Building Electrical System Modeling Solutions

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Executive Summary

Over time, many buildings go through numerous expansions and equipment updates over the years to meet changing business requirements and advancing technology. As such, increased demand of the electrical distribution system becomes of critical importance to the facility owner and operator.

As such facility owners and operators continue to keep pace, their facilities often develop electrical distribution problems that resulted in electrical equipment failures, problems with harmonic distortion & power factor, slowdown of their process related equipment, and substantial increased energy consumption.

The traditional solution offered by equipment manufacturers and engineering firms is to recommend expensive catch-all solutions and equipment that is short lived, as they do not address the specific root cause of the existing facility problems. Prior to considering expensive stop gap repair and/or replacement of existing equipment which may create resonance on other parts of the existing system, we recommend that a thorough and comprehensive testing and troubleshooting survey be conducted.

INBALANCE approach is to conduct a cursory on site evaluation, which includes field observations, discussion with building staff and review of existing facility documentation, including energy utility bills, drawings, one line electrical information and previous summary reports which outline some of the existing electrical problems at the facility. Armed with that information, we have prepare a scope of work for the testing and troubleshooting of the entire electrical system, with a primary objective of utilizing the most appropriate and cost effective process for locating and identifying the specific electrical problems at the facility

After collection of data from the survey, INBALANCE has the unique capability to create a road map of the existing power system and model the load flow/harmonic with SKM High Wave analysis software. This analysis allows us to isolate the exact nature of the problems and then recommend proper (cost effective) solutions in a comprehensive report. Our proposal will also recommend proper solutions to cost effectively eliminate their issues with harmonics, to improve power quality, efficiency, reliability and longevity of the electrical system, without creating resonance in other parts of the existing system

Approach:

The following is the <u>on-site testing technical scope</u>:

1. Conduct a survey of the electrical distribution and prepare accurate and complete single line drawings using available documents and gathered field information.

2. INBALANCE will identify specific power quality monitoring and data logging locations

3. Collect data at a minimum of four locations that will log and trend-harmonics, voltage transients, current spikes, power factor and neutral/ground currents.

4. Conduct grounding test to ensure Integrity of ground system and that the facility has single point ground to maintain equi-potential. INBALANCE will provide locations within the facility to take ground reading measurements with Ohm Meter in relation to reference ground points nearest structural columns, water pipes or main switch board ground bus

5. Determine efficiency of all motors greater than 10 HP, and record motor nameplate information & run times. INBALANCE will identify specific motors on a line to check for issues with power factor and load factor on the suspect line

6. Check magnetic interference for inductive coupling of field using Gauss meter. This will spot locations of stray magnetic mutual coupling that causes harmonic interference. With that, INBALANCE will identify suspect locations particularly where transformers are located directly above another

7. INBALANCE will use cutting edge equipment, including a ***Power Explorer Px5 Power Quality Analyzer*** to take the necessary accurate readings.

The following is the <u>Computer Analysis technical scope</u>:

8. INBALANCE will use load flow/harmonic analysis software which will allow us to isolate the exact nature of the problems and then recommend proper (cost effective) solutions to Berry in a comprehensive report.

Objective

The objective of the harmonic analysis study is to develop measures to reduce the magnitude of the current and voltage harmonics in the power distribution system. Harmonics are produced by the operation of non-linear loads like AC/DC drives and rectifiers.

Harmonics could originate the overheating of transformers and cables, and could originate overvoltages if the power system has a resonant point near the frequency of one of the harmonics present in the system

Input Data (Needed From Building Owner/Operator) or this can be obtained via field survey by INBALANCE

Information of the utility system at the point of service: Short Circuit available at the point of service: three phase and single line to ground fault levels in Amps and X/R ratios

Needed Information on the power distribution system:

- Nameplate data of main transformers
- Information on cables and overhead lines
- Information on non-linear loads: type of load, number of pulses, rated voltage, rated kW and KVAR
- Nameplate data on existing harmonic filters
- Nameplate data on existing power factor correction capacitor banks
- Existing Short circuit and coordination study done for Arcflash Data.

Voltage and current harmonic measurements (from recording instruments)

1. Voltage and current measurements obtained with a power analyzer at the following points:

- Point of service from utility company
- Main distribution buses
- Near or at significant non-linear loads

2. Definition of operating conditions of the power system: normal condition, contingency conditions, position open/close or bus tie circuit breakers

Methodology

- Review of measurement data to identify areas with highest concentration of harmonics
- Development of a computer model of the power distribution system using the SKM HI_WAVE software. The computer model includes:
  - Thevenin Equivalent of the utility company
  - Transformers, cables, motors, existing harmonic filters, existing capacitor banks
  - Non-linear loads will be modeled by current sources with a frequency spectrum that matches the measurement information

1. Computer model tuning – The magnitude of the system load will be adjusted so that the computer model reproduces harmonic distortion levels similar to those determined by on site measurements. Internal non-linear loads can be represented using the software internal library or using the frequency spectrum provided by the measurements
2. Development of measures to mitigate power factor problems and harmonic distortion – harmonic filters will be designed to eliminate the harmonic which is dominant in the system. The filters will be tuned to the frequency of the dominant harmonic. The placement of the filters will be selected to minimize the propagation of the harmonics, reduce the overload on cables and transformers and also to compensate for power factor deficiencies
   a. **We will incorporate various solutions to improve system wide power factor to 0.9 or above**
   b. **We will incorporate various solutions to improve system wide Harmonics to meet IEEE standard 519 and IEEE 399 and IEC 61000**
   c. If necessary, we may also incorporate active filter technology which monitors suspected dirty power, all three phases of the low voltage line current in real time and process the measured harmonics by means of a Digital Signal Processor (DSP) based system.
3. Analysis of different operating conditions to verify that unwanted points of resonance are not introduced in the system, and to confirm that such points are not in proximity to frequencies present in the system
4. Development of technical characteristics of the recommended filters
5. Development of additional recommendations

Deliverables

A study report will be developed, which will include:

- Input Data
- Assumptions
- Methodology
- Computer Model
- Accurate and Complete Single Line Drawings
- Results
- Analysis
- Recommendations with cost estimates
- Conclusions

Additional Services:

1. For the purpose of long term strategic planning related to the electrical distribution systems at the facility, INBALANCE will maintain all SKM computer model files, and provide updates as necessary for system wide changes, including removal, replacement and/or addition of building and process equipment. The benefit of such a service is that any planned modifications to the facility can be input into the model and optimized in advance of engineering and procurement of equipment. This in turn will mitigate any possible resonance in the facility for the long term.

2. **Contract Administrative Services during installation of Engineered Solution.** If so desired by our client, INBALANCE will provide turnkey project Design Engineering, Procurement, Construction Management, Commissioning, and Monitoring & Verification services, to assure that work is installed in accordance with client budget, timetable and specifications.

Appendix:

SKM Harmonics Analysis Software - http://www.skm.com/products_hiwave.shtml

Overview

HI_WAVE simulates resonance and harmonic distortion in industrial, commercial, and utility power systems.

Harmonic current and voltage sources may be defined at multiple locations in the power system. Capacitor banks, single tune filters and high pass filters may be included in the voltage and current distortion evaluation, impedance resonance scans, and in harmonic load flow results.

Any type of system design, with any combination of voltage levels may be evaluated with this highly interactive, user friendly software. With HI_WAVE, new power systems may be examined before they are built and the harmonic effects addressed during the design. Existing power systems may be studied and corrective filter designs evaluated before they are installed. Every bus and branch in the power system may be quickly evaluated for harmonic content and for resonant impedance characteristics.

Benefits:

- Save time and money by trouble-shooting harmonic problems and evaluating alternative solutions quickly.
- Improve power system reliability by identifying potential resonance conditions and minimizing harmonic distortion.
- Minimize I 2 R heating losses and increase equipment life.
- Save money and improve designs by predicting resonance, distortion and filter effectiveness before the system is built.

Features:

- Large library of feeders, transformers, and harmonic sources.
- Models radial, loop systems, and multiple independent systems with multiple voltage levels.
- Models harmonic voltage sources at buses, and/or current sources at loads and motors.
- Automatic modeling of standard transformer connections, phase shift, & triplet harmonic paths.
- Automatic modeling for the positive, negative and zero sequence networks.
- User definable utility harmonic impedance.
- Models all filters and capacitors in harmonic load flow.
- Models loads as series RL or parallel RL at harmonic frequencies.
- Models non-linear frequency dependent effects for cables and transmission lines.
- Models non-linear frequency dependent effects for transformers.
- Harmonic source phase angles included in calculations.
- Single tune and high pass filter design calculators.
- Calculate telephone interference factors (TIF, IT).
- Frequency spectrum and locus plots for current and voltage distortion.
- Up to 20 steps per harmonic order frequency scan for all system resonance points with self or mutual impedance options.
- Graphical results for voltage and current frequency spectrum in log or linear scale, wave distortion
- Graphical results for impedance frequency scan in log or linear scale.
- Comparison of multiple studies on the same graph.
- Detailed reports for distortion and frequency scan.
- Advanced sparse matrix and current injection techniques provide extremely fast solution times.

Talk to INBALANCE

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