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Introduction

Power line communications use existing power line infrastructures as a cost-effective alternative to wireless and other wired communications standards, introducing intelligent monitoring and control to industrial applications such as smart metering. With the many protocol standards and modulation schemes available, developers need a flexible development platform that simplifies design, allows for optimization to environmental conditions, supports local regulations, and can be easily adjusted to conform to evolving standards.

TI Delivers Flexible Power Line Communications Solutions

Given its ability to transfer data over the same lines used to carry power, power line communication (PLC) technology offers a cost-effective communication media for a wide range of applications. By eliminating the need to install additional wires to interconnect devices, PLC substantially reduces system cost and increases reliability while enabling efficient communications in environments that might otherwise be too expensive to network.

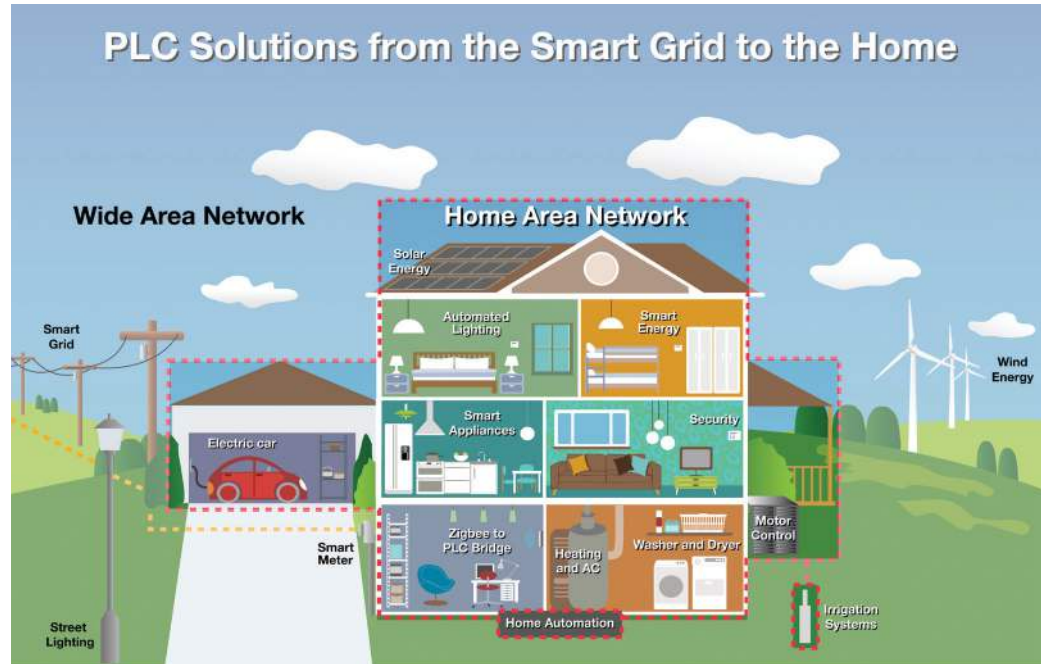
The ability to leverage the existing power line infrastructure has positioned PLC as one of the leading enabling technologies for smart-grid applications. By being able to monitor electricity usage based on time of day and even by device or application, utility companies will be able to provide pricing structures that give consumers incentives to adjust their energy consumption, thus reducing peak load and avoiding the need to construct power plants. PLC also enables more intelligent management of systems, including lighting control, home and building automation of heat and air conditioning, and security.

As a technology, PLC is appropriate for both high-speed broadband network connections, such as to the Internet, as well as for applications requiring narrowband control or low-bandwidth data collection where low cost and high reliability are essential. For smart metering applications, for example, narrowband PLC provides a robust alternative to wireless communication.

More than 200 million electricity meters with communications capabilities are expected to be deployed in Europe, the Middle East and Africa over the coming years. In these regions, concentrators/substations are already electrically connected to between 500 and 1,000 meters, making narrowband PLC a very attractive technology for serving as the infrastructure for the smart grid in these regions. Similarly, narrowband PLC is also gaining ground in home networking, lighting and solar applications.

For applications like smart meters, implementing a low-frequency narrowband PLC technology provides an optimal fit in terms of bandwidth, power and cost requirements. Operating in the narrowband domain (frequencies up to 500 kHz) ensures data integrity while minimizing system cost. With data rates that can vary from 1.2 Kbps up to 128 Kbps based on the existing standards, narrowband PLC also provides sufficient bandwidth for applications such as remote data collection from power meters, lighting control and home automation.

Ultimately, the smart grid will allow remote monitoring and control of end-user equipment using energy consumption reduction strategies based on up-to-date information accessible through the power line. These benefits extend from the home and office to the factory and other industrial applications (such as solar systems, data servers, motor control and irrigation systems). Using PLC, as long as a system is connected to a power grid network, its efficiency and operation can be intelligently managed and improved.



▲ **Figure 1.** With the Texas Instruments (TI) plcSUITE™ developers can optimize their designs to specific requirements of an application with the assurance they can adapt to new standards and opportunities as they arise.

The Power Line Communications Challenge

Developing an efficient PLC implementation is not without its challenges. Power lines are inherently noisy and require a robust architecture to ensure data reliability. In addition, each application and operating environment is different, requiring developers to optimize designs and accommodate a variety of factors. PLC implementations that are too fixed in function can only be applied in a limited number of applications and represent a risky design strategy as standards continue to evolve. Developers need a flexible platform that enables them to optimize designs to the particular requirements of each application and that will allow designs to adapt to new standards and market opportunities as they arise. In this way, intellectual property can be reused across multiple applications to accelerate development and speed time to market while expanding market opportunities.

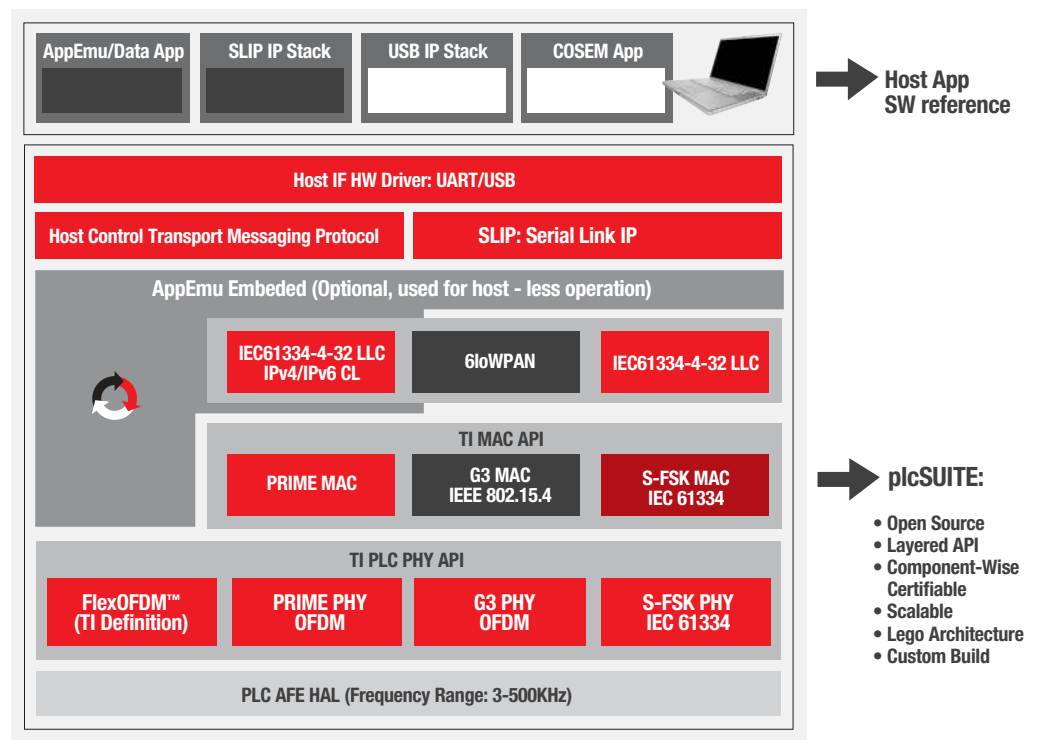
A key part to achieving flexibility is a modular architecture in terms of hardware and software. Breaking down complex PLC systems into a number of independent subsystems allows developers to change one aspect of a design – such as the modulation scheme or protocol used – without having to completely redesign the entire system.

- **Modulation Scheme:** Flexibility at the hardware level enables developers to implement the most efficient modulation scheme for a particular application. For example, several modulation schemes are available for narrowband communications, including spread frequency shift key (S-FSK) and orthogonal frequency-division multiplexing (OFDM) modulation. With a choice of modulation schemes, developers can evaluate the effectiveness of each before selecting one to use in a design.
- **Communication Protocols:** For purposes of interoperability, devices may need to be compliant to a particular protocol standard. By utilizing a flexible platform, developers can easily implement all of the popular PLC standards – including SFSK (IEC61334), PRIME and G3, as well as keep devices up-to-date as standards continue to evolve. Additionally, it becomes a simple process to migrate designs to new applications – and therefore standards – without having to completely redesign hardware or firmware.

- **Compliance to Local Regulations:** Enthusiastic support for green electronics has resulted in increasing regulation (CENELEC, FCC, ARIB, etc.), which can substantially impact smart-grid and other PLC-based applications. Developers need tools to not only ensure that devices meet such regulations but also to help speed compliance testing and approval to minimize any delays to market.

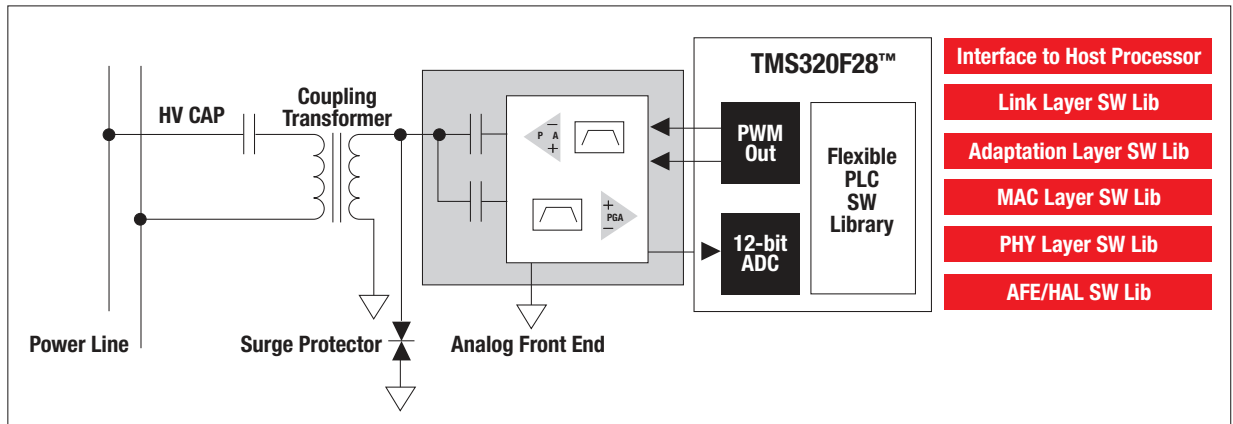
Flexible Design

Texas Instruments (TI) eases development with its flexible PLC development platform. The PLC modem hardware tool comprises separate analog front end (AFE), MCU and docking station modules. Modularity allows developers to easily adjust a system's hardware capabilities to match the various PLC modem specifications without impacting other areas of the design. For example, in addition to PRIME and G3 standards support, TI is supporting a proprietary, fully-programmable OFDM-based system with the FlexOFDM™ library, which allows developers to further improve efficiency by tuning performance and robustness for specific environmental factors or, if required, quickly define a custom OFDM implementation with configurable frequency band, number of data tones, etc. These improvements can be made independently of protocol and application software. Once the design is completed, developers can cost-reduce the various modules into a single hardware component.



▲ **Figure 2.** plcSUITE software frame

The PLC modem software (plcSUITE™) is delivered as a powerful framework aimed at enabling developers to quickly develop and test robust PLC implementations. The flexibility of the platform allows developers to separate the modulation implementation, protocol design and application development from each other. The platform also utilizes a graphical user interface (GUI) for easy visualization and tuning of key PLC modem performance parameters.



▲ **Figure 2.** TI's narrowband PLC solution

By abstracting the complexity of PLC modem design, TI has lowered the entry barrier to introducing PLC to a wide range of industrial applications. The efficiency and flexibility of TI's PLC solution enables quick differentiation and customization to specific application requirements and gives developers the option of cost-effectively introducing PLC to existing designs. In addition, plcSUITE will be scalable across the entire C2000™ MCU family, allowing developers to select an ideal MCU with the right blend of processing capacity and peripherals for implementing a complete application plus PLC.

With its unique modular hardware architecture and flexible software framework, the TI PLC modem is the industry's only PLC technology, capable of supporting multiple standards and modulation schemes with a single platform. TI's PLC road map will also provide developers with PLC solutions for every stage of the smart grid, from utility substations through the entire home area network.

Power line communications promises to change the way we monitor and control our world. By leveraging the existing power line infrastructure as a data link, for many applications PLC is the most cost-effective communication media available.

Leading the industry with the most flexible PLC solutions on the market, TI continues to invest heavily in smart-grid and smart-metering technology. TI has recently opened a worldwide PLC design center in Dallas and is a principal member of PRIME, as well as serving as a contributing member of the HomeGrid Alliance, IEEE P1901.2, ITU G.hnem and SAE/ISO-IEC. Designers can further accelerate time to market for PLC-based products by leveraging TI's extensive OFDM modulation and signal-processing expertise in industrial and analog designs. For more information about TI's power line communication products, visit www.ti.com/plc.

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