Linking MV-LV for a Full SCADA-Metering System

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Introduction

- Deregulation in energy market is pushing MV network automation and AMR data collection with the aim to improve both network operations and customer service.
- In Europe, two-way AMR systems based on PLC over LV lines are the preferred solution, large deployments and continuous roll-out are a reality.
- From many years ago, low bit-rate PLC solutions are available to support basic telecontrol on MV distribution networks.
- Can we provide a solution to meet the requirements and needs of a modern DA/DSM system combining both SCADA and metering functions on a single communication platform based on PLC over MV distribution networks?
  - Reducing operating costs to a minimum
  - Giving the utility full control of the system
The Scenario
comCAT-10 Technology at a Glance

- A new DLC system capable to support typical DA/DSM applications
  - Distribution Automation
  - Metering data collection based on NEStechonology powered by Echelon
  - Load Management
  - Narrowband value-added services

- System core built on two major components:
  - A DSP processor from TI driving the OFDM engine
  - A Spartan-3 FPGA device from Xilinx with an embedded MicroBlaze RISC processor to manage both the PLC MAC functions and external system interfaces
comCAT-10 works in the frequency range from 29 to 88 kHz with an OFDM approach

- In accordance with applicable IEC and Cenelec regulations
- Avoiding the problem related to PLC signal “spillover” from MV networks to LV networks
- Notching capability to avoid potential blocking of other PLC signals on LV sections (PL3120 for NES metering services, any other non-multicarrier technology applied for metering purposes)
The OFDM Engine (I)

- Non-coherent Differential QPSK (DQPSK) signal scheme
  - No need for external clock recovery
  - Bandwidth efficient to allow additional coding bits
- OFDM approach
  - 60 carriers with 1 kHz spacing (from 29 kHz to 88 kHz) and notching capability to avoid interference with LV PLC single-carrier systems
  - Variable packet length
  - Combating multi-path effects / frequency-selective fading
- Data scrambling and convolutional coding
  - Reducing very high “crest factor”
  - FEC codes/Viterbi to allow error recovery
- Channel estimation and frequency equalization to combat phase distortion
  - Channel estimation in the preamble portion
  - Optimized algorithm for frequency equalization to reduce DSP processor MIPS
The OFDM Engine (II)

- **AGC operation**
  - AFE1230 codec includes a variable gain amplifier
  - Gain range from 0 to 21 dB in 3 dB steps
  - Continuously updated by the DSP through a digital interface

- **DSP selection**
  - TMS320C54x family: flexibility, low power and “glueless” connection to the selected Codec through McBSP interface and DMA engine
  - C5409A version with sufficient memory for receive buffering and application firmware

- **AFE selection: AFE1230 from TI**
  - Transmit section
    - 16-bit delta-sigma converter with integrated digital filters
    - Direct interface to 3V DSP and Line Drivers
  - Receive section
    - 16-bit delta-sigma converter with integrated PGA
    - Direct Interface to DSP
The MAC Layer Approach

- IEC TS 61334-5-4 MAC layer profile with add-ons to share the channel for IP-based metering data
  - Both confirmed and unconfirmed PDUs
  - Medium access controlled by Initiator
  - Support for different processing times for RTUs and DCs – MAC service classes
  - Multi-hop transmission transparent to MAC users
  - Transmission error detection capabilities by using cascaded timers
  - Programmable Time-Slots for metering data traffic
Interfaces and Configuration

- **Telecontrol Port**
  - Support of IEC 870-5-101 (unbalanced transmission mode)
  - Easy integration into systems based on other common protocols (IEC 870-5-x, DNP3.0, Modbus, TCP/IP,...)

- **Metering Port**
  - Support of PPP for connection to a metering DC of a NES-based system
  - Easy integration into any IP-based AMR system

- **Ethernet Port**
  - Substation LAN interface in Master units
  - Same port used for configuration in Master/Slave units

- **Configuration**
  - Local/remote configuration through standard web browser
  - Embedded web server and TCP/IP stack for network management functions
System Highlights (I)

- Two way communication between MV substations and transformer stations, with enough bandwidth to manage the target applications (DA functions, AMR systems, load management, ...)
  - “Quasi” Real-Time operation for distribution automation functions
  - Channel capacity shared with metering data concentrators based on specific time-slots allocation

- Standard interfaces to connect RTUs, metering data concentrators and substation LAN

- Use of state-of-the-art coupling methods
  - Conventional capacitive coupling devices for overhead lines
  - Inductive coupling for shielded MV cables, typical underground cables for urban areas
System Highlights (II)

- 5 W maximum output power with a potential coverage of 10 km. with no need of repeaters
- 120 kbps maximum raw data rate with all carriers in operation
  - Net data rate close to 20 kbps under normal conditions
- Intelligent repeater functionality embedded into all units
Conclusions

- A DLC-based communication platform over MV networks capable to manage SCADA and metering functions, linking with existing PLC-based metering technologies, is an attractive proposition which avoids dependencies from telecom operators and give network control to the utility, and significantly reduces the operating costs for large deployments.

Technology is now mature to build advanced DLC systems in a reliable and cost-effective way to make the above proposition a reality.
Thank You

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