

Power Factor Improvement for Induction Motor by Using Capacitor Bank

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Abstract: Power factor improvement of induction motor loads by means of shunt capacitors has been a practice of pulling its full weight. In an AC circuit there is a connecting the capacitors directly at the motor terminals has developed in order to permit switching of the capacitors and motor as a unit. This will not result in adverse motor operation if the number of capacitors is selected properly. The power factor of these motors varies from 0.30 to 0.95, depending on the size of the motor and other operating conditions. Therefore, the power factor level is always a concern for industrial power systems, utilities, and the user. The system performance can be improved by correcting the power factor. Since the number of power electronic based devices is increasing, it leads to designing more and more capacitor bank. Shunt capacitor banks are used to improve the quality of the electrical supply and the operation of the power system.

Keywords: power factor, induction motor, capacitor bank

1. Introduction

The main objective of this study is to design an energy saving scheme for an industrial distribution network losses and improving the main electric load operation to a better efficiency level. Most plant loads are inductive and require a magnetic field to operate motors transformers and florescent lighting. The magnetic field is necessary, but produces no useful work. The utility must supply the power to produce the useful work. These two types of current are active and reactive. Shunt capacitor banks are mainly installed to provide capacitive reactive compensation/power factor correction. Industrial power distribution network encounter increase in power losses and increase in the type of load is accompanied with low power factor which leads to huge transfer of reactive power from the utility through the work. The main drawback of this problem is increase the network losses and reduction in the voltage level. It can result in poor reliability, safety problem and higher energy costs. Power system load consist of resistive, inductive, and capacitive loads. Example of resistive loads is in candescent lighting and electric heaters. Inductive loads are induction motors, transformer and reactors. And capacitive loads are capacitor, variable and fixed capacitor bank, generator and synchronous motor.

Power Factor: The power flowing on alternating current

(AC) load is not always pulling its full weight. In an AC circuit there is a phase difference between voltage and current. The term $\cos \Phi$ is known as power factor. The power factor is a ratio of Active power to the apparent power. Active power (measured in KW), also known as real power or true power, is the working power in a circuit and Reactive power (measured in KVAR) is the non-working power. Active power and Reactive power together make up apparent power (measured in KVA).

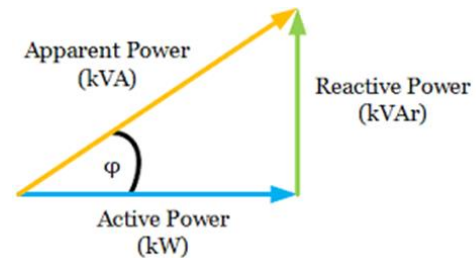


Fig. 1. Power triangle

Power factor = Active Power / Apparent Power

Power factor correction is a technique of counteracting the undesirable effect of electrical load that create a power factor less than one. If the circuit is inductive, the current is lags behind the voltage and the power factor is called lagging power factor and if the circuit is capacitive then current leads to voltage and the power factor is said to be leading power factor. Power factor correction may be applied either by an electrical power transmission utility to improve the stability and the efficiency of the transmission network or the correction may be installed by individual electrical customers to reduce the cost charge.

Low power factor is an issue, which can be solved by adding power factor correction capacitor to the plant distribution system. Capacitor work as reactive current generators "providing" needed reactive power (KVAR) into the power supply. By supplying their own reactive power source, the industrial user frees the utility from having to supply it, and therefore the total amount of power supplied by the utility will be less.

Power factor of an induction motor:

Power factor is a very important in induction motor. The induction motor must operate at a lagging power factor. The

power factor of induction motors varies with load, typically from around 0.85 or 0.90 at full load to as low as about 0.20 at no-load, due to stator and rotor leakage and magnetizing reactance's. Power factor can be improved by connecting capacitors either on an individual motor basis or, by preference, on a common bus covering several motors. For economic and other considerations, power unity power factor. Power capacitor application with harmonic currents requires power system analysis to avoid harmonic resonance between capacitors and transformer and circuit reactances. Common bus power factor correction is recommended to minimize resonant risk and system to simplify power analysis.

At no load: Induction Motor when started at no load has very poor power factor in the range of 0.1 to 0.3. For understanding the effect of loading on the power factor of Induction Motor, we will consider three components of current flowing in an induction motor namely magnetizing current, stator loss Component of Current and Load Component of Current an induction motor draws a large magnetizing current and a small active component to meet the no-load losses. Therefore, the induction motor takes a high no-load current lagging the applied voltage by a large angle. Hence the power factor of an induction motor on no load is low i.e., about 0.1 lagging.

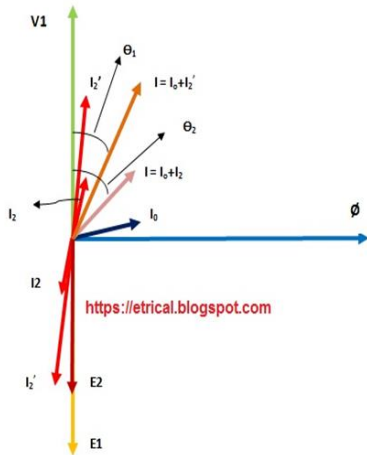


Fig. 2. Phasor diagram

At loaded: As the Induction Motor is loaded, the load component of current increases from its no load value. The increment of load component of current from its no load value is responsible for supplying the load torque. Thus the load component of current increases from its no load value of I_2 to I_2' . When I_2' is added with I_0 vectorically the resultant current $I = I_2' + I_0$ makes an angle of θ_1 which is less than θ_2 . Thus as we increase the load θ_1 decreases which in turn means an improvement in power factor.

The power factor of Induction Motor becomes 0.85-0.88 when it is loaded 80-90% but beyond this loading power factor decreases slightly because of prominent effect of Stator and Rotor leakage reactance drop.

2. Simulation results

Using simulink toolbar and its respective library, a sequence of model can be created to meet the requirement.

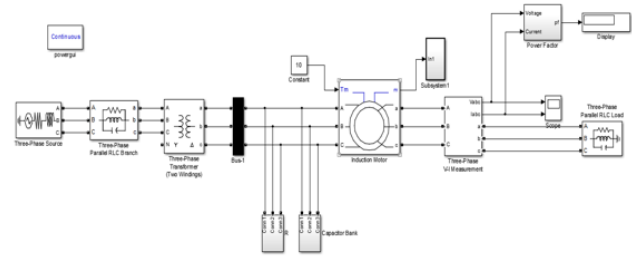


Fig. 3. Simulation model of three phase induction motor connected with parallel with capacitor bank

Table 1
Power factor at different load condition

S. No.	Motor Load Factor	Power Factor
1	Unloaded	17%
2	1/2 Loaded	73%
3	Full loaded	84%
4	Overloaded	87%

Table 2
After power factor correction

Load	Capacitor Value	Power Factor
100	2	0.9311
100	3	0.9356
100	4	0.9423
100	5	0.9501

In the Table 2, it is shown that power factor is improved by using capacitors. Power factor is very low at no load it can be improved from 0.17 to 0.9501 at full load.

3. Conclusion

By observing all aspects of the power factor it is clear that power factor is most significant part for the utility company as well as for the consumer. Utility company rid of from the power losses while the consumer free from low power factor penalty charges.

By installation suitable sized power capacitor into the circuit the power factor can be improved and the value become near to 1 thus minimizing line losses and improve the efficiency of an induction motor.

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