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Fuzzy Based Analysis of Inverter Fed Micro Grid in Islanding Operation-Experimental Analysis

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Article Info	ABSTRACT
	Islanding operation in essence connotes isolating part of a power system not unlike distributed generation. This thesis puts forward fuzzy logic controller for inverter fed micro-grid in islanding operations which is assessed using hardware implementation. It's assisted by power electronics which imparts the control and flexibility essential for the micro grid concept. A correctly designed controller guarantees that the micro grid can meet its utility's demands. The efficacy and robustness is deliberated in the design of fuzzy system. The testing is performed by employing hardware components namelyATMEGA-328microcontroller, TLP250 opto-coupler and a MOSFET circuit. The test results demonstrate very good consistency and show noteworthy implications of the control of micro grid using inverters and fuzzy controllers.

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1. INTRODUCTION

At the present time, micro grid can be regarded as a controlled cell of a power system. Example gratia, the cell may well be controlled as a single dispatch able load, which can react in little time to provide the demands of the transmission system. On the customer side micro grids can be constructed to meet unique needs. They boost the local reliability, lessen feeder loss, support local voltages, deliver superior efficacy through castoff waste heat, voltage sag correction and providing uninterruptible power supply functions. These days distributed generation is fetching more recognition in a de-regulated environment. Incorporation of distributed generation and assimilation of controllers has lead to conventional power network to function as an active power networks. Under this disruption the power network splits into part generators and loads. The load demand can be tallied with the supply power of an island. In case of commercial and industrial sensitive loads the necessity of superior power quality and reliability is great. A micro grid can be a DC grid system, an AC system or even a high frequency AC grid system. A Micro grid system is organised as an island. The key concern to be deliberated for distributed generation is the technical problem associated with control of a considerable number of micro sources. The basic problem with an intricate control system is that a failure of the control module or a software error will bring the entire system down.

In this thesis, a fuzzy controller was realised with inverter fed micro grid for islanding operation and evaluated against conventional controller. The performance results of Fuzzy controller are obtained using Mat lab/Simulink as well as hardware implementation. This manuscript employs a reference frame, which is instantaneously synchronized to the micro grid bus voltage, to develop a dynamic model of an islanded micro grid. Here in the Section II of the manuscript exhibits the system's elementary structure while Section III proposes a supervisory control arrangement to control the voltage and frequency of the micro grid and

presents simulation results of an islanded micro grid based on instantaneous synchronization. Section IV concludes with the results of hardware implementation.

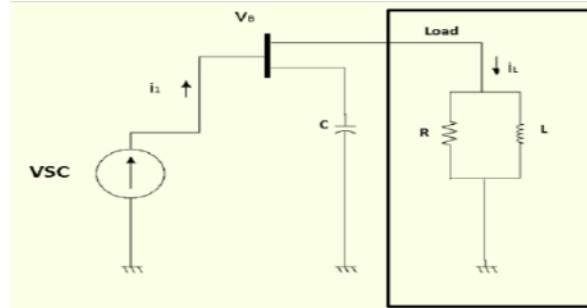## 2. POWER NETWORK IN ISLANDED MODE

Figure 1. Converter based Power Network in islanded mode

The Figure 1 infers the arrangement of a basic micro grid. The system comprises of a collector bus, a converter, a bus capacitor C and a load. The load is denoted as a parallel combination of resistance R and inductance L and the load is presumed to be in an imbalanced condition. With all these assumptions, a fundamental frequency model of the converter is justified, where the converter is modelled as an average current source.
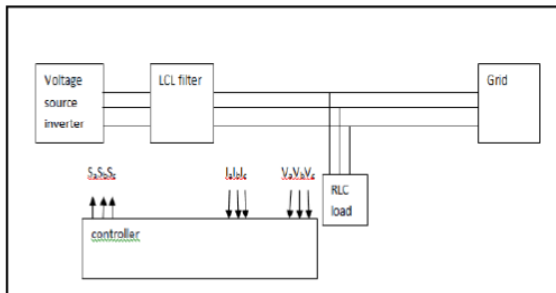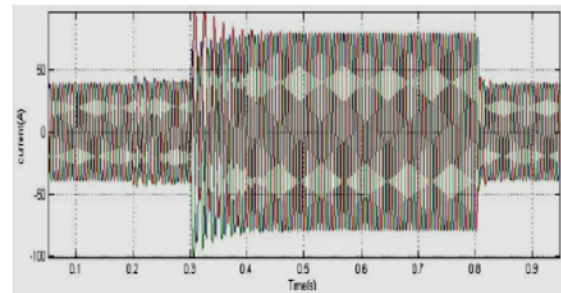

Figure 2. Inverter fed Microgrid

Figure 3. Inverter current

The Figure 2, displays the converter fed Microgrid. It comprises of a dc source, LCL filter and RLC load which is developed and scrutinized in MATLAB/Simulink. The dc source voltage is 400V. Figure 3 shows the grid voltage across the island mode.
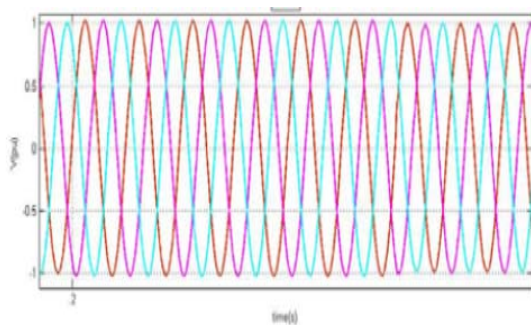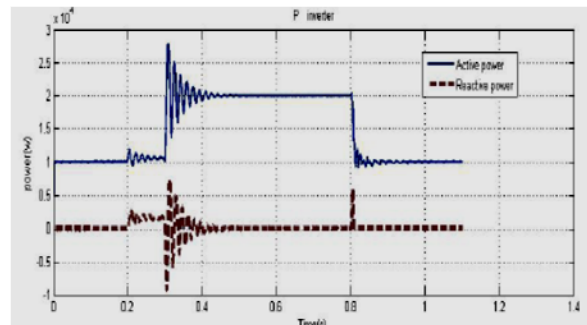

Figure 4. Grid Voltage

Figure 5. Active and Reactive power

Subsequently the synchronization, inverter current rises to 80A. At the time 0.8 sec the DG senses the islanding condition and the control mode changes. From 0.8 sec onwards the current is reduces which indicates the disconnection from grid. This is exhibited in Figure 4. Figure 5 illustrates the active and reactive power after which it is detaches DG from the grid. At 0.2 sec the DG is connected to grid and after synchronization the total active power delivered by the DG becomes 20kW. At 0.8 sec the DG senses the islanding condition and goes to islanding mode so that the active power supplied is reduced to 10kW.
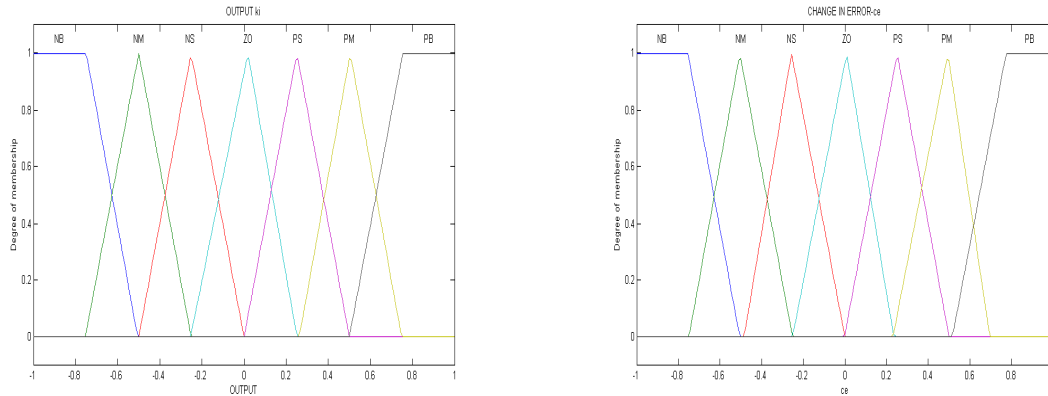

Figure 6(a), (b) Fuzzy membership function for input and output

3. PROPOSED FUZZY-PI CONTROLLER

By presenting the fuzzy technology, the voltage and frequency can be manipulated with a single controller. The error signals from voltage and the frequency block is fed to the fuzzy controller to obtain gain error. The Fuzzy membership function for input and output is illustrated in the Figure 6.
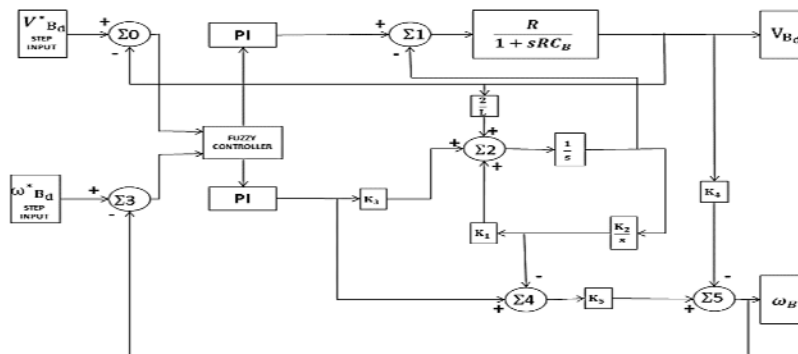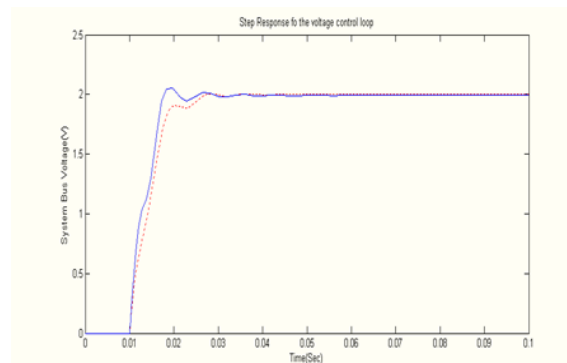

Figure 7. FUZZY-PI based controller

Figure 8. Comparing Fuzzy and PI output for voltage control 'RL' load

From the Figure 8 which demonstrates that for the normal R-L load, the voltage step response has a rise time of 11 ms for a PI Controller. But for the same load, the voltage step response has a rise time reduced to 8 ms and is well damped with 10% overshoot in fuzzy controller.
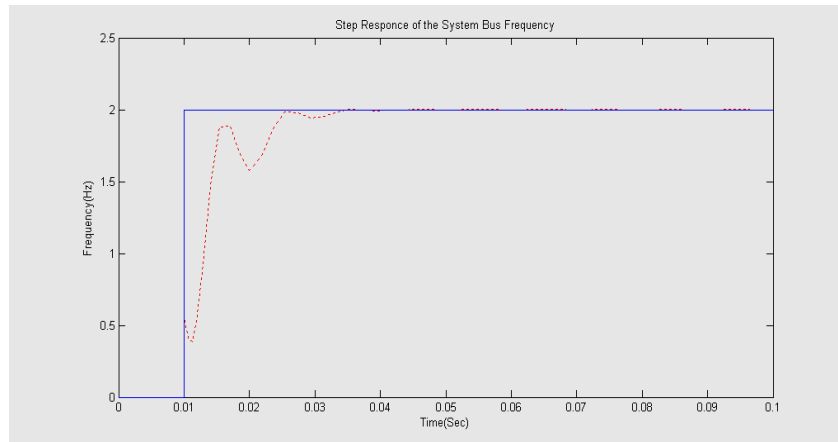

Figure 9. Comparing Fuzzy and PI output for Frequency control 'RL' load

From the Figure 9, for a normal R-L load, the frequency step response has a rise time of 14 ms and a settling time of 28 ms in PI Controller. But for the same load, the voltage step response has a rise time reduced to 8 ms and is well damped with negligible overshoot in fuzzy controller. But for the same load, the frequency step response has risen and settles down immediately at the point in fuzzy controller.

4. IMPLEMENTATION OFF HARDWARE- SECTION IV

A single phase inverter is engineered for this design. The key control component of the Microgrid is the inverter so a single phase inverter is realised. An open loop single phase inverter block diagram is illustrated in Figure 10.
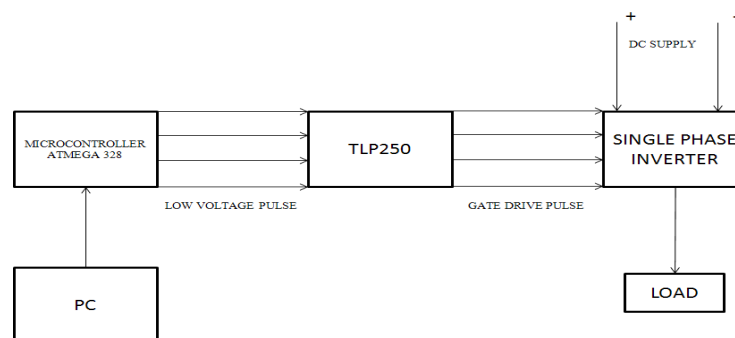

Figure 10. PWM voltage source single phase inverter

5. ISOLATION AND GATE DRIVER CIRCUIT

The opto-coupler TLP250 is employed to impart isolation amid the control circuit and power circuit. Any atypical state in the power circuit may lead to adversely disturb the control circuit through the switch gate terminals. So with the assistance of opto-couplers the physical connection between the control and the power circuit is separated and the signal is given optically from one side to the other. This opto-coupler is employed to drive the MOSFET since the microcontroller will get the pulse only up to 3v, but for driving the MOSFET we require at least 10v pulse. This is realised by application of TLP250opto-coupler.

Experimental Arrangement of the Project

Figure 11. Experimental preparation

Figure 12. Experimental preparation with ATMEGA-328

The experimental preparation of the single phase inverter is illustrated in the Figure 11 & Figure 12 with microcontroller ATMEGA-328, opto-coupler TLP250 & MOSFET circuit.

6. DISCUSSION

The performance of the proposed control strategies was evaluated by computer simulation using MATLAB-Simulink and hardware implementation. The result for PI controller and fuzzy controller were evaluated. It can be observed that:

For a pure resistive load of 3.98 Ω, the voltage step response has a rise time of 25 ms in PI Controller. But for the same load, the voltage step response has a rise time of only 13 ms in fuzzy controller and settles down at those points immediately shown in Figure 8.

Figure 9. Shows that for the normal R-L load, the voltage step response has a rice time of 11 ms in PI Controller. But for the same load, the voltage step response has a rise time reduced to 8 ms and is well damped with 10% overshoot in fuzzy controller.

Figure 14. Shows the response of a pure resistive load of 3.98 Ω, the frequency step response has a rise time of 25 ms in PI Controller. But for the same load, the frequency step response rises and settles down immediately at the point in fuzzy controller.

For the normal R-L load, the frequency step response has a rice time of 14 ms and a settling time of 28 ms in PI Controller. But for the same load, the voltage step response has a rise time reduced to 8 ms and is well damped with negligible overshoot in fuzzy controller. But for the same load, the frequency step response rises and settles down immediately at the point in fuzzy controller as shown in Figure 14.

For Fuzzy-PI controller the starting time of step input is 0, with unit step input. For RL load the closed loop voltage response settled at 0.027sec and for frequency response settled at 0.038 sec, which is shown in Figure 13 and Figure 14.
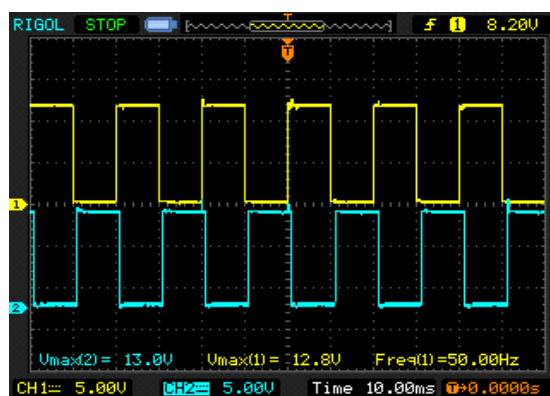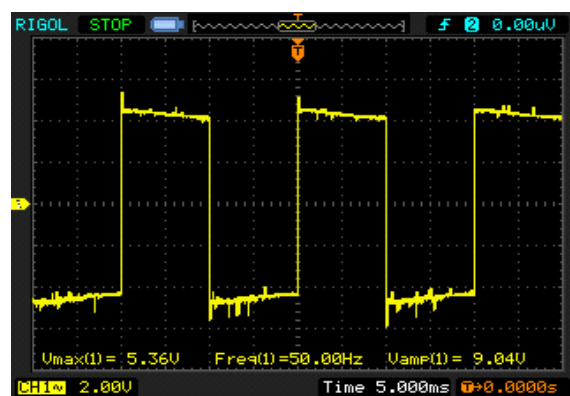

Figure 13. PWM pulse from opto-coupler

Figure 14. Single phase inverter output for R Load

7. CONCLUSION

It can be concluded that distributed generation units can be run in islanded mode by connecting it to the grid via power electronics converters. Fuzzy model of an islanded Microgrid is articulated in a reference frame that is promptly synchronized to the collector bus voltage. Simulation and implementation outcome establish legitimacy of the model and robustness of the suggested control scheme to change system loading and power factor. Simulation results and hardware implementation endorse that this method is efficacious in voltage and frequency manipulation with changing network strictures.

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