ENHANCING ELECTRICAL POWER GRID RELIABILITY
CRITICAL ASSET MONITORING

• **OPTIMIZES ASSET PERFORMANCE**

• **INCREASES RELIABILITY**

• **LOWERS TOTAL MAINTENANCE COST**
  • **EXTEND THE LIFE OF POWER ASSETS**
  • **MINIMIZE DOWNTIME THROUGH PROACTIVE PLANNING AND REPAIR**

• **AVOIDS CATASTROPHIC FAILURE**

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PREDICTIVE MAINTENANCE

- **Run to failure results in lengthy, unexpected outages.**

- **Periodic inspection is inconsistent**

- **Continuous monitoring under normal operating conditions shows true health of the asset and reduces outages**
PRIMARY CAUSES OF ASSET FAILURE

- **COMPROMISED CONNECTIONS**
  - Poor contact, connections, corrosion, wear, or loosening
  - Results in elevated heating

- **INSULATION INTEGRITY DEGRADATION**
  - Aged, worn, or damaged insulation creates dielectric breakdown
  - Results in corona and partial discharge

- **AIR DIELECTRIC BREAKDOWN**
  - Excess environmental moisture and condensing atmosphere
  - Results in tracking and flashover from high humidity
iSAW CRITICAL ASSET MONITORING (CAM)

COMPREHENSIVE, CONTINUOUS, REAL-TIME MONITORING FOR ELECTRICAL ASSET PRIMARY FAILURE MODES:

- Elevated heating
- Partial discharge events
- High humidity
CAM APPLICATIONS

CRITICAL ASSET MONITORING SYSTEMS PROVIDE CONTINUOUS HEALTH METRICS OF ELECTRICAL ASSETS:

• LOW, MEDIUM AND HIGH VOLTAGE SWITCHGEAR
  • INCOMERS, FEEDERS, BUS TIES
• BUS DUCTS / ISO PHASE BUS DUCTS
• RING MAIN UNITS
• TRANSFORMERS
• GENERATORS
• GENERATOR CIRCUIT BREAKERS
• LOAD TAP CHANGERS
• RECTIFIER STACKS
• CAPACITOR REACTANCE MATCHING BANKS
IntelliSAW ON THE GRID

Generation
Transmission
Distribution
Customers

Power Generation Plants
Transmission Substations (step-up)
Transmission Substations (step-down)
Commercial Customers
Steel Plant
Aluminium Plant
Data Center
Distribution Substations
Hospital
Petrochem
Underground Distribution Substations
Heavy Industrial Customers
Residential
TEMPERATURE MONITORING
SURFACE ACOUSTIC WAVE (SAW) TEMPERATURE SENSORS

• **PASSIVE** SENSOR MODULES
  - Powered by RF interrogation signal
  - Range: -25°C to +125°C

• **20+ YEAR SENSOR LIFE EXPECTANCY**
  - Crystal Resonator Technology
  - Proven technology since 1918

• **DESIGNED FOR ELECTRICAL POWER ASSET APPLICATIONS**
  - Sensor baseplate matches bus-bar construction
  - No internal sharp points, prevents corona
  - Type Tested
    - IEC 62271-1 Withstand voltage: 95kV/1m and 185kV impulse
    - IEC 62271-200 Short circuit withstand: 63kA/3s, 171kA peak
CRYSTAL RESONATORS

• PRODUCED ON A SINGLE-CRYSTAL QUARTZ SUBSTRATE, A PIEZOELECTRIC MATERIAL.
  • CHANGES SHAPE AT A MICROSCOPIC LEVEL BASED ON APPLIED ELECTRIC FIELD

• THE CRYSTAL “CUT” PROVIDES WELL KNOWN TEMPERATURE CHARACTERISTICS

• A HIGH Q SUBSTRATE PROVIDES NARROW-BAND FREQUENCY RESPONSE AND LONG ELECTRICAL DELAYS
SAW FREQUENCIES AND CALIBRATION

• **12 UNIQUE SENSOR FREQUENCY BANDS**
  • **THE 2 IDTs PROVIDE FREQUENCY RESPONSES WITHIN THE DESIGNATED BANDS**

• **SENSOR CALIBRATION SLOPES ARE ASSIGNED TO ~1% NOMINAL.**
1. Think of a bell.
2. When the bell is struck, you will hear a sound.
3. The sound you hear is a pressure wave that is a dampened harmonic waveform.

Hit the bell in the summer, the frequency of the sound will be lower because it has expanded due to the heat.

Hit the bell in the winter, the frequency of the sound will be higher because it contracted due to the cold.
SAW OPERATIONS

Resonator-1
Frequency Range

Resonator-2
Frequency Range

Difference = 85°C

434.421 MHz

433.734 MHz
SENSOR INSTALLATION EXAMPLES
SENSOR INSTALLATION EXAMPLES
SENSOR INSTALLATION EXAMPLES
LARGE SCALE SENSOR INSTALLATION

A total of **340 cabinets (35kV)** with a 6-sensor configuration were commissioned and integrated into customer’s SCADA system.
CAPACITIVELY COUPLED SENSORS

• DESIGNED FOR INSTALLATION IN LV SYSTEMS
  • LV SWITCHGEAR
  • MOTOR CONTROL CENTER (MCC)
  • LV DISTRIBUTION BOARDS (LVDB)

• EASILY MOUNTED WITH CLIPS OR TIE WRAPS; CUSTOM MOUNTING AVAILABLE

• MEASURED THROUGH CAPACITIVE ISOLATION OVER AN IEC STANDARD AIR GAP.

• UP TO 60MM (4kV) RANGE TO AIR INTERFACE
LOW VOLTAGE (CC) INSTALLATION

ASIATIC AND INDO-ASIAN LVDB FUSE HOLDERS
PARTIAL DISCHARGE (PD)
WHAT IS PD?

• **Localized breakdown of insulation**

• **Arts within or along surface of insulator**

• **The breakdown causes emissions such as:**
  
  • **Current spikes between conductors**
    
    • Milliamp to Ampere currents
    
    • Pico to Nano-Coulomb discharges

  • **Electromagnetic (radio or light)**

  • **Acoustic**

  • **Ozone**
WHY MEASURE PD?

• **A LEADING INDICATOR OF CABLE DAMAGE AND INSULATION FAILURE.**

• **PD MAGNITUDE IS RELATED TO THE RATE OF DETERIORATION SINCE EACH DISCHARGE CAUSES FURTHER DAMAGE.**

• **TRENDING PD IS MOST IMPORTANT**
  
  • **A LOW LEVEL OF PD INCREASING QUICKLY WILL SIGNIFY A MAJOR DEFECT**
  
  • **A HIGH LEVEL OF PD THAT IS STABLE INDICATES THERE IS A MAJOR DEFECT, BUT IT IS NOT GETTING WORSE**
THE INTELLISAW UHF PD SOLUTION

• **Real-time UHF PD Detection System** with concise data reporting for **TRENDING**

• **Distinguish Actual PD Events from Noise** with real-time algorithms & banded hardware filters
  - ISAW system does not require an “as installed” baseline measurement
  - Calibrated to a reference source

• **Completely Non-contact to Provide HIGHEST SAFETY**

• **Applicable to Monitoring All Critical Assets** due to low cost and ease of installation.
SIGNAL FILTERING TO REJECT NOISE

- **Front end filters are used to select signals from one of three bands** (300MHz, 600MHz, and 1200MHz)
- **UHF energy in the selected frequency band is AM detected & processed**
- **Typical PD broadband frequencies in assets:**
  - Motors, Transformers, Long Cables are **Low Frequencies**
  - Switchgear cabinets have **Medium Frequencies** centered on cavity resonance
  - GIS/GIL, Bus ducts act as waveguides and transmit **High Frequencies**

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SIGNAL CLASSIFICATION

• **NOISE:**
  - Signals not correlated to line frequency
  - May have other modulation for data transmission
  - Might be transient or persistent

• **SURFACE DISCHARGE:**
  - Typically occurs at negative polarity because of the physics of metal-air boundaries
  - Occurs at periods directly related to the line frequency

• **INTERNAL DISCHARGE:**
  - Typically polarity independent
  - Depends only on the defect breakdown field strength
  - Occurs at periods directly related to twice the line frequency
QUANTIFYING PD DATA FOR TRENDING

PROCESS:

• **ANALYZE** DEFECTS FOR ONE POWER CYCLE
• **CALCULATE** CUMULATIVE CHARGE FOR ALL DEFECTS
• **PROVIDE** ONE DATA POINT AS A WEIGHTED AVERAGE

PD = 10,500 pC cum/cycle
PD MONITOR INSTALLATION EXAMPLE
CAM Air Interfaces are used for PD monitoring and temperature sensor measurements.
HUMIDITY MONITORING
WHY MEASURE HUMIDITY?

• HUMIDITY CONTAMINATION AND MOISTURE ON THE INSULATION SURFACE RESULTS IN LONG TERM INSULATION DAMAGE AND METALLIC CORROSION:
  • LEADS TO ELEVATED HEATING
  • PARTIAL DISCHARGE / SURFACE TRACKING
  • POTENTIAL FOR SHORTS AND FLASHOVER
INDUSTRIAL HUMIDITY SENSOR

• Ideal for bus ducts and switchgear cable compartments
• Humidity & Ambient Temp monitoring
• Rugged construction:
  • Sintered cap
  • Threaded stainless steel body
  • M12 water resistant connectors
  • 4kV surge protection
• Multi-drop for up to 8 sensors
CAM-4

- **4.3” touch panel HMI**
- **Monitoring Capabilities**
  - **Up to 12 temperature sensors**
  - **Up to 4 PD air interfaces**
  - **Up to 8 humidity**
- **Universal input power (100 – 250V AC/DC)**
- **4 alarm outputs**
- **Extended data storage (USB interface)**
- **Multiple unit interface (up to 7 readers)**
- **Industry standard communications**
MULTI-UNIT

SCADA
SYSTEM DEPLOYMENT
MEDIUM VOLTAGE SWITCHGEAR INSTALL

TYPICAL INSTALL INCLUDES:

• **SAW** TEMPERATURE SENSORS
  • **BREAKER** INPUT & OUTPUT
  • **BUS CONNECTIONS**
  • **CABLE CONNECTIONS**

• **TEMP AIR INTERFACES**

• **PD / TEMP INTERFACE**

• **CAM BASE UNIT**

• **HUMIDITY SENSOR**
Substation installations are often a distributed system with the CAM platform monitoring temperature, PD, and humidity at multiple locations. An RTU provides the data to a SCADA System.
GCB FAILURE PREVENTION: US UTILITY

• **US** UTILITY PEAK POWER PLANT USED SEMI-ANNUAL INSPECTION.

• **During** transition to continuous monitoring observed completely corroded GCB contact.

• **If** this generator had been brought into service, $250K & loss of life.
• **Power Plant**
• **System Monitoring Found 12KV SWGR (SG7602) CB 2nd R Phase Temp. is 20 C higher than S & T Phases.**
• **Scheduled Shutdown Found Isolation Insulator Crack is Root Cause.**
• **Replaced Insulator, Problem Resolved**
• *(Note – PD Monitoring Might Have Caught This Much Earlier)*
CAPACITOR BANK: UAE UTILITY

- **Gulf Region Utility**
- **Temperature rise of 33kV Series Capacitor Reactance Matching Banks during peak operation**
- **Confirmed iSAW alarm reporting using FLIR system**
- **Cap banks taken down for repair**
PD DETECTION: US UTILITY

- NORTH EAST USA UTILITY
- HUMIDITY CONDENSING IN BUS DUCT CAUSING PARTIAL DISCHARGE
- RECOMMENDED INSTALL OF MORE HEATERS
• This peak power plant experienced a bus duct flashover due to condensation.
  • Even when heaters are used to control humidity, heater failure can go undetected.

• The new bus duct has added continuous humidity monitoring.
LVDB PANEL: UAE UTILITY

- **Gulf Region Utility**
- **Temperature rise of fuse contact during peak operation, becoming worse over several days**
- **Confirmed iSAW alarm reporting using FLIR system**
- **Reseated fuse and returned normal operation**
CONTINUOUS ASSET MONITORING

Continuous Monitoring
- Primary Failure Detection:
  » Temp, Humidity, PD
- Integrates into existing SCADA infrastructure

Early Warning
- Data captured
- Trends analyzed
- Alarm thresholds set for automatic alerts

Resolution
√ Assets protected
√ Costly downtime and injury avoided
√ Reliability raised

Vigilance
The Intelligent Choice In Critical Asset Monitoring.