SIMULATION AND ANALYSIS OF MICROGRID WITH DISTRIBUTED ENERGY SOURCES

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Abstract:

This paper investigates compensation of a robust energy management solution which will cause the optimum and economic control of energy flows throughout a microgrid network. The enlarged penetration of renewable energy sources is highly intermittent in nature; the proposed solution exhibit highly efficient energy management. This study enables proper management of power flows by predicting of renewable energy generation, calculating the availability of energy at storage batteries and raise the proper mode of operation, based upon load demand to have efficient and economic operation.

Key Words - Energy management, Efficient and Economic operation, managing the distribution of energy across the load.

1. Introduction:

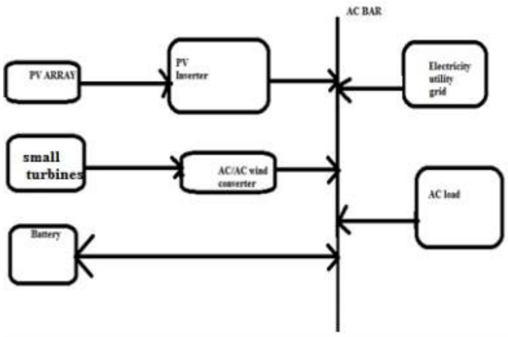
The traditional mass power generation, transmission and distribution system is facing lot of technological challenges to fulfil the operation demand and increased penetration of distributed energy resources. The existing infrastructures are also obsolete, which hinders the integrating of new technology for capacity enhancement and refined monitoring and control. Hence the need as arisen for distributed generation which can coexist between the existing bulk power networks. In recent years, there has been significant growth in renewable energy generation through wind and solar resources. A microgrid is a small version of the bulk power system with distributed energy resources capable of serving an independent electrical island separated from bulk power system. Microgrid employs environmentally benign energy sources like solar, wind and solar cells. The higher the penetration of sustainable energy sources the more the social-economic benefits will be. The recent advances in control and communication technology facilitate robust and smart control of microgrids. Optimal energy dispatch is established for grid connected with photovoltaic(PV), fuel cell, Diesel generator(DG), and battery energy storage system(BESS). PV power system have become one of the most promising renewable generation technologies because of their attractive characteristic such as abundance of solar and clean energy. DG is the combination of a diesel energy with an electric generator to generate electric energy. Batteries are one of the most cost-effective energy storage technologies available with energy stored electrochemically.

The following modules consist of the Existing system, modes of operation, Stability and Power Sharing, Proposed system, Experimental result, conclusion, are discussed below.

2. Energy management and Energy Distribution in a grid connected system

2.1 Existing system:

Power station connected to grids are often located near energy resources such as a source of fuel or to take advantage of renewable energy resources, and away from heavily-populated areas. A bulk-power transmission network is therefore used to move the power long distances, sometimes across international boundaries, until it reaches its wholesale customer (usually the organization that owns the local electric power distribution network). The electric power is therefore steeped up to a high voltage for the electric power transmission system. Reaching at a substation, the power will be stepped down from a transmission level voltage to a distribution-level voltage. As it exists the substation, it enters the distribution wiring. Finally, upon reaching at the service location, the power is stepped down once again from the distribution voltage to the required service voltage(s).



Grid connected PV system

2.2 Modes of operation:

The microgrid operation has been grouped into two major categories. On grid mode and Off grid mode. During On grid mode of operation, the whole system is powered by the utility grid as energy sources. The mutuality of loads between sustainable DES is controlled by the EMS as per the defined control algorithm. In Off grid mode of operation, the entire microgrid will be in islanded mode from the utility grid, all the connected loads will be function from the local energy sources and storage system connected in the network. In transition mode, all the critical loads are serviced by the UPS and this mode is a state in between On grid mode and Off grid mode.

2.3 Stability and Power Sharing

In Off Grid mode it is necessary that all the connected DES synchronize properly and form a grid. For grid tied inverters, a reference voltage source is required for pumping PV power into the microgrid . In the proposed network, the UPS will provide the reference voltage and help the PV inverter to build power. Once the grid is settled, the stability of the grid is to be maintained by appropriate control of voltage (V), frequency (F), active power (P) and reactive power (Q). The grid impedance will be checked by PV inverters to sense the grid existence. The PV inverter's active power (P) is controlled as a function of frequency (F) to ensure sustained operation in islanded mode. When the microgrid frequency reaches a Fstart *(50.2 Hz) then the PV inverter starts to lessen the active power generation. Further, if the microgrid frequency increases and reaches a maximum permissible limit Fstop (54 Hz), then the PV inverter disconnects from the microgrid network.*

$$Pe = (E \cdot V/ X) \sin \delta \sim= (E \cdot V/ X$$
$$)\delta \; E - V \sim= XQ/E$$
$$d\delta/dt = \omega(t) - \omega MG$$

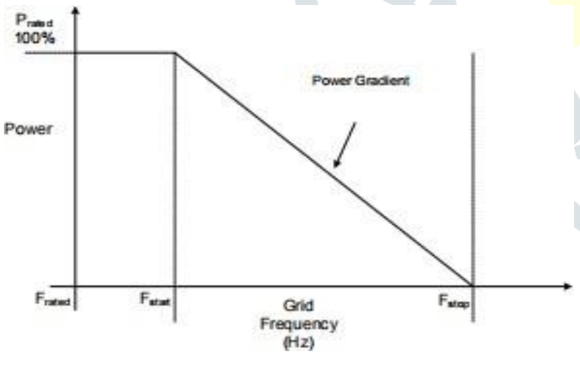


Figure 2.3.1 Power gradient diagram for active power (P) versus frequency (F) control function in the PV inverter

Here, ω is the angular velocity of the generator (DG or PV generator output), ωMG is the angular velocity of the microgrid at the point of common coupling(PCC). The microgrid output power is controlled by varying the frequency of the PV inverter and similarly the reactive power (Q) is controlled by varying the output voltage or excitation to the DG. In Off grid mode, the secondary control is critical to ensure the stability as the sources are not stiff and will easily fall out of sync.

$$f - fo = -kp\ (P-Po)$$
$$V-Vo = -kQ\ (Q-Qo)$$

Figure 2.3.2 Active power (P) vs Frequency (F) relation and Reactive power (Q) vs. Voltage (V) relation at PCC

3. **Proposed system:**

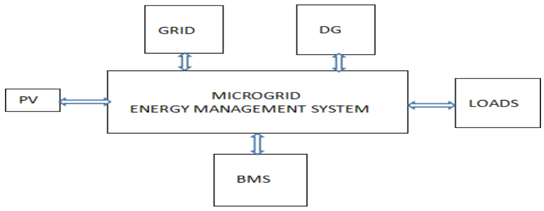


Fig 3.1 Microgrid EMS block diagram

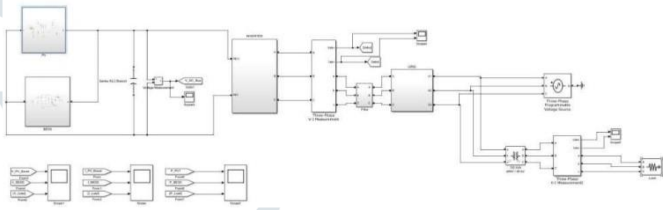


Fig 3.2 Microgrid EMS controller MATLAB diagram

The below table lists the voltage and power specification for the source and load connected in a system; these limits are critical for both on grid and Off grid mode of operation.

Serial No.	Type of source/load	Specification
1	Total network capacity	100 kVA, 400V, 3PH
2	PV generator	25 kW
3	Diesel generator	50 kW
4	BESS	25kW, 50kWh
5	UPS	15kVA, 400V, 3PH
6	Manage Loads	400kVA, variable loads

The above MATLAB diagram represent the microgrid architecture under consideration for an energy management system(EMS). The proposed microgrid system comprises sources like the utility grid, a diesel generator, photovoltaic(PV) generator, and a battery energy storage system(BESS) and load. All the loads are connected directly either from utility grid or from distributed energy sources (DES). All the sources are connected through suitable circuit breakers. The current and voltage feedback signals from loads and local feeder lines are fed to the EMS controller. EMS go-between control signals and circuit breakers for proper operation.

Presently there are many microgrid architectures under research, and the focus is mainly on developing energy management solutions through refined artificial intelligence technologies for achieving superior economic benefits. Having fine control at the individual device or source level and at the network controller level will facilitate the faster response, smooth transition of load sharing between sources*, and more reliable* *operation of microgrids. EMS is proposed to establish control at the device level and over all system level with help of state of art communication technology.*

4. Experimental results:

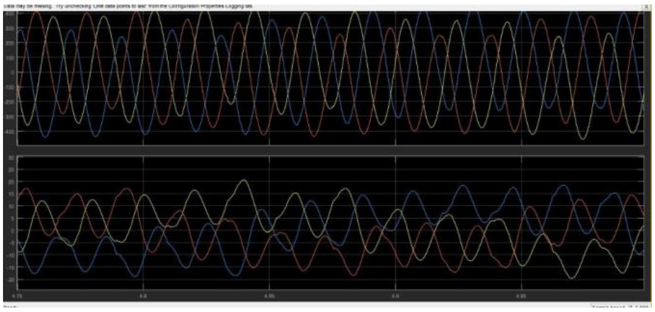


Fig.4.1 A graph of V-I characteristic of load during off grid mode

From the above figure it is seen that the output V-I characteristic of load during off grid mode condition.

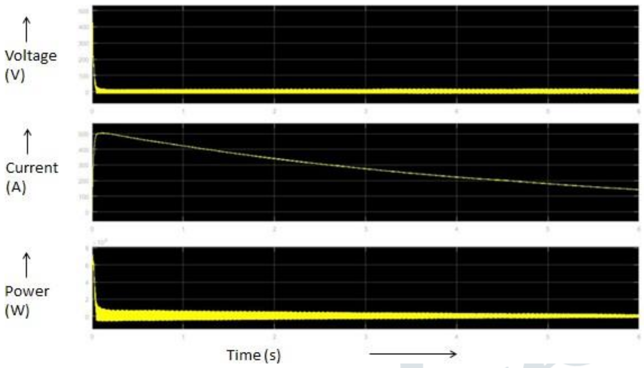


Fig.4.2 Output of voltage, current and power of BESS *The output voltage, current and power of BESS is shown in above graph. Voltage and Power rises to certain value and remain constant where as current rises to a peak and decreases.*

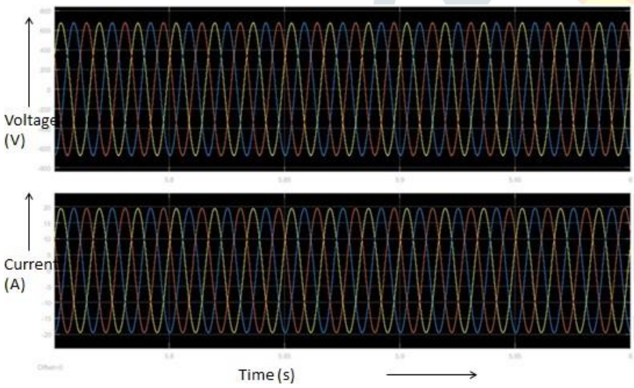


Fig.4.3 Load Output Waveform

The above waveform explains the 3 phase power output of the load. The output power obtained is sinusoidal and harmonics are removed from the filters.

5. Conclusion:

A elaborate study of microgrid system has been carried out with objective to formulate and efficient control algorithm to integrate, manage and control various generation power source like PV, DG, BESS, UPS and utility grid with connected loads. The difficulty lies in the smooth transition of load sharing from PV source to a BEES or the utility grid during clouding effect on PV source. Since the incursion of PV sources are on the rise, the intermittency will pose a bigger concern to ensure the stability of microgrid operation during those condition. This problem was tackled by having coordinated control of PV generation and BESS management for sharing loads in the network. This paper investigates a solution to effectively manage the DES and load to achieve stable operation and economic load dispatch in the entire microgrid network. The load management and control can be further improved by using artificial intelligence and optimization techniques as future work. Microgrid gives drift to use of renewable sources of energy. Reliability is achieved due to spreading of supply. In case of power grid failure Microgrid usage is one of the best method.

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