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DESIGNING AND OPERATIONAL MODES OF DHPS CONNECTED TO MICROGRID

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Abstract
The preparation of renewable energy in modern power system, microgrid has become a popular application in worldwide. In this paper bidirectional converter for AC and DC hybrid microgrid application is proposed in a convinent interface. This concept proposes a control design methodology for the design of Distributed Hybrid Power System (DHPS) connected to microgrid. There is a generic current loop for different modes of operation to ease the transition between different modes, including stand-alone inverter mode, grid-tied inverter mode, ac voltage regulation is of importance because of the sensitive loads in dc-microgrid applications. DHPS requires a bi-directional inverter to control the power flow between the dc bus and ac grid, and to regulate the dc bus to a certain range of voltages. To reach the goal of DHPS operation of bidirectional power conversion, both rectifier and inverter modes are analyzed. The simulation results are carried out by Matlab/Simulink to verify the performance of the proposed method.

Index Terms: DHPS, Bidirectional converter, PWM technique, Distributed Generation system.

I. INTRODUCTION

Currently, industrial countries generate most of their electricity in large centralized facilities, such as coal, nuclear, hydropower or natural gas-powered plants. These plants have excellent economies of scale, but usually transmit electricity over long distances. Most plants are built this way due to a number of economic, healthy, safety, logistical, environmental, geographical and geological factors. For example, coal power plants are built away from cities to prevent their heavy air pollution from affecting the populace; in addition, such plants are often built near collieries to minimize the cost of transporting coal.

Distributed generation is another approachto the manufacture and transmission of electric power. It reduces the amount of energy lost in transmitting electricity because theelectricity is generated very near where it is used, perhaps even in the same building. This reduces the size and number of power lines that must be constructed [9]. If renewable energy resources are used as distributed generation resources, the distributed hybrid power systems can also be referred as renewable energy systems. Figure 1.1 illustrated a typical renewable energy system with a conventional utility grid.

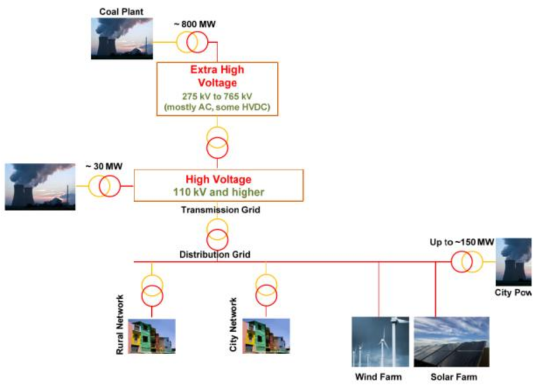

Fig 1. Large scale renewable energy system interacted with utility grid

Distributed hybrid power systems (DHPS) consist of ac and dc sub-systems connected to various load types, where the DG resources can beeither dc or ac sub-system-based [10]. A self-sustainable energy system has been built in the lab of Centre for Power Electronics Systems (CPES), and was interconnected with a solar converter, a utility grid, and load in boththe power and communication sense; in addition, a wind converter was wired to be part of the system.

The critical component of this system is the bi-directional converter, which connects the dc and ac sub-systems together, and connects the system with the utility grid. Figure 1.2 shows a probable single-phase DHPS with energy storage on the dc side and other renewable energy resources through the system.

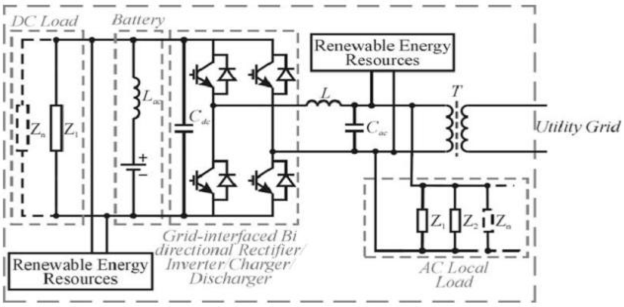

Fig 2. Structure of Single phase DHPS

II. DISTRIBUTED HYBRID POWER SYSTEMS (DHPS)

In recent years, due to the growing concern with energy shortage and network stability, the concepts of distributed generation (DG), microgrid systems, ac/dc hybrid power systems have all become progressively more popular; especially with the decreasing costs of various clean renewable energy sources (RES), such as: wind, solar, and fuel-cells to name a few and more adoption of dc powered residential loads, such as solid state lighting. These DG systems would be connected to the utility grid under normal operating conditions, but also have the additional capability to sustain a local system (micro- or nanogrid) by sourcing power directly from the renewable energy sources and energy storage devices if necessary to make grid transmission level black- and brownouts seem transparent to the local system loads.

Distributed hybrid power systems (DHPS) consist of ac and dc subsystems connected to various load types, where DG resources can be connected on the ac or dc systems. The critical component for such a system is the ac/dc bidirectional, pulsewidth-modulation (PWM) converter that connects the ac and dc subsystems together and to the utility grid. The diagram in Fig3 illustrates an example of a , DHPS with renewable energy sources throughout the system.

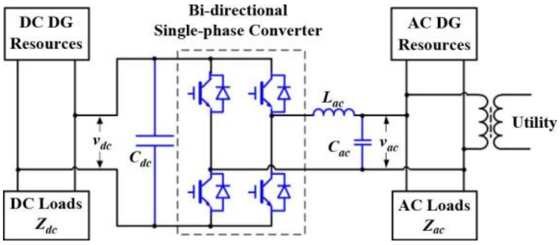

Fig 3 single phase AC/DC interactive renewable energy system

Using this type of system configuration, the ac/dc converter of a DHPS should operate in the following modes

1) Stand-Alone Mode (SAM): When the grid is lost, the converter regulates the ac bus voltage and frequency feeding the ac loads while drawing energy from dc-side, supported by the renewable energy sources or energy storage on the dc-side. The RES on the ac side act as current sources in this case.

2) Grid-Connected Mode (GCM): When the grid is present, the converter acts as an ac current regulator, injecting or sinking power from the grid to achieve: a) Inverter submode: Regulate the power flow (active and reactive) between the dc and ac subsystems,while other dc sources regulate the dc bus voltage , b) Rectifier submode: Regulate the dc bus voltage and performs energy balancing to sustain dc bus integrity while other dc side energy sources operate as current sources.

3) Grid-Disconnected Mode (GDM): When the grid is lost, the converter still operates as GCM inverter/power flow control supplying ac loads. Normally, GDMis the transient state inmode transition between GCMand SAM; however, given the nondetection zones (NDZ) [8], GDM could exist for a while.

III. MODES OF OPERATION: MODELLING AND CONTROL STRUCTURE

Many of the existing methode requires a different control system for each mode of operation, which increases the complexcity and decreases the reliability and also increase the difficulty between the modes of operation. As it will be shown some of them requiring different control approaches.

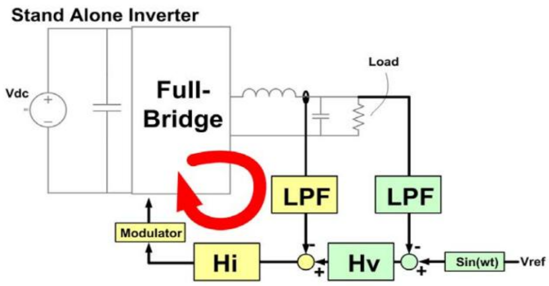

Fig 4 control structure of SAM

The dc-link voltage is one of the state-variables for the grid-tied rectifier mode; the dynamic of the dc-link voltage should be taken into consideration, since it leads to the non-linearity for the rectifier mode. From the average state space model, the state matrix is not constant, varying with the duty cycle. The eigen value of the system would be changing with the duty cycle. In other words, the characteristic of the system would vary all the time.we will see the low frequencies, the system dynamics would be more affected by the dc link capacitor.

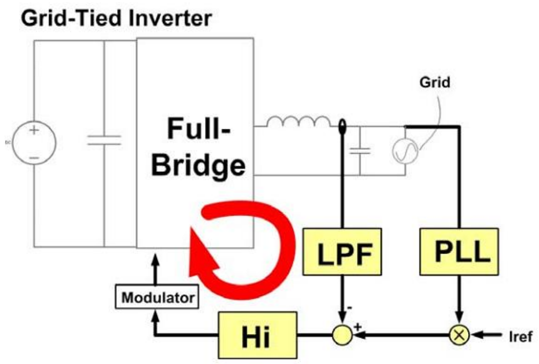

Fig 5 Control Structure of GCM inverter

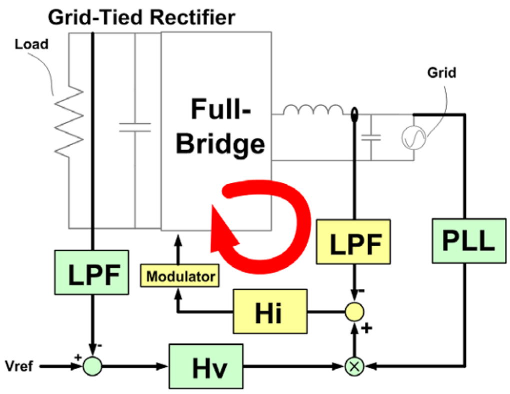

Fig 6 Control Structure of GCM rectifier

We can see that all modes have an inner-line inductor current loop. This paper proposes that all modes share the same inner current loop. In order to combine the inner current loops, the current loop dynamic response should be checked particularly at the crossover frequency. The proposed control structure is selected asdouble loop feedback controller as shown in Figure . The inner loop is selected as the ac current of the line inductor to achieve fast dynamic response for input disturbances, and the outer loop is designed with different compensators to regulate the desired control variables, such as ac voltage, dc voltage and dc charging current.

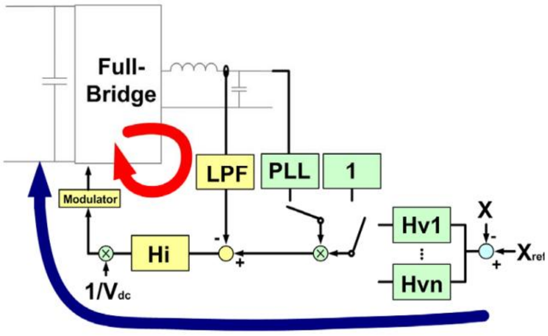

Fig 7 Control Structure of Hybrid system

IV. SIMULATION RESULTS

The performance of the proposed control strategies was evaluated by computer simulation using MATLAB/SIMULINK platform. Here simulation is carried out in different cases as described above.

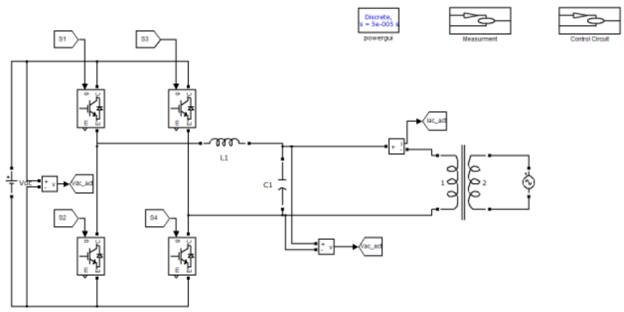

Fig 8 Matlab/simulink model of GCM inverter model

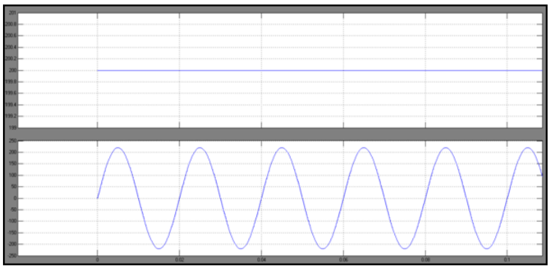

Fig 9 shows the output voltage of GCM inverter

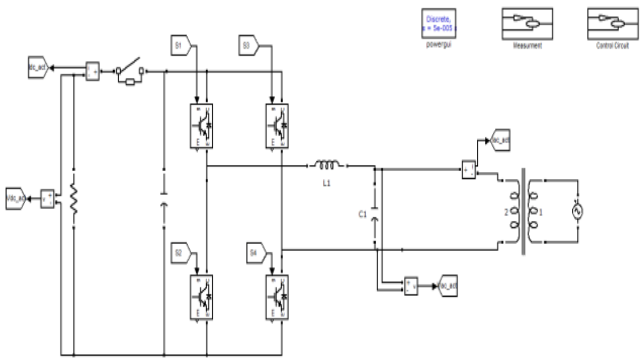

Fig 10 Matlab/Simulink model of GCM rectifier mode

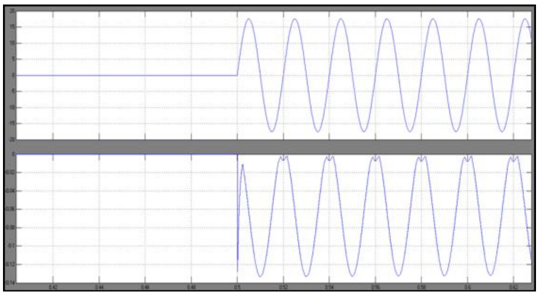

Fig 11 shows the output of GCM rectifier mode

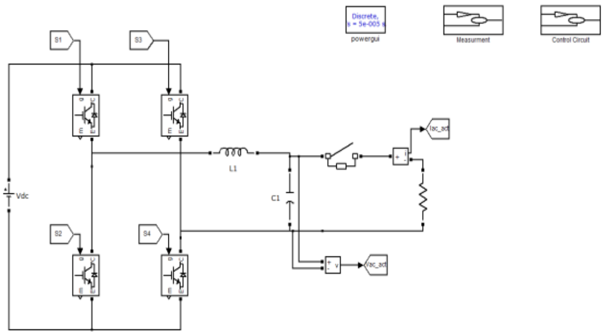

Fig 12 Matlab/Simulink model of SAM inverter mode

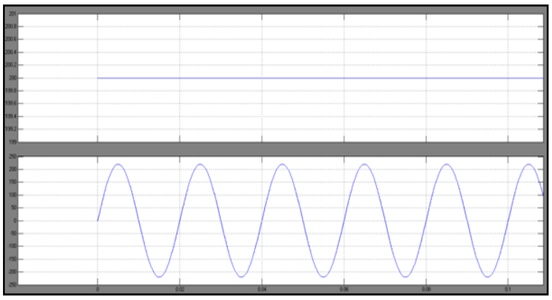

Fig 13 shows the output voltage of SAM inverter mode

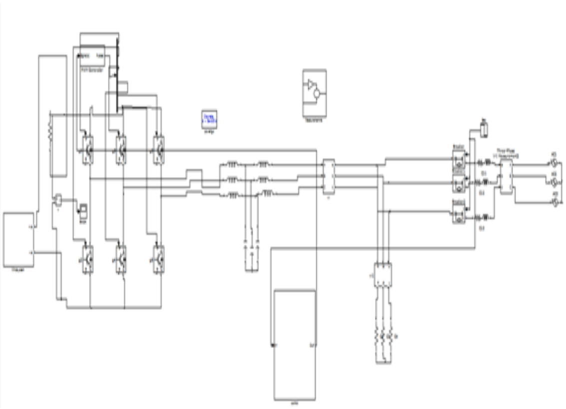

Fig 14 MAtlab/Simulink model of proposed hybrid system

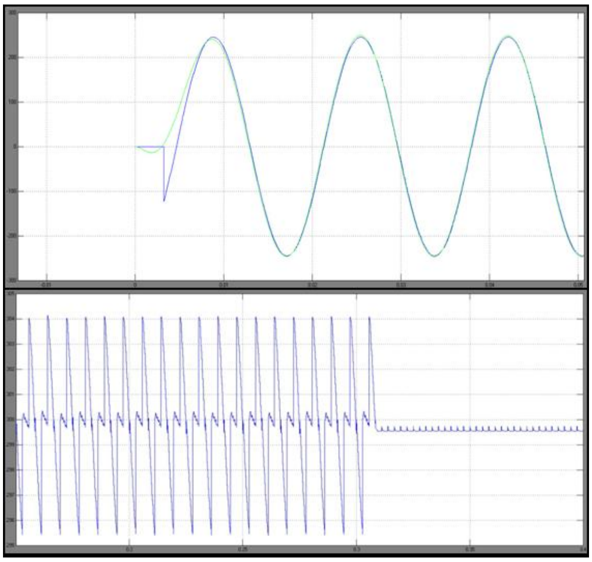

Fig 15 shows the output of Hybrid system

V. CONCLUSION

In general, the energy source in a hybrid distributed energy power system is a fuel cell, a micro turbine, or a photovoltaic cell. These energy conversion devices produce a DC voltge, which must be converted into AC voltage for residential or industrial application. A voltage & current control design is used to interface with grid connected operation. The proposed system shows the acceptable response of operation, where the voltages and currents are in acceptable levels.

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