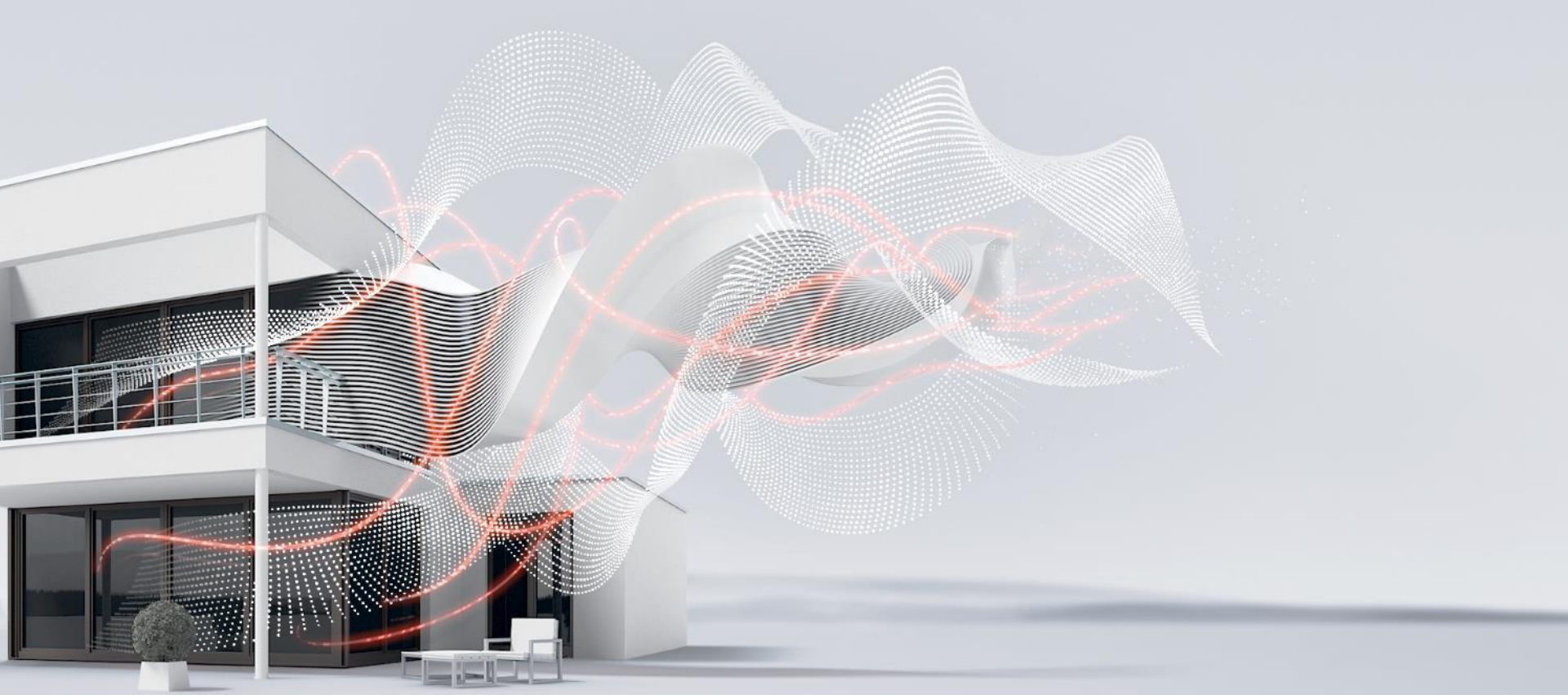


17TH APRIL 2017

# Switch Board Monitoring

## Protecting Switchboard

Courtesy of ABB. www.fengshengelectric.com.sg

# Agenda

1. Introduction
2. IEC 61439
3. Why Switchboard Monitoring
4. Switchboard Monitoring Types
5. Project References
6. Why Arc protection
7. Arc Guard System
8. How it works
9. Projects

# Introduction

Electrical Switchboard has to be **safe** and **available** balanced with the constraints of **reliability** and **maintainability**.


Switchboard conforming to **IEC 61439** provides insurance on switchboard realization quality

# IEC 61439

## Type Test Verification

| | |
|---|---|
| 10.2 | Strength of material and parts |
| 10.3 | Degree of protection of enclosures |
| 10.4 | Clearances and creepage distances |
| 10.5.2 | Effective continuity between parts and PE |
| 10.5.3 | Effectiveness of the ASSEMBLY for external faults |
| 10.6 | Incorporating of apparatus |
| 10.7 | Internal electrical circuits and connections |
| 10.8 | Terminals for external conductors |
| 10.9.2 | Power frequencyt withstand voltage |
| 10.9.3 | Impulse withstand voltage |
| **10.1** | **Temperature rise limits** |
| 10.11 | Short circuit withstand strength |
| 10.12 | EMC |
| 10.13 | Mechanical operation |

# IEC 61439

## Temperature Rise

**9.2 Temperature rise limits**

The ASSEMBLY and its circuits shall be able to carry their rated currents under specified conditions (see 5.3.1, 5.3.2 and 5.3.3), taking into consideration the ratings of the components, their disposition and application, without exceeding the limits given in Table 6 when verified in accordance with 10.10. The temperature rise limits given in Table 6 apply for a mean ambient air temperature up to 35 °C.

**10.10 Verification of temperature rise**

**10.10.1 General**

It shall be verified that the temperature-rise limits specified in 9.2 for the different parts of the ASSEMBLY or ASSEMBLY system will not be exceeded.

**10.10.2.3 Methods of test**

**10.10.2.3.1 General**

In 10.10.2.3.5 to 10.10.2.3.7 three methods for test are given, which differ in the number of tests needed and in the range of applicability of the test results, an explanation is provided in Annex O.

# IEC 61439

## Temperature Rise Type Test

**RECORD OF PROVING TESTS**

**Laboratory Reference No: 00944-14-0318**

ASTA



**Test results (continued)**

| Measuring points | | Classification / Designation | Temperature-rise limit for mean/maximum ambient temperature of 35/40 °C [K] | Final temperature [°C] | Final temperature rise [K] |
|---|---|---|---|---|---|
| 14 | L1 | Connection between section C02 and section C03 in the lower main busbar | 95 [1)] | 65.4 | 34.3 |
| | L2 | | | 61.4 | 30.3 |
| | L3 | | | 57.7 | 26.6 |
| 15 | - | Air above the main busbar in section C03 | - | 76.1 | 45.0 |
| 16 | L1 | Connection between upper main busbar and ACB connection busbar in section C03 | 95 [1)] | 82.8 | 51.7 |
| | L2 | | | 81.1 | 50.0 |
| | L3 | | | 75.5 | 44.4 |
| 17 | L1 | Connection between section C03 and section C04 in the upper main busbar | 95 [1)] | 73.9 | 42.8 |
| | L2 | | | 73.5 | 42.4 |
| | L3 | | | 70.4 | 39.3 |
| 18 | L1 | Connection between section C03 and section C04 in the lower main busbar | 95 [1)] | 59.8 | 28.7 |
| | L2 | | | 56.3 | 25.2 |
| | L3 | | | 53.3 | 22.2 |
| 19 | - | Air above the main busbar in section C04 | - | 71.8 | 40.7 |
| 20 | L1 | Connection between upper main busbar and ACB connection busbar in section C04 | 95 [1)] | 71.0 | 39.9 |
| | L2 | | | 69.5 | 38.4 |
| | L3 | | | 66.6 | 35.5 |
| 21 | - | Air above ACB E6.2V in section C01 | - | 63.1 | 32.0 |

# IEC 61439

## Temperature Rise Type Test

**Test and measuring circuits (continued)**


Diagram 5: Arrangement of selected temperature-measuring points along the main busbar

# IEC 61439

## Temperature Rise Type Test

**Test and measuring circuits (continued)**

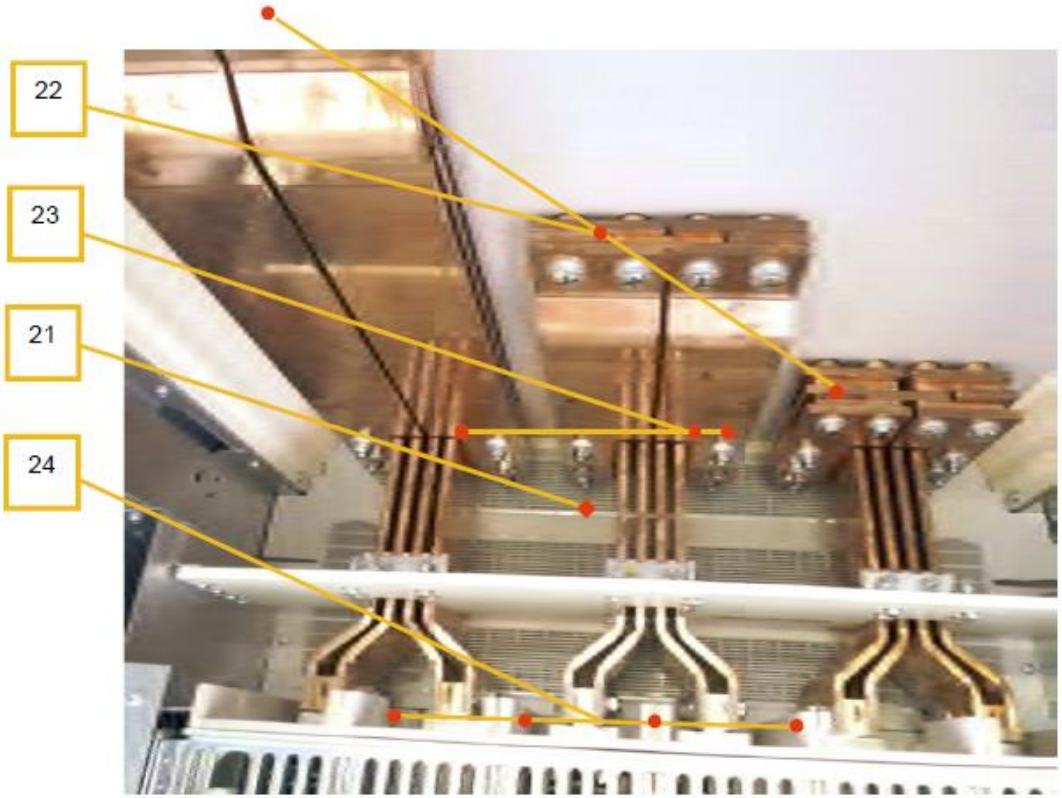



Diagram 6: Arrangement of selected temperature-measuring points in section C01

# IEC 61439

## Temperature Rise Type Test

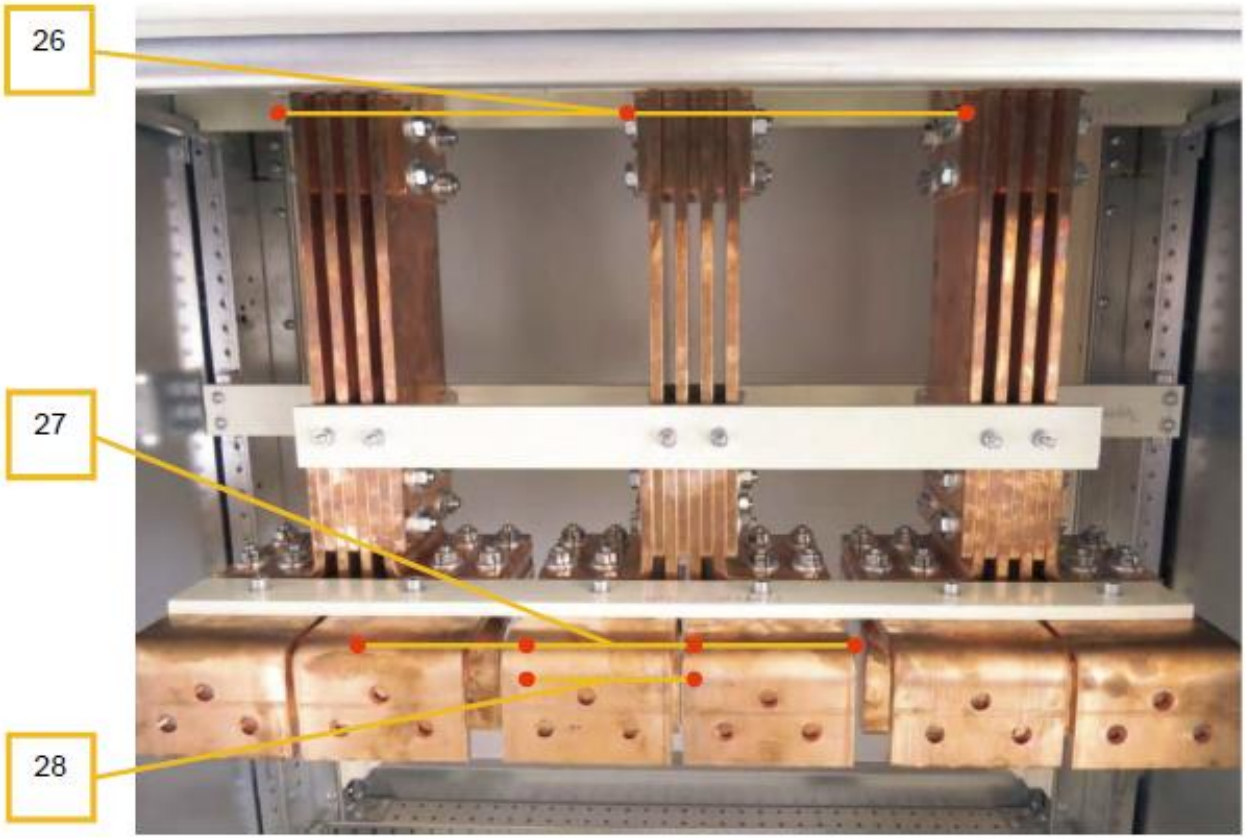



Diagram 7: Arrangement of selected temperature-measuring points in section C01

# IEC 61439

## Temperature Rise Type Test

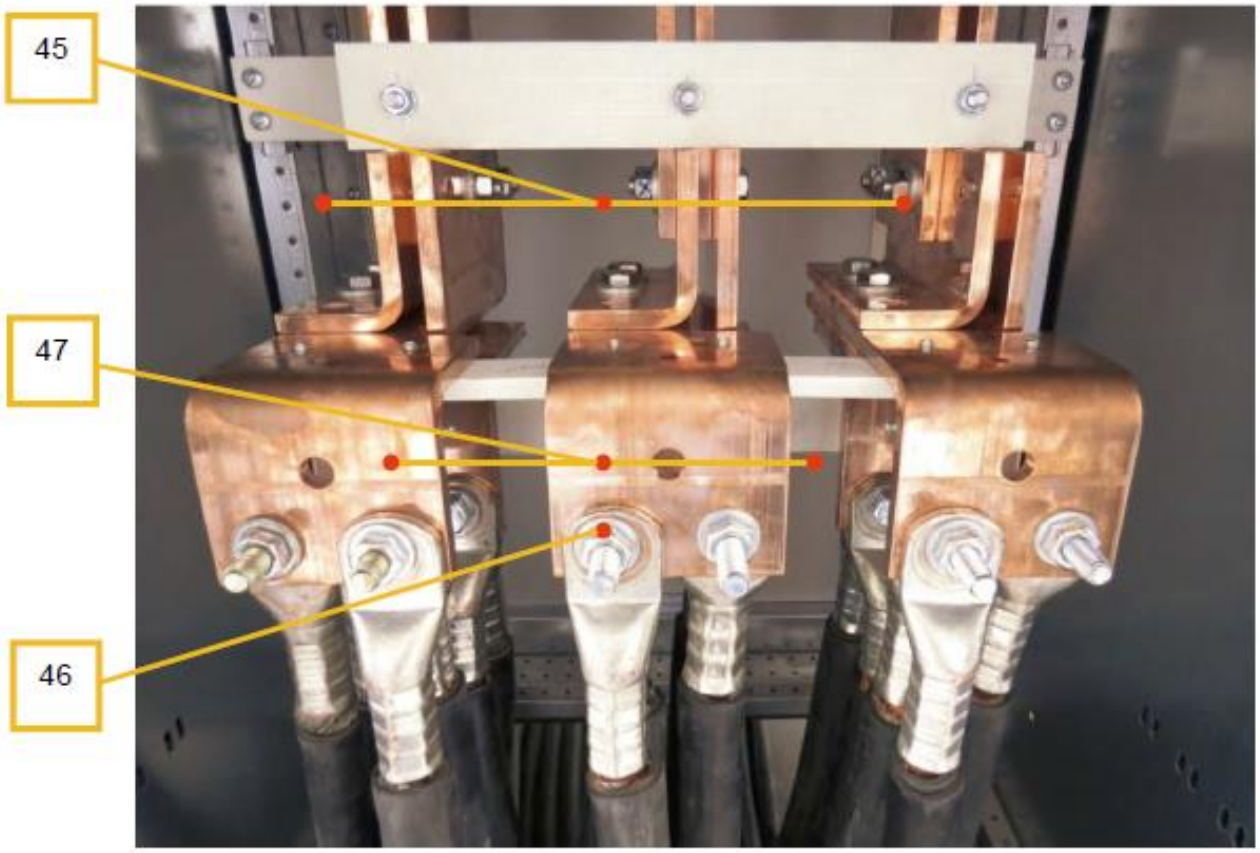



Diagram 11: Arrangement of selected temperature-measuring points in section C03

# Why Switchboard Monitoring?

- Reduce electrical failures
- Increase equipment reliability
- Lower maintenance and repair cost
- Prevent system failures
- Less interruption time

# Temperature

Tell tale signs of switchboard health

Temperature rise in switchboard can be due to:

- Overload
- Phase imbalance
- Power factor
- Corrosion
- Poor electrical connections

# Effects

- Flash over
- Fire and Explosion
- Injuries to personnel
- Loss of operations
- Loss of productivity

# Types of Temperature Monitoring

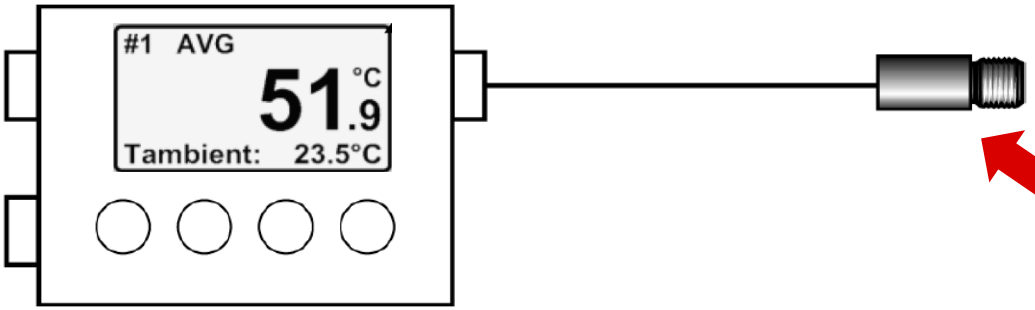
Predictive Maintenance

1. Infrared (IR) Sensors

2. Linear Heat Detectors

# Type of Temperature Monitoring

## Infrared (IR) Sensors

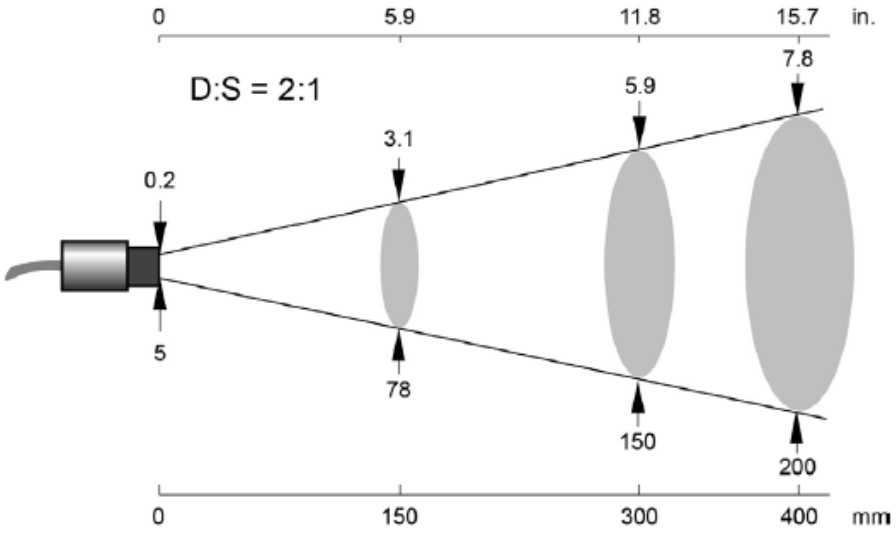



**IR Sensor**
- Senses IR thermal reading

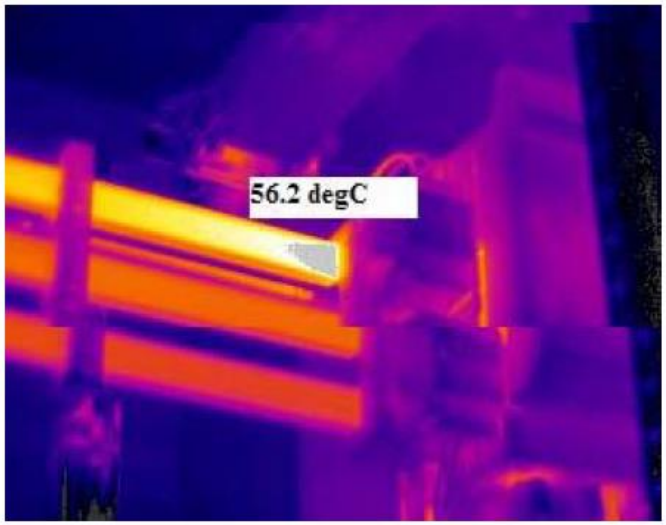
**Communication Module**
- Display actual temperature
- Sends reading to BMS/PMS

# Type of Temperature Monitoring

## Infrared (IR) Sensors



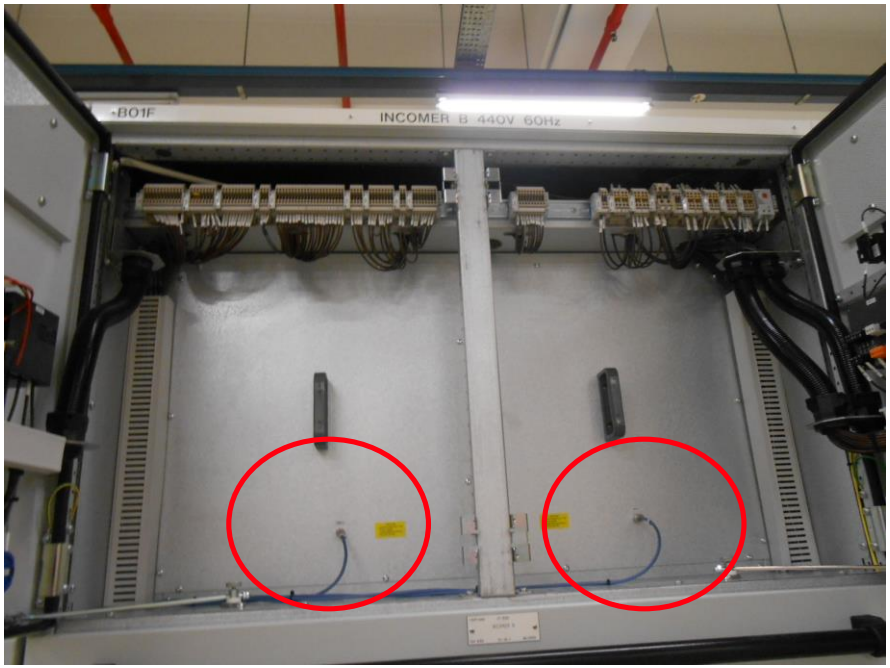

Optical Spot Size



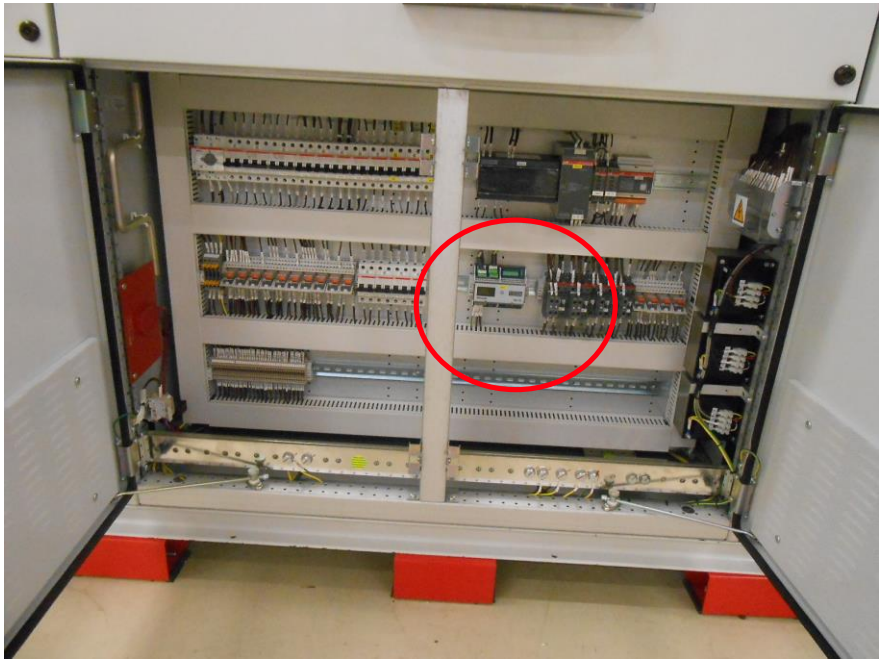

Busbar Thermal Imaging

# Projects

## Oil & Gas Project



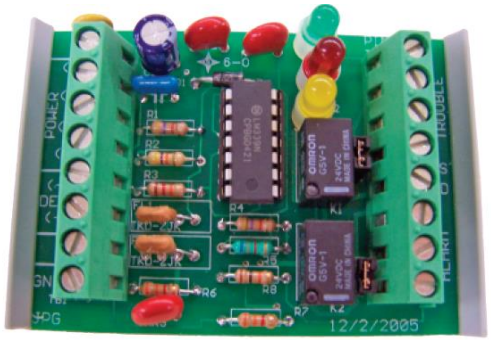

IR Sensors



Communication Module

# Type of Temperature Monitoring

## Linear Heat Detector



**Linear Heat Detector Wire**

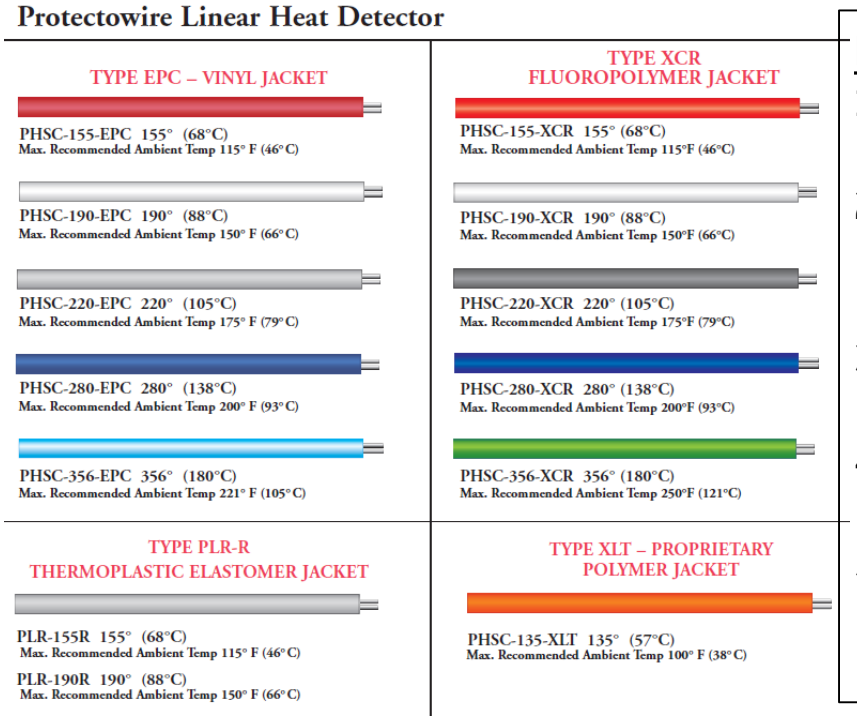
- Detects short of sensing cable sends alarm to BMS/PMS when specific temperature reached.

**Communication Module**

- Detects short of sensing cable sends alarm to BMS/PMS.

# Type of Temperature Monitoring

## Linear Heat Detector




**How it works**

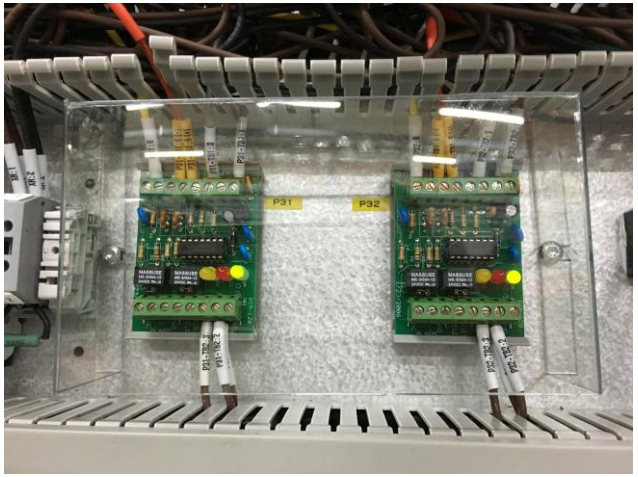
1. Linear heat detector wires are a fixed temperature detector
2. Constructed of twisted pair of conductors coated with thermoplastic coating of specific temperature.
3. When wire reach specific ambient temperature, the wire insulation softens.
4. This results in the conductors in contact with each other creating short circuit.
5. Communication module sense this and sends an alarm.

# Projects

## Infrastructure Project

Heat Detector Cable

Heat Detector Cable




Communication Module

# Arc Guard System

## Why Arc Protection

# Arc Guard System

## Arc Flash Incidents

asiaone NEWS

ASIAONE » NEWS » SINGAPORE

**Man in ICU following Tanglin Mall explosion**


Share: 0 0 0 Share Tweet

By Dominic Ho
My Paper
Wednesday, Jan 09, 2013

SINGAPORE - It seemed like any other day when store assistant Rita Mohd, 37, opened her clothing shop, Petit Bateau Store, on the second storey of Tanglin Mall at 9am yesterday.

However, just 15 minutes later, she heard a very loud explosion. She then saw a lot of smoke pouring out from the door opposite her store, from which a man without his shirt ran out with burns all over his neck, screaming for help.

**Arc Flash Kills Two Electrical Contractors in Morley, Australia**

by Hugh Hoagland, on February 10, 2014


AN ELECTRICAL ARC FLASH CRITICALLY INJURED SEVERAL WORKERS IN MORLEY, AUSTRALIA.

High Energy Service Pty Ltd was conducting work in the vicinity of the Morley Galleria shopping centre, where their employees and subcontractors were injured in an electrical explosion.

**Jury Finds Qualcomm Liable in Arc Flash Incident**

Feb 17, 2016

EMAIL SHARE Tweet G+1 Recommend 30 COMMENTS 4

Qualcomm will pay $7.1 million to a man who suffered severe burns in 2013 while inspecting electrical equipment at the company's San Diego headquarters.

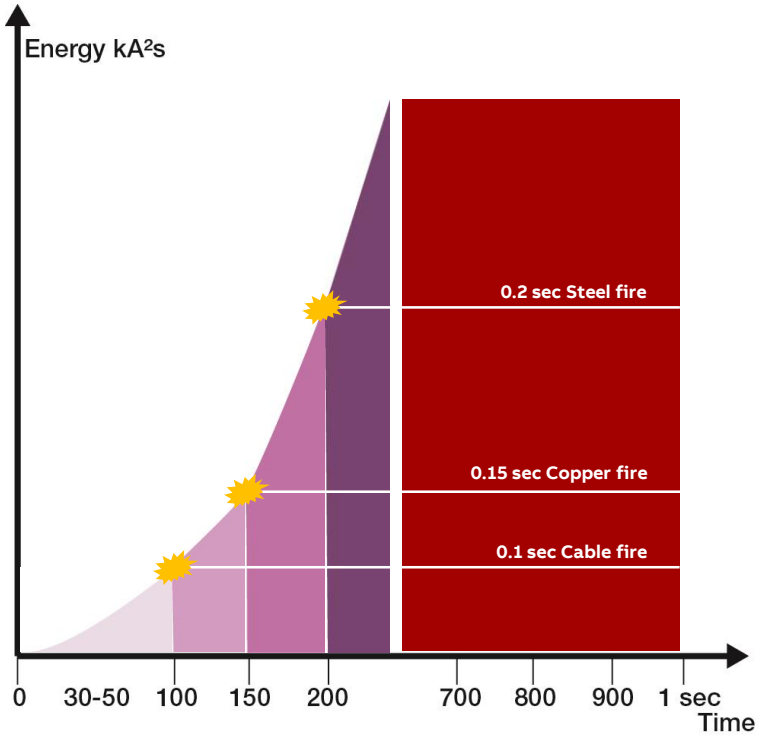
A Pasadena-based law firm has won a verdict against Qualcomm, the global semiconductor and telecommunications giant and one of San Diego's largest employers. Qualcomm will pay $7.1 million to a man who suffered severe burns in 2013 while inspecting electrical equipment at the company's San Diego headquarters. That verdict was handed down on Feb. 10 by a trial jury in San Diego. The plaintiff, Martin Sandoval, was represented by attorneys Dan Powell and Michael O'Connor of Thon Beck Vanni Callahan & Powell.

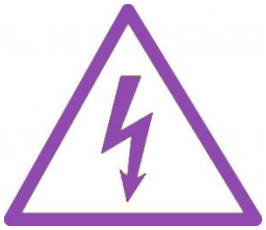
QC makes its own electricity. It uses a switchgear system to control, protect, and isolate electrical equipment. According to court records, ROS Electrical Supply & Equipment Company, based in Pico Rivera, was contracted to inspect Qualcomm's switchgear system for an upgrade. On August 3, 2013, Martin Sandoval of Ros Electrical arrived at Qualcomm to conduct that inspection. Sandoval was badly burned in an arc flash fire from a live circuit breaker that was left on during the inspection, according to court

He told Shin Min Daily News yesterday at the hospital that when he and a manager were in the room overseeing electrical works, they saw a sudden flash of light before hearing a very loud explosion.

# Arc Guard System

What happens? Time matters!



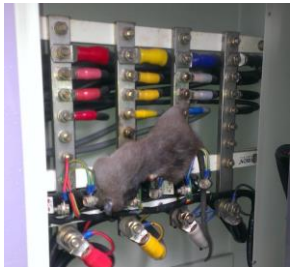



**12 kV, 40 kA**

# Arc Guard System

## Causes of Arc Accidents

| | |
|---|---|
| The most common reasons for arc flash accidents | Human errors |
| | Mechanical faults |
| | Bad connections |
| | Aging/Insulation defect |
| | Animals |



| | |
|---|---|
| When do arc flash accidents occur? | 25 % without operator |
| | 10% with operator in front of a closed door |
| | 65 % with operator working in the switchgear |

# Arc Guard System

## Dangers of Arc Blast

Flying debris:

- Copper expands by a factor of 67,000:1 when turning from solid to vapor (water going from ice to vapor expands with a factor of 40,000:1)
- Molten metal and shrapnel travel as fast as 1600km/hour

Pressure:

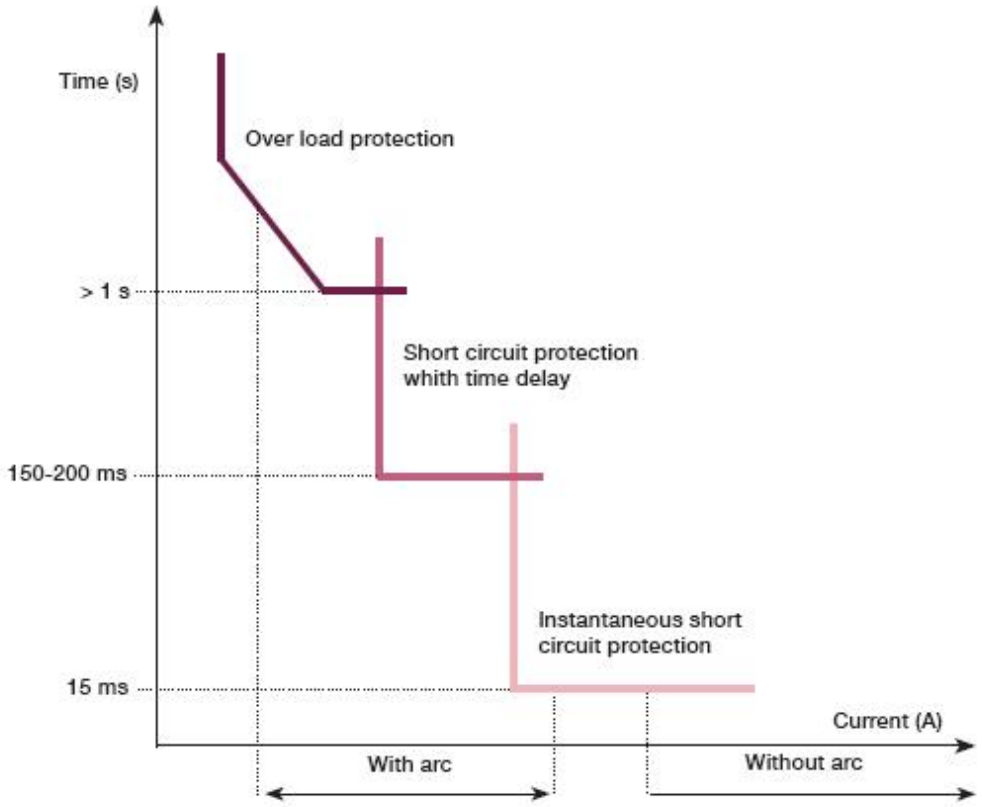
- The sound of an arc blast can easily surpass 160dB (OSHA limit is 115dB for max 15 minutes, NIOSH limit is 112dB for max 56 seconds)
- Arc blasts can and *have* caused death at distances above 10ft (3m)

Extreme heat:

- Temperature of arc an blast can reach over 20,000 °C (surface of the sun is roughly 5500 °C)

# Why isn’t short circuit protection enough?

## Short Circuit – Current behavior with and without arc



# Arc Guard System

## TVOC-2

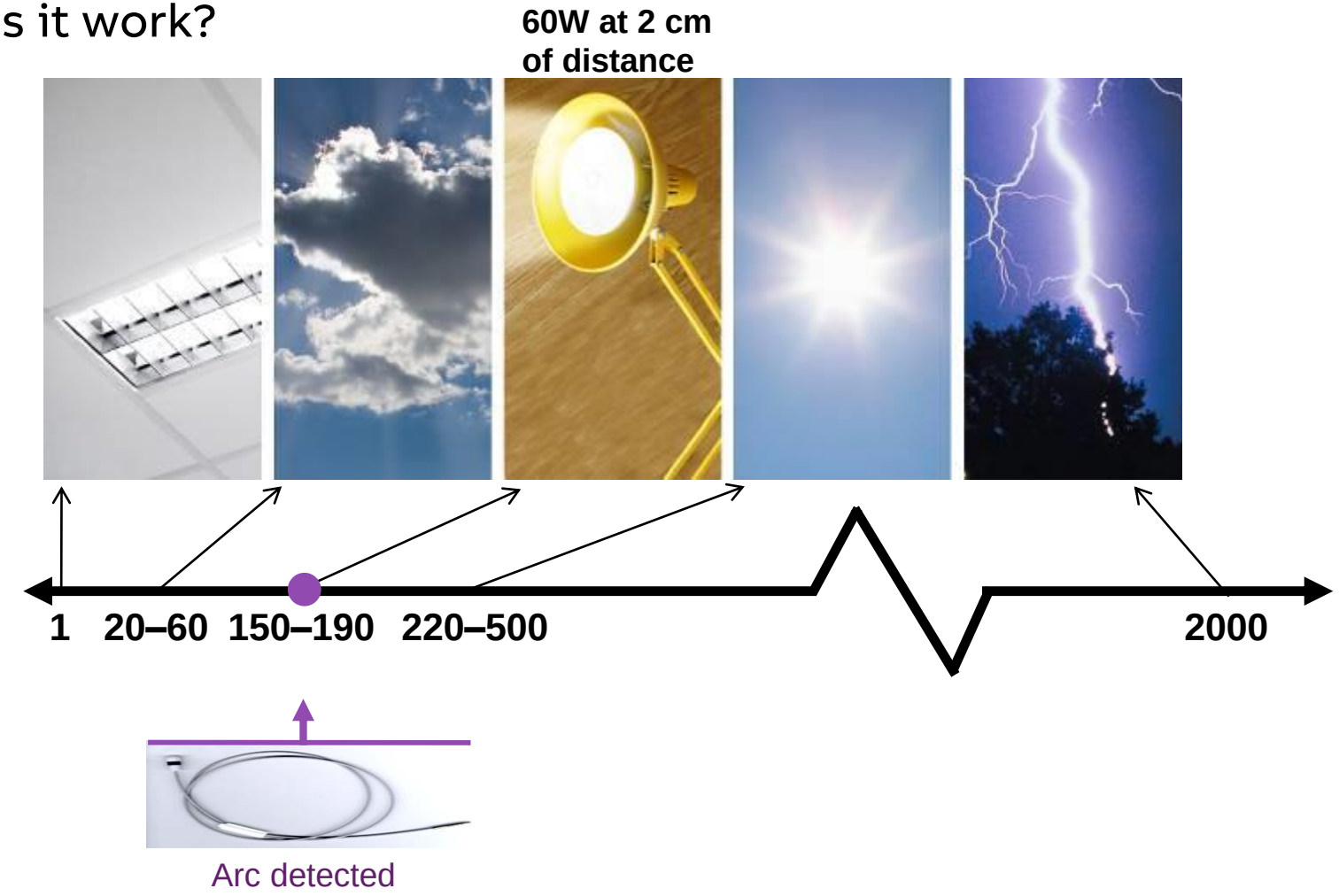
# Arc Guard System

## How does it work?

1. Arc is detected by the fiber optic sensor
2. Signal is sent to the TVOC-2 arc monitor
3. TVOC-2 arc monitor sends a trip signal to shunt trip of circuit breaker
4. All this occurs in under 1ms

# Arc Guard System

## How does it work?



# Arc Guard System

## Safety Integrity Level - SIL

Safety Integrity Level (know as SIL) as per IEC-61508 and IEC-62061

- A measure of safety system performance in terms of Probability of Failure on Demand (PFD), established to define a metric for evaluating a system's (or function's) level of operational reliability with regards to maintaining safety

- TVOC-2 is certified with a PFD of 3.49 x $10^{-03}$ (0.00349) per year for a period of 10 years after it is first connected (as long as suggested maintenance is performed annually)

# Arc Guard System

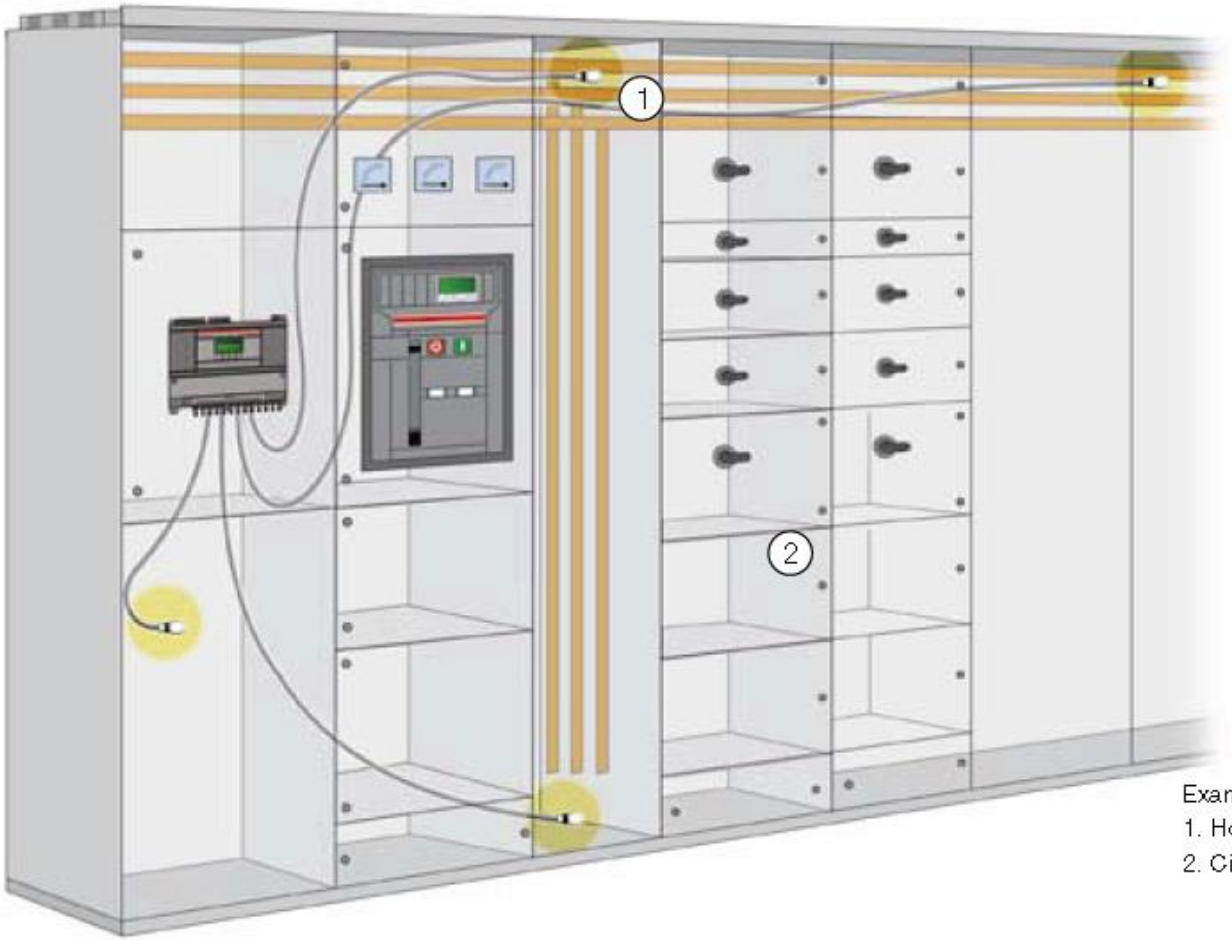
## Safety Integrity Level

To meet SIL-2 safety standards, we need:

- Redundancy
  - Hardware (IGBT's, relay outputs, IRF,etc)
  - Software (HMI, PC boards, etc)
- Reliability
  - Self-monitoring of internal faults
  - All light sensors will be manufactured and tested in similar conditions according to EN ISO 13849-1
- Reduce the probability of errors caused by external factors
  - Cannot adjust the sensitivity of the sensors
  - Cannot shut down the system for maintenance
  - Cannot change safety configuration parameters via HMI
- Third-party certification
  - TVOC-2 is certified SIL-2 by TÜV Rheinland

# Arc Guard System

## Installation Example




Example showing the position of detectors in:
1. Horizontal and vertical bus bar system
2. Circuit-breaker cubicle

# Arc Guard System

## Current Sensing Module


- Used to monitor current
- Simply connect CT's with an output of 1, 2 or 5A
- Can monitor only 1 phase although 3 is suggested
- Must be adjusted to nominal current level
- Once current reaches 140% of set level, trip signal is sent
- 2 types of signals sent from CSU to TVOC-2
  1. Light = no fault, proper operation
  2. No light = overcurrent signal
- Total reaction time of TVOC-2 + CSU = 2-3ms when monitoring current on 3 phases

# Projects

## Where the system is used

Chemical Plant

Oil Rigs

Substation

# Projects

## Where the system is used

Hospital

Manufacturing

Transport