International Journal for Modern Trends in Science and Technology
ISSN: 2455-3778 |Volume No: 02 | Issue No: 02 | February 2016

Analysis of Fuzzy Inference Power Control Strategies for Islanding Operation of Microgrids

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Keyword

Distributed resources
Islanding
Micro grid
Power sharing
Voltage regulation

ABSTRACT

Microgrid is a latest notion for future energy distribution system that enables renewable energy integration. It generally consists of multiple distributed generators that are usually interfaced to the grid through power inverters. Fuzzy controller is proposed at Distributed Generation (DG) units for the islanding operation of ac microgrids. Two important jobs are to divide up the load demand among multiple parallel connected inverters proportionately, and maintain the voltage and frequency stabilities. Finally, this paper presents the deviation in power and frequency of micro grids with DG Units.

I. INTRODUCTION

Modern power situation of there is extremely need to control of power control at AC micro grid side. A micro-grid is a portion of a power system which includes one or more DR units and is expected to remain operational after separation from the system. In the context of the study system of Fig. 1, the distribution system, including the loads and the two DG units, constitutes the micro-grid. a large number of renewable energy sources (RESs) have been integrated into the power distribution system in the form of distributed generations (DGs). However, the outputs of many RESs are unregulated dc power or ac power at variable frequencies. To ensure the robust interconnection of these RESs, the interfacing converter with the main grid [1], [2].The islanding phenomenon that results in the formation of a micro-grid can be due to either pre planned or unplanned switching incidents. In the case of a replanted micro-grid formation, appropriate sharing of the micro-grid load amongst the DG units and the main grid may be scheduled prior to islanding. Thus, the islanding process results in minimal transients and the micro-grid continues operation, albeit as an autonomous system. Pre-planned islanding and subsequent micro-grid operation is discussed in [6]. In the context of this paper, a preplanned islanding system can happen by scheduled opening of the circuit breakers at both ends of the line.

Thus, the severity of the transients experienced by the micro-grid, subsequent to Test system used for simulation of interconnected power system is typically divided into control areas, with each consisting of one or more power utility firms. Sufficient supply for generation of each connected area to meet the load demand of its users, load frequency control is one of them. In this work, test system with two areas is considered both are used to determine the parameters of change in frequency of wind power plant in interconnected power system and tie line power according to the system dynamics and statistics. Both conventional and fuzzy techniques are similar in the sense that these two techniques are popular to obtain user require control over the designed system parameters with all constrains of load demand.

An unplanned islanding and micro-grid formation is due to either a fault and its subsequent switching incidents or some other unexpected switching process. Prior to islanding, the operating conditions of micro-grid could be widely varied, e.g., the DG units can share load in various manners and the entire micro-grid portion of the network may be delivering or importing power from the main grid. Furthermore, the disturbance can be initiated by any type of fault and line tripping may be followed up with single or even multiple reclosure actions. Utility diagram of microgrid is shown in figure.

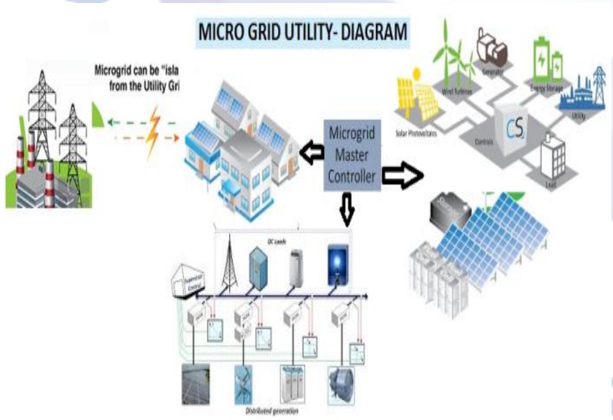

Fig.1. Utility diagram of Microgrid

For analysis of load frequency control, power system with single generator that supplying power to load is considered.

II. Grid Interfacing System

The islanding phenomenon that results in the formation of a micro-grid can be due to either intended or unplanned switching incidents. In the case of a pre-planned micro-grid formation, appropriate sharing of the micro-grid connected load amongst.

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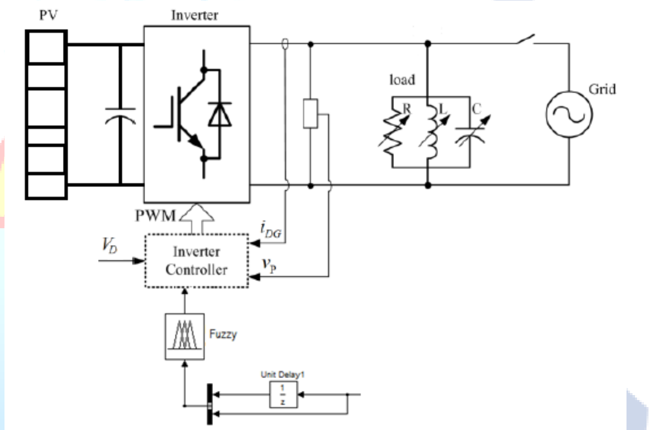

Figure 2. Interface with fuzzy modelling

In order to analyse the load frequency control [4] of power system with mathematical modelling, the needful transfer functions [15] of model. Transfer function of test system i.e. Speed Governor, Turbine and plant are shown as 1st, 2nd and 3rd term of equation. The boundary limits of these parameters define the zone. If the local loads have similar power capacity of the DG system, i.e., all the generated power is consumed locally, then voltage and current levels at the point of common coupling will only vary slightly when islanding occurs. The system variables will be then within the boundary limits and the islanding condition will remain undetected. Passive methods have, therefore, a large grid current. Methods are conceptually simple and easy to implement and do not introduce any change to the power quality of the system.

The relocation and mapping of the frequencies in *f* and *df*, due to the *abc* to *dq*0 transformation of digitized signals, indicate that the high-frequency half-band will have nonzero contents only for transient disturbances. Since the frequencies associated with such events are of nonperiodic and nonstationary natures, the application of a single-stageWPT, to
process *f* and *df*, will return nonzero values for the high frequency subband in the presence of a transient disturbance
such as the islanding condition. The determination of the WPT
high-frequency subband for *sd*[*n*] and *df* can be achieved by a half-band digital high-pass filter *f*, whose coefficients rate of change of frequency [11], voltage unbalance and harmonic distortion [12] are a few examples of passive islanding detection methods. Through the detection of islanding event, these methods allow the control system to precisely decide an appropriate operational mode accordingly. Many islanding-detection algorithms have been proposed in the literature. In general, the islanding detection can adopt either passive or active methods [4]–[7].
However passive methods are based on the measuring parameters of the power system and setting thresholds for the measured parameters. The role interconnecting various types of distributed energy resources, for example, renewable power and energy storage, into the ac electric grid or microgrid. More and more interests are brought into the technical challenges associated with the distributed or local control of these converters in terms of achieving stable steady-state operations, seamless power transitions between grid-connected mode and islanded mode, and the compliance with the general standards and grid codes. Nonetheless to date, very few efforts have been focused on the converter's transient behavior operating from grid-tied mode to islanded mode, which is very crucial to avoid the potential system failure.
The main argue in passive methods is selecting suitable thresholds such that the islanding detection algorithm will not operate under noisy conditions. In this paper, a new method based on a combination of previous methods for diagnosing of an islanding state is proposed because it utilizes of passive methods of high speed that based on measuring and also avoids of wrong diagnosis of the islanding state that

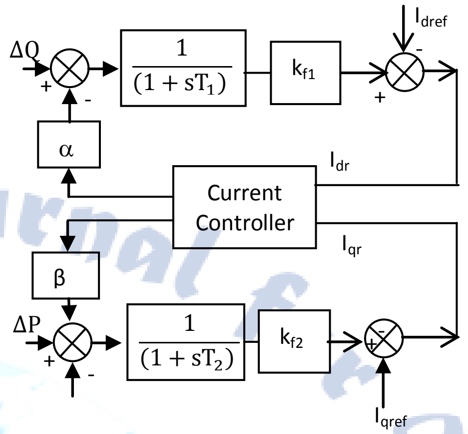

Figure 3. Conventional controller for I_{dr}, I_{qr}

III. Proposed Fuzzy Inference Method for Test System

Three fuzzy inference controller is used in simulation of test system. Original values of data set are change in frequencies ΔF(s) and $\Delta\dot{F}(s)$ are used for improving transient response of power system. TheMamdani method has several variations. There are different t-norms to use for the connectives of the antecedents, different aggregation operators for the rules, and numerous defuzzification methods that could be used. As the foregoing example illustrates, the two Mamdani methods yield different shapes for the aggregated fuzzy consequents for the two rules used. However, the defuzzified values for the output. The power of fuzzy rule-based systems is their ability to yield "good" results with reasonably simple mathematical operations.

Merits of fuzzy logic controllers are mainly solves the non linear problems with vague inputs, not needed an accurate mathematical model, handling nonlinearity. For controlling such a complicated system, fuzzy logic controllers gives very good results like this application. Inputs for fuzzy logic controller are used from wind turbine plant and thermal plant.
Inputs to a fuzzy logic controller are usually a frequency deviation and change in frequency deviation. Here the two inputs for fuzzy logic controller are ΔF and $\Delta\dot{F}$. The values that indicate input variables change of frequency and derivative of change in frequency. Linguistic terms used for the membership functions are such that are terms NL(Negative Large), NM(Negative Medium),

NS(Negative Small), ZE(Zero), PS(Positive Small), PM(Positive Medium) and PL(Positive Large). Fuzzification block converts crisp inputs to one or many membership grade values; where the change in frequency and derivative of change in frequecy accordance with variation of tie-line power, are described by membership functions given in Figure 13 and Figure 14. Membership function of output of control vector is shown in Figure 15. Afterwards, it is possible to apply descriptive rules of reasoning Power searching was POSITIVE and LARGE and the last change of desired change in frequency was PL then keeps tracking the derivative of change in frequency in the same PL direction with PL increment. Rules like this are involved in block “rules table”, and they are given in Table 2. Finally, the fuzzy set of output reference change in frequency is back “deffuzified” to convert it to the actual value.

The membership functions for the ΔF , $\Delta \dot{F}(s)$ and the control output u. The input signals are first expressed in some linguistic variables using fuzzy set notations such as NL(Negative Large), NM(Negative Medium), NS(Negative Small), ZE(Zero), PS(Positive Small), PM(Positive Medium) and PL(Positive Large).

Table 1: Decision table of 7×7 rule base

	$\Delta \dot{F}(s)$						
ΔF(s)	NL	NM	NS	ZE	PS	PM	PL
NL	ZE	PS	PM	PL	PL	PL	PL
NM	NS	ZE	PS	PM	PM	PL	PL
NS	NM	NS	ZE	PS	PS	PM	PL
ZE	NM	NM	NS	ZE	PS	PM	PM
PS	NL	NM	NS	NS	ZE	PS	PM
PM	NL	NL	NM	NM	NS	ZE	PS
PL	NL	NL	NL	NL	NM	NS	ZE

Table 1 shows a set of decision rules[9], also expressed in linguistic variables relating input signals to the control signal.

The test with voltage regulator and comparator with pulse generator is shown in figure 4. Proposed fuzzy system is also shown. Voltage regulator takes reference value of reactive component power from comparator block. Regulator produce output to park transformation block. Ouput of frequency controller was properly weighted with gain factor and fed to fuzzy system. The error and deviation in error are inputs to fuzzy and evaluated output is controller vector. This control vector produce the required pulse generation to inversion operation of converter circuit.

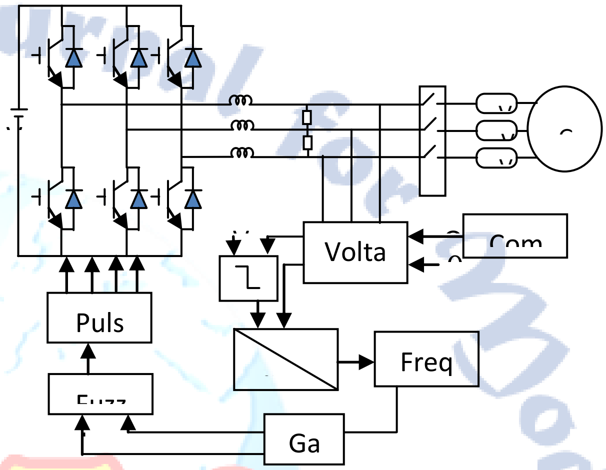

Fig.4. Test system with proposed fuzzy controller.

Input and output membership functions of Fuzzy inference’s are taken as trapezoidal and triangular membership functions respectively. And also 5 numbers of membership functions are used in two inputs and one output of Fuzzy inference. First and second inputs of Fuzzy inference’s are shown in figures.

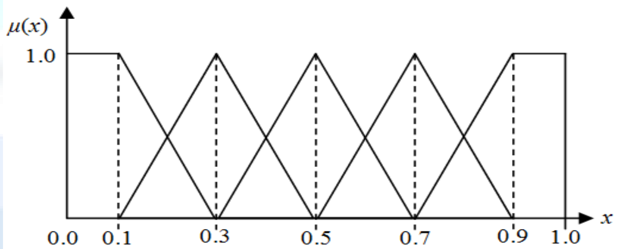

Fig 5. Mebembership funtions of Inputs

Fuzzy with two inputs and one output with 25 rules is shown in figure 5.

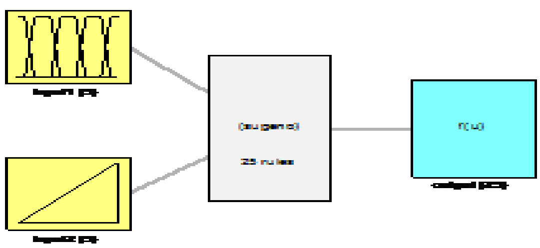

Figure 6. Fuzzy Inference system.

International Journal for Modern Trends in Science and Technology
ISSN: 2455-3778 |Volume No: 02 | Issue No: 02 | February 2016

Membership grades are shown in figure 7.

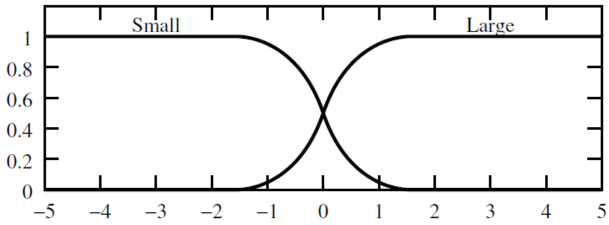

Fig 7. Fuzzy Membership grades of “small” and “Large”

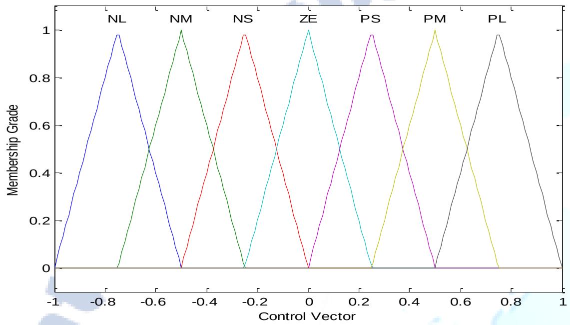

Figure 8. Output control vector, u

IV. Simulation Results

Under islanding conditions, due to a lack of phase margin, the inverter system becomes unstable with a frequency drift away from its steady state. Based on the impedance of the inverter, it can be concluded that the grid-tied inverter with the Fuzzy system in islanding method has the potential to destabilize the grid connected inverter system when the grid is weak. Power and grid voltage are plotted with proposed method.

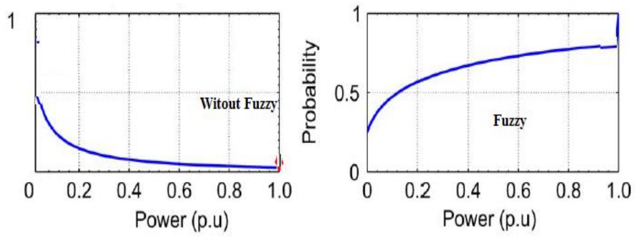

Fig.9 Power at inverter side of microgrid

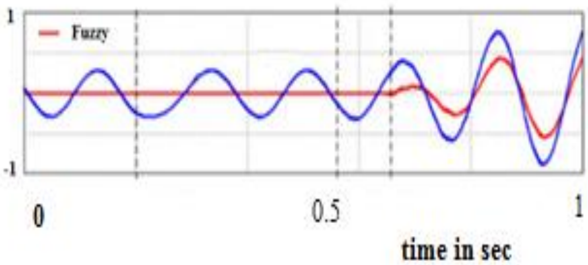

Fig.10 DC Voltage oscillation.

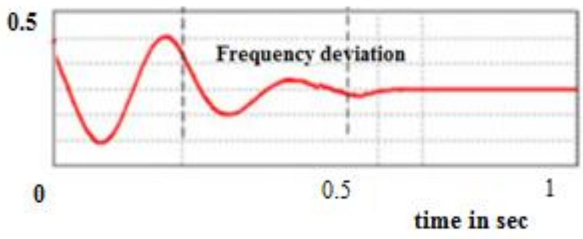

Fig.11 Frequency deviation.

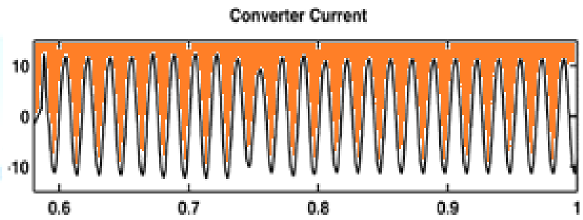

Fig.12 Converter Current.

Steady state of response is obtained at 0.5sec to simulation time. Simulation results with test system shows improved performance. In all cases, fuzzy exhibits its superiority in improving results such as voltage at grid and frequency deviations.

V. Conclusion

The output abc 3-phase quantities of a grid-tied inverter was modelled in the *d-q* concept. The model shows that improved output of the converter and shown better power control. For these reasons, DG systems must detect an islanding condition and immediately stop producing power; this is referred to as anti-islanding. Islanding detection can be approached. The converter current also is in the limits of +0.1 to -0.1 p.u. With proposed fuzzy system, the DC voltage, output power and frequency oscillations are considerably reduced.

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