POWER QUALITY MANAGEMENT: A REVIEW

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Abstract: This paper gives a brief introduction to power quality and ways for Energy Conservation. Electric power quality may be defined as a measure of how well electric power service can be utilized by customers. The term Power Quality means different things to different people. There is no agreed definition for power quality, it may be defined as the problems manifested in voltage, frequency and the effect of harmonics, poor power factor that results in misoperation/failure of customer equipment. The widespread use of high-power semiconductor switches at the utilization, distribution and transmission levels have made non-sinusoidal load currents more common. Certain type of power quality degradation results in losses and thus losses in transmission and distribution system have come under greater scrutiny in recent years.

Keywords: energy conservation, power quality, distribution system

1. Introduction

Electric power quality may be defined as a measure of how well electric power service can be utilized by customers. When wave shapes are irregular, voltage is poorly regulated, harmonics and flicker are present, or there are momentary events that distort the usually sinusoidal wave, and the power utilization is degraded. This is referred as degradation of power quality.

2. Power Quality

The term Power Quality means different things to different people. Power quality is the quality of the electric power supplied to electrical equipment. Poor power quality can result in mal-operation of the equipment the electric utility may define power quality as reliability and state that the system is 99.95% reliable.

No real life power feed will ever meet this ideal. It can deviate from it in the following ways (among others):

Variations in the peak or rms voltage (both these figures are important to different types of equipment) When the rms voltage exceeds the nominal voltage by a certain margin, a surge is produced. A dip is the opposite situation: the rms voltage is below the nominal voltage by a certain margin. A sag occurs when the low voltage persists over a longer time period.

Variations in the frequency, Variations in the wave shape - usually described as harmonics. Quick and repetitive variations in the rms voltage. This produces flicker in lighting equipment. Nonzero low frequency impedance (if the appliance draws more power the voltage drops)

3. Causes of Power Disturbances

- Power disturbance originate both outside and inside customer facilities.
- Load switching causes surges because of collapsing fields ($-e = l * di/dt$)
- Over loaded power distribution systems can cause significant voltage variations between peak and off-peak hours.
- Significant momentary load changes, such as heavy inrush currents can cause severe voltage variations
- Black-outs can cause severe voltage surges both on loss and return of power.

4. Results of Power Disturbances

- Sags and under voltages can cause component overheating or destruction
- Surges and over voltages can cause component overheating, destruction or can trigger other electronic components such as SCR's.
- Component overheating reduces the life and deteriorates the real reliability as opposed to the estimated reliability based on steady-state conditions of the product.

5. Voltage

In the context this issue must be viewed from two different directions. The first direction is variation in supply voltage due to the factors arising from transmission and distribution of power. The second direction is variation in voltage within a network due to the characteristics of the loads connected therein. It is well known fact in many other developing Countries that the quality of voltage supplied by the utilities varies widely depending on the type of distribution network and the geographical locations of such networks. The problem of voltage variation in this regard becomes more acute in rural distribution network.

Similarly on particular feeders, which supply highly fluctuating loads of an industrial nature, it is common to find voltage variations beyond permissible limits. The impact of such voltage variations is to cause higher energy consumption due to a combination of factors. Some of the important factors are

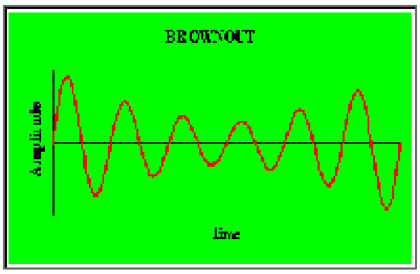
- For a given MW of power rating, the current drawn goes up inversely in proportion to the voltage. Consequently, a drop in voltage would result in increased current flowing on the network. This increased current then causes increase in I2R losses of the network. For ex: a 20% drop in voltage would increase the losses in the network by 56%. Further, this increased current will contribute to increasing the voltage drop and thereby intensifying the problem.

5.1 Voltage imbalance have the following adverse effects:

- Overheating of motors lead to insulation breakdown.
- Imbalanced currents.
- Negative voltage sequence
- Motor bearings failure.
- Speed variation in motors.
- Reduced production quality.
- Reduced motor efficiency.
- Wasted energy which leads to higher electric bills-KWD, KWH.
- Wasted investment and operation capital.

5.2 Brownouts

Brownout by definition is low voltage for an extended period of time (greater than half a cycle) in which the magnitude of the voltage is reduced.



5.3 Brownouts cause the following adverse effects:

- Temporary low line voltage.
- Shutdowns.
- Loss of microprocessor memory.

- Loss of control.
- Overheating of motors - insulation breakdown.
- Protective device tripping.
- Speed variation
- Reduced motor torque, which can lead to stalling

6. Frequency

While this is also an important factor, it is more stable than the voltage due to the fundamental nature of electricity generation, transmission and distribution. Frequency variations can occur, due to the load levels on the electricity supply system, for ex: a highly overloaded power system will experience a drop in frequency.

7. Harmonic Distortion

The problem of Harmonic distortion primarily occurs in modern electrical networks due to feedback of Harmonic currents from nonlinear loads. Harmonic Voltage distortion is created due to interaction of such Harmonic currents with source impedances. Consequently, this can be treated as a form of electrical pollution on the network. The presence of Harmonic distortion has a significant impact in increasing energy consumption. Some of the important reasons for this are listed below:

- All electromagnetic equipment such as transformers, motors etc, have two key constituents of losses namely, iron loss and copper loss. The iron loss is also a function of the power of the frequency. Consequently, presence of higher frequency components such as 5th harmonic, 7th Harmonic etc, will result in an increase in iron losses.

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Harmonics cause the following adverse effects

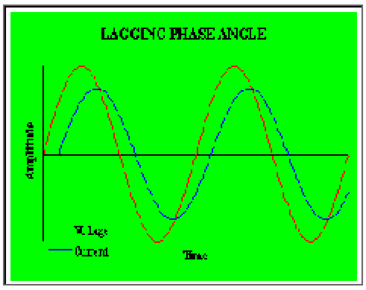
- Overheating of transformers (K- Factor), and rotating equipment.
- Increase Hysterisys losses
- Neutral overloading / unacceptable neutral-to-ground voltages.
- Distorted voltage and current waveforms.
- Failed capacitors banks.
- Breakers and fuses tripping.
- Unreliable operation of electronic equipment, and generators.
- Erroneous register of electric meters.
- Wasted energy / higher electric bills -KWD & KWH.
- Wasted capacity - Inefficient distribution of power.
- Increased maintenance of equipment and machinery

A. Power Factor

Power factor is the phase shift between voltage & current**.** While the theoretical definition of Power factor is the ratio of active power to apparent power, it is well known that in electricity distribution systems this is measured as a ratio of active energy to apparent energy over a specified time period.

8. Low Power Factor Causes The Following Adverse Effects

- Increased line losses I^2R
- Wasted generation capacity (KVA)
- Wasted distribution /transformer/ capacity (KVA)
- Wasted system capacity (KVA)
- Reduced system efficiency (KW)
- Increased maximum demand (KVA), and related charges.
- Possible power factor charges

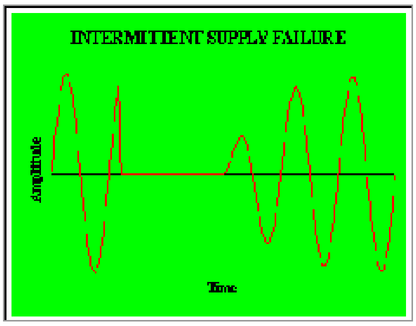


9. Intermittent Supply Failure

Generally, intermittent supply failures are caused by the utility company switching loads, lines, and source supplies.
The fastest this switching can occur is three to five cycles.
During this period, there is a complete drop-out.
This may or may not be a concern for all industries but intermittent supply failure takes its toll on the operation and efficiency of equipment and machinery.

10. Supply failure Causes the following Adverse Effects

- Voltage control relay tripping.
- Phase imbalance relay tripping.
- Plant and equipment shutdown - downtime!
- Loss off critical microprocessor memory.
- Possible jogging, pinching and stalling of motors.
- Loss of control and resetting of equipment.
- Loss production



A. Phase Loss

In case of phase loss, a lost phase from the remaining two phases causes interruption of power supply to industries and thus causing loss of valuable production time.

B. Phase loss causes the following adverse effects:

- Imbalanced operation of three phase motors, resulting in insulation breakdown and destruction.
- Increased downtime
- Loss of production.
- Major maintenance and replacement capital requirement

11. Solutions to power quality problems:

There are two approaches to the mitigation of power quality problems. The first approach is called load conditioning, which ensures that the equipment is less sensitive to power disturbances, allowing the operation even under significant voltage distortion. The other solution is to install line conditioning systems that suppress or counteracts the power system disturbances. A flexible and versatile solution to voltage quality problems is offered by active power filters. Currently they are based on PWM converters and connect to low and medium voltage distribution system in shunt or in series. Series active power filters must operate in conjunction with shunt passive filters in order to compensate load current harmonics. Series active power filters operates as a controllable voltage source. In addition to it we can also use capacitor demand meter for better power quality.

12. Conclusion

The Power Quality issues such as voltage variations, Harmonic distortions and power factor combine together to reduce the overall operating efficiency of electrical networks and also result in increased power supply demand and unnecessary wastage of energy.

Power quality can be improved by providing capacitor demand meter, capacitor banks at the load side. In this paper the use and advantages of applying Series active power filters to compensation power distribution systems has been presented. The principles of operation of series active power filter have been presented.

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