Ever since the advent of the concept of the smart grid, public utilities, businesses, consumers, the U.S. and other governments worldwide, as well as equipment and IC chip manufacturers have been eager to cash in on and tap into energy savings and new market opportunities through higher energy efficiency usage levels. One of the hottest areas in automating the smart grid is in residential and commercial automated meter reading (AMR) as part of the advanced metering infrastructure (AMI).

Today, two general methods are being used for AMR, wireless and wired via the ac power line. The former is relatively inexpensive but suffers from a lack of reliability, a limited range, and potential security breaches. Wired communications using power line communications (PLC) are more secure, but they also suffer from a lack of reliability due to challenging power line noise and interference effects, not to mention high costs as well.

Using power line communications is a lower-cost option than wireless communication in several areas. PLCs use the existing power line infrastructure whereas wireless methods requirerepeaters and other infrastructure. Wireless modules that use ZigBee and other protocols are typically more expensive to implement than PLC modules.

Another area is concentrators and data management. Using PLCs, a single concentrator can support up to 200 m, providing a bridge to utility communications methods like Ethernet, etc. Wireless routers and repeaters add to the installation cost. In addition, using wireless communications, particularly in larger-scale implementations, raises reliability issues. Wireless connectivity depends on the environment it is used in which changes.

The value of wireless communications is its mobility which is not a required attribute for smart grid applications. PLC is used in a fixed and controlled environment that will not change over time, affording less maintenance and support costs.

In addition, no general interoperability standard for power line communications has yet to be agreed upon by everyone (see the sidebar “Competing Power Line Approaches Agree To Co-Exist”) in the online version of the article at http://powerelectronics.com. Semitech has proved there can be interoperability across various devices.

Semitech Semiconductor has now unveiled the SM2200, a next-generation PLC transceiver designed for AMR where low cost and high performance levels are pre-

A power line communications chip from Semitech provides a cost-effective, versatile communications option for designers implementing automated meter reading systems.

Modem PLC Transceiver IC Meets Low-Cost/High-Performance Needs

Fig. 1. This SM2200 next-generation PLC transceiver from Semitech Semiconductor Ltd. for automated meter reading (AMR) on the smart grid fulfills low-cost and high-performance user requirements. Aimed at low- and medium-voltage (1 to 35 kV) power line networks, it contains a complete packet data modem with a physical layer (PHY) network protocol.
requisites (Fig. 1). Aimed at low- and medium-voltage (1 to 35 kV) power line networks, it contains a complete packet data modem with a physical layer (PHY) network protocol.

When combined with a microcontroller unit (MCU), it provides a cost effective solution for data links and point-to-point, star, and ad hoc networks. The chip can work with any standard MCU like the Texas Instruments MSP430. According to Semitech, the orthogonal frequency division multiple access (OFDMA) technology has been tested and successfully deployed in over 4000 nodes in China over the last two years.

The SM2200 is frequency agile. It adapts to the noise environment of an electrical power line and chooses the most effective transmission frequency. "With governments around the world driving initiatives focused on the smart grid, combined with the need for over 100 million meters per year to be replaced over the next 10 years, the introduction of the SM2200 could not have come at a better time," notes Mike Holt, Semitech’s vice president of marketing and sales. “The SM2200 makes power line communications reliable and cost effective. Power line communications is favored by utilities because it is the most natural approach, and allows the utilities to move data over an infrastructure that they control. Until now, with the introduction of the SM2200, power line communication solutions have not tolerated the harsh and noisy environment we find on the power grid," he adds.

The chip features a three/four-wire serial-peripheral interface (SPI) for the MCU and interrupt request (IR) outputs for control and data transfer. Key to the S2200’s performance is the use of OFDMA to further improve reliability.

The chip transmits data at a 175-kbit/s rate maximum. The user can change the modulation technique between binary phase-shift keying (BPSK) and quadrature PSK (QFSK), where the latter modulation technique is used to double

![Fig. 2. Block diagram of the Semitech Semiconductor SM2200 PLC transceiver IC.](image)

**Fig. 2. Block diagram of the Semitech Semiconductor SM2200 PLC transceiver IC.**

**What is OFDM?**

OFDM simply splits one fast carrier into many slower carriers. By spreading data across three carriers, one bit is three times the length for roughly the same bandwidth. Each bit is much longer, so is more immune to noise.

![What is OFDM?](image)

**What is OFDMA?**

Like OFDM, OFDMA employs multiple closely spaced sub-carriers, but the sub-carriers are divided into groups of sub-carriers. Each group is named a sub-channel. The sub-carriers that form a sub-channel need not be adjacent.

![What is OFDMA?](image)

**Fig. 3. Semitech’s orthogonal frequency division multiple access (OFDMA scheme is a multi-user version of the orthogonal frequency division multiplexing (OFDM) method used by other PLC makers. Multiple accessing is achieved by assigning subsets of subcarriers to individual data streams. This allows more reliable simultaneous transmission of several individual data streams.**
the transmission bandwidth. The carrier frequency ranges from 5 to 500 kHz and is independently programmable in 3-dB steps with power regulation. 54 carriers are grouped into 18 independent OFDMA channels allowing frequency division.

The chip also features a programmable band in use threshold circuit for noise avoidance and has buffers for 18 whole packets in reception and transmission modes (Fig. 2). The chip is now sampling and is available in a LQFP48 package. It is priced at $4.89 each in 10,000-unit quantities. It is available in a 48-pin TQFP.

Besides AMR, other applications for the SM2200 include street lighting control, smart energy home area networking, home automation, building automation, and other deployments requiring communications over an existing power line.

Semitech also offers the SM6401, an integrated power line communication SoC designed for power line communication network applications. This chip integrates an ultra-reliable and robust narrow-band power line transceiver with two 32-bit MCUs for both network communication management and user application process. Onboard 32-kbytes of flash memory make it a cost effective and versatile PLC product for AMR and home-automation applications.

A CLOSER EXAMINATION

According to the white paper “Enhancing Reliability in Medium Voltage Power Line Communications,” authored by Semitech and Lizhou Dai of the Harbin Institute of Technology in Harbin Province, China, three narrow-band communications techniques are currently employed on medium-voltage networks. These include single-carrier modulations such BPSK and frequency shift keying (FSK), orthogonal frequency division multiplexing (OFDM), and direct-sequence spread-spectrum (DSSS) together with code-division multiple access (CDMA).

Narrow-band communications typically operate at 500 kHz or less. In North America, China and Japan, the frequency range of up to 500 kHz is available for power-line communications and offers a reasonably wide communications bandwidth. Frequencies of 148.5 kHz and less have been approved by the European Committee for Electrotechnical Standardization (CENELEC) for broadly deployable PLC systems. Within this range, resulting data rates are modest, ranging from 1 kbit/s to 200 kbits/s.

The first technique, single-carrier modulation, is inherently low in cost but is prone to electrical line noise and signal propagation over these lines, which can also vary with time. It faces reliability issues mostly caused by large attenuation and narrow-band interference sources present in the communication channel. More recent OFDM and DSSS techniques have improved this shortcoming and are more resistant to narrow-band interference and many multi-path effects but can still be improved further. This is where OFDMA comes in.

OFDM has been used in broadband communications for quite some time and only recently has been tried for narrow-band modulation for PLCs. It works by splitting the signal into multiple smaller sub-signals that are then transmitted simultaneously at different (orthogonal) frequencies. Each smaller data stream is then mapped to an individual data sub-carrier and modulated using some sort of PSK or quadrature amplitude modulation (QAM), i.e. BPSK, QPSK.

In addition to its high spectral efficiency, an OFDM system reduces the amount of crosstalk in signal transmissions, and can efficiently overcome interference and frequency-selective fading caused by multipath.

While OFDM addresses communications in noisy smart grid environments, it is still insufficient to achieve reliable communications in very harsh conditions. Collin and Dai conducted tests on area noise and signal levels on medium-voltage power lines in China’s Hebei Province and found that they vary widely and that no two such networks have identical transmission characteristics. They point out that the two most critical factors that influence a smart grid’s communications’ characteristics are the network topology and the loads connected to the network.
To further improve reliability, the OFDM method can be combined with a multiple access scheme, hence OFDMA. This new approach is a multi-user version of the OFDM scheme. Multiple accessing is achieved in OFDMA by assigning subsets of subcarriers to individual data streams. This allows simultaneous transmission of several individual data streams (Fig. 3).

OFDMA, a multi-user version of OFDM, further improves OFDM robustness to fading and interference, but more importantly, the individual data streams can be used either to communicate with multiple nodes (power meters) simultaneously or for redundancy, thus greatly improving the reliability of the system.

The result of a communication trial using OFDMA with a redundancy scheme has shown performance improvements with signals reduced by 18 dB more than existing approaches (Fig. 4). The result is that although the channel capacity was reduced to less than half its previous value, OFDMA was still able to reliably communicate with 100% of the packets successfully transmitted across a small (and variable) number of the sub-channels. It can be seen that OFDMA significantly enhances both throughput of data, as well as the reliability when part of the carrier frequency spectrum is blocked by either noise or attenuation.

A LOWER-COST ALTERNATIVE

More recently, Semitech has unveiled the SM2101 which it claims is the lowest-cost and highest-reliability PLC for AMR on the market (Fig. 5). A simplified modem-only version of the SM640, it does not contain an MCU and flash memory. It does, however, offer a user-selectable choice of BPSK and FSK modulation and choice of 8 factory preset communications frequencies, dynamically selectable with programmable bit rates from 5.4 kbits/s to 1 kbit/s, for avoiding power line interference.

The PLC also features -80 dBV receiver sensitivity, triple data encryption standard (DES) and decryption capability, forward error correction, and combines a core that is compliant with the 709.1 American National Standards Institute/Electronic Industry Association (ANSI/EIA) standard, as well as the ANSI/EIA 709.2 power line transceiver standard. It also supports CENELEC A, B and C band operations.

The PLC is available at a price of $1.95 each in 10,000-unit quantities.