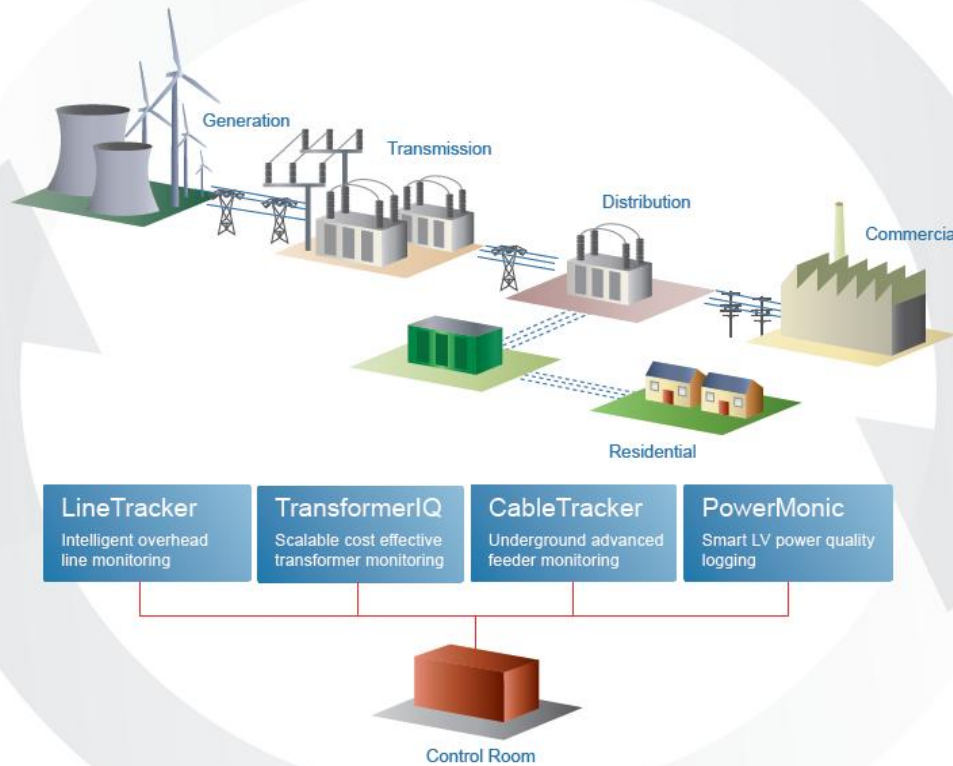


# Intelligent Monitoring for the Power Network

## GridSense – 2011





**LineTracker**  
Intelligent Grid Monitoring

**TRANSFORMERIQ**  
Intelligent Affordable Monitoring

**BUSHINGIQ**  
Online Bushing Monitoring System

**CableTracker**  
Smart Substation Monitoring

**PowerMonic**  
Portable Power Monitoring

**LiveLine**  
Intelligent Network Maintenance



# LineTracker

## Intelligent Grid Monitoring

- ✓ Rapid installation for instant intelligence
- ✓ Versatile applications
- ✓ Industry leader
- ✓ Smart Grid Monitoring Compatibility
- ✓ Power Quality Functionality
- ✓ Superior Remote Communication Options
- ✓ International Protocol Compatible



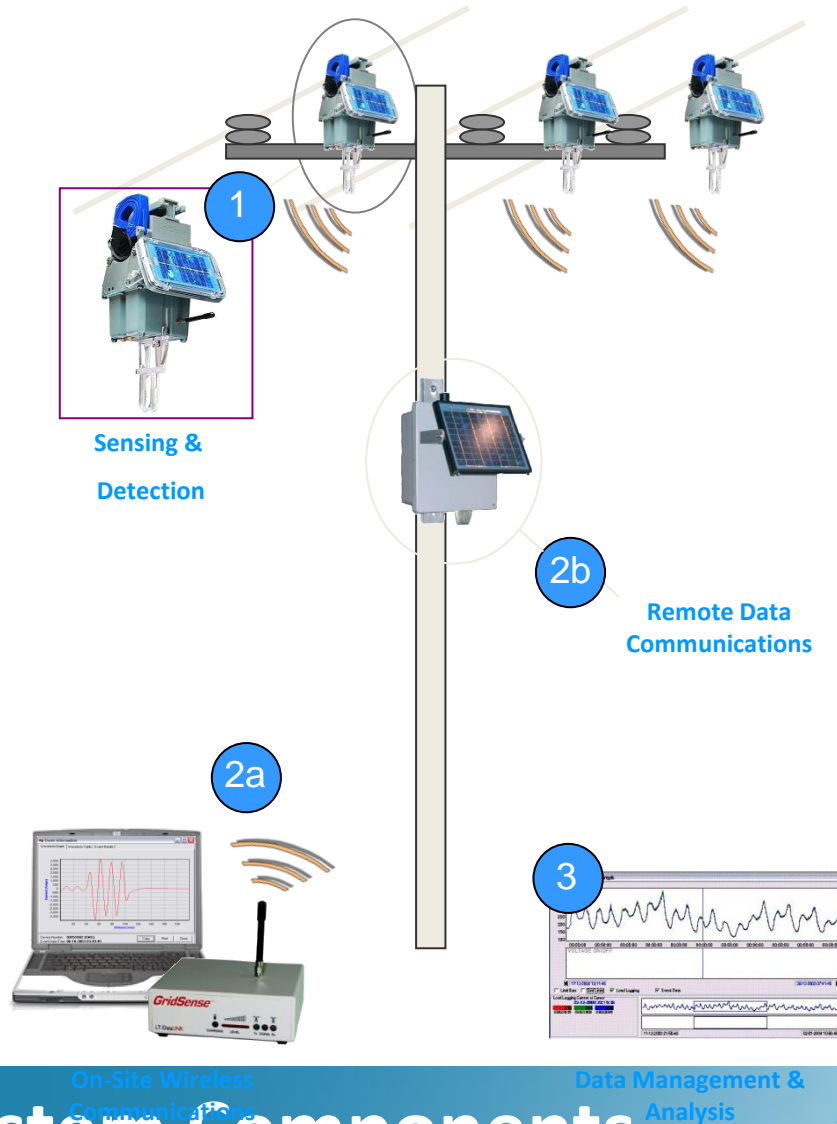
## ▪ PRODUCT BACK GROUND

- Fourth generation design with over 15 years line monitoring experience.
- Widely adopted throughout North America, Oceania, Asia Pacific & Europe.
- Robust Australian design & manufacturing.

## ▪ DESIGNED FOR THE UTILITY CUSTOMER WITH OUTSTANDING FEATURES

- Rapid live line installation up to 138kV minimising installation costs.
- Intuitive software for quick and effective identification of troublesome networks.
- High speed flexible communication module options to suit your network.
- Compatible with international protocols for direct connection to control/SCADA systems.
- Designed to international standards.





## 1. Sensing & Detection

- **LTCMS** Conductor Mount Sensor
- Monitoring current, conductor & ambient temperature
- Time stamped Event and Load data

## 2. Wireless Communications

- Low powered radio communications
- Wireless configuration & downloading
- **LT-DataLINK** and **LineMan** software

## 3. Data Management & Analysis

- View load, fault and outage data
- Analytical and export tools
- **LineView** Analysis software



- LT Conductor Mount Sensor
  - Adaptive sensing of I & V
  - Ambient and conductor temperature logging
  - Load logging up to 3,000 amps
  - Fault logging up to 25,000 amps
  - Voltage rating up to 132kV
  - Outage detection and logging
- Unique features
  - Solar and battery power (7yrs)
  - Rapid live line installation
  - Wireless download while installed
  - Local and remote monitoring
  - Flexible communication (3G/NextG/SAT/Zigbee/Wifi,etc)
  - Compatible with international protocols for direct connection to control/SCADA systems

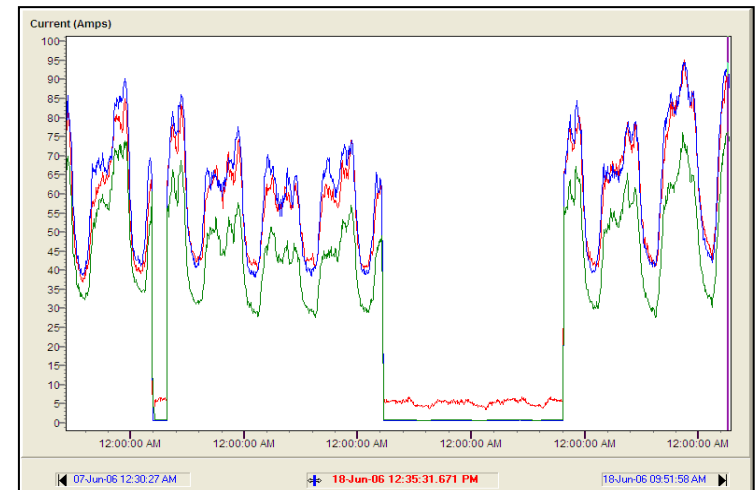
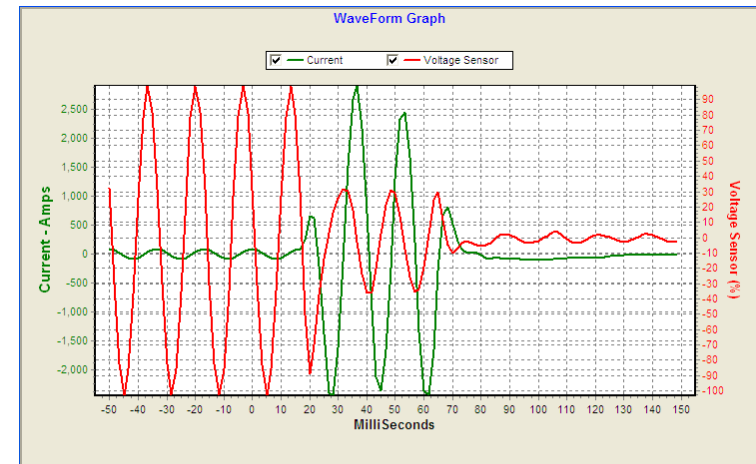


## LOGGED DATA

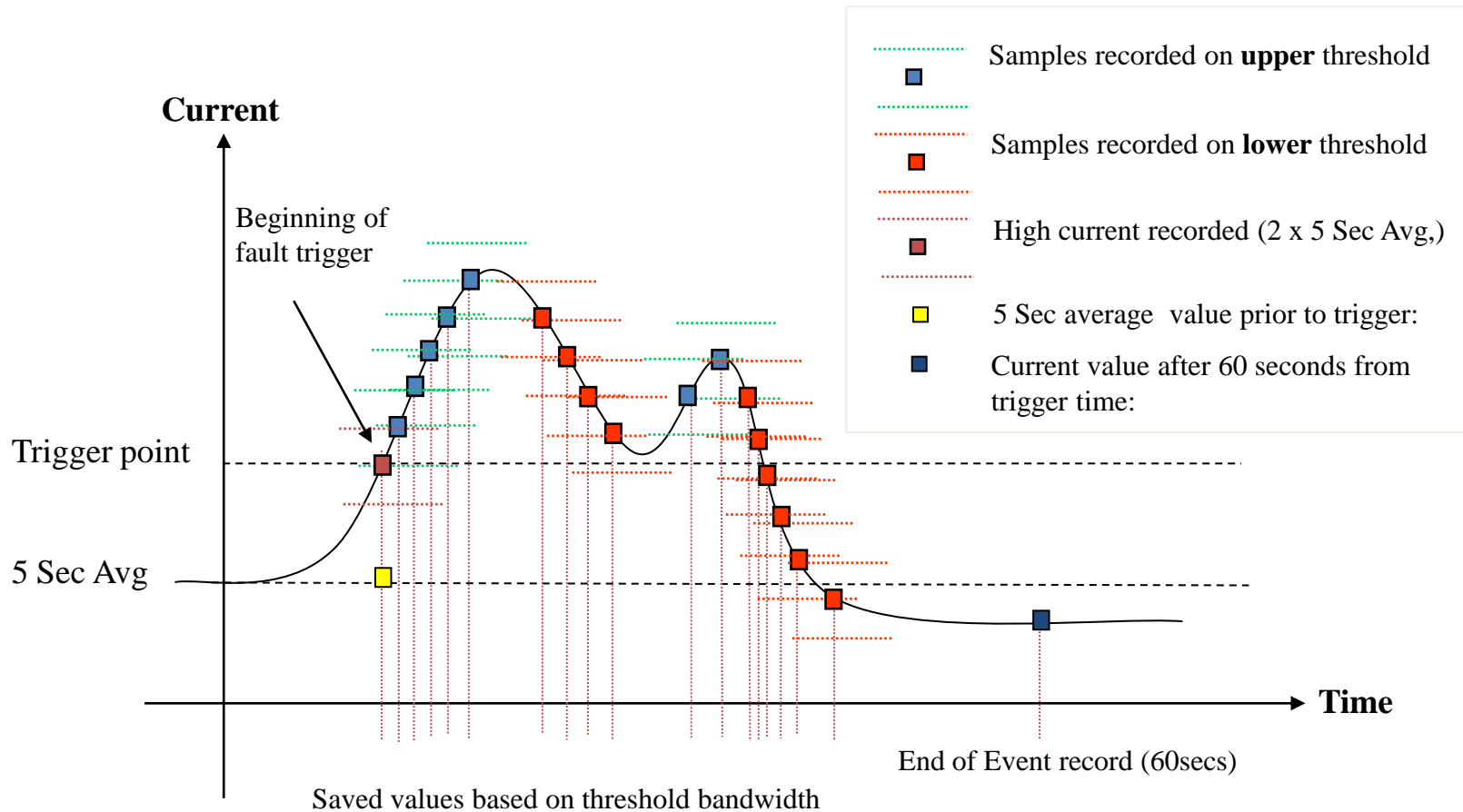
- I & V sensors adapting to line conditions
- Auto-Event Capture Thresholds
  - Fault Current
  - Power Off
  - Power On
- Ambient and conductor temperature
- Power Factor

## EVENT DATA

- 60-second Event profile
  - Pre, fault & post measurements
  - Protection and outage measurements
  - 10-cycles of Fault waveform
- \* Stored in a partitioned rolling memory.



- Event Trigger and profiling principles





## Outage Management Support

- Identifying fault paths minimizing outage times
- Preventative outage management
- Reliability performance data (SAIDI, CAIDI SAIFI & MAIFI)

## Network Planning

- Peak load monitoring
- Demand Side Management
- Investment planning
- Temperature monitoring to enable dynamic rating of lines

## Asset Protection

- Substation transformer monitoring
- Breaker and recloser monitoring

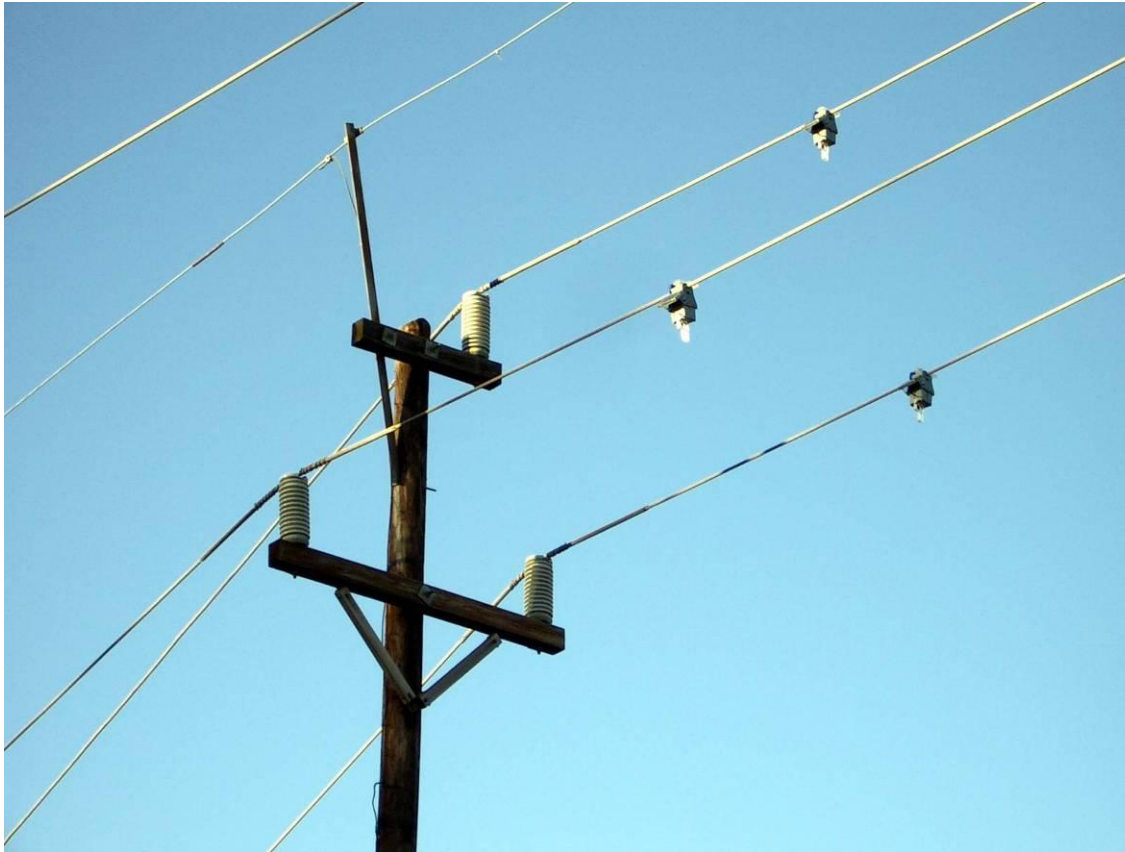
## Condition Monitoring

- Identifying problem areas, i.e. Tree Trimming,
- Locating the cause of an outage
- Earth leakage monitoring



## Local Load & Fault monitoring

3xCMS units installed on 44Kv line



Installation Example



## Local Load & Fault monitoring

3x CMS units and installed at substation



## Installation Example





## Load & Fault monitoring

3xCMS units installed at substation



# Installation Example



## LineTracker Indication Chart

**Xenon Flash** (1 flash every 4 to 8 seconds - fast by day, slow at night)



**Fault with Sustained outage** - resets after 4 hours \* (Red LED backup starts, as below) or on **voltage return** (Red LED changes to 2 flashes, i.e. transient)

**Red LED** (10 seconds between flash bursts)

		No of Flashes	
● ● ●	3		<b>Fault with Sustained Outage</b>
● ●	2		<b>Fault with Short Interruption</b>
●	1		<b>Fault detected with no interruption</b>
○	0		<b>No fault</b>

**Amber LED** (30 seconds between flash bursts)

● ● ●	3	<b>No volts present on conductor</b>
● ●	2	<b>Volts on, low load current detected**</b>
●	1	<b>Normal Operating Conditions</b>
○	0	<b>Check battery volts with LTC30. If OK, return for service</b>

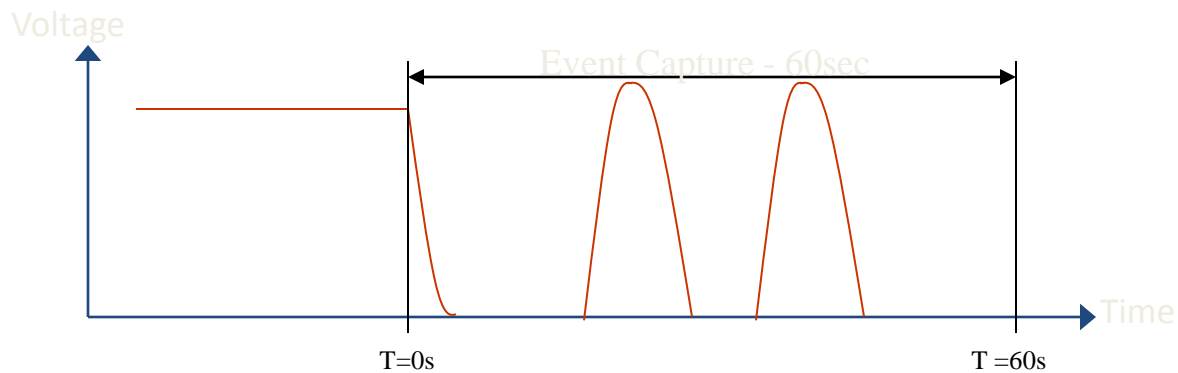
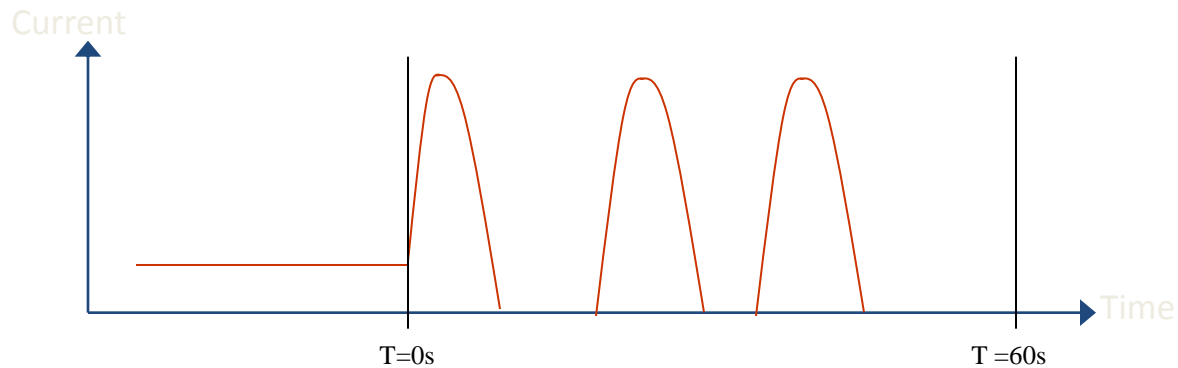
\* To vary reset times, or set Xenon flash for transient faults etc., consult operating instructions

\*\* Depends on configuration and mounting distance, but usually less than 5 amps

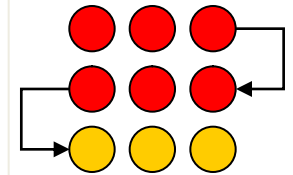




- Fault detected with sustained outage



### Indication



↘ Red Led flash burst every 10 seconds

↘ Amber Led flash burst every 30 seconds

↘ Time, manual or line restoration reset

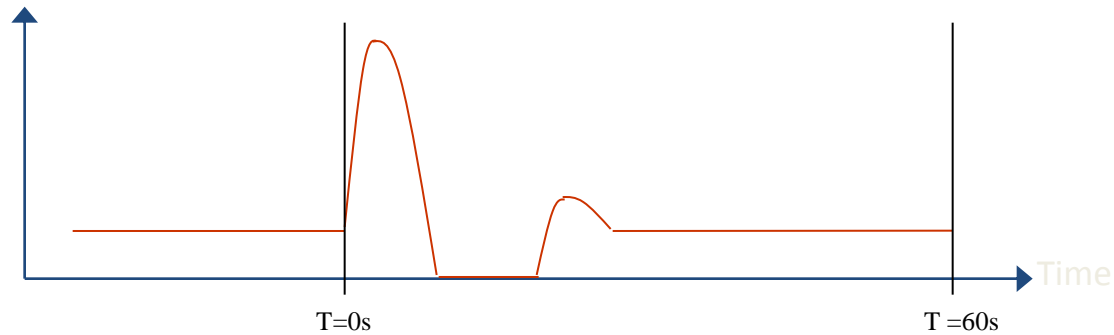
***Possible cause – Pole down or tree on line***

## Example 1 Permanent Fault

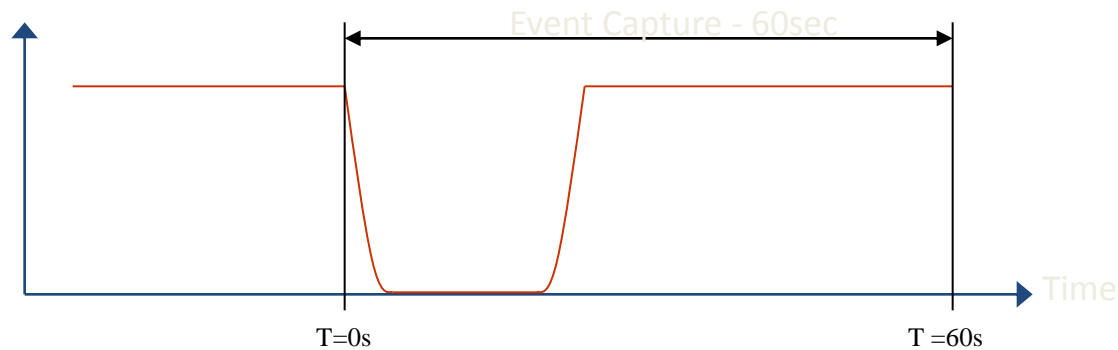


- Fault detected with momentary interruption

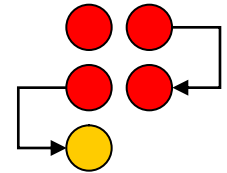
Current



Voltage



## Indication



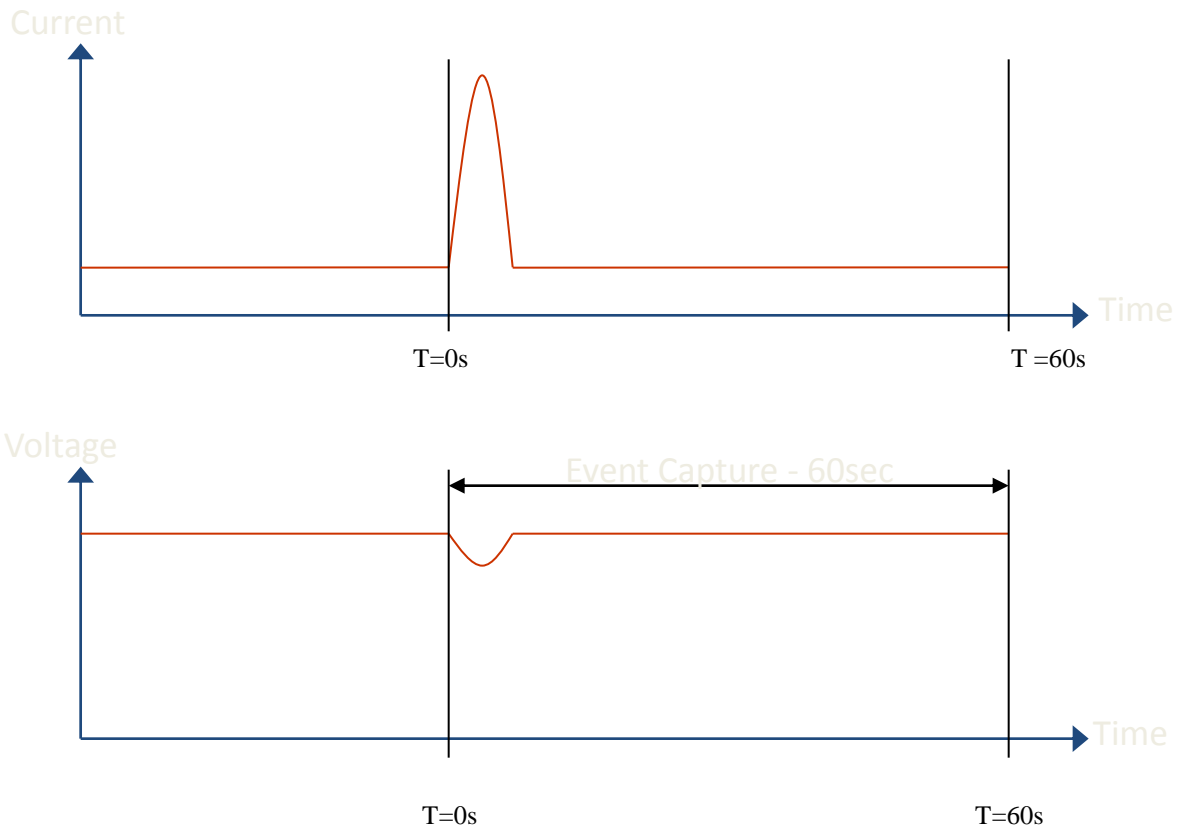
- Red Led flash burst every 10 seconds
- Amber Led flash burst every 30 seconds
- Time or manual reset

**Possible cause – Tree branch touching or birds**

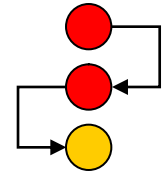
## Example 2 Momentary Fault



- Fault detected without interruption



## Indication



- ↘ Red Led flash burst every 10 seconds
- ↘ Amber Led flash burst every 30 seconds
- ↘ Time or manual reset

**Possible cause - Cracked insulator or frayed wire**

# Example 3 Self-Clearing Fault



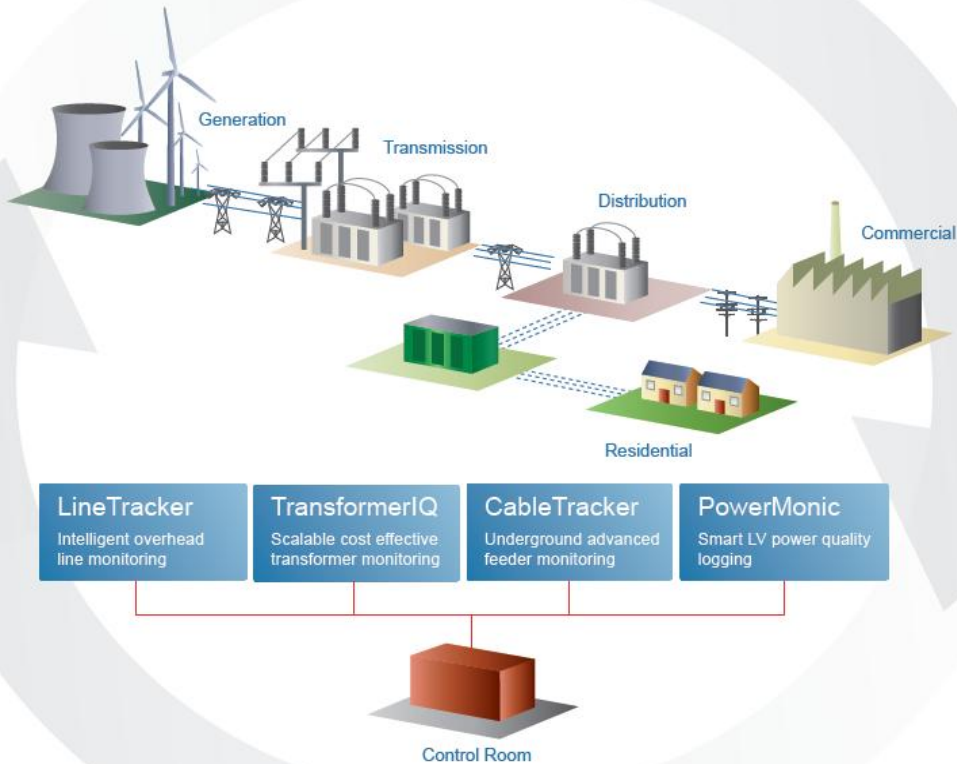
## ■ LineTracker

- Focussed on providing a flexible and scalable solution for bringing instant intelligence to your network.
- Can be used in conjunction with other GridSense solutions to provide 360 degree network coverage.
- Rapid live line installation to minimise impact and cost (30 min install per site).
- Smart, accurate monitoring system to provide reliable data on your networks reliability and performance.

## ■ GridSense

- Industry specialist with over 30 years experience.
- Customer feedback used to create intuitive smart utility solutions.
- Product currently used by major global organisations including:
  - ETSA (Australia)
  - Southern Electric (USA)
  - PowerCo (NZ)
  - Scottish Power (UK)
  - ESKOM (South Africa)
  - NPC (Philippines)





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Intelligent Network Maintenance





# TRANSFORMERIQ

Intelligent Affordable Monitoring

- ✓ Cover All Failure Modes
- ✓ Designed for Retrofit
- ✓ Substations & Distribution
- ✓ Programming Simplicity
- ✓ Web Data Access



## ■ MONITORING FEATURES

- Top & Bottom Oil Temperature
- Oil Moisture/Humidity
- Calculated WHS modeling
- WHS – Fiber Optic probes
- Load Current Logging
- Voltage and PF modeling
- Cooling System Control
- Insulation Loss of Life modeling
- LTC Differential Temperature
- LTC Position recording
- LTC Motor current recording
- Core Ground Fault Current
- Bushing Monitoring
- DGA Monitor Trending

## ■ APPLICATIONS

- Substation Transformers
- Distribution Transformers
- Vaults & Multiple Units
- Distribution Switching & Feeders

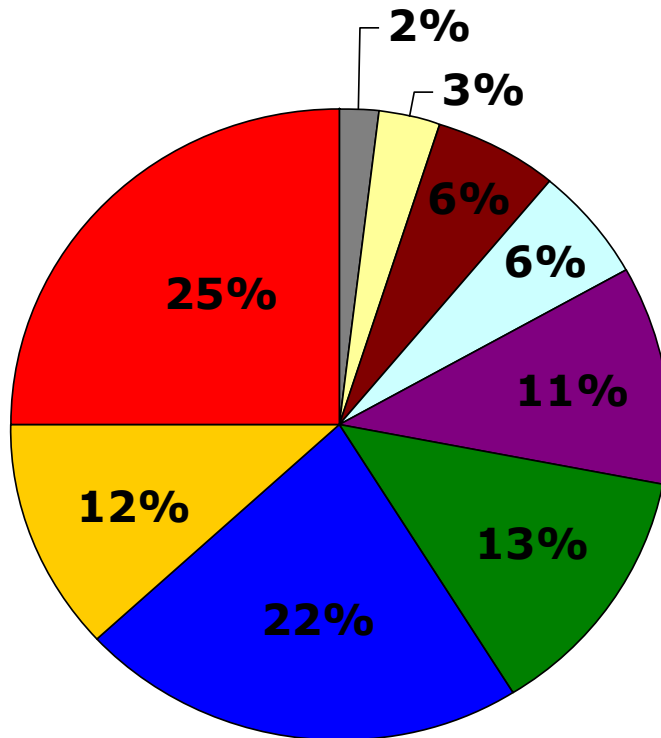
## ■ DATA ACCESS

- Display Interface – no manual needed
- Software – again, no manual, no cost
- Web Hosting & Email Alerts

# Rugged Design



## ▪ ADDRESSING ALL FAILURE MODES



- Through Faults
- Insulation Deterioration
- Inadequate Maintenance
- Moisture
- Loose Connections
- Workmanship
- Overloading
- All Others

- **Most failures can be prevented with continuous condition assessment.**

William H. Bartley, P.E. The Hartford Steam Boiler Inspection and Insurance Co.; 2008



## ■ ALARM ANNUNCIATION

- Map any/all alarms (48+ possible) to any discrete relay to RTU
- Programming time delays & latching as with familiar annunciators
- Report status on easy, walk-up display

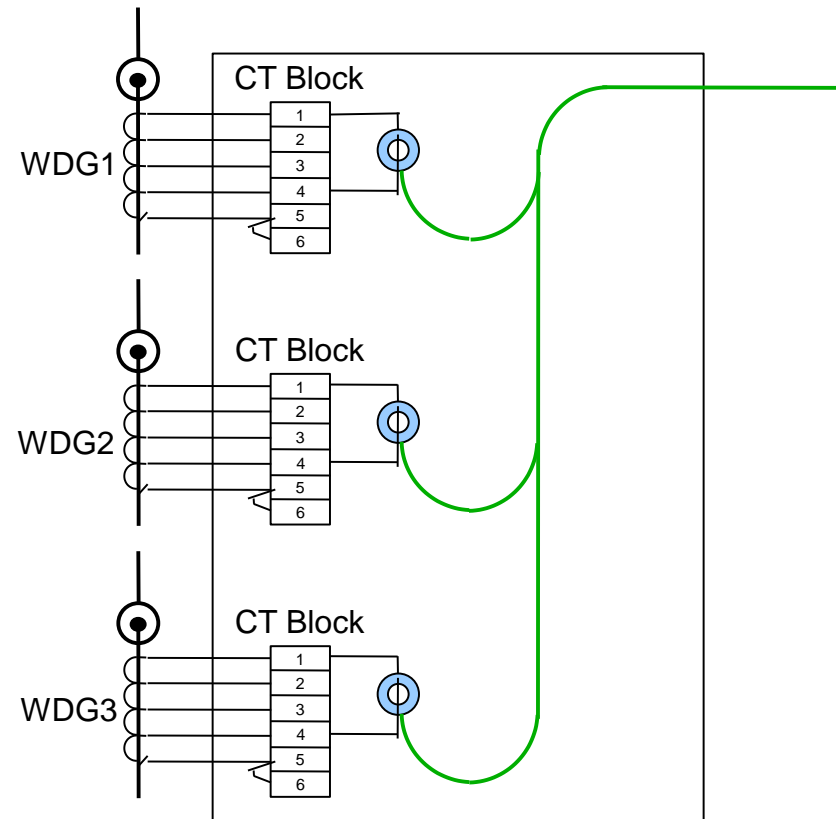
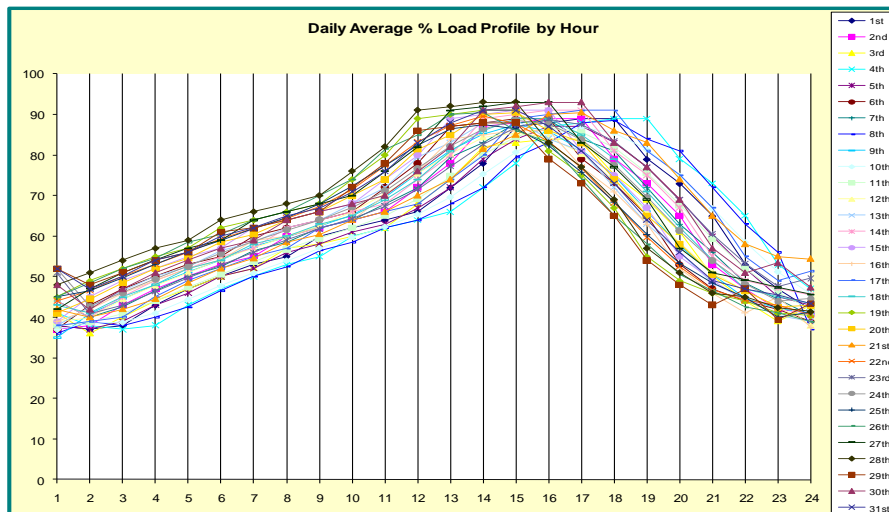
## ■ ARCHIVING

- Alarms time-stamped to 1 second
- Last 100 alarms stored & accessible by keypad or Excel download
- Last occurrence of each alarm also saved



## LOAD LOGGING

- Up to 12 windings
- Voltage and power factor (TIQ EXCLUSIVE!)
- Current transformers or Rogowski coils accepted (TIQ EXCLUSIVE!)
- Store hourly loads for 30 days
- Store average monthly load for one year

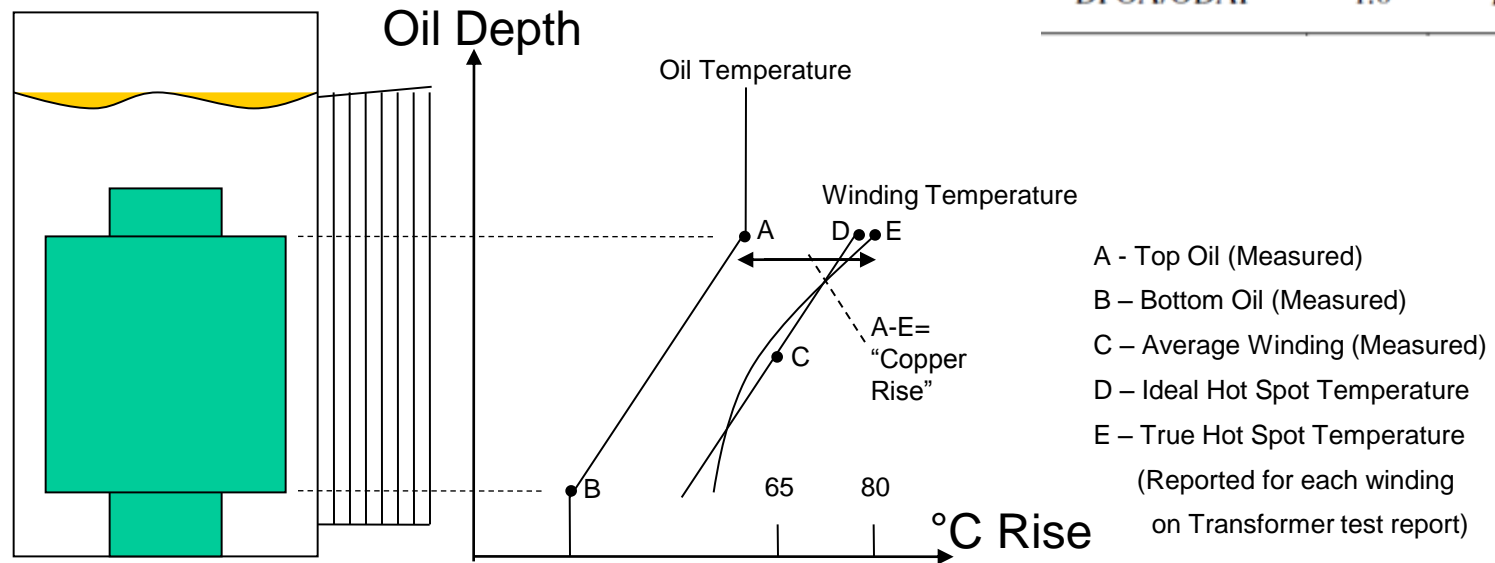




## ■ CALCULATED HOT SPOT

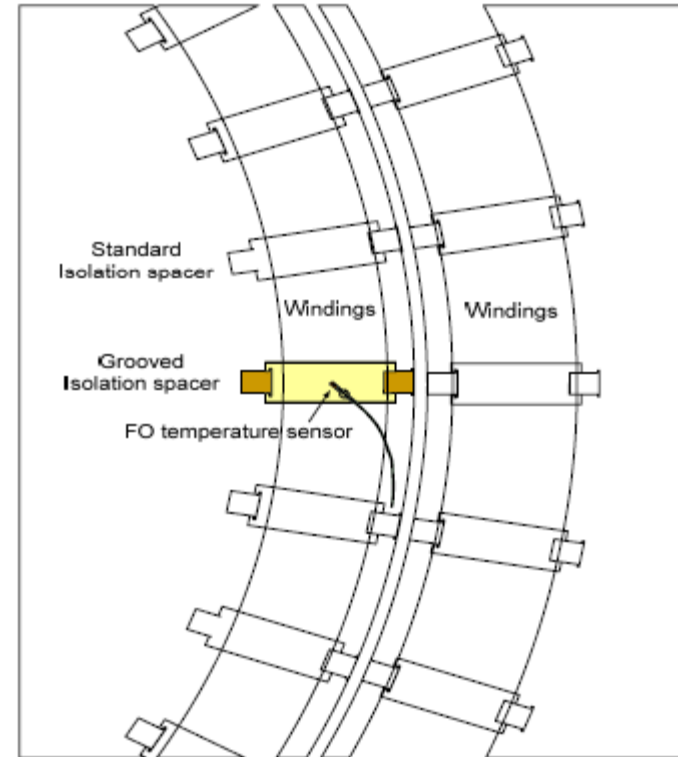
- Up to 12 windings in 6 different tanks (TIQ EXCLUSIVE)
- Perform ANSI/IEC standard calculations using variable winding exponents 1.6-2.0
- Hotspot = Topoiltemp + (A-E)\*loadfactor ^2m

Type of Cooling	IEC	IEEE
	<i>m</i>	<i>m</i>
OA/ONAN	0.8	0.8
FA/ONAF	0.8	0.8
NDFOA/OFAF	0.8	0.8
DFOA/ODAF	1.0	1.0



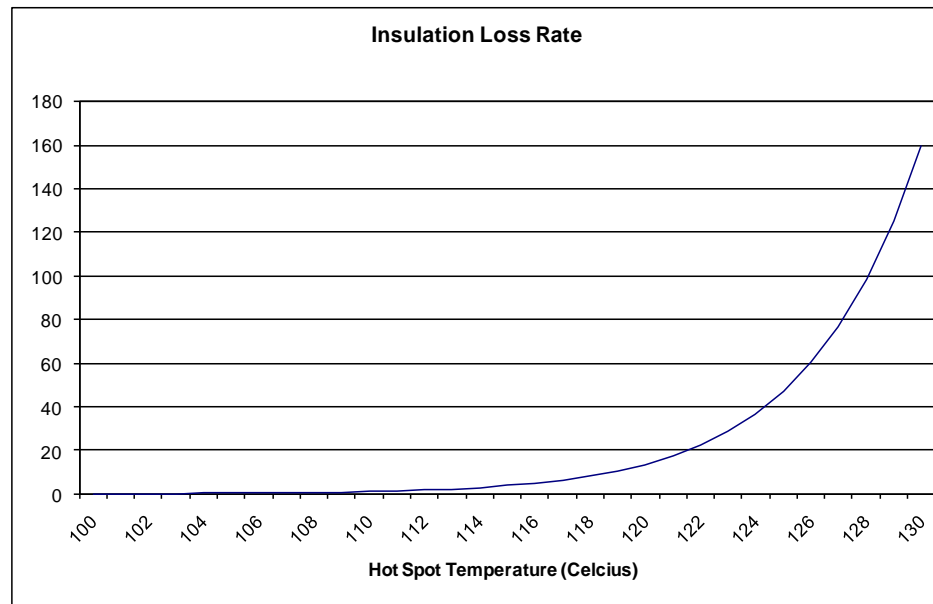
## ▪ DIRECT MEASURED HOT SPOT

- Access 3<sup>rd</sup> party fiber optic controllers as slaves on RS485 via MODBUS
- Smallest temperature error
- Excellent long term reliability as well as durable sensors for new transformer installation
- Only technology that cannot be retrofitted



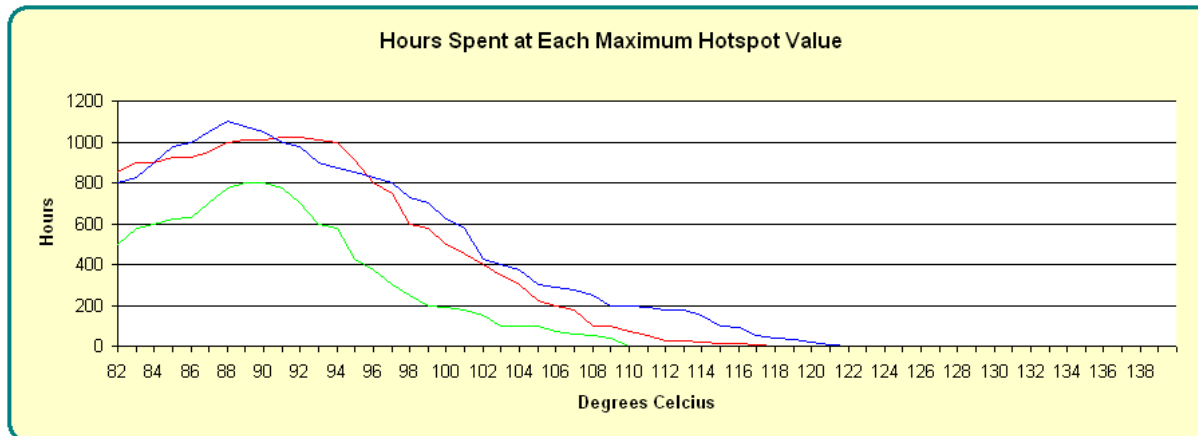
## ▪ DEFINING INSULATION LOSS OF LIFE

- Loss rate =  $(10^{(B/383)}) / (10^{(B/(Hotspot^{\circ}C+273))})$ , where B=17000 per ANSI C57.92
- Nominal loss( 180,000 hrs=20.54 yrs) at 110°C
- Custom relationship allowed (TIQ EXCLUSIVE!)
- Notice that <80°C has virtually no life lost while >140°C is above flash point of oil



## LOSS OF LIFE CALCULATION

- Store time spent at each temperature to recalculate entire life lost
- Store for 12 different windings on different transformers
- LOL is extrapolated back to transformer install date



	Transformer/Winding 1	Transformer/Winding 2	Transformer/Winding 3
Nameplate Date of Manufacture	1999	1998	1999
	1997 (write value)	1998 (write value)	1999
Hours Monitored with Hot Spot <=81°C	13760	15100	8220
Hours Monitored with Hot Spot >=140°C	0	0	0
Total Hours Monitored	32960	36475	19470
Hours Life Lost While Monitored	1149	4727	290
Hours Estimated Un-monitored Life Lost	47700	47700	47700
Hours Predicted Total Life Lost	52980	52980	52980
% Life Lost Based on Expected Life	29	29	29
Expected Life (Hours/10)	18000	18000	18000
	18000 (write value)	18000 (write value)	18000 (write value)
Annual Unmonitored Load Increase(%)	3	3	3
	3 (write value)	3 (write value)	3 (write value)



## ■ DISSOLVED GAS & MOISTURE TRENDING

- Integrate 3<sup>rd</sup> party sensors via analog input or MODBUS
- Single system then reports all data to SCADA
- Trend total combustible gases, moisture or independent gases (Newly integrated to TIQ)



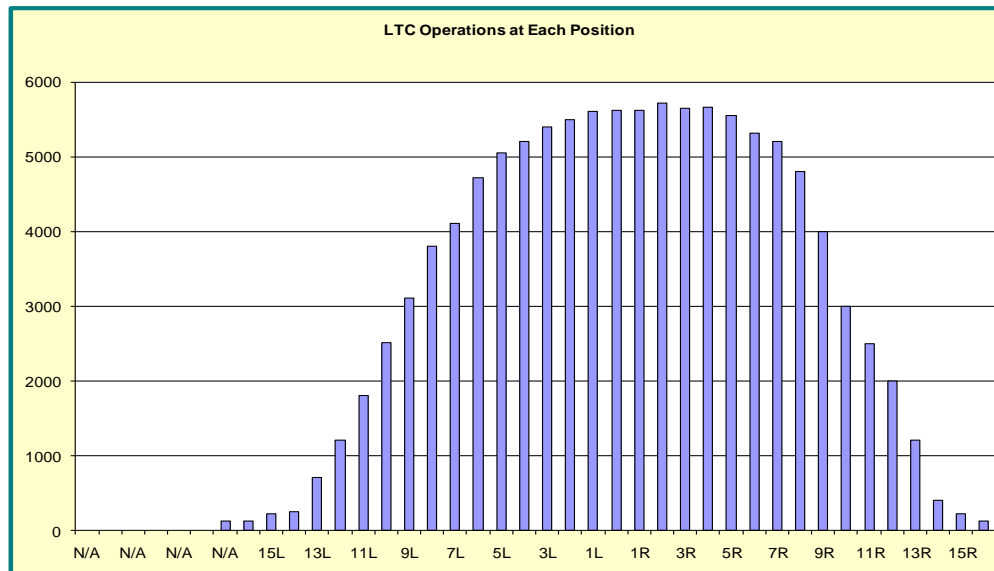
Oil Sampling		
87	Oil Device ID	0
88	First Import Address	0
89	Gas PPM Register #	0
90	Max Analog Gas PPM	0
91	mV @ Max PPM Gas	0
92	mV @ 0 PPM Gas	0
93	Gas Alarm PPM Level	0
94	Addresses Imported	0
95	H2O PPM Register #	0
96	Max Analog H2O PPM	0
97	mV @ Max PPM H2O	0
98	mV @ 0 PPM H2O	0
99	H2O Alarm PPM Level	0





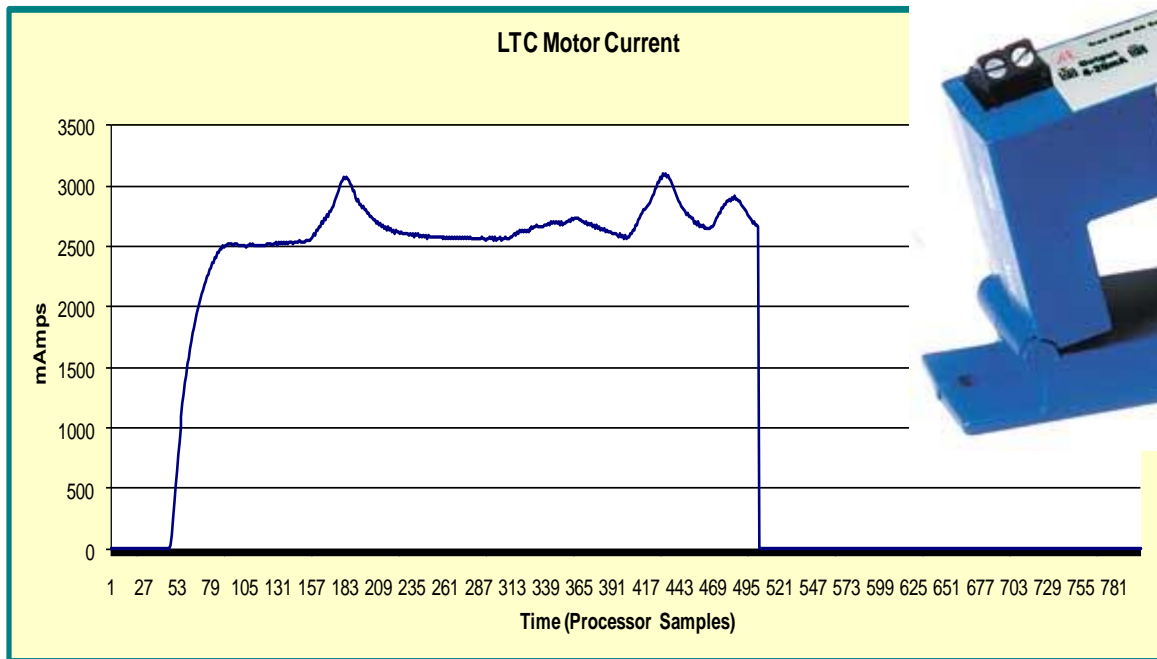
## ▪ LTC POSITION FEEDBACK AND TRENDING

- Tap changes per position recorded to better interpret LTC usage and maintenance
- Determine proper de-energized tap changer placement (Too many ops above or below neutral)
- Sense incomplete tap change at time of command (LTC Command Failure Alarm)
- Determine excess daily operation or narrow bandwidth (Hunting & Excess Operations alarms)



## ▪ LTC MOTOR CURRENT PROFILING

- Motor time-current profile should be constant in size & duration
- Symptomatic of motor failure, mechanism binding, or contact wear
- Can be compared with each tap change and analyzed over time



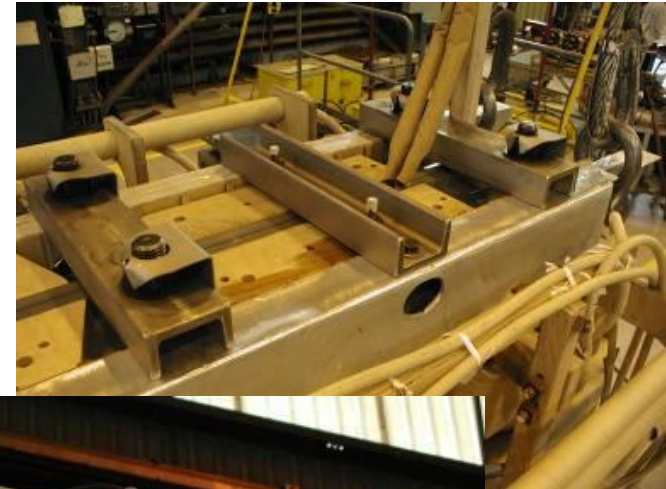
## ▪ LTC-MAIN TANK TEMPERATURE HEAT TRANSFER

- Ideally no heat should be generated inside LTC compartment
- Main Tank-LTC tank oil temp difference senses this heat flow
- Heat flow will vary with transformer loading
- Slowed or reversed heat flow symptomatic of contact heating



## ■ CORE GROUND FAULT ENERGY SENSING

- Fault point completes path for current to flow through tank wall
- Gases can be generated from breakdown of oil (can be low or high energy)
- Can be continual current or sputtering
- Transformer monitors on a half-cycle basis and records maximum value in last second, hour over last month, and month over year
- Core ground alarm signal alarm threshold reached



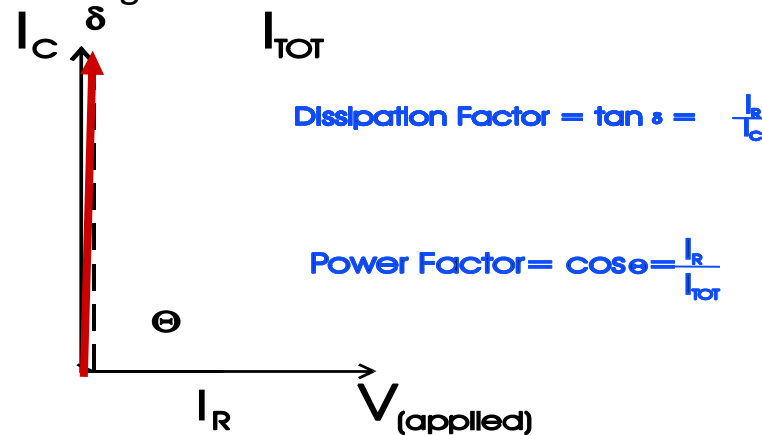
- Rogowski coils is attached over external core ground bushing when available





## ▪ BUSHING CONDITION MONITORING

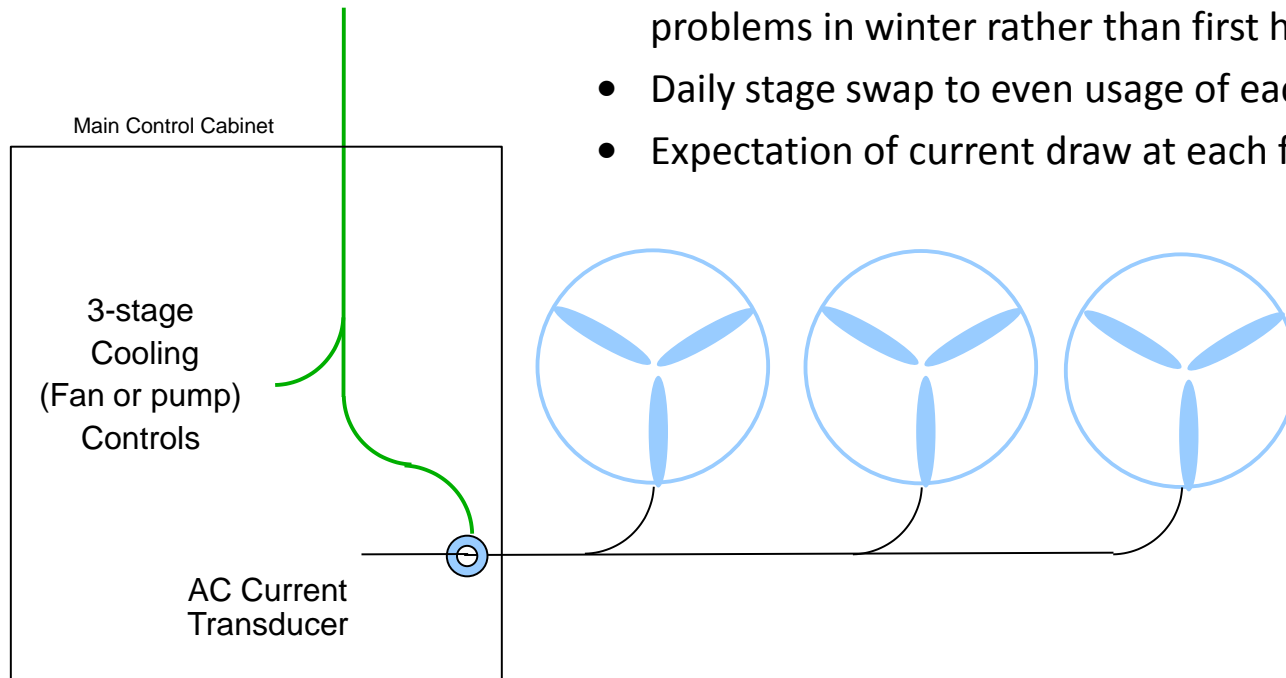
- Gridsense recently acquired On-Line Monitoring Inc., with over 3000 bushings of experience
- Applicable to capacitor or “condenser” bushings
- System continually looks for changes in power factor between 3-bushing sets
- Continuously comparing bushings negates temperature & moisture variations
- Alarm is dispatched upon reaching alarm threshold
- Power factor refers to measurement of resistive leakage current,  $I_R$





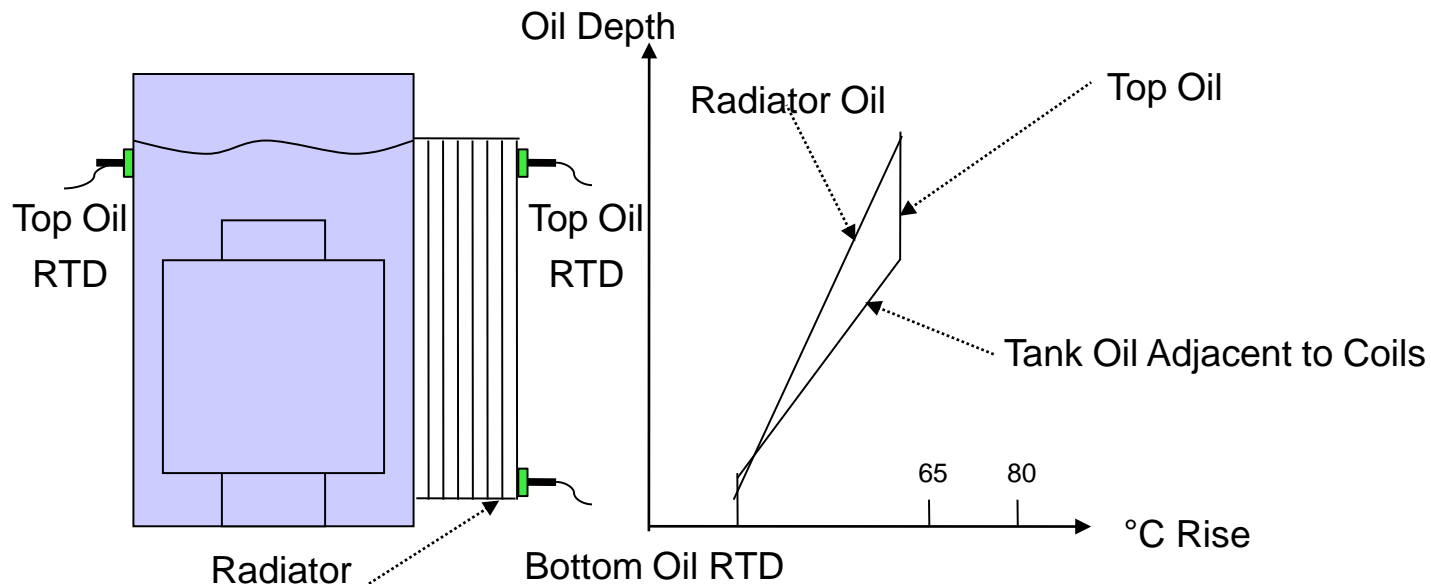
## ■ COOLING CONTROL & MONITORING

- Fan contactor counters to sense control issues
- Cooling stage hour meters to sense fan usage
- Daily exercising to free bearings and sense fan problems in winter rather than first hot day
- Daily stage swap to even usage of each stage
- Expectation of current draw at each fan stage



## ▪ COOLING EFFICIENCY (HEAT TRANSFER)

- Heat flow = Transfer Coefficient \* ( Average case temp – Ambient temperature)
- Transfer Coefficient should be constant if transformer is cooling properly
- Gridsense has a patent on calculated and trending this heat transfer coefficient and trending against changing load and environmental conditions
- An alarm is triggered when the heat transfer degrades below threshold value



## ▪ DISTRIBUTION TRANSFORMER APPLICATION

- Compact size fits compartment
- Identify fault phase & magnitude
- Asset loss of life back to install
- Data logging used to determine asset utilization
- Voltage, current, power factor measured
- Distribution power reading for theft detection
- Hand-held display for quick programming & data
- 600VAC powered with ride-through energy storage



## ▪ MULTIPLE TRANSFORMER/VAULT APPLICATION

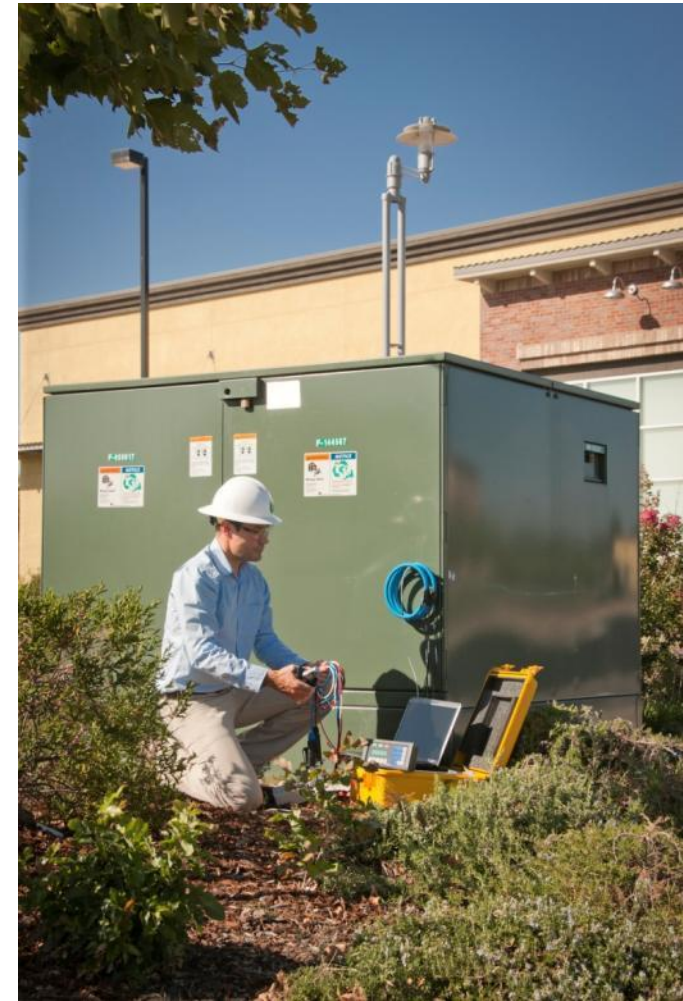
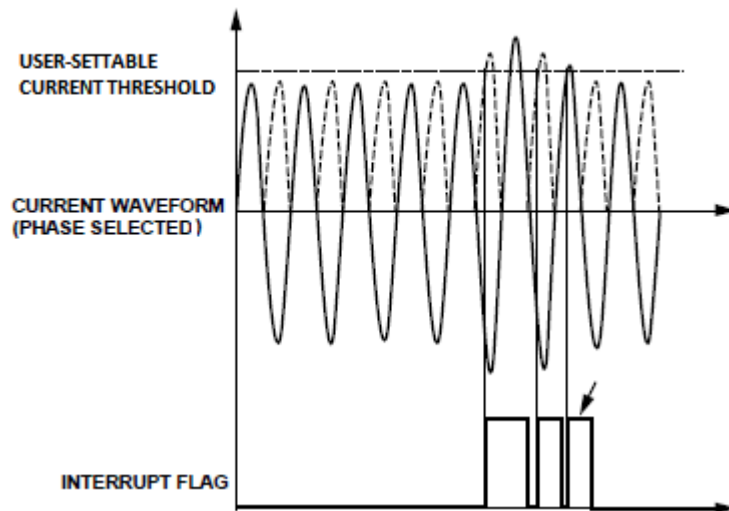
- Assign up to 12 windings to 6 different transformer tanks
- Winding hot spots calculated independently
- Insulation life lost calculated per winding
- Voltage and power factor captured on all windings
- Termination enclosure (break-out-box) allows for permanent utility connection point while maintaining quick disconnect of processor or any component





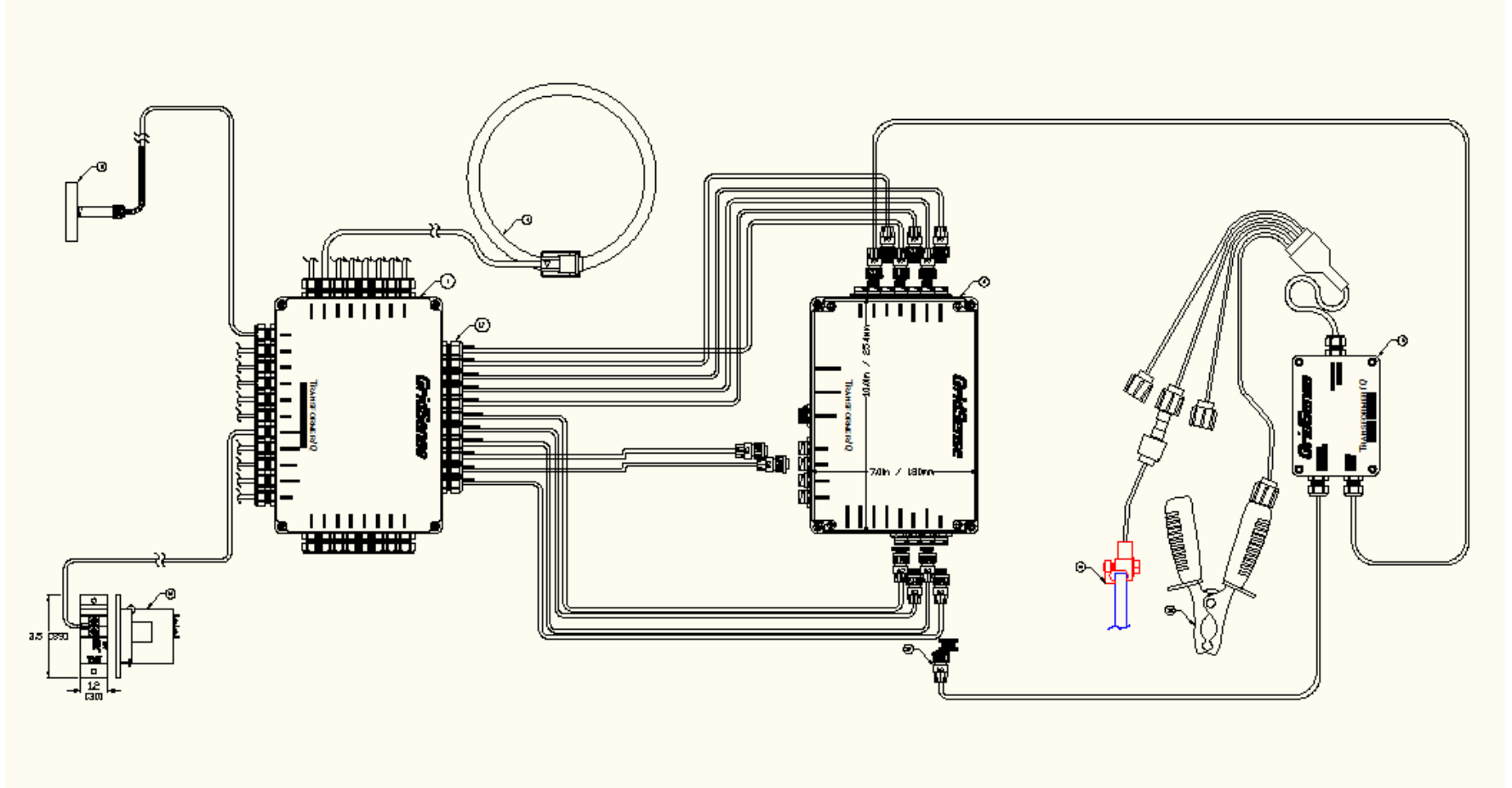
## ▪ FEEDER MONITORING APPLICATION

- Enclosure attaches magnetically inside compartment
- Monitor up to 4 feeders
- Rogowski coils attach easily around insulated cables
- Capture fault as short as  $\frac{1}{2}$  cycle
- Record fault magnitude and identify feeder





## ■ DISTRIBUTION MONITORING EQUIPMENT

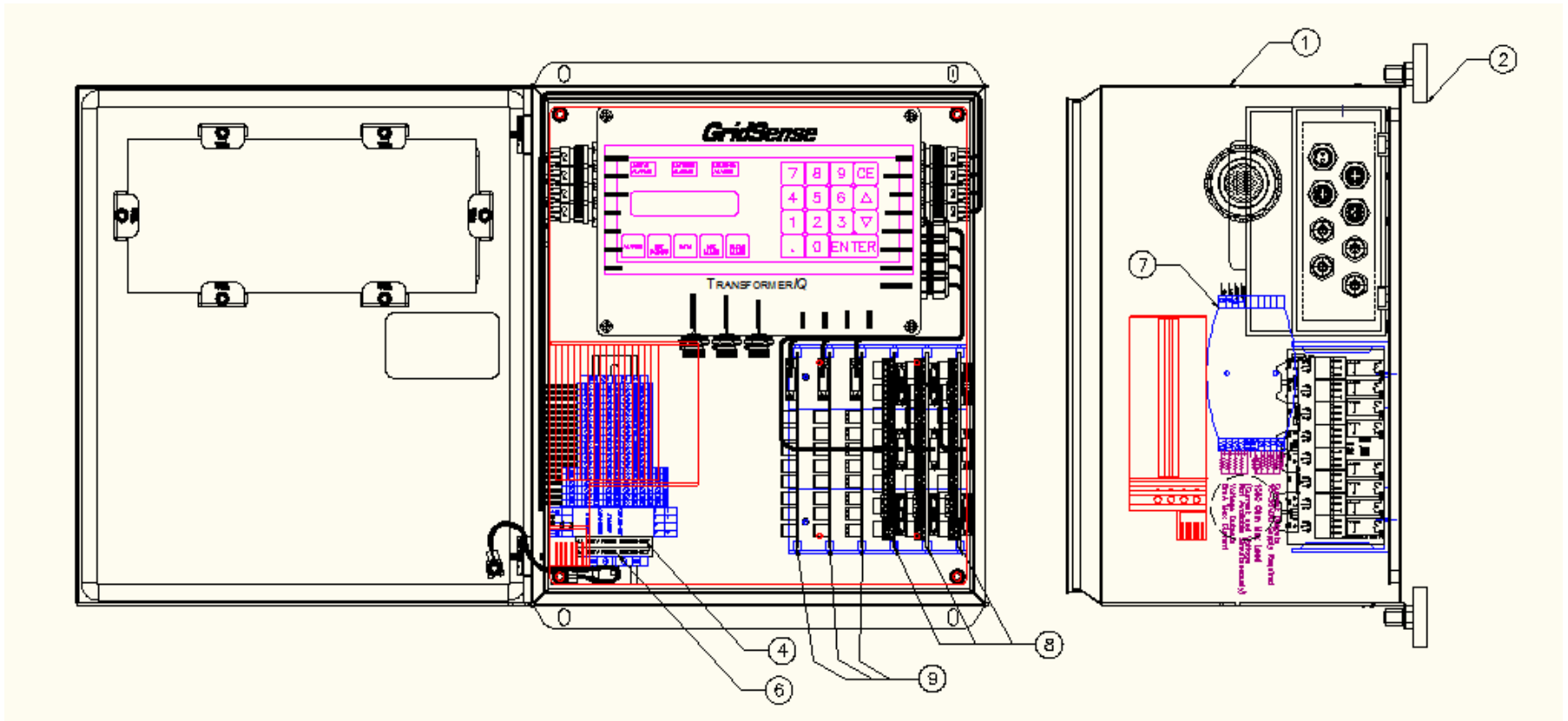


## ■ SUBSTATION TRANSFORMER APPLICATION

- Comprehensive monitoring of all failure modes
- Designed for retrofit – even re-deployable
- Easy to configure to complex units with simple Q&A wizard
- Easily locate in any existing enclosure or use best-in-industry stainless cabinet
- Walk-up display requires no manual
- LCD keypad can be mounted in adjacent cabinet panel cut-out or mounted in control room



## ■ SUBSTATION TRANSFORMER APPLICATION EQUIPMENT



## ■ DASHBOARD SOFTWARE

- Access data from serial connection or any number of networked units simultaneously
- Modify set points
- Excel sync for programming or comprehensive data download
- Configurable archiving period
- Perform firmware upgrades

The screenshot displays the SubstationIQ Dashboard software interface. The main window is titled "SubstationIQ Dashboard" and features a menu bar (File, Edit, View, Go, Tools, Help) and a toolbar with buttons for New, Properties, Refresh, and other functions. The interface is divided into several sections:

- Transformers:** A tree view on the left shows "TransformerIQ Locations" with sub-entries for "Raleigh - Downtown : 2 alarms are active" and "Cary : One alarm is active".
- Transformer Details: Raleigh - Downtown (3:56 PM):** The main content area displays various data points:
  - Alarms:** A table with columns "Alarm #", "Name", and "Status".
 

Alarm #	Name	Status
1	Discrete Input #1	Inactive
2	Discrete Input #2	Inactive
  - Analog Inputs:** A table with columns "Name", "Current Value", and "Peak Value".
 

Name	Current Value	Peak Value
LTC Position	33	33/0
Winding 1 Load	200 %	200 %
  - Discrete Inputs:** A table with columns "Input #", "Name", and "Energized".
 

Input #	Name	Energized
1	Discrete Input #1	<input type="checkbox"/>
2	Discrete Input #2	<input type="checkbox"/>
  - Discrete Outputs:** A table with columns "Output #", "Name", and "Energized".
 

Output #	Name	Energized
1	Transformer Watchdog Relay	<input checked="" type="checkbox"/>
2	Fan Stage 3 Relay	<input type="checkbox"/>

The status bar at the bottom indicates "Ready" and "2 alarms are active." along with a "Connected" indicator.





## ■ PROGRAMMING & DATA RETRIEVAL MADE EASY

- English Q&A Programming
- Comprehensive graphing
- Import to reports

Copy of TransformerIQ\_Console\_v02\_00 (2).xls [Read-Only] [Compatibility Mode] - Microsoft Excel

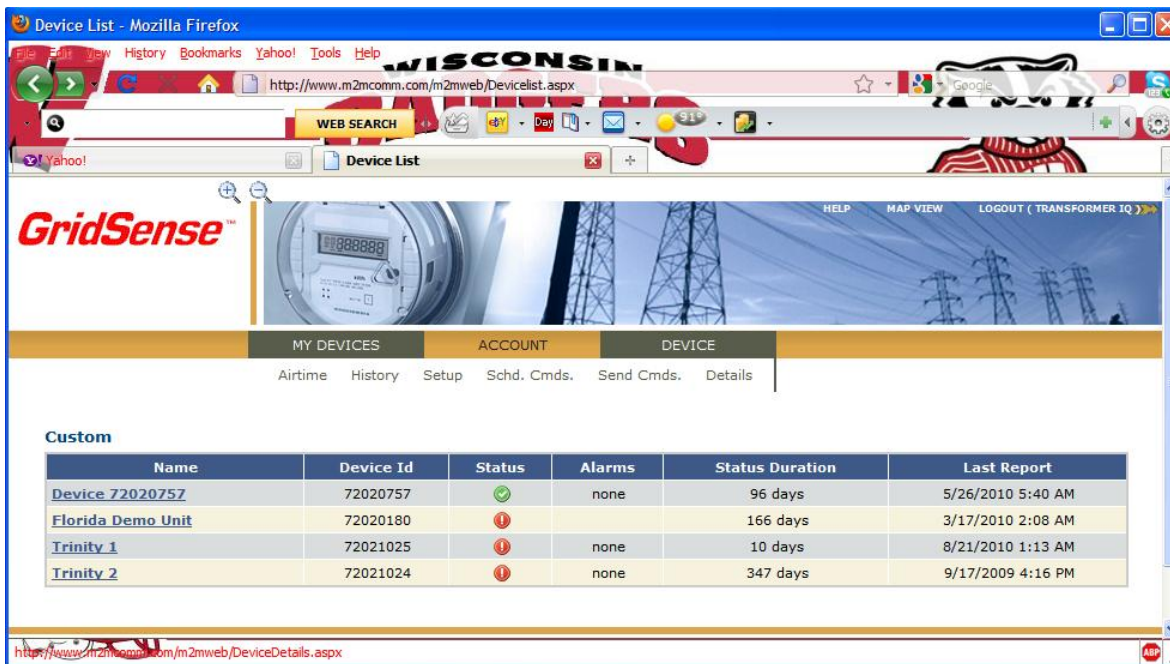
Programming Questions											
<b>Winding Load Monitoring</b>			Wdg 1	Wdg 2	Wdg 3	<b>Programming Analog Inputs &amp; Outputs</b>			<b>Load Tap Changer (LTC) Monitoring</b>		
10	1.Which windings have their load monitored?	Yes	Yes	No	33.What temperature is RTD0 measuring?	102	69.Does the transformer have an LTC?	Yes			
11	2.Winding kVA	93330	93330		34.What temperature is RTD1 measuring?	106	70.Is the LTC position being monitored?	Yes			
12	3.Winding Line-Line kV	161.7	69		35.What temperature is RTD2 measuring?	105	71.What is the minimum sensor mV output?	500			
13	4.What bushing amps are the CTs rated for?	400	800		36.What temperature is RTD3 measuring?	0	72.What is the sensor step size in mV?	110			
14	5.What amps are output by the bushing CTs?	5	5				73.How many daily reversals should trigger alarm?	0			
15	6.What are input amps of the AC-DC transducer?	10	10				74.How many daily operations should trigger alarm?	0			
16	7.What are output mV of the AC-DC transducer?	10000	10000		39.Is an optional analog output module used?	No	75.Is the LTC motor current being monitored?	Yes			
17	8.What are full-load winding rises above top oil?(°C)	15	15		41.Is gas-in-oil input as an analog signal?	Yes	76.What are input amps of current transducer?	50			
18	9.What year was(were) the transformer(s) built?	2009	2009		42.Is H2O-in-oil input as an analog signal?	Yes	77.What are output volts of current transducer?	10			
19	10.What is the anticipated transformer life in hours?	180,000			43.Is H2O-in-oil input as an analog signal?	Yes	78.What +/-% error should motor current alarm at?	10			
20	11.What was annual unmonitored load increase?	0			44.What signal should go to output 1?	1	79.Is the load tap changer temperature monitored?	Yes			
21	12.What max % load should trigger LOAD ALARM?	60			45.What signal should go to output 2?	2	80.Is the LTC mounted below the top of coils?	No			
22	13.What is the winding exponent used?(2.0 default)	2.0			46.What signal should go to output 3?	14	81.What min tank-LTC°C should trigger LO alarm?	4			
23	<b>Cooling Monitoring and Configuration</b>			Stage1	Stage2	Stage3	47.What signal should go to output 4?	16	<b>Bushing Monitoring Configuration</b>		
24	14.What stages of fan cooling are present?	Yes	Yes	No	48.What output % should fixed output be?	50	82.What min tank-LTC°C should trigger LO-LO alarm?	2			
25	15.Is the cooling motor current being monitored?	No			49.Select inputs with 1VDC offset?(Input 1=right bit)	00000000	<b>83.How many bushings will be monitored?</b>				
26					<b>Port Configuration</b>						
27					50.Should acknowledging alarm clear output relays?	No					
28					52.Is this TransformerIQ equipped with Ethernet?	Yes					
29					53.What is 4-digit display programming PIN?(0=none)	0					
30					54.What is the MODBUS device ID of monitor?	1	<b>Fiber Optic Winding Monitoring</b>				
31	21.What top oil temperatures trigger fan stages?	55	65		55.What BAUD rate is the 8,1,N slave port?	38400	88.Are fiber optic probes embedded in windings?	Yes			
32	22.What hot spot temperatures trigger fan stages?	65	75		<b>Gas Monitoring</b>			89.What manufacturer of equipment is used?	Opsens		
33	23.What is fan delay after temp rise?(seconds)	30			56.Are dissolved gases or moisture being sensed?	Yes	90.What temp is measured by probe 1?	1			
34	24.Should fan stages 1 & 2 swap each day?	No			57.Is the gas monitor accessed by analog or serial?	Analog	91.What temp is measured by probe 2?	2			
35	25.Minutes should all cooling cycle at noon?(0=off)	0			61.What GAS PPM level should the alarm occur at?	1500	92.What temp is measured by probe 3?	3			
36	26.What max % load should all fans engage at?	101			63.For scaling, what DC voltage equals 0 GAS PPM?	0	93.What temp is measured by probe 4?	0			
37	<b>Trip and Alarm Temperatures (°C)</b>			Alarm	Trip	64.What DC voltage is output at maximum GAS PPM?	2000	94.What temp is measured by probe 5?	0		
38	27.What hottest top oil temp should trigger alarm?	90	105		65.What is maximum GAS PPM?	2000	95.What temp is measured by probe 6?	0			
39	28.What winding 1 temp should trigger alarm & trip?	105	120		66.What DC voltage equals 0 H2O PPM?	0	96.What temp is measured by probe 7?	0			
40	29.What winding 2 temp should trigger alarm & trip?	105	120		67.What DC voltage equals maximum H2O PPM?	5	97.What temp is measured by probe 8?	0			
41	30.What winding 3 temp should trigger alarm & trip?	105	120		68.What is maximum H2O PPM?	2000	98.What temp is measured by probe 9?	0			
42	31.What low cabinet temp should trigger alarm?	0									
43	32.What high cabinet temp should trigger alarm?	60									
44	<b>Watchdog</b>										
45	32a. Is the TransformerIQ fitted with Watchdog timer circuit?	Yes									
46											





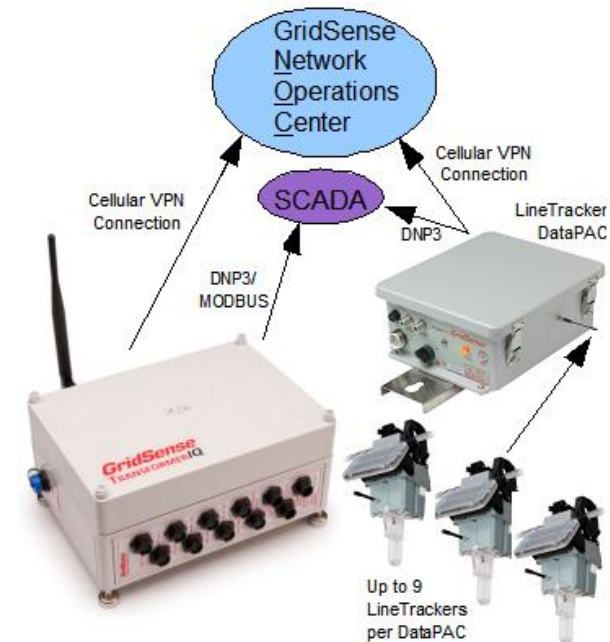
## ■ WEB DATA HOSTING

- Units report on schedule and by exception through secure VPN connection
- Email alerts dispatched upon receiving new alarm or when unit fails to report on schedule
- User logs on through regular browser to see details of fault, time of event and all regular data
- Extremely cost effect at less than the price of a cell phone bill – approximately \$35/month



The screenshot shows a web browser window displaying the GridSense 'Device List' page. The page features a navigation menu with 'MY DEVICES', 'ACCOUNT', and 'DEVICE' sections. Below the menu is a table with the following data:

Name	Device Id	Status	Alarms	Status Duration	Last Report
<a href="#">Device 72020757</a>	72020757	✓	none	96 days	5/26/2010 5:40 AM
<a href="#">Florida Demo Unit</a>	72020180	!	none	166 days	3/17/2010 2:08 AM
<a href="#">Trinity 1</a>	72021025	!	none	10 days	8/21/2010 1:13 AM
<a href="#">Trinity 2</a>	72021024	!	none	347 days	9/17/2009 4:16 PM



## BushingIQ - Bushing Monitoring Solutions





## Why Monitor?

- Safety
- Protect Equipment
- Eliminate Unscheduled Downtime
- Reduce Maintenance Costs
- Extend Life of Assets; Reduce Risks/Liability
- Identify Incipient Faults & Avoid Catastrophic Failures





# Risk of Not Monitoring



# Limitations to Conventional Monitoring

- **Field Testing is limited to:**
  - ✓ **Visual Inspection for:**
    - ✓ **Oil Levels and Leaks**
    - ✓ **Cracks /Chipping of the porcelain**
    - ✓ **Pollution deposits**
- **Capacitance Measurement**
- **Power Factor Test**
  - ✓ **The Above Two Electrical Tests are Performed Using Doble (M 3000),or Megger Test Equipment (Delta 3000) at up to 10 kV AC.**





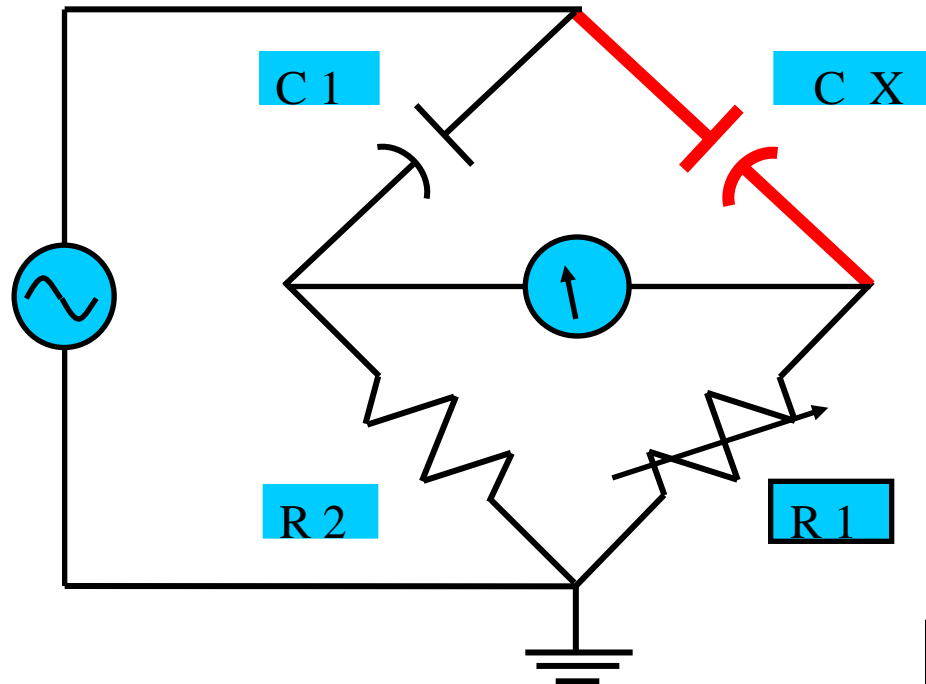
# Limitations to Conventional Monitoring

- **Offline Power Factor Test Is Normally Performed On A Mild Day with Low Humidity. Our experience has found:**
  - **Humidity Due To Rain And Other Precipitation will Impact Power Factor Readings on Bushings with Incipient Faults.**
  - **Causes can Vary from Moisture Ingress from Gaskets/Seals to Loss of Glaze on the Ceramic.**



# Measuring Methodology

PF/Tan  $\delta$  calculation is based on the conventional **Schering Bridge** used in laboratories and offline test sets.



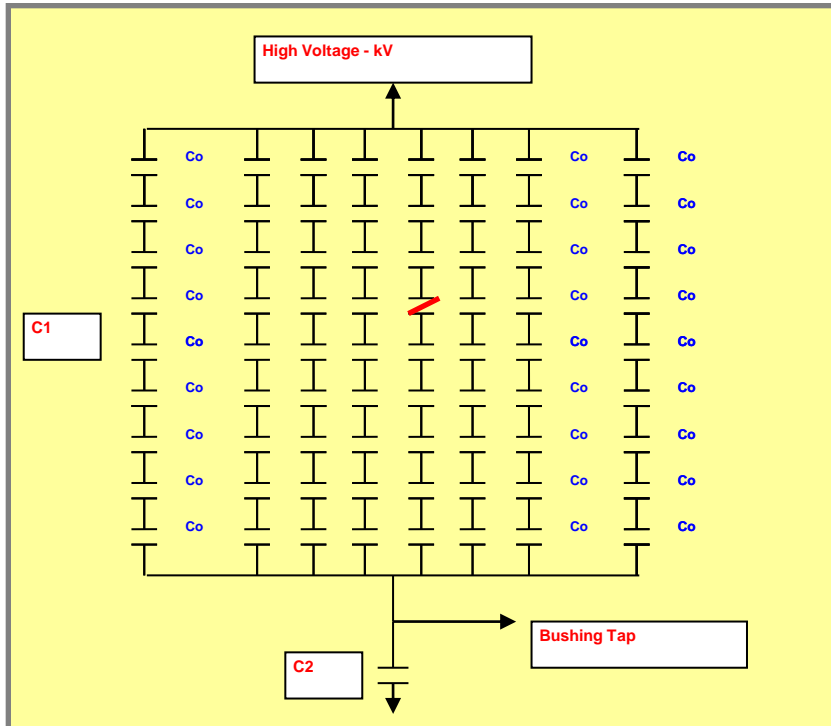
The **Schering Bridge** uses a voltage reference taken from a bushing that simulates a reference capacitor (CX) and compares it to the bushing under test (C1).

- This Provides a more reliable method of PF/Tan  $\delta$  measurement.

- Software Controlled “**Schering**” Bridge



## BushingIQ & PF Live System



- Electrical representation of a bushing by several small capacitance values in series and parallel
- As a fault occurs in the bushing, some of these very small capacitors become resistive.
- The leakage current from deep inside the bushing is miniscule when measured to ground.
- The Voltage drops due to these resistive components are sensed and measured.



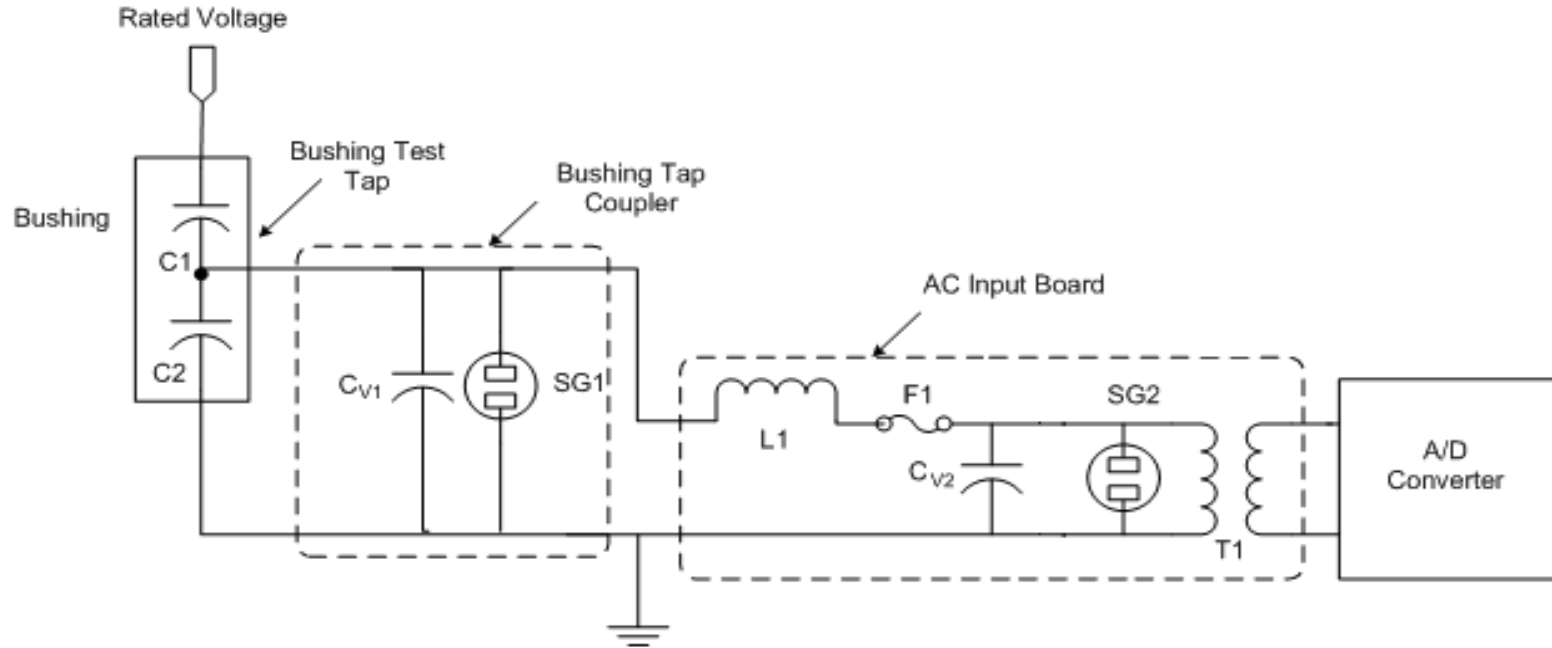
# Monitoring Methodology

- Determining the “CONDITION” Value
- A Multi-Step Statistical Analysis to Diagnose the True Condition of the Bushing
  - ✓ Recent Changes - indication of more recent changes in the data.
  - ✓ Swing Indicator - standard deviation calculations to predict a trend.
  - ✓ Seasonal Slope Estimator (Kendall Slope) - test for randomness against trend.
  - ✓ Mann-Whitney Test - sensitive to differences between latest data and the reference data.



# BushingIQ & PF Live System Schematic

- The Capacitance measurement is determined by a Voltage Divider Network formed by a capacitor in the Bushing Tap Coupler.





## BushingIQ System



- Bushing Tap Coupler is attached to the capacitance tap.



## PF Live System





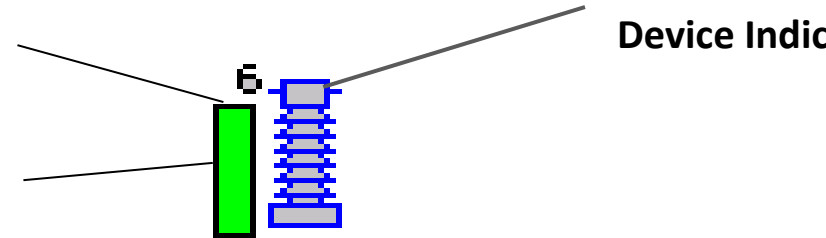
## BTC Installation



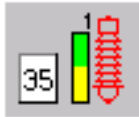
# Condition Value

Unit ID Number

Unit Condition

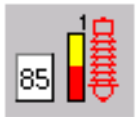


**Green (normal) Condition:** Green indicates a condition value of 0.



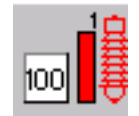
Range (0 < 70) If green, with yellow increasing, approaching a warning condition.

- **Yellow (warning) Condition:** Yellow indicates a concern, investigate the particular unit.



Range (70 < Y < 100) If yellow, with red increasing, indicates approaching alarm.

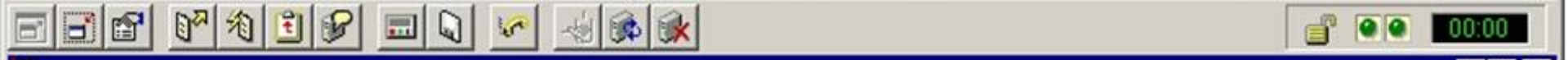
- **Red (alarm) Condition:** Red indicates an Alarm condition exists.



Range (R > 100)

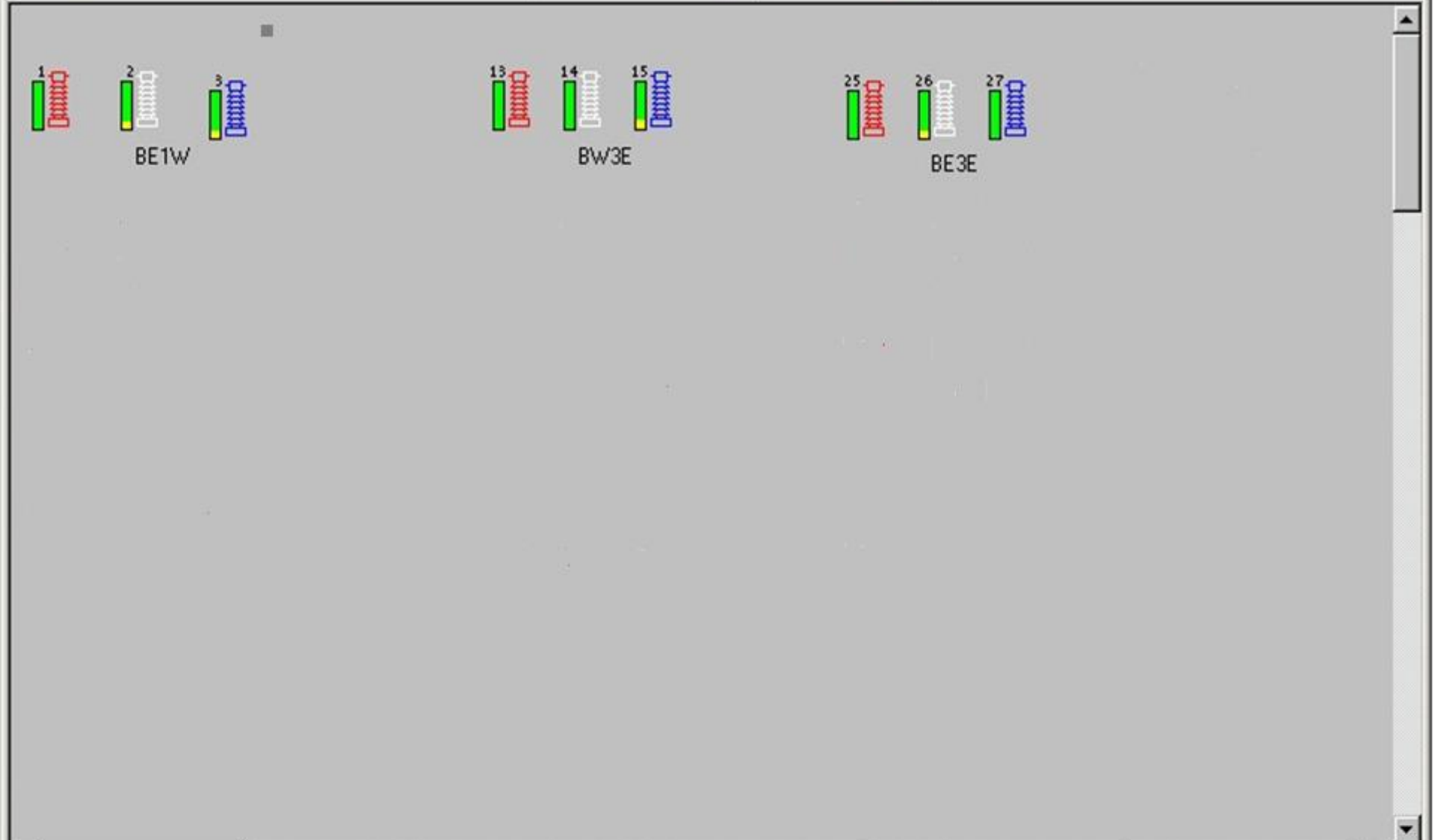
- **No Condition Available:** Gray rectangle indicates the condition value is not available.





File Pause Process Reset Communication Alarm Status Export Data Help

View: All Signal integrity:  Condition:  Temperature [C]: N/A Humidity [%]: N/A





File Configuration Data Help

Select Configuration

Substations:

SS1

Transformers:

TR1

Devices to be sampled (only in-service devices):

Phase A - PF (Ch: 1, ID: 2)

Phase B - PF (Ch: 2, ID: 3)

Phase C - PF (Ch: 3, ID: 4)

Data Acquisition



Please connect the cable between the PCMCIA A/D card and the PF Live Interface Cabinet and click the button when ready.

Check all channels

Sample and Store

Signal Graphs

Instantaneous PF

Raw Data

Test Device: Phase B on channel 2

RMS: 7.81V

Mean: -0.02V

Reference Device: Phase A on channel 1

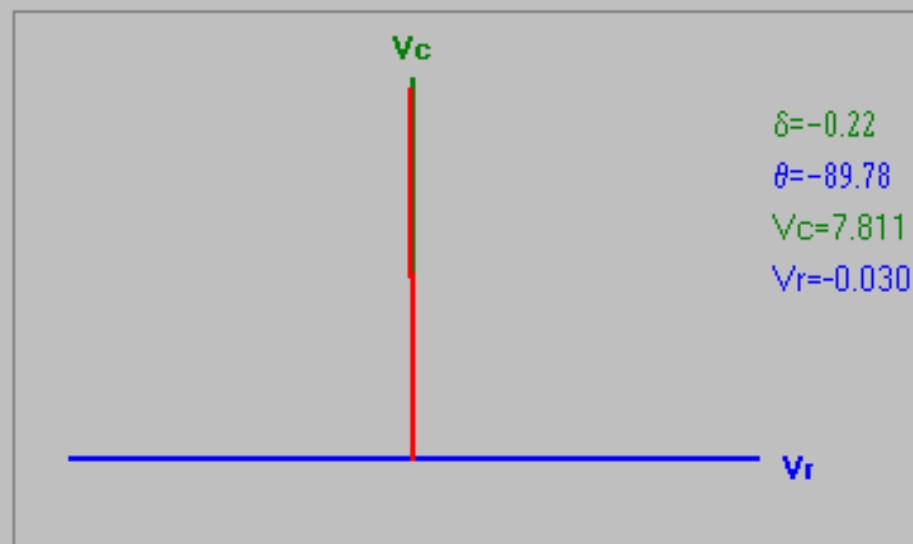
RMS: 7.24V

Mean: -0.02V

Relative Power Factor: -0.38%

Off-line PF value: 0.000%

PF Offset: 0.000%



Sample and calculate

Please select a single device from the list ("devices to be sampled")

Devices of Transformer "TR2" at Substation "SS1"

Substations **Transformers** Devices

Cha...	Type	Description	In Service	Pha...	Man...	Seri...	Fee...	Lev...	Lev...	Le
1	PF	Phase A	Yes	A	GE	5444...	F2	0.00	0.00	0.
2	PF	Phase B	Yes	B	GE	4443...	F2	0.00	0.00	0.
3	PF	Phase C	Yes	C	GE	6549...	F2	0.00	0.00	0.

Device Detail

Transformer: TR2

Type: LEVEL Phase: A

In Service?  Channel (1-16): 14

Description: Phase A Hydrogen

Manufacturer: GE

Serial Number: H2134

Feeder: F2

New

Delete

Save

Cancel

Level Device Scaling (only for level devices):

Units of Measure: PPM

Upper Voltage: 10.0 Upper Value: 2000

Lower Voltage: 0.0 Lower Value: 0

## Bushing Monitor Family

- *PF Live*
- BushingIQ

### Key Features:

- Modular - Upgradeable
- NEMA 4 Enclosures
- Rated for -40°C to 65°C Operating
- DC Analog Inputs available
- Capable of displaying Relative Power Factor Measurements



## BushingIQ & PF Live Installations

- Over 100+ Customers and 3000 bushings Worldwide
- US Customers Include:
  - ✓ BPA
  - ✓ TXU
  - ✓ Deseret Power
  - ✓ ONCOR
  - ✓ PSEG (NJ)
  - ✓ GA Power
  - ✓ MANY MORE.....

*Please request a complete customer list!*



# PowerMonic

Portable Power Monitoring

- ✓ Rugged Design
- ✓ Versatile Applications
- ✓ Industry Leader
- ✓ CAT IV Safety Standard
- ✓ Power Quality Monitoring
- ✓ Superior Software
- ✓ Multistage Event Capture





## ▪ HIGH QUALITY DESIGN AND MANUFACTURE

- Designed to meet international IP65 weather rating.
- Withstand 3ft/1m drop test.
- Over 15 years industry knowledge & experience.
- Robust Australian design & manufacturing.

## ▪ DESIGNED FOR THE UTILITY CUSTOMER

- Designed to withstand the harshest outdoor conditions.
- Tamperproof design with intelligent features such as LCD configuration options.
- Rapid deployment, powered from metered A phase.
- Intuitive software for quick and effective identification of problems.
- High speed flexible communication module options to suit your network.



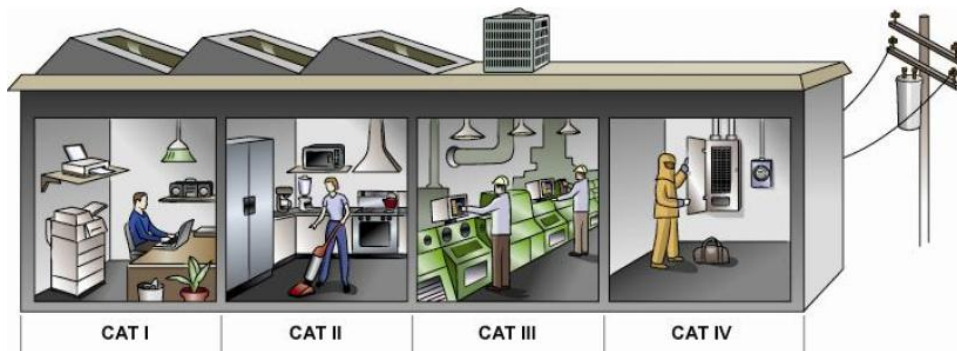
## ■ PM45

- Designed and manufactured to 600V CATIV approved safety rating.
- Approvals: C tick, CE and IP66 weather rating.
- Designed to meet IEC power quality standards.
- Manufactured in Australia under strict quality management procedures.



## ■ PM25/35

- Designed and manufactured to 600V CATIII guidelines.
- Approvals: C tick, CE and IP66 weather rating.
- Designed to meet IEC power quality standards.
- Manufactured in Australia under strict quality management procedures.



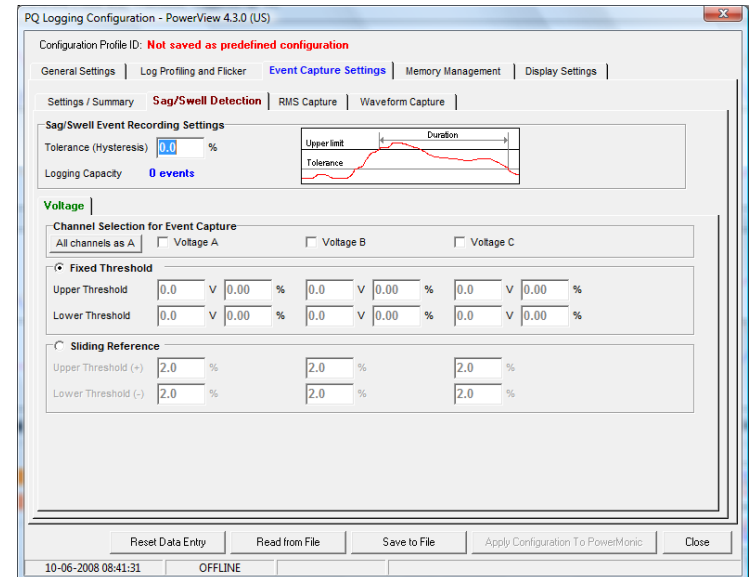
*“CAT IV refers to the power lines at the utility connection, the origin of installation, or service entrance. It includes outdoor overhead and underground cable runs that could be affected by lightning, as well as utility meter locations, and primary breakers or fuses” – [www.powersight.com](http://www.powersight.com)*

## ■ Configuring the PowerMonic:

- Simple intuitive wizard style configuration.
- One program for configuring, download and interpretation.
- Tick box selection with help hints to understand what you are monitoring.
- LCD display options.
- Smart memory management.
- One program for all PM range.
- Licence free to customers.
- Export facility direct to a Excel file in CSV format.
- Save memory configurations.

### Configurations Options

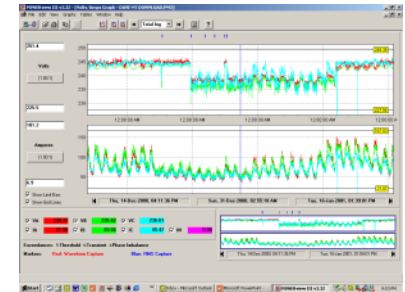
- 4 x Voltage & 4 x Current
- Flicker and Imbalance
- Power Factor
- Total Harmonic Distortion
- Harmonics and Inter-harmonics
- Voltage Connection (Delta/Wye/Split Phase)
- Log Interval (5 sec-4 hrs)



# Ease of Configuring

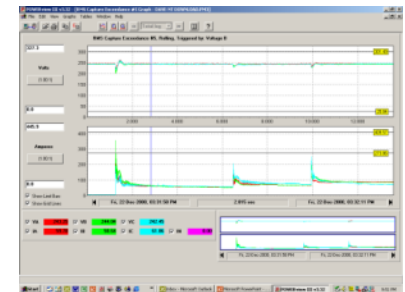
## Power Trending

- Voltage & Current Average/Min/Max
- Power (kW, kVA, KVAR) & Total Power
- Power Factor (TPF, DPF)
- Total Harmonic Distortion (THD-F/THD-R)



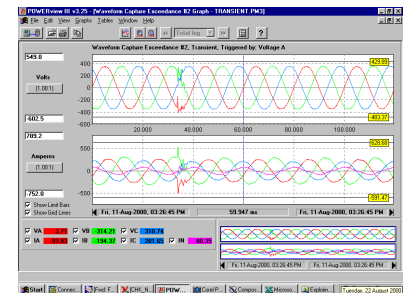
## High Speed Event Recording

- Sag/Swell table capture
- RMS Event Capture (1/2 cycle RMS over 5-30s window)
- Transient Capture (100ms pre-event / 300ms post)
- Independent voltage and current trigger settings



## Power Quality Parameters

- Harmonics (up to 48<sup>th</sup>)
- Harmonic Phase Angles
- Interharmonics
- Flicker (Pst/Plt)
- Voltage & Current Unbalance



## Three Powerful Event Capture Options:

### 1) Sag/Swell table capture:

- Simple and efficient way to capture voltage problems.
- Export data easily to Excel for regulatory report writing.
- Simple 'one click' action to open more event data.

### 2) RMS Event Capture:

- Effective way to capture high speed events such as motor starts & protection operations.
- Half cycle RMS values are recorded over a 5 – 30 second period with adjustable pre-trigger recording.

### 3) Waveform & Transient Capture:

- Capture rapid, high speed events such as capacitor switching, lighting etc.
- Capture event data including 100ms pre-event / 300ms post event data.
- Samples per cycle 170 @ 60Hz and 204 @ 50Hz.





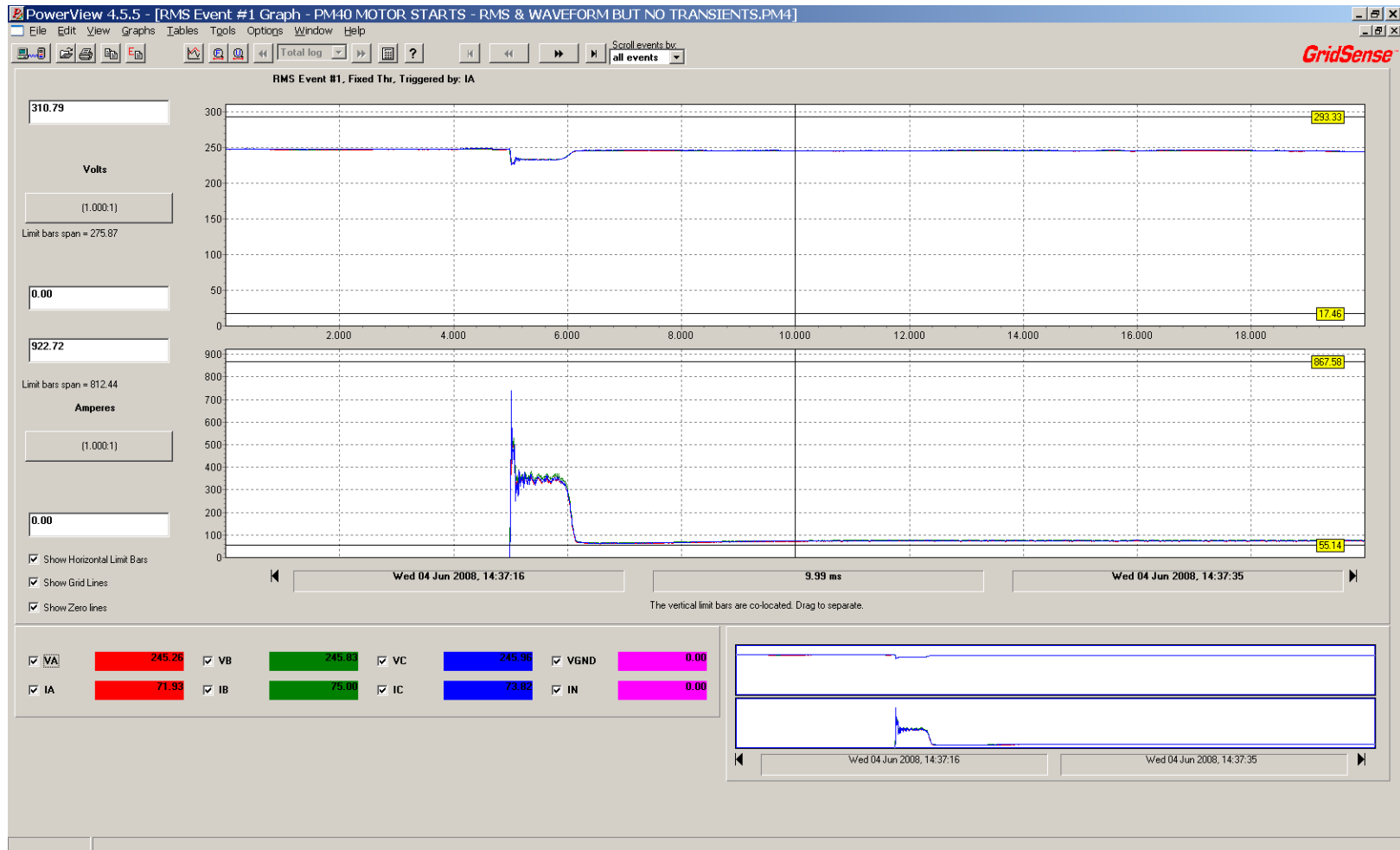
PowerView 4.5.5 - [Sag/Swell Event Summary - PM40 TRANSIENTS.PM4]

File Edit View Graphs Tables Tools Options Window Help

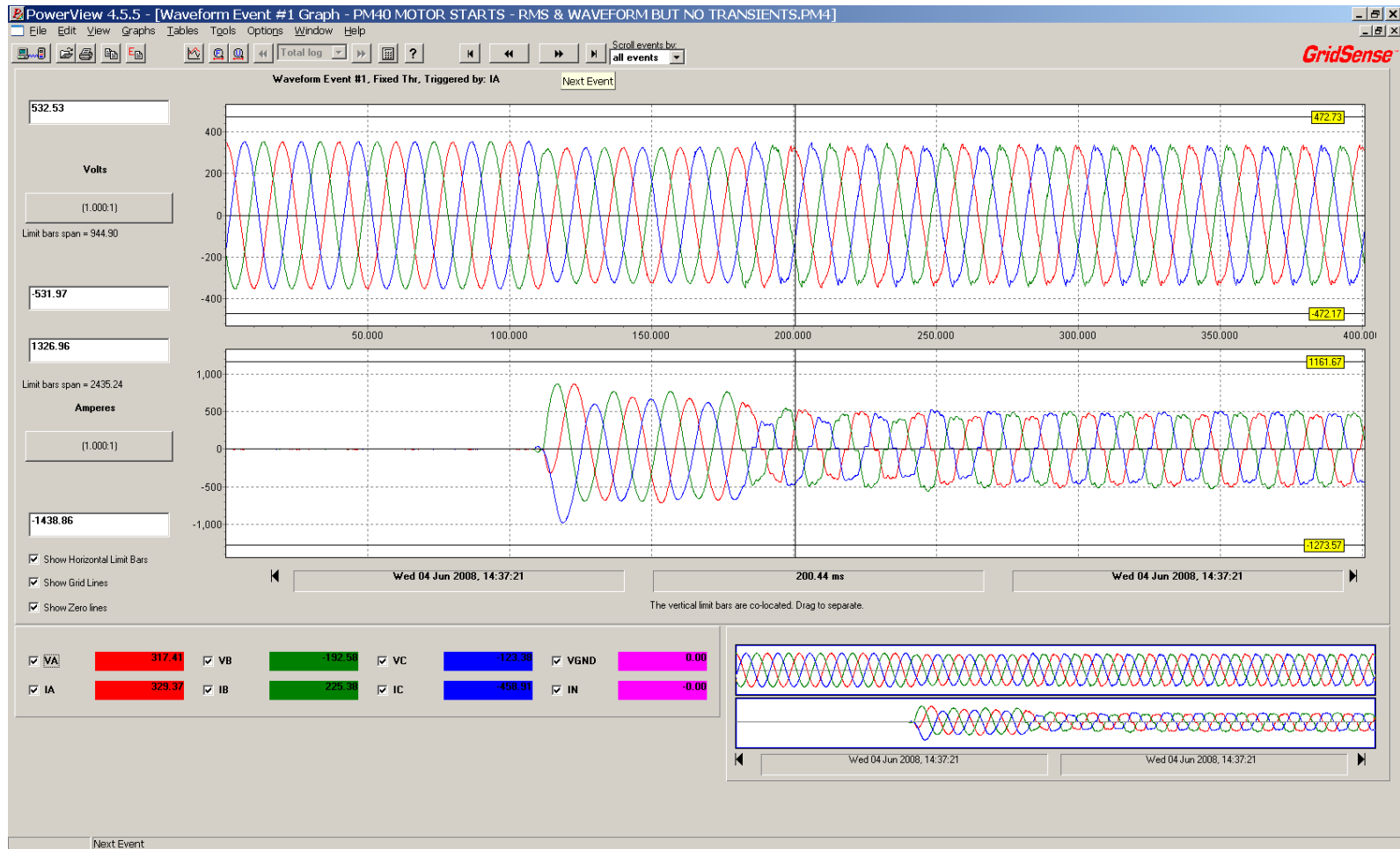
Total log

Rec	Date	Time	Cause	Channel	Dur. (m.s.ms)	Min/Max (V)	Half cycle	Triq type
1	Fri 23 Jan 2009	11:47:22	Swell	VB	09:34.050	248.8	247.6	Fixed Thr
2	Fri 23 Jan 2009	11:47:23	Swell	VC	09:33.720	248.3	247.2	Fixed Thr
3	Fri 23 Jan 2009	12:33:29	Swell	VA	18:03.960	248.2	247.3	Fixed Thr
4	Fri 23 Jan 2009	11:57:13	Swell	VB	54:20.740	250.0	247.3	Fixed Thr
5	Fri 23 Jan 2009	11:57:28	Swell	VC	54:05.010	249.8	247.2	Fixed Thr
6	Fri 23 Jan 2009	12:51:36	Swell	VA	23:27.710	249.3	247.2	Fixed Thr
7	Fri 23 Jan 2009	12:51:35	Swell	VB	23:28.390	250.6	247.2	Fixed Thr
8	Fri 23 Jan 2009	12:51:35	Swell	VC	23:28.370	250.6	247.2	Fixed Thr
9	Fri 23 Jan 2009	13:15:06	Swell	VA	02:06.150	248.0	247.2	Fixed Thr
10	Fri 23 Jan 2009	13:15:06	Swell	VB	02:06.590	249.1	247.4	Fixed Thr
11	Fri 23 Jan 2009	13:15:06	Swell	VC	02:06.590	249.4	247.2	Fixed Thr
12	Fri 23 Jan 2009	13:17:59	Swell	VA	02:45.320	247.9	247.2	Fixed Thr
13	Fri 23 Jan 2009	13:17:15	Swell	VB	03:29.880	249.0	247.3	Fixed Thr
14	Fri 23 Jan 2009	13:17:15	Swell	VC	03:29.880	249.0	247.4	Fixed Thr
15	Fri 23 Jan 2009	13:20:55	Swell	VB	14:08.510	252.1	247.2	Fixed Thr
16	Fri 23 Jan 2009	13:20:53	Swell	VC	14:10.090	252.7	247.2	Fixed Thr
17	Fri 23 Jan 2009	13:45:47	Swell	VA	21:48.970	250.3	247.2	Fixed Thr
18	Fri 23 Jan 2009	13:42:42	Swell	VB	24:53.990	251.6	247.2	Fixed Thr
19	Fri 23 Jan 2009	13:42:42	Swell	VC	24:54.200	251.6	247.2	Fixed Thr
20	Fri 23 Jan 2009	14:29:27	Swell	VA	04:13.680	247.5	247.2	Fixed Thr
21	Fri 23 Jan 2009	14:28:18	Swell	VC	05:23.060	248.5	247.8	Fixed Thr
22	Fri 23 Jan 2009	14:33:41	Sag	VA	00:29.380	0.0	19.0	Fixed Thr
23	Fri 23 Jan 2009	14:33:41	Sag	VC	00:29.380	0.0	82.5	Fixed Thr
24	Fri 23 Jan 2009	14:34:10	Swell	VA	00:27.000	249.4	247.4	Fixed Thr

## Sag/Swell Table Capture



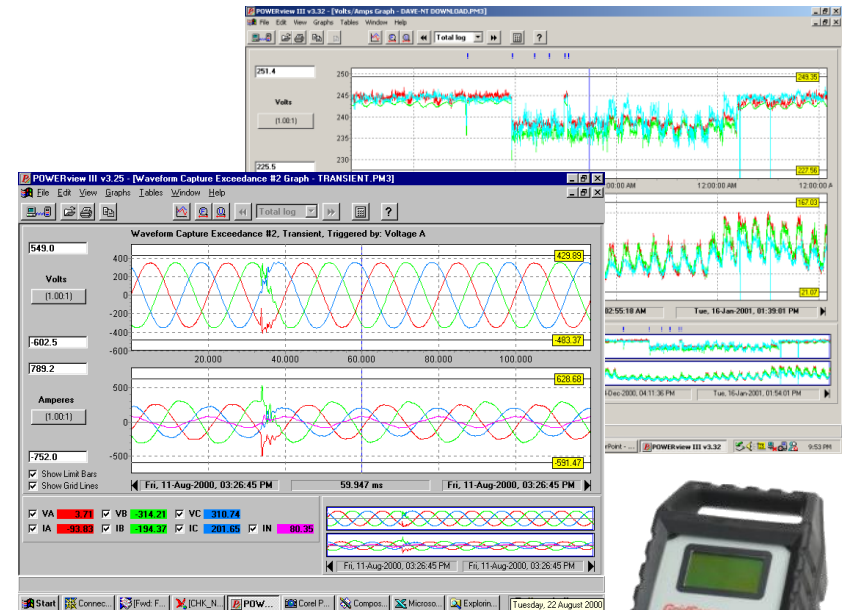
## RMS Capture



## Waveform Capture

## ■ Applications

- Voltage investigations
- Power surveys
- Power quality surveys
- Disturbance monitoring and analysis
- Power factor correction
- Demand side management and planning
- Process control and plant monitoring





## ▪ PowerMonic

- Focussed on utility company needs and applications.
- Proven, reliable product with over ten years field experience.
- Truly weatherproof and robust for use in any environment.
- Intuitive design with best in class software.
- Built to meet tough global specifications both in safety and monitoring.

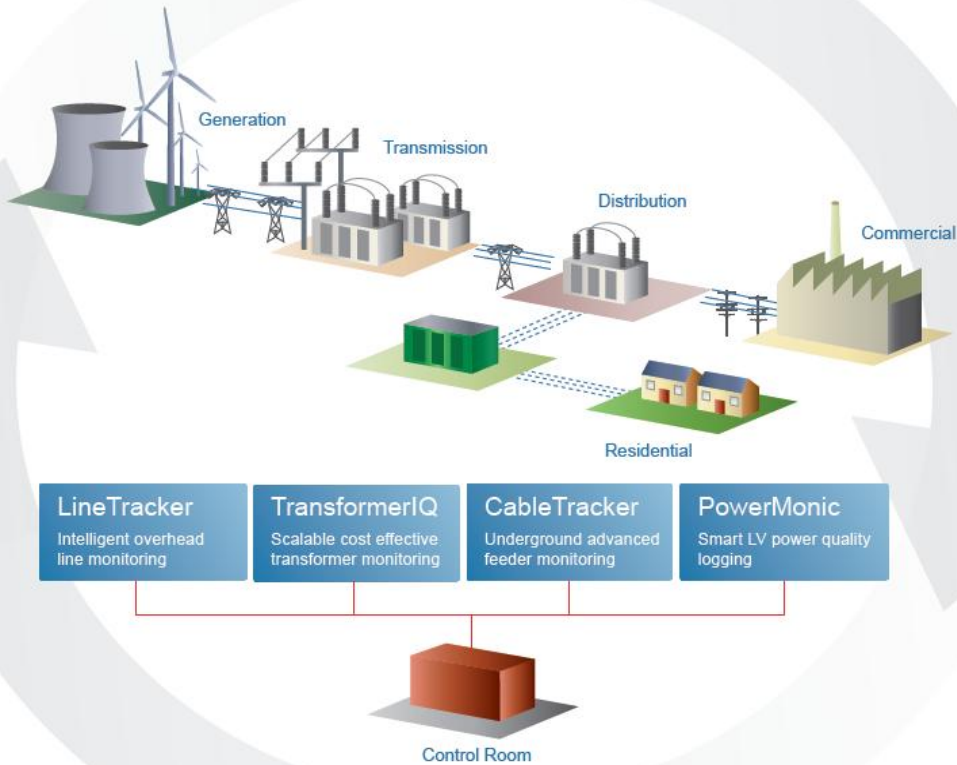
## ▪ GridSense

- Industry specialist with over 30 years experience.
- Customer feedback used to create intuitive smart utility solutions.
- Product currently used by major global organisations including:

- PG&E
- GEORGIA POWER
- COUNTRY ENERGY
- SCOTTISH POWER
- UNITED NATIONS
- GENERAL MOTORS
- ESKOM
- ENERGY AUSTRALIA

*'GridSense have sold over 2,000 PowerMonic units around the globe. They are currently used in every major continent'*





**LineTracker**  
Intelligent Grid Monitoring

**TRANSFORMERIQ**  
Intelligent Affordable Monitoring

**CableTracker**  
Smart Substation Monitoring

**PowerMonic**  
Portable Power Monitoring

**LiveLine**  
Intelligent Network Maintenance



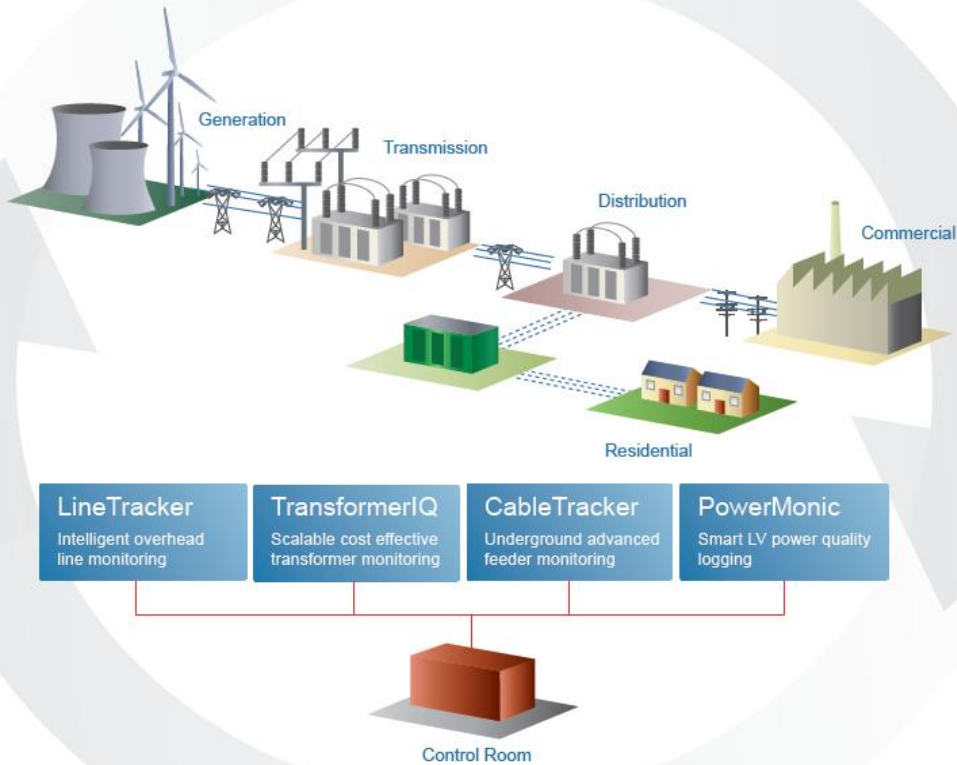
## ■ Transformer IQ

- Flexible and cost effective solution for bringing instant intelligence to your networks transformers.
- Can be used in conjunction with other GridSense solutions to provide 360 degree network coverage.
- Scalable solution that can be installed on existing on new infrastructure to provide a wide range of monitoring options.
- International standard communication protocols provides remote connection to SCADA/Control Rooms.

## ■ GridSense

- Industry specialist with over 30 years experience.
- Customer feedback used to create intuitive smart utility solutions.
- Product currently used by major global organisations including:
  - Florida Power & Light (USA)
  - Portland Gas & Electric (USA)
  - PowerCor (Australia)
  - ETSA (Australia)





**LineTracker**  
Intelligent Grid Monitoring

**TRANSFORMERIQ**  
Intelligent Affordable Monitoring

**CableTracker**  
Smart Substation Monitoring

**PowerMonic**  
Portable Power Monitoring

**LiveLine**  
Intelligent Network Maintenance





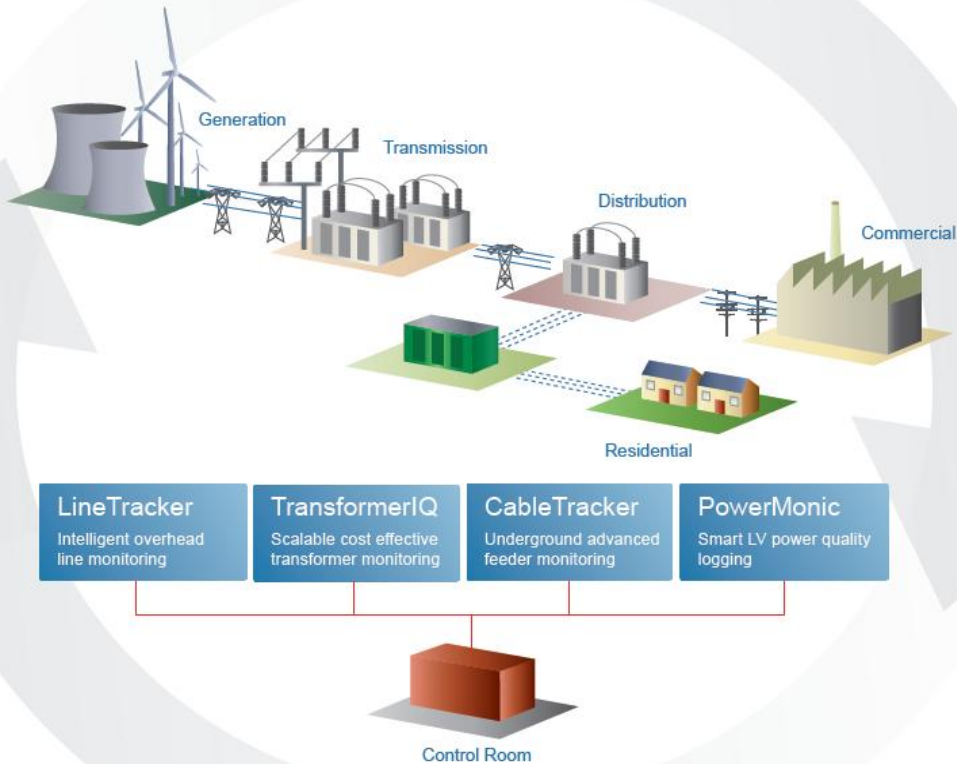
# CableTracker

Smart Substation Monitoring

# Coming soon!

GridSense CableTracker offers multi channel logging and monitoring capability for connection in pad mount/kiosk substations. Details and specs to be released late 2010!





**LineTracker**  
Intelligent Grid Monitoring

**TRANSFORMERIQ**  
Intelligent Affordable Monitoring

**CableTracker**  
Smart Substation Monitoring

**PowerMonic**  
Portable Power Monitoring

**LiveLine**  
Intelligent Network Maintenance



# LiveLine

## Intelligent Network Maintenance

- ✓ Rapid deployment via hotstick
- ✓ Rated for use up to 235kV
- ✓ High quality wireless image
- ✓ One-touch built in image capture
- ✓ Portable, rugged and weatherproof
- ✓ Built-in high intensity LED lights



## ▪ PRODUCT BACK GROUND

- The LiveLine camera was developed to enable utilities to inspect live energized assets in a safe and cost effective manner.
- Widely adopted throughout North America, Oceania, Asia Pacific & Europe.
- Robust Australian design & manufacturing.

## ▪ FUNTIONALITY & BENEFITS

**The LiveLine inspection camera can be used to safely inspect assets including:**

- Pole top transformers and switch gear.
- Fault finding assessing assets for visible damage.
- Using in conjunction with thermal imaging camera to investigate a hot spot detected.
- Reading name plates and serial / part numbers of installed equipment prior to replacement or maintenance.
- Monitoring gauges, meters and levels.

