Detection Of Power Grid Synchronization Failure By Monitoring Frequency And Voltage Using Embedded System

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Abstract - **Grid synchronization failure can cause complete black out. So, there is always a need for a system that can sense any abnormalities and take actions accordingly to prevent black outs. A grid is connected with several power generating units like thermal, nuclear, wind etc. to deliver power to the load. In India, the generating units have to deliver power according to the Indian Electricity Grid Code, 2010 which states that the variation in voltage should be within the limit of ±5% and that for the frequency should be within ±3%. If any value higher/lower is detected, then that particular feeder should be disconnected from the grid temporarily in order to protect the grid. In this paper, we will be discussing about a system based on the microcontroller of MCS-51 family and op-amps, that will be used to monitor the variation in voltage and frequency of the any external supply source, and automatically disconnects the supply source from the load.**

keywords - **Black out, Embedded system, Frequency, Islanding, Microcontroller, Power Grid, Synchronisation, Variation, Voltage.**

I. INTRODUCTION

In our daily life, we use electricity or various devices running on electricity around us. Almost all our work depends upon electricity in one way or another. The modern society is so much dependent on electricity that the life without it would be difficult to imagine. The electricity that we use, is generated in the generating stations with the help of alternator and is then transmitted to the consumers via an electrical grid. A grid receives power from several generating stations, all of which are in synchronism with the network. The generated voltage and frequency must be within the specified limit for the optimal working of the whole network. If in any case, the generated voltage or frequency falls below or rises above the specified limit (as per the Indian Electricity Grid Code, 2010) then there is a need to disconnect that particular feeder from the grid, which is termed as Islanding [1]. Islanding itself poses a threat to the utility workers, who may assume that there is no power once the utility power is shut down [2], but the grid may be still powered due to the distribution generators. Therefore, a system is required that can sense such variations and warn the grid in advance thus, providing safety to the workers and maintaining the optimal working of the grid.

Here, in this paper we will be discussing about a system based on the Microcontrollers of 8051 family or Arduino based application. The microcontroller will be monitoring the under/over voltage which is being derived from the set point of the comparators [3]. As the supply frequency cannot be changed, we will be using IC 555-timer to produce variable frequency and for varying the voltage standard, variac is being used [4]. A lamp will be used as load to indicate the possible black or brown out due to the variation in supply voltage or frequency. The LCD screen will be displaying the real time voltage and frequency variations and the message for the normal, over and under voltage or frequency, will also be displayed accordingly.

Figure 1 is the block diagram of the system for detecting the variation in voltage and frequency.

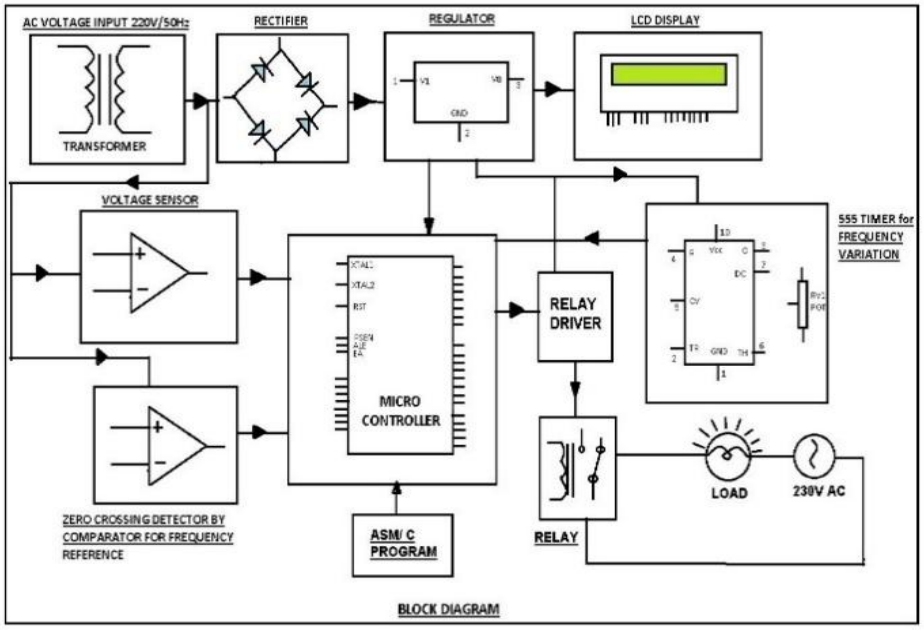

Fig.1: Block Diagram of the system

II. COMPONENTS USED

- TRANSFORMER
- DIODES
- VOLTAGE REGULATOR
- LCD DISPLAY
- OP-AMPS
- MICROCONTROLLER
- RELAY
- 555-TIMER
- LAMP
- RESISTORS
- CAPACITORS

III. CIRCUIT WORKING

The input supply voltage to the system is 220V AC but, the voltage requirement of the most of the electronic components is much smaller than the supply voltage here [5],[6]. So, a step-down transformer here is used to step-down the voltage to 12V DC, via a rectifier. The microcontrollers of 8051 family requires 5V input for their operation and thus, a voltage regulator regulates the 12V into 5 V DC [7]. The microcontroller is interfaced with the LCD display, relay driver and voltage, frequency detectors. The voltage of the system is varied by using voltage potentiometer and variable frequency is produced using IC 555-timer [8],[9]. The voltage and frequency detector senses for any abnormalities in the supply through a reference value and returns the sensed data to the microcontroller [8] which analyses the data to generate output signals for other devices and perform tripping action through relay driver, according to the higher/lower value sensed. The lamp is used to indicate the synchronization failure of the supply. Whenever there is a synchronization failure of the source (i.e. abnormal voltage or frequency), the relay circuit is triggered and the lamp stops glowing which gives indication of the synchronization failure.

IV. VOLTAGE SENSING

For voltage sensing part, an op-amplifier IC (LM339 or window comparator) is used and voltage regulator is used to vary the input voltage [10],[11]. The controller is connected to the zero- crossing circuit for frequency reference to ensure that the input supply frequency is normal (i.e. 50 Hz) [12].

At normal input supply voltage, the output pins of one of the both op-amp IC are at low and other at high level due to which no interrupt signal is generated for the microcontroller and thus, relay circuit is closed and lamp will glow. Now, on increasing the input voltage above the normal value by using the voltage regulator, the normal high pin of op-amp will go low and interrupt signal will be given to the microcontroller which then switch off the relay driver and the lamp stops glowing. Similarly, the voltage regulator is varied so that the input voltage is lower than the normal value, the normal low pin of the op-amp IC goes high and the microcontroller on receiving this interruption signal, switches off the relay driver and the lamp stops glowing [12]. In both, under and over voltage condition, the lamp stops glowing which is the indication for the synchronization failure of the input supply due to the abnormalities in the supply voltage.

Figure 2 is the block diagram of the basic window comparator circuit.

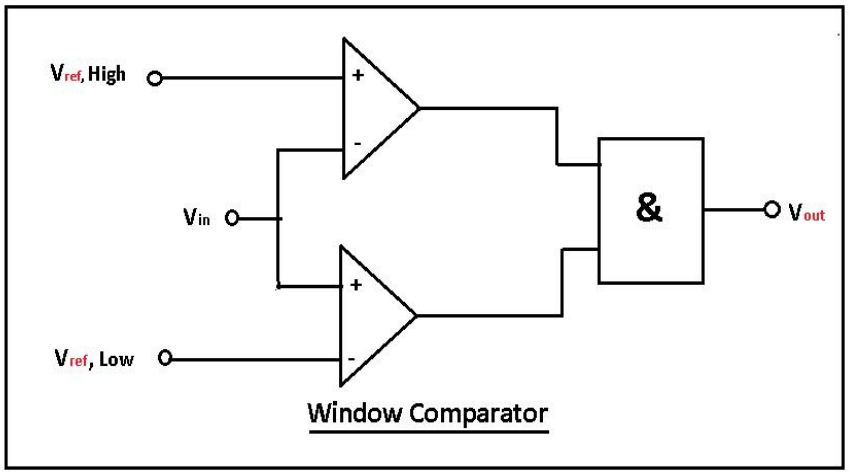

Fig.2: Basic Window comparator

V. FREQUENCY SENSING

For varying the input frequency, IC 555-timer is used [13]. The voltage of the system is kept at normal value via a regulator. The output of the IC 555-timer is connected to the pin of the microcontroller through a PNP transistor. The IC 555-timer works in astable mode to produce signals at frequencies that can be adjusted using the variable frequency [14],[15]. This output is connected to the internal timer of the microcontroller which then calculates the frequency of the frequency accordingly [15]. For frequency value lower/higher than the normal, the relay circuit is triggered, the relay driver is switched off and lamp stops glowing, giving an indication for the synchronization failure due to abnormalities in supply frequency.

VI. ADVANTAGES

Now, let's discuss about the advantages of having such a system that we have proposed in this paper. Following are the some of the advantages -:

- Having such a system can protect the grid from complete failure and prevent black-out or brown-out. In case of detection of asynchronization, the system warns the grid in advance and disconnects the feeder from the grid [16].
- Such a system is advantageous in power houses where different supply sources are connected together in parallel to fulfil the demand for the load.
- The system could be used in home automation, where consumer have more than one energy source.
- The consumer load can be automatically shifted to different sources available.
- As compared to manual system, the proposed system is more compact and reliable [17],[18].
- As compared to other system, this system is less expensive.

VII. DISADVANTAGES

Following are the few disadvantages of the system that we have proposed -:

- The system that we have discussed is based on the embedded system (Microcontroller of 8051 family) which itself is sensitive thus, any failure of microcontroller will ultimately cause the failure to the whole system [16].
- Sensors along with the controllers are used to detect abnormalities and thus, if they stop working then there is need to replace them [18].

VIII. CONCLUSION

Electrical grid is an important part of the generation, transmission and distribution network but one of the major challenges faced by the grid is the failure due to asynchronization caused by abnormal values of voltage and frequency of the supply. As per the Grid Code the variation of voltage and frequency should be in the acceptable range. If any deviation from this range occurs then it is compulsory to disconnect the grid to prevent large scale black-outs. The system that we have discussed in this paper is simple and cheap and is used to sense any abnormalities, intelligently takes action accordingly with the help of microcontroller.

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REFERENCES

[1].H. Karimi, A. Yazdani, and M. R. Iravani, "Negative-sequence current injection for fast islanding detection of a distributed resource unit," IEEE Trans. Power Electron., vol. 23, no. 1, pp. 298–307, Jan. 2008.
[2].Olivares, D. E., Mehrizi-Sani, A., Etemadi, A. H., Cañizares, C. A.,Iravani, R., Kazerani, M., & Jimenez-Estevez, G. A. (2014). Trendsin microgrid control. IEEE Transactions on smart grid, 5(4), 1905-1919.

[3]. Yang, X., Choi, M. S., Lee, S. J., Ten, C. W., & Lim, S. I. (2008). Fault location for underground power cable using distributed parameter approach. IEEE Transactions on Power Systems, 23(4),1809-1816.
[4]. Blaabjerg, F., Teodorescu, R., Liserre, M., & Timbus, A. V. (2006). Overview of control and grid synchronization for distributed power generation systems. IEEE Transactions on industrial electronics, 53(5), 1398-1409.
[5].J. Svensson, "Synchronization Methods for Grid-Connected Voltage Source Converters," IEEE Proceedings in General Transmission Distribution, vol. 148, no. 3, pp. 229–235, 2001.
[6]. Wallnerström, C. J., Stenberg, S., & Hilber, P. (2012). Fault Management at a Distribution System Operator. In PMAPS 2012, The 12th International Conference on Probabilistic Methods Applied to Power Systems, June, 2012, Istanbul.
[7]. Hèctor Beltran, Francisco Gimeno, Salvador Seguí-Chilet and Jose M. TorreloInstituto de TecnologíaEléctrical Av. Juan de la Cierva, 24 - ParcTecnològic 46980 Paterna, València (Spain) paper on ―Review of the Islanding Phenomenon Problem for Connection of Renewable Energy Systems.
[8]. Amin Safari paper on ―A Novel Islanding Detection Technique for Distributed Generation (DG) Units in Power System.February, 2013 International Journal of Advanced Science and Technology Vol. 51.
[9]. S.N. Singh ,S.C. Srivastva, Electric power industry reconstructing in India, Present Scenario and future prospects, Senior Members, IEEE.
[10]. Text Book-The 8051 Microcontroller and Embedded systems‖ by Muhammad Ali Mazidi and Janice GillispieMazidi, Pearson Education.
[11].Ajit S Gaikwad, Ch. Malla Reddy, Pravin S Gulhane, "Developing Islanding Detection Arrangement for Grid on Sensing Voltage or Frequency Variation"- International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering, Vol. 3, Issue 7, July 2015.
[12].Nitin Dhama, Abhishek Gupta, Ajay Mundra, EktaRai, Shreya Singh, "Developing Islanding Arrangement Automatically For Grid on Sensing Voltage or Frequency Beyond Range"-International Journal of Engineering Research & Management Technology, Volume 2, Issue-2, March- 2015.
[13]. Dr. Paul Wright,, "The Next Generation of Power and Energy Measurements"-European Meterology Research Programme, March 2011.
[14]. Haoyang Lu, Lingwei Zhan, Yilu Liu and Wei Gao, "Power Grid Frequency Monitoring over Mobile Platforms"-P.hd Dissertation.
[15]. CH H S RAVI TEJA, "Analysis of Grid Synchronisation Techniques for Distributed Generation System During Grid Abnormalities- June 2013.
[16].Zongjie Liu, Lifeng Zhu, Li Deng, Lijun Qin, Feng Jiao, "The Research of Islanding Detection about the Photovoltaic Grid-Connected Generation System"- International Journal of Computer and Electrical Engineering, Vol. 5, No. 3, June 2013.
[17].V. V. Mehtre, S. G. Desai and D. S. Bankar, "Analysis of a Doubly Fed induction generator based wind farm," 2016 IEEE Technological Innovations in ICT for Agriculture and Rural Development (TIAR), Chennai, 2016, pp. 139-145.
[18]. de Araujo Ribeiro, R. L., Jacobina, C. B., da Silva, E. C., & Lima, A.M. N. (2003).