Detection and Indication of Faulty Contactors in APFC Panel

Mugdha Korade, Umme Hani Mun, Aarya Kulkarni, Poonam More

Student, Student, Student, Assistant Professor
Usha Mittal Institute of Technology

Abstract—Automatic Power Factor Control (APFC) Panels are consisting of a microprocessor controller and multiple capacitors and are mainly used for the improvement of Power Factor. They are mainly used in industries to maintain the power factor around unity. But after a long run capacitors and contactors may get damaged, due to which power consumption of the fac-tory/industry machine increases, which results in heavy penalty charges imposed on the factory. The objective of this project is to detect the faultiness of contactors and indicate it.

Index Terms—Contactor, APFC Panel, Arduino UNO, NodeMCU, LCD.

I. Introduction

APFC Panel is an automatic control system consisting of a microprocessor controller and multiple capacitors. To keep the industries from excess power consumption, the government has made a law that the power factor value should be around unity. To maintain this value of power factor, an APFC panel is used. In these APFC panels, components like capacitors and contactors are used. But after a long run capacitors and con-tactors may get damaged, due to which power consumption of the factory/industry machine increases, which results in heavy penalty charges imposed on the factory. And to check the entire panel and replace the capacitors or the contactors, takes at least some time, which results in more power consumption and inevitably more penalty imposition on the factory. In this paper we are proposing a method to detect and indicate the faultiness of the contactors in the APFC Panels.

II. Literature Survey

A. History of the topic

The power factors in APFC panels can be defined as ratio of actual power to apparent power. As mentioned in the introduction, they are used in industries to keep the industries from consuming excessive power. It's function is to improve and maintain the power factor. Power factor serves as a measure for how efficiently the system actually uses power. It is a measurement of the phase shift between the line voltage and current as well as their distortion. A typical power factor value is within the range of zero (0) to unity (1), the preferred values being between the ranges of 0.8 and unity. According to [1], depending on the power factor, the types of loads can be classified as resistive, capacitive or inductive. But the capacitors and contactors get damaged after certain time passes because of which the accuracy and functionality of the APFC panel degrades. This is due to the high voltage that is passed through the capacitor and contactor for years almost everyday.

B. Review of Various Papers

We referred several papers to understand the power factor concept such as [1], [3], [4]. Along with it we were also able to learn the different existing and proposed methods through which power factor, power quality indexes, etc can be monitored using the methods proposed in these papers.

In [3] the paper proposes a system for measuring the power quality indexes with remote notifications and consists of 4 blocks, one for signal pre-processing, ADC, Algorithm execution and a block for remote alarm notification. If the designated PQIs fall below a certain threshold, a message is sent to the user where all the values calculated such as active power, reactive power, apparent power, power factor would be included in the message. Whereas in [4], it is believed that digital techniques are better choice over analog techniques as complex algorithms can be easier to be implemented through digital means and along with this the programming, to build a sustainable model, better performance of the model, all of this can be achieved if digital implementation is done. The main motive of this paper is a predictive algorithm is derived based on Boost Topology. Through the simulation outputs given in
[4] it can be concluded that the near unity PF can be achieved when wide input voltage and load current conditions were met.

In [1] studies were done to analyze the impedance varied on the power factor. Through the studies it was also found that amplitude of the current is inversely proportional to inductance. Through reference book [5] we got to know about

the various circuits, such as Absolute Value Output Circuit, Zero Cross Detector and were able to implement them as a part of our experiment to find the optimal circuit to include in the hardware of our project.

The reference paper [2], written by Bhagavathy P., Latha R., Thamizhmaran E., gives us an insight on how we can build an IoT based system to know the status of capacitor banks and letting the user know the about the status of the capacitor bank through the means of SMS i.e. if it's not working. But this paper gives a solution only for detection of faultiness in capacitor banks. Since there is a chance that the contactors may get damaged, the efficiency of this model is reduced as it has no possible solution for the condition when contactors gets damaged. This is the main disadvantage of [2] as contactor is also an important component of APFC panel, whose damage will also make a great impact on the efficiency of the panel as well as of the capacitor to which the faulty contactor is attached.

III. System Architecture

Fig. 1 represents the detailed block diagram of our project. The signal would be drawn from the Power and Control Circuit of the APFC panel and with the help of 230V AC to 5V DC converter module, this signal from the APFC Panel would be give to the micro-controllers via Voltage Regulator LD117AV3. The information will be processed by micro-controllers according to the condition given to the micro-controller and the output will be displayed on LCD, which will be the on-site indicator of our model. Along with this on-site indicator, we built an app that is compatible to the system which will give timely notifications and alerts according to situation.

A. Hardware Design

In the APFC Panel there are two main circuits, the Power Circuit and the Control Circuit. To explain first lets take up the Control Circuit. The signal from the Control Circuit will be passed to AC to DC convertor. This is done to step down the high voltage from the AC to DC converter as micro-controller boards that are used in this project requires voltages less than 5V to work efficiently and the Voltage from APFC Panel more than 230V. The output from AC to DC converter module is given to micro-controller, here arduino board, via Voltage Regulator to the determine if the contactor is working or not based on the flow that passes through the contactor and the signal that was drawn from Panel. Similarly, the signal from Power Circuit will also be passed to AC to DC Converter and via the Voltage Regulator, it will then be carried forward to the Micro-controller Board. The micro-controller interfaced with an app will show the details of the contactors and will be updated after regular intervals on the app. Fig. 2 is a prototype model of this project.

B. Software Design

We built an app through which the user will be able to display the values of signal from contactor that is calculated by

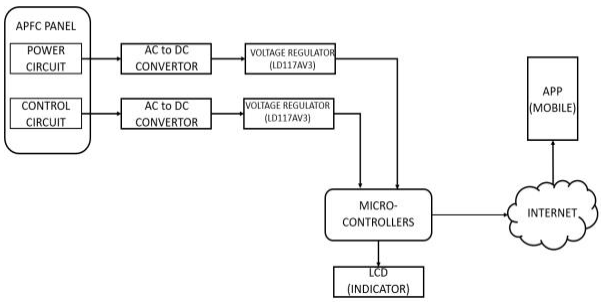

Fig. 1. Block Diagram of the Project

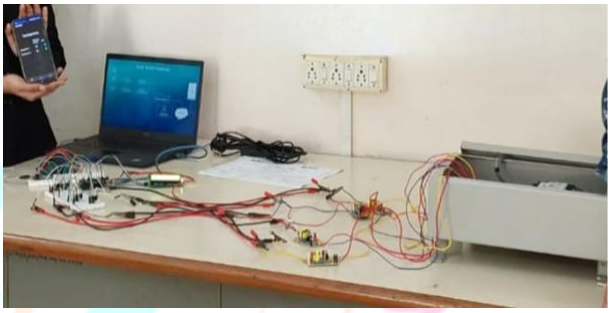

Fig. 2. Project Model

the micro-controller board. Micro-controller such as, Arduino can be used but in this project, NodeMCU is connected to the Arduino UNO board as the Wifi feature is to required for interfacing the App with micro-controller and this feature is inbuilt in NodeMCU. We will be using the language JAVA to code our app. The platform we will be using to compile and test our code is the Android Studio platform.

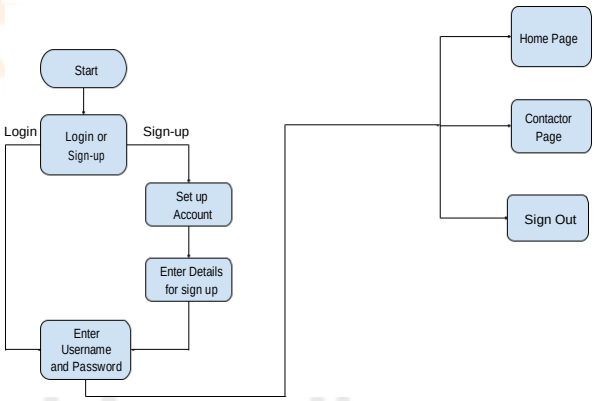

Fig. 3. Flowchart of App

Fig. 3 represents the flowchart of the the app built for monitoring the status of contactor. There are 4 pages in this. First, there is a Login Page. This is for the existing users.

Second, for those who are new users, they will have to click on the sign up button present in the app screen. This will take them to the Sign up page and there they will have fill all the necessary details such as their name, email id (username), password and the details of the APFC Panel. Then after entering the username and password, the user will be directed to the homepage. At the bottom of the page, there is a navigation bar which will consist of Home Page button leading to Home Page, Contactor button leading to Contactor Page and the Sign out button. The Contactor Page will consist of the status, i.e. whether the contactor is in the working state or not working state.

IV. Results and Discussion

In this project, we aim to detect and indicate the status of the Contactors of APFC Panel i.e. whether they are working correctly or not. We were able to achieve this by drawing the signal from the Power and Control circuit of APFC Panel using AC to DC convertor. This signal from the AC to DC convertor is also sent to the Arduino UNO for processing, detection and indication via Voltage Regulator LD117AV3. The output is displayed on the LCD, providing the users with a real-time information about their panels. To provide users with alerts and notifications about the system, we developed an app compatible with the system. The Arduino board is connected to NodeMCU board to show the status of the contactors.

Fig. 4, Fig. 5 and Fig. 6 show the status of the contactors i.e OFF condition, Working condition and Not Working condition respectively. For sending the data to App via NodeMCU we used the ESP8266WiFi library to make a connection between the app and NodeMCU. One limitation of this system is that it cannot detect and indicate the status of Capacitor Banks, which is also an integral part of the APFC Panel. Overall, the proposed system provides an efficient and effective way for users to monitor the contactors used APFC panels, improving the reliability and performance of their electrical systems.

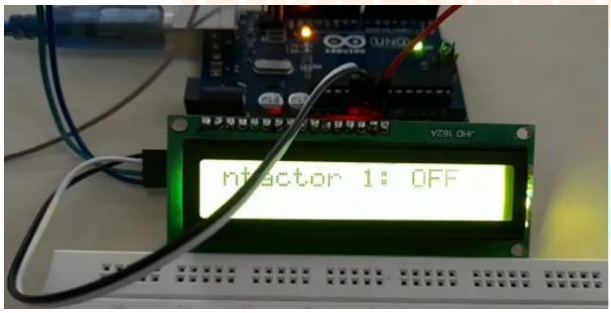

Fig. 4. Project Model: OFF Condition

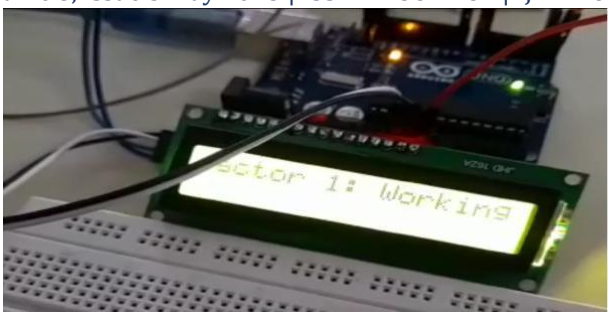

Fig. 5. Project Model: Working Condition

Fig. 6. Project Model: Not Working Condition

V. Conclusion

From environmental and economic view, it is essential for industries to maintain the power factor value of APFC Panels around unity. Through our project, detection and indication of faultiness in contactors will be able to alert the users and take a decision according to the situation before the contactors get damaged completely.

The method proposed in this paper would not be taking over the manual detection completely, but it will be giving an early alert to the users if there are any faults detected in the signal drawn to process the working of the contactors in the panel. Thus, they will be able to some save the time that is spent on the manual detection which industries get to know only after receiving the penalty charges with the included with the bill from the electricity board and also the money that will spent on paying the penalty charges and unnecessary power consumption will also be reduced.

Acknowledgment

Foremost, we would like to express our sincere gratitude to Professor Dr. Santoshi Pote, Head of Department (Electronics and Communication), and our guide, Prof. Poonam More for her valuable guidance and continuous support; her patience and motivation, enthusiasm, and immense knowledge. Her direction and mentoring helped us to work successfully on the our project topic. Our sincere gratitude to Dr. Shikha Nema, Principal (Usha Mittal Institute of Technology) for her valuable encouragement and insightful comments. We would also like to thank all the teaching and non-teaching staff for

their valuable support. Last but not least we would like to thank our family and friends.

REFERENCES

[1] Abhinav Sharma, Saleem Khan, Shavet Sharma, Parveen Lehana, "De-pendence of Power Factor on Inductive Loads for Microcontroller based Power Systems" IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE), Vol. 7 no 2, pp. 30-35, July-Aug 2013.

[2] Bhagavathy P., Latha R., Thamizhmaran E., "Development of IoT Enabled Smart APFC Panel For Industrial Loads," 10th ICCCNT 2019, July 6-8, 2019, IIT - Kanpur, Kanpur, India, July 6-8, 2019.

[3] J. Deng, C. Lam, M. Wong, L. Wang, S. Sin and R. Paulo Martins, "A Power Quality Indexes Measurement System Platform with Remote Alarm Notification" IECON 2018 - 44th Annual Conference of the IEEE Industrial Electronics Society, 2018.

[4] Wanfeng Zhang, Guang Feng, Yan-Fei Liu, Bin Wu, "A Digital Power Factor Correction (PFC) Control Strategy Optimized for DSP" IEEE TRANSACTIONS ON POWER ELECTRONICS, VOL. 19, 2004.

[5] Ramakant A. Gayakwad, "OP-AMPS and Linear Integrated Circuits", Pearson Publications, 2021.

[6] Muhammad Ali Mazidi, Janice, Gillispie Maizidi, Rolin D. Mckinaly, "The 8051 Microcontroller and Embedded system using Assembly and C", PEARSON Prentice Hall, 1999.