SPC

International Journal of Engineering & Technology, 7 (2.24) (2018) 460-463

International Journal of Engineering & Technology

Website: www.sciencepubco.com/index.php/IJET

Research paper

Embedded Design in Synchronization of Alternator Automation

S. Sheeba Rani[1], V. Gomathy[2], R. Geethamani[3], Rameez Khan.R[4], Mohan Raj.D[5]

[1,2,3]Assistant Professor, Department of EEE, SKCET, Coimbatore,
[4,5]UG Student, III yr., Department of EEE, SKCET, Coimbatore,
**Corresponding Author Email: sheebaranis@skcet.ac.in*

Abstract

In this paper, a new method for automatic synchronization of alternator has been developed without the necessity of manual interpretation. Any Alternator can be connected automatically to the infinite bus bar with this developed control unit. The phase voltage, phase angle, phase sequence and frequency of the incoming alternator is compared with the reference infinite bus bar with the help of various sensing modules and interpreted by microcontrollers. If the conditions are observed to be optimistic then automated synchronization is done with a prior indication. The system is entirely automated and works entirely on LabVIEW environment. This synchronization technique is cost-effective, reliable, fast and precise to be used for measurement, control, monitoring and parallel operation of alternator. This research is made to overcome the drawbacks of manual methods of alternator synchronization.

Keywords: *synchronization of alternator; my RIO; LabVIEW; zero crossing detectors(ZCD); LM 397; Pinguino PIC32; embedded C; High voltage DC chopper; Steam controller valve; Electrical Contactors.*

1. Introduction

The process of connecting and operating two or more alternator in parallel to each other or connecting one alternator to the infinite bus bar is known as synchronization of alternator. Electrical power generation and transmission system consists of the interconnection of large numbers of alternator operating in parallel, interconnected by transmission lines and supplying a large number of widely distributed loads. The phase sequence, voltage and frequency of the infinite bus bar are mostly same and considered constant. The are many benefits of parallel operation of alternator like the continuity of power supply, reliability, expandability, flexibility and high efficiency. The above mention needs can't be met by a single alternator so several alternators are connected in parallel to supply power for large loads. During periods of scheduled maintenance, inspection, damage, light load, one or more alternator may be shut down and cut off from the infinite bus bar. During when the remaining alternator operate to meet the power demand of loads and maintains the continuity of supply. If there is an increasing demand in future machines can be added without disturbing the original installation. The manual method of synchronization demands a skilled operator and is suitable for no-load operation or normal frequency condition. Under emergency condition such as lowering of frequency or synchronizing of large machines a very fast action is needed, which may not be possible for a human operator. Hence there is a need for automatic synchronization.. In automatic synchronization process, the adjustment of the magnitude of phase voltage, phase angle, phase sequence and the generating frequency of the incoming alternator is done automatically. When all the parameters of synchronization are satisfied and synchronized with that of the infinite bus bar, the incoming machine is connected to the infinite bus which is done by the electrical contactors under the instructions from my-RIO. This entire process is developed on LabVIEW environment which makes this synchronization technique much user friendly.

2. Parallel Operation of Alternator

The alternators are operated parallelly to supply power to meet large load demand. The alternators are connected in parallel to each other only if the required conditions are satisfied. The conditions to checked for synchronization of alternator are given below:-

- The phase sequence and phase angle of the incoming alternator and reference bus bar should be same.
- The phase voltage of incoming alternator and reference bus bar should be equal.
- The frequency of the incoming alternator and reference bus bar should be equal.

In the earlier system the phase sequence is measured with the help of phase sequence meter, the phase voltage is measured by voltmeter, the frequency is measured with the use of synchroscope and synchronization is done by two bright and one dark lamp method. But due to certain limitations of the earlier methods of synchronization resembles to be more bulky and costly. Hence automatic synchronization comes in existence.

3. Working and Implementation

The output voltage both, from the reference infinite bus bar & incoming alternator is given to a potential transformer.
This Potential Transformer(P.T.) reduces the high voltage to a corresponding scale of low-level voltages which can be easily measured by measuring instruments and sensors. The Output feed of the PT is divided into three feeds given to various sensing ends to measure the various parameters before synchronization.

Feed 1 (Phase sequence and Phase Angle Parameter): Output of the PT is given to a Phase Sequence Detector to measure the phase sequence and phase angle difference of RYB of the incoming alternator with the reference bus bar. The Phase Sequence detector is made up of ZCD (Zero Crossing Detector). The ZCD gives the pulses when the sine wave passes the zero magnitude. Based on the time difference of the pulses between each phase of 3 phase AC output voltage, the parameters like phase sequence and phase angle between the phases are calculated. The output of the phase sequence detector of both the alternator and the infinite bus bar is given to my-RIO for processing. My-RIO checks for the ideal condition where this parameter matches the same between the incoming alternator and busbar.

Feed 2 (Generating Frequency): Another Output of the PT is given to a Zero Crossing Detector to measure the frequency of the incoming alternator and the reference infinite bus bar voltage. The ZCD gives a signal based on the frequency to the microcontroller Pinguino PIC32. Based on the frequency data this microcontroller controls the steam flow pressure valve, which directly alters the speed of the turbine. Since this Turbine is coupled with the Alternator. That Alternator speed is also varied. So, this PIC microcontroller proportionally controls the alternator speed. Since,

$$N = \frac{120\,f}{P}$$

Where N = Synchronous speed

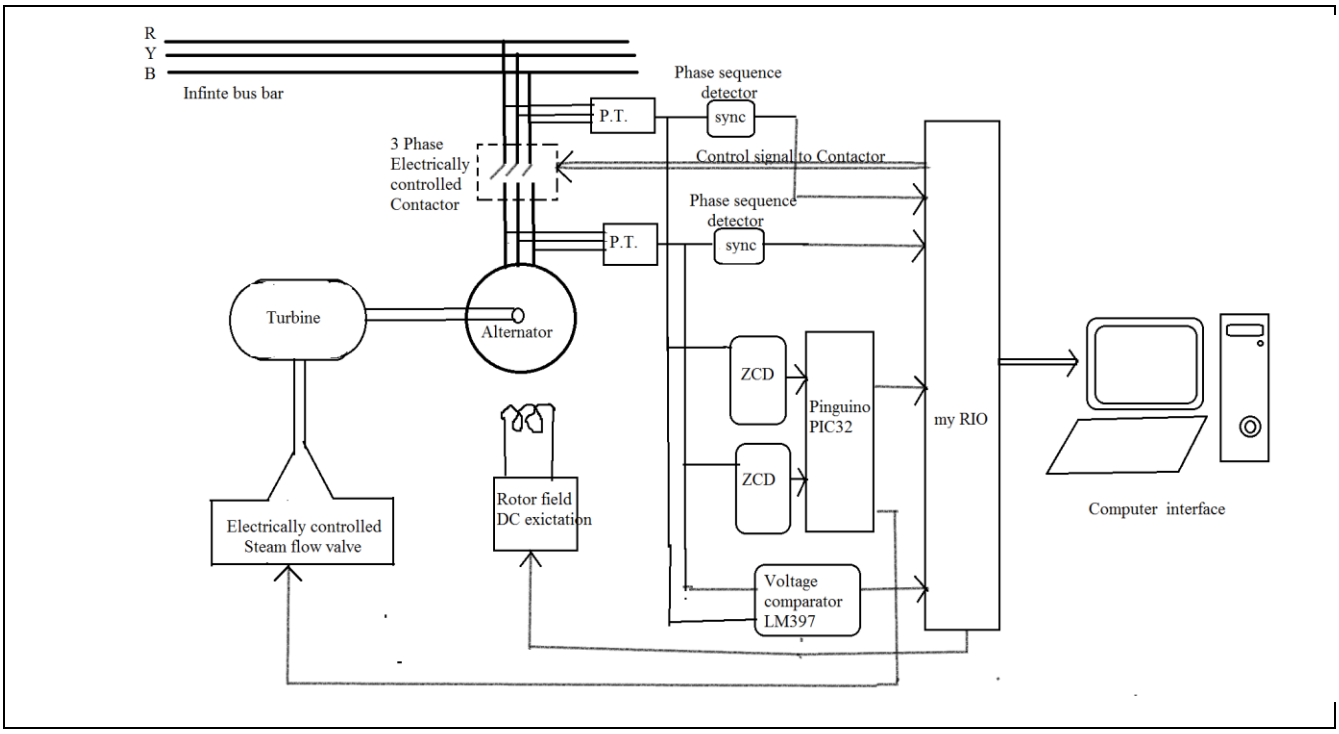
f = Frequency

P = Number of poles

So, from the above equation, the frequency of the alternator is directly proportional to the synchronous speed of the alternator. Thus, by controlling its speed, we can control the generating frequency of the alternator. When the generating frequency is greater than the infinite bus bar frequency, the speed of the alternator is decreased and when the frequency is lesser, the vice versa is done. Thus, the PIC controller controls the frequency of the incoming alternator with the reference bus bar frequency by controlling the steam flow pressure valve. The output of the microcontroller is given to the my-RIO micro-processor.

Feed 3 (Phase Voltage): The last feed from the PT transformer is given to the Voltage comparator LM397 which compares the phase voltages of both incoming alternator and the reference bus bar. The LM397 consist of an OP-AMP which is operated in voltage comparator mode. The sensed feed form the IC is sent to my-RIO. If the incoming alternator voltage is observed to deviate from the reference voltage, then the voltage is adjusted by the controlling the Rotor field excitation DC voltage by switching regulator. Since, controlling the DC excitation can proportionally control the generated voltage of the alternator. The control signal from the IC is sent for my-RIO which in turns control the gate pulse of the switching regulators.

The my-RIO has inbuilt ADC which convert this analog signal to digital signals. My RIO works on LabVIEW environment, so the suitable algorithm is implemented in it. It compares the incoming signals form phase sequence detector, Pinguino PIC32 and voltage comparator LM397 of both incoming alternator and reference infinite bus bar. When all the parameters perfectly match with each other My RIO confirms it and synchronize the alternator to the grid's infinite bus bar automatically with the prior indication to the manual operator via computer. The synchronization is done by sending a pulse from My RIO to the electrically controlled Contactor which opens and closes an HV TPDT switch. My RIO is connected to an external PC using simBUS communication. All the working of the entire system can be monitored and controlled form that PC.



Block Diagram of Working Model

4. Function of sensing element

The individual function of various sensing element are listed in the following:

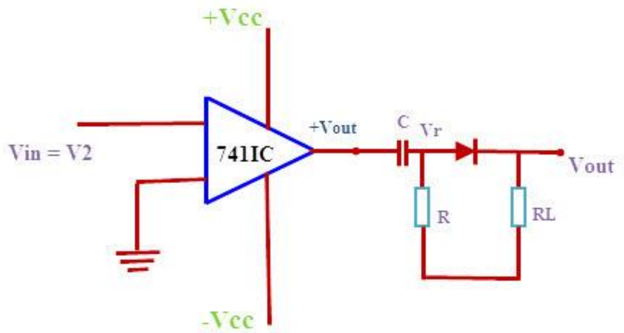
A. ZCD as phase sequence and phase angle detector

A ZCD can be used to measure the phase sequence and phase angle of RYB connection and phase angle between two voltages. A sequence of pulses are generated when the sine wave crosses the "0" magnitude or when it changes form +ve to -ve half or vice versa, based on time interval between these successive pulses from all three phases of AC voltage, the phase sequence and phase difference can be detected. This interval of time is related to the phase difference between the two i/p sine wave voltages. Similarly, the time interval obtained between the occurrence of first pulse in each phase of RYB connection is used to detect the phase sequence. The scale of phase sequence meter ranges from 0° to 360°.

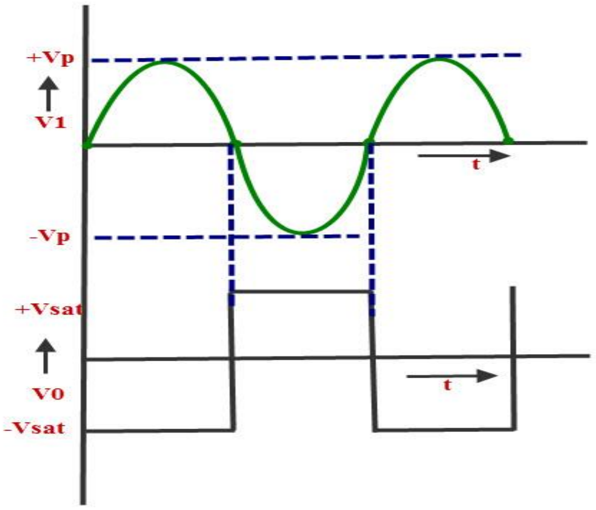
Detailed ZCD working

The zero-crossing detector circuit which is also named as the sine to square wave converter operates in both inverting or non-inverting modes. The Input voltage(Vin) is to be compared, must be reference voltage equal to zero (Vref = 0V) which generates pulses when same voltage is encountered.

These are shown in the following inverting comparator circuit diagram with a 0V reference voltage.



The waveforms for Vref=0V is given below. As shown in the below waveform, when the input sine wave permits through zero voltage and goes in the direction of positive. The output voltage is driven into negative half of a square wave. In the same way, when the Vin permits through zero and goes in the direction of the negative, the Vout is driven to give an positive half of a square wave. Additional Clamp diodes are used for protection of OP-AMP against damage due to increase in Vin.



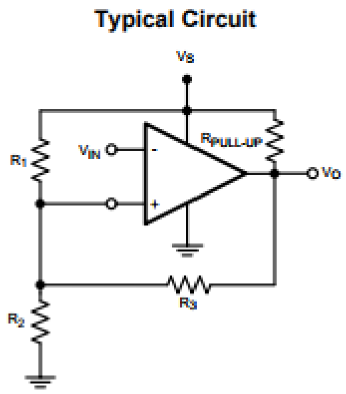
As shown in the above diagram, for each zero-crossing state of sine wave an equivalent square wave is generated. This square wave can be used to interpret the time interval between two successive zero crossing time. The obtained square wave is further subjected to a clipper and clamper circuit to obtain suitable form which can be interpreted by microcontroller. The clamper circuit removes the negative half of the generated square wave by rising its amplitude by a unique value about the x-axis. This finally obtained signal can be easily interpreted by the microcontroller to calculate the phase sequence and phase angle parameters.

B. ZCD as frequency detector

ZCD can also be used to find out a frequency of the three-phase AC signal. Since it sends out a pulse signal whenever the AC signal crosses the zero value, the pulses can be measured along with a clock pulse counter(like PIC microcontroller) to count and identify the time interval of two successive zero crossing. From this time interval T, the frequency F of the AC voltage can be obtained by calculations. This frequency data is compared between the incoming alternator and infinite bus bar until they become ideal and same. Thus ZCD is used as a frequency synchronoscope.

C. LM 397 as a voltage comparator

The LM397 device is a single voltage comparator with an input common mode that includes ground. The LM397 is designed to operate between 5-V to 30-V power supply. Thus, this high voltage is reduced to a corresponding range for this IC measurement. Its low supply current is virtually independent of the magnitude of the supply voltage. The LM397 features an open-collector output stage. The LM397 IC gives output based on the voltage difference detected between the two ends of the input. This voltage difference is send to the my-RIO microcontroller which correspondingly alters the voltages until the ideal voltage is obtained.



When the voltage level is observed to be same between the incoming alternator and reference bus bar voltage, this voltage comparator sends a feed to the microcontroller. Thus, a sensing on the voltage is obtained.

D. Controlling Alternator DC excitation

Output feed is obtained from LM397 IC is send to my-RIO to control the phase voltage, the my-RIO process this signal and correspondingly controls the gate pulse switching regulator where high voltage controlling switching device (IGBT or MOSFET) is present. Based on the incoming gate pulses feed, chopping operation occurs and DC excitation is controlled. When the incoming alternator generating voltage is lower than the bus bar voltage, the rotor field excitation of the alternator is varied by the gate signal provided to the chopper circuit. This gate pulse is varied until there is an ideal condition of same phase voltage between the infinite bus bar and the incoming alternator. Thus, this method provides a control on the DC excitation.

5. Conclusion

The automatic synchronization of alternators is achieved by satisfying synchronizing parameters by making voltage, frequency, phase sequence and phase angle of the incoming alternator equal to that of the reference infinite bus bar. Hence this technique successfully made automatic synchronization of alternators, without any manual interpretation.

References

[1] W. M. Strang, C. J. Mozina, B. Beckwith, T. R. Beckwith, S. Chhak, E. C. Fennell, E. W. Kalkstein, K. C. Kozminski, A. C. Pierce, P. W. Powell, D. W. Smaha, J. T. Uchiyama, S. M. Usman, and W. P. Waudby, "Generator Synchronizing Industry Survey Results," IEEE Transactions on Power Delivery, Vol. 11, Issue 1, pp. 174–183, Jan. 1996.

[2] R. A. Evans, "A Manual/Automatic Synchronization Circuit for a 37.5 MVA Steam-Turbine-Driven Generator," IEEE Transactions on Industry Applications, Vol. 26, Issue 6, pp. 1081–1085, Nov./Dec. 1990.

[3] L. C. Gross, L. S. Anderson, and R. C. Young, "Avoid Generator and System Damage Due to a Slow Synchronizing Breaker," Proceedings of the 24th Annual Western Protective Relay Conference, Spokane, WA, October 1997.

[4] IEEE Std. C37.118-2005, IEEE Power Engineering Society, IEEE Standards for synchro phasers for power system, 2005.

[5] Emam, S.E.A., automatic digital synchronization, the international conference on electrical, ICEEC'04. (2004).

[6] B.L. Theraja, A.K. Theraja, a textbook of electrical technology, S.Chand & Company LTD., 2002

[7] Ashfaq Hussain, Dhanpat Rai & Co. (Pvt) Ltd., Electric Machines. (Second Edition), 2005.

[8] Dr P.S.Bimbhra, Khanna Publishers, Power Electronics,(Fourth Edition).2009.

[9] S.V.Manikanthan and D.Sugandhi " Interference Alignment Techniques For Mimo Multicell Based On Relay Interference Broadcast Channel " International Journal of Emerging Technology in Computer Science & Electronics (IJETCSE) ISSN: 0976-1353 Volume- 7 ,Issue 1 –MARCH 2014.

[10] T. Padmapriya and V. Saminadan, "Distributed Load Balancing for Multiuser Multi-class Traffic in MIMO LTE-Advanced Networks", Research Journal of Applied Sciences, Engineering and Technology (RJASET) - Maxwell Scientific Organization , ISSN: 2040-7459; e-ISSN: 2040-7467, vol.12, no.8, pp:813-822, April 2016.