A microcontroller based islanding detection for grid connected inverter

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***Abstract*-This paper presents the development of a microcontroller based islanding detection for grid connected inverter with very simple under/over voltage and under/over frequency islanding detection algorithms. The system based on a microcontroller from Microchip Technology Inc. PIC family. A PIC microcontroller searches the under/over voltage and under/over frequency from utility grid and processed the value of voltage and frequency for turned on – off relay between grid connected inverter and utility grid.**

I. INTRODUCTION

Islanding is a condition in which a portion of the utility system, which contains both load and generation, is isolated from the remainder of the utility system and continues to operate. The isolation point is generally on the low voltage distribution line when an islanding condition exists, but islanding may also occur on the higher voltage distribution or transmission lines when large numbers of photovoltaic (PV) and other distributed generation are present. The islanding may occur from accidental opening of the normal utility supply by equipment failure, utility switching of the distribution system and loads, human error, act of nature, etc. There are many reasons that islanding should be prevented with photovoltaic or any other distributed energy generation. Safety, liability and maintaining the quality of delivered power to customers ranks high on the list of reasons. Utilities are liable for providing quality power to paying customers therefore they require anti-islanding on PV inverters because: 1. The utility cannot control voltage and frequency in the island, creating the possibility of damage to customer equipment in a situation over which the utility has no control. 2. Utilities, along with the PV distributed resource owner, can be found liable for electrical damage to customer equipment connected to their lines that results from voltage or frequency excursions outside of the acceptable ranges. 3. Islanding may create a hazard for utility line-workers or the public by causing a line to remain energized that may be assumed to be disconnected from all energy sources. 4. Reclosing into an island may result in re-tripping the line or damaging the distributed resource equipment, or other connected equipment, because of out of phase closure. 5. Islanding may interfere with the manual or automatic restoration of normal service by the utility [1].

Figure 1. shows the overall block diagram of photovoltaic generation system and a microcontroller based islanding detection. The photovoltaic generation system is composed of the photovoltaic array, the step up full bridge dc-dc converter, the full bridge dc-ac inverter, LC filter and protection circuit. In this paper focused on protection circuit, the protection circuit consisted of voltage, current and frequency sensors, microcontroller and LCD display. This paper describes the implementation of a microcontroller based islanding detection for grid connected inverter, which has the capabilities of searching the value of voltage and value of frequency for under/over voltage and under/over frequency islanding detection algorithms. The system is controlled with a PIC16F877 microcontroller for processed the voltage and frequency for turned on – off relay between grid connected inverter and utility grid.

II. EXPERIMENTAL DESIGN

A microcontroller based islanding detection for grid connected inverter developed is 120 x 80 mm, low cost, 10-bit system with 2 analog input channels designed for automatic voltage and frequency data collection. The main component of the microcontroller based islanding detection for grid connected inverter is the PIC16F877 microcontroller that is driven by 4 MHz crystal oscillator. The PIC16F877 features 256 bytes of EEPROM data memory, self programming, an ICD, 8 channels of 10-bit Analog-to-Digital (A/D)converter, 2 additional timers, 2 capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I^2C™) bus and a Universal Asynchronous Receiver Transmitter (USART) [2]. Figure 2. shows the hardware details of microcontroller based islanding detection for grid connected inverter. The circuit consisted of PIC16F877 microcontroller, voltage, current and frequency sensors circuit, AD536A integrated circuit True RMS-to-DC converter (from Analog Deviced Inc.) and 16x1 LCD display circuit. The microcontroller collected information about the value of voltage and frequency through an analog input. All these data are processed by the microcontroller where under / over voltage and under/over frequency islanding detection

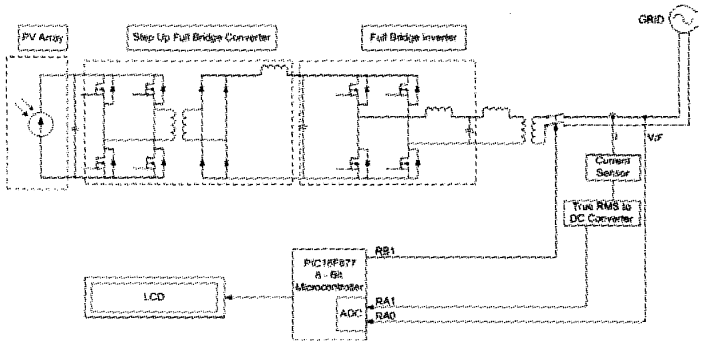

Fig. 1. The overall block diagram of photovoltaic generation system and a microcontroller based islanding detection.

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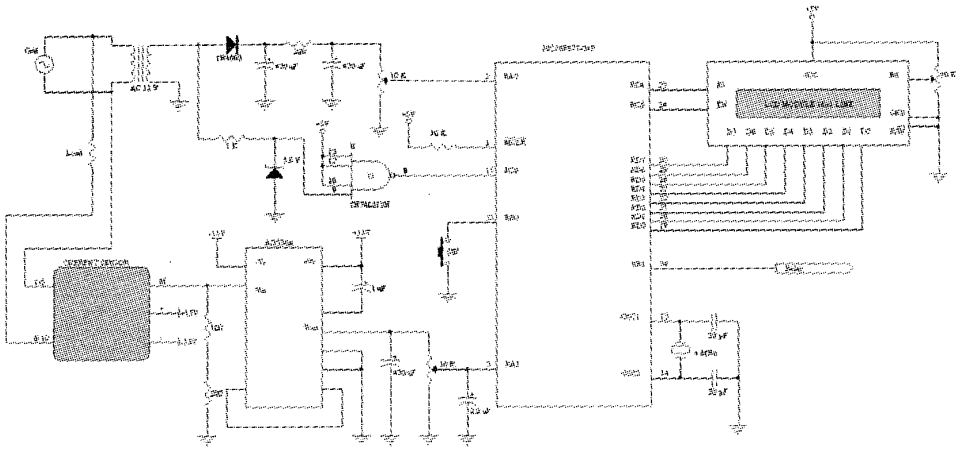

Fig. 2 Circuit diagram of the microcontroller based islanding detection for grid connected inverter.

algorithms has been software implemented, using the pic basic-pro programming language. Figure 3. shows the control algorithm flowchart, where V is the voltage and F is the frequency. After power on and initialization. The value of voltage and frequency are read from the utility grid, converted from analog signal to digital signal and stored in memory inside microcontroller for processing. The microcontroller got the voltage data and frequency data from memory and compared with voltage and frequency constant data from under/over voltage and under/over frequency islanding detection algorithms, when the voltage data or frequency data from the memory out of range the algorithms, the microcontroller sent signal to turned off the relay for disconnected the system.

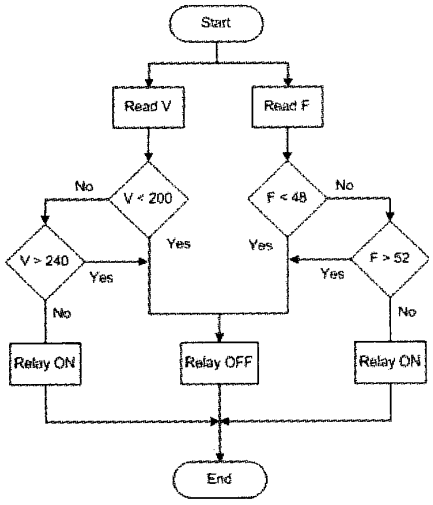

Fig. 3. Control algorithm flowchart of a microcontroller based islanding detection.

TABLE I: Threshold of detection algorithm.

Detection algorithm	Threshold
under voltage	200V
over voltage	240V
under frequency	48Hz
over frequency	52Hz

III. EXPERIMENTAL RESULTS

There are two kinds in islanding detection. Two islanding detection algorithms are the grid voltage detection and the grid frequency detection. The voltage is calculated the voltage instantaneous value about every cycle (The voltage detection focused on under and over voltage from the utility grid). The grid frequency is calculated the voltage instantaneous value from the first zero cross to the third zero cross (The frequency detection focused on under and over frequency from the utility grid). In case of under/over voltage algorithm, when the grid voltage was changed under 200V or over 240V, The grid voltage was over the threshold (see in table I). At the time, the output signal from microcontroller to turn off the relay for disconnected grid connected inverter and utility grid (see in figures 4). In case of under/over frequency algorithm, when the grid frequency was changed under 48Hz or over 52Hz, The grid frequency was over the threshold, at the time the microcontroller sent signal to turned off the relay for disconnected grid connected inverter and utility grid (see in figures 5). Figure 6. shows the final prototype from experiment and figure 7 shows test result of prototype.

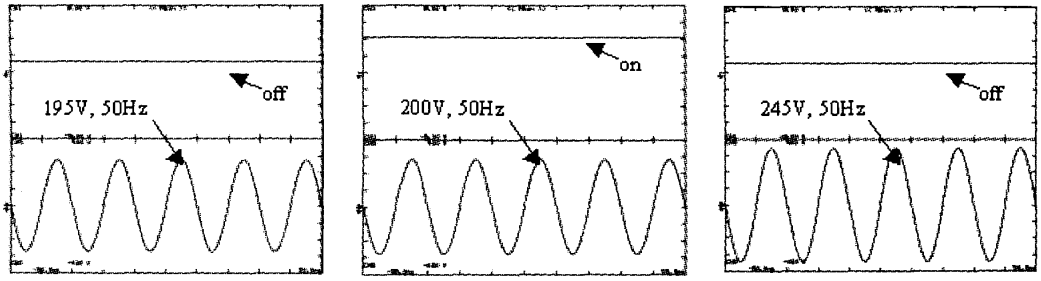

Fig. 4. Output and input waveform in case of under/over voltage algorithm.

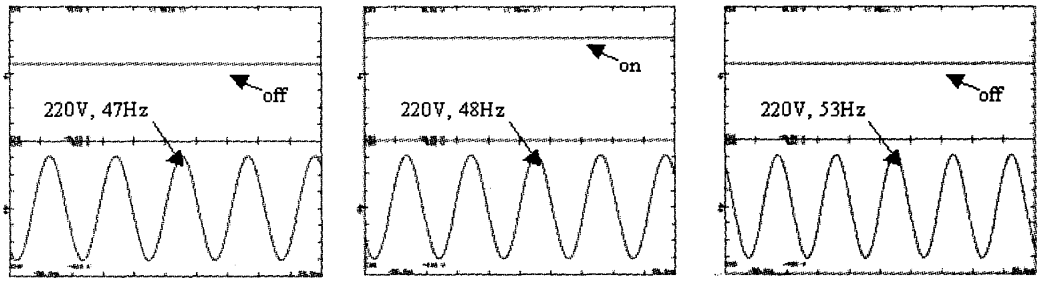

Fig. 5. Output and input waveform in case of under/over frequency algorithm.

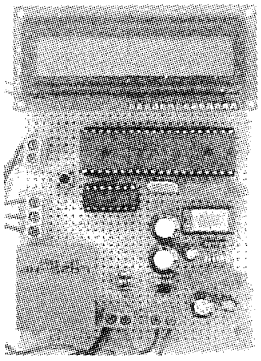

Fig. 6. Prototype of microcontroller based islanding detection for grid connected inverter.

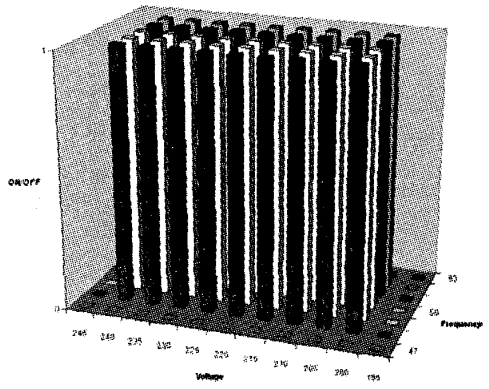

Fig. 7. Test result of prototype (0=off and 1=on)

IV. CONCLUSIONS

The paper shows a microcontroller based islanding detection for grid connected inverter. It describes the minimum hardware used to implement the simple under/over voltage and under/over frequency islanding detection algorithms. A low cost and real-time system has been developed which can monitor voltage and frequency, and controlled relay for turned on – off the system.

ACKNOWLEDGEMENTS

The authors are pleased to acknowledge the support provided by Joint Graduate School of Energy and Environment (JGSEE), Electrical Technology Education and King Mongkut's University of Technology Thonburi (KMUTT).

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