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Automatic Power Factor Detection & Correction using Microcontroller

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Abstract: Electrical energy is an essential part of modern life important to the economy of country. It is importance is very much for industrial as well as commercial purpose as for lighting, heating, cooling and for operating appliances as computers, electronic machinery and public transportation systems. Mostly the loads are inductive due to which electric current lags the voltage. As a result, larger current is needed to compensate the inductive load compare to resistive load which is not a good sight for power efficiency. To overcome this problem we have developed an Automatic power factor correction system that reads power factor from line voltage and line current. When power factor is not unity the system uses the capacitor bank to compensate excessive components and improve power factor nearly unity.

Keywords: Power factor, Microcontroller, Arduino, AC, lagging, Transformer, Capacitor, DC.

1. Introduction

Electrical energy is the basic necessity for the economic development of country. Many functions necessary to present-day living grind to halt when supply of energy stops [1]. It is practically impossible to estimate the actual magnitude of the part that energy has played in the building up of present-day civilization [2-3]. The availability of huge amount of energy in the modern times has resulted in a shorter working day, higher agricultural and industrial production, a healthier and more balanced diet and better transportation facilities [4-5]. As the need of electrical energy increased day by day it is essential for the betterment of its quality and efficiency [6]. One very important aspect for improving the quality of supply is the control of power factor. Low power factor means poor electrical efficiency [7-8]. The lower power factor, the higher the apparent power drawn from the distribution network [9]. This means that supply company must install larger generation capacity, larger size transmission line and cables, transformers and other distribution system devices, which otherwise would not be necessary [10-12]. This result in a much higher capital expenditures and operation costs for electricity Supply Company, which in many cases is passed on the consumer in the form of higher tariff rate [13].

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Adding factor correction is usually achieved capacitive load to offset the inductive load present in the power system [14]. The power factor of the power system is constantly changing due to variations in the size and number of the motors being used at one time. This makes it difficult to balance the inductive and capacitive loads continuously [15]. To face this problem we have developed the Automatic power factor correction system using the microcontroller to stable the power factor automatically and reduced overall costs for both the consumers and suppliers of electrical energy [16-18].

2. Methodology

Automatic Power Factor correction device is developed basing on Arduino UNO. The voltage and current sampled is used to detect real and apparent power using Emon lib. The V and I sample signals are feed to the microcontroller at ANALOG IN pins A1 and A2 through voltage divider and Emon lib. The values are displayed in the 20x4 LCD module after converting suitably. The capacitor banks are switched as per calibration in steps.

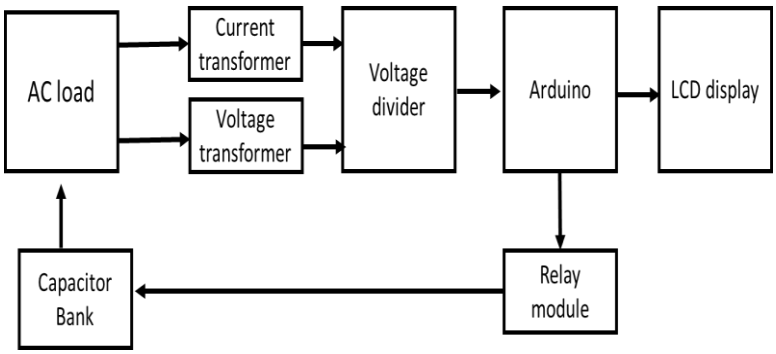

Fig.1- Block Diagram

3. Project Hardware and Software

The hardware part consists of Arduino UNO, Current transformer, Potential transformer, LCD and Relay module.

Arduino UNO: The Arduino UNO is an open-source microcontroller board depending on the Microchip Atmega328P microcontroller and created by Arduino.cc [5]. Arduino receives commands sent by the user according to programming code [1]. It can be controlled by a USB link or by an outside 9-volt battery; however, it acknowledges voltages between 7 and 20 volts.

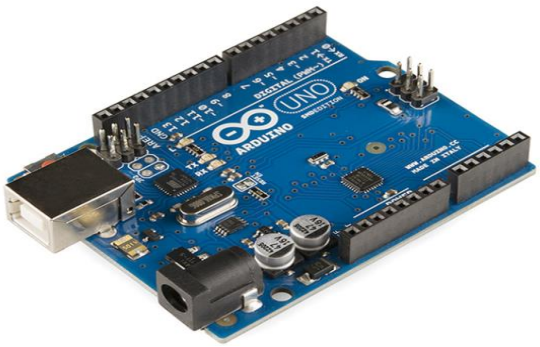

Fig. 2 – Arduino UNO Board

Current Transformer CT: Current transformer lower the measured current to a reasonable value that can be used in measurement and within protective relaying and converted into an equivalent voltage representation. We use a split core transformer clamp on AC current with primary current 0-30A and secondary 0-1V.

Fig. 3 – Current Transformer SCT013-30

Voltage Transformer PT: Potential transformer is a voltage step down transformer which reduced the voltage of a high voltage circuit to a lower. The potential transformer here has a voltage ratio of 230:9 i.e when input voltage is the single phase voltage 230V, the ouput is 9V. it is essential to take caution that microcontroller can only take in certain range of input voltage from 0 to 5V with current limiting of 20mA.

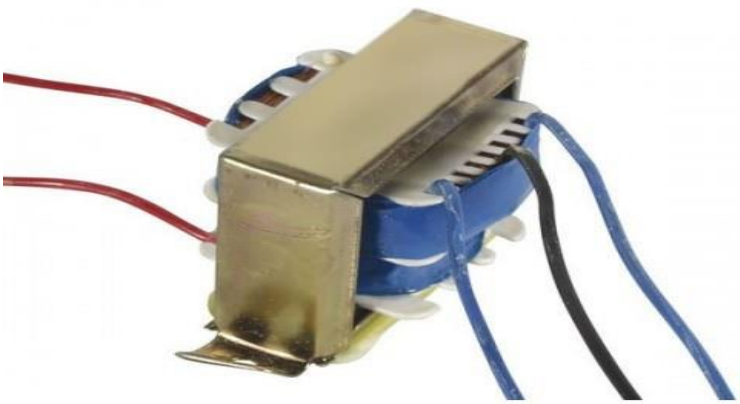

Fig. 4 - Voltage Transformer 230/9V

LCD display module: LCD (liquid crystal display) screen is an electronic display module and find a wide range of applications. A 20x4 LCD display is very basic module and is very commonly used in various devices and circuits. LCDs are economical and easily programmable.

Fig. 5 – LCD 20x4

4 Channel Relay Module Board: It can be used to control various appliances and equipments with large current. It has a standard interface that can be controlled directly by Arduino UNO.

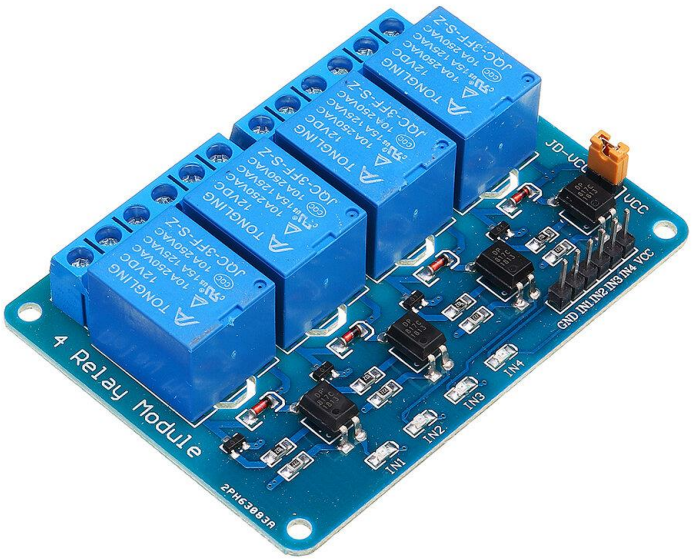

Fig. 6 – 4 Channel Relay Module

Capacitor Bank: A capacitor bank is a grouping of several identical or non-identical capacitors interconnected in parallel or in series with one another. These groups of capacitor are used to correct power factor lag in alternating current power supplies.

Fig. 7 – Capacitor Bank

Proteus 7 Professional: ISIS proteus design suit 7.0 is a Virtual System Modelling VSM that combines circuit simulation, animated components and microprocessor models to co-simulate the complete microcontroller based designs.
Arduino IDE: It is open source software that is used to write codes and upload them to the Arduino board. It is a cross-stage application that is written in capacities from C and C++. The Arduino IDE contains a text editor for writing codes, a message area, a text console, a series of menus along with a toolbar with buttons, the programming codes are known as sketch.

4. Result And Discussions

When the load is inductive and lagging power factor is detected by the developed system, the Arduino microcontroller gives command to relay module to switch on the capacitor bank to compensate the inductive load and unity power factor can be achieved. The V and I samples are automatically compared with time, if any phase difference is achieved the microcontroller switches on or off the capacitor banks using relay module.

5. CONCLUSION

The power factor controller using Arduino microcontroller has successfully designed. The circuit design for power factor measurement and correction was successfully produced. Using this developed system consumer can be charged at lower tariff rate and the power system efficiency may be also stable.

6. Future Recommendation

The device is designed for maximum 30A and single phase household devices, it can be improved for 3-phase and current rating more than 30A for larger electrical systems. Using other fast response switches as BJT, IGBT instead of relay for faster and noise free response.

7. References

[1] Smith, R., & World Economics Association. (2016). Green capitalism: the god that failed. London: College Publications.

[2] Figueroa Helland, L. E., & Lindgren, T. (2016). What goes around comes around: From the coloniality of power to the crisis of civilization. Journal of World-Systems Research, 22(2), 430-462.

[3] Eremina, N. (2016). Advent of a new civilization project: Eurasia in–US out?. Journal of Eurasian studies, 7(2), 162-171.

[4] Hathaway, M. D. (2016). Agroecology and permaculture: addressing key ecological problems by rethinking and redesigning agricultural systems. Journal of Environmental Studies and Sciences, 6(2), 239-250.

[5] Cagliano, R., Worley, C. G., & Caniato, F. F. (2016). The challenge of sustainable innovation in agri-food supply chains. In Organizing supply chain processes for sustainable innovation in the agri-food industry. Emerald Group Publishing Limited.

[6] Kyriakopoulos, G. L., & Arabatzis, G. (2016). Electrical energy storage systems in electricity generation: Energy policies, innovative technologies, and regulatory regimes. Renewable and Sustainable Energy Reviews, 56, 1044-1067.

[7] Soni, J., & Panda, S. K. (2017). Electric spring for voltage and power stability and power factor correction. IEEE transactions on industry applications, 53(4), 3871-3879.

[8] Kalair, A., Abas, N., Kalair, A. R., Saleem, Z., & Khan, N. (2017). Review of harmonic analysis, modeling and mitigation techniques. Renewable and Sustainable Energy Reviews, 78, 1152-1187.

[9] Mukherjee, S., Paul, A. K., Chakraborty, A., & Datta, A. K. (2017). Reactive Power compensation–A case study. International journal of Electronics, Electrical and Computational systems (IJEECS), 6(12), 151-154.

[10] Wang, W., Huang, X., Tan, L., Guo, J., & Liu, H. (2016). Optimization design of an inductive energy harvesting device for wireless power supply system overhead high-voltage power lines. Energies, 9(4), 242.

[11] Birchfield, A. B., Xu, T., Gegner, K. M., Shetye, K. S., & Overbye, T. J. (2016). Grid structural characteristics as validation criteria for synthetic networks. IEEE Transactions on power systems, 32(4), 3258-3265.

[12] Bollen, M. H., & Rönnberg, S. K. (2017). Hosting capacity of the power grid for renewable electricity production and new large consumption equipment. Energies, 10(9), 1325.

[13] Shaner, M. R., Atwater, H. A., Lewis, N. S., & McFarland, E. W. (2016). A comparative technoeconomic analysis of renewable hydrogen production using solar energy. Energy & Environmental Science, 9(7), 2354-2371.

[14] Kabir, Y., Mohsin, Y. M., & Khan, M. M. (2017, February). Automated power factor correction and energy monitoring system. In 2017 Second International Conference on Electrical, Computer and Communication Technologies (ICECCT) (pp. 1-5). IEEE.

[15] Dhameliya, R., Domadiya, K., Miyani, P., Savaliya, H., & Jariwala, P. (2017). Automatic power factor control using arduino uno. International Journal of Advance Engineering and Research Development (IJAERD), 4(4).

[16] Dhameliya, R., Domadiya, K., Miyani, P., Savaliya, H., & Jariwala, P. (2017). Automatic power factor control using arduino uno. International Journal of Advance Engineering and Research Development (IJAERD), 4(4).

[17] Mohamad, M. M., Abd El-gawad, A. F., & Ramadan, H. S. (2016). Power factor improvement for pumping stations using capacitor banks. International Journal of Emerging Electric Power Systems, 17(5), 597-605.

[18] Singh, R. R., & Chelliah, T. R. (2017). Enforcement of cost-effective energy conservation on single-fed asynchronous machine using a novel switching strategy. Energy, 126, 179-191.