

A woman with long dark hair, wearing a grey jacket, is shown in profile, looking towards the left. She is in a control room or monitoring station, with several computer monitors in the background. The monitors display various technical data, including graphs, charts, and diagrams. The word "SAFETY" is overlaid in large, bold, green letters across the center of the image.

SAFETY

Continuous Thermal Monitoring

Peace of mind thanks to condition-based monitoring of MV & LV switchgear

Ken Box, P.E.

Thermal Monitoring is a timely and relevant topic

Enabling Predictive Maintenance Using Condition Monitoring Course Launch

- 10:00am CT

Live Q&A following the presentation

REGISTER

This session is sponsored by: HID

Fundamentals of Vibration-Based Condition Monitoring Course Launch -

12:00pm CT Live Q&A following the presentation

REGISTER

This session is sponsored by: HID

Using Wireless Sensors and Real-Time Data to Improve Maintenance

Practices Course Launch - 2:00pm CT

Live Q&A following the presentation

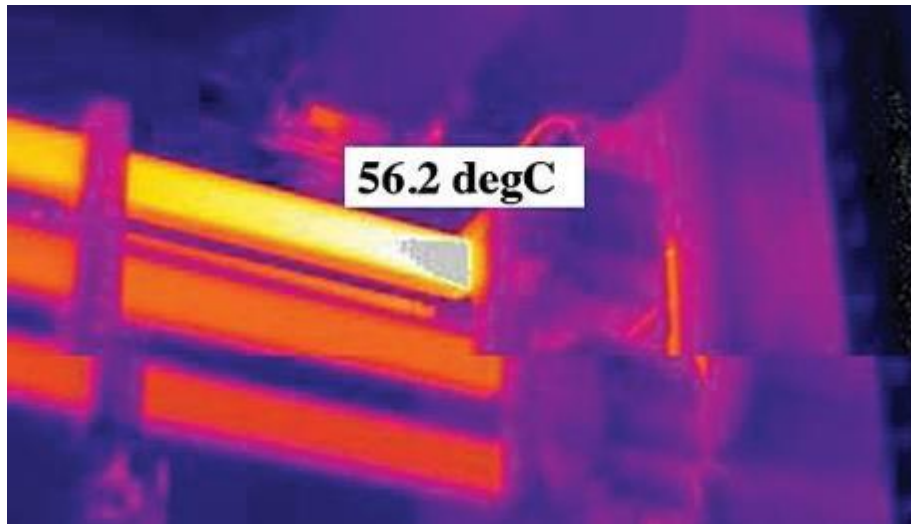
REGISTER

Outstanding applications in maintenance and quality 4.0 Course Launch -

3:00pm CT

Live discussion forum following the presentation

REGISTER



Life Is On

Schneider
Electric

"It Wasn't Supposed to Happen"- Atlanta's Hartsfield-Jackson Airport Fire

- *We know there was a failure in the switchgear that caused the fire that absolutely created the issue,"* said Paul Bowers, president and CEO of Georgia Power, speaking on ABC's *Good Morning-America* Monday morning.



Would Periodic IR Scanning Have Prevented the HJIA Cable Fire?

“Root cause for airport outage still a mystery for Georgia Power”

Atlanta Journal-Constitution, January 25, 2018 by Anastacia Ondieki

- *Georgia Power said visual inspections of the underground cables and switches was last conducted a month before the incident. The underground system was installed between 1985 and 1988 and the company said it conducts visual and infrared inspections on the equipment at the tunnel every 12 to 18 months.*
- *The fire which occurred in an underground tunnel that runs cables that supply power to the main terminal, concourses and the plane train disrupted operations during the busiest travel season. Power delivery to the Control Tower and the North Airfield Lighting vault was also affected.*

Faulty connections are a major cause of electrical equipment failures

Critical connections in the field :

- Cable connections
- Withdrawable breaker connections
- Bus bar connections
- Transformer connection

Continuous thermal monitoring for early detection

- 24/7/365 monitoring
- Prevent unscheduled downtime
- Increase operator and equipment safety
- Optimize maintenance: from **time** based to **condition** based maintenance
- no more need for periodic thermography



Local and remote alarming based on wireless and battery less sensors

Remote connection to

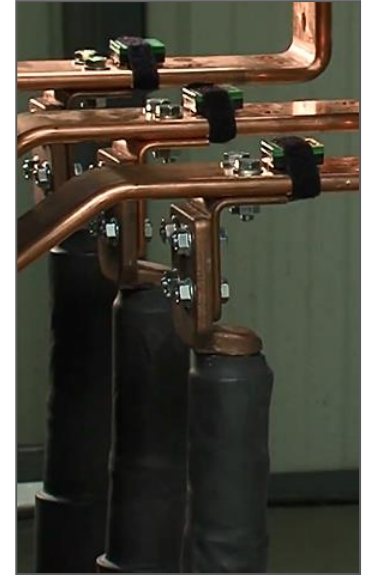
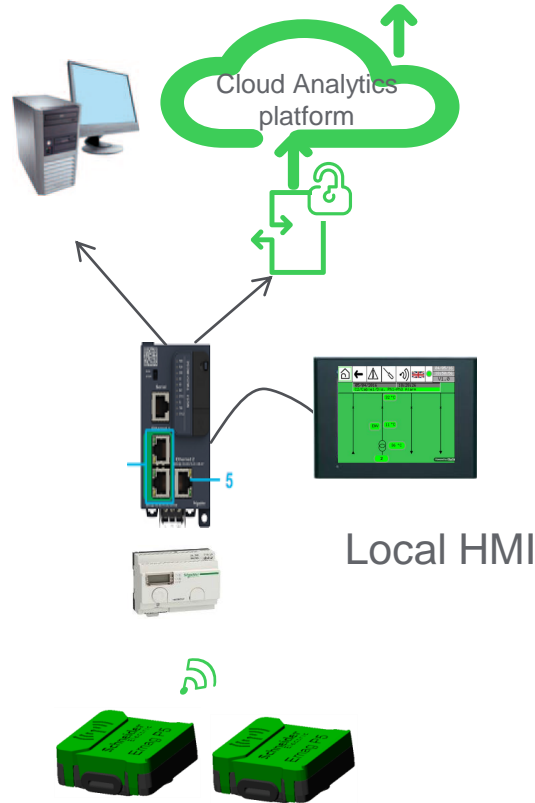
- SCADA, BMS
- Enable advanced services

Switchgear Monitoring Device :

- In busway, switchgear, transformers, MCCs
- Algorithm => Local alarming

Thermal sensors :

- Measurement of critical point



What's in it for your client?

- Wireless sensor
- Self powered sensor
- Small size sensor
- In contact of measured point
- Algorithms based on cubicle characteristics
- Dedicated HMI
- Ethernet communication
- SMS (texting)

Easy installation for new and retrofit

No battery

Monitoring of all **critical points**

Accurate monitoring

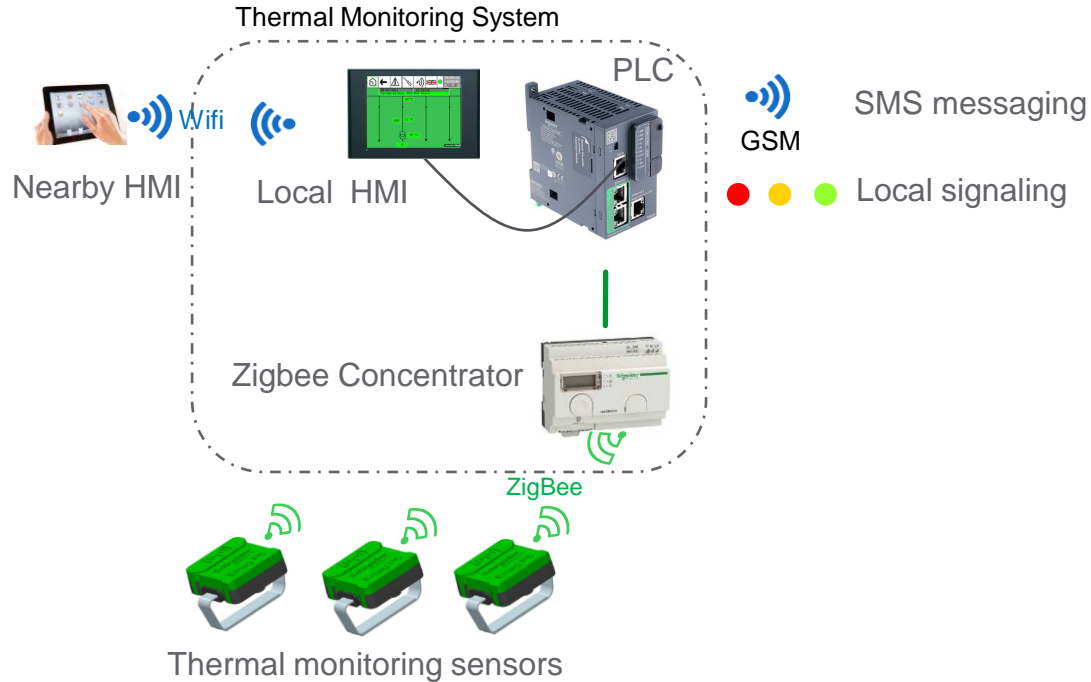
Early detection

Easy identification of bad connections

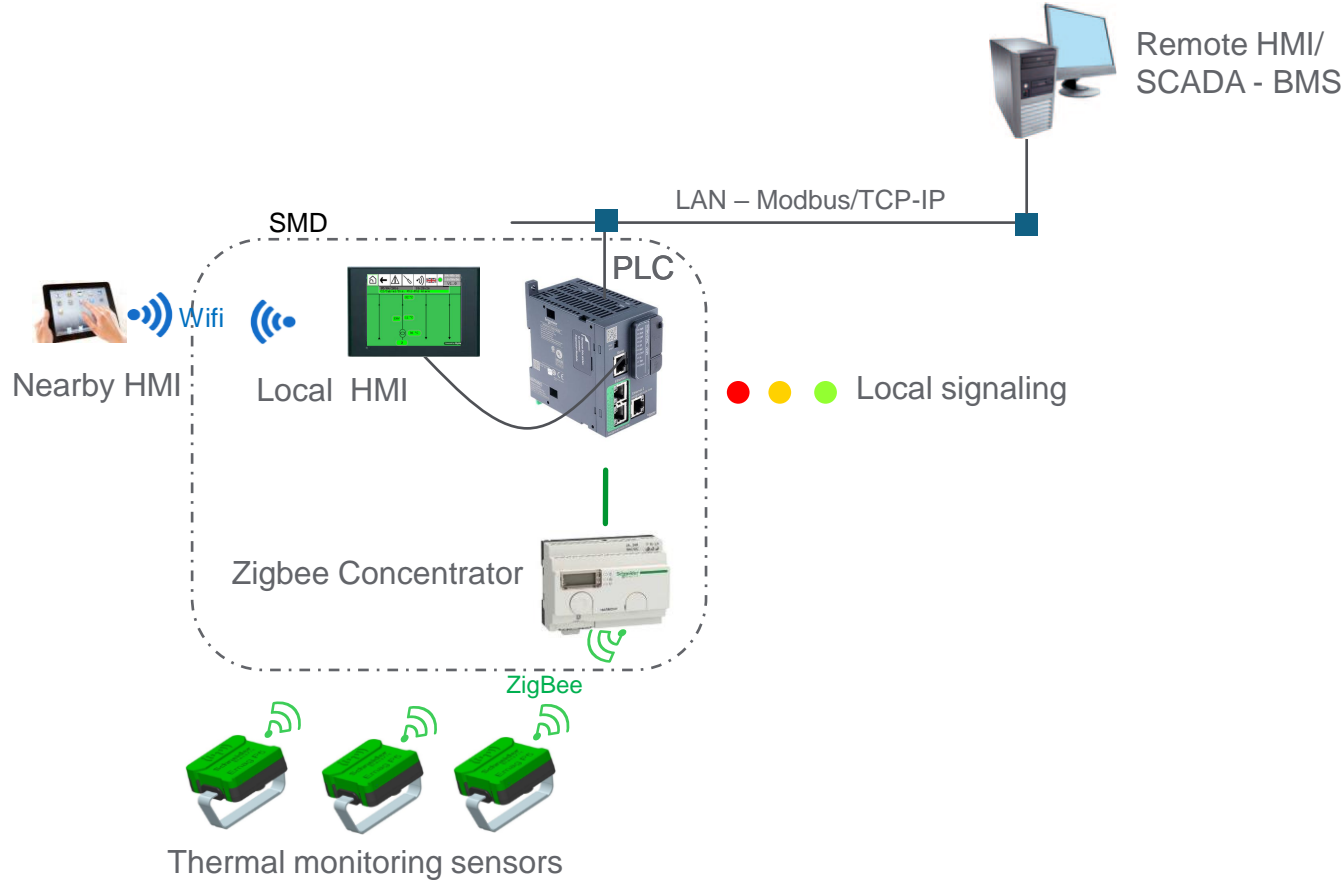
Remote monitoring and **alarming**

Simple **7x24 alarming**

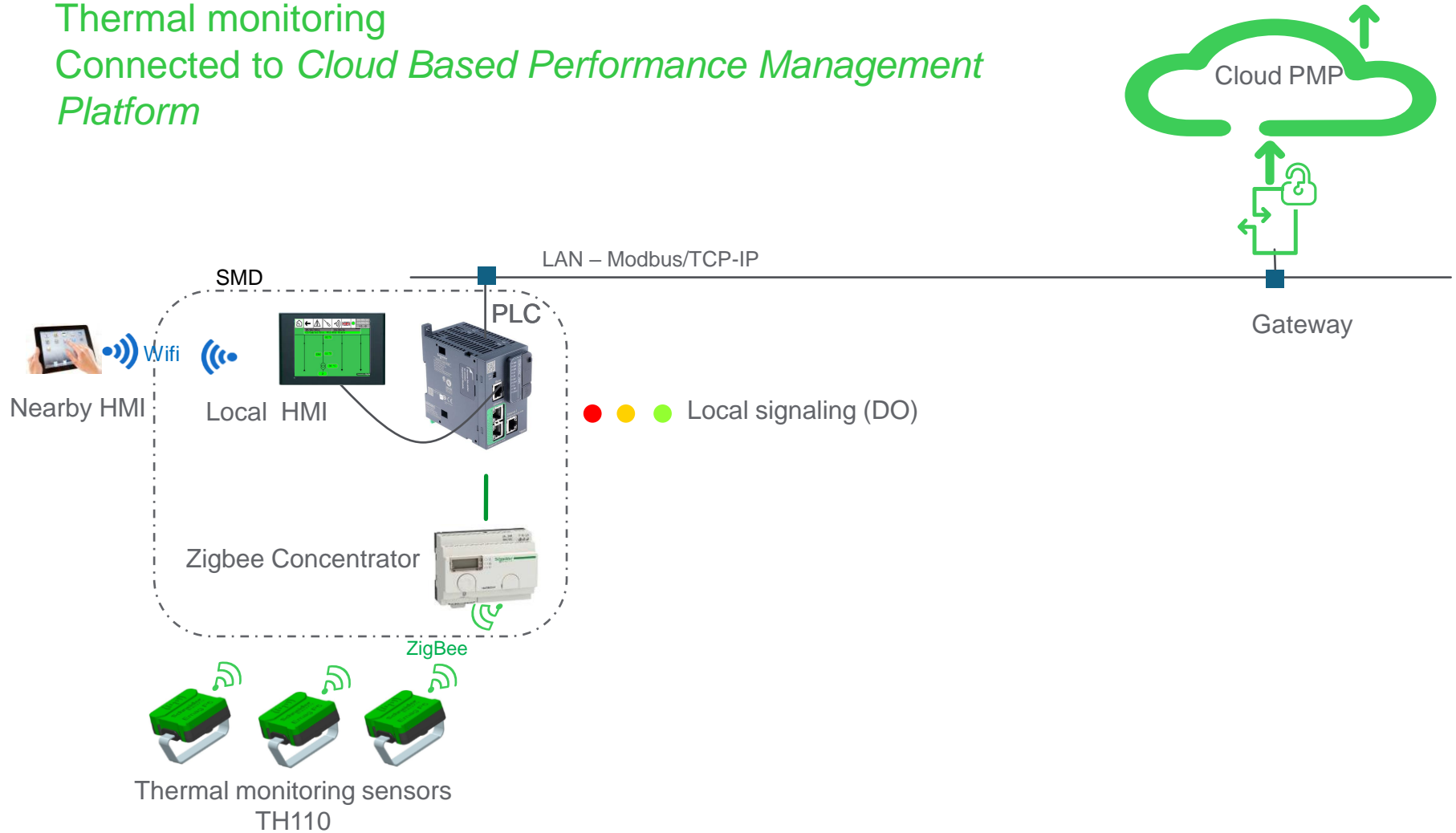
Thermal monitoring – Stand alone system with SMS alarming



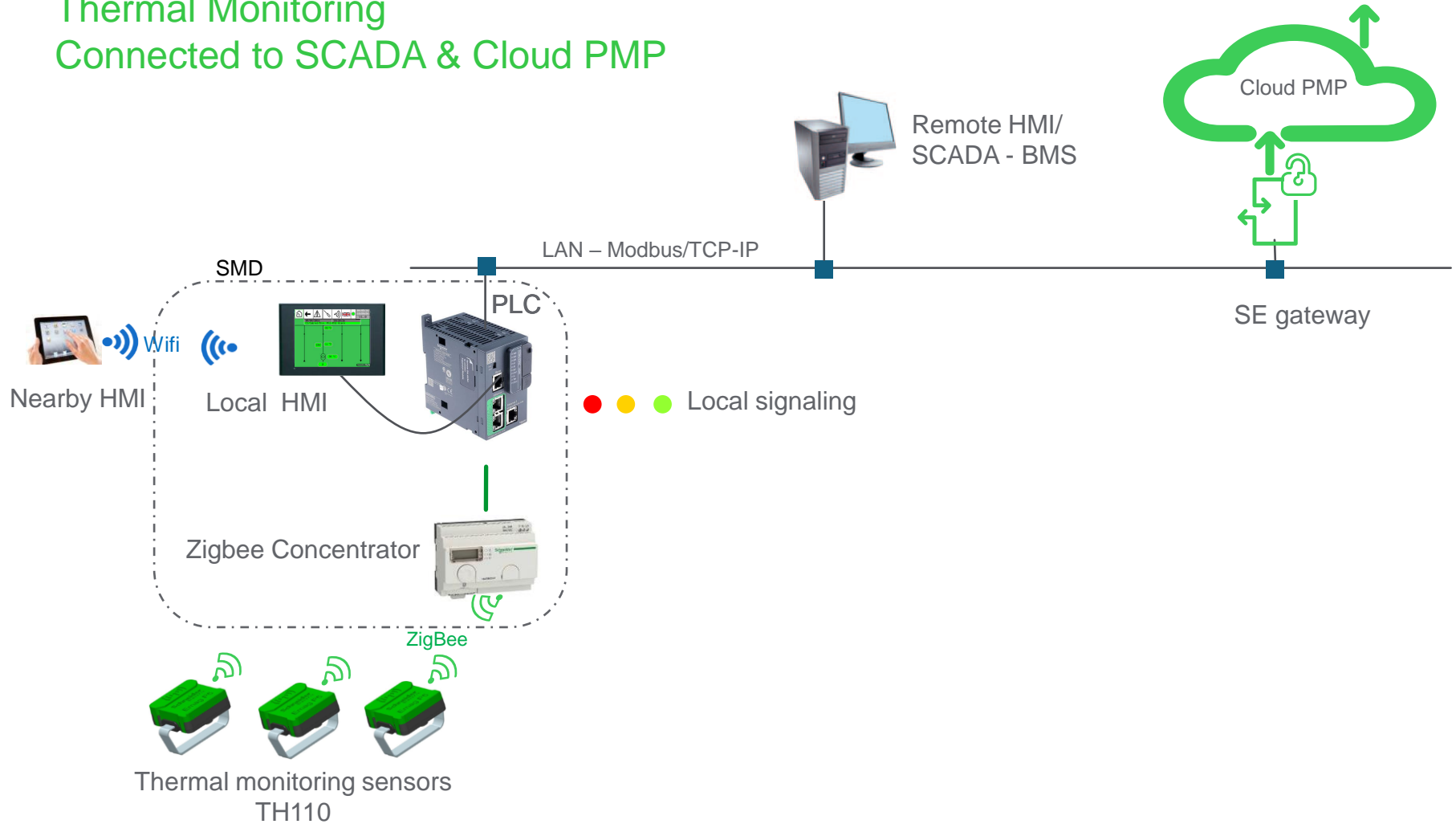
Thermal Monitoring System Connected to Remote HMI/ SCADA



Thermal monitoring Connected to *Cloud Based Performance Management Platform*

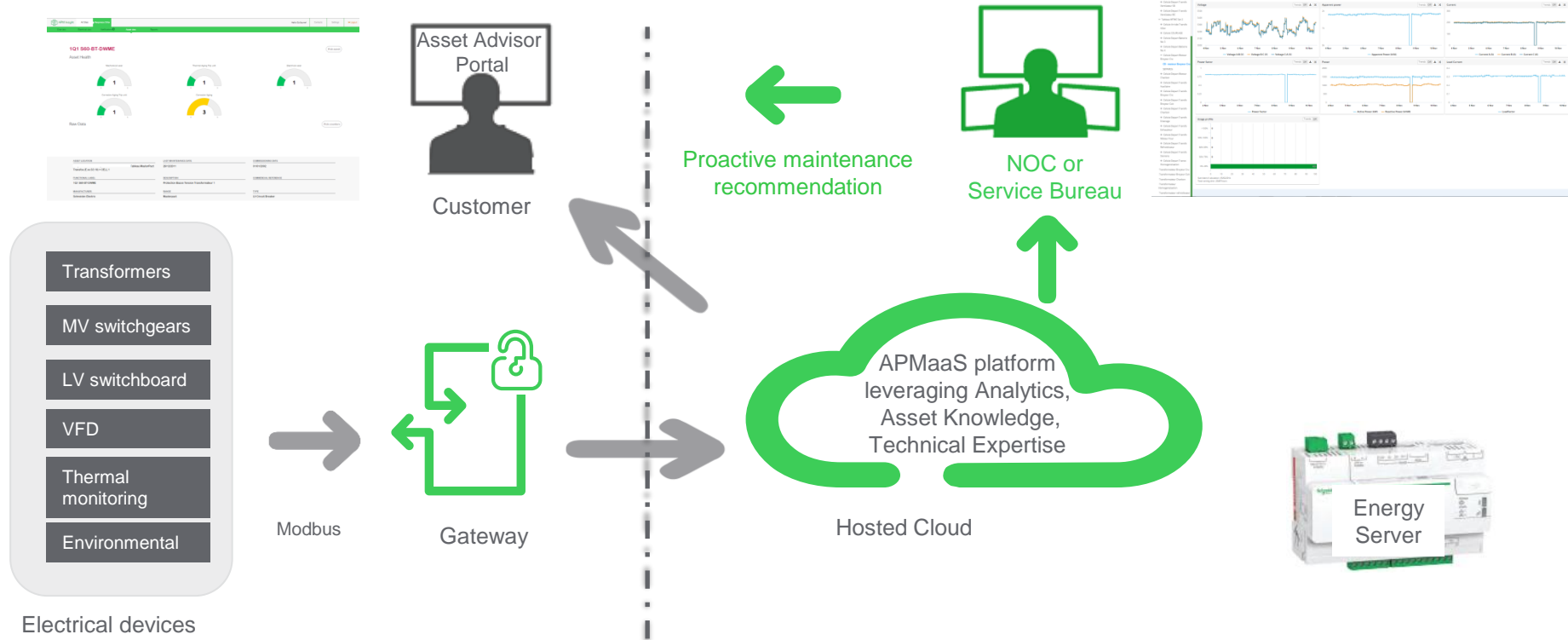


Thermal Monitoring Connected to SCADA & Cloud PMP



“Asset Advisory” Software in the Cloud – “Your Built in Doctor”

End-to-end service supported by experts and platform to provide actionable maintenance recommendations up to action on site



Modern infrastructure for modern times – IoT 4.0

Connected Medium Voltage Electrical Distribution Equipment Choices

- Busbar connections
- Busbar at power cable connections



Air Insulated MV Switchgear

- Busbar connections
- Power cable connections



Gas Insulated MV Switchgear

- Busbar connections
- Power cable connections



Shielded Solid Insulated Switchgear

- Busbar at power cable connections



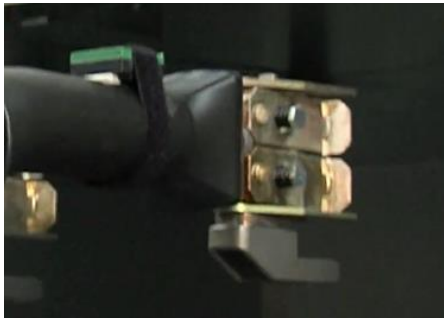
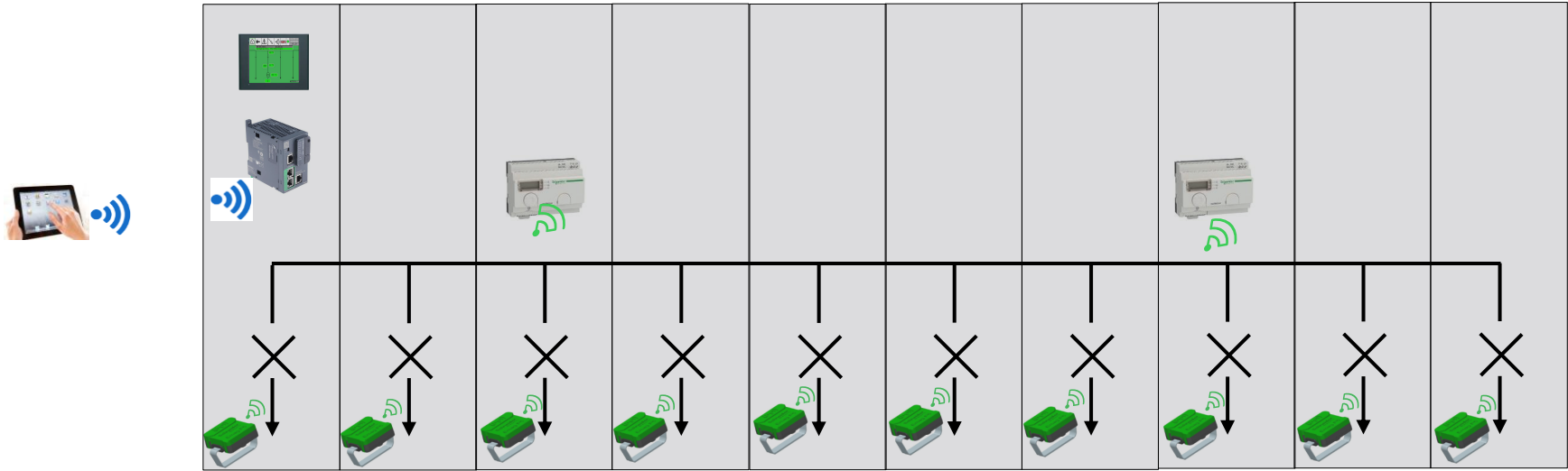
Low Voltage Draw Out Switchgear

- Busbar junctions
- Tap-off units



Busway

Thermal Monitoring – Example of 10 MV Switchgear Cubicles



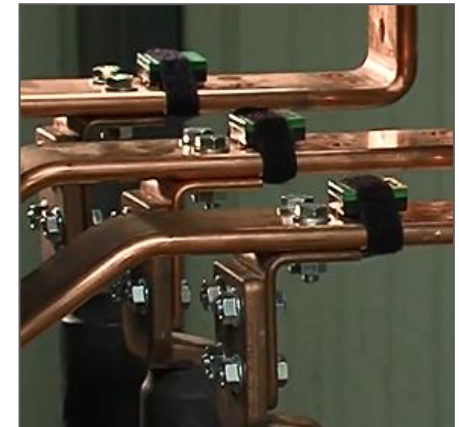
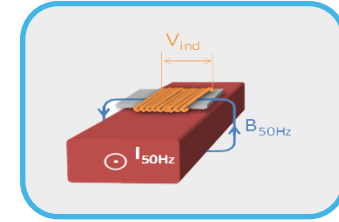
- temperature sensors (inside MV compartments)
- 2 concentrators (inside LV cabinet)
- 1 PLC (inside LV cabinet)
- 1 HMI (front face of main LV cabinet)
- nearby monitoring (on any smart phone, tablet)

(1 concentrator for 60 sensors)

Battery free and wireless thermal sensor

Characteristics

| | |
|----------------------------|--|
| Power supply | Energy harvested from power circuit by magneto-generator based on solenoid coil and ferromagnetic core |
| Minimum activation current | 5A |
| Metering principle | Thermistor |
| Accuracy | +/- 2°C |
| Temperature Range | -25°C +150°C (5X at max T) |
| Transmission period | 60 s |
| Wireless Communication | ZigBee Green Power 2,4GHz |
| Emission power | 0 dBm |
| Dimension | 31x31x13 mm (1.23 x 1.23 x .52 inches) |



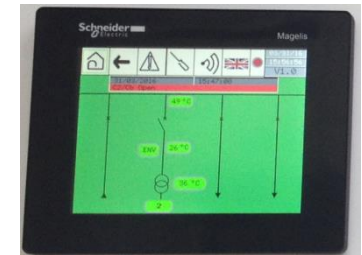
Substation Monitoring Device Characteristics

Characteristics

| | |
|----------------|---|
| Functions | Thermal monitoring of connections Local and remote alarming |
| Power Supply | 24Vdc |
| Inputs/outputs | 3 Digital outputs for local signaling |
| Communication | Modbus TCP/IP for remote interface (*) Modbus serial line for relays communication (*) GSM for SMS transmission (*) Wi-Fi for nearby HMI (*) Zigbee Green Power for sensors |
| HMI | Local color display (on cubicle) |



PLC



Local HMI

Thermal monitoring algorithms

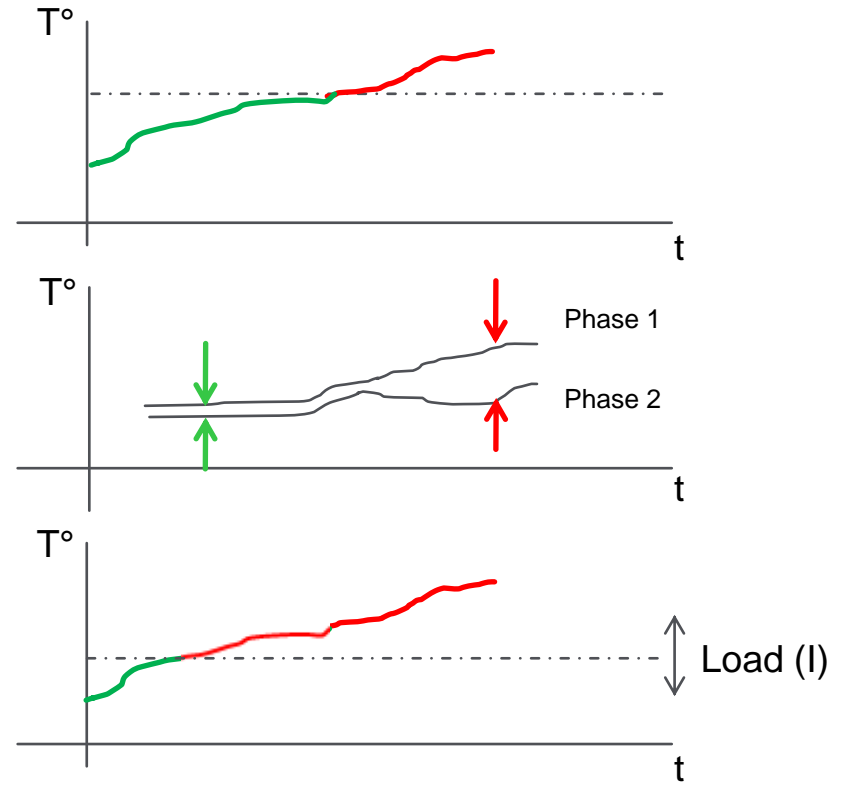
Tracking faulty electrical connection (cable, bus bar, CB)

Basic

- **Absolute temperature threshold**
 - Detection of hot point
 - Threshold is based on installation characteristic
- **Phase comparison**
 - Detection of one phase evolution

Advanced

- **Predictive threshold**
 - Detection even at low load before any trouble
 - Threshold adapted in regards of load (I)



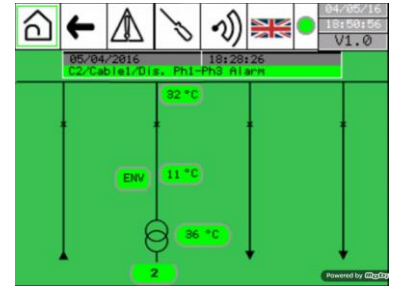
HMI for Local Alarming

- **HMI Color display**

- Synthetic temperature value presented on single line diagram
- Detailed information for each cubicle, transformer
- Navigation thanks to touchscreen
- Warning (Yellow) and Alarm (Red) notification
- **Nearby HMI on mobile or tablet as an option**

- **Red / Yellow / Green digital outputs**

- Give a synthetic level of alarm
- Interface to local lights, RTU, Alarm display panel,...



04/05/16 18:51:09 V1.0
05/04/2016 18:28:26
C2/Cable1/Dis. Ph1-Ph3 Alarm

Cubicles: 2

| | PH 1 | PH 2 | PH 3 | Dis |
|------------|------|------|------|-----|
| Busbar °C | 30 | 32 | 31 | |
| CB Up °C | | | | |
| CB Down °C | | | | |
| Cable 1 °C | 11 | 8 | 8 | |
| Cable 2 °C | | | | |

Powered by QZ

04/05/16 18:54:04 V1.0

| | | | |
|------------------------------|----------|-------|---|
| C2/Cable1/Dis. Ph1-Ph2 Alarm | 05/04/16 | 18:28 | ▲ |
| C2/Cable1/Dis. Ph1-Ph3 Alarm | 05/04/16 | 18:40 | ▲ |
| C2/Cable1/Dis. Ph1-Ph3 Alarm | 05/04/16 | 18:40 | ▲ |
| C2/Cable1/Dis. Ph1-Ph3 Alarm | 05/04/16 | 18:40 | ▲ |
| C2/Cable1/Dis. Ph1-Ph2 Alarm | 05/04/16 | 18:48 | ▲ |
| C2/Cable1/Dis. Ph1-Ph3 Alarm | 05/04/16 | 18:48 | ▲ |

Powered by QZ

Interface for Remote Alarming

- **Alarming thanks to “SMART” mobile application**

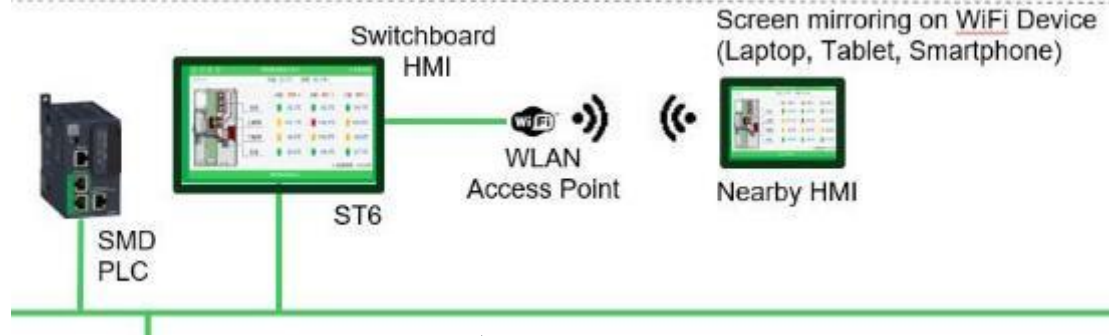
- It is a digitized maintenance log-book
- Alarm notification on a mobile device or emails to maintenance team

- **Alarming through SMS**

- Alarm and warning generate SMS to one number

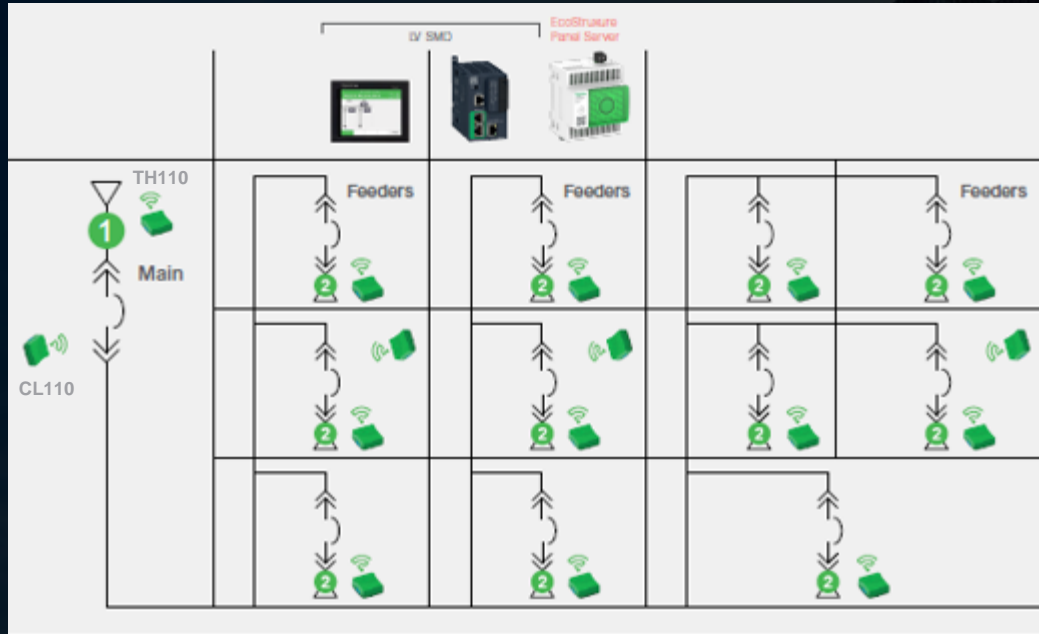
- **Remote connection for SCADA or service**

- All temperature and alarms
- Modbus/TCP-IP protocol



LV Switchgear ANSI C37.20.1/UL-1558

Factory Assembled Solution



| | | | | | |
|-------|---|---|---|---|---|
| TH110 | 3 | 9 | 9 | 9 | 6 |
| CL110 | 1 | 1 | 1 | 1 | 1 |

Providing info that was hidden before

Up to 60 sensors per Server/Concentrator to monitor Field Connections

- 1 Incoming Phase Connections of Main Breaker(s)
- 2 Outgoing Phase Connections of Feeder Breakers

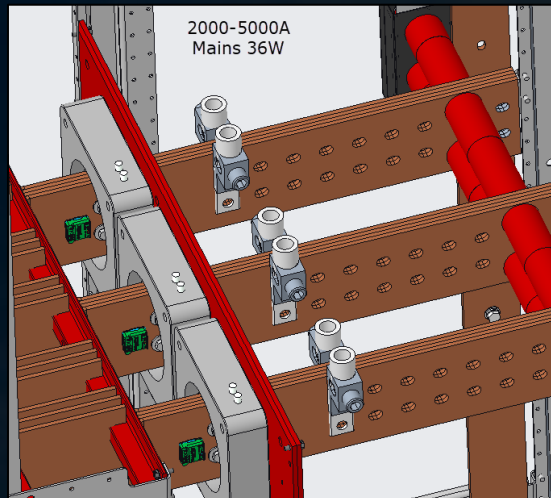
Note:

- Not available on Busduct or Close Coupled Transformer connections nor bus splices or joints since they aren't cables and are considered maintenance free joints when torqued with spring loaded washers
- Must reserve space to prevent Concentrator from being farther away than 2 sections from farthest sensor. Zigbee Concentrator can be in A-D cell but can be no farther away from sensors than 2 sections. (i.e. Section 1 for 1-3 section lineup, section 3 for 4-5 section lineup, section 3 and 6 for 1-8 sections, sections 3 and 8 for 9-10 section lineup.

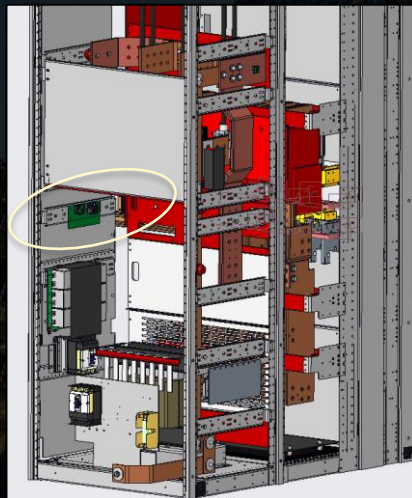
LV Switchgear ANSI C37.20.1/UL-1558

Sensor Placement

Mains Section

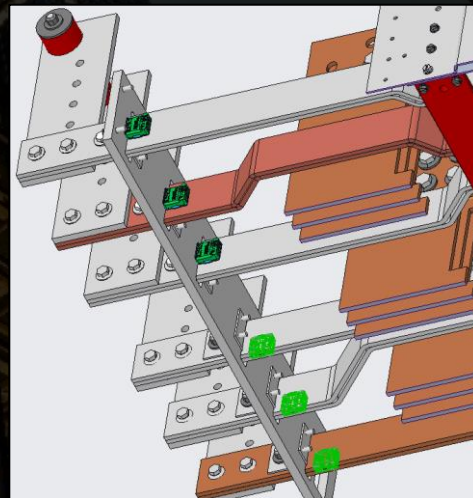


TH110

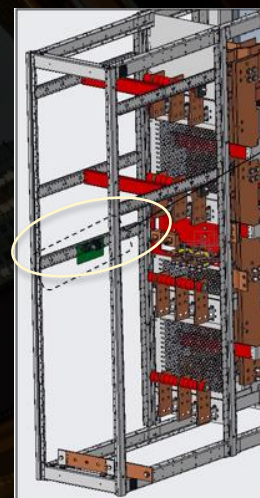


CL110

Feeder Section



TH110



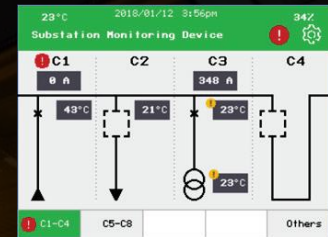
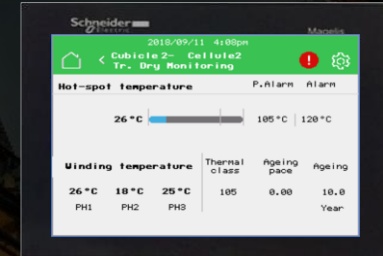
CL110

Digital Local Thermal Monitoring

Enabling your Connected Equipment

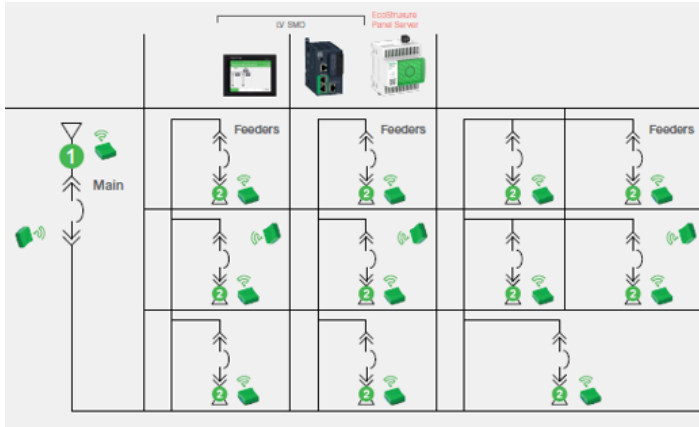
Local HMI

- Door mounted HMI and local Pilot Lights
 - Green = No Alarms
 - Amber = Pre-alarm
 - Red = Alarm
 - Contact output available
- Local, cost-effective real-time monitoring and Alarming.
- Single Line Diagram representation with temperature values and journal of alarm on color display



Conventional IR Window Cost

CTM vs. IR is about \$3,500 more.



- Each vertical section gets (2)-IR windows in the rear.
- A double with section gets 4 windows.
- \$1,600 installed cost per window.
- \$16,000 installed cost.
- Add cost of professional service to scan and prepare a written report. ~ \$2,500.
- CTM pays for itself in year 2 or the next time you would have conducted IR scanning.

Price for LVDO Continuous Thermal Monitoring

- Price for Continuous Thermal Monitoring Pretested: Local HMI, SMD, Zigbee Concentrator, Sensors

+Thermal Sensor Adder per Breaker = \$850 net

+Adder per 5 Sections (accounts for SMD/Concentrator) = \$8,500

+Moisture Sensor Adder per Section = \$850 Net

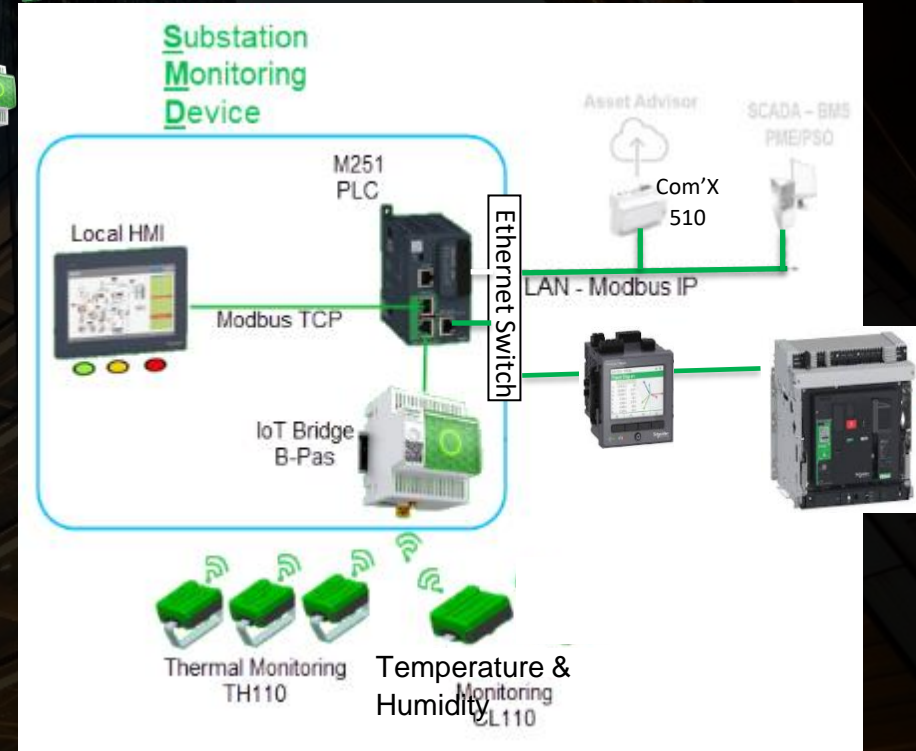
+Adder for Local HMI = \$3000 Net



- Optional Price for Cloud Gateway Adder per Lineup = \$2000 net to allow connection to APMaaS in the Cloud, otherwise you get one Ethernet (Modbus TCP/IP) connection

- Optional Price for an Ethernet Switch if lineup has comms already for Breaker/Meters network

- Total \$21,700, w/o moisture sensors, \$25,100 with moisture sensors. Add \$2000 for the APMaaS Cloud package.



What About UL 891 Switchboards?

- Not practical for group mounted feeder breakers.
- (9) feeder breakers will require (27) – thermal sensors assuming one conductor per phase.
- Add neutral connections and your total is now 54 sensors.
- It's gets expensive quickly.





Busway Thermal Monitoring

Wireless Sensors for 24/7 Busway Monitoring

Risk Control Bulletin-Low Voltage Busway Systems

CNA Insurance Companies

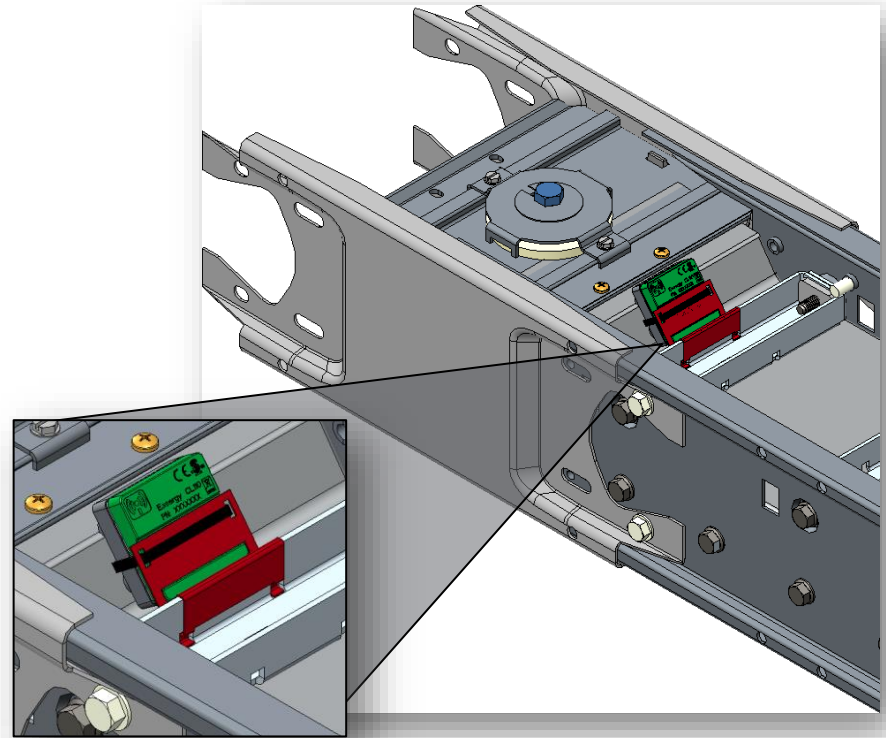
- **Lack of a formal Electrical Preventive Maintenance program.**
- Excessive ambient temperature accelerates the rate of insulation degradation.
- Excessive internal temperatures due to high resistance at loose connections.
- Contamination by water or condensation causing corrosion and high resistance at connection points ultimately damaging insulation.
- Dirt and/or dust leading to arc flashover
- Improper or inadequately supported busway
- Misalignment; improper installation, such as loosening of bolts; improper vertical support, creating permanent deformation of the busway due to bowing.
- Uneven pressure or expansion forces cause the busway to bend at “weak points.”
- Thermal expansion
- Increased loads from original design.

https://www.cna.com/web/wcm/connect/fab67ce0-bffe-49f2-b2a4-ea6e9e733d76/RC_Bul_Prop_EB_LowVoltageBusway_CNA.pdf?MOD=AJPERES&ContentCache=NONE&CACHEID=fab67ce0-bffe-49f2-b2a4-ea6e9e733d76

Busway Thermal Monitoring

Providing Valuable Insight

- Become more proactive in managing Busway systems
 - Ensures proper torque on connections
 - Monitors bus joints 24/7
 - Eliminate Infrared Scans in hard-to-reach areas
 - Can be used within existing systems to provide early notification of changes
 - Establish baseline based on utilization (loads)
 - Can be combined with load profile, ambient temp and humidity to provide context in the analysis



- Bus Joints
- Bus Plugs

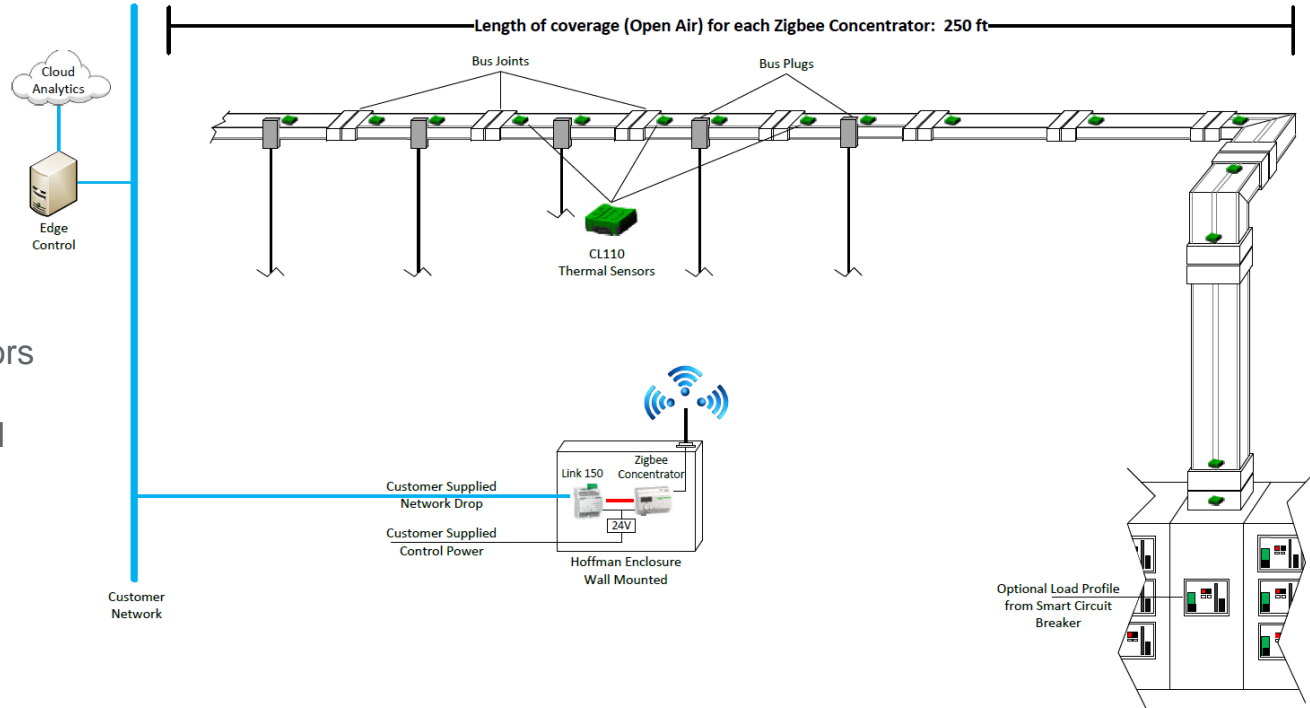
Busway Thermal Monitoring

What impacts the price?

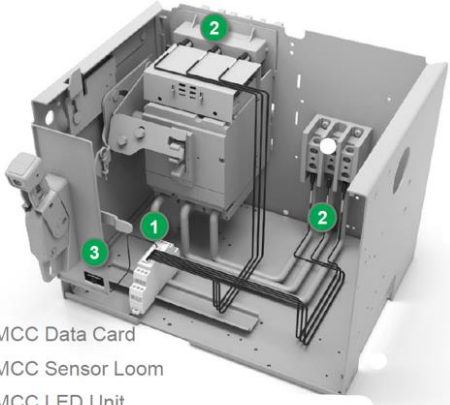
- Access to Busway
- Number of Bus Plugs
- Length of Busway
- Scope of Project
 - Number of Zigbee Concentrators required
 - Each Zigbee can accommodate (60) Sensors
- On-site installation support
- Cloud / Edge Control / Local Monitoring

Customer to Supply:

- Network Drop
- Control Power
- Any programming to an existing system (if connected to Edge Control)



Motor Control Center Thermal Monitoring



- 1 MCC Data Card
- 2 MCC Sensor Loom
- 3 MCC LED Unit

MCC Bucket



11 Section MCC

Evolution of Thermal Monitoring

Resolving Industry Challenges



Factors that put critical MCC applications at risk

- The impact of constant thermal cycling on the joints
- Weakening of spring-type connectors (jaws)
- The high number of site made terminations
- Difficult to monitor thermal data at multiple locations
- Limited Thermography Tests or other measurement procedures
- Addition of IR windows are costly and require periodic manual use

Traditional Thermal Imaging

| | |
|-----------------------|--|
| <i>Inspection</i> | 1 /365 = <0.01% available time |
| <i>Low Load</i> | Extremely difficult to detect faults |
| <i>Position/ View</i> | External / Limited |
| <i>Maintenance</i> | Intrusive Maintenance |
| <i>Reliability</i> | Dependent on equipment & thermographer skillset |
| <i>Availability</i> | Data is not real-time or integrated to BMS/SCADA |
| <i>Safety</i> | Places operator at potential risk |

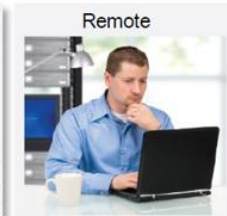
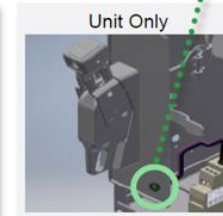
Thermal Monitoring Solution

| | |
|-----------------------|--|
| <i>Inspection</i> | Permanent monitoring 365/365 |
| <i>Low Load</i> | Dynamic fault detection even at low load |
| <i>Position/ View</i> | Internal / Unlimited |
| <i>Maintenance</i> | Fit & forget |
| <i>Reliability</i> | No human involvement/ Continuous & accurate data |
| <i>Availability</i> | Real-time data integrated into SCADA/BMS |
| <i>Safety</i> | Increases facility / operator safety |

Motor Control Center Thermal Monitoring

- Quick and Easy fit to any MCC
- 'In-drawer' solution disconnects & removes with drawer
- Warning and Critical thermal alarms
- Temp imbalance alarm for phases.
- Front mounted LED provides local visual condition status
- Networking capability via Ethernet/IP
- Increased operator and facility safety
- Increased operational uptime

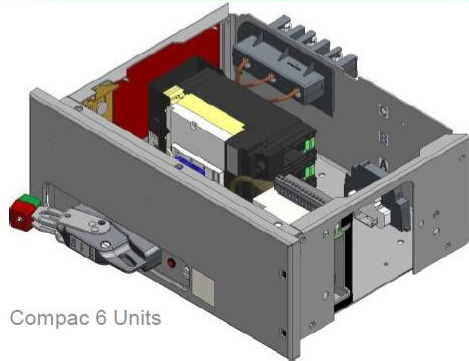
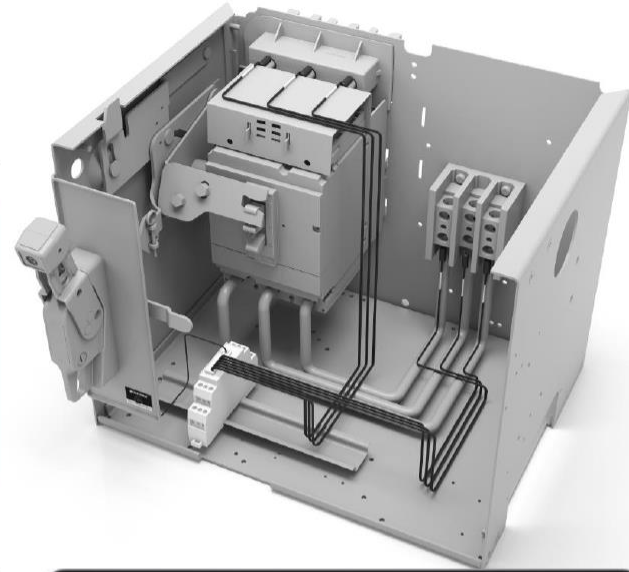
| THERMAL MONITORING | |
|--------------------|-----------------------|
| ● | OPERATING |
| ☀ | LINE/LOAD DELTA T |
| ● | TEMPERATURE IMBALANCE |
| ☀ | HIGH TEMPERATURE |
| ● | SENSOR SIGNAL LOSS |
| ● | NOT OPERATING |



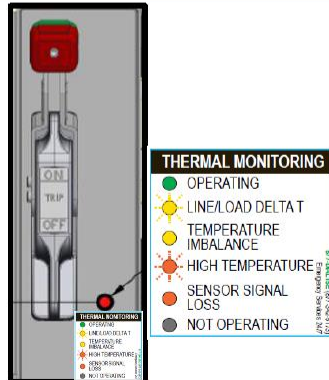
Design Features

Stand Alone – Unit Only

- Continuous 24X7 monitoring
- All factory made connections available
- Configured To Order using product selectors
- Available in all unit sizes
- Retrofits units available for all models made in 1992 & later

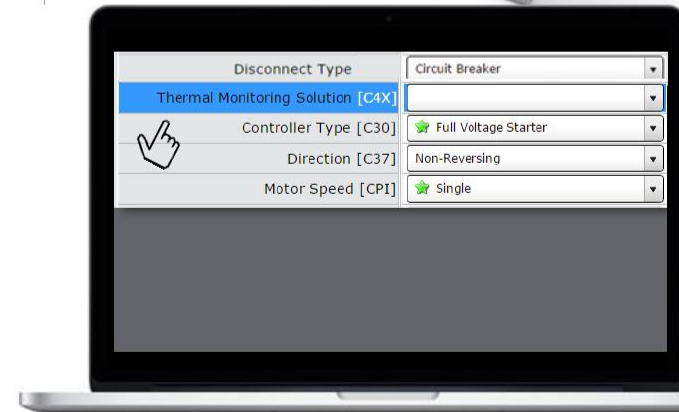


Compac 6 Units

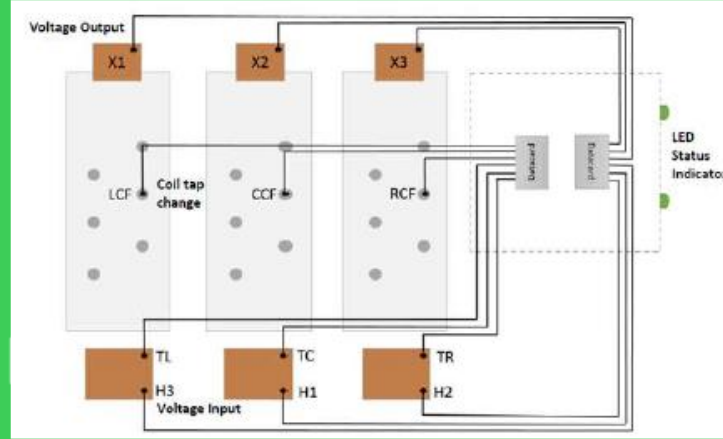


LED Indicator

| THERMAL MONITORING | |
|----------------------|-----------------|
| ● OPERATING | ● NOT OPERATING |
| ☀ LINE/LOAD DELTA | |
| ☀ TEMPERATURE | |
| ☀ IMBALANCE | |
| ☀ HIGH TEMPERATURE | |
| ● SENSOR SIGNAL LOSS | |



Low Voltage Distribution Transformers with Continuous Thermal Monitoring



UNIQUE 24X7 TEMPERATURE MONITORING OF TRANSFORMER CONNECTIONS:

The Modbus Transformer Solution (MTS) provides the ability to permanently install thermal Sensors, which continuously monitor the Primary, Secondary, and tap connections within the transformer housing. The output from the Sensors is analyzed by Modbus Transformer Data cards (MTDs) which are mounted in box connected to top side of the transformer housing and provide a high level alarm.

ALARMS

For compromised terminations, a high level alarm is generated.

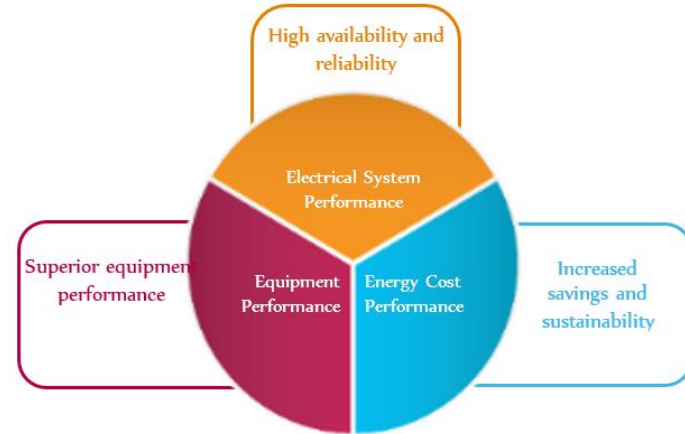
This alarm is visible via an external LED status light situated on the front/side of the enclosure.

The LED provides system status, alarm type and location. The alarm is also available via a relay contact (remote alarm)

All status information in MTS can be monitored 24/7 via a Modbus RS485 connection.

Continuous Thermal Monitoring Summary

- **Safety:** Eliminate unsafe activities for your client's maintenance staff
- **Reliability:** Predict & prevent electrical equipment failures
- **Cost Savings:** Optimize your client's maintenance budget. 7x24 monitoring-it's always on.



Life Is On



Schneider
Electric

