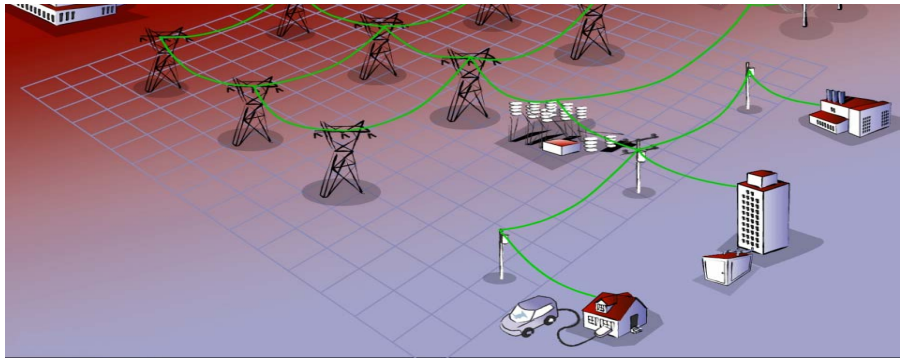
NATIONAL ENERGY TECHNOLOGY LABORATORY



HV BPL Project Summary

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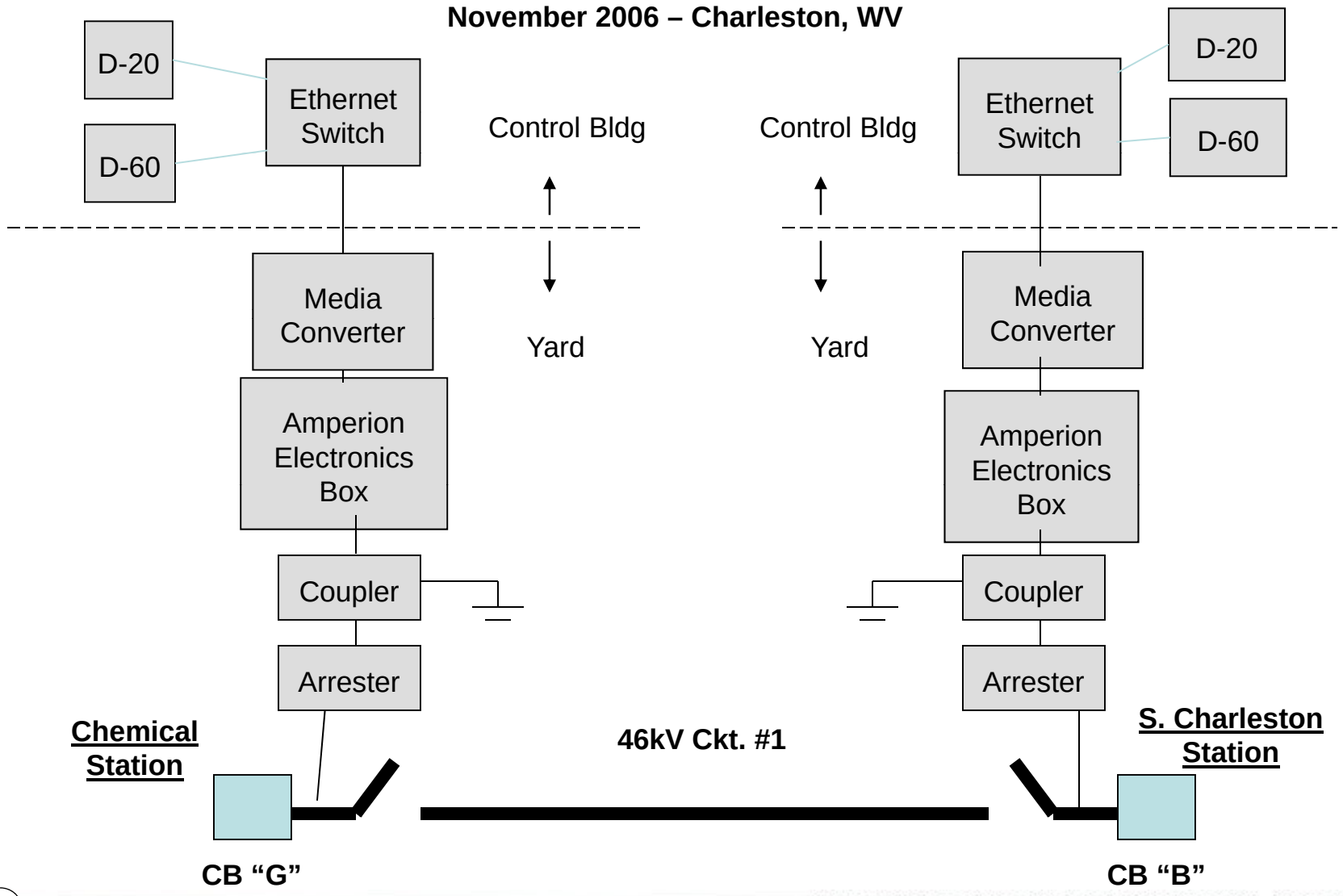
HV BPL Demonstration Project Background

- One of DOE's funded demonstration projects of advanced technology for smart grid applications (substation automation)
- Project started in Nov 2007.
  - SOW was based on earlier 2006 work in Charleston, W.V.
  - Program supported by the Office of Electricity Delivery & Energy Reliability
  - Program administrator is DOE/NETL (National Energy Technology Laboratory)
- Key applications
  - Replace old pilot wire for protective relay applications. Motivation: significant cost savings. Pilot wire technology is being phased out
  - SCADA expansion to remote stations. Motivation: economical way to extend control and visibility to remote stations
  - Station surveillance. Motivation: protect critical assets (e.g. copper theft) and comply with DHS requirement
  - Advanced protection. Motivation: employing such new digital technologies as WAMs and SIPS

Transmission BPL Proof of Concept Demo

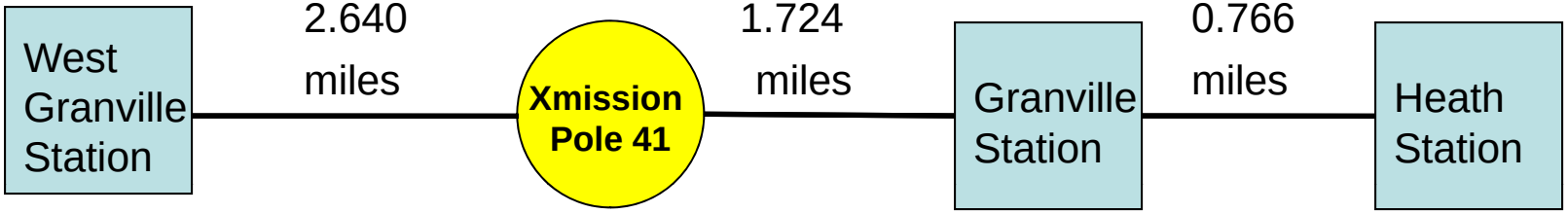


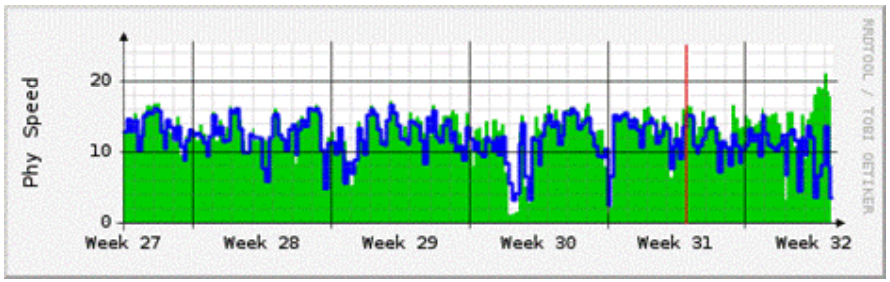
HV BPL Project Plan

- Project Phases
  - Phase 1: Establish point-to-point station communications between Heath and Granville stations over a single 0.77 miles HV BPL link
    - Requires only HV station class couplers
  - Phase 2: Establish HV BPL communications between Granville and West Granville, over 4.4 miles using repeater links
    - Requires also HV pole mounted T-line couplers for the intermediate repeater nodes
- Project Steps
  - Lab evaluation of HV arrester technology
  - Design and build of HV couplers
  - Field installation and establishing HV BPL communications
  - Remote monitoring and continuous measurements
- Project Milestones 2008
  - Completed phase 1 deployment successfully on May 2nd
  - Completed phase 2 deployment successfully on October 10th

5.13 Mile 69 KV Network Diagram

Typical Round Trip Latency = 5 milliseconds





HV BPL Phase 2 Demo – Granville to West Granville

Communications Over 4.4 Miles

Highly efficient differential coupling on phases 1 and 3 with balanced lines
Provides noise cancellation and signal recovery even in poor SNR conditions

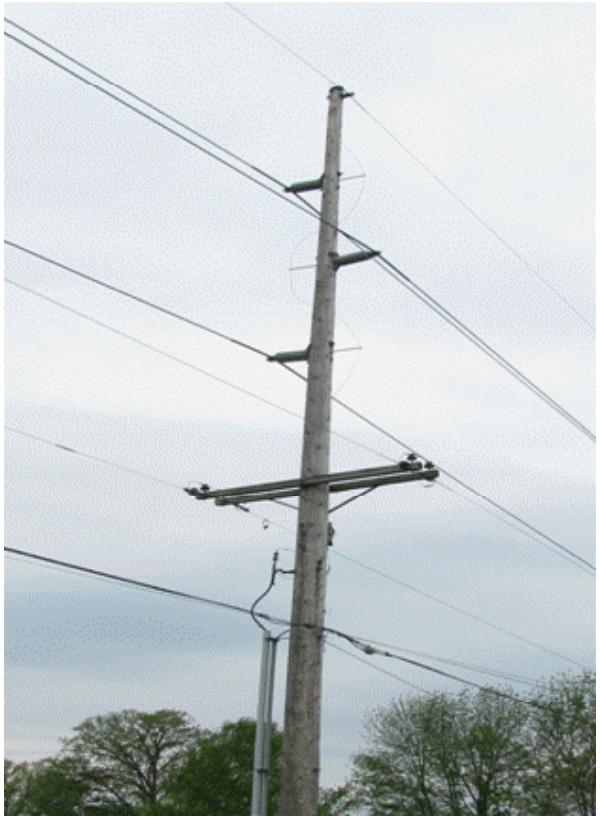
Granville Station

West Granville Station

69kV HV Station Coupler Installed in Granville

Griffin With Differential Coupling on Phases 1 & 3 at Heath Station

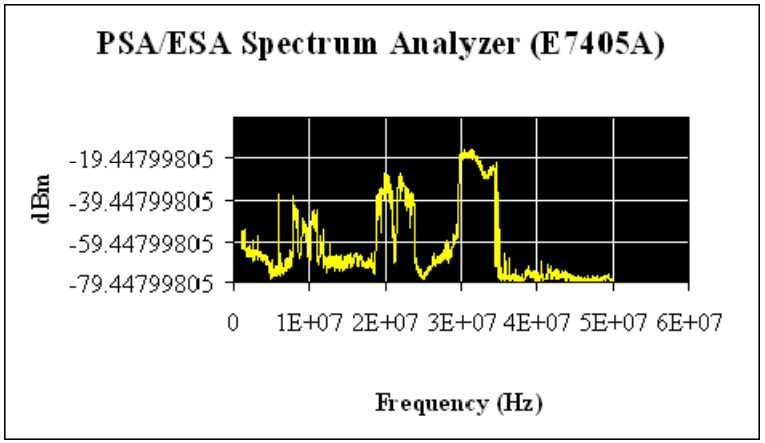
Granville to West Granville Intermediate T-Line Repeater Installation on Pole 41



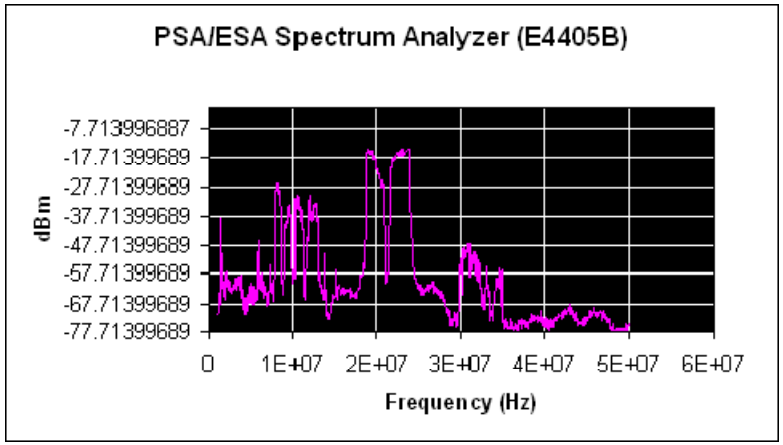
Pole 41 Before the installation and …After with all 4 HV couplers installed

Griffin Mounting Bracket with BBU – Battery Back Up Unit on Pole 41

Views From Spectrum Analyzers in Both Stations



West Granville shows all 3 BPL links



Granville shows all 3 BPL links

BPL Links use 5Mhz bands: 8 to 13Mhz, 18 to 23Mhz and 29 to 34Mhz

Added Benefit of BPL – Early Detection of Failures Improving Grid Reliability and SAIFI

- Initial site surveys prior to BPL deployment can locate noise sources to be cleaned up (Exacter used for this project)
- BPL system can be used for early detection of failures on the HV feeder
- The network management system provides continuous monitoring of the lines and can be configured to send alarms to a back office application when a noise event is triggered or a low BPC threshold is reached
- Complete link health reports can also be sent automatically from the management system for further analytics

Summary: HV BPL Substation Communications

- HV BPL Applications
  - •Protective Relaying
    - - Replacing pilot wire
    - - Advanced protection schemes
  - •SCADA Expansion
    - - Connecting remote substations
  - •Station Surveillance
    - - Protecting unmanned stations and utility assets with wireless cameras

- HV BPL RF Coupling Technology
  - •Uses standard utility arresters
  - •Uses differential coupling for noise cancellation and improved stability
  - •Lab testing 138kV technology
  - •Field tested on 46kV and 69kV lines

Project Goals Met or Exceeded

- Continuous BPL operation achieved for more than 6 months over a 5-plus mile link using one station-based and one line-based repeater
- Noise source location methods developed and found effective
- Arrester coupling techniques successful and scalable
- Differential coupling techniques developed and proven
- FCC compliance demonstrated
- Next Steps
  - Increase to 138 KV operation using similar techniques
  - Increase repeater-less distance
  - Survey noise characteristics on a variety of HV lines
  - Develop low cost method to power transmission line repeaters from line voltage
  - Improve noise source location diagnostics
  - Develop correlation of noise sources and line defects
- **Most recent accomplishment: Station-to-station repeater-less link over 4.4 miles demonstrated**

For More Information

For additional information:

http://www.netl.doe.gov/moderngrid