Power Factor Improvement of Single Phase Induction Motor

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ABSTRACT

The paper defines greatest concern related to power factor of rapidly growing industries which consume inductive load and distortion due to electronic equipment. Injection of leading current to the line to improve low power factor near to unity. The power availability will be more as the system will operate at highest efficiency due to decrease line losses. Paper describes micro level study of single phase system by adding capacitor bank across induction motor as load with automatic switching

Keyword: - *Power factor, capacitor bank, automatic switching*

1. INTRODUCTION

In an electrical power system, loads are of resistive, inductive and capacitive. The loads like motor and transformer are inductive in nature as it has coils which are inductive. Hence loads on power system are resistive as well as inductive. Resistance of the power system is low as compared to inductance. Hence the current lags behind the voltage by angle. That angle called as lagging power factor of the system. Industries which primarily depend on inductive load suffers problem of low power factor. Ultimately overall efficiency of the system gets reduced due to increase in line losses.

Power sources in power system act as non-linear loads, which draws a distorted waveform that contains harmonics. These harmonics causes problems ranging from telephone transmission interference to degradation of conductors and insulating material in motors and transformers. The summation of all harmonics in a system is known as total harmonic distortion (THD). Therefore the system with the low power factor has harmonics cause unbalance. Harmonic distortion can have severe effects on power equipment. An unwanted distortion can increase current of system which effects in high temperature in neutral conductor and distribution transformers. High order harmonics can cause excess core loss in motors which results in additional heating of core of motor. Those high order harmonics are causing disturbance in the communication of transmission lines since it oscillate at the same frequencies as the transmit frequency. It can greatly shorten the life of power electronic equipment and damage to power systems.

Reactive power is not actually utilized in power system but use for generation of magnetic field. The capacitor used in power factor correction is major sources of reactive power. By adding reactive power to the system, the receiving end voltage gets boosted.

1.1 POWER FACTOR

Power factor can be defined as ratio of an active power in KW to an apparent power in KVA. It shows how much real power utilized in power system.

$$pf = \frac{Active\ power}{Apperent\ power}$$

$$= \frac{VICOS\emptyset}{VI}$$

Where, cos Ø is power factor of system and Ø represents an angle between voltage and current. If power factor is unity, that is angle between voltages and current is zero and both are in phase with each other. Loads serve which is resistive in nature. If current is inductive i.e. current lags behind the voltage by some angle is called as lagging pf. If current is capacitive i.e. Current lead the voltage by some angle is called as leading pf.

1.2 POWER FACTOR CORRECTION

Power factor correction is the term given to a technology that has been used since the turn of the 20th century to restore the power factor to as close to unity as is economically viable.
This is normally achieved by the addition of capacitors to the electrical network which compensate for the reactive power demand of the inductive load and thus reduce the burden on the supply. There should be no effect on the operation of the equipment. To reduce losses in the distribution system, and to reduce the electricity bill, power factor correction, usually in the form of capacitors, is added to neutralize as much of the magnetizing current as possible. Capacitors contained in most power factor correction equipment draw current that leads the voltage, thus producing a leading power factor.

2. CAUSES OF LOW POWER FACTOR

The various load like motor, many electronic equipment like television, mobile chargers, CFL. Due to this, system fails to maintain the power factor near to unity. Therefore, current draw is more than required. Hence, losses get increases. This will leads to increase electricity bill.
In small scale industry, loads are varying. The requirement of current also is varying. The power factor gets change continuously.
Due to improper power factor, the energy consumption is more. The penalty charges will increase due to excessive consumption of reactive power. Due to flow of heavy current, the equipment may get damage. Also saturation of parts of equipment may take place. This will cause increase maintenance cost. The system will not be efficient.
While designing the equipment, designer should consider overcurrent condition and design appropriate parts of equipment. The cross sectional area of conductor required more due to more current. This will leads to increase in initial cost.
In case of induction motor, it lead to frequent maintenance and also shortening the life of motor as it generate lot of heat. This will increase in losses affects efficiency. Low power factor may affect the overall performance of motor.

3. NEED OF POWER FACTOR CORRECTION

In recent year the industrialization is growing rapidly. The low power factor is a major concern to industries which uses motors in operation. A use of electronic equipment has increased in domestic, commercial and industrial purpose. These devices have rectifier in circuits, which is main reason for production of harmonic distortion. These devices used for convert the AC supply to DC supply which causes the notching which periodic voltage disturbance is caused by normal operation of power electronic devices when current is commutated from one phase to another. Pulsating current in dc supply contains harmonics which results in additional losses in cables. Also it affect increase

current in binding of rotating machines and transformers and noise emission in many types of equipment. The rectifier connected to AC mains is major source of this problem. Thus in order to decrease the effect of the distortion, power factor correction circuit are added to load side of equipment used in industries and domestic applications tends to increase the overall efficiency of power usage.

4. POWER FACTOR CORRECTION OF SINGLE PHASE SYSTEM

After the distribution transformer, the three phase three wire system transforms into three phase four wire system. Further the single phase system feed to domestic as well as small industrial and commercial loads. Due to globalization, the use of electronic equipment has been increased from last few years. It produces harmonics in line and disturb the power factor in system. This leads to losses in line and affects power quality of the system.
Capacitor injects leading current in line which is 90 degree with voltage. The resultant of current will changes and the angle between voltage and current get reduced. Therefore, the power factor will get near to unity. Capacitor is major source of reactive power. It supplies the adequate reactive power in line for the voltage stability.
This will help to maintain the power quality of a system.
Following formula used for improvement of power factor

$$\boldsymbol{Kvar = P(tan\emptyset 1 - tan\emptyset 2)}$$

Where,

P is power consumed by the load in KW
Ø1 is cosine inverse of power factor which to be improved
Ø2 is cosine inverse of desired power factor.
By calculation we get the reactive power in KVAR which should be added by the switching of capacitor. This makes system achieve desired power factor.

5. SPLIT PHASE INDUCTION MOTOR

Induction motor has wide application in industry as well as in domestic. Due inductive coil used in construction, voltage lags behind current. Hence, motor runs at lagging power factor. When motor is on no load condition, power factor of motor is low. Hence, current requirement get increase. This will lead to greater losses in motor and further it will affect overall efficiency.
Split phase induction motor runs on single phase supply have wide application in domestic purpose. The application of moderate starting torque like fan, washing machine, oil burner and small machine tools uses split phase induction motor. Power rating is between 60W to 250W.

6. SIMULINK MODEL

Power factor correction using Mat lab Simulink model supplying split phase induction motor.

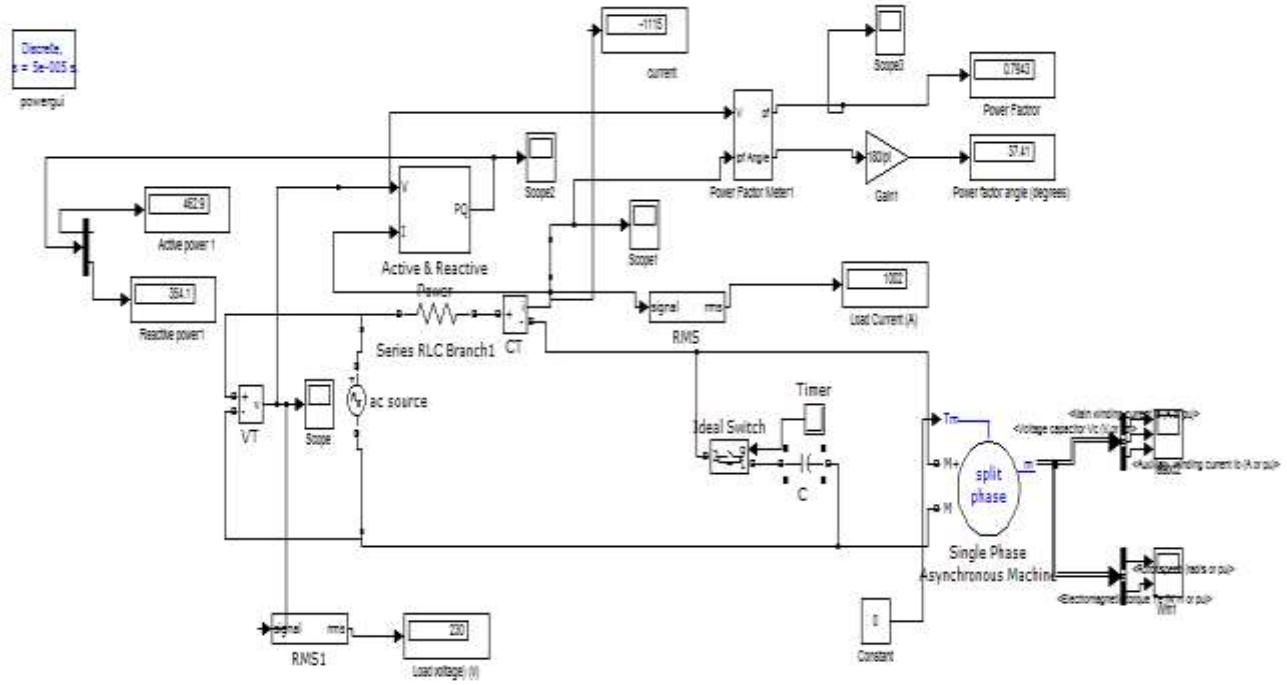

Fig -1: Simulink model

Split phase motor is 1.5 H.P., 1500 rpm is connected to 230 Vrms voltage. Power factor calculation block and motor parameter can be obtained by model. The ideal switch and timer is added to set switching time of capacitor. This will make automatic switching of capacitor. Therefore, it can analyze the real-time conditions with greater accuracy.

The observation made by Simulink model is as follows

Sr.no	Voltage (V) Vrms	Current (A) Irms	Capacitance (microfarad)	Power factor obtained
1	230	50.56	0	0.463
2	230	49.76	2.17	0.468
3	230	44.15	20.94	0.53
4	230	38.17	36.42	0.59
5	230	27.81	79.13	0.808
6	230	24.15	99.34	0.92
7	230	22.16	118.3	0.99

Power rating of spilt phase induction motor (P) =1.5 HP

Power factor before addition of capacitor (CosØ1) = 0.46
Desired power factor (CosØ2) = 0.99
By using equation (4),

$$Kvar = P(tan\emptyset 1 - tan\emptyset 2)$$

tanØ1 =1.930
tanØ2=0.142
Putting these values in equation

$$Kvar = 1.11(1.930 - 0.142)$$
$$= 1.985$$

By converting KVAR to farad, 118 microfarad capacitance must be added to improve power factor up to 0.99.

7. RESULT

Following are the results obtained by Simulink of MATLAB .It gives clear result that after adding the capacitor the current get reduced and we get the improved power factor. The load current becomes almost half of previous current. This will reduced losses ultimately and improve the overall efficiency.

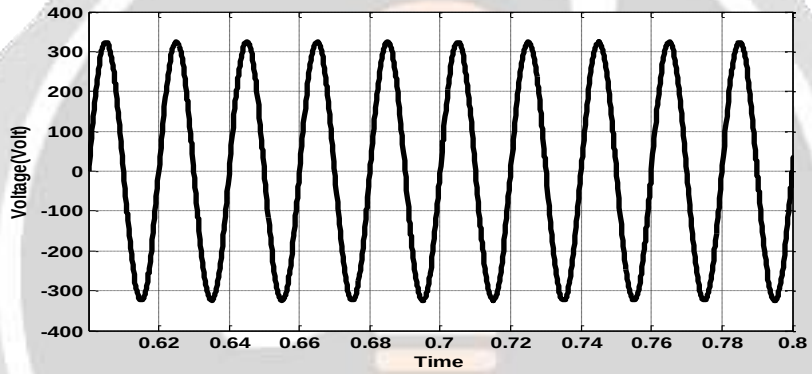

Fig -2: Voltage

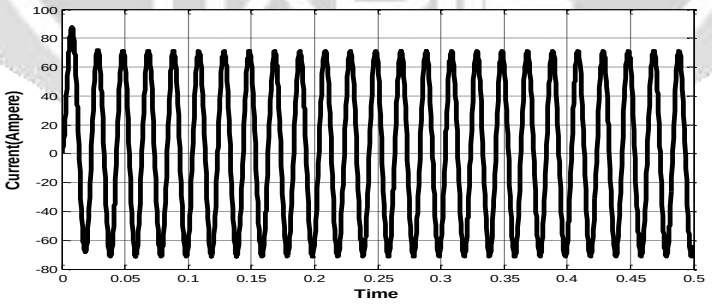

Fig -3: Current before adding capacitor

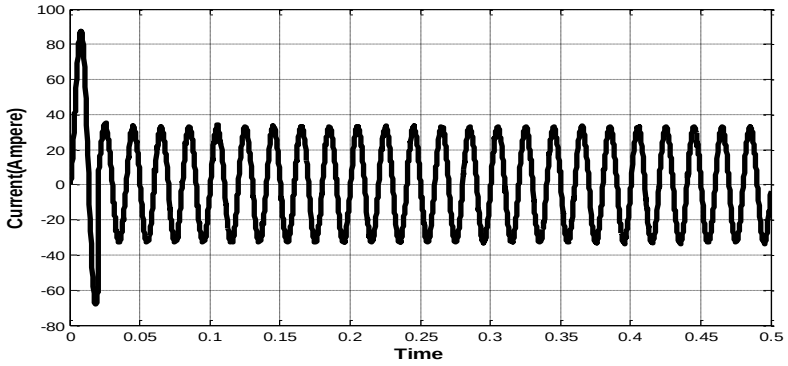

Fig -4: Current after adding capacitor

8. CONCLUSION

Power factor of system is low due to nonlinear load such as power electronic equipment which generates harmonics in system. Power quality of system which has harmonics and low power factor is poor. Injecting the capacitance in line will make power factor near to unity.

By supplying non-linear loads, the power factor degrading and harmonics exceeds. This will help to maintain power quality of system.

9. REFERENCES

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