MITSUBISHI ELECTRIC POWER PRODUCTS, INC.

Power Systems Engineering Services Department
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POWER SYSTEMS ENGINEERING SERVICES

COMMERCIAL & INDUSTRIAL POWER DISTRIBUTION SYSTEMS

"Advanced Power Systems Engineering for Technical Analysis, Training, and Support"

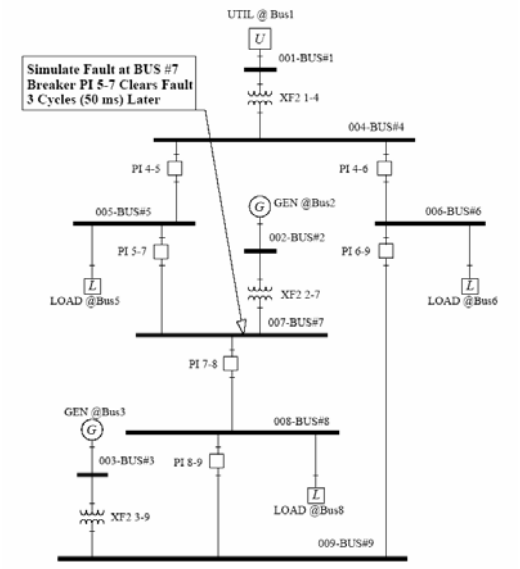
Mitsubishi Electric's Power Systems Engineering Services Department provides technical analysis, training, and support for commercial and industrial power distribution systems rated 72.5 kV through 208 V. A wide range of technical study areas and support services are available to our customers.

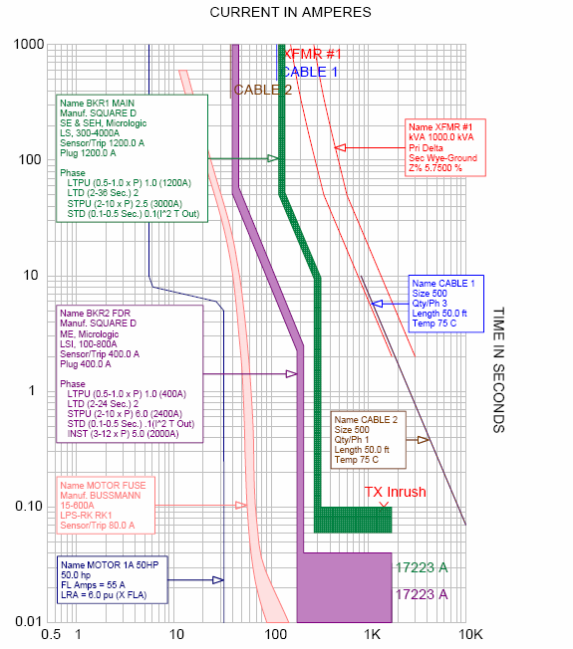
ENGINEERING STUDIES

Short-Circuit

All power systems are subjected to the potential damaging effects of high magnitude currents flowing from short-circuits occurring in system components. To ensure that circuit protective devices are capable of quickly isolating faults to minimize equipment damage and personal hazard, it is essential that a short-circuit study be performed on the electrical design of new and existing facilities. The purpose of a short-circuit study is:

- To calculate the system fault currents and compare these values to the first cycle (momentary) and interrupting short-circuit current ratings of circuit protective devices such as circuit breakers and fuses
- To compare the calculated system fault currents to short-time, or withstand ratings of electrical components such as cables, transformers, and reactors
- To provide the system fault current data needed to perform a protective device coordination study for the power system





Protective Device Coordination

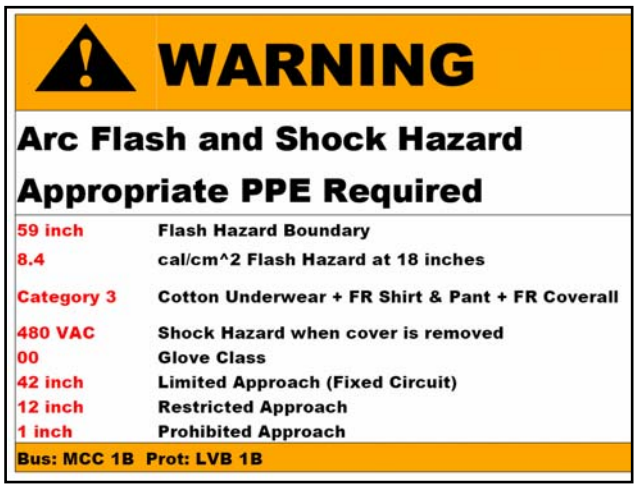
There are three major aspects to consider when performing a protective device coordination study: safety, equipment protection, and protective device selectivity. Safety requirements are satisfied if the protective devices are rated to carry and interrupt maximum load currents and withstand and interrupt maximum fault currents. Protection goals are fulfilled if protective devices are set to operate above normal load conditions and below equipment damage curves. Selectivity objectives are satisfied if during a system fault or overload condition, a minimal amount of electrical equipment is removed from the system. The purpose of a protective device coordination study is:

- To specify the proper protective devices (relays, fuses, and circuit breakers) to protect distribution equipment
- To calculate the proper circuit breaker trip unit and protective relay settings to minimize damage to the faulted component and selectively remove the faulted device from the power system
- To ensure that protective devices do not operate under normal load conditions
- To generate the time-current curves (TCCs) needed to perform an arc-flash hazard study on the power system

Arc-Flash Hazard

An arcing fault is the flow of current through the air between phase conductors, or phase conductors and neutral or ground. An arcing fault can release tremendous amounts of concentrated radiant energy in a small fraction of a second resulting in extremely high temperatures, a significant pressure blast, shrapnel hurling at high velocities (in excess of 700 mph), and severe or fatal injuries to personnel. The purpose of an arc-flash hazard study is:

- To determine and label the maximum incident energy available at every location along the distribution network likely to require examination, adjustment, service, or maintenance
- To specify the protective clothing and personal protective equipment (PPE) required for the application
- To determine the arc-flash boundary distance (safe working distance) that must be maintained by unprotected plant personnel



Load Flow

Load flow studies are performed for normal as well as emergency operating conditions of a facility. A load flow study will determine whether the distribution system will operate properly under various conditions. This type of study should be considered for the design of new power systems as well as for evaluating the impact of changes to an existing distribution system. The purpose of a load flow study is:

- To determine bus voltage levels and branch current levels for a given load condition
- To determine if bus voltage levels are within acceptable limits for both normal and emergency operating conditions
- To determine if the calculated power flows are within the ratings of all electrical equipment

MEPPI Headquarters located in Warrendale, PA

Voltage Regulation

In a power system, voltage drops (or rises) can greatly affect the operation of voltage sensitive equipment such as magnetic solenoids, lighting circuits, power electronic equipment, and computers. When line-starting a large induction motor, the voltage drop experienced for several seconds at the terminals of the motor reduces the available accelerating torque of the machine. As a result, the overall motor starting performance is compromised. A voltage regulation study should be performed for new power system designs as well as for changes to existing designs. The purpose of a voltage regulation study is:

- To determine the voltage decrease (or increase) due to the application of impact loads, line-starting large induction motors, or adding capacitors to the power system
- To determine necessary remedial actions if voltages are not within acceptable operating tolerances (increase cable cross-sectional area, adjust voltage taps of substation transformers, etc.)

Power Factor

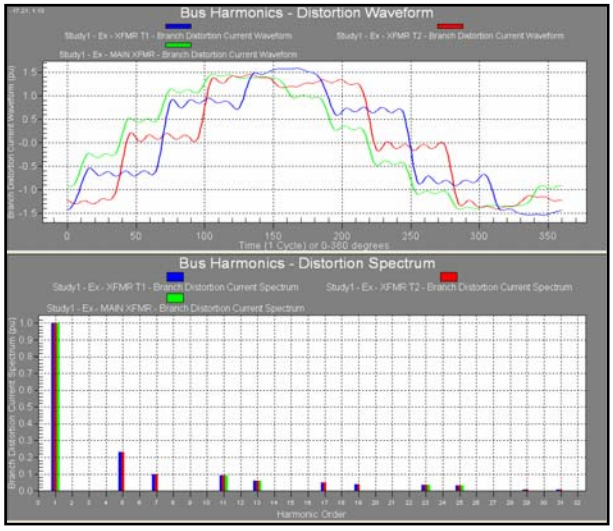
Many benefits provided by power factor improvement result from the reduction of reactive power in a power system. These benefits include: lower purchased energy costs (if the utility company enforces a power factor clause and/or demand charge), increase of available system electrical capacity, voltage profile improvement, and lower system losses. Adding capacitors is generally the most economical and efficient means to improve overall plant power factor. The purpose of a power factor study is:

- To determine the proper sizing and placement of capacitors in a power system to improve overall plant power factor
- To ensure the addition of power factor correction capacitors will not create abnormal resonance problems with the existing power system configuration
- To minimize electrical utility service penalties (low power factor and demand charges)

Harmonics and Power Quality

Within all commercial and industrial facilities, there are many non-linear harmonic producing loads. Examples of these types of loads include: adjustable speed motor drives, static power converters, computers, UPS systems, and electronic ballasts for lighting. These types of loads cause distortion of the sinusoidal voltage and current waveforms in the power system. This could lead to improper operation and/or complete failure of the connected electrical equipment. The purpose of a harmonics and power quality study is:

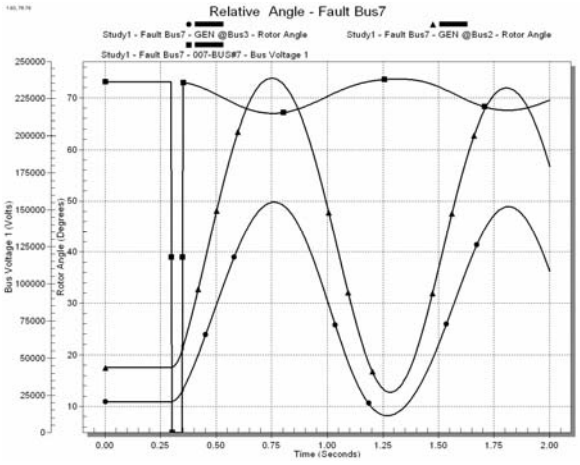
- To evaluate the harmonic voltage and current distortion at the point of common coupling (PCC) with the electric utility service to ensure compliance with IEEE 519
- To calculate system resonances in the existing power system or future power system design
- To select and locate capacitors and/or passive filters to mitigate the effect of harmonics and optimize system performance



Transient Stability and Dynamic Performance

Transient stability and dynamic performance studies are usually performed on commercial or industrial power systems with large amounts of local generation. This type of study is essential when adding or upgrading generators within a facility. Stability is defined as the ability of a power system to experience a sudden change in generation, load, or system characteristics without a loss of synchronism. The purpose of a transient stability and dynamic performance study is:

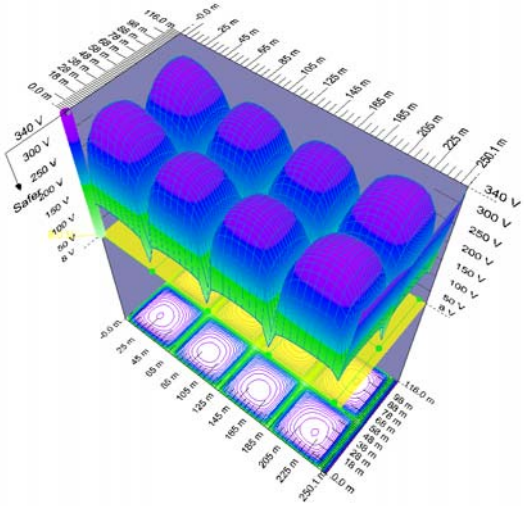
- To determine the system response during and after transient disturbances such as faults, load changes, switching, large motor starting, loss of a utility connection, and loss of a local generator
- To determine the system response during and after transient disturbances while including the dynamic responses of automatic voltage regulator and speed governor systems
- To evaluate protective device schemes and settings associated with the local generation and utility interface



Ground Mat

A properly designed ground mat limits the neutral to ground voltages normally present during ground faults to levels that the human body can tolerate. Safe ground mat design is essential for all sizes of substations for proper protection of plant personnel. The purpose of a ground mat study is:

- To calculate the earth potential, touch potential, step potential, and perform a safety analysis of the substation grounding system per IEEE Standard 80
- To identify unsafe areas within existing and proposed ground mat designs
- To optimize the ground mat design and verify that the design is safe throughout the area in question



ADDITIONAL SERVICES

In addition to the aforementioned power distribution systems engineering and analysis capabilities, Mitsubishi Electric's Power System Engineering Services Department has other services to offer to the commercial and industrial power distribution systems market including:

Power System Protection

- Specify and provide settings for electro-mechanical, digital, and microprocessor based protective relays
- Program microprocessor based protective relays including protection and control logic settings, monitoring and reporting settings, and communication settings
- Review/recommend protection schemes for generators, buses, transformers, capacitors, and motors using existing protective devices or new specified solid state protective equipment
- Specify lightning and surge protection for medium voltage equipment
- Review/recommend proper grounding techniques for electrical equipment and ground fault protection

Equipment

- Specify emergency generation equipment and transfer switches
- Specify pad mounted oil-filled transformers for outdoor substation applications and dry-type transformers for indoor unit substation equipment
- Specify metal clad switchgear, switchboards, load break switches, bolted pressure switches, and motor control centers
- Specify electronic voltage regulation equipment
- Specify AC/DC adjustable speed drives and other solid state power conversion equipment
- Specify electronic power conditioning and uninterruptible power supply (UPS) systems
- Specify power monitoring equipment and power system data acquisition systems
- Specify/program programmable logic controllers (PLCs) for power control related projects

Documentation

- Review one-line and three-line power drawings and breaker control logic diagrams for completeness and correctness
- Review/recommend breaker control logic schemes including close/trip circuits and lock-out relay operation

On-Site Field Work

- Perform measurements of all electrical quantities including voltage, current, real and reactive power, harmonics, and power factor
- Investigate and/or troubleshoot power distribution systems problems
- Gather necessary data required to perform engineering studies

Other Support

- Provide training seminars, short courses, and tutorials related to power distribution systems
- Expert witness litigation services

Mitsubishi Electric is dedicated to providing products and services to help bring our customers into the 21st century with technology that is proven and reliable. Whether it's solving power quality related issues, analyzing power distribution operating procedures, or providing advanced instruction, we offer the dedication, expertise, and quality to better serve your needs now and into the future.

Please contact us to discuss your organization's power system engineering service needs.

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