



An Update on Short Range Wireless Technology

By Rich Howell

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The **IEEE 802.15.4** standard originated in response to the need for robust, low-cost, low-power wireless control networks. Operating in the 868 MHz, 902 - 928 MHz, and 2.4 GHz ISM radio bands, 802.15.4 defines the fundamental lower levels of these networks: the physical layer (PHY) and media access control (MAC). While these layers manage the **RF** and data transmission functions, the upper layers—security, networking, and application must also be defined in order to provide a complete **networking solution**. A growing number of specification sets have evolved, each of which addresses the unique requirements of a specific group of end users.

RF4CE defines an emerging two-way, wireless remote control standard for home entertainment components. Backed by Sony, Samsung, [Panasonic](#), and Phillips, and more recently by the ZigBee Alliance, RF4CE replaces line-of-sight infrared control with a thru-the-wall RF signal. It will allow consumers to control HDTV, home theater and audio components from anywhere in the house, plus it works better with new energy efficient LED backlight technologies. RF4CE also opens the door to two-way communications between home entertainment components and the user's remote. The RF4CE Consortium and the [ZigBee](#) Alliance are working on an RF control profile that will soon be made available to consumer electronics manufacturers worldwide.

WirelessHART is an extension of the HART standard, a hardwire control protocol used in industrial processing. One of WirelessHART's strengths is that it is backward compatible. Using simple adapters, machines running the wired protocol can be easily connected to a [WirelessHART](#) network. HART is global standard with a vast installed base. For many of these users, WirelessHART will offer the path of least resistance when updating to wireless control.

By far, the largest standards group at work in **802.15.4** is the **ZigBee® Alliance**. A worldwide consortium of over 250 companies, the Alliance's mission is to develop networking, security, and applications protocols; establish testing and compliance standards; and ensure the interoperability of [ZigBee products](#).

ZigBee protocols target applications such as home and building automation, industrial control, HVAC and lighting control, medical data collection, and AMR/AMI (Automatic

Meter Reading/Advanced Metering Infrastructure). ZigBee as a standard is well established and a wide range of ZigBee-enabled products are already available. These include smart utility meters, smart home thermostats, HVAC control units, and smart-energy electrical outlets.

Software Advances

As the world embraces wireless control, we'll see more and more [wireless product](#) designs undertaken by engineers with little or no **RF** experience. Software and hardware tools are rapidly evolving to help these engineers get their wireless mesh networks up and running and off to market.

Last year saw the introduction of **ZigBee PRO**, which continues to improve upon and optimize the ZigBee standard. ZigBee PRO also offers a variety of packaged application profiles designed to simplify and accelerate time-to-market. These include home automation, smart energy, building automation, telecommunications, and personal health care.

ZigBee PRO is offered alongside ZigBee 2006, an updated version of the original feature set standardized by the Alliance. ZigBee PRO offers a number of features designed for the support of larger networks. Where ZigBee 2006 used a complex tree structure to assign addresses to nodes, **ZigBee PRO** uses stochastic addressing. This simplifies routing structures and makes it much easier to add new nodes to a network.

ZigBee PRO also employs asymmetric link handling. This optimizes link paths, which in turn leads to faster throughput and better reliability. A new many-to-one routing technique also helps minimize traffic in networks where multiple nodes report back to a single point, opening up more bandwidth for improved data transmission.

Network-wide encrypted security, an option on ZigBee 2006, is built in to ZigBee PRO. This can be of benefit to certain applications, but it requires increased processing space, and so comes at the expense of the space available for application code.

Power management, always a concern in networks employing battery-powered devices, has also evolved. ZigBee Pro networks allow end nodes to “nap” for fixed periods of time, employing the ZigBee router as a proxy when the node is asleep. The protocol allows network designers to define and control these sleep periods to best meet the needs of their application.

Companies like **Synapse** are also making it easier for engineers outside the RF world to design and implement 802.15.4 **wireless mesh networks**. Their [SNAP®](#) and **Portal® software** tools enable the development of networks by designers with no embedded programming skills. Synapse also offers Sleepy Mesh™; a network synchronization tool that enables all nodes, including routers, to sleep. This eliminates the need for line-powered routers and substantially reduces the amount of power consumed by the network.

802.15.4 Hardware

802.15.4 is widely supported by semiconductor manufacturers, a good indication of its acceptance as a viable standard. Ember, [Freescale](#), [Texas Instruments](#), [California Eastern Laboratories \(CEL\)](#), and others offer a wide variety of transceiver and microprocessor ICs. Range extension components like LNAs, power amplifiers and RFIC switches designed to boost transceiver output are also widely available, as are **modules** that package these components into complete miniature radios.

Drop-in radio modules, many with built in antennas, can be loaded with pre-packaged application software to quickly test and prototype designs. When certified and qualified, they're an excellent means for getting products to market quickly and with reduced risk. **Modules** are also a good choice for engineers for whom radio design is not a core competency (i.e., HVAC, industrial control, medical instrumentation, etc.). IC solutions are more often seen in products that are manufactured in large volume, where development costs can be amortized.

802.15.4 IC solutions come in a variety of flavors. Network Co-Processor ICs like Ember's EM260 combine a transceiver with an on board flash-based co-processor. (Fig. 1) The EM260 stores the ZigBee stack in its flash memory and works closely with the host processor that's resident in the end-user application. The host processor controls the radio through a traditional serial interface. This approach is especially useful in networks that already have an MCU as part of the system. It allows users to write host control commands into their end application, eliminating the need to write code for additional MCUs. It also lets designers add RF connectivity to their products, while continuing to work with the microcontrollers with which they are familiar.

CEL combines the EM260 with a 100 mW power amplifier in a miniature radio module called the [Apex LT](#). The added amplification helps boost the module's output to +20 dBm, which can be critical for reliable, accurate transmission in noisy environments. It also helps boost range for long distance and helps overcome physical barriers like those found in Smart Energy applications, where outdoor utility meters must communicate through exterior and interior walls to reach smart thermostats and other energy-management devices.

Some solutions pair a transceiver IC with a second, complementary microprocessor device, but the trend is toward combining both functions on a single piece of silicon. Both 8-bit and 16-bit MCU processing is readily available on 802.15.4 transceiver platforms, and devices with more processing power are beginning to arrive upon the scene. In June, [Freescale](#) began sampling its [MC13224](#), a single chip, platform-in-package (PiP) transceiver with integrated 32-bit [ARM7](#) processor (Fig. 2). This 32-bit MCU, combined with generous on-chip memory, promises to help designers eliminate the peripheral processing devices that less powerful platforms require to run complex applications. For designers seeking a simple drop-in radio based on the MC13224 platform, CEL offers its [FreeStar PRO](#) module. Like many 802.15.4 radio modules on

today's market, the FreeStar PRO is FCC, IC and CE certified, eliminating the need for designers to go through a costly and time-consuming process certifying their designs.

802.15.4 and ZigBee standards are gaining wide acceptance. In 2008, overall sales revenues for chipsets and modules increased by nearly 50% over the previous year. Some industry analysts are forecasting 2009 sales to nearly double the 2008 numbers. The 802.15.4 market continues to show strong growth, even during these trying economic times.

With widespread adoption of **802.15.4**, the technology sometimes finds itself entering uncharted waters (Fig. 3). New and unique applications are demanding chipsets that deliver more processing power, more output power, more memory, faster data rates—and unique features like the ability to transmit voice and video (Fig. 4). At the same time, other applications are beginning to demand stripped-down, purpose-built ultra-low power devices designed to run on energy “harvested” from sources like ambient light, vibrations and thermal gradients.

Futurists have been trumpeting the arrival of the “Internet of Things,” a world in which sensors, computers and controllers are all merged seamlessly across the environment. 6LoWPAN is an internet protocol standard that defines the compression of internet data packets for transmission over 802.15.4. Developed by the IETF (Internet Engineering Task Force), this standard will encourage the development of new and imaginative uses for **wireless mesh networks**.

In spite of the current state of the economy, the state of IEEE 802.15.4 and the products that support it looks healthy. While it may not be as appreciated as the sexier technologies driving consumer handsets, 802.15.4 has the potential to be ubiquitous, replacing wired networks in both homes and industry as well as enabling future applications of which we can only dream.



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