DEVELOPING A FLEXIBLE PLC IMPLEMENTATION FOR WORLDWIDE DEPLOYMENT

By Olivier Monnier and Xiaolin Lu

Driven by the rise of Smart Grid applications, Power Line Communication (PLC) technology enables more intelligent management of systems across industries, including metering, solar and lighting control, home and building automation, and electrical vehicle charging to name just a few. These types of applications require only minimal bandwidth for data collection, and narrowband PLC with operating frequencies up to 500 kHz provides high reliability at the lowest cost (see Figure 1).

There are several challenges developers must address when introducing PLC technology to a design. Within the Smart Grid, for example, there are three major market sections – grid infrastructure (i.e., concentrators), utility meters, and home/building management – each with varying application requirements. Manufacturers must also be able to accommodate the different channel and noise characteristics of each region where they plan to deploy devices. Furthermore, while there are PLC standards in place, these standards are still evolving, making them a moving target to design for. To address all of these applications and considerations with the same PLC design, as well as be able to quickly enter new markets as they arise, developers need a flexible implementation approach.

Texas Instruments (TI) is a leading participant in the development of PLC technology, serving as a principal member on both the PRIME and G3-PLC consortiums and as a contributing member for the IEEE P1901.2 narrowband PLC specification. Offering a comprehensive PLC solution, complete with fully programmable C2000™ real-time control microcontrollers, industry-leading integrated analog front ends, the extensive plcSUITE™ application software library, and flexible protocol and modulation implementations, TI is the only company providing a single PLC platform that can be deployed world-wide.

OPTIMIZED FOR POWER EFFICIENCY AND SYSTEM COST

PLC is still an emerging technology. Many markets have not yet settled on a particular standard, and even those standards which do exist are still changing as market requirements continue to be refined. For a significant number of applications, especially those based on closed networks, developers have the freedom to select the most appropriate standard for their application, even one requiring a proprietary implementation. With a hardware-based PHY approach, systems are fixed in their implementation and must be redesigned if they are to support multiple standards.

With a software-based physical layer (PHY), a single device can serve in multiple markets. TI’s PLC solutions, for example, support PRIME, G3-PLC, IEC 61334, and IEEE P1901.2, as well as PLC-Lite™ library and FlexOFDM™ library, which provide an optimized implementation for proprietary and closed networks. In addition, TI supports multiple modulation schemes, including FSK, S-FSK, and OFDM. TI is the only PLC provider that addresses all of these technologies and standards with a common hardware configuration so that manufacturers can quickly target varied market segments in different regions worldwide.

TI has optimized the cost and power efficiency of its software-based approach to PLC by integrating its powerful VCU technology into its Piccolo™ F2806x-based microcontroller series. The Viterbi and Complex Math Unit (VCU) is an instruction-level dedicated coprocessor which substantially accelerates OFDM processing by performing compute-intensive calculations in hardware for Viterbi, CRC, and complex arithmetic operations. This enables F2806x microcontrollers to provide full PLC processing performance with significantly less MIPS. In this way, developers can leverage the flexibility of a software-based approach with hardware processing efficiency to create the optimal implementation for their application without compromising performance, power, or profit. In addition, the ability to support different standards and modulations schemes with the same design allows manufacturers to enter multiple market segments simultaneously.

In addition to improving cost, performance, and power with its VCU technology, TI has also reduced the bill of materials (BOM) cost of adding PLC to designs by introducing its AFE031 fully integrated PLC analog front end. Providing all of the functionality required to provide reliable, high-performance connectivity for each of the various PLC standards, the programmable AFE031 seamlessly connects to TI microcontrollers and reduces external component count by 10x compared to discrete implementations. With multiple power saving modes and integrated EOS protection, the AFE031 substantially reduces board space requirements and system cost, as well as lowers power consumption and provides greater system reliability. Together, the F2806x microcontroller series and AFE031 provide a robust and cost-effective approach to PLC that is compatible with the large deployments being discussed for Europe.

A WORLDWIDE FIELD TEST EXPERIENCE

A big challenge manufacturers face is that every country has a different grid infrastructure. In addition, the particular channel and noise characteristics of crossing the medium voltage (MV) to or from low voltage (LV) transformers have not been well-understood at frequencies from 20 to 500 kHz. As a result, a system that works in France may not work in Turkey. Over the past months, TI has performed extensive PLC field tests all over the world, testing for instance G3-PLC in the US, Europe, China and Japan. These provide invaluable field return data that contributes to improving
PLC software development and research. In addition, TI has made significant investments to simulate and make in-field measurements of channel and noise characteristics at sites around the world to develop its robust software PHY and networking layers. Through its extensive modeling and measuring of home infrastructure and interference sources coming into the home, TI has been able to divide noise into different categories so each can be addressed within the PHY or with assistance from the MAC. From a networking perspective, TI is able to simulate networks of 1000+ meters to test meter reading success performance and network topology stability for both single hop and mesh networks. TI has also made these field test results available to the ITU and IEEE standards committees to help guide standardization and is one of the major contributors to the channel models being developed by these organizations.

For applications which do not necessarily need to follow an industry standard like PRIME or G3-PLC, including solar inverter arrays and lighting control, TI has leveraged its in-field testing data to develop the FlexOFDM library. The FlexOFDM library combines the strengths of PRIME and G3-PLC with variable bandwidth capabilities, adaptive tone mask capabilities, advanced modulation schemes such as coherent modulation, and the ability to work with an application-specific stack to provide the highest performance and reliability under all operating conditions. For low-cost applications, TI also offers the PLC-Lite library, which provides many of the advantages of the FlexOFDM library but at a lower system cost by reducing the feature set such as lowering the data rate to meet the application need.

**FAST TIME-TO-MARKET**

To assist developers in quickly evaluating the different PLC standards and modulation schemes and bringing robust products to market quickly, TI offers a complete PLC development environment with its PLC Modem Development Kit (TMDSPLCKIT-V3) which enables developers to take a modular approach to design.

Offering 2 PLC modes, the development kit supports the PRIME, G3-PLC, G3-FCC (half-band), standards, as well as the FlexOFDM and PLC-Lite libraries with scalable data rates up to 128 kbps for single-phase applications. Support for G3-FCC full-band and P1901.2 is currently under development. TI also offers the PLC System on Module (SoM), a full PLC system on a single module that can be plugged into existing systems complete with schematics and gerber files to facilitate integration of module IP into a manufacturer's own designs.

With its plcSUITE software reference design package, developers have access to all the libraries they need to quickly develop and test robust PLC implementations (see Figure 2). Delivered as a powerful framework, developers are able to separate modulation implementation, protocol design, and application development from each other. Free of royalties and NREs, plcSUITE is scalable across the entire C2000 microcontroller platform and allows developers to select the ideal microcontroller with the right balance of processing performance and peripherals for their particular application.

For quicker time to market, plcSUITE also has a zero-configuration GUI which automatically detects nodes so that developers can plug the development kit into a PC and immediately begin communicating across power lines without having to first become familiar with any MAC or PHY configuration details. For more complex operations, such as sending a special signal across the entire grid to measure performance, the GUI supports advanced configuration modes, which allow developers to easily visualize and tune key PLC modem performance parameters.

**A FULL SMART GRID EXPERTISE AND SUPPORT**

With its extensive digital and analog portfolio, TI is able to provide design recommendations and provide solutions for every stage of the Smart Grid – from utility substations to the individual devices and appliances within the home – including communications technology throughout the rest of the network such as Wi-Fi, ZigBee, and proprietary RF.

TI’s complete PLC solution offers a modular approach to design, enabling manufacturers to quickly and easily introduce PLC to a wide range of new applications. With the flexibility to optimize by modulation scheme, protocol, and application, developers can not only maximize reliability while minimizing cost, they can ensure that systems will be able to adapt to evolving standards and varying grid operating conditions. With the combination of the powerful F2806x microcontroller with the VCU and integrated analog front end, external components can be eliminated to reduce system size and cost without compromising performance or reliability. TI also brought integration to the next level by delivering the C2000 Concerto™ dual-core microcontroller series, the first chip in the market to combine an ARM® Cortex™-M3 host processor and a C28x real-time processor, which is ideal for PLC processing and application firmware onto one single device.

With its extensive field experience and unique approach to PLC, TI offers the industry’s only PLC solution which can serve the world-wide market with a single hardware platform.

TI will be demonstrating its PLC Technology in booth #A68 at Metering Billing/CRM Europe in Amsterdam, The Netherlands on October 4 - 6. 

**Links:**

Power Line Communications Solutions: www.ti.com/plc
Smart Grid solutions for grid infrastructure, utility metering, communications, and home/building automation: www.ti.com/smartgrid

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