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An Intelligent Management of A Microgrid in Grid-Connected and Islanded Modes Employing (Mas) Procedure With Fuzzy

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ABSTRACT

This paper presents an intelligent control of a microgrid in both grid-connected and islanded modes using the multiagent system (MAS) technique. This intelligent control consists of three levels. The first level is based on local droop control, the second level compensates power balance between the supply and the demand optimally, and the third level is at the system level based on electricity market. An intelligent MAS was developed and implemented based on foundation for intelligent physical agents standards by representing each major autonomous component in the microgrid as an intelligent software agent. The agents interact with each other for making their own decisions locally and optimally. The coordination among the agents ensures power quality, voltage, and frequency of the microgrid by determining the set points that optimize the overall operation of the microgrid. The proposed control architecture and strategies for the real-time control of microgrids were analyzed in detail, and tested under various load conditions and different network configurations. In extension we proposed fuzzy controller .It is a real time controller or advanced controller for removing the harmonics and it give high accuracy.

I.INTRODUCTION

Microgrids are low-voltage power distribution systems with distributed energy resources, such as photovoltaic (PV) systems, fuel cells (FCs), and microturbines together with storage devices, such as flywheels, energy capacitors and batteries, and controllable loads, offering good control capabilities over the network operation. Microgrids can be interconnected to the main power grid or islanded from the main power grid based on the operating conditions and the status of the microgrid and the main power grid. The control and management of microgrids concerns the functions such as energy management, system stability, voltage quality, active and reactive power flow control, islanding detection, grid synchronization, and system recovery. Nowadays, microgrid control and energy management are gaining significance in research due to its distributed characteristics and necessity of advance control capabilities for the modern active network operation. In recent years, interest in the multiagent system (MAS) technique has been growing in order to deal with the complex and distributed problems in electrical power engineering. MAS technology is being investigated in a variety of applications in power engineering, including system restoration disturbance diagnosis and secondary voltage control. Very recently, agent-based technology has been deployed to manage power distribution systems. McArthur *et al* gave an insight into concepts, approaches, technical problems, and potential values of the MAS for power engineering applications. In addition, standards, tools, supporting technologies, and design methodologies that could be incorporated for the implementation of MAS for power engineering were described. In-depth theory of autonomous systems in power system control and operation is discussed.

Dimeas and Hatziargyriou [18]–[20] have described the agent-based technology for the control of microgrids and presented how local intelligence of agents can provide optimal and effective control solutions. Their research mainly focused on the implementation of real-time market-based microgrid operation. In addition, the applications of MAS in power engineering are highlighted in [21] and [26]. These research works show the potential of this distributed computational intelligent technique for the future power system operation. In this paper, an intelligent MAS architecture for the control and management of a microgrid is proposed. Logenthiran *et al.* [27] have presented an MAS for a realtime operation of a microgrid through a real-time digital simulator, but it mainly concentrates only on the real-time power management. This paper deals with a real-time control of microgrid from a power electronics perspective, and the implementation issues are discussed in detail. Intelligent control concepts used to ensure stable real-time operation are also presented. In the test system, generators and FCs are capable of producing controlled active power on demand. Hence, they are used to regulate voltage and frequency during islanded operation. In contrast, PV system is not a dispatchable source because its output power mainly depends on climatic conditions. Therefore, it is optimally used as a supplementary source during the operational mode of the microgrid. Furthermore, a power-sharing method was developed for dispatching distributed generators (DGs) in the microgrid.

To effectively control distributed resources within a microgrid, distributed and cooperative control architecture is facilitated within the MAS technology. Control strategies were developed by representing each major component in the microgrid as an autonomous intelligent agent, which is able to communicate with other agents to make its own decisions. The MAS was implemented in Java Agent Development Framework (JADE) [28], which is an open source foundation for intelligent physical agent (FIPA) [29] complaint multi agent platform. The microgrid was modeled in MATLAB. A real time communication interface between the MAS and the microgrid was implemented

II.CONFIGURATION OF A MICROGRID

This paper considers a hybrid microgrid that is suitable for integrating renewable and distributed energy resources as well as including an energy storage system. Fig.5.1 shows a schematic configuration of a hybrid microgrid, which was modeled in MATLAB. Microgrid has several distributed energy resources and each resource has their own characteristics.

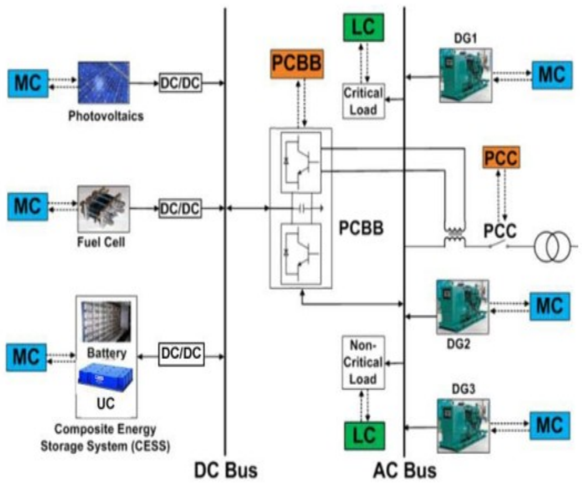

Fig 1. Configuration of a hybrid microgrid.

Microsources

The microgrid consists of several distributed energy resources, such as PV system, FC, and DGs. They are connected via suitable power electronic interfaces. PV system generates power from solar radiation that varies with time. FC operates under steady-state conditions. The available models of PV and FC [30] were used in the microgrid modeling. All these distributed energy resources have their own MCs. In order to construct the test case, real insolation and temperature data for PV were used. DGs participate in an electricity market that is run by the secondary level control. In the case study, three DGs operating with diesel, biodiesel, and natural gas were included. Their power outputs are controlled based on their fuel costs.

Composite Energy Storage System

Energy storage is extremely important in a renewable powered microgrid due to the intermittent nature of renewable energy sources and continuous variations in load-side demand [31]. Composite energy storage system (CESS) consists of a high energy density storage component such as battery to meet the demands of intermittent nature of renewable energy sources such as PV systems and highpower density storage element like ultracapacitor to meet quick fluctuations of load demands. In this paper, a battery bank and an ultracapacitor-based CESS is utilized to smooth out power fluctuations in the renewable energy generation, thereby improving the reliability and efficiency of microgrids. The dc bus voltage of microgrid is fixed and controlled by CESS. A real-time CESS model was used to model the microgrid.

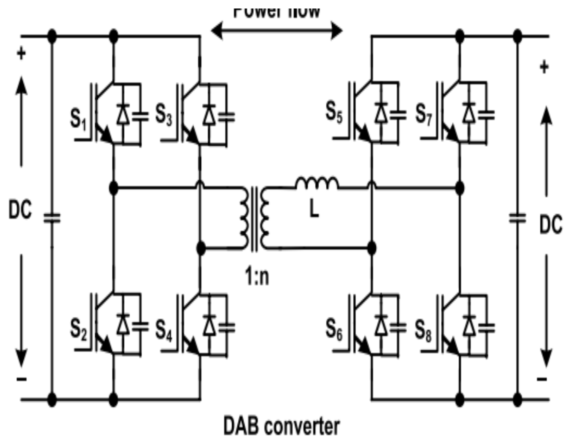

Fig.2. DAB bidirectional dc–dc converter.

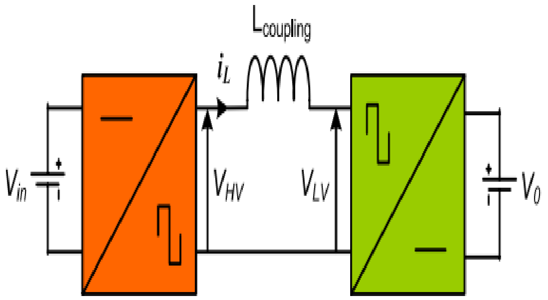

Fig.3. Simplified equivalent circuit of DAB dc–dc.

The power interface of CESS is achieved through the dual-active-bridge (DAB) converter as shown in Fig.2 and its simplified equivalent circuit is shown in Fig.5.3. Any number of parallel DAB branches can be used to meet the requirements of CESS. Power transfer is achieved by phase shifting the voltage across the primary and secondary sides of the high-frequency transformer. The detailed operating principle of DAB and its model is presented.

The average output current of the DAB converter is given by

$$I_0 = \frac{T_S n V_{in}}{2L}(d - d^2) \qquad (1)$$

where I_0 is the output current on the secondary side, d is controlled phase shift, V_{in} is the input voltage on the primary side, L is the coupling inductance, T_s is switching time, and n is the turns ratio of transformer. The average output power of the DAB converter is expressed as

$$P_0 = \frac{n V_{\text{in}} V_0 T_S}{2L}(d - d^2) \qquad (2)$$

$$P_0 = V_0 I_0 \qquad (3)$$

$$P_0 = \eta P_{in} \qquad (4)$$

where Pin is input power on the primary side, P_0 is output power on the secondary side, η is conversion efficiency, and V_0 is secondary side terminal voltage. Lumped model of energy storages in CESS is characterized by energy capacity, power ratings, and maximum ramp rate of

power. The state-of-charge (SOC) of CESS is calculated based on current integration, which is

$$\Delta \text{SOC} = \frac{\Delta Q}{Q} = \frac{\int i_{\text{ES}} dt}{Q}$$

where Q is rated capacity and i_{ES} is current drawn from energy storage.

III.PROPOSED CONTROL ARCHITECTURE

Smart grid, a future power system, looks for fully decentralized control architecture but it cannot be changed suddenly from centralized to decentralized control architecture. It should be changed gradually. Currently, researchers propose some new partially decentralized control architectures for different types of power systems and do case studies to validate them. Various control and management architectures have been proposed in the literature for microgrid control. In this paper, the three-level control architecture, as shown in Fig.5.4, is proposed for microgrid control. The proposed control concepts are defined according to the performance and requirements of the overall system. Even though this paper mainly focuses on the real-time control of microgrid, it presents all control levelsfrom the bottom level to the top level.

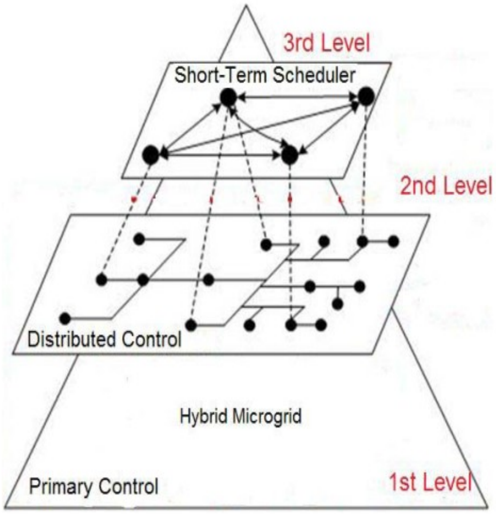

Fig.4. Three-level control architecture for microgrids.

First-Level Control

The bottom-level control incorporates local controllers (LCs) for microgrid elements. They have the ability to respond quickly. The LCs control the resources without any communications. Controllers respond based on local measurements and system dynamics to ensure power balance between supply and load. These controllers provide instantaneous power balance when frequency deviation occurs. The first-level control is designed using a governor control system, which controls the change in frequency or speed of generators when any incident occurs.

Second-Level Control

The second-level control is used for compensating power imbalance between the power supply and the load optimally. The second-level control is also responsible for control actions when a microgrid frequency deviation occurs. It calculates the amount of power needed to bring the system to the reference frequency, and shares that power among the resources optimally. This control strategy is based on real-time measurements, and the control procedure takes all the sources into account. The new generation set points are produced by adding the calculated power correction to the initially assigned power. In this paper, these are carried out by the corresponding individual agents.

Third-Level Control

The third-level control is at the top of the control architecture, and implemented with a short-term scheduler (i.e., day-ahead planner) whose basic functionalities include generation scheduling, demand side management, market participation, load forecasting, wholesale energy price forecasting, and renewable energy forecasting [36]. This control performs supply–demand matching in 30-min intervals as wholesale market price varies in 30-min intervals.

IV.EXISTING RESULTS WITH PI CONTROLLER

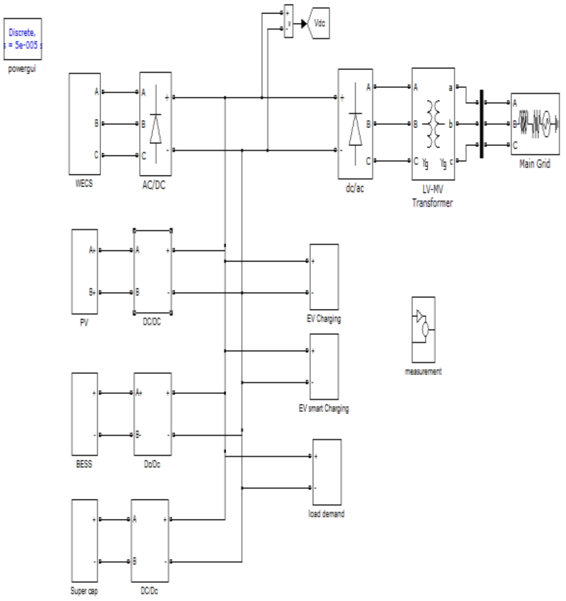

FIG 5 MATALB/SIMULINK DIAGRAM OF PROPOSED SYSTEM

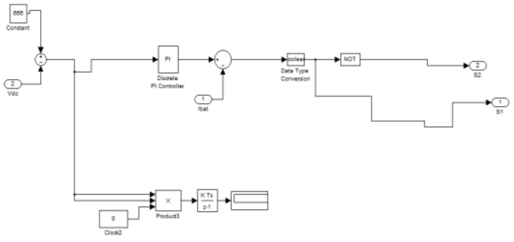

FIG 6 Subsytem of controller with PI

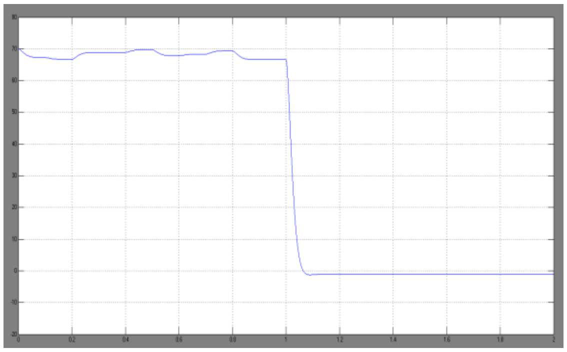

Fig 7 MESS power

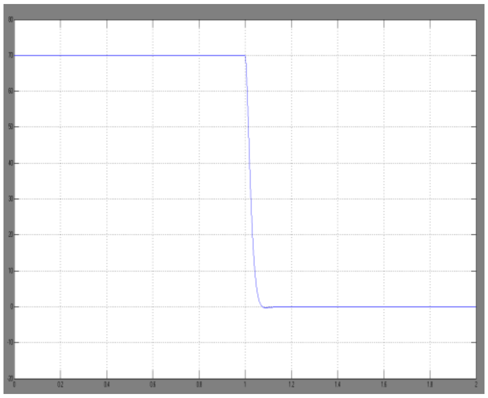

Fig 8 BESS power

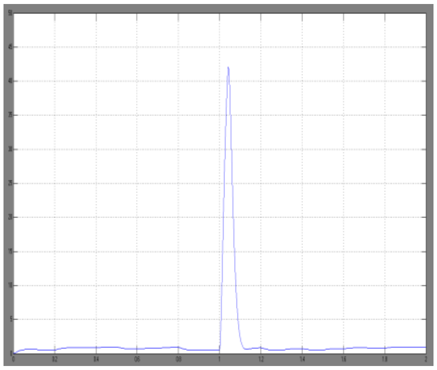

Fig 9 Super capacitor active powe

II. EXTENSION RESULTS WITH FUZZY CONTROLLE

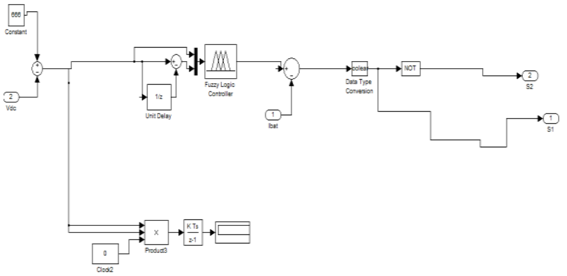

FIG 10 Subsytem of controller with FUZZY

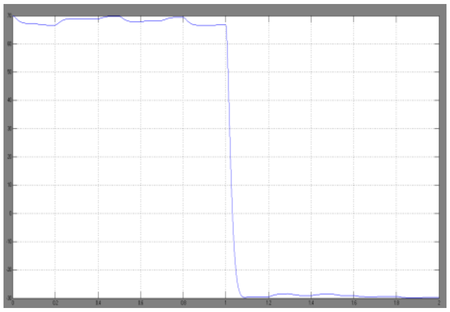

Fig 11 MESS power

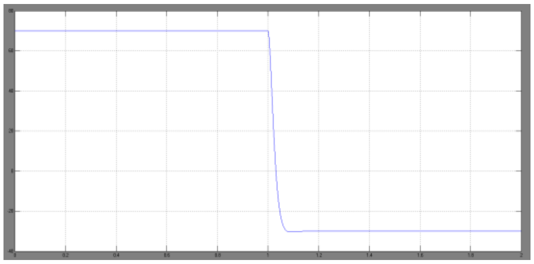

Fig 12 BESS power

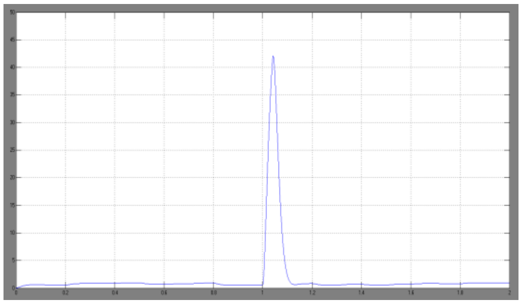

Fig 13 Super capacitor active power

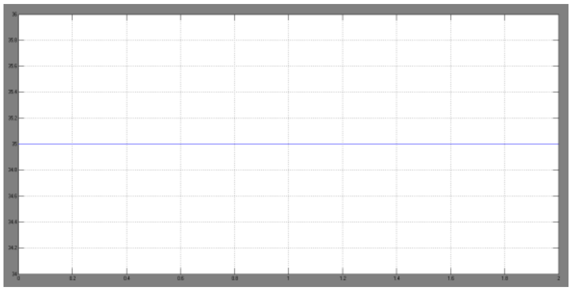

Fig 14 grid active power

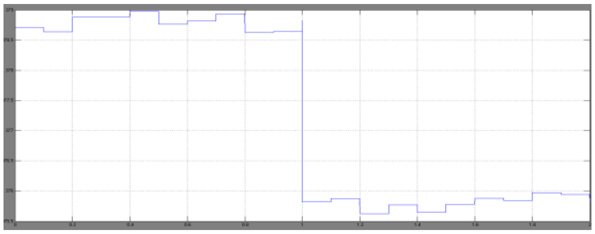

Fig 15 Vdc

CONCLUSION

This paper presented an MAS approach for the intelligent control and management of a microgrid. The distributed realtime control system is proposed with droop-based LCs and some deliberative controllers. The proposed control system is implemented on an MAS. Details about the multiagent architecture and the development of the MAS were described in this paper. Further, details about modeling of microgrid and its components are described in this paper. The agents manage the corresponding energy sources and loads according to their individual objectives and goals. The MAS provides a two-way communication channel for all elements in the microgrid. This communication channel is used for cooperative, competitive, and negotiation processes among the entities for the real-time control of the system. To demonstrate the effectiveness of the proposed multiagent-based control system, some case studies were carried out on a hybrid microgrid. Outcomes of the studies show the proposed approach can provide successful performance for the real-time control of microgrids. In extension we proposed fuzzy controller .It is a real time controller or advanced controller for removing the harmonics and it give high accuracy

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