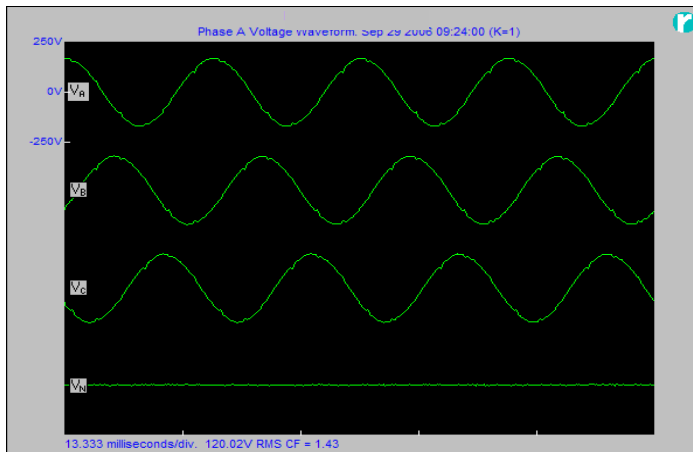


Harmonic Analysis and Power Factor System Studies

Power Systems Analysis



This brochure outlines power systems analysis performed by Phaseco Incorporated for medium and low voltage power systems. These analyses are conducted to evaluate the potential impact, on the power distribution systems when applying shunt capacitor banks and/or harmonic filters.

Our system evaluation focuses on the design, specifications and system impact of new and existing capacitor banks or harmonic filters. The results of a system study will provide recommendations on equipment design, installation and operational features to meet the

customer's requirements. In many cases the Power System Study will pay for itself in reduced utility cost or improved system operations and overall power quality improvements.

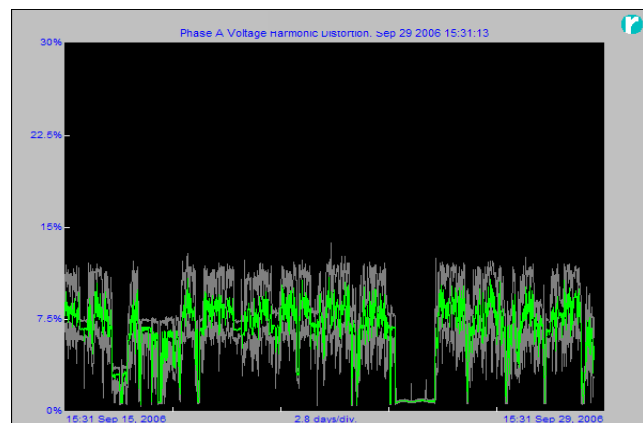
Introduction

Installing large shunt capacitor banks or harmonic filters creates concerns for many large industrial, commercial, manufacturing and institutional customers. The major considerations are harmonic resonance, increased harmonic distortion, switching surges and over-voltage as a result of adding power factor correction equipment. Most informed customers believe it is in their best interest to perform a system study to insure the power factor correction capacitor and/or harmonic filter bank is properly designed to prevent any adverse affects, on the power system.

Primary Areas of Concern

- Switching Surges
- Harmonic Distortion
- Harmonic Resonance
- Bus Over-Voltages

Measurements and Data Collection



The purpose of measurements and data collection is to gather the necessary information to perform the capacitor/filter bank evaluation. The data is collected for both normal and abnormal operating conditions. Future system conditions are also considered. It involves power system measurements at the point where the capacitor bank is being considered, data validation, local utility data collection and discussions with in-plant personnel.

Data Requirements

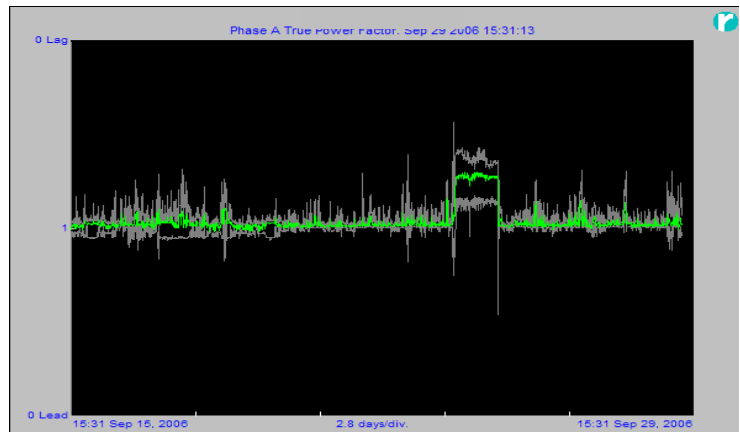
The minimum data required to perform a capacitor/harmonic filter bank analysis is listed below:

- Electrical System Impedance Data
- Electrical one or three line schematic which should include transformers, generators, motor loads, non-linear loads, location and size of existing and future capacitor banks or harmonic filters
- Utility Impedance Data
- Future System Requirements
- Existing system normal and abnormal operating conditions

Power Measurement Requirements

Power system measurements are necessary to verify the existing electrical conditions such as power factor, load level, system harmonics distortion levels and other system parameters.

In most cases existing capacitors and/or harmonic filters, as well as other loads, may have to be de-energized to obtain all required evaluation data. Coordination to do the switching [normally done by in-plant personnel] will be accomplished in advance.

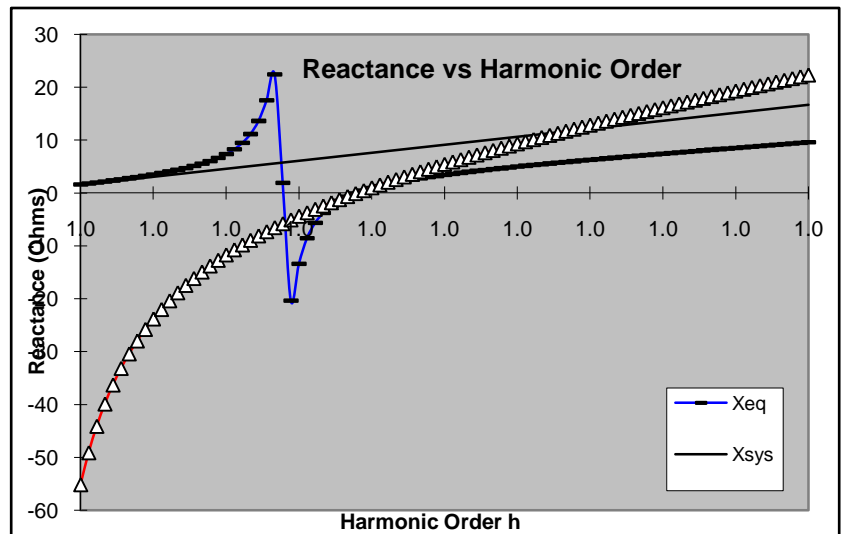


Harmonic Analysis

The harmonic analysis involves the use of predictive computer software to identify potential harmonic problems and resolve mitigation solutions. Phaseco utilizes several different industry standard software packages, including SKM & ETAP that can integrate and identify harmonic problems and solutions.

Major features of the software include:

- Predictive Harmonic Impedance Scans
- Voltage and Current Distortion Calculations
- Harmonic Filter Design Specifications



Capacitor Bank/Filter Bank Design

The design of the capacitor or harmonic filter bank is based on the information contained in the harmonic analysis. This information is evaluated to insure the equipment meets the functional requirements of the project, while insuring the specific components meet or exceed the performance requirements. Close coordination must be accomplished between in-plant personnel and local utility engineers to insure the equipment has the required operational controls as well as the necessary protective equipment.

The capacitor/harmonic filter bank specifications would contain the following minimum data:

- Individual capacitor cell rating
 - Voltage L-N
 - BIL Rating
- Harmonic Reactor Rating
 - Voltage Rating
 - BIL Rating
 - Impedance Rating
 - Ohm Rating
 - Minimum Current Rating
 - Tuning Frequency
 - Heat Rise Requirements
- Bank Configuration
 - Wye Grounded
 - Wye Ungrounded
 - Double Ungrounded Wye
 - Delta
- Protection Requirements
 - Overcurrent
 - Current Limiting Fuses
 - Vacuum Circuit Breaker w/Protective Relay
 - Unbalance
 - Current Detection
 - Neutral Protection
- Automatic Switching Requirements
 - Transit Inrush Reactor Requirements
- Control Requirements
- Disconnect Requirements