Significance of using Detuned Reactors

Combination of Active Harmonic Filter & Detuned Capacitor Banks

Why Reactive Energy Management ?

AC loads in an electrical network consumes two types of power, active power (kW) and reactive power (kvar).

- ***Active Power(kW):*** It is the real power transmitted to loads which is converted to useful work
- ***Reactive Power(kvar):*** It is used to supply magnetic circuits of machines, motors and transformers
- ***Apparent Power(kVA):*** It is the combination of active and reactive power

Circulation of reactive power in the electrical network has major technical and economical consequences:

- *Low Power Factor*
- *Higher energy consumption*
- *Inflated electricity bills*
- *Overload of transformers*
- *Thermal stress on cables*
- *Large voltage drops*

There is a great advantage to generate reactive energy to prevent unnecessary circulation of current in the network.

What are the techniques for reactive compensation ?

Different types of compensation techniques are available depending upon the performance requirements and complexity of loads:

Fixed: connecting a fixed value capacitor bank

Automatic: single panel having number of capacitor steps, that provides compensation adjustable to requirement using typically contactors

Active: compensation using advanced IGBTs, ideal for fast fluctuating loads, capable of providing lagging/leading compensation effectively

What is the effect of harmonics on capacitors ?

Harmonic distortion means that the available voltage and current are distorted ones and deviates from ideal sinusoidal waveform. Harmonic currents are generated by non-linear loads. Flow of harmonic current generates voltage harmonics which in turn effects the supply voltage.

Capacitors are sensitive to harmonics since their impedance decreases proportionally to the order of harmonics present. This means that capacitors act as sink and provide low opposition to the flow of harmonic current through it. Capacitors are meant to supply reactive power only. Harmonic current when allowed to pass through the capacitors result in damage and failure.

What is Resonance ??

Resonance is a phenomenon, typical of normal capacitor banks, whereby natural resonance frequency of capacitor and network combined happens to be closed to any of the harmonic frequency present. Resonance is responsible for greatest harmonic distortion in distribution network and major cause of correction capacitor overloads. A serious consequence of resonance is severe magnification of harmonic distortion (both current and voltage).

Harmonic distortion itself has several undesirable effects. Magnified harmonic level means that the detrimental effects are manifolded several times. Serious consequences of harmonic amplification on electrical network and capacitors can be summed up as follows:

- *Capacitor overload and failures*
- *Exceeded harmonic level than specified IEEE limits*
- *Failure of sensitive equipment*
- *Reduced efficiency & reliability of system*
- *Increased power losses*

What are Detuned Reactors ?

Detuned reactors are specifically three phase inductors dedicated to attenuate the amplification of harmonics on highly polluted network and to protect different components of the installation. Reactors have to be associated to capacitor banks for power factor correction in systems with significant non-linear loads generating harmonics.
Capacitors and reactors are configured in a series resonant circuit, tuned so that the series resonant frequency is below the lowest harmonic frequency present in the system. Detuned reactors generate an over voltage at the capacitor terminals and therefore rated voltage of capacitors has to be increased.

Detuned filtering is a technique to correct the power factor avoiding the risk of resonance condition performed by shifting the resonance frequency to lower values where no harmonic currents are present.

Which Detuned Reactor should be used ?

Tuning frequency corresponds to the resonance frequency of the L-C assembly. It can be expressed by the relative impedance of the reactor (in %). Commonly used values of relative impedance are 5.7%, 7% and 14%

Detuning Factor	*Resonance Frequency for 50HZ*
5.7%	**210 Hz**
7%	**189 Hz**
14%	**134 Hz**

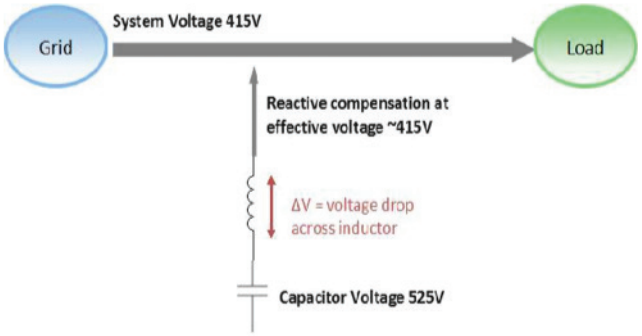
- ★ 5.7% is typically used when harmonics >11th order are dominant
- ★ 7% is typically used when 5th, 7th harmonic orders are dominant
- ★ 14% is typically used when 3rd, 5th, 7th harmonic orders are dominant

Following negative impacts can be avoided by use of detuned reactors:

- ★ Over current during switching on the capacitor banks
- ★ Overload of capacitor banks due to harmonic resonance
- ★ Short lifetime of capacitors
- ★ Overheating of distribution transformers
- ★ Unintended triggering of the protective devices

What should be the capacitor rated voltage with detuned reactor ?

Typically, capacitor banks present in normal PF correction panels are rated at voltage level of 415V. We recommend to connect a reactor coil (commonly known as detuning reactor) in series with capacitor banks to avoid resonance phenomenon. Capacitor banks to be used along with detuned reactors must be rated at voltage level of 525V. This is because reactor coil draws some voltage drop across it which will effectively result in reactive compensation (by capacitor banks) at system voltage of 415V. This can be well depicted from the illustrative diagram presented below:



Considering voltage drop across reactor, capacitors will provide reactive power at system voltage of 415V

What will be happen if Active Harmonic Filter is operated in presence of Resonance ??

Active harmonic filter is advanced IGBT based technique that is capable of providing instantaneous harmonic current compensation. Keeping in view the prolific use of non-linear loads these days, harmonic level getting exceeded than its specified limits is expected. Meeting the set standards for harmonic distortion is the prime aim that every facility looks for.

Operation of active filter in presence of resonance (phenomenon caused by normal capacitor banks) has several major disadvantages Consider the scenario explained below:

Case-I…

Facility having normal capacitors

- Load current 1000A
- iTHD 10% , vTHD 3% (without capacitor banks)
- iTHD 20%, vTHD 6%(with normal capacitor banks)
- Resonance: High
- Rating of AHF needed: 250A

Case-II…

Facility having detuned capacitors

- Load current 1000A
- iTHD 10%, vTHD 3%(without capacitor banks)
- iTHD 11%, vTHD 3%(with detuned capacitor banks)
- Resonance: Negligible
- Rating of AHF needed: 120A

Case-I shows typical scenario when the facility has normal capacitor banks and harmonic amplification is quite significant. Harmonic filter rating needed in this case is 250A.

Case-II shows typical scenario when the facility has detuned capacitor banks and harmonic amplification is almost negligible. Harmonic filter rating needed in this case is 120.

It can be well concluded that:

- Over rated unit is required for harmonic filtration in presence of resonance which results in unnecessarily over priced solution
- Harmonic current fed by active filter may enter normal capacitor banks (acting as sink) instead of compensating at the correction point, thereby, distorting the situation further
- Certain components of unit might get over stressed when operated in presence of resonance over prolonged period of time

Why Active Harmonic Filter + Detuned Capacitor Banks ?

It can be well concluded that combination of active harmonic filter along with detuned capacitor panel is the most coherent, cost effective and efficient solution scheme where power factor improvement and harmonic mitigation are prime area of concern. Recommending active harmonic filter in the absence of resonance will result in effective harmonic reduction using a lower rated unit added with long operating life and superior performance.