioning Outputs From Direct Drive Linear Wave Energy Converters,” *IEEE Trans. Appl. Superconduct.*, vol. 23, no. 3, June 2013, Art. No. 5000705.

[5]. Jianwei Li, Anthony M. Gee, Min Zhang, Weijia Yuan, “Analysis of battery lifetime extension in a SMES-battery hybrid energy storage system using a novel battery lifetime model,” *Energy*, vol. 86, pp. 175–185, June 2015.

[6]. Jianwei Li, et al., “Design and test of a new droop control algorithm for a SMES/battery hybrid energy storage system,” *Energy*, vol. 118, pp. 1110–1122, Jan. 2017.

[7]. Zheng Wang, ZhixiangZou, and Yang Zheng, “Design and Control of a Photovoltaic Energy and SMES Hybrid System With Current-Source Grid Inverter,” *IEEE Trans. Appl. Superconduct.*, vol. 23, no. 3, June 2013, Art. No. 5701505.

[8]. Shu Wang, et al. “Design and advanced control strategies of a hybrid energy storage system for the grid integration of wind power generations,” *IET Renew. Power Gener.*, vol. 9, no. 2, pp. 89–98, 2015.

[9]. Somayajula, D., Crow, M. L.: 'An integrated dynamic oltagerestorer-ultracapacitor design for improving power quality of thedistribution grid', IEEE Trans. Sustainable Energy, 2015, 6, (2), pp616-624

[10]. Hajizadeh, A., Golkar, M.A., Feliachi, A.: 'Voltage control and activepower management of hybrid fuel-cell/energy-storage power conversionsystem under unbalanced voltage sag conditions', IEEE Trans. EnergyConversion, 2010, 25, (4), pp 1195-1208

[11]. Jayaprakash, P., Singh, B., Kothari, D.P., et al.: 'Control of reduced-ratingdynamic voltage restorer with a battery energy storage system', IEEETrans. Industry Applications, 2014, 50, (2), pp 1295-1303

IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) is UGC approved Journal with Sl. No. 4198, Journal no. 45125.

Nandeesha BC “Hybrid Energy Storage Supported Backup For Photovoltaic Based icrogrid." IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) 14.4 (2018): 14-19.