Distribution Components
Smart Grid Overview, Components, Applications

Distribution Grid Sensors
Agenda
- Energy Distribution Challenge
- Addressing the Challenges: Application Overview
- The Market for Grid Modernization
- Smart Grid Sensors – What, Where, Why, and How
  - Fault Detection
  - Asset Management
  - FDIR/FLISR
  - VVO/CVR
  - Feeder Metering
- The CT/PT Sensor Solution
- Line Post Sensors
- Sensor Design Project Installation in Pinetops, NC
Distribution Grid Sensors
Need for improved energy efficiency and reliability

- 40% of losses occur on the distribution network
- Reducing losses by 10% could save 65 billion kWh
- For each 1% reduction of peak demand, (32) 250MW power plants do not need to be built
- Reducing outage frequency and duration saves maintenance and regulatory costs

The future of power distribution relies on utilities to maximize their efficiency and optimize the network to consistently deliver power to consumers at minimal cost.

Top benefits of the Smart Grid
Distribution Automation

Survey: What are the Top 3 benefits of implementing Smart Grid technologies?

- Increased asset utilization
- Improved power quality and reliability
- Increased security
- Ensuring future energy demand is met
- Increased efficiency of intermittent generation and demand
- Reducing or eliminating time to recovery
- Customer control and a platform to integrate non-dispatchable resources
- Reduced distribution losses and grid failure
- Increased reliability and control
- Reduced or peak demand

Source: GreenTech Media Research, 2012

Distribution Automation Projects
Current and Future Market

71 Smart Grid Projects with DA Components in U.S. today

Distribution Automation Market Forecast – United States 2012-2016

Source: GreenTech Media Research, 2012
Distribution Intelligent Grid Landscape

Functional Tiers

Tier 1

Tier 2

Tier 3

Typical Sensor Block Diagram

Fundamental building blocks for DA Devices: Relays, Meters, FCLs, Reclosers, Cap Bank Controllers, Voltage Regulators, etc.!

Distribution Sensor Applications

Focus on Distribution Automation

1. Volt-Var Control
   - Volt-Var Optimization (VVO)—Eliminate Waste
   - Conservation Voltage Reduction (CVR)—Reduce Excess
2. Protection and Control—Better Manage Resources
   - Fault, Detection, Isolation, & Restoration (FDIR): Reclosers, Sectionalizers
3. Fault Indication—Information to assist
   - Fault Current Indication (FCI): Overhead and Underground
   - Power Line Monitor: Load & Peak Current Waveforms, Conductor Temperature
4. Monitoring & Diagnostics—Maintenance
   - Asset Health Services for Switchgear, Breakers: Temperature, Aging
5. Feeder Metering—Comparison of what is going out vs coming in
   - Power Quality
   - Theft Detection
Key Application: Fault Indication (>10%)
FCI and Power Line Monitoring

Fault Current Indicator (FCI):
Visually identifies and locates high current events remotely to assist maintenance crews
Low-cost, lightweight, & hot-stick mountable design for fast and easy installation

Reliability Benefits of FCI's:
- Reduces interruption time and lost revenue
- Improves customer satisfaction
- Reduces SADI, SAIFI penalties
- Lowers OPEX (i.e. crew cost)

Power Line Monitor
- Remotely measures fault events, timestamps, temperature, power quality, and waveforms
- Fully integrated wireless solution, containing A/D, microcontroller, power supply and radio

Provides all Benefits of FCI, plus:
- Faster outage detection and location search
- Remote configuration of fault parameters
- Visibility of fault signatures
- Event recording and tracking

Key Application: Monitoring & Diagnostics (1% - >2%)
Asset Health Indication

Monitoring and Diagnostic sensors measure key health indicators of critical power systems assets, such as Switchgear and Breakers.

Asset Health Indication:
- Records diagnostics history
- Monitors temperature and aging wear
- Reduces risk of a catastrophic event
- Predicts health trends and alarms

Sensors & Components:
- Temperature sensors
- Current Transducers
- Pressure Sensors
- Partial Discharge
- Gateway/Webserver
Key Applications: Distribution Automation (0.5% - 2%)

**FDIR/FLISR**

- Fault Detection, Isolation, and Restoration (FDIR):
  - Prevents outages that cause loss of revenue and customer dissatisfaction
  - Identifies and locates faults remotely and automatically restores power with loop schemes

**Reliability Benefits of FDIR:**
- Improve customer satisfaction
- Reduces interruptions
- Avoids SAIDI, SAIFI penalties
- Lowers OPEX (i.e., crew cost, tree trimming)

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**Sensors for FDIR/FLISR**

**Embedded, Line-Post Sensors and Voltage Transformers**

- Pole-Embedded or Line-post Sensor:
  - Voltage and/or Current
- IED:
  - Relay or Controller (RER620 or REF615)
- Wireless or Wired communications
- Substation gateway (ABB COM600)

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**Key Applications: Distribution Automation (0.5% - 2%)**

**Conservation voltage reduction**

- **Challenges**
  - Utilities must regulate the voltage delivered to within ±5% of the required nominal voltage for each consumer.
  - Conservation voltage reduction
    - Allows utilities to deliver consistent power to all consumers and allow for lowering of demand during peak hours if necessary
    - Conservation voltage reduction helps utilities:
      - save as much as 3-5% on generation costs
      - improve customer satisfaction
      - limit wasted energy and lower costs
      - lessen the potential for brownouts
Key Applications: Distribution Automation (0.5% - 2%)
Volt/Var optimization

Challenges
Reactive power can account for a significant portion of distribution losses.

Volt/Var optimization
Allows utilities to balance the amount of active and reactive power on the network to conserve energy and reduce power losses.

Volt/Var optimization helps utilities reduce:
- CO2 emissions
- peak demand and associated costs
- generation load by as much as 4-6%

Sensors for CVR/VVO
Line-Post Sensors

Line-post Sensor: Voltage and/or Current

IED: Cap Bank Controller (CQ900R)
Wireless or Wired communications
Substation gateway (ABB COM600)

Sensors for CVR/VVO
SCC-125 capacitor bank controller sensor

Taking advantage of the wide range of capacitor controller capabilities with:
- Standard current/voltage output
- Strong performance at high harmonic levels
- Limited phase angle and ratio correction compensation
- Control power for the controller and the switches
Output Values
SCC-125 capacitor bank controller sensor

• Delivers traditional 5A and 120V output of the standard current transformers
  • No additional programming or hardware necessary for the controller
  • Strong signal, not dependent on input impedance
• Split core design allows for easy, live installation
• Combines the benefits of current/voltage transformer technology with the innovative design of a line post sensor.

Phase Angle / Ratio Correction
SCC-125 capacitor bank controller sensor

More reliability, less complexity
• Phase angle shift not required
  • Provides real-time reading of the current waveform
• Exceeds 0.3 metering class accuracy
  • Additional ratio correction factor compensation not necessary
  • Saves installation time, maintenance and training costs

Performance
SCC-125 capacitor bank controller sensor

• Supports readings up to the 66th harmonic, or 4kHz
• Meets C100 relay accuracy in addition to IEEE revenue class metering accuracy
• Inherent ability to identify fault currents with integrated with a controller
  • Displays values up to 12kA
Key Application
Feeder metering – maximize revenues

Challenges
Utilities can lose millions annually through errors in metering, losses, and theft.

Feeder Metering
Measures the distribution of energy to commercial and residential sectors and compares those readings with revenue to ensure the utility is properly billing for energy consumption.

Feeder metering helps utilities:
• Improve system planning
• Identify other issues such as phase imbalances, poor power factor, voltage sags.
• Maximize revenue
• Reveal instances of energy theft
• Discover problems with meter accuracy

Feeder analysis
No energy theft / metering errors

Source: Accenture
Analysis

• Energy balance feeder analysis using linear regression
  • Comparing customer metered loads with utility supplied load
  • Ideally should be a one-one relationship
• Slight difference in slope indicates typical 4% technical losses from transformers and conductors.
• Maximized revenue in terms of non-technical losses

Feeder analysis
Constant theft

Source: Accenture
Analysis

Y-intercept significantly greater than zero
Even if metered load goes to zero, the utility will still be supplying power to point(s) on the feeder
Incurring the cost of delivering power without any compensation erodes profitability

Data indicates a relatively consistent loss of 100kW throughout the day
Feeder analysis
Periodic Theft

Two trend lines developed via linear regression
Energy theft levels changes during different periods of the day
Most likely dealing with a more sophisticated partial bypass scenario
Data indicates at period 2 with over triple the energy loss due to theft and over double the technical losses

Sensors for Feeder/Primary Metering
ABB GridSync™ Monitoring System

Sensor:
Split-core CT/PT (ABB SCC-125)

Smart meter

Wireless or Wired communications

Substation gateway (ABB COM600)

SCC-125
Easy installation, revenue class accuracy

Appropriate for applications where easy installation is important and metering class accuracy is required:
- Unique split-core design
- Proven instrument transformer technology
- Hydrophobic cycloaliphatic epoxy (HCEP) insulation
- IEEE revenue-class accuracy
- Provides any phase, 120 V control power
GridSync™ feeder monitoring system
Focused on Flexibility

- Pole mounted NEMA 4X rated enclosure available in:
  - Polycarbonate (Standard)
  - Aluminum
- Voltage/Current Protection:
  - Voltage fuses (Standard)
  - Current shunting block (Standard)
  - FastTest (FT) switch
- Other Options include:
  - Amphenol Connections (Standard)
  - 120VAC power outlet
  - Power supply (Standard)
  - Laird antenna (Standard)
- Mounted height based on location
Integration experts will customize the enclosure to ensure desired results in both design and data acquisition.

Focused on Flexibility

- Line Post Sensors
  - Voltage and/or current line post sensor
  - Voltage-Only Sensor
    - Multi-Ratio – 120V output
    - Lightweight, simple retrofit
    - <2% ratio accuracy
  - Voltage/Current Combination Sensor
    - Voltage sensing – 120V output
    - Voltage divider / multi-ratio
    - <2% ratio accuracy
    - Current Sensing – 600:1A output
    - <1% accuracy
    - Simple, cost effective integration with IEDs (meter, relay, controller)
    - HCEP Insulation

VLS-110 Voltage Line post sensor

- Voltage-Only Sensor
  - Installs live
  - Lightweight, simple retrofit
  - 120V output
  - <1% ratio accuracy
- Used with:
  - Reclosers
  - Cap banks
  - FDIR
  - VVO/VVC/CVR
Sensors
Line post sensor - Combo

Current/Voltage Combination Sensor
- Current Sensing
- <1% accuracy
- 600:1A output
- Current transformer technology
  - Detects fault currents
  - Cleaner wave forms

Used with:
- Cap banks
- FDIR
- VVO/VVC/CVR
- 3-ph Switches

DistribuSense VLS-110
Voltage Sensor Installation

New Sensors - ViziSense
Low Voltage Transformer Monitoring Sensor

- Outdoor Rated Design
- Split Core current transformer
  - 600:1 A ratio, rating factor 2
  - <1% accuracy
- Built-in CT/voltage leads
- Simple field retrofit creating a “smart transformer” to enhance distribution grid optimization applications
  - Asset Management
  - Revenue Protection
  - System Planning
  - Operational Support

Current/Voltage sensing of pole-top distribution transformers
Sensors
Low Voltage Transformer Monitoring Sensor

- Distribution transformer monitoring for:
  - Revenue Protection
  - System Planning
  - Operations Support
  - Asset Management
- Outdoor Rated Design
- Voltage clamp
- Split-Core current transformer
  - 0.5% accuracy
  - 600:1A ratio

Data from the smart grid
Distribution Transformer Metering

- A distribution grid with sensors enable utilities to navigate feeder complexity, identify lost revenue and increase overall:
  - Efficiency...precise management and control of power usage
  - Optimization...improved power quality through volt var management
  - Reliability...provide real time voltage and power status and control 24/7

The future of power distribution relies on utilities to optimize the network and deliver power to consumers with greater reliability and efficiency at minimal cost – know the sensors that best fit your application.
Preparation at the top of the pole.

Simultaneous preparation of the GridSync sensors on the ground.

Mounting the frame to the pole with the eye-bolt located on the frame.

Beginning the assembly lift by the frame.
Securing the mounting frame on the pole.

Connecting grounded wire to the mounting frame.

Mounting the communication box to the base of the pole and making ground connections.

Securing the cable/conduit to the pole and connecting to the SCC-125 junction boxes.

Laying bare conductor in split core groove and attaching clamps/cap.

Running the cables/conduit into the control box.
Pinetops Design Project Installation

Control Box View:
- Phases color-coded.

Installation Complete: Bucket-Truck View.