# Methods of Power Factor Correction & Its Impact on Power Savings and Power Losses

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*Abstract*— In today's age power consumption is rising day by day. Also the system losses are increasing. To operate the power system economically is a big challenge and necessity today. Some of the power Called 'reactive power' is the wasted power. While we only uses the active power. Power Factor which is the ration of active power to apparent power play important role in power Consumption. Ideally the power factor should be unity. But inductive loads causes it to lag below unity. To improve the power factor is a necessity for economical operation. There are Different methods like capacitor banks, synchronous motor etc.

***Key words:*** Power Factor Correction, Power Savings

## I. Introduction

The power factor is simply a cosine of angle between the voltage and current. Also it can be defined as the ration of real power to the apparent power. The real power is given by the multiplication of voltage, current and power factor.

$$\text{POWER FACTOR}= \frac{ACTIVE\ POWER}{APPARENT\ POWER}$$

As much the power factor is higher the value of the active power becomes higher. So it is necessity to improve power factor. We will undergo some circumstances and causes of low power factor and also study about the methods of power factor improvement.

## II. Causes of Low Power Factor

The most common source of low power factor is induction machines weather single phase or three phase. The induction motors causes the current to lag behind the voltage. And thus causes the power factor low. But in common use it is not possible to avoid use of induction machines. Also some heating process involves induction heating, also reduces the power factor. Also discharge lamp such as sodium lamp also causes the reduction in power factor. The transformer which is the unchangeable part of the power system causes deduction in power factor. The harmonic current causes the lowering of power factors. Most of the sources of low power factor cannot be avoided

## III. Disadvantages

The low power factor causes larger line losses. As the power factor reduces the line current increases which further increases in line losses. The generating stations are rated in KVA. So as the power factor decreases the reactive power increases while the real power consumption is still constant. So to fulfil the necessity the apparent power generation must be increased because

$$S = P + jQ$$

Apparent power = active power + reactive power

Hence the loading on the generating station increases so to fulfil the necessity the large rating generating equipment are required. As the reactive power will increases also the voltage regulation of such system gets poorer. As the current in system increases the further need of larger conductor is arise. In industrial connections the consumer have to pay penalty charges on the reactive power usage extended to some predefined limit. So low power factor will cause larger reactive power and hence have to pay penalty to utility. The efficiency of system also gets reduced due to reduction in power factor of the system. Hence there are different type of losses and difficulties that arises due to low power factor. So the power factor is must to be corrected for the better usage of the power system.

## IV. Methods of Power Factor Improvement

There are different methods of power factor improvement which are given below. Here we are talking about the improvement in case of the AC systems.

1) synchronous condenser
2) phase advancer
3) capacitor banks

### A. Synchronous Condenser:

The synchronous condenser is nothing but synchronous motor running on no load. The characteristics of synchronous condenser is as below.

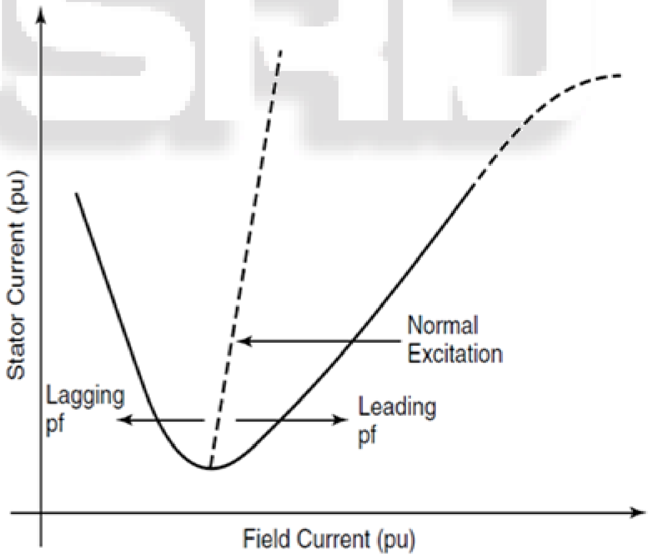


Fig. 1: synchronous condenser [2]

1) *Advantages:*
- Long life
- High reliability
- No harmonics generation
- Easy fault removal
- Low maintenance

2) *Disadvantages:*
- Cost is high
- Device is required for starting of the synchronous motor noisy machine

### *B. Phase Advancer:*

*1) Advantages:*

- Motor's lagging KVAR is improved by the phase advancer
- It is used where the synchronous motor cannot be used.

*2) Disadvantages:*

- For small size machines the phase advancer cannot be used. It is not economical for small size machines

### *C. Capacitor Bank:*

*1) Advantages:*

- Losses are comparatively low
- No need of maintenance
- It can work in any atmospheric condition
- No foundation are required
- Size is compact and less weight

*2) Disadvantages:*

- The age is comparatively less about 8 to 10 years
- For damaged capacitor repairing is costly
- Switching of capacitor is difficult

Among them the mostly used system is capacitor bank. Because of economics and view of size the capacitor bank is perfectly appropriate for usage.

## V. SIMULATIONS

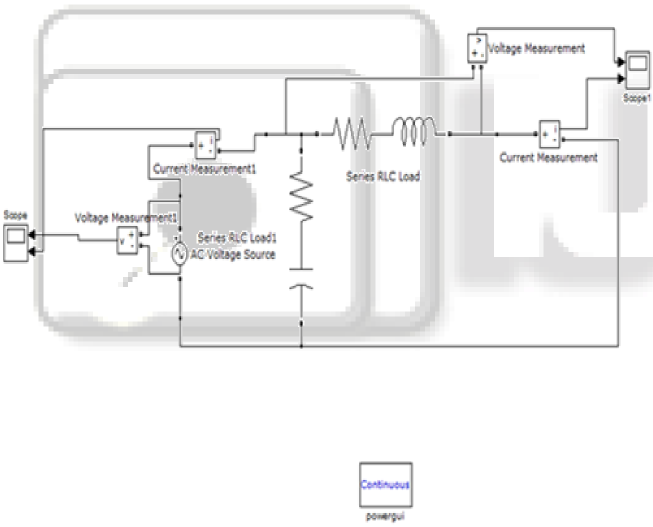


Fig. 2: simulation model

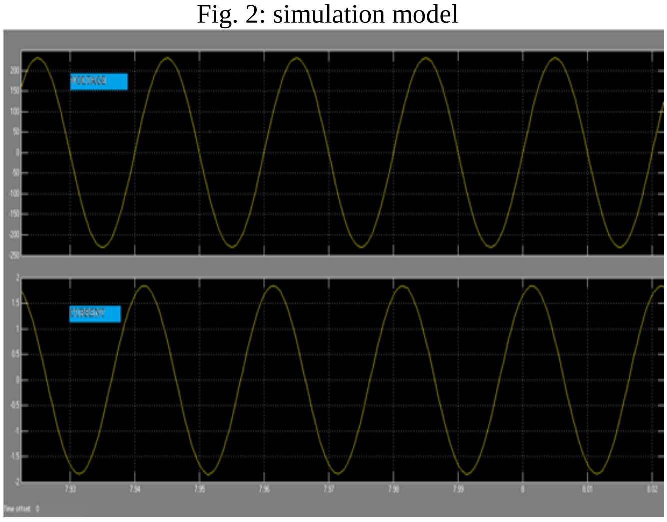

Fig. 3: Unimproved power factor waveforms

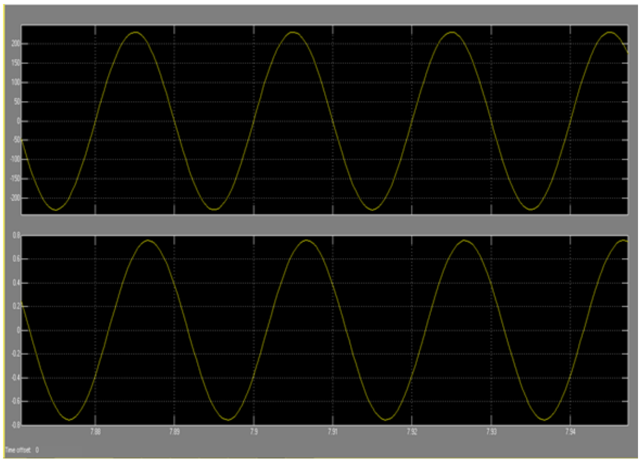

Fig. 4: Improved power factor waveform

Here from fig 1 we can see the model of system which is applied with the correction. Here the waveforms in figure 2 is taken from the scope at input while the waveforms of fig 3 is taken from output side scope. So here we can see the change in the time lag in both figures. Here in MATLAB we have simulated using only the capacitor bank. But a satisfactory results. The calculations are done according to below equations.

## VI. CALCULATION OF SAVING OF POWER LOSS

The power factor correction can be calculated in below steps.
STEP 1: calculate actual load
Load power (Kw) = √3×volts V× current I× power factor pf
STEP 2: calculate required power factor correction (KVAR)
Power factor correction KVAR = power Kw ($\tan\theta i - \tan\theta d$)

$$\theta_i = \cos^{-1} initial\ power\ factor$$

$$\theta_d = \cos^{-1} required\ power\ factor$$

STEP 3: actual power factor correction

$$\text{Actual power factor correction pf} = \cos\left(\tan^{-1}\left(\tan\theta i - \frac{correction\ Kvar}{power\ Kw}\right)\right)$$

By this steps we can calculate the data about power factor correction and required reactive power for the correction.

## VII. POWER SAVING

As we here consider that the data for example
Voltage = 400 V
Power factor = 0.6
Power load = 415.7 KW
Apparent power = 692.8 KVA
Now from equation
Load power (Kw) = √3×volts V× current I× power factor pf
Current = 1000 A

Now here we need the power of 0.957 so requirement of reactive power for the correction can be calculated
Above equations. The value is 417.6 KVAR.
We provide the KVAR of 400 KVAR
Hence the data after correction
Voltage = 400 V
Load power = 415.7 KW
Power factor = 0.938
Corrected current = 640 A

Apparent power = 443 KVA
Saving in power = 249 KVA
Therefore reduction in current = 360 A

So there will be also less requirement of power generation so the coal saving is also done. Reduced current causes reduced ohmic losses.

## VIII. CONCLUSION

Here we seen different methods of power factor correction. Each method provides correction but the synchronous machine is used mostly in large systems of certain MW because for smaller systems it becomes uneconomical. Same thing happens in case of the phase advancer. Due to its economic nature the capacitor banks are used as the correction device mostly.

Here we seen that the correction in power factor causes to reduction in total or apparent power need. This in terms causes energy saving and saving of resources used for power generation. Although residential loads are charged based on the active or real power consumed, in case of the industrial load power factor saves penalty charges and then saving in total charges. Thus here we can see that power factor correction saves energy and money too.

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