A PROTOTYPE OF POWER FACTOR METER USING ARDUINO-UNO MICROCONTROLLER

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Abstract: This paper is a prototype of a low-cost electronic power-factor meter that can replace the conventional electrodynamics type meter. The alternating voltage and current signals are passed through a zero-crossing detector which basically works as a comparator in open loop mode and produce a square wave signal. Then the two square wave signals corresponding to voltage and current signal are fed to the XOR IC. The pulse width of the XOR output signal is proportion to the phase difference of voltage and current signals. The duration of this pulse width is measured with the help of microcontroller, ARDUINO-UNO (ATmega328p).

IndexTerms **- Power factor, comparator, Arduino, Pulse width, smart meter.**

I. INTRODUCTION WITH LITERATURE SURVEY

The major goal for designing any measuring instrument is to obtain a device that can measure with high precision the quantity which it was designed to measure and obtaining minimal error. Over the years, different wattmeters, power factor meters have been designed to measure electrical parameters. These have been classified as analog and digital meters. There are wattmeters that can measure sinusoidal and non-sinusoidal waves with frequency between the range of 50hz and 60hz. In 1995, S. Svensson described an instrument that utilizes digital sampling techniques which has been built and evaluated at the Swedish National Testing and Research Institute (SP). The Digital Sampling Watt Meter (DSWM) is based on standard laboratory equipment: digital millimeters, voltage dividers, shunt resistors and a PC. The DSWM is versatile and can be used for calibrations of many quantities. The most basic ones are the (total) active power and the amplitude and phase angle of individual harmonics of non-sinusoidal voltages and currents. The DSWM was first verified for sinusoidal signals. At 120 V and 5 A and power factor one for resistive load.
In July 1988, Don Kirk designed an analog-based talking wattmeter. The design included a single chip microcomputer and an analog-to-digital converter.
In recent days it is very essential to measure the power factor along with the active power so that user can make compensation technique so that reactive power can be injected to the system to improve the power factor to unity. Now a days simple method is used to measure the power factor with Arduino microcontroller and automatically select the required capacitor bank to improve the power factor. In this paper only the power factor is measured with Arduino microcontroller.

Assuming the current and voltage to the load are pure sinusoidal waveforms, the power factor can be measured. Each waveform is fed into a zero-crossing detector (sometimes known as a sine to square wave converter) which is simply an IC-LM339 in comparator mode where the comparison voltage is 0V. When the sine wave is in the negative cycle a negative DC pulse is generated, and when the sine wave is positive a positive DC pulse is generated. The two square waves are then compared using an exclusive OR (XOR) logic gate, which will output a positive high DC pulse only when the square waves do not overlap, and 0V when they overlap. The output of the XOR gate is therefore time difference (delta t) between the two waves from the point they cross the zero point. This difference signal can then be timed by a microcontroller and converted to power factor.

II. HARDWARE DESIGNING

This is a block diagram of the entire process of how we are measuring the power factor. The entire process can be divided into 4 parts as explained in details below. First part deals with generating current and voltage signal of the circuit for which power factor is to be measured. Second part deals with how the signals are represented as square waves. The third part deals with generating a pulse whose width is proportional to the phase difference between the voltage and current and the last part is about how the power factor is calculated from the pulse obtained in the third part.

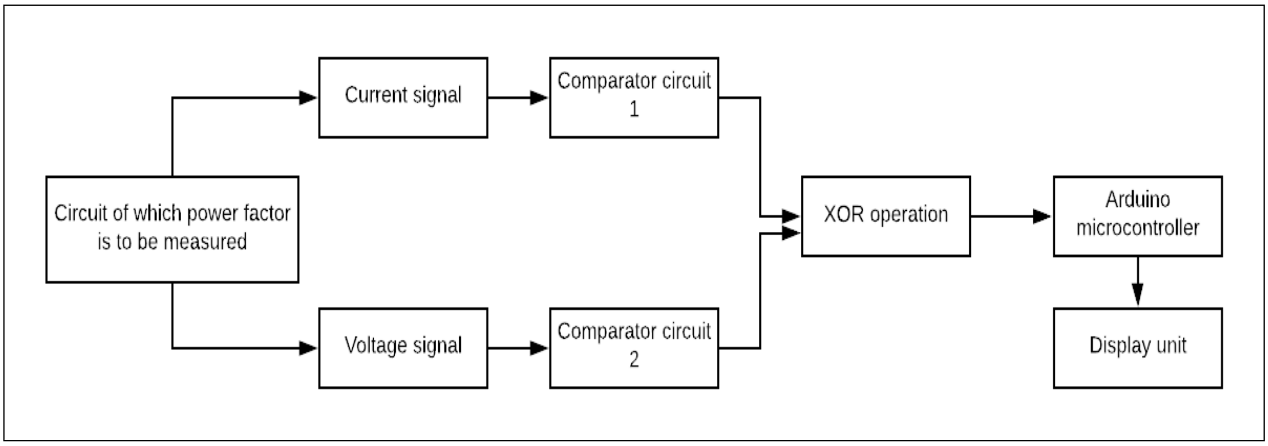

Figure 1: block diagram of power factor measurement unit

II.1 Generating square wave from corresponding voltage and current signals

- Each signal is passed through a set of two comparators. The arrangement is shown in the fig. below.
- The output from the first comparator has some noise of around 2V present in it.
- To eliminate the noise, the output from the first comparator is passed through a second comparator whose negative terminal is given a potential of 2.5V from a voltage divider circuit as shown in the figure.
- To eliminate further noise, capacitors are being used.

We have used 2 LM339 ICs for the comparator arrangement for square wave generation.

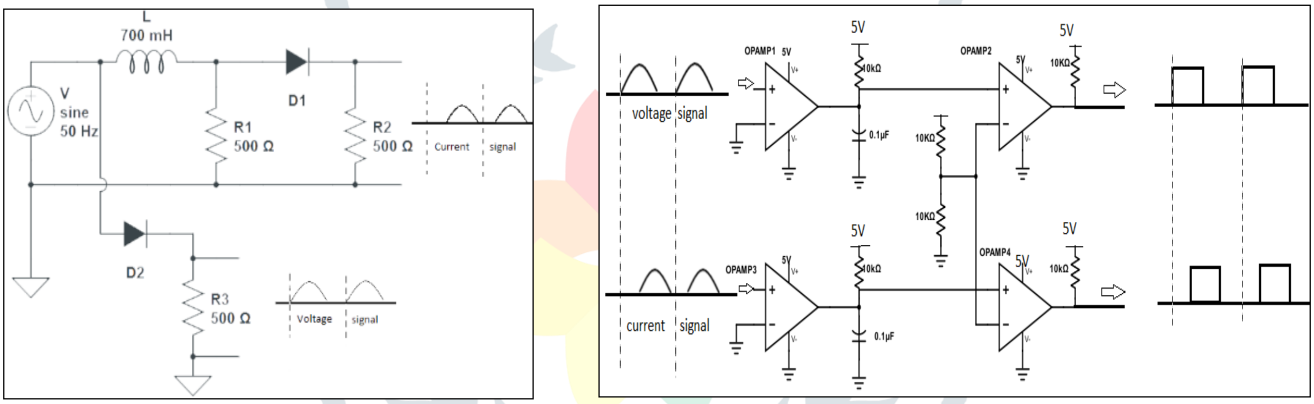

Figure 2.1: (a) Circuit of which power factor to be measured (b) square wave generator using comparator

II.2 Obtaining pulse corresponding to the phase difference between voltage and current signals

- The outputs from the two comparators are passed through an exclusive OR (XOR) logic gate,
- The XOR gate will output a positive high DC pulse only when the square waves do not overlap and 0V when they overlap.
- We have used LM7486 IC for executing this XOR operation.
- The pulse width of the XOR output signal is proportional to the phase difference of voltage and current signals.

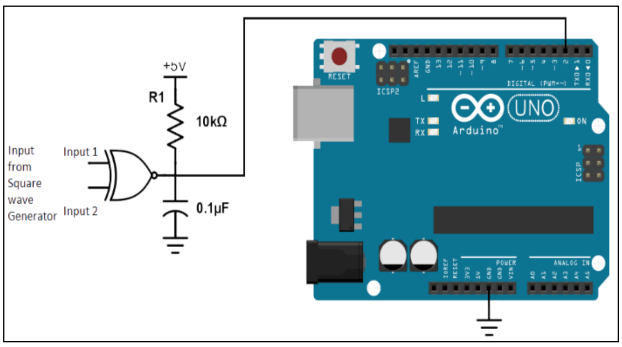

Figure 2.2: circuit for obtaining power factor from the output of square wave generator

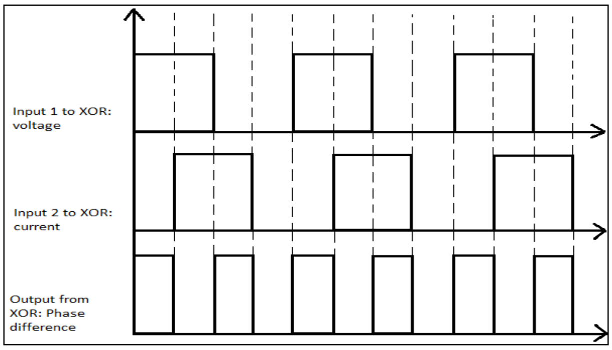

Figure 2.3: Input and output waveform of XOR gate

II.3 Obtaining power factor from the output of XOR gate

- The output obtained from the XOR is in time scale.
- To convert it to angles a microcontroller is needed. Here we have used an Arduino UNO for this purpose.
- XOR output is fed to Arduino.
- The pulse width is converted to angles and the cosine of the angle hence power factor is calculated.

III. SOFTWARE

Algorithm and flowchart for power factor measurement

STEP 1: START
STEP 2: Initialize the variables *r, final1, channel*
STEP 3: Set serial port for communication
STEP 4: Print the value to serial port
STEP 5: final=(channel/1000) *18
STEP 6: r=final*(3.14/180)
STEP 7: final1=cos(r)
STEP 8: print pf=final1
STEP 9: END

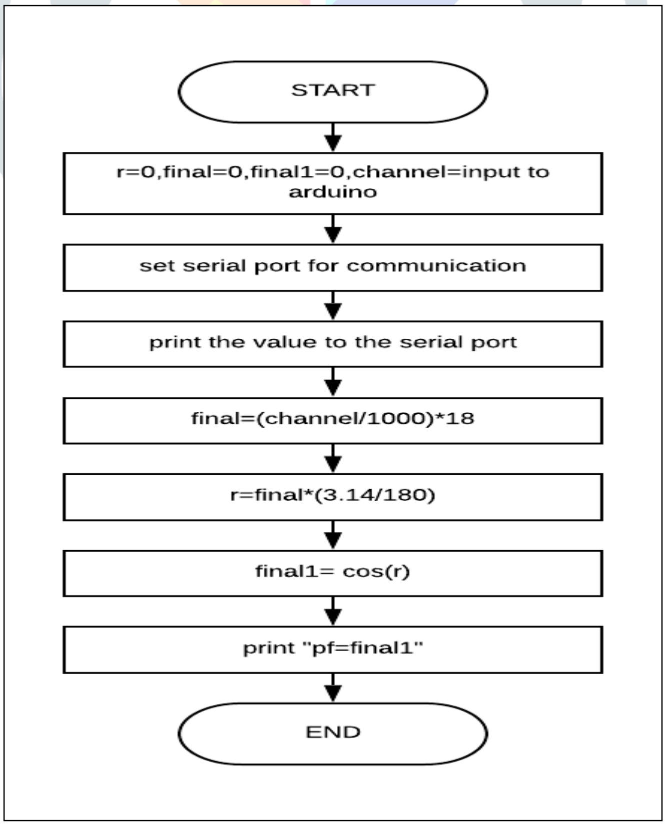

Figure 2.4: flowchart of Arduino program for p.f. measurement

IV. RESULTS AND DISCUSSIONS

These are the waveforms obtained when we have tested our circuit.

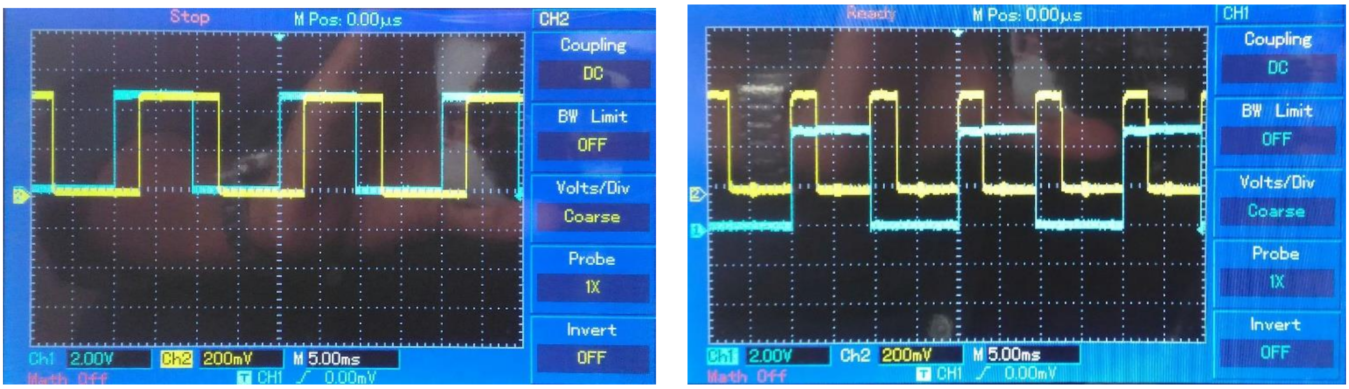

Figure 3.1: left image showing 2 phase- shifted square waves corresponding to voltage and current signal & right image showing the initial output waveform which we obtained from XOR gate.

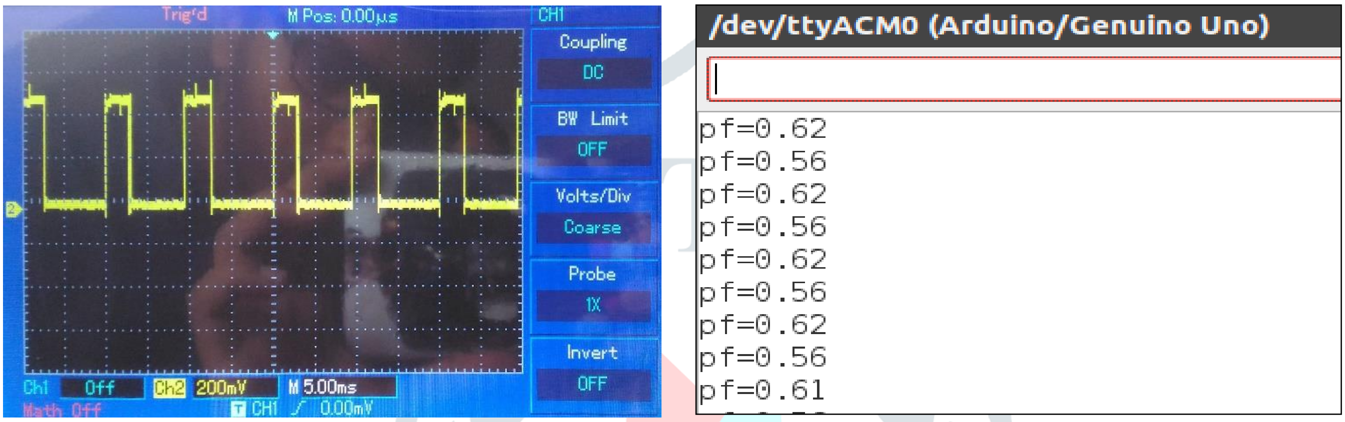

Figure 3.2: left image showing the initial output waveform which we obtained from XOR gate & right image Value of power factor showing on serial monitor window.

V. CONCLUSIONS.

The power factor measurement unit using Arduino that we have designed was successfully able to calculate the power factor of the power circuit with a little bit of fluctuation. We were having problem getting a proper square wave from half wave rectified signals. We have tested with different ICs like LM741, LM324 and finally used 2 comparator arrangement using LM339 for generating noise free square waves. We have eliminated the noise using capacitors. It can be upgraded to Wattmeter as well as smart energy meter. This equipment can perform remote sensing and also transmit reading via wireless to the concerned Electric Supply organization.

It can also be upgraded to APFC device. In industry most of the load is inductive in nature which results in lagging power factor that is why there is loss and wastage of energy which results in high power bills and heavy penalties from electricity boards. If the load is uneven it is very difficult to maintain unity power factor. To overcome this difficulty APFC panel is used where it automatically detects the power factor of the system, according to which it enables the required capacitor bank to maintain the P.F. close to unity.

TABLE 1 LIST OF COMPONENTS

Circuit	*Parts needed*	*QUANTITY*
Power circuit for which power factor is to be measured	230/6-0-6V, 1A, center -tapped	1
	700 mH inductor	1
	Resistors- 500 Ω	3
	Diodes	2
Square wave generating circuit	230/12-0-12V, 1A, center-tapped	1
	Diodes for bridge	4
	7805 IC	1
	LM339 IC	2
	14-pin IC base	2
	Resistors - 10 kΩ	6
	Ceramic Capacitors- 0.1	2

Circuit for calculating phase difference	LM 7486 IC	1
	14-pin IC base	1
	Resistors-10 kΩ	1
	Capacitors-0.1μF	1
	Arduino UNO	1
	Vero board	1

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