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# Overview on Development of Simulation and Implementation of Micro-grids with Distributed Solar PV for Efficiency Improvement

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***Abstract-*** *The work with the use of simulation in the software Matlab / Simulink / Sym Power Systems environment considers construction of a local Smart Grid energy supply system with distributed solar power plants. The obtained model allows us to investigate the work of the intelligent network in any quasi-steady and transitional modes, including emergency ones. A distinctive feature of the proposed model is the localization of places for the installation of power active filter-compensating devices, the use of which allows providing the necessary quality of electric energy and achieving the minimum energy losses in the elements of the energy supply system. According to the results of the simulation, the comparison of the energy efficiency of the traditional energy supply system and Smart Grid has been made. The implementation of microgrid with solar power plants allows increasing 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. The aim of the research is to study of the operating modes and energy efficiency assessment of local microgrid on the basis of distributed solar power plants, power consuming storage and power filtering devices using simulation tools.*

***Keywords:-*** Energy supply system, Microgrid, Minimum energy losses, Solar power plant, efficiency, Short cut power, Useful power.

**Introduction**

Micro grid (MG) is an interconnection of distributed energy resources mostly of renewable based power sources such as wind, solar photovoltaic (SPV), micro turbines, fuel cells and bio-fuels integrated with energy storage devices. However the definition and explanation for MG generally varies and is viewed in different perspectives while implementing distributed generation. The CIGRÉ C6.22 Working Group defines as Microgrid as electricity distribution systems containing loads and distributed energy resources, (such as DG, storage devices, or controllable loads) that can be operated in a controlled, coordinated way either while connected to the main power network or while islanded. On the other hand, the U.S. Department of Energy

Microgrid Exchange Group, 2011 (A report on ―DOE Microgrid Workshop Report‖, 2011) describes the microgrid as a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that act as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode. In India the MG projects are initiated as a part of the smart grid project and many researches are going on (in academic and research organization) in the field of design, modeling and development of MG systems. The implementation of any microgrid system involves i) analysis of consumer site and estimation load demand, ii) selection of sources, iii) assessment of source variability, iv) optimization of power sources, v) modeling of MG system, vi) development of metering infrastructure.[23] Estimation of load demand - The power capacity of the sources feeding power to the consumer load is selected based on the peak power demand. During the estimation of load Demand, the capacity of the dump load should also be included in order to maintain the power balance between the generated powers to the consumer load. It also provides the possibility of optimal energy management to match the generation and load demand. Selection of Sources - Most of the MG systems are powered from the renewable energy sources such as solar Photovoltaic (PV), small wind generator, fuel cells, bio fuels and sometimes small hydro. Some MG systems are employed with battery back-up and diesel generator preferred for specific load application. Recent MG systems are designed with two renewable sources of which solar PV and wind offer the best combination for reliable operation. After analyzing the load demand and source, one can select the MG architecture best suited for their application [19].

Estimation of Resource Availability - Similar to the load assessment, resource assessment is also essential to predict the maximum power extraction from the selected sources throughout the life time of the system. Further estimation of the resource availability acts as an input tools for the optimization procedure.[24]Optimization of the Power Sources -Proper optimization of power sources helps in reduction of initial cost in case of over sizing and increases the system reliability to match the load verses demand.

## II. Methodology

2.1 Local Microgrid Block Diagram

As an object for the implementation of microgrid we shall consider a local energy supply system, which is a collection of small households, whose electricity is supplied from the transformer substation along the trunk circuit with a four-wire 0.4 kV cable line (Fig. 4.1). The useful installed power of the load is 8, 5, 4.2, 3 and 4 kW respectively. The reactive power of the load is 7, 4, 2, 2 and 4 kVAr respectively. The third load contains nonlinear elements. The distances between the loads are 100 m, and the cable cross-section of the cable lines starting from the transformer are 10, 6, 4, 2.5 mm2 respectively. We shall suppose that some distributed households have a solar power plant nominal power of 10, 5and 3 kW installed that can operate in both the network and autonomous Modes. The following figure depicts the Microgrid schematics of the local energy supply system.

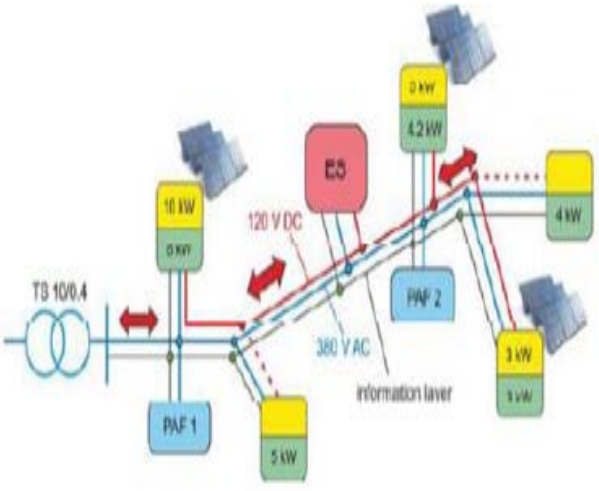


**Fig. 1. Microgrid schematics of the local energy supply system**

The implementation of microgrid is carried out by installing specialized power equipment, the work of which is controlled by the information management system, according to the state of the ESS at the current time.

Parallel power active filters (PAF) (blocks PAF 1 and PAF 2) are connected in common connection points of loads. The tasks solved by installing filters related to ensuring the required quality of electricity are compensation of reactive power, elimination of higher harmonic components of network currents and asymmetry of currents in terms of uneven loading of phases.

At an even distance from the distributed solar power plants, a system energy-saving storage device (ES) is installed which is designed to solve two key tasks – performing the function of the backup power supply in the autonomous operating modes of the system and the alignment of the load profile, that is, the elimination of daily peaks and failures in power consumption. The implementation of these functions, combined with the installation of power active filters will minimize losses in the line and elements of ESS [19, 20]. The results of the performed calculations have shown that, depending on the parameters of the ESS, the theoretically possible reduction in the energy losses is in the range of 2 to 15% [19]. If the level of loss reduction is greater than the loss in the installed equipment, the implementation of these measures is energy justifiable.

The formed network structure allows implementing separately the energy supply system of direct current (Fig. 4.1). The system energy storage is charged from distributed solar power plants, and in case of full charge, network inverters are switched on, and renewable sources give energy to the AC network. In offline mode, when the automatic switch in the beginning of the AC supply lines is open, with the help of a stand-alone inverter, the sinusoidal voltage is formed with a frequency of 50 Hz and the energy supply of the loads connected to the microgrid is carried out from the system ES. Independent DC power can be connected by the appropriate low-power load or electric vehicles, both for recharging onboard batteries and as additional backup sources. The diversity of the modes of operation of microgrid is provided by an additional information level (Fig.4.1), which collects information about the status of each element of the system and, in accordance with the priority algorithms, control impacts are formed, which are worked out by power semiconductor converters.

## III. Results

The study of the control algorithms and operating modes of microgrid at the design stage is carried out conveniently using computer simulation tools, for example, in the Matlab /Simulink / SimPower Systems environment. The structure of the microgrid computer Matlab-model, which corresponds to the ESS scheme.

The model consists of three Solar Station units simulating distributed solar power stations with a rated power of 10, 5 and 3 kW, an Energy Storage unit simulating a system drive, five Load 1-Load 5 units simulating linear active-reactive and non-linear loads, and two PAF 1, PAF 2 blocks imitating parallel power active filters. Consider the structure of the main blocks of the model. The model of the solar photo module in Matlab environment is created using standard Solar Cell blocks of the SimElectronics library, which reproduce a detailed mathematical model of the solar cell that takes into account the features of its electrical and thermal characteristics. The proposed model is represented by the following figure.

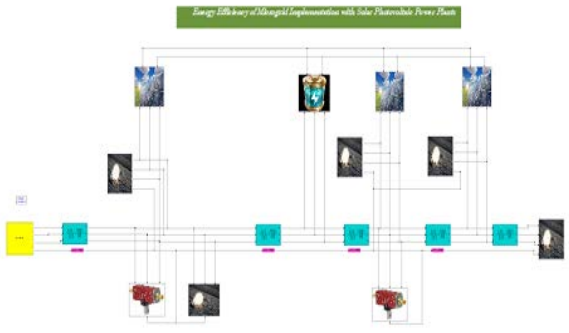

Fig. 2. Proposed Model

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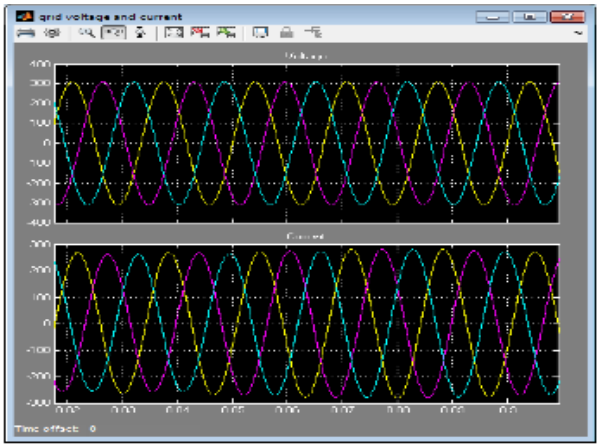


**Fig. 3. Grid Voltage and Current**

The next figure shows the waveform for the parallel power active filters 1 output.

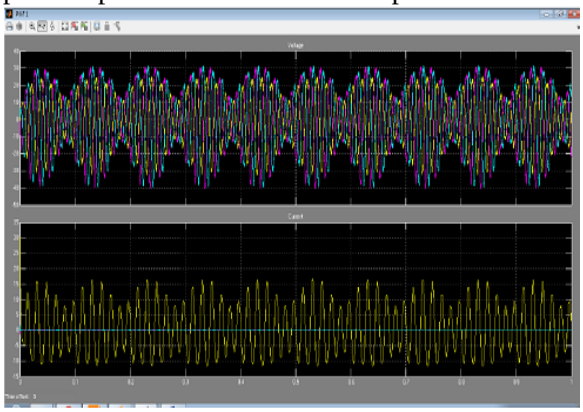

**Fig. 4. Waveform of Parallel power active filters 1**

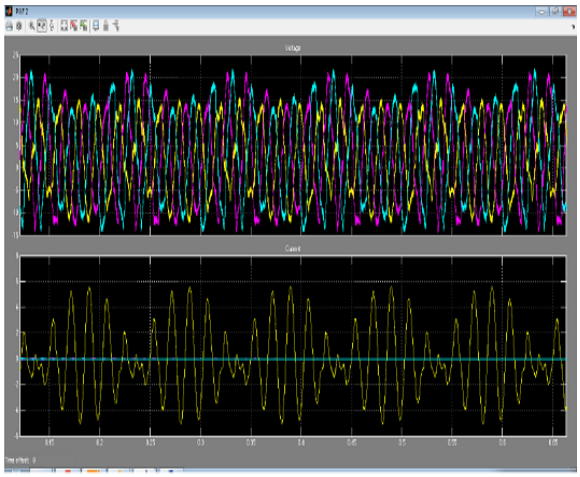

**Fig. 5. Waveform of Parallel power active filters 2**

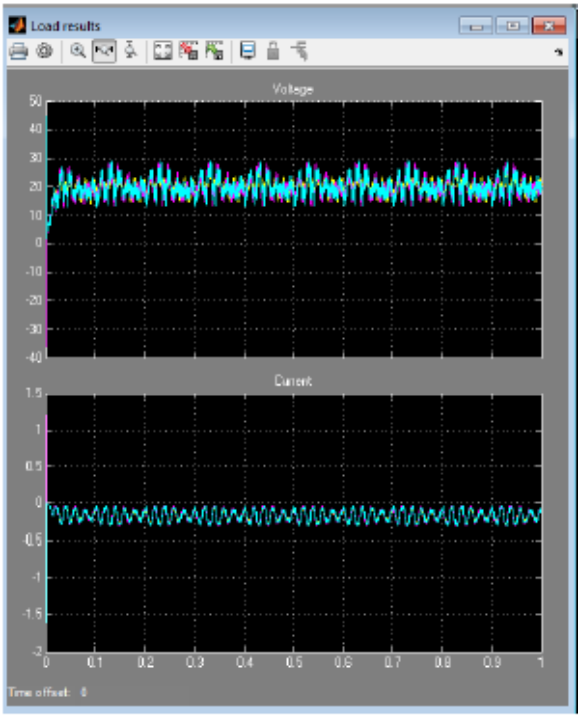


**Fig. 6. Load result voltage and current**

The above waveform describe the behavior of voltage and current during loading conditions.

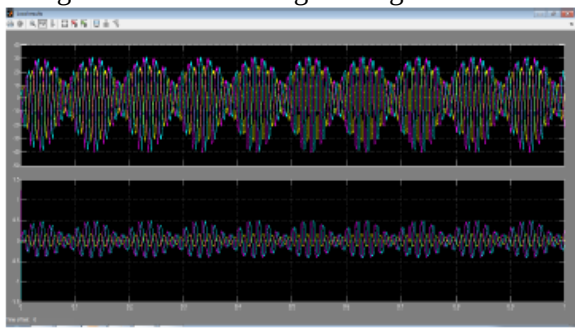

**Fig. 7. Load Result 2**

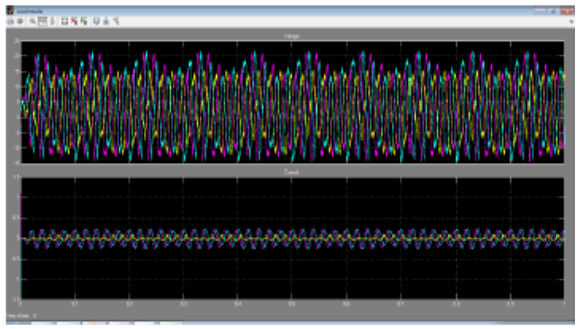

**Fig. 8. Load result 3**

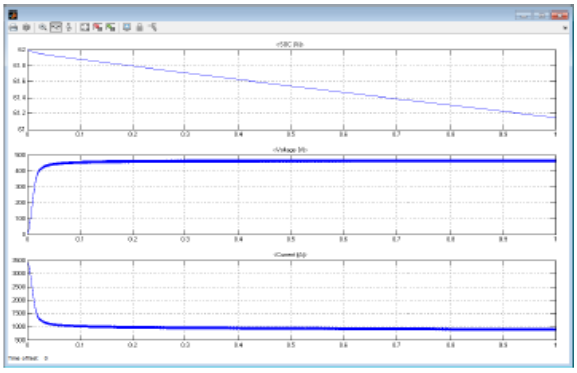

Fig. 11. State of Charge of the Battery

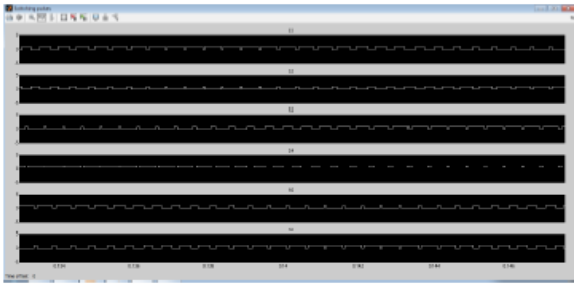

Fig. 12. Switching pulses

## IV. Conclusion

Concerning the future work, a design of the solar panel parking will be done and an experimental small scale microgrid will be realized to test whether it should be implemented or not. Smart Microgrid are the future of the grids since they provide concrete solutions to the problems faced by the old grid. They can be implemented in small areas as well as large ones such as cities.

a. The modeling and control can be done for the islanded mode of operation.

b. The control mechanism can be developed for a microgrid containing unbalanced and nonlinear loads.

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