



Automatic Power Factor Correction Unit Using Arduino

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ABSTRACT: We are in the need of energy which we have to make major corrections in which the energy is wasted in form of reactive power. So, the required energy can be utilized in which the energy can have the major correction to form a power factor. The power factor can be developed with the required energy the utilized power is used in a proper way. The reactive power can be compensated using capacitor banks and this can be termed as power factor correction. The power factor correction is a major problem in an industry to compensate a reactive power factor. The reactive power can be compensated with a reactive and it makes into real power. Hence according to the load the power factor can be compensated using Arduino microcontroller and switching operation is done with the regular power factor and this can be controlled with microcontroller. The microcontroller is programmed with to operate with the necessary coding.

KEYWORDS: Power factor, capacitor bank, solid state relay, precision rectifier, superdiode, phase measurement, AC signal measurement, Arduino.

I. INTRODUCTION

In India power market is very critical and it is not enough to serve the people according to the generation. In order to reduce the energy losses we have to make up the losses which are wasted by means of reactive power generation. The huge industries may consume large amount of power in rating of kW sanctioned by the electricity department. We have a term called power factor in power system which can be defined as the ratio of losses to the total power generated to the power received in the consumer terminals. If the term power factor is maintained at a nominal value, then the energy losses can be reduced. For this purpose, we are using capacitor bank to compensate the reactive power generated. The power factor may vary depending on the rating of the load which are connected to supply mains. If we connect a less amount of inductive load, then the power factor will be less. If the load is resistive then the power factor is maintained at unity. If we switch on the capacitors according to the load variations at correct time, then the power factor can be maintained at constant. So, these are the introduction of our project.

II. THEORY

In this theory we will study about the installation of capacitor banks according to the load connected in power system. There are two methods available for the calculation of capacitor banks to load connected. They are i. Thumb rule, ii. Determining the power factor as we required, iii. Thumb rule:

$$\text{TOTAL LOAD} = 250 \text{ kVA}$$

$$\text{kVA TO kW}$$

$$= 250 \times 0.8 = 200 \text{ kW}$$

$$\text{kW to HP}$$

$$= 200 / 0.746 = 268.09 \text{ HP}$$

$$\text{capacitor rating (in kVAR)} = 268.09 / 3 = 89.365 \text{ kVAR}$$

So, according to thumb rule capacitor bank to be implemented to 250 kVA is 90 kVAR approximately.

i) Determining the power factor as we required:

ACTUAL POWER FACTOR WITHOUT CAPACITOR BANK= COS
 $\Phi_1=0.7$ REQUIRED POWER FACTOR TO BE MAINTAINED AS PER
 NORMS= $\text{COS}\Phi_2=0.9$

$$\Phi_1=\text{COS}^{-1}(0.7) =45.57$$

$$\Phi_2=\text{COS}^{-1}(0.9) =25.84$$

IMPROVEMENT IN PHASE= $\Phi_1-\Phi_2 = (45.57-25.84) =19.73$
 IMPROVEMENT FACTOR = $\tan (\Phi_1-\Phi_2) =\tan (19.73) =0.358$
 REQUIRED CAPACITOR BANK RATING=LOAD X
 IMPROVEMENT FACTOR= $250 \times 0.358 =89.6 \text{ kVAR} =$
 90(APPROX)

So, as we discussed in the theory part if the connected load is 250 kva then the capacitor banks to be installed is about 90 kvar approximately

III. MEASURING THE POWERFACTOR

As we discussed in the introduction part, before entering the power actor correction we have to calculate the power factor in power system depends upon the load connected to the system. There are various methods involved in the power system to calculate the power factor. In this discussion we use potential transformer and current transformer and some electronic circuits to calculate the power factor. The electronic components are

- i) Op-amp (LM358)
- ii) Ex-Orgate
- iii) Microcontroller (Arduino Uno Atmega325)

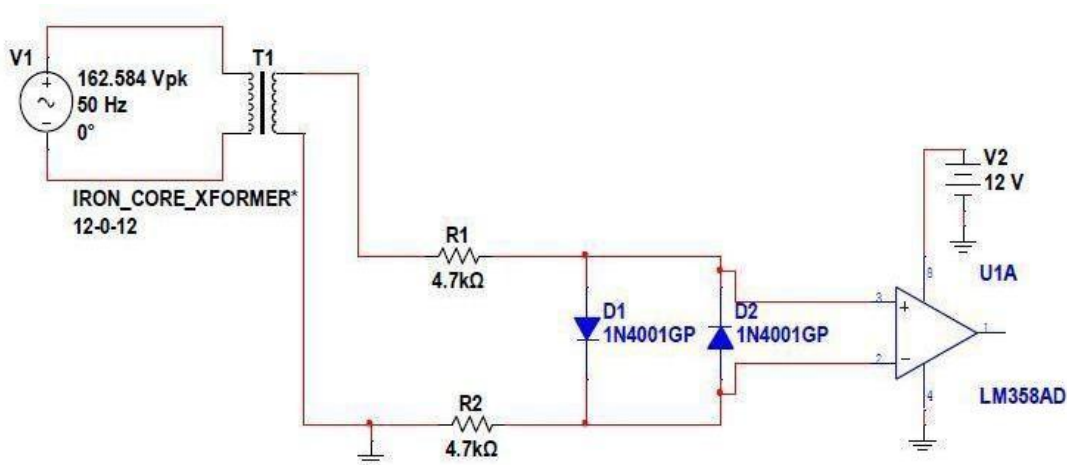


Fig.1 Zero-crossing detector circuit.

Usually we will have a sine waveform in a supply. In order to measure a power factor, we need to find the time period in electric pulse present in the supply. We cannot able to find the time period using the sine waveform which is available in the supply. So, in order to calculate the time period, we need to convert the sinusoidal waveform into square waveform. This can be achieved using the zero-crossing detector circuit using the Op-amp circuit. We have used potential transformer and its output is given to the rectifier circuit to convert the AC signal into pulsating dc signal and its given to the op amp terminals the output of the op amp is feed to Arduino microcontroller for the voltage signal. The same circuit is repeated for the current signal using the current transformer and its output is fed to the Arduino microcontroller. Both the current and voltage signals are feed to EX-OR gate in order to obtain a single square waveform to give o the Arduino microcontroller.



IV. INTERFACING OF ARDUINO

The Arduino is a microcontroller with simplest form of programming language and easily available sets of programming and header files available on internet. I have a micro controller IC and several input and output terminals available which are easy to make connections to external connection. It can be connected to a system with a USB cable and can be programmed easily through a common platform given by the Arduino. The 5v power adapter is provided to connect to a main supply after he is programming is done.

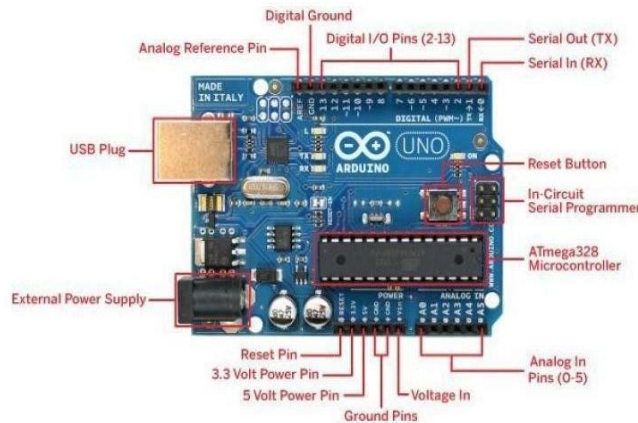


Fig 2: Clear explanation of the Arduino and its parts.

V. SWITCHING OPERATION ALGORITHM

Once the power factor is calculated then using the value of the power factor, we can able to switch upon the various capacitors to compensate the reactive power generated. The function used for the switching operation of capacitor banks are if (power factor < 0.98)

```

{
    digitalWrite
    (cap1, HIGH); getpf
    ();

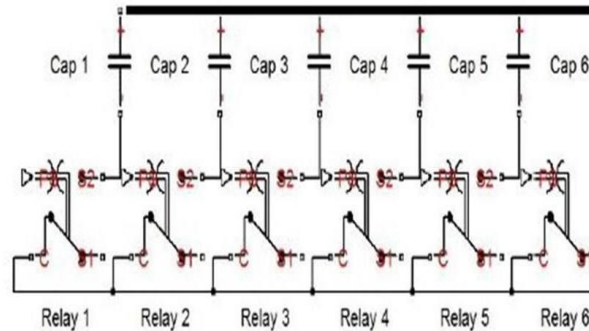
    Serial.print("\tThe corrected Power factor
    is:\t\t"); Serial.println(power_factor); if
    (power_factor<0.98)

    {
        digitalWrite
        (cap2, HIGH); getpf
        ();

        Serial.print("\tThe corrected Power
        factor is:\t\t"); Serial.println(power_factor);
        if (power_factor<0.98)
        {
            digitalWrite
            (cap3, HIGH); getpf
            ();

            Serial.print("\tThe corrected Power
            factor is:\t\t"); Serial.println(power_factor);
        }
    }
}
    
```

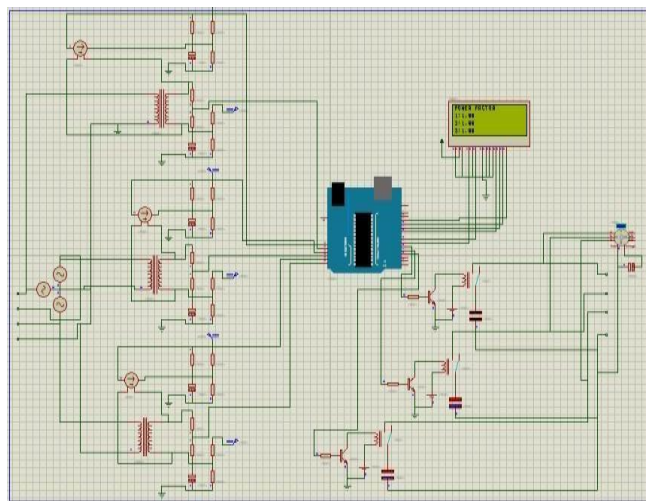
Hence the power factor is set at 0.98 value and till it reaches he 0.98 the capacitor bank connected will keep on



increasing according to the load and vice versa.

VI. PROTEUS SIMULATION

The proteus is a software which helps to simulate a critical circuit which have the proper platform with which the blocks were used to obtain a proper simulation medium with electronic circuits and the required value can be viewed with the initial manner. the Arduino is also interfaced with the proteus simulation to get a proper output and this can be viewed with the proper value.



Result of our concept and hence the output has been verified with our targeted outputs. in the simulation we have used motor as a load and transistors as a switch for the switching operation.

Here system is divided into following major components.

1) Zero crossing detection of voltage and current signal:

Zero crossing detection is done for both voltage and current signals. The power signal voltage is stepped down to lower level using 6-0-6/750mA step down transformer and then is applied to LM358 based ZCD circuit. The ZCD circuit then gives zero crossings for voltage signal. For power line current we use noninvasive current transformer to step down it to lower level. This signal is then applied to ZCD to get its zero crossing. From these to ZCD outputs we know the phase difference between voltage and current signals using single XOR gate.

2) Pulse generation corresponding to phase difference between voltage and current:

The two ZCD outputs are then applied to EXOR logic gate to get a pulse corresponding to phase difference between voltage and current signal.

Arduino based decision making: The Arduino microcontroller forms the main decision maker here. Its functions can be divided into following component parts.

3) Phase difference measurement:

The pulse output from EXOR gate is applied to Arduino. of pulse. The pulse width corresponds to phase. The Arduino then measures the width difference measurement. Thus, by measuring pulse width we have effectively measured phase difference between voltage and current signal.

4) Power factor measurement:

From the value of measured pulse width, the Arduino now finds out the power factor.

5) Capacitor calculation:

From power factor it finds out required value of capacitor to bring power factor back to unity. For this we use following formula= $KVAR / (2 \times \pi \times f \times V_{rms} \times V_{rms})$

6) Capacitor switching:

Arduino then adding required capacitor value across the load using thyristor-based switching scheme. It generates the required gate drive for thyristor to switch it ON.

7) Thyristor based capacitor bank:

The capacitor bank used in our project is thyristor based. capacitor is added in line.

All the algorithms and methods discussed above were tested on the experimental setup. Some of the results are discussed in this section.

Table1: Result Analysis

Before Correction			After Correction		
PF	I(A)	A.P(VA)	PF	I(A)	A.P(VA)
0.85	0.77	171	0.96	0.70	156
0.72	1.02	229	0.96	0.79	177
0.60	1.22	271	0.96	0.80	178
0.50	1.35	301	0.95	0.76	172



Fig4: Load condition before and after power factor correction

VII.CONCLUSION

This project provided one of the techniques used to overcome power losses due to low power factor associated with common house hold and small industrial units. In this project AC load voltage and current was measured by sampling rectified sine wave. For rectification, a precision rectifier was designed and applied using op-amp. The sampling was started when the input wave crosses the horizontal axis in both cases of voltage and current. For measuring phase difference, EXOR gate was used for finding the phase difference between voltage and current, and thus measuring the on time of EXOR output gives the angle. All rest information (i.e. RMS voltage and & current, active power, reactive power, apparent power, power factor, capacitance) was worked out using different formulas. Moreover, based on this analysis, a corrective algorithm was established to achieve power factor close to unity. This algorithm incorporates switching capacitances inline automatically through solid state relays in order to compensate the lagging powerfactor.

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