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Automatic Synchronisation of Alternator for Small Power Plant

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ABSTRACT
In this paper, automatic synchronization unit has been developed for the parallel connection of alternators with temperature protection. Two synchronous generators are connected in parallel automatically with the developed control unit. Synchronous generators are also connected in parallel with infinite bus bar. The voltage, frequency and phase sequence of the incoming alternator is compared with the reference alternator with the help of Peripheral Interface Controller (PIC) parallel operation of alternators are realized automatically when all parallel connection condition are occur. The system doesn't required additional measuring tools for monitoring and control processes.The developed automatic synchronization unit is fast, cost effective, reliable and precise to be used for monitoring, measurement and parallel operation of synchronous generators. This paper work is made to overcome the drawbacks of manually operating synchronization methods.

Keywords - Synchronisation, Synchronous Generator, Peripheral Interface Controller (PIC), infinite Bus bar and Prime Mover.

I. INTRODUCTION

The method of connecting two or more alternator in parallel to each other or one alternator to the infinite busbar is known as synchronisation. Electrical power system consist of the interconnection of large numbers of alternator operating in parallel, interconnected by transmission lines and supplying large number of widely distributed loads. The voltage and frequency of the infinite busbar is constant [1]. There are many benefits of operating many alternators in parallel to each other like continuity of power supply, reliability, high efficiency, flexibility and expandability. Single Alternator Is Not Capable Of Supplying Large Load. Several alternators can connected in parallel to supply large loads. During periods of light load, one or more alternator may be shut down and those remaining operate at or near full load and thus more efficiently. When one machine is taken out of service for its scheduled maintenance and inspection, the remaining machine maintains the continuity of supply [2], [3]. If there is breakdown of alternator, there is no interruption of power supply. In order to meet the increasing future demand of load more machines can be added without disturbing the original installation.Synchronization by means of manually operated switching is not suitable for the system having large capacity.

Hence there is a need of automatic synchronization in a power station or in an industrial establishment where generators are employed. In automatic synchronization process, the adjustment of magnitude of voltage, frequency and phase sequence of incoming alternator is done automatically. When all the parameters of synchronization are satisfied, closing of the circuit breaker of the incoming machine is done by the automatic synchronizer [2]. 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.The paper introduced here is for the complete automation of synchronization i.e. the adjustment of magnitude of voltage and frequency of incoming alternator is done automatically. When all the requirements of synchronization are satisfied, closing of the main switch of the incoming machine is done by the automatic synchronizer.

II. PARALLEL OPERATION OF ALTERNATORS

The alternators are connected in parallel to supply power to the large load demand. The alternators are connected in parallel to each other

only if the required conditions are satisfied. The conditions for synchronisation are as given below:-
The phase sequence of incoming alternator and reference alternator should be same.The reference voltage and incoming machine voltage should be equal.The frequency of the incoming alternator and reference alternator should be equal. In addition, the auto synchronizer has been designed so that the alternator is started with in minimum voltage and minimum frequency conditions.In earlier system the phase sequence is measured with the help of phase sequence meter, the voltage is measured with voltmeter and frequency is measured with the use of synchroscope. But due to certain limitations like the system become more bulky and costly, it is not preferable hence automatic synchronisation comes in existence.

The figure 1 shows the hardware implementation of automatic synchronisation unit.
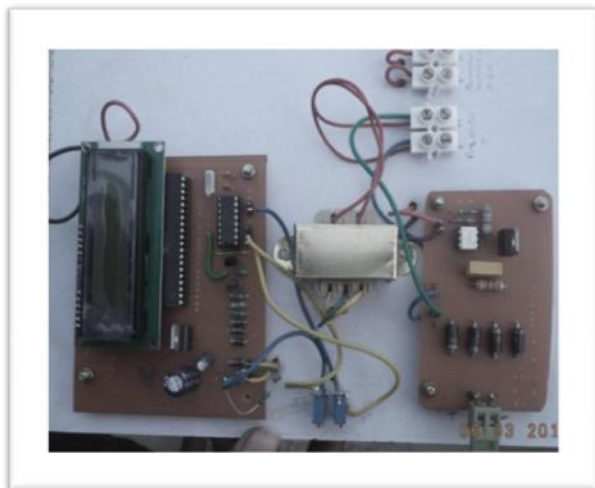

Fig1:- Hardware Implementation of Synchronisation Unit

III.   AUTOMATIC SYNCHRONISATION UNIT FOR ALTERNATOR

Figure 2 shows the block diagram of automatic synchronization of alternators. This diagram consists of two alternator blocks, Incoming and Reference alternator block. The voltage output of both the alternator is given to PIC using Potential transformer (P.T.) A Zero Cross Detector (ZCD) is connected to count the number of Positive pulse for frequency calculation. Power Supply block is provided to supply 5V dc to the PIC a LCD (16x4) is connected to see the output. The LCD will display the output result of the PIC. A Prime Mover (DC SHUNT MOTOR) is connected to provide mechanical input to the incoming alternator. N-MOSFET is connected for switching purpose in order

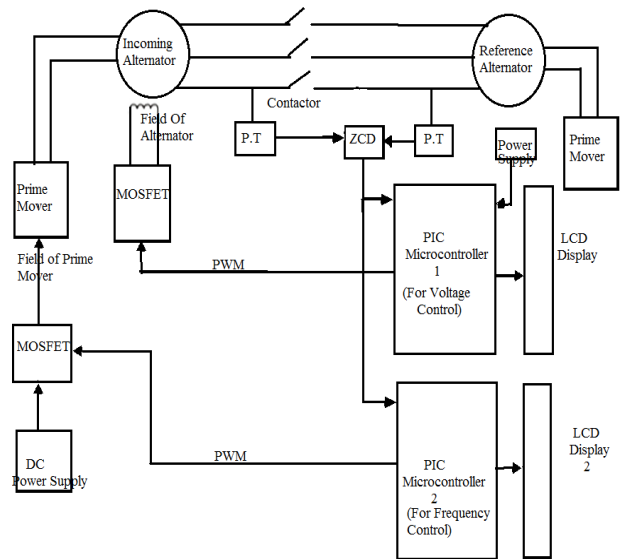to vary field excitation of alternator and prime mover.

Fig 2: Block Diagram of Synchronisation Unit

The voltage of three phases of both the units are monitored using pic, the difference in the voltage is then displayed on the LCD. The excitation voltage is provided to the field of alternator and prime mover by dc supply block. The excitation of field winding of alternator and speed of prime mover is controlled by Mosfet.
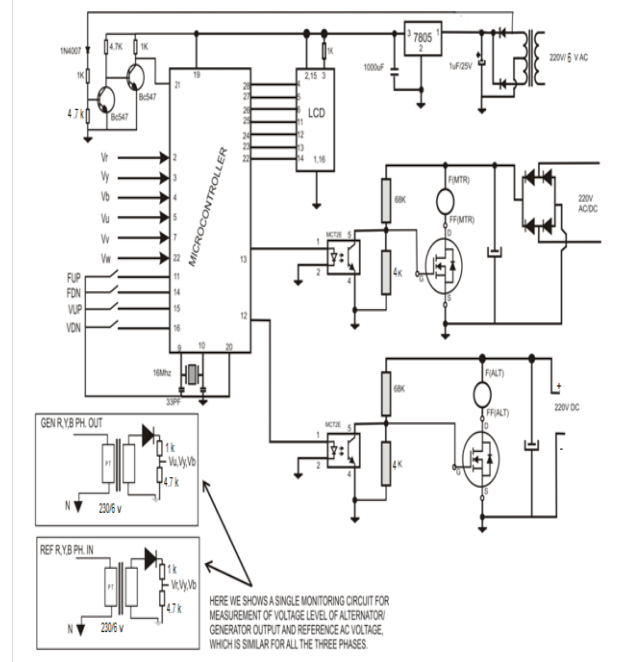

Fig 3: Circuit Diagram of Synchronisation Unit

The output voltage both, from the reference & incoming alternator is given to PIC using potential transformer. The PIC has inbuilt ADC Successive Approximation) which convert this analog signal to digital signals. The PIC compares the incoming voltage to the reference voltage and generate equivalent PWM signal. This PWM signal is a square wave with Ton & Toff time. It is given to the Opto-coupler. Opto-coupler consists of LED and Photo Diode. This will simultaneously turn on & turn off the LED, which will operate the photo-diode. Now when LED is OFF the resistance of Photo diode will be more and hence the positive current from the 220V dc will gate the MOSFET and this will turn on the MOSFET and thus the negative terminal of field winding will be connected to negative terminal of dc supply and this will increase the excitation voltage of alternator, thus increasing output voltage of the alternator.

The same process repeats if the incoming voltage is more than that of reference voltage, the LED will be ON, which will decrease the resistance the 220V will be grounded through photo-diode and the MOSFET will be OFF thus decreasing the excitation of the alternator. For the measurement of frequency a ZCD (Zero Cross Detector) circuit is connected to PIC. The input from incoming alternator is given to ZCD using a Half Wave Rectifier unit. The ZCD counts the no of positive to zero going pulse which is equivalent to the frequency.The ZCD is set at 50 Hz frequency, if the incoming frequency is less it will generate equivalent PWM and the same process repeats as the prime mover used here is field excited.

The result is displayed on the 16x4 LCD display. A step down transformer along with full wave rectifier circuit is used to provide 5V dc supply to the PIC & LCD Display. LM 7805 is used as voltage regulator IC to provide constant voltage to the PIC.

IV. CONCLUSION

The automatic synchronization of two alternators is achieved by satisfying synchronizing parameters by making voltage, frequency and phase sequence of the incoming alternator equal to the voltage, frequency and phase sequence of the reference alternator. This synchronizing system is designed to control the voltage and frequency of the incoming alternator. The frequency can be varied manually as well by increasing or decreasing the speed of the prime mover i.e. DC shunts motor.

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, *international conference on electrical, ICEEC'*04. (2004).

[6] B.L. Theraja, A.K. Theraja, a text book 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