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Research Paper

Design of Digital power factor meter

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ABSTRACT: *Nowadays, Power factor is important parameter in power Industries. Power factor of power system indicate overall efficiency and Health of Power system. It is very important to maintain near unit power factor in power system. In today technology all Electric grid are replaced by smart grid, and IOT enabled grid, so for this it is important to replace all electromechanical power factor meters replaced by Digital meters. So in this paper taking A. Arduino board & programming it the digital meter is designed. Using this method power factor is easily measured and this data can be further utilizing for smart grid, automatic correction of power factor and IOT applications. Conventional power factor meters are energy consuming but this is compact and energy efficient and small space consuming and economical as no copper coil is required.*

KEYWORDS: *Power factor, Digital meters, Smart Grid, Arduino.*

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I. INTRODUCTION

The power factor of an AC power system is defined as the ratio of the real power absorbed by the load to the apparent power flowing in the Electric circuit. Because of Energy stored in the load and returned to the source, or due to a non-linear load that distorts the wave shape of the current drawn from the source, the apparent power may be more than the real power, so more current flows in the circuit than would be required to transfer real power. In power system, a load with a low power factor draws more current than a load with a high power factor for the same amount of useful power transferred. The more currents increase the energy lost in the distribution system and require larger wires and equipment's. Because of the costs of larger equipment and wasted energy, electrical utilities will usually charge a more cost to industrial or commercial customers where there is a low power factor. Power-factor correction increases the power factor of a load, improving efficiency for the distribution.. Linear loads with a low power factor can be corrected with a passive network of capacitors or inductors. Non-linear loads, such as rectifiers, distort the current drawn from the system. In such cases, active or passive power factor correction may be used to counteract the distortion and raise the power factor. The devices for correction of the power factor may be at a central substation, spread out over a distribution system, or built into power-consuming equipment.

II. ANALOG POWER FACTOR METER

The power factor meter measures the power factor of a transmission system. The power factor is the cosine of the angle between the voltage and current. The power factor meter determines the types of load using on the line, and it also calculates the losses occur on it. The power factor of the transmission line is measured by dividing the product of voltage and current with the power. And the value of voltage current and power is easily determined by the voltmeter, ammeter and wattmeter respectively. This method gives high accuracy, but it takes time. The power factor of the transmission line is continuously changed with time. Hence it is essential to take the quick reading. The power factor meter takes a direct reading, but it is less accurate. The reading obtained from the power factor meter is sufficient for many purposes to expect precision testing.

The Analog power factor meter has the moving system called pointer which is in equilibrium with the two opposing forces. Thus, the pointer of the power factor meter remains at the same position which is occupied by it at the time of disconnection.

Types of analog Power factor meters
1) Single Phase Electrodynamometer 2) Three Phases Electrodynamometer

The construction of the single phase electrodynamometer is shown in the fig.1 below. The meter has fixed coil which acts as a current coil. This coil is split into two parts and carries the current under test. The magnetic field of the coil is directly proportional to the current flow through the coil.

The meter has two identical pressure coils A and B. Both the coils are pivoted on the spindle. The pressure coil A has no inductive resistance connected in series with the circuit, and the coil B has highly inductive coil connected in series with the circuit.

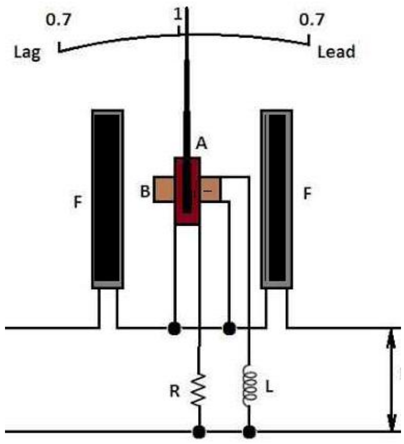

Fig .1 Analog single Phase Power Factor Meter

Since no controlling torque is provided in this instrument, therefore, when it is not connected in the circuit, the moving coils will remain in the position in which these are turned. This will only happen when the moving system is perfectly balanced. When the instrument is connected to the load circuit, current flows through the fixed coils FF and Moving coils A and B, flux is set by the fixed coils and moving coils. By the alignment of two fields, torque develops i.e. the resultant field produced by the moving coils tries to come in line with the field produced by the fixed coils and torque develops till both of them come in line with each other. when the field produced by moving system tries to come in line with the field produced by the fixed coil, deflecting torque is exerted on the moving system which deflects the pointer attached to it .This type analog meters have some draw back such has

1. Working forces are small.
2. The scale is not extended over 360 degree.
3. Calibration of electrodynamometer type instruments are highly affected by the changing the supply voltage frequency.
4. These instruments have so many errors
5. These instruments are not accurate.
6. These instruments have hysteresis losses and eddy current losses in their iron parts.
7. They are quite costly
8. They are not energy efficient as it consist of moving parts.
9. Not useful in SCADA and smart grid
10. Stray magnetic field affects the reading.

So due to above disadvantages it is better to move digital Power factor meters

II. DESIGN OF DIGITAL POWER FACTOR METER

To design digital power factor meter first using current transformer or using shunt resistance current is step down to low value . The microcontroller handles very less amount of current in turns of mA .so by using CT or shunt Resistance the value of current is reduced but the shape of current signal is same as original. Similarly the voltage can be reduced by using Potential transformer upto the safer value to handle by Microcontroller i.e. 3 to 4. volts

In next step to findout the Power factor ,first it is important to find out angle difference between Voltage and Current signal as shown in fig.3

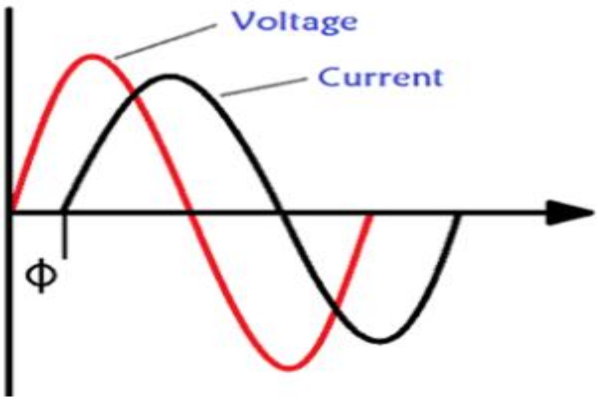

Fig.2 Current and voltage at leading Power factor

So to find out Phase shift beetwen current and Volage each signal is pass through zero crossing detector .The zero crossing detector convert this sin wave signal of current and voltage into square wave signal with exactly at staring or zero of current and votage signal as shown in fig.4

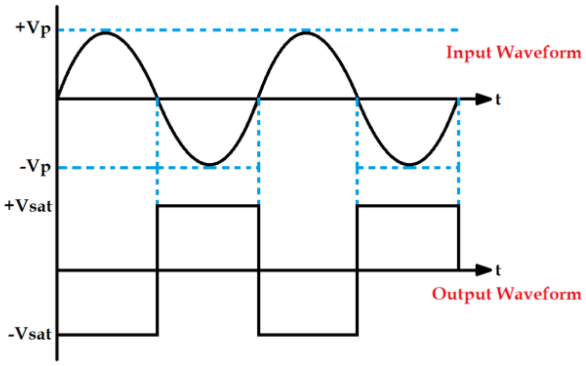

Fig .3 Output of ZERO CROSSING DETECTOR.

Now this square signals are fed to Ex-OR gate , as Ex-or gate have two inputs and one out put XOR gate output will be 1 just when the inputs have different signals so when the load is resistive XOR gate output is 0 because both voltage and current phases start and ends in the same time, but when the load is inductive or capacitive XOR output is 1 because there are phase shaft between voltage and current.

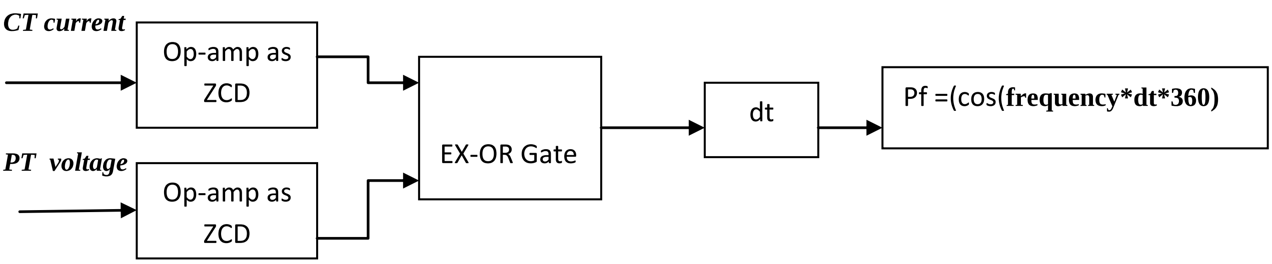

Fig.4 BLOCK DIAGRAM of DIGITAL POWER FACTOR METER

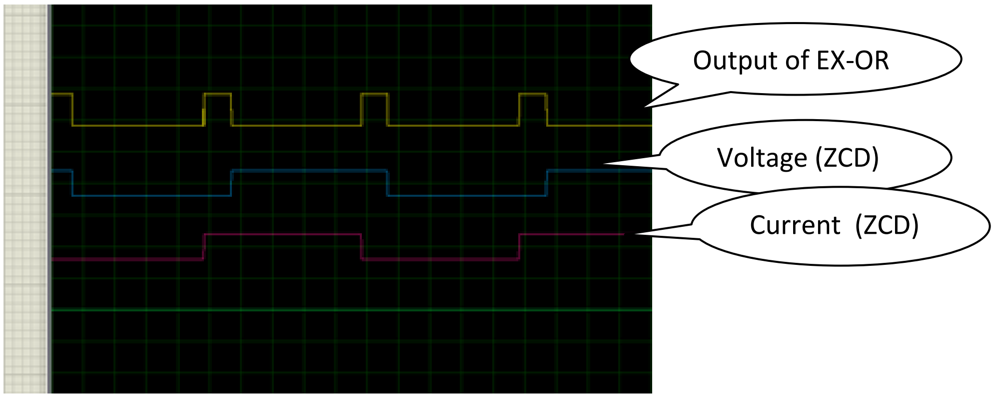

Fig. 5 Output of EX-OR Gate

Hence we can find the power factor by measuring the "ON-time" of Ex-OR output, and put it in the power factor

Power factor = Cosine(frequency*dt*360)

dt=Time difference between two phases and/or Ex-OR output ON-time (S)

III. Results (Software simulation)

To get simulation is done in Proteos software . As shown in fig .5 all the connections are made and by changing the Resistive ,Inductive and capacitor load the desired result of power factor obtained.

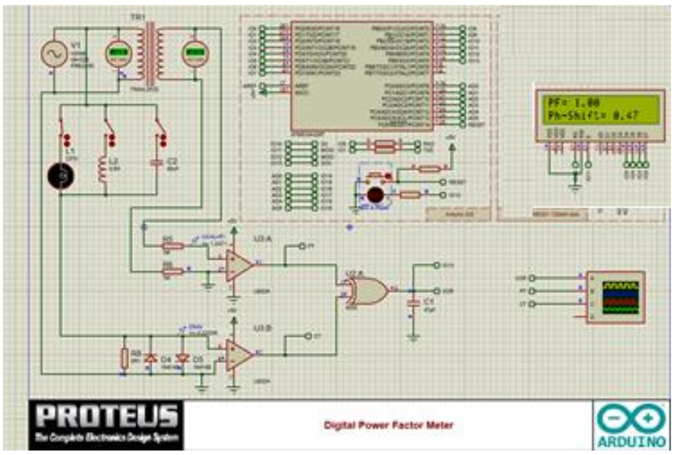

Fig.6 Simulation of Digital Power Factor Meter

IV.Hardware Implementation Requirement.

A. Arduino board
B. LM324
C. IC 4030 or IC 4070 (XOR gate)
D. Voltage Transformer 15V or less
E. Current transformer 5A/5mA
F. Resistor 100K,220,200
G. Potentiometer 10K or 100K
H. Capacitor 47pF (2pcs),100nF(1),470uF(1)
I. LCD display 16x2
J. Diode 1N4148 (4pcs)

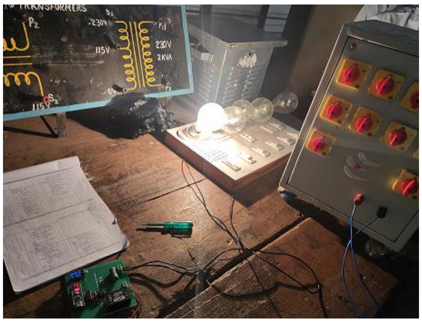

Fig.7 Experiment Setup for different types of load to test designed Power factor meter

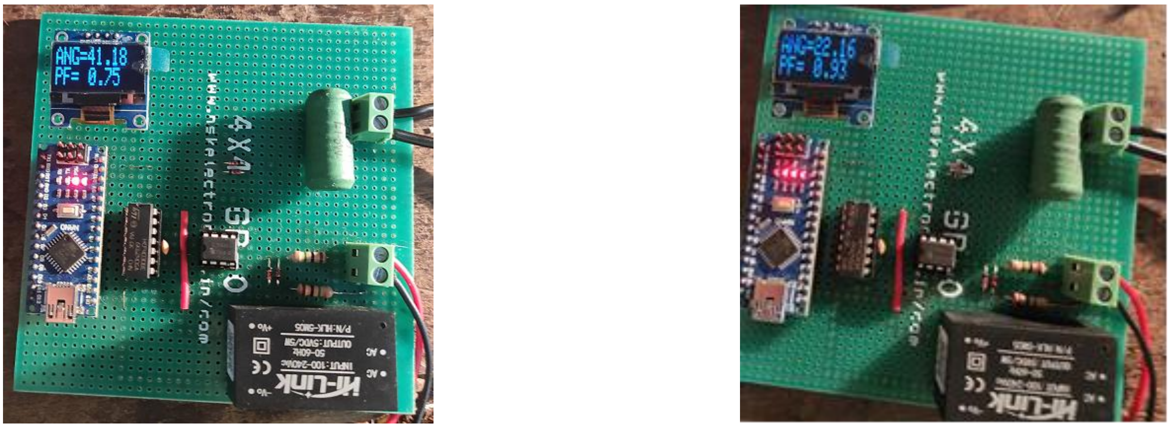

Fig.8 Output result for different type of load on Arduino board.

V.DIFFERENT TYPES OF LOAD AND POWER FACTOR INDICATED BY DESIGNED DIGITAL METER

Sl.no	Resistance of the resistor (R) Ω	Inductance of the inductor (L) H	Capacitance of the capacitor (C)	cosφ
1	200 Ω	1H	0.000015	0.89
2	200 Ω	1 H	0.001 F	0.54

3	**200 Ω**	**0.2 H**	**0.001 F**	**0.95**
4	**200 Ω**	**0.4 H**	**0.001 F**	**0.85**
5	**200 Ω**	**.6H**	**0.001 F**	**0.73**
6	**200 Ω**	**.8H**	**0.001 F**	**0.62**
7	**200 Ω**	**1H**	**0.001F**	**0.54**
8	**200 Ω**	**1H**	**.0001F**	**0.57**
9	**400 Ω**	**1H**	**0.0001 F**	**0.81**

Table: 1

VI .CONCLUSION

After series of test, it was discovered that the operating power factor of a load depends on the type of load being measured either inductive or resistive load. The values of the power factor gotten are close to the standard power factor of the load. Code is also small so that it Runs fast can used in Real time applications such as smart grid, IOTs & automatic Power Factor correction.

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