Power Quality -

Customer Need:

*Poor power quality (interruptions, voltage sags, flicker, etc.) costs production facilities literally billions of dollars annually in lost production, retooling and scrap.*

ABB can ensure that your electrical distribution system is ready to provide reliable and safe power for today’s sophisticated manufacturing processes. We want to be your partner from trouble shooting to turnkey installation.
Power Quality -

**FIND THE CAUSE:**
- Harmonic Analysis
- Switching Surge Studies
- Motor Starter Analysis
- Protection/Insulation Coordination Studies
- Reliability Analysis
- Lightning Protection
- Equipment Assessment and Field Measurement

**MITIGATE THE CAUSE:**
- SVC & DVR Installation and Commissioning
- Series and Shunt Capacitor Installation and Commissioning
- Breaker and Transformer Upgrades
- Relay Testing, Calibration and Retrofit
- Project Management
- On-going Maintenance
BASIC SYSTEM LAYOUT

TYPICAL ELECTRICAL SYSTEM

Power Plant

Switchyard

Transmission Lines

Switchyard

Industrial Loads

Distribution Lines

Residential and Commercial Loads
POWER QUALITY STUDIES

POWER QUALITY

- Voltage Sags
- Voltage Spikes
- Momentary Interruptions
- Voltage Flicker
- Harmonics
- Improper grounding

SOLUTIONS

- Harmonic Filter
- Sub cycle Switches
- UPS, ABB DVR
- ABB SVC
- Improved system design
- Proper grounding
POWER QUALITY STUDIES

CONCEPTUAL DESIGN STUDY

- Short circuit Analysis
- Harmonic Analysis
- Switching Studies
- Motor Starting Analysis
- Reliability Analysis
- Power Flow Calculations
- Protection
- Transient Stability Study
POWER QUALITY STUDIES

RELIABILITY ANALYSIS

OPTION 1

DATA

<table>
<thead>
<tr>
<th>Component</th>
<th>Failure Rate/year</th>
<th>Mean time to repair-hrs</th>
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<tbody>
<tr>
<td>Utility Feeder</td>
<td>0.53700</td>
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<tr>
<td>Breakers</td>
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<td>20.60</td>
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<td>Transformers</td>
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<tr>
<td>Bus</td>
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</table>

RESULT

Reliability of Bus A

Sustained Interruptions/year 0.0073
Outage Duration in hours 1.64698
POWER QUALITY STUDIES

RELIABILITY ANALYSIS

OPTION 2

<table>
<thead>
<tr>
<th>Component</th>
<th>Failure Rate/year</th>
<th>Mean time to repair-hrs</th>
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</tr>
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</table>

Reliability of Bus A

Sustained Interruptions/year  0.003525
Outage Duration in hours  0.137613
POWER QUALITY STUDIES

RELIABILITY ANALYSIS

THIS ANALYSIS PROVIDES:

COMPARISON OF VARIOUS ALTERNATIVES BASED ON QUANTITATIVE RELIABILITY ANALYSIS
## RELIABILITY ANALYSIS

### RESULTS:

<table>
<thead>
<tr>
<th>Option</th>
<th>Sustained Interruption/ Year</th>
<th>Outage Duration in Hrs</th>
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<tr>
<td>OPTION 1</td>
<td>0.00731</td>
<td>1.64698</td>
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<tr>
<td>OPTION 2</td>
<td>0.003525</td>
<td>0.137613</td>
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</table>

Option 2 is much better based on reliability considerations

Need to evaluate additional cost associated with Option 2
POWER QUALITY STUDIES

- SYSTEM TRANSIENT STUDIES

TRANSIENT ANALYSIS IS PERFORMED TO STUDY SYSTEM BEHAVIOUR AS IT MOVES FROM ONE STATE TO THE OTHER.
POWER QUALITY STUDIES

- SYSTEM TRANSIENT STUDIES

EXAMPLES:

- CAPACITOR SWITCHING
- VOLTAGE NOTCHING ASSOCIATED WITH RECTIFICATION
- TRANSIENT RECOVERY VOLTAGE IMPOSED ON BREAKERS
- PWM DRIVE TRIPPING
- OTHERS..............................
POWER QUALITY STUDIES

INSULATION COORDINATION

This analysis is used to:

• Size Surge arresters

• Ensure adequate protection for electrical equipment

• Ensure Coordination between various surge arresters and equipment BIL

• Establish clearances within the substations in special applications

• Verify the size and adequacy of the ground wire
SHORT CIRCUIT ANALYSIS

BRAKERS MUST BE CAPABLE OF CARRYING NORMAL LOAD CURRENT AND SHOULD BE ABLE TO INTERRUPT FAULT CURRENTS. HENCE, BREAKERS HAVE TWO RATINGS; RATED CURRENT AND INTERRUPTING RATINGS. IF BREAKERS ARE CALLED UPON TO INTERRUPT CURRENTS HIGHER THAN THEIR INTERRUPTING RATINGS DISASTEROUS CONSEQUENCES CAN FOLLOW.
POWER QUALITY STUDIES

SHORT CIRCUIT ANALYSIS

WHY DO WE NEED THIS ANALYSIS:

TO ENSURE THAT THE EXISTING AND NEWLY INSTALLED BREAKERS WILL NOT BE OVERDUTIED UNDER SHORT CIRCUIT CONDITIONS.

REQUIRED IF:

• THERE IS A SIGNIFICANT PLANT EXPANSION

• NEW LOCAL GENERATION HAS BEEN ADDED

• NEW UTILITY FEED HAS BEEN INSTALLED

• NEW LARGE MOTORS HAVE BEEN ADDED TO THE SYSTEM

• NEW LARGER TRANSFORMERS HAVE BEEN INSTALLED

• TRANSFORMERS HAVE BEEN REPLACED WITH LOWER IMPEDANCE UNITS
POWER QUALITY STUDIES

PROTECTION COORDINATION

PROPER COORDINATION:

FOR A FAULT AT 1 BREAKER F SHOULD BE THE ONLY BREAKER THAT SHOULD OPERATE.

FOR A FAULT AT 2 BREAKER E SHOULD BE THE ONLY BREAKER THAT SHOULD OPERATE.

IMPROPER COORDINATION:

FOR A FAULT AT 1, THE OPERATION OF BREAKERS A AND D IS UNDESIREABLE.

FOR A FAULT AT 2 THE OPERATION OF BREAKERS A AND B IS UNDESIREABLE.
POWER QUALITY STUDIES

PROTECTION COORDINATION

WHY DO WE NEED THIS ANALYSIS:

- TO ENSURE THAT THE BREAKERS OPERATE IN A DESIRED SEQUENCE
- BREAKER CLOSEST TO THE FAULT SHOULD BE THE ONE ISOLATING THE FAULT. OTHER UPSTREAM BREAKERS SHOULD OPERATE ONLY IF THE CLOSEST BREAKER FAILS TO OPEN.

REQUIRED IF:

- THERE IS A SIGNIFICANT PLANT EXPANSION
- NEW LOCAL GENERATION HAS BEEN ADDED
- NEW UTILITY FEED HAS BEEN INSTALLED
POWER QUALITY STUDIES

PROTECTION COORDINATION

REQUIRED IF:

- NEW LARGE MOTORS HAVE BEEN ADDED TO THE SYSTEM
- NEW TRANSFORMERS HAVE BEEN INSTALLED
POWER QUALITY STUDIES

POWER FLOW ANALYSIS

ARE
Voltage Levels
Current Flow
Real Power Flow
Reactive Power Flow
WITHIN LIMITS?

Source

V=138 kV

TRANSFORMER

V=13.8 kV

CABLE

E

B

C

D
POWER QUALITY STUDIES

POWER FLOW ANALYSIS

WHY DO WE NEED THIS ANALYSIS:

- TO ENSURE THAT CABLES, TRANSFORMERS, TRANSMISSION LINES ARE SIZED APPROPRIATELY TO CARRY REQUIRED LOAD
- TO MAKE SURE THAT THE TRANSFORMER TAPS ARE SET APPROPRIATELY TO OBTAIN Satisfactory VOLTAGE PROFILE WITHIN THE AREA OF STUDY.

REQUIRED IF:

- THERE IS A SIGNIFICANT PLANT EXPANSION
- NEW LOCAL GENERATION HAS BEEN ADDED
- NEW UTILITY FEED HAS BEEN INSTALLED
POWER QUALITY STUDIES

POWER FLOW ANALYSIS

REQUIRED IF:

- NEW LARGE MOTORS HAVE BEEN ADDED TO THE SYSTEM
- NEW TRANSFORMERS HAVE BEEN INSTALLED
- ADDITION OF SIGNIFICANT LOADS
POWER QUALITY STUDIES

HARMONIC ANALYSIS

UTILITY

TRANSFORMER

DISTORTED WAVEFORM RESULTING IN:

- INCREASED LOSSES

- MISOPERATION OF CONTROLS

- LOSS OF LIFE OF ELECTRICAL EQUIPMENT

Computer
Rectifiers
Adjustable Speed Drives
Arc Furnace
POWER QUALITY STUDIES

HARMONIC ANALYSIS

UTILITY

TRANSFORMER

CAPACITOR

Computer
Rectifiers
Adjustable Speed Drives
Arc Furnace

ADDITION OF UNTUNED CAPACITOR BANK IN A HARMONIC ENVIRONMENT CAN BE A RECIPE FOR DISASTER.

----- SYSTEM RESONANCE MAY RESULT CAUSING EXTREMELY HIGH VOLTAGES WITHIN THE ELECTRICAL SYSTEM.

---- WAVEFORM EXTREMELY DISTORTED
POWER QUALITY STUDIES

HARMONIC ANALYSIS

UTILITY

TRANSFORMER

Computer
Rectifiers
Adjustable Speed Drives
Arc Furnace

FILTERS
OR
STAT VAR
COMPENSTATOR

SOLUTION
POWER QUALITY STUDIES

MOTOR STARTING STUDY

UTILITY

TRANSFORMER

LARGE MOTOR >300 HP

THIS ANALYSIS NEEDED TO:

DETERMINE THE IMPACT ON SYSTEM VOLTAGE DURING STARTING

DETERMINE WHETHER THE MOTOR START WILL START SATISFACTORILY AND COME UPTO SPEED

IF THE SYSTEM VOLTAGE DROPS DOWN TO <75% LOSS OF ALL MOTORS AND OTHER SENSITIVE LOADS MAY OCCUR
POWER QUALITY STUDIES

- MOTOR STARTING STUDY
  - UTILITY
  - TRANSFORMER
  - LARGE MOTOR >300 HP

STUDY NEEDED

• FOR NEW INSTALLATION
• IF CUSTOMERS REPORTS PROBLEMS SUCH AS LOSS OF SENSITIVE LOADS AND OTHER MOTORS
POWER QUALITY STUDIES

TRANSIENT STABILITY STUDY

THE SYNCHRONOUS GENERATOR/MOTOR MUST REMAIN IN SYNCHRONISM WITH THE UTILITY AT ALL TIMES DURING SYSTEM DISTURBANCE SUCH AS FAULTS OR SUDDEN CHANGE IN LOAD OR GENERATION THE MACHINES MAY GO UNSTABLE AND LOSE SYNCHRONISM.
TRANSIENT STABILITY STUDY IS USED TO SIMULATE FAULTS AND SUDDEN LOAD OR GENERATION IMPACTS.

THE RESULTS IDENTIFY SYSTEM WEAKNESS, IF ANY, AND RECOMMEND CRITICAL TIME TO ISOLATE THE LOCAL MACHINE TO AVOID DAMAGE.
Transient Stability Study is required when synchronous machines are installed.

- Utility
- Transformer
- Local synchronous generator or motor
- Industrial facility
POWER QUALITY STUDIES

- Cerromataoso: (Arc furnace in Columbia)
  - Short Circuit and Protective Device Coordination

- Inland Steel: (Arc furnace)

- Harmonic Study, Powerflow, Power Factor, and Furnace Capability

- Phillip Morris:
  - Reliability Study

- Stora: (Canada)
  - Insulation Coordination
POWER QUALITY STUDIES

Reynolds Aluminum
  Power Quality Support

Bayer: (Baytown)
  System Protection, Power Quality Analysis

North Star Steel
  Load Profile Study

HYLSA Puebla
  Reactive Power and Voltage Flicker
POWER QUALITY STUDIES

- Dow Chemical
  - Rectifier Transformer Failure Analysis, System Resonances, and Rectifier Control Interaction

- Oxy Chemical
  - Rectifier Tripping Investigation

- North American Stainless
  - Short Circuit and Protection Coordination Study

- Reynolds Metals
  - Short Circuit and Protection Coordination Study
POWER QUALITY STUDIES

- Birmingham Steel
  - Reactive Power, Flicker, Furnace Power Capability, and Insulation Coordination Studies

- American Steel Wire
  - Harmonics and Filter Design

- HYLSA Monterrey
  - Reactive Power, Flicker, Furnace Capability, Harmonics, Filter Design, Insulation Coordination Studies & Transients Studies

- HQ Tembec
  - Harmonic Studies
POWER QUALITY STUDIES

ABB CONSULTING:

CONTACTS FOR INDUSTRIAL STUDIES:

DON E. MARTIN 919-856-2463