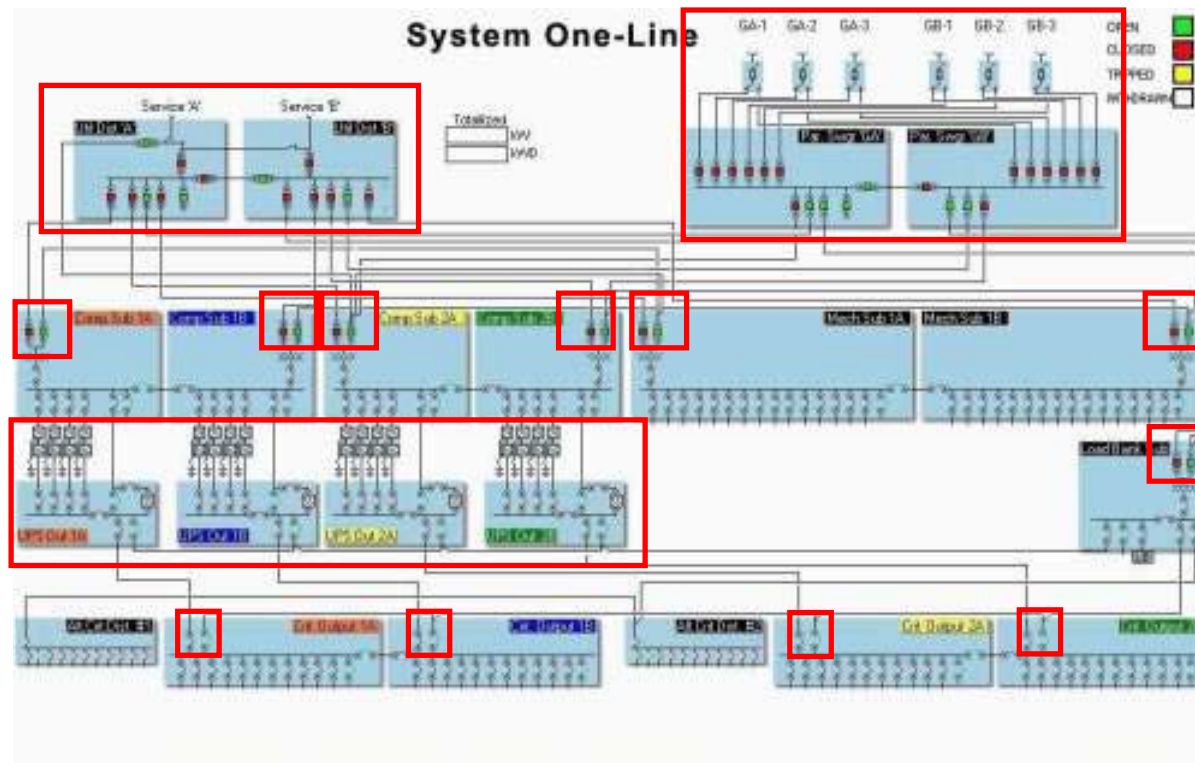


Electrical Power Monitoring in Data Center

Typical Data Center One-Line Diagram?



Unit Based Power Substations (UPS)

Coordination and Engineering Studies

- **Performed w/ electrical analyses software**
- **Develop optimal settings for selectable breakers, Protective relays, and fuse sizes**
- **Isolated faults and/or overload**
- **Provide protection to system components and personnel**
- **Double check electrical design**
- **Load flow study for transient stability**

Why Monitor Power In a Data Center?



- **Disaster Avoidance**
 - Power Quality problems
 - Early warning of overloads and mechanical conditions leading to downtime
 - Correct root cause of problems, avoid future incidents
- **Verify Energy Consumption, Bill to Users, and Verify up-time**
- **System Planning**
 - Preparing for new equipment and change outs
 - Improve maintenance efficiency
- **Overall Improved Customer Service**
- **Help Manage Energy Consumption and Integration w/ HVAC**

Monitor to Assure Up-Time

■ Take warning from electrical events that do not cause outages

- Transients
- Sag & Swell
- Harmonics

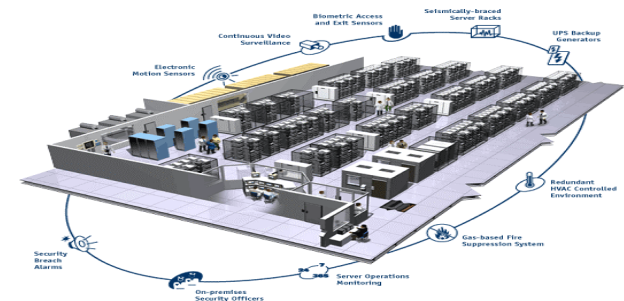


■ Information for forensic 'root cause' investigation

■ Sequence of Events Recording

■ Monitor non-electrical parameters that can cause problems

- Rack Temperature
- Air Flow
- Generators



Transients in Power Systems

- **Duration-less than a microsec to several millisecc.**
- **Originate inside facility or out on the utility's grid**
- **Stress electrical insulation**
- **75% of IC failures may be due to voltage transients**

Transients in Power Systems

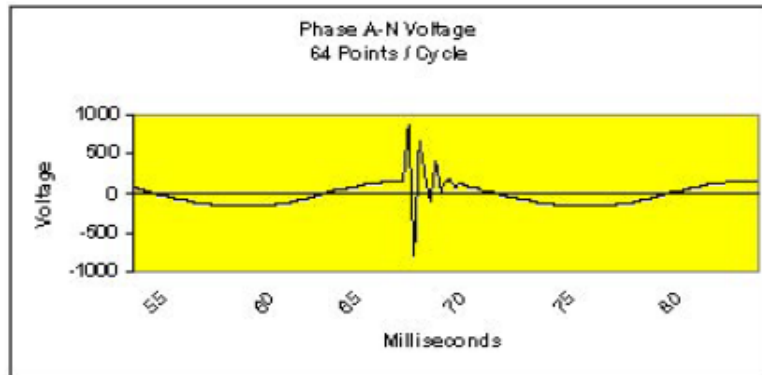


Figure A: Event captured using the 64 Sample/Cycle Monitor (without a TVSS on the load)

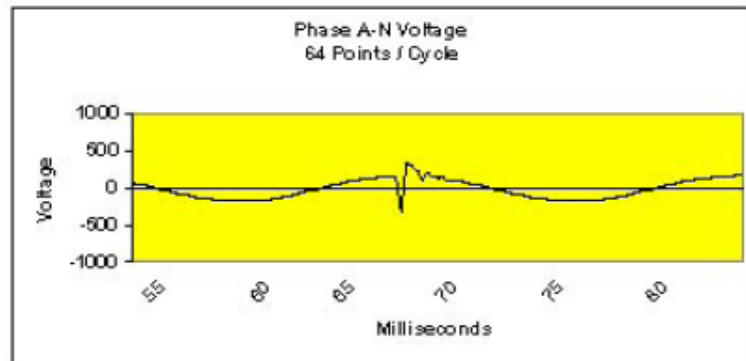


Figure B: Event captured using the 64 sample/cycle monitor (with a TVSS on the load)

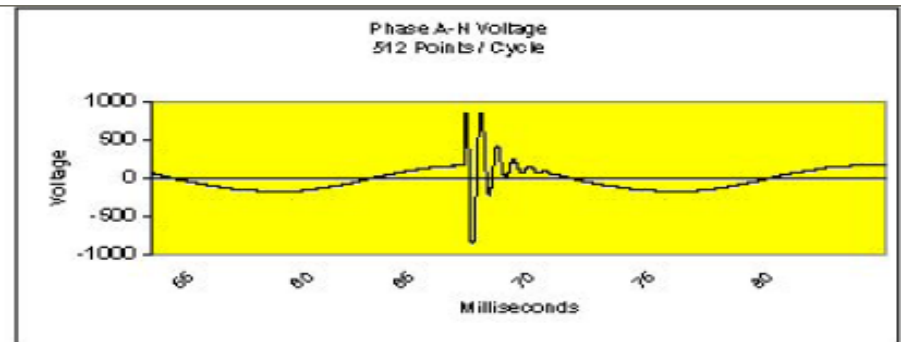


Figure C: Event captured using the 512 sample/cycle monitor (without a TVSS on the load)

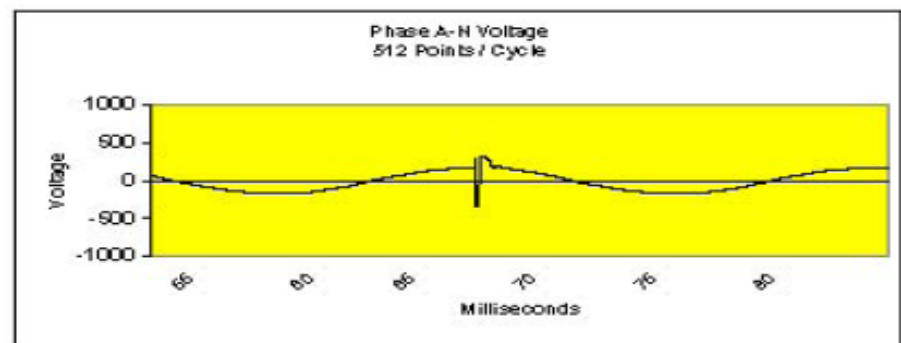


Figure D: Event captured using the 512 sample/cycle monitor (with a TVSS on the load)

Transients in Power Systems

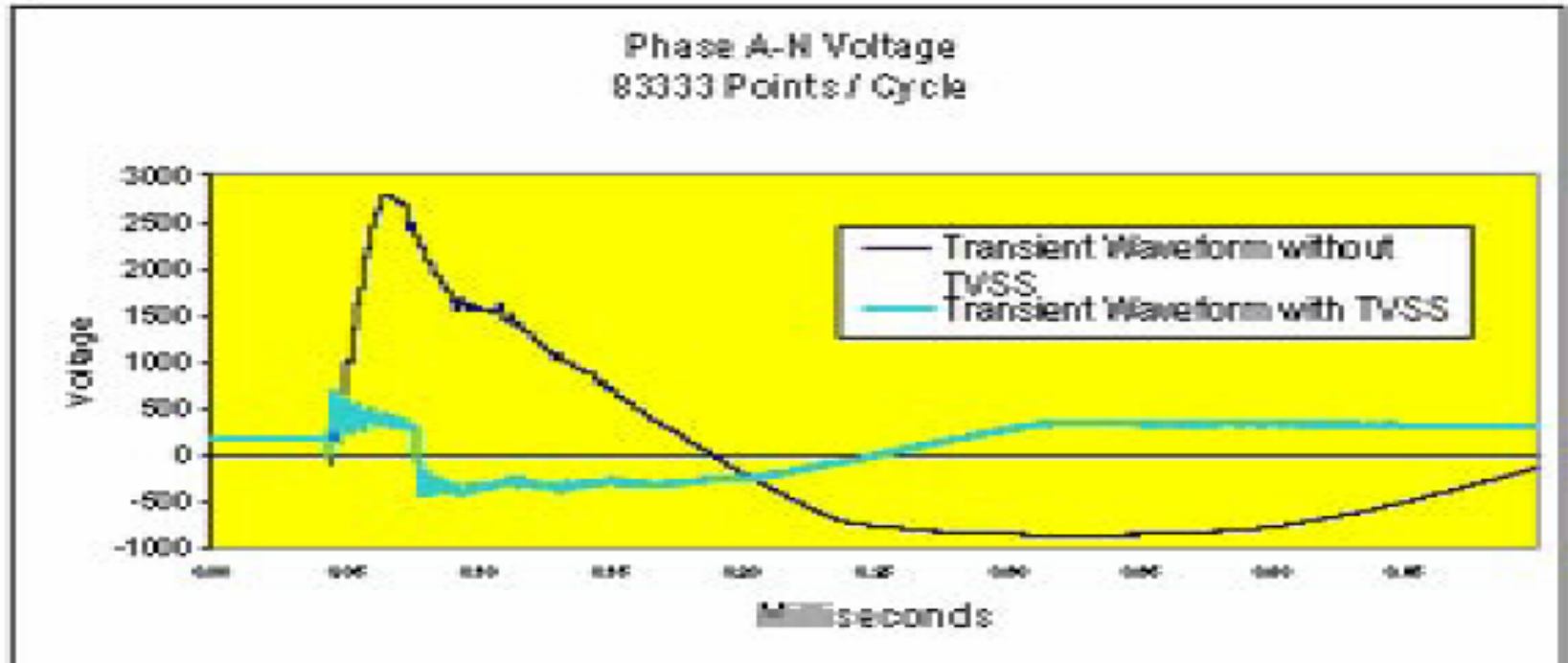


Figure E: Event Capture using high end meter

Facility Wide Power Monitoring

Monitor the following:

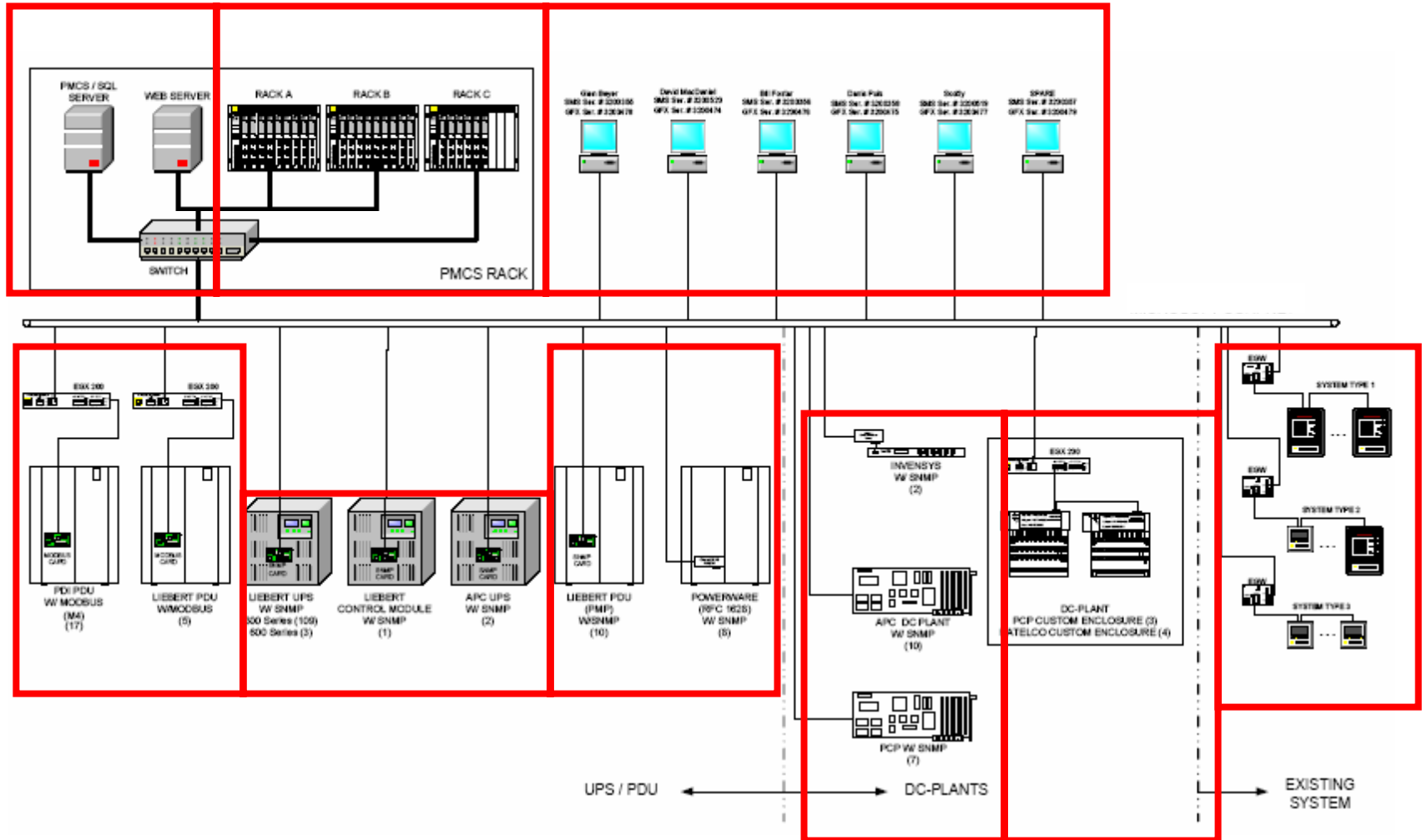
- Power Distribution Units
- UPS
- Diesel Generators
- Transformers
- Transfer Switches
- Switchgear and breaker trip units
- Surge Protection – TVSS
- Filters



MGE
UPS SYSTEMS



Power Monitoring System Overview



What to monitor? Service Entrance

	Monitored Parameters	Recorded Data Log	Waveform Capture	Alarm Relay	Software Functions
Surge Protection	Blown Fuse	Voltages	Min. 60 cycle Pretrigger 10cycles	To Central Monitoring Station	Page and E-Mail
Ground Fault	Alarm and Trip Contacts Zone Information	Ground I Neutral I Phase I Voltages	60 Cycle	To Central Monitoring Station	Page and E-Mail
Trip Unit	Trip Status	Instantaneous V,I Demand I	60 Cycle	To Central Monitoring Station	Page and E-Mail
Feeder Transformer	Fan Failure Coil Temp. Overtemp	Feeder Demand K-Factor Current THD		To Central Monitoring Station	Page and E-Mail (to local Utility)
Utility	Synch Pulse Interruptible Rate	Demand Power Factor	4 cycle	To Generators and Transfer Switch	Interruption: Page and E-Mail
Transfer Switch	Position Status Test Position	Gen Demand Gen V,I,THD	60 Cycle	To Central Monitoring Station	Page and E-Mail

What to Monitor? Generator

	<i>Parameters</i>	<i>Forced Data Log</i>	<i>Waveform Capture</i>	<i>Alarm Relay</i>	<i>Software Functions</i>
Battery Charger	DC Bus Level			To Central Monitoring Station	DC Voltage History Log Priority Alarm
Ambient Temp.					Priority Alarm
Sensors	Water Temp OV / UV Fuel	Generator Demand V, I, THD, Hz	60 Cycle	To Central Monitoring Station	Page Event Priority Alarm
Generator Output	Sag / Swell	Generator Demand V, I, THD, Hz Ambient	60 Cycle	To Central Monitoring Station	Page Event Priority Alarm
Protective Relays	Reverse Power High / low Oil Water Temp OV / UV Overspeed Fuel	Generator Demand V, I, THD	60 Cycle	To Central Monitoring Station	Page Event Priority Alarm
Parallel Switch Gear	Status Change	Generator Demand V, I, THD	60 Cycle	To Central Monitoring Station	Priority Alarm Page Event

What to Monitor?

UPS

	<i>Parameters</i>	<i>Forced Data Log</i>	<i>Waveform Capture</i>	<i>Alarm Relay</i>	<i>Software Functions</i>
UPS Alarms	UPS on Battery UPS on Bypass UPS Summary UPS On Line	UPS Output V,I Ambient	60 Cycle UPS Output UPS Input	To Central Monitoring Station To Generator	Priority Alarm Page Event
UPS Input	Even Harmonics UPS Input THD	Input THD	4 Cycle		Priority Alarm History Log of Harmonics
UPS Output	Sag Swell	UPS Demand V, I, THD	60 Cycle	To Central Monitoring Station	Page Event Priority Alarm
UPS Battery	Ambient Temp. DC V,I				History Log
UPS Data	Internal Alarms UPS Measures: Bypass V,I UPS V,I Input V,I DC V,I				Custom Table Alarm Log

What to Monitor?

PDU

	<i>Parameters</i>	<i>Forced Data Log</i>	<i>Waveform Capture</i>	<i>Alarm Relay</i>	<i>Software Functions</i>
<i>PDU Alarms</i>	Transformer OT EPO	K- Factor Output Demand Output V,I Ambient	60 Cycle	To Central Monitoring Station	Priority Alarm Page Event
<i>PDU Output</i>	Load Currents Overload Limits	Current		To Central Monitoring Station	Priority Alarm History Table
<i>Environmental Conditions</i>	Water Detection Temperature Humidity	Temperature		To Central Monitoring Station	Page Event Priority Alarm

High-End Circuit Monitor Features



- **Impulsive Transient Detection**
Capture extremely short duration events to find cause of problems
- **Sag/swell and disturbance detection**
Detect the cause of equipment shutdown
- **Waveform capture to 255th harmonic**
Find tough power quality problems
- **Adaptive waveform capture**
Look at events up to 60 seconds long
- **0.04% typical accuracy, meets ANSI C12.20**
Billing and auditing with confidence
- **Continuous fast sampling, meter to 255th harmonic**
Accurate data in challenging electrical environments
- **Log at up to 10 times/second**
Trend motor starts for predictive maintenance
- **16 Meg of on-board data logs**
Capture all data and waveforms to find problems

Functionality Summary



Low-end Metering

Metered parameters:
kWH, kW, kVA, VAR,
Power factor (3 ϕ +
total), Amps (3 ϕ +
total), Volts L-L (3 ϕ +
total)



Mid-range metering option

Metered parameters:

- Basic Power Metering
- Basic Power Quality
- THD
- Alarm & event recording
- On board data logging
- Modbus, Jbus communications

Benefits of Branch Circuit Monitoring

- Eliminates labor and cost intensive system of manual measuring thousands of circuits each week.
- Instantly warns NOC before breakers are tripped due to overload.
- **Ability to bill customers** for actual energy used.
- Optimizes floor space and available power to cope with rising load densities = **more customers in the same space!**



No more labor intensive manual monitoring

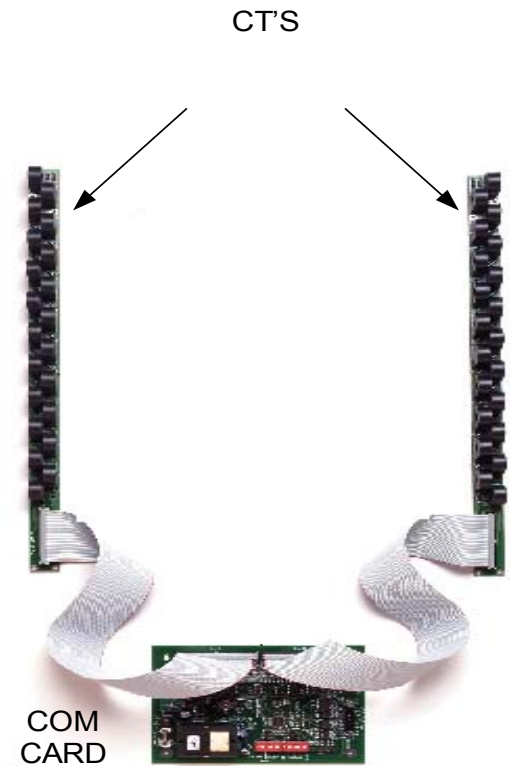
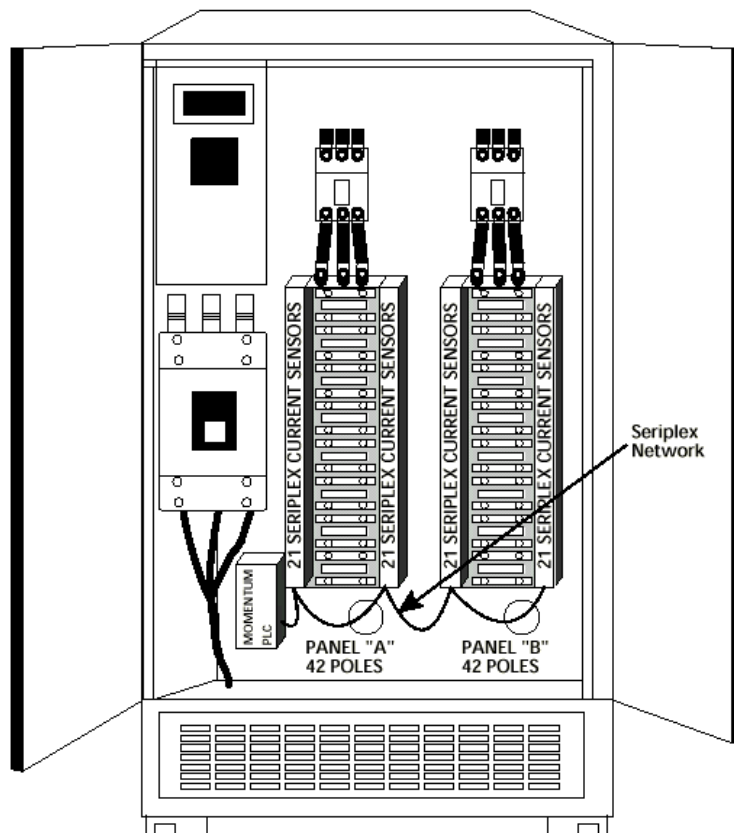


Per breaker monitor charts customer power use in detail, and avoids accidental circuit overloads

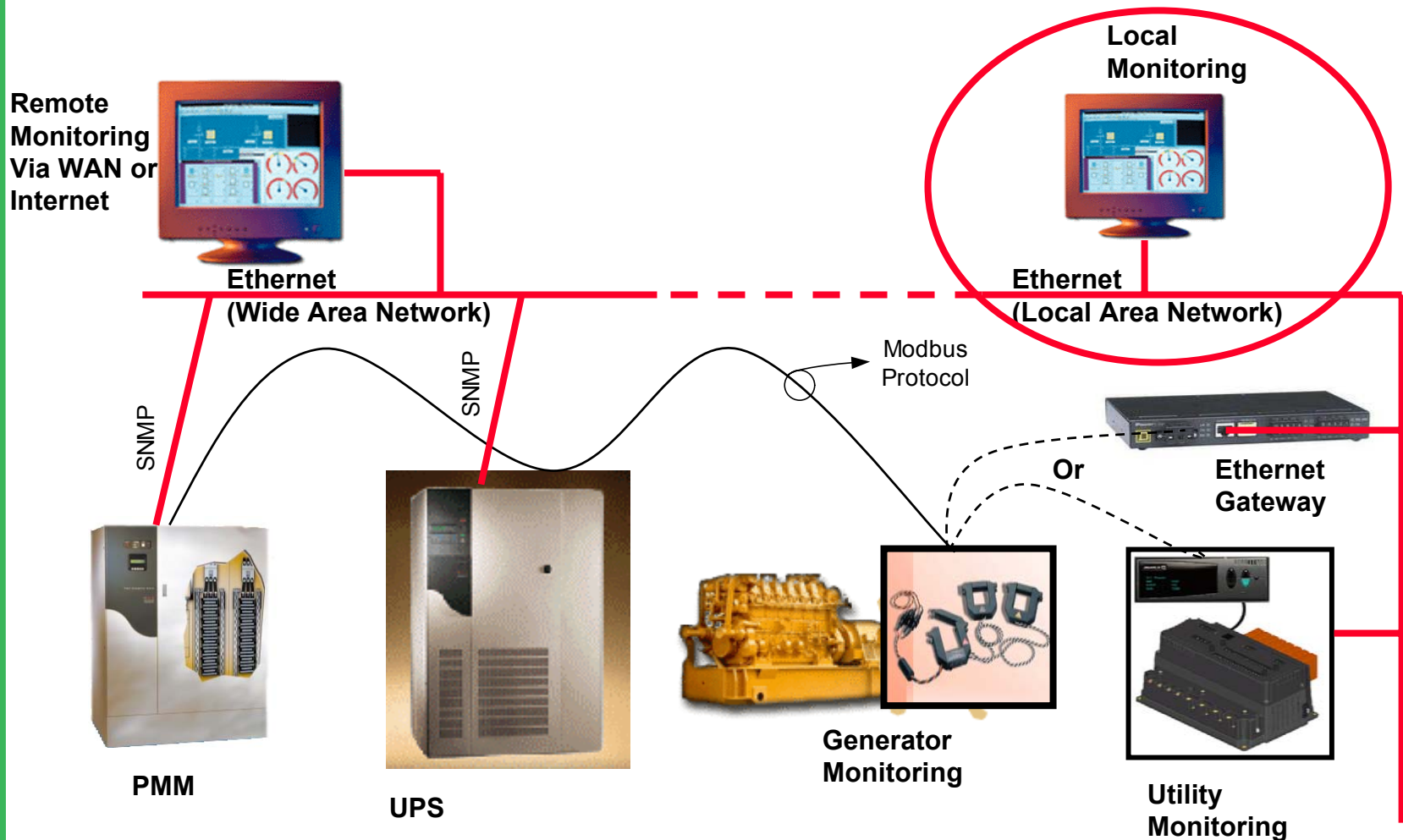


Branch Circuit Monitor Components

PDU BREAKER PANEL Branch Circuit Current Monitoring System



Local and Remote Monitoring and Control



Web-Enable User Interface

- **Real Time Data**
- **Multiple Alarm levels (1,2,3, etc.)**
- **Historical Reports - Trends, Tables, Graphs, Charts**
- **Events Analysis**
- **SQL 2000 Database**
- **Graphic Screens**
- **Data exportable to spreadsheet (ODBC)**
- **Crystal Report Capability**

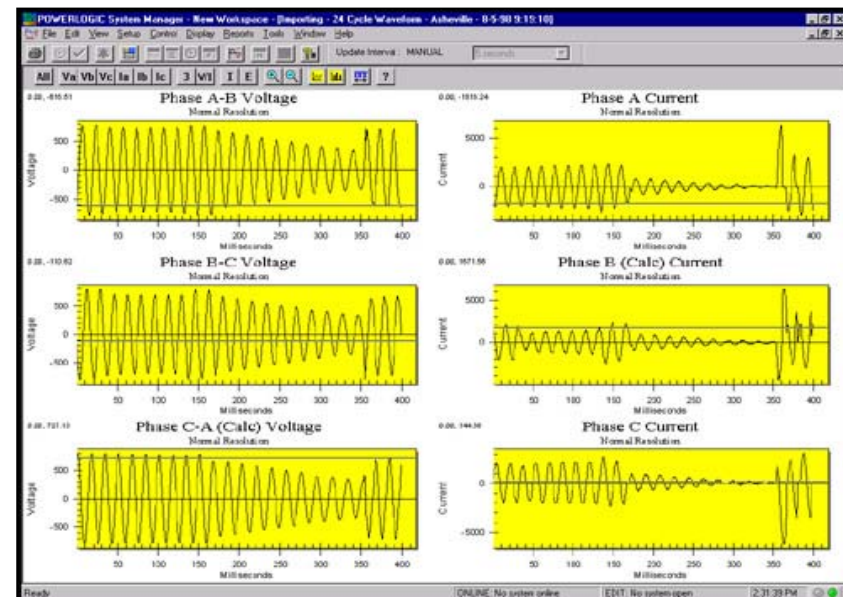
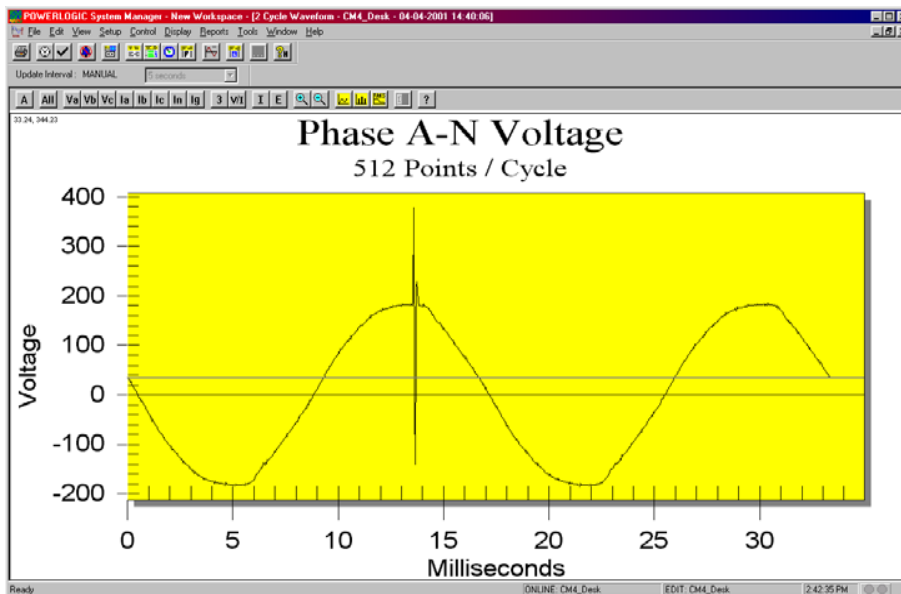
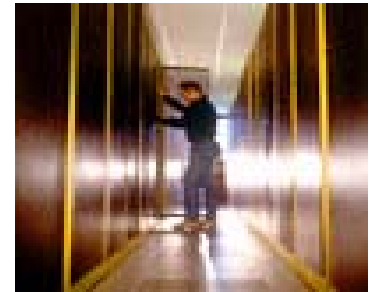
Fast Notification - Preempt Problems

- Automatic Paging via software
- E-mail
- Remote monitoring via intranet or internet using web browser



Power Disturbances Cause Computer Down Time

- Transients
- Harmonics
- Loss of power
- Disturbance direction (Upstream/Downstream)



Questions