Distribution Sensors
A overview of history and an update on new technology and applications
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Agenda

1. Xcel Energy Overview
2. A History of Distribution Sensors
3. Use Cases and Applications
4. Questions
Gas Customers 1.9 M
Electric Customers 3.5 M
A HISTORY OF SENSORS
Evolution of the sensor

• First – manual fault indicators
  – Horstmann in 1946, Schweitzer in 1948
  – Manually reset
• Then – manual indicators with lights
  – Auto resetting
• Then – remote fault indicators
• Along the way –
  – Pole top sensors
  – Integrated sensors into switches / reclosers
  – Hang PT’s and CT’s, use a meter
• Nothing for high-accuracy, power quality measurements
  → Purpose built sensors
Why do we need advanced sensors on the distribution system?

- Detect and report faults
- Measure current & voltage
  - Required for advanced applications
- Measure data from assets
  - Capacitors, switches, mobiles
- Measure feeder loading
  - Through addition, measure power transformer loading
- Quickly deployable for temporary applications
- Need to keep up with programs!

Let’s start with the first purpose – detecting faults!
Sensors to detect faults

Sometimes the fault sends a smoke signal
Sometimes they are pretty obvious

http://media.rhizome.org/blog/2361/sparks.jpg
Sometimes they are really obvious

http://cdn.abclocal.go.com/content/wabc/images/cms/automation/vod/683672_630x354.jpg
And sometimes, there’s not much to see
Fault indicators, many, many options!


http://smartgridsolutionsinc.com/ESCOUT_FI-3A.html


You see them everywhere
You can even find them on Ebay

Then we started to ask for more

PDP Smart Navigator
https://www.horstmannmbh.com/rs/filestore/7/8/2_0178aab35bc819d/782_alt_3290_8f412fddd1a2177.png

Cooper / Eaton S.T.A.R.
http://www.cooperindustries.com/content/public/en/power_systems/brands/star.html
Modern Sensors

- Integrated communications
  - Cell, radio, short-range to aggregator
- Multiple power options –
  - Operate with very little line current
- ‘Last gasp’ to report fault
- Added the ability to measure fault current
- Configurable fault pick-up

GridSense LineIQ,
Other types of distribution sensors


G&W Viper http://2.bp.blogspot.com/-or-4Hq3gr0E/T_BIQ3AFdiI/AAAAAAADtw/Bocl4Jt5bFk/s1600/15kV+VIPER+ST+RECLOSER.+VIPER+ST.jpg

NEXT GENERATION-
POWER SENSORS
A lot of growth in the past five years

• Evolution of the “Smart” Sensor
• Began as ‘bird on a wire’ style
  – Measured current and fault magnitude
  – Measure E Field (detect voltage presence)
• Has recently evolved into doing more
  – Accurate voltage, power quality features
  – MW, MVAr, MVA, kV, Harmonics, Temperature, GPS clocks, fast sampling rates etc…
• Many vendors provide back-end software
  – Data analytics
    • Fault capture & Fault waveforms
  – Device Management
  – Data concentrator for other systems (ADMS)
• Work on most wire size and voltages
Sentient Energy, MM3 sensor
http://192.185.156.33/~sentnewsite/wp-content/uploads/2016/02/MMS_2016-1.png

QinetiQ LineWatch Sensor.

Voltage Measuring - Optical Sensors

https://www.greentechmedia.com/content/images/articles/OptiSense_LineDeploy.jpg

Voltage Measuring – Voltage Divider

Recap

• Manual Fault Indicators (1940’s – today)
  – Very cheap
  – Quick to install, provide fault notification, can be configurable

• Remote Fault Indicators (2000’s – today)
  – A little more expensive
  – Add communications, fault magnitude capture, configurable fault pick-up, some advanced sensing

• Power Sensors (2010’s – today)
  – Highly accurate measurements
  – Add power quality sensing
  – Add data analytics back-end
  – Similar cost to remote fault indicators
SENSOR USE CASES AND APPLICATIONS
So, why is this necessary?

- We require better data!
- New systems like the Advanced Distribution Management System (ADMS) require accurate data
- Alternative methods to get the data are expensive
- Need to be able to deploy fast
- Necessary for reliability improvements
Advanced Distribution Management System (ADMS) – Refresher from earlier...

• What it is
  – Real-time network modeling
  – Enhanced visibility and control
  – Platform that enables high-value apps

• Benefits
  ✓ Enhanced reliability
  ✓ Improved voltage control
  ✓ Enables more distributed resources
Use Cases for Sensors

- Small substation monitoring
- Feeder load monitoring
- Fault Location Prediction
- State Estimation and Load Flow
- Data for planning / operations
- Waveform capture
  - Fault analysis
- Capacitor bank and switch monitoring
- Mobile Sub monitoring
Substation Monitoring – can be hard to do
Many subs don’t have room for a control house
Many substations equipped with power sensors
Data comes back over 4G cell
Data first hits sensor management system, then is passed to EMS
Data is displayed as feeder data
- MW
- MVar
- Voltage
- Fault indication / magnitude
- Additional data stored in management system for engineering use
Multiple feeders are summed to display transformer loading
Data will be used with ADMS Advanced Applications
ADVANCED GRID APPLICATIONS
Fault Location Prediction

• What it is:
  – Uses accurate impedance model
    • Model comes from GIS
  – ADMS calculates fault location with real-time topology
  – Other utilities are predicting faults to within a few spans

• Benefits
  ✓ Enhanced reliability
  ✓ Improved customer experience
  ✓ Improved employee safety
State Estimation and Load Flow

• What it is:
  – Foundational aspects of ADMS
  – Uses accurate impedance and connectivity model
    • Model comes from GIS
  – ADMS calculates current flow and voltage at all nodes on the system
  – Depends on good data!

• Benefits
  ✓ Data for Volt/VAr Optimization
  ✓ Data for control center operators
BACK TO THE SENSORS
Fault Waveform Capture – Blown fuse
Reclose trip, then blown fuse
Power on – Inrush Current
Multiple trip & reclose attempts
Power Measurements
Capacitor Monitoring

• Pole top sensors can be a cumbersome installation
• CT’s oversaturate (no fault magnitude)

Future – move to power sensors?
• As long as we’re spending the money, we might as well get all the data!

This creates challenges
• ADMS needs to recognize data from a capacitor as usable for apps
• Sensor vendors and capacitor vendors need to interact
Recap

• Sensors aren’t just for fault indication anymore!
• When combined with analytic tools and ADMS, they can be very powerful
• A cheap alternative for substation load data or generation monitoring
• Hope for the next generation to be:
  – Standards based
  – Vendor agnostic
  – Multi-application
• Options still needed for underground applications
QUESTIONS?
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