Power Factor Improvement For 3 Phase Induction Motor Using PLC

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Abstract- *In this paper we describe the power factor improvement of three phase induction motor using switching of shunt capacitors and controlling of those capacitors are done by programmable logic controller.At no load condition motor is operated at low power factor as it draws large magnetising current. Active power delivered by motor is low which is used for compensate the no load losses. It is necessary to make power factor unity to avoid penalty from electrical distributors. So it is neccessory to improve power factor of induction motor, as it is operated at lagging power factor. Automatic improvement power factor techniques used in the industries. Power factor mostly operated near to the unity to make system efficient and stable.*

Keywords- Induction motor (IM), Pogrammable logic controller (PLC), Zero crossing detector (ZCD), Capacitor bank, Current transformer (CT), Potential transformer (PT).

I. INTRODUCTION

In the present generation, power factor has one of the major and important issue. Any motor that operates on ac requires apparent power, but apparent power is addition of active power and reactive power. The load is consuming active power. Reactive power is also important for load, because reactive power is the power demanded by the load and returned to the power source. Power factor is the ratio between the useful (active) powers to the total power consumed by an electrical equipment or motor i.e ratio between KW and KVA.Also it defines,to perform a useful work how much of electrical power utilized.

The idealy power factor is unity. If power factor is less than unity it means that excess power is required to perform the actual work. The basic idea for Power factor improvement of a motor, we have to connect a capacitor in parallel with the device which having low power factor. One of traditional method for power factor correction is static type compensation, in which static type capacitors are used for power factor correction. Therefore capacitors should not subject to rapid on-off conditions.

Power Factor Improvement:

This can be achieved by the addition of capacitors to the electrical network which compensate for the reactive power demand of the inductive load ,which reduces the burden on the supply. The addition of external capacitor not affect the operation of the equipment.To reduce losses in the power system and to reduce the electricity bills power factor correction is required. usually capacitors are added to neutralize as much as possible the magnetizing current. Capacitors contained in most power factor correction equipment draw current that leads the voltage, thus producing a leading power factor.

If capacitors are connected to a circuit that operates at a normally lagging power factor the extent that the circuit lags is reduced proportionately. Typically the corrected power factor will be 0.92 to 0.95. Some power distributors offer incentives for operating with a power factor of better than 0.9, for example, and some penalize consumers with a poor power factor. There are different ways that this is metered but the net result is that in order to reduce wasted energy in the distribution system, the consumer is encouraged to apply power factor correction. Most network Operating industies now penalize for power factors below 0.9.

Advantages of power factor improvement :

a) Efficiency of induction motor increases due to reduction of power consumption.
b) Due to reduced power consumption there will be less greenhouse gases(generation is less).
c) Reduction of electricity bills .
d) Extra KVA available from the same existing supply(increases capacity)
e) Reduction of I^2R losses in transformers,distribution network and induction motor (heat loss reduced).

The Causes of Low Power Factor:

The cause of low power factor is due to inductive loads. The current in an inductive load lags behind the voltage. Therefore power factor is lagging. That inductive load is responsible for low power factor are as follows:

i. Low power factor is caused by inductive loads such as lighting ballasts.
ii. Three phase induction motor operate at a power factor of about 0.8 lagging at full load. At light loads this motor work at a very small transformers, induction motors, generators and certain Power factor in order of 0.2 to 0.3 lagging. Single phase induction motor at power factor of about 0.6 (lag)
iii. A induction motor draws magnetizing current from the supply. At full load current does not affect the power factor much but at light load the primary current power factor is low
iv. Electric discharge lamp , arc lamp, industrial heating furnaces, welding equipment operate at low lagging power factor.

Power Factor Improvement Methods :

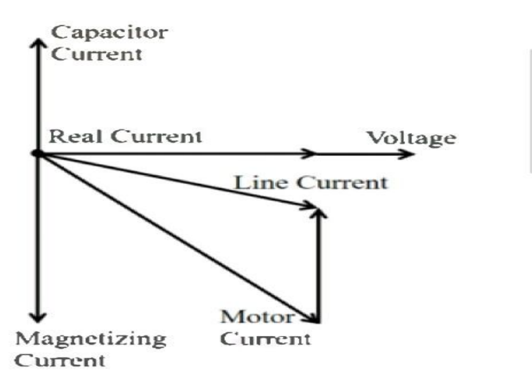
1. Capacitor Bank
2. Synchronous Condenser
3. Phase Advancer

Power Factor of Induction Motor:

The current drawn by an induction motor from the source is the vector sum of the magnetizing current (imaginary current) and working component (torque producing component or real current).

The imaginary current component is required to overcome the reluctance of the air gap present between the stator and rotor of the induction motor by producing the required flux in the air gap. It does not contribute to the actual working of the motor, but contributes to the power dissipated in the supply and distribution system.

The real current of the motor depends on the load on the induction motor. At no-load operation, an induction motor has a very low pf of about 0.2 to 0.3lagging, as it draws a large imaginary current component and a small real current component to meet the no load losses.

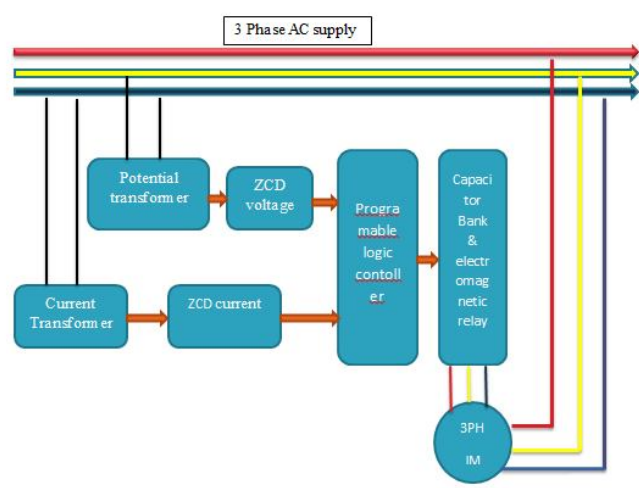


Under loaded condition, the IM draws a larger amount of real current to meet the increased load and losses while the magnetizing component of the current remains almost constant.

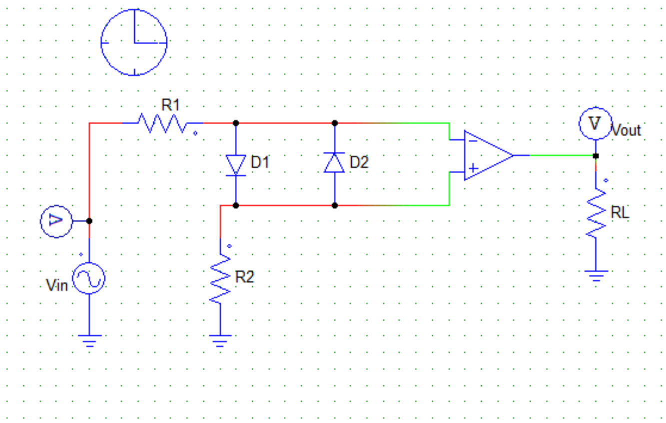
As a result, the pf of the motor is increased. The pf is about 0.6 to 0.8 lagging. At different loading conditions the pf of an induction motor can be improved to a range of 0.9 to 0.95 lagging by use of appropriate capacitor banks in parallel with the IM.

These capacitors provide the required reactive power for the induction motor i.e. the capacitors provide a leading current to the induction motor in phase opposition to the magnetizing current component, as shown in Fig. resulting in pf improvement even at no load condition.

II. BLOCK DIAGRAM:



Zero Crossing Detectors:



The zero crossing detectors converts sine-wave to square-wave . The reference voltage in this case is zero.

The output voltage waveform shows when and in what direction an input signals crosses zero volts.

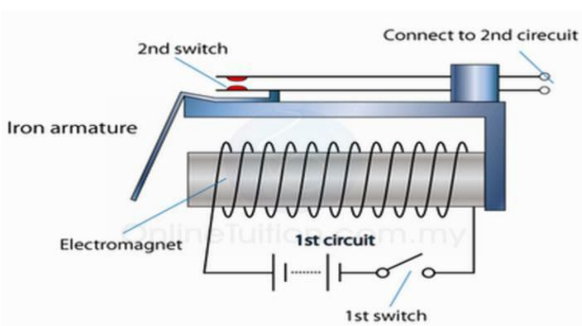
If input voltage is a low frequency signal, then output voltage will be less quick to switch from one saturation point to another.

If there is noise in between the two input nodes, the output may fluctuate between negative and positive saturation voltage is V_{sat}.

Electro Magnetic Relay :

These are varying much reliable devices and widely used on field. The operating frequency of these devices are minimum 10-20ms.That is 50Hz –100Hz. The electromagnetic relay operates on the principle magnetism (electromagnetic induction).

When the base voltage appears at the relay driver section, the driver transistor will be driven into saturation and allow to flow current in the coil of the relay, Which create a magnetic field and the magnetic force produced due to that will act against the spring tension and close the contact coil .



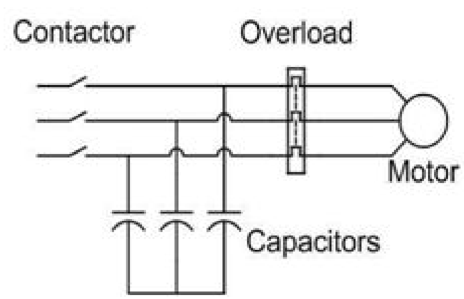
The electromagnetic relays normally having 2 contact points. Named as normally closes (NC) , normally open (NO). Normally closed points will so a short CKT path when the relay is off. Normally open points will so a short CKT path, when the relay is energized.

Capacitor Bank:

As a large amount of the inductive or lagging current on the supply is due to the magnetizing current of induction motors, it is easy to correct each inductive magnetizing current of the induction motor.

In many installations employing static power factor correction, the correction capacitors are connected directly in parallel with the motor windings. When the motor is Off Line, the capacitors are also Off Line.

When the motor is connected to the supply, the capacitors are also connected providing correction at all times that the motor is connected to the supply



This removes the requirement for any expensive power factor monitoring and control equipment.

In this situation, the capacitors remain connected to the motor terminals as the motor slows down. An induction motor, while connected to the supply, is driven by a rotating magnetic field in the stator which induces current into the rotor.

When the motor is disconnected from the supply, there is for a period of time, a magnetic field associated with the rotor. As the motor decelerates, it generates voltage out its terminals at a frequency which is related to its speed.

The capacitors connected across the motor terminals, form a resonant circuit with the motor inductance. If the motor is critically corrected. It is imperative that motors are never over corrected or critically corrected when static correction is employed.

Loading Test of 3 Phase Induction Motor:

3 phase delta connected 7.5HP 12A 420V 1500rpm 4pole IM

Sr. No.	I_{ac}(Amp)	W_1(watt)	W_2(watt)
1	1	60	0
2	2	90	20
3	2.3	130	50
4	3.8	200	90
5	5	260	120
6	7.1	360	140
7	8.9	440	160

From above observation table found out that power factor is vary in between 0.5 to 0.84 from no load to full load.

IV. CALCULATIONS

By using two wattmeter method we can calculate the actual power factor of induction motor as,

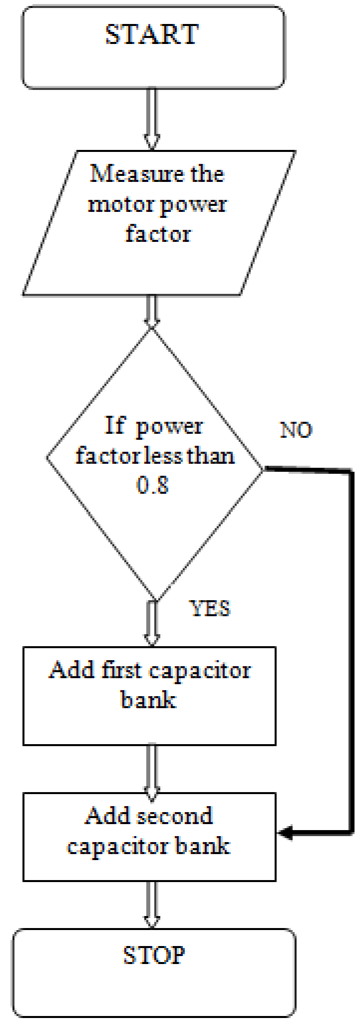
$$\cos\varphi = \cos\tan^{-1}\sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$$

Corrective KVAR calculated as,

KVAR = Total connected load[tan $\cos^{-1}$ (actual power factor)-tan $\cos^{-1}$(required power factor)]

Sr.No	I_{ac} (Amp)	Actual PF	KVAR Required	Capacitor (Microfarad)
1	1	0.5	6.96	128.6
2	2	0.67	3.269	60.41
3	2.3	0.79	2.916	40.58
4	3.8	0.83	1.052	19.44
5	5	0.84	1.01	18.67
6	7.1	0.79	1.62	29.94
7	8.9	0.78	1.766	32.64

V. FLOW CHART



APPLICATIONS :

Electricity industry: power factor correction of linear loads.

VI. CONCLUSION

Low power factor is not that much of problem in residential consumers it become a problem in industry where multiple large motors are used. So there is requirement to improve the power factor in industry.

Generally for power factor improvement capacitor banks are used or try to correct the problem here we used the PLC based system for power factor correction. By using capacitor bank we can improve lagging power factor thereby system will be safe from different disadvantage of lagging power factor. By use of this system the power factor control becomes very fast and accurate than other methods and also the electric bill are reduced.

In a world of automation there is huge use of PLC in industries. Power factor is serious problem in industry due to inductive loads. So the power factor correction is also having a much importance. So along with other automation process the PLC can be used significantly for correction of power factor.

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