

Management of power factor and harmonic

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Abstract - This paper discusses about the power factor improvement and reduction in harmonic system. Poor power factor causes increased electricity charges, penalty for low power factor and unnecessary effect in the system and poor power quality. To smooth such negative effects, the power factor correction is carried out, also reduce harmonic content in the system filters are used. Automatic Power Factor Correction relay is one of the smart relay used to control the capacitor with respect to output. The proposed system is characterized by no generation of harmonics and reduction of transmission losses.

Key Words: Harmonics, Power Quality, Power factor correction.

1. INTRODUCTION

In power system, power factor and harmonics plays very important role. For optimum utilization of available power the reactive power consumption should be reduced or nullified i.e. power factor should be unity.

As we know the most of industrial load is inductive which causes the production of low power factor and harmonics respectively. Power factor correction (PFC) is a technique of counteracting the undesirable effects of electric loads that create a power factor that is less than one. Power factor correction maybe applied either by an electrical power transmission utility to improve the stability and efficiency of the transmission network or correction may be installed by individual electrical customers to reduce the costs charged to them by their electricity supplier. For stable load the fixed KVAR compensation is required, while for variable load the KVAR requirement also changes as per the load duration cycle, thus in such cases the automatic power factor control panel is required.

1.1 POWER FACTOR

In general power factor is the capacity of the equipment to do the work. In electrical field, it is another form of energy which is transferred in per unit time. In AC circuits we have inductor and capacitor as components. Inductor stores energy in magnetic energy form where as capacitor stores in electrostatic energy form. None of them dissipates it.

Further there is phase shift of 90° between voltage and current, but the circuit containing resistor (R), inductor (L), capacitor (C) has some phase difference angle between

voltage and current. And the cosine of this angle (angle between voltage and current) is known as power factor. The value of the power factor will be always between 0 to, which represents the fraction of total power that is used to do the useful work.

Causes of low power factor

- i. Single phase and three phase induction motor
- ii. Varying load in power system
- iii. Industrial heating furnaces
- iv. Electrical discharge lamps, Arc lamps
- v. Transformers
- vi. Harmonic currents

Effect of low power factor

- i. Increase in losses
- ii. Large KVA rating, size of electrical equipment
- iii. Greater conductor size and cost
- iv. Poor voltage regulation and large voltage drop
- v. Penalty from electric power supply company on low power factor

Methods for improvement of power factor

- i. Static capacitor bank
- ii. Synchronous condenser
- iii. Phase advancer

The most commonly used method for power factor improvement is the static capacitor bank.

1.2 HARMONICS

It is a component of a periodic wave having a frequency that is an integral multiple of the fundamental power line frequency. Due to contribution of all harmonics present in the system distribution of wave occurs and total harmonic distortion can be calculated.

There are two types of harmonics one is characteristic harmonics and other is non-characteristic harmonics.

1. Characteristic harmonics

It is a signal or wave having integral multiple of frequency of the fundamental signal or wave. It can be calculated by following equation

$$H = (n \times p) \pm 1$$

2. Non-characteristic harmonics

It is a signal or wave having other than characteristic harmonics which are not integral multiple of fundamental frequency is known as non-characteristic harmonics.

Causes of harmonics

- i. Use of power electronic devices
- ii. Variable frequency drives
- iii. Linear and non-linear loads

Effects of harmonics

Harmonics present in the system will affect the following things

- i. Conductor overheating
- ii. Capacitors
- iii. Fuses and circuit breakers
- iv. Transformer
- v. Generators
- vi. Utility meters
- vii. Drives or power supplies
- viii. Computer and telephones

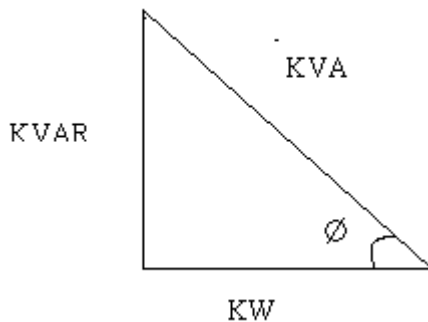
Methods for suppressing harmonics

- i. No load
- ii. DC choke
- iii. Line reactor
- iv. 12-pulse converter
- v. 12-pulse distribution
- vi. Harmonic trap filter
- vii. Broadband filters

Mostly filter are used for harmonics reduction.

1.3 CALCULATION OF CAPACITOR VALUE

Calculation of power factor from current and required power value.



Active current $I_m = \text{current value} \times \text{actual power factor}$
 Active current $I = I \times \text{required power factor}$
 $I = I_m / \text{required power factor}$
 Reactive current $I_m = \text{Current value} \times \sin \phi$
 Reactive current $I = I \times \sin \phi$
 $I_c = \text{Reactive component of current } I_m - \text{Reactive component current } I$
 $I_c = V / X_c$
 $1 / X_c = 2 \times \pi \times f \times c$
 $I_c = V \times 2 \times \pi \times f \times c$

2. APFC RELAY

For optimum utilization of available power the reactive power consumption should be reduced means power factor should be unity, hence, most of the Power Distribution companies have policy to penalize the

industrial and commercial consumers for not maintaining power factor above certain limit i.e. above 0.90 value.

1. Need for Automatic Power Factor Correction

Normally there is varying power demand on the supply system. Therefore power factor also varies as a function of the load requirements and it is difficult to maintain a consistent power factor by use of fixed compensation i.e. fixed capacitors. When there is leading power factor under light load conditions (fixed compensation) results in over voltages, saturation of transformers and so the industry penalties by electric supply authorities.

Where in APFC due to automatically variation, without manual intervention, the compensation to suit the load requirements, leading power factor will be also prevented.

However, due to reactive power drawn by capacitive or inductive load in the consumer premises the power factor is either lagging or leading, thus to maintain it within limit i.e. for compensating or supplying required KVAR, the capacitors or reactors in case lagging or leading PF are connected across the system. Therefore for the variable load the APFC panel is installed.

The major components of APFC panel comprises of capacitor or inductor segregated in various stages, Power Factor control Relay and contactors (ON/OFF). The APFC relay monitors the various electrical parameters such as KVAR requirement, Power factor, Voltage, Current and Power consumption, of the system and uses its intelligence to control the parameters within required limit. Thus by sensing actual voltage and current of the system the APFC relay computes the system power factor and KVAR requirement, and by the control signal relay connects/disconnects the capacitor bank to the system with the help of contactors.

2.1 HARMONIC FILTER

Capacitor bank connected with an inductor in order to reduce the harmonic effects. This combination constitutes a filter for harmonics.

Previously, to avoid the negative effects of resonance, we have to insert an inductor in series with capacitor. But it is possible to think of placing in a point of the combination of an inductor and capacitor well dimensioned in order to get same resonance frequency for eliminating the harmonic current

In this way combination of inductor-capacitor presents a very low reactance in order to harmonics eliminated which shall circulate in the assembly without affecting the whole network. This filter is called as "passive filter". They are defined on a case basis, according to particular harmonic is filtered and they are cost effective and easy to be connected into the function.

"Active filter" are instead automatically eliminate the current harmonics present in the network in wide range of frequency. They can inject a system of harmonics which is able to which neutralize those present in the network. The active filter has an advantage that filtering simultaneously dozens of harmonics as well as it does not involve design cost for dimensioning.

A. CAPACITOR BANK

Capacitors are used to cancel the lagging current effects. Capacitor also can reduce system losses as well as help to provide voltage support. Another one benefit of capacitor is they can reduce the total current flowing through a wire, therefore leaving capacity in the conductors for additional load.

Capacitor banks can be switched manually, automatically locally. For example, system control centers operator switch capacitor bank on and off to meet load requirements or system stability reactive power demand requirements. By using capacitive support we can maintain the good system voltage and reduce the system losses as well as maintain the power factor.

B. CONTACTORS

A contactor is a electrically controlled switch, and it is used for switching a power circuit. A contactor is a very heavy duty so relay used for switching magnitude. Alloy containing silver is used for high current contacts. The unavoidable arcing causes the contacts to oxidize and silver oxide is still a good conductor. The overload sensing devices are a form of heat operated relay where a coil heats a bi-metal strip, or where a solder pot melts, releasing a spring to operate auxiliary contacts. These auxiliary contacts are in series with the coil. If the overload senses excess current in the load, the coil is de-energized. Contactor relays can be extremely loud to operate, making them unfit for use where noise is a chief concern.

UA contactors are used for the switching of capacitor banks. For capacitor banks inrush current do not exceed 100 times the rated current. The capacitors must be discharged. And in this case their electrical life corresponds to 100,000 operations. A and AF contactors are also suited for capacitor bank switching with peak currents lower than 30 times the rated current.

C. MCB

A circuit breaker is an automatically operated electrical switch. It used to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect fault condition and, by interrupting continuity, to immediately discontinue electrical flow. Unlike a fuse, which operates once and then must be replaced, a circuit breaker can be reset to resume normal operation.

3. CONCLUSIONS

The proposed single-phase and three-phase automatic power factor correction system has certain reactive current or reactive power ratings. The proposed system performs better than the traditional methods in mitigating harmonics and power factor improvement.

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