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Design and implementation of automatic grid synchronization relay using microcontroller

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Abstract
In today's world, microcontrollers are preferred for the process of synchronization between the grid and the generator system. This is due to the fact that it is highly reliable and stability of the overall system increases. Synchronization is the process of matching four parameters of the incoming supplies. These parameters are the magnitude of voltage, the frequency, the phase sequence and phase difference. This process can be done either manually or automatically. In this paper, the design of synchronization relay is such that the overall cost for synchronization is relatively less. There are many ways of calculating frequency and phase difference. We have used the concept of zero crossing detector (ZCD) for the above mentioned purpose. When the generator parameters and grid parameters are matched, relay will issue close signal for synchronization. Our papers shows how this technology can be used for synchronization with reduced cost in an automatic way.

Keywords: Implementation, synchronization, microcontroller

1. Introduction

Synchronization of Generator with grid power supply is the process of equating the parameters like Voltage, Frequency and Phase difference of both power sources. Here we will concentrate on delivering power to the grid during generation. For this purpose, the generator has to be connected to grid power supply with proper synchronization or otherwise it will lead to severe damage. There are two types of synchronization procedure available in power plant i.e. Manual Synchronization and Automatic synchronization.

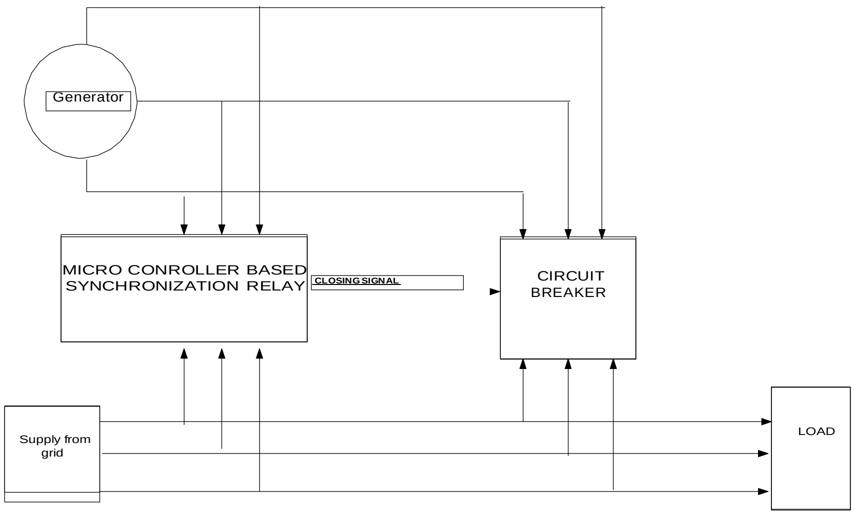

Fig 1: Block Diagram of Automatic Grid Synchronization Relay.

2. Purpose of Study

The purpose of this paper is to synchronize the grid and generator without any human factor in consideration and synchronizing them automatically by adjusting parameters required.

When it is done manually many problems are faced, since human factors are present, human errors comes into consideration. In manual process, the operator has to observe the parameters on the control panel and when the parameters are nearly matched the operator will manually press the button for synchronization which is subjected to human errors, poor synchronization and an increased simulation time. Also, closing time of the breaker can create damage to generator & its auxiliaries and it may create disturbance in the system. Therefore, there is a need for an automatic process which will synchronize the generator with the grid solving the issues stated above. This can be achieved with this paper using ATMEGA-16 microcontroller which will generate automatic closing signal.

3. Theoritical Basis

In order to synchronize an ac generator with the grid, the following parameters must be matched:

- Voltage Magnitude
- Phase sequence and phase difference
- Frequency

The system when is in synchronization should follow certain range of voltage, frequency and phase difference. The limit is shown below:

- The voltage magnitude difference should not be more than ±2-5% (±4.5V)
- The phase angle should not differ by more than ±10°.
- Frequency should not differ by more than ±0.25% (±0.375Hz).

For proper synchronization of generator and ac power grid, these four parameters have to be considered

A. Phase Sequence: It is important that, the three phases of both generator and ac network grid should be in same sequence for proper synchronizing. Generator alternator has three 120° apart phases which can be delta or star connected. This phase sequence should be perfectly matched with grid phase sequence for correct synchronization.

B. Voltage Magnitude: Every generator is designed to give specific output voltage magnitude. While synchronizing generator to respective grid, voltage level should satisfy essential condition in which the voltage magnitude (sinusoidal) generated by must be equivalent to the magnitude of the grid voltage.

C. Frequency: Generator produces electrical energy at certain specific frequency designed by manufacturer as per requirement. The generator frequency should be equal to the frequency on which grid operating. Frequency matching is very important in order to reduce post synchronization transients on overall system. Generally Syncroscope is used to consider frequency parameter.

D. Phase sequence: Phase angle is an angle between the voltage generated by the generator and the voltage of grid. This phase angle difference must be zero while synchronizing a generator to grid. From observation of peaks and zero crossing incidence of the sinusoidal waveform (i.e. 0 to 360°), the phase angle can be measured [1].

4. Methodology

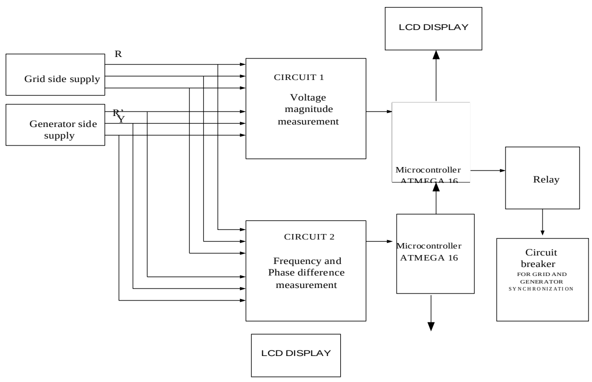

Fig 2: Block diagram of Automatic grid synchronization relay.

1. Measurement of Magnitude

For measuring the magnitude of the voltage of incoming three phase supply from both the power sources, voltage magnitude sensors are used. The signals R, Y and B are the phase voltages of grid side whereas the signals R', Y' and B' are those of the generator side. After sensing unit, the obtained signals are then sent to the ADC pins of the microcontroller Atmega16.

2. Measurement of Frequency and Phase difference

For the measurement of phase difference and the frequency of the power sources, the concept of zero crossing detectors (ZCD) is used. Zero crossing detection is the most common method for measuring the frequency or the period of a periodic signal. When measuring the frequency of a signal, usually the number of cycles of a reference signal is measured over one or more time periods of the signal being measured. Measuring multiple periods helps to reduce errors caused by phase noise by making the perturbations in zero crossings small relative to the total period of the measurement. The net result is an accurate measurement at the expense of slow measurement rates. Zero crossing is the point of choice for measuring phase and frequency. The reference is usually easy to establish and the signal's amplitude rate of change is maximum at signal zero [2].

5. Design and Implementation

a) Simulation

The simulations for the paper work were performed in PROTEUS DESIGN SUITE 8.0 by Labcentre Electronics. The simulation work is divided into two parts i.e. simulation for magnitude of voltage and simulation for frequency and phase difference. For measuring the magnitude of

the voltage of incoming three phase supply from both the power sources, voltage magnitude sensors are used. The signals R, Y and B are the phase voltages of grid side whereas the signals R',Y' and B' are those of the generator side. After sensing unit, the obtained signals are then sent to the ADC pins of the microcontroller Atmega16.
The signals which are input to the ADC pins are shown in red color in fig. The voltages to be measured are displayed on 20*4 LCD which is connected to the microcontroller. The voltages of grid side are denoted as Vr, Vy and Vb and those of generator side are denoted as Vr',Vy' and Vb'. For the measurement of phase difference and the frequency of the power sources, the concept of zero crossing detectors (ZCD) is used. In this paper, the zero crossing detection is done using optocoupler 4N25. The 230 volts phase voltage is applied to bridge rectifier through 45kΩ resistor. The output of this rectifier is pulsating DC voltage. This voltage is applied across 4N25 optocoupler through 1kΩ resistor. The optocoupler collector is connected to constant 5 volts via a 10kΩ resistor. The emitter is grounded. Whenever there is voltage across the optocoupler, the output terminal will have zero volts through ground terminal. Whereas, whenever there will be no voltage across the optocoupler i.e. at the zero crossing instant, the output will show constant 5 volts. Thus, whenever the zero crossing will appear, there will be a spike of 5 volts at the output. Hence, the zero crossing will be detected.

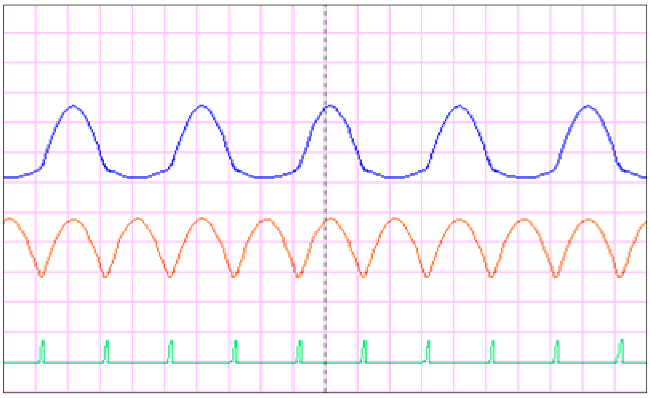

Fig 3: Waveform of output of Zero crossing detector

The output waveform of the ZCD is shown in fig. The yellow color waveform shows the input sinusoidal voltage. The blue waveform indicates the pulsating DC voltage which is the output of the rectifier. The red waveform shows the 5 volt spikes obtained at the zero crossing.
In this paper, there are six such arrangements of zero crossing detectors for the six incoming phase supplies. The output of these six ZCDs is then given to the port pins of microcontroller via Multiplexer IC74151.

b) Hardware Design

In the hardware setup, two microcontrollers are used for the process of synchronization. The microcontroller used in the paper is ATMEGA 16.
In the first microcontroller, the inputs of magnitude sensing unit are given to ADC pins. The inputs R, Y, B, R', Y' and B' are given to port pins PA0, PA1, PA2, PA3, PA4 and PA5 respectively.
The LCD is connected to port B pins. The program is written is BASCOM AVR software. The LCD displays the voltage magnitude of the three phases of both the power sources. The microcontroller sets the port pin PD6 when the parameters are within specified limits for synchronization. This signal is given to relay.
In the second microcontroller, the output of multiplexer IC 74151 is given to the port pin interrupt pin (PD2). The timer of microcontroller is used to find the time period of the wave from the ZCD output. When phase difference and frequency are within specified limits, this microcontroller will set port pin PA5. This output is given to first microcontroller at port pin PD2. The LCD is connected to port C.

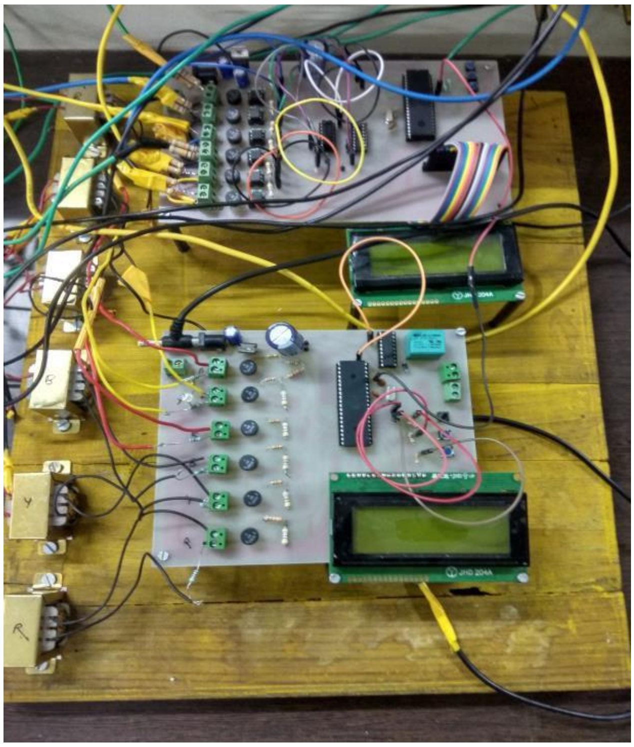

Fig 4: Overall arrangement of grid synchronization relay.

Table 1: Result showing comparison of voltage magnitude

Para meter	Applied voltage (volts)	Voltage shown in LCD in simulation (volts)	Voltage shown in LCD in hardware implementation (volts)
VR	231	229.45	232.32
VY	230	229.68	228.65
VB	229	229.68	229.51
VR'	250	250	248.62
VY'	248	249.77	247.55
VB'	249	250	249.33

6. Results

The result of microcontroller based synchronization relay was verified using the dark lamp method which determined the synchronization of the power sources. When the synchronization is achieved, all the lamps are dark and at this condition the micro- controller has generated a closing signal to the circuit breaker. Whereas, when synchronization is not achieved, the lamps glow and no signal is issued for circuit breaker closing.

Fig 7(a): During synchronization

Fig 7(b): Out of synchronization

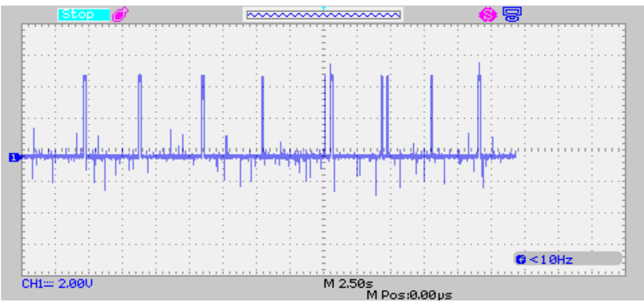

Fig 8: Waveform of port pin PA5 during synchronization

The instants at which the waveform of port pin PA5 is at peak of +5

Fig 9: Results showing magnitude of voltage of both power sources

Fig 10: Results showing frequency and phase difference of both power sources

Table 2: Comparison of frequency and phase difference

Parameter	Actual value	Value shown in LCD in simulation	Value shown in LCD in hardware implementation
Phase diff R	0°	0°	0-10°
Phase diff Y	0°	0°	0-10°
Phase diff B	0°	0°	0-10°
F1	50.00 Hz	50.08 Hz	49.84 Hz 1.
F2	50.00 Hz	50.08 Hz	49.92Hz

In addition to this the results are show using DSO as well. When the frequency and phase difference achieve synchronizing conditions, the port pin PA5 is set. When the parameters are not in specified limits, the pin is reset.

Table 3: Real time Results of automatic grid synchronization relay

S. No	Conditions	Status of Circuit Breaker
1	Voltage Magnitude, phase difference and frequency beyond limit	OFF(No synchronization signal)
2	Voltage Magnitude, phase difference and frequency within limit	ON (Synchronization signal generated)

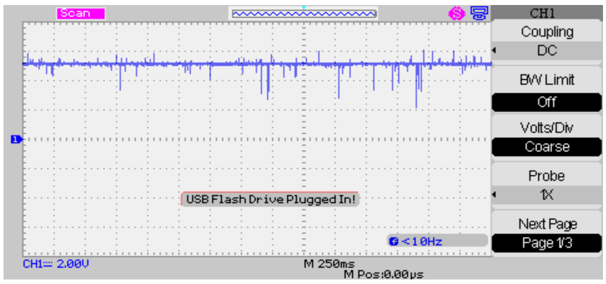

Fig 11: Output waveform of automatic grid synchronization relay

7. Conclusion

The design and implementation of automatic grid synchronization relay using microcontroller is presented in this paper. The voltage magnitude, frequency, phase difference and phase sequence are matched using different setups. For measuring voltage magnitude, ADC pins of microcontroller Atmega 16 are used. For measuring frequency and phase difference, concept of zero crossing detector (ZCD) are used. Two microcontroller are used to make operation less complex and reduce the time of synchronization. The results are verified using three dark lamp method. The voltage magnitude difference is less than ±2.5% (±4.5V). The phase angle difference is less than ±10°. Frequency difference is less than ±0.25% (±0.375Hz).

8. References

1. Ruturaj V Shinde, Prof. PD Bharadwaj. A Review on Generator Grid Synchronization Needs Effects, Parameters and Various Methods. IJRASET. 2016; 4(4).
2. Wall RW. Senior Member, IEEE, Simple methods for detecting Zero Crossing, 2012.