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Enhancement of Power Factor with PSO Algorithm Using Arduino as a Low-Cost Solution

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ABSTRACT:To boost power factor, a variety of approaches and procedures are available. The first step in improving power factor is to measure it, and the second step is to rectify it. Adding capacitors to the circuit is usually used to rectify the problem. The measurement of PF in this work is done using a low-cost approach. The calculated capacitor value is then used to adjust the measured PF. Power factor correction research has become a popular issue in order to increase transmission efficiency. Many Power Factor Correction (PFC) control approaches have been presented. The ability to absorb the reactive power supplied by a load is known as power factor correction.This may be done manually by switching capacitors in the case of constant loads, but in the event of quickly fluctuating and distributed loads, it becomes impossible to maintain a high-power factor by manually switching capacitors on/off in proportion to load change within an installation. This disadvantage is remedied by employing an automated power factor correction (APFC) panel, which measures power factor from the load using a PIC microcontroller or Arduino and triggers the necessary capacitors to adjust for reactive power and bring power factor close to unity.

KEYWORDS: Power factor correction, Zero Crossing Detector,Arduino, Capacitor banks, Inductive load.

I.INTRODUCTION

Power is extremely valuable in today's technology development. As a result, we must investigate the reasons of power outages and work to enhance the power system. The quantity of reactive power used in some situations may even be more than the amount of active power generated. This unfavourable feature exerts an unnecessary strain on the electrical grid. As a result of industrialisation, the usage of inductive loads has increased, and the efficiency of the power system has decreased. As a result, we'll need to find a way to boost the power factor.The Automatic Power Factor Correction (APFC) gadget is particularly effective for enhancing the efficiency of active power transmission. When a consumer connects an inductive load, the power factor lags; when the power factor falls below 0.97 (lag), the electric utility charges the consumer a penalty. As a result, it's critical to keep the Power Factor below a certain threshold. By calculating the delay in the arrival of the current signal with respect to the voltage signal, the automatic power factor correction (APFC) device determines power factor from line voltage and line current.

$$Power\ Factor = \frac{Real\ Power}{Apparent\ Power}$$

The phase angle and power factor for these time values are then calibrated. The values are then shown on the LCD module. The motherboard then calculates the compensation needed and switches on the appropriate capacitor banks. The Ardiuno microcontroller was used to create this. These voltage, current, and power factor measurements are sent to a computer through a serial interface connection (RS232). The power factor, voltage, and current values are saved on the computer. Automatic power factor adjustment techniques may be used in industries, power systems, and even households to make them more stable. As a result, the system becomes more stable, and the system's and apparatus' efficiency improve. The cost of using a microcontroller is reduced.The power factor can take on any value between 0 and 1. When all of the power present is reactive power, the power factor approaches to zero, and this is referred to as an inductive load. PF, on the other hand, is a resistive load when there is just actual power available. PF correction simply entails changing the electrical circuit to get the power factor closer to 1. Improving the Power Factor to near 1 compensates for the reactive power in the circuit, resulting in the majority of the power being actual power. As a result, power line losses are reduced.Power factor adjustment can be used in conjunction with an electrical power source to improve system efficiency while also stabilising the transmission network. Furthermore, improvements may be

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achieved by power suppliers charging for single electrical users in order to obtain cost reductions. Power factor correction research has become a popular topic in the quest to increase transmission efficiency.

II.METHODS FOR IMPROVING POWER FACTOR

Using Capacitors:

In order to improve PF, the phase difference between the voltage and the current must be reduced. Reactive power is required for inductive loads to function. A bank of capacitors linked in parallel to the load provides reactive power. Capacitors are believed to be a source of local reactive power, and as a result, less reactive power flows from the line. They reduce the voltage and current phase difference.

When capacitors are employed, losses are minimal, and maintenance is minimal. Because of their reduced weight, capacitors are simple to install and do not require a foundation.

Using Synchronous Condenser:

The Synchronous Condensers are three-phase synchronous motors with no load on their shaft. The synchronous motor has the ability to operate at any power factor, including leading, lagging, and unity, depending on the excitation. A synchronous condenser is attached to the load side in the event of inductive loads, and it is then overexcited. When they are overexcited, they act like a capacitor. When such a machine is connected in parallel to the supply, it draws leading current, which partially neutralises the load's lagging reactive component, improving power factor. The use of a synchronous condenser allows for greater power factor control as well as improved thermal stability. The flaws are simple to correct. The motor suffers losses.It has a considerable maintenance expense.

Phase Advancer:

This is an A C exciter, which is primarily used to increase the induction motor's power factor. When synchronous motors aren't an option, phase advancers come in handy. For motors with less than 200 horsepower, phase advancers are not cost-effective.

III.PROPOSED SYSTEM

There are two types of power factor correction Techniques:

A. Passive power factor correction methods

In these strategies, the consonant current can be constrained by utilizing an LC channel that passes the current just at line recurrence (50 or 60 Hz). Consonant flows are diminished and the nonlinear gadget looks like a straight burden. Power variables can be improved by utilizing inductors and capacitors. Yet, the hindrance of latent PFC is that it requires high current inductors which are costly and cumbersome.

B. Active power factor correction methods

Active power factor correction (APFC) is the most successful method for remedying the power element of electronic supplies. A boost converter is set between the bridge rectifier and the load. The converter attempts to keep steady DC Output voltage and keep the line current in stage with the line voltage and the equivalent frequency. The upsides of the boost APFC are dynamic wave forming of supply current, separating of the high recurrence exchanging, criticism detecting of the source current for waveform control, and feedback control to direct result voltage.

Active Power Factor Correction circuit components:

The primary circuit comprises a single-stage full-wave bridge rectifier, boost converter, and load. The control circuit comprises of blunder speaker, the result of which is increased by the corrected voltage Vin and a component to get i_f, i_f is then compared with I_L and the outcome is taken care of to the drive circuit which gives heartbeats to the MOSFET change to accomplish unity power factor.

The crucial APFC standard is that the rectifier voltage which is the input (AC) signal is changed over into (DC) voltage utilizing the bridge diode rectifier and it is changed into a current signal by the DC/DC converter utilizing control techniques. So the current signal would auto be able to follow the voltage signal to be in stage.

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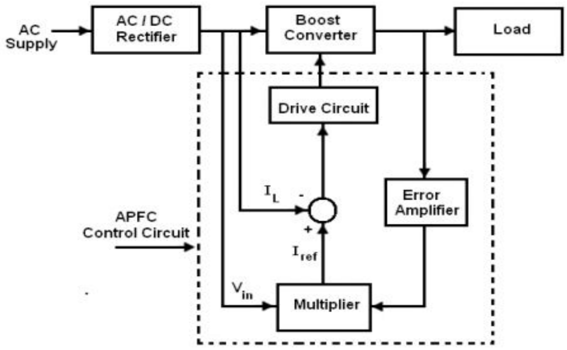

Fig 1. Structure of APFC

In Fig. 1 the reference current i_f is analyzed with the inductor current I_L and the outcome is taken care of to the drive circuit that gives the signal to the boost converter switch.

Particle Swarm Optimization:

The Particle swarm improvement is a computational strategy that upgrades an issue by utilizing cycles also, attempts to upgrade an up-and-comer arrangement as indicated by a given proportion of value. It tackles an issue by having a populace of competitor arrangements, here called particles, these particles move around in the hunt space as indicated by a straightforward numerical equation over the position and speed of the particles. Each development of the molecule is impacted by its neighborhood best-known position, yet it is additionally directed toward the best-known situations in the pursuit space which are refreshed as better places that are found by different particles. So the multitude moves towards the best position.

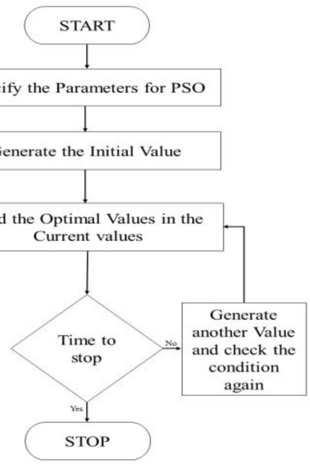

Fig 2. Flowchart of PSO Algorithm

IV.RESULT AND DISCUSSION

Study of Simulation:

To investigate the effectiveness of the controller acquired in the above area, a simulation study for a single-phase rectifier circuit providing a DC motor is done. In the first place, the system is simulated without the APFC circuit. Then, at that point, it is simulated by utilizing the APFC circuit. For each situation, the power factor, the current, and the voltage waveforms are acquired by utilizing the two current control methods clarified above. The popular simulation package, MATLAB/SIMULINK is utilized in this simulation work. And also we simulate with the proteus software for the preparation of Hardware.

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MATLAB Simulation:

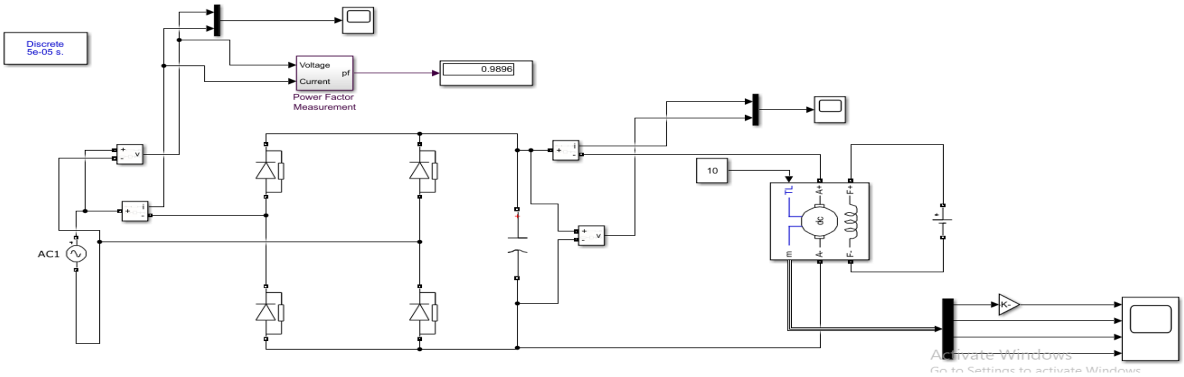

Fig 3. Simulation of the System without APFC

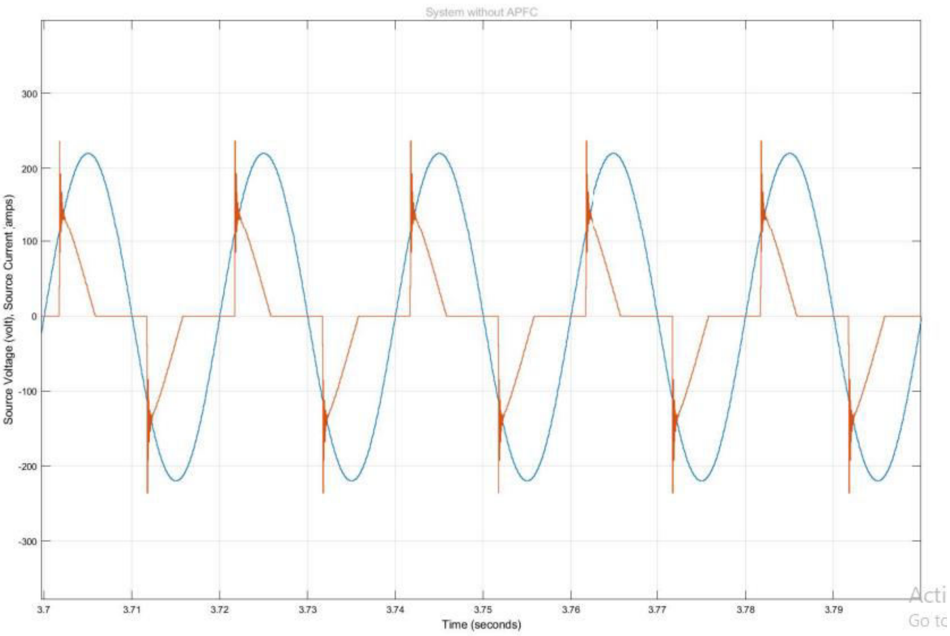

Fig 4. Source voltage and current waveform

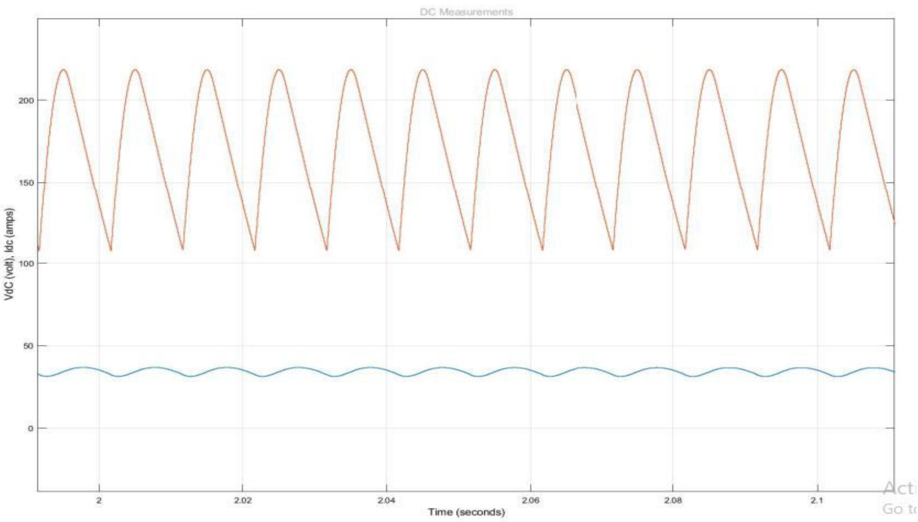

Fig 5. DC Output of the System without APFC

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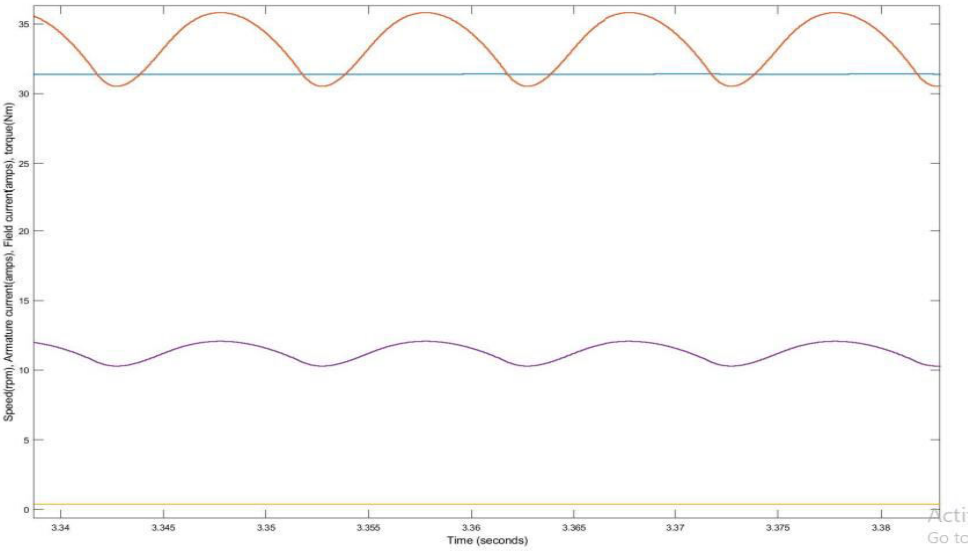

Fig 6. Overall Output of the system without APFC

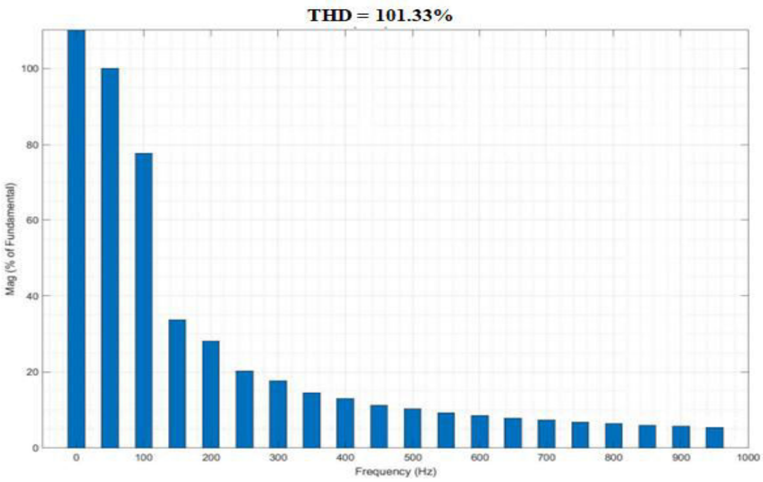

Fig 7. FFT Analysis of the system without APFC

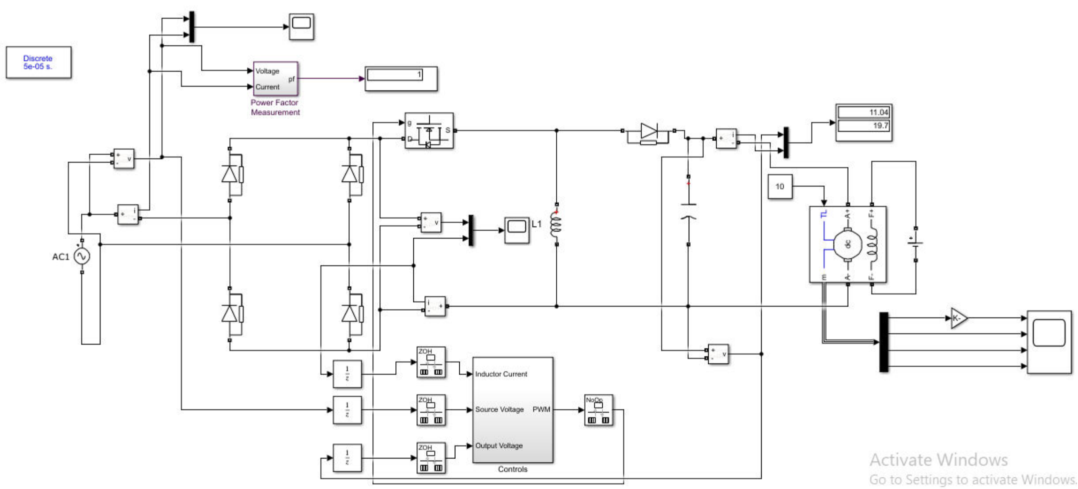

Fig 8. Simulation of the system with APFC

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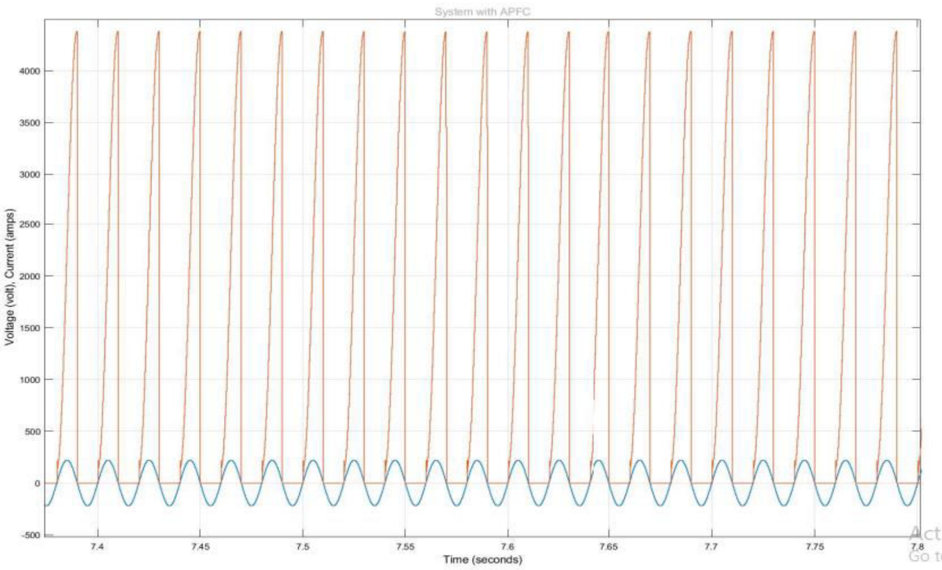

Fig 9. Source Voltage and Current Waveform

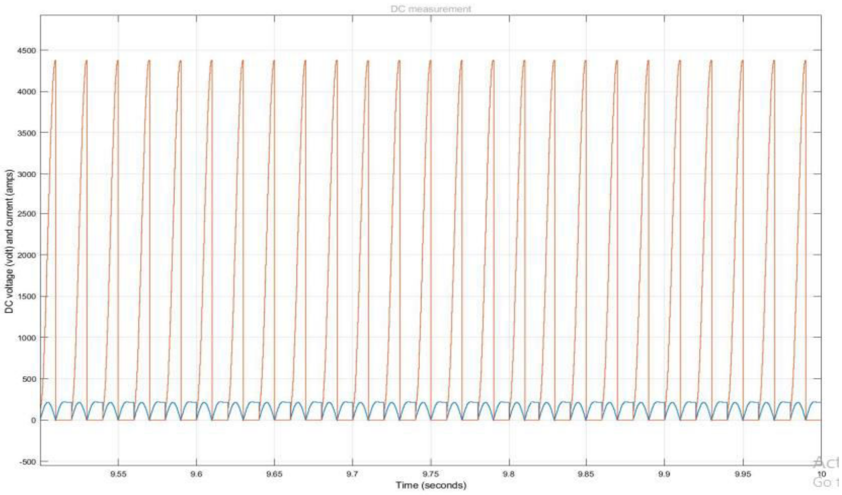

Fig 10. DC Output of the system with APFC

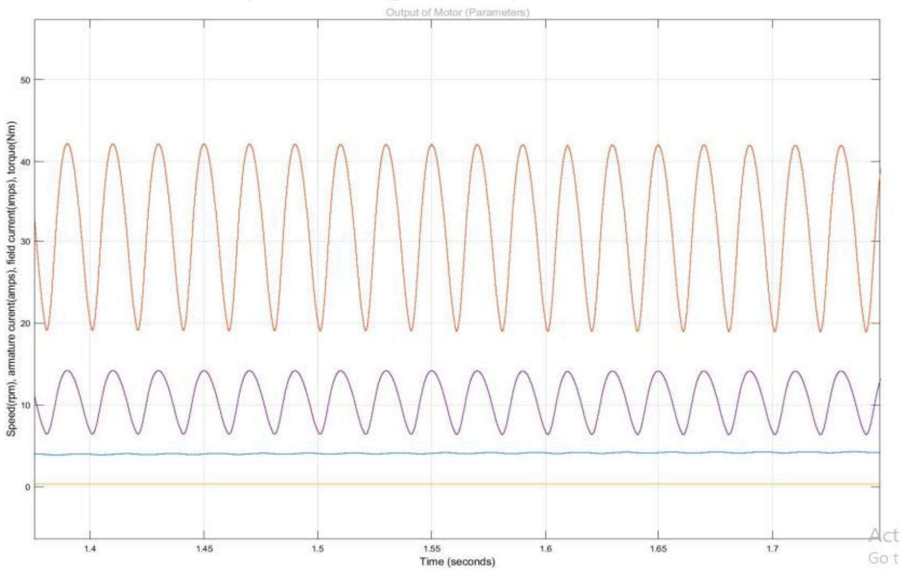

Fig 11. Overall Output of the system with APFC

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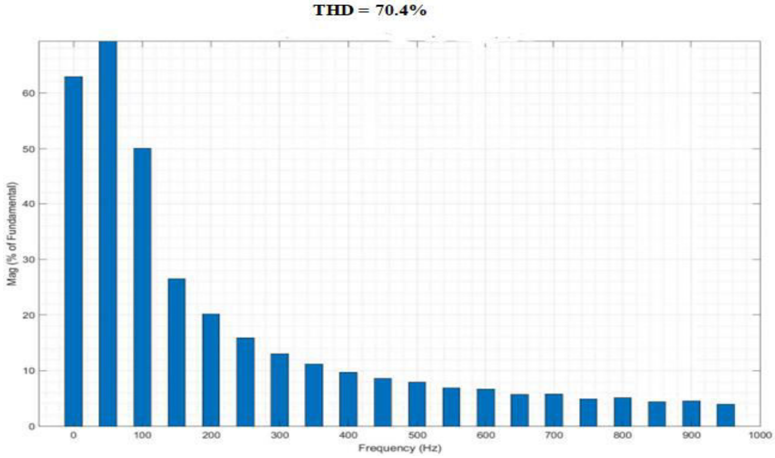

Fig 12. FFT Analysis of the system with APFC

Proteus Simulation:

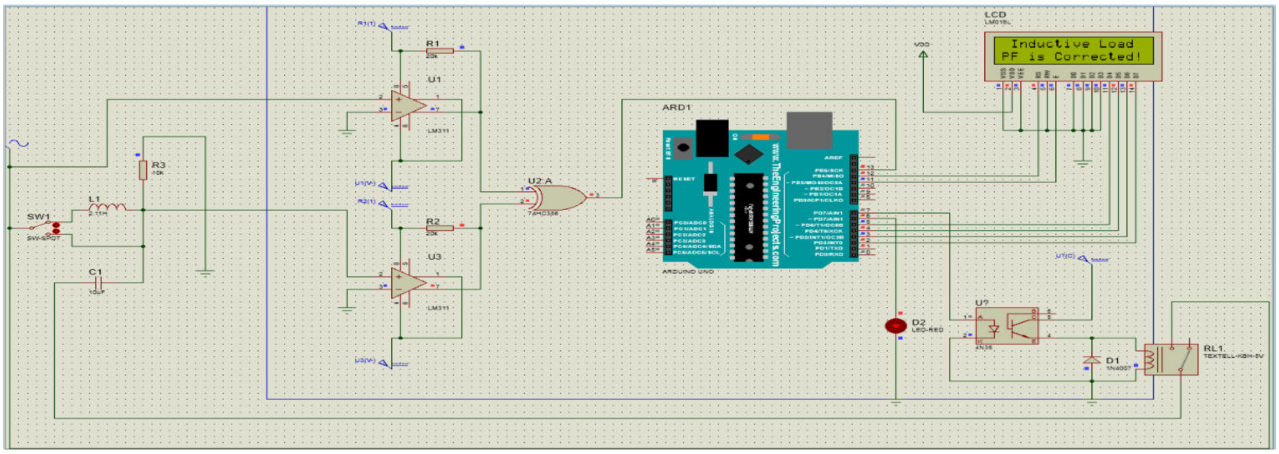

Fig 13. Simulation of the Hardware

Hardware Implementation:

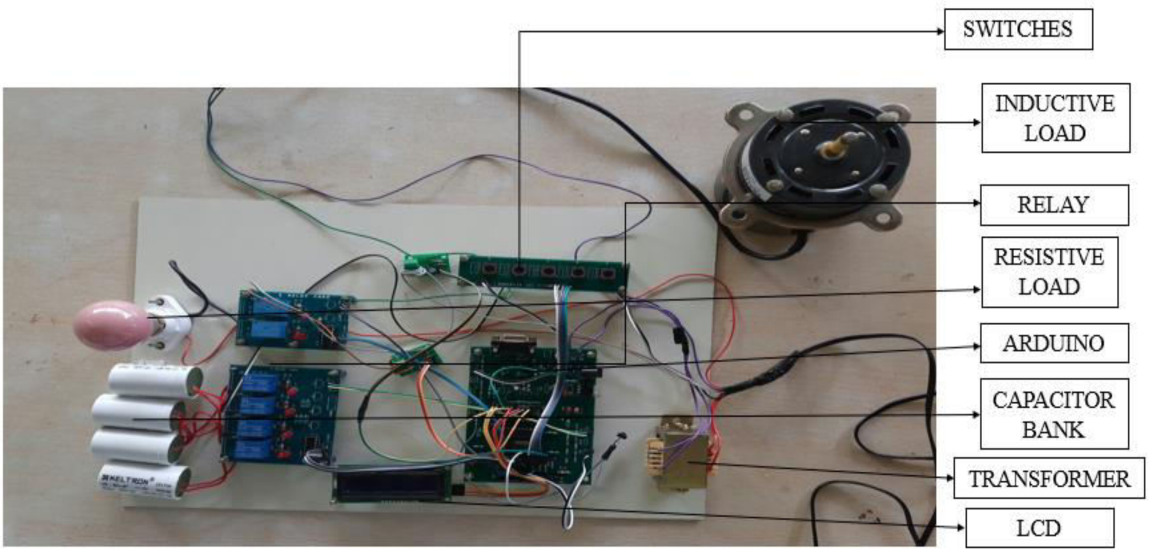

Fig 14. Hardware setup of the Project

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V. CONCLUSION

The Automatic Power Factor Detection and Correction approach is a cost-effective solution to increase the power factor of a power system. In manufacturing and distribution lines, static capacitors are almost often employed to enhance power factor. However, capacitors are only used in this arrangement when the power factor is low; otherwise, they are disconnected from the line. Any distribution line's power factor may be readily enhanced using a low-cost small-rating capacitor. From the load side, this system with static capacitor can enhance the power factor of any distribution line.

Future scope:
For large ratings of APFC systems, a prototype-built GSM system can be employed. The planned equipment has been tested in the laboratory and may be installed in my substations with suitable protection to ensure that the operation is verified in a real-world setting.

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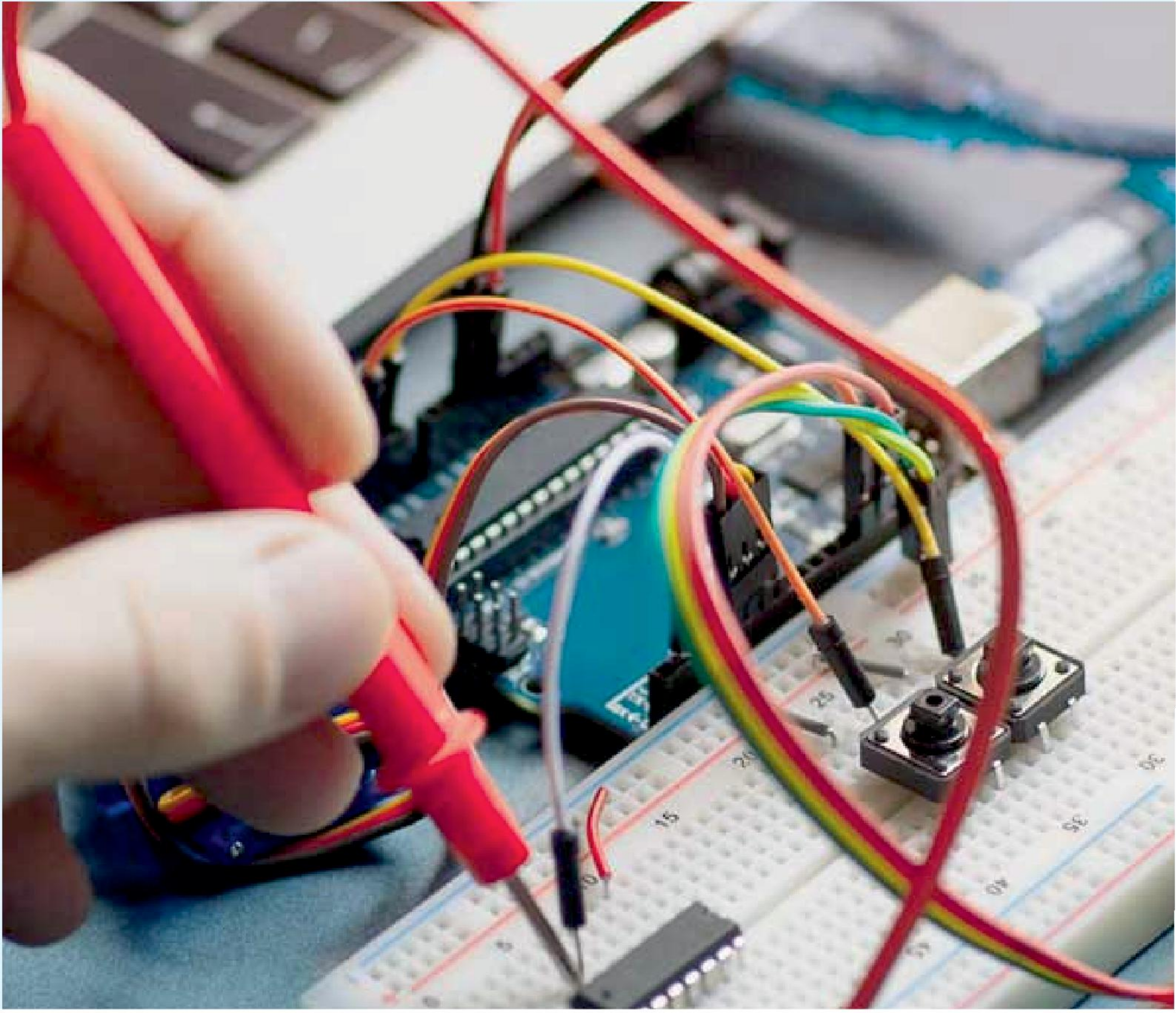

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