RF Modules Rule the Waves

Jon Titus, Senior Technical Editor

Every electronic product seems to come with a wireless link. My neighbor's sprinkler system includes a wireless unit that lets him sit indoors and program his watering times and sequences. A variety of chips and modules from many manufacturers makes it easy for engineers to drop a wireless link into new and existing designs. Many of those devices conform to the IEEE-802.15.4 specification for a wireless personal-area network (WPAN) that accommodates low data rates, short-range communications and low-power operations. But in some cases, non-standard chips and modules work just as well.

Some confusion surrounds the 802.15.4 standard which specifies a radio or "physical layer" that communicates information. The popular ZigBee protocol, for example, builds upon radios that comply with the 802.15.4 standard. ZigBee requires a "stack" that defines how applications communicate. Keep in mind that ZigBee and 802.15.4 are not one and the same (Figure 1). Protocols other than ZigBee can use 802.15.4 radios, too. (The ZigBee stack is much like the TCP/IP stack; a series of software layers that separate hardware from application programs.)

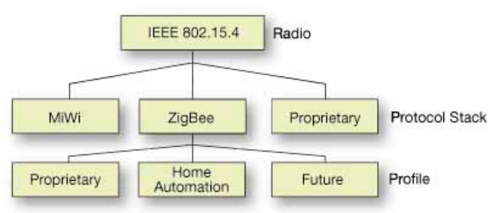


Figure 1. The heirarchy of communications shows an overarching IEEE 802.15.4 radio and underlying protocol stacks and profiles. Communications other than ZigBee can use 802.15.4 radios.

Anyone can obtain and use a ZigBee stack which comes built into some radios. But, that does not guarantee interoperability with ZigBee devices from other vendors. So far, the ZigBee Alliance has developed one standard profile for the makers of home-automation products. Companies that use that profile can offer devices, such as thermostats and switches that communicate with each other. Engineers in other industries are on their own when it comes to compatibility between products. Depending on the end application, proprietary communication products and protocols that use 802.15.4 radios can work as well as, or better than, those that use ZigBee.

Engineers can choose from a cornucopia of chips, modules, development kits, software tools and related products that provide ZigBee or proprietary-communication protocols. We will cover some products and companies and list others in the "Wireless Chip and Module Resources [1]" list.

ZigBee Spreads a Wide Net

Radios in a typical ZigBee mesh network cover a large area and communicate over many radio-to-radio hops. Networks can take many configurations, as shown in Figure 2. "You find a mesh network in meter-reading systems," said Rodger Richey, senior applications manager in the Advanced Microcontroller Architecture Division at Microchip Technology. "Energy, water and gas meters would 'talk' to each other and relay messages to a main data-collection point."

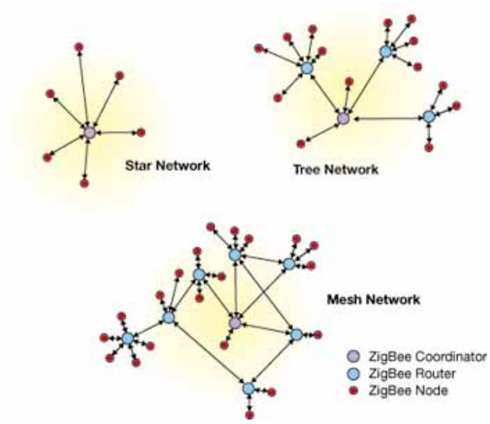


Figure 2. ZigBee networks provide for three architectures, from a simple star arrangement to a mesh network that allows for multiple hops between nodes, routers and a coordinator.

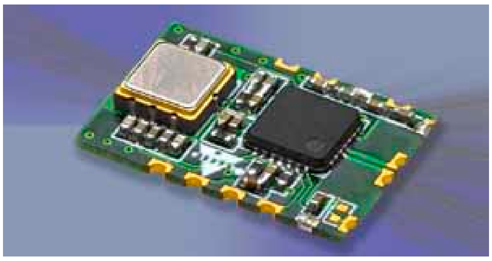
You could find ZigBee in a home-control system that includes 10 to 12 nodes such as light switches," noted Richey. "ZigBee supports over 64,000 nodes, so the protocol comes with a lot of code that maintains routing tables and other protocol information. A typical ZigBee stack requires from 64 to 96 Kbytes and some stacks reach 128 Kbytes, so even a simple ZigBee-compatible light switch could require a large and expensive MCU. In some cases, ZigBee may be overkill."

To assist engineers with small networks, Microchip developed its own protocol stack called MiWi -- basically, a "thin" media-access-control (MAC) layer that works with an 802.15.4 radio. The MiWi stack takes about 4 Kbytes of memory which lets it run in PIC16 MCUs. The protocol operates with up to 1,000 nodes in star, tree and mesh networks, and messages can make as many as four node-to-node hops.

Cirronet's modules include a complete ZigBee stack. And, Cirronet provides its own ZigBee profile so that programmers need not write any code to control communications. "Most of the time, engineers just use our profile," explained Tim Cutler, vice president of marketing at Cirronet. "If they want a node to automatically wake up and transmit data after a timer times out, our profile can control that type of operation."

If developers need their own protocol, application engineers at MaxStream can help them define one. "Often, an application does not need a sophisticated protocol," noted John Schwartz, technical support manager at MaxStream. "A transceiver sends a packet and receives a response. If it does not receive a response, it retransmits a packet a set number of times. As developers start to design a protocol for their equipment, they must think about how a network will communicate and how it will handle potential problems." If developers now have a simple wire connection between devices, they may not have considered how to detect errors and request retransmissions of data.

Proprietary radio types also have a place in the array of products available to engineers. The RF Waves division of Vishay, for example, produces modules that use direct-sequence spread-spectrum and frequency-hopping spread-spectrum radios which operate in the 2.4-GHz license-free ISM band. Although many devices crowd into the ISM band, the Vishay modules "coexist" nicely with them.



This complete module from the RF Waves division on Vishay provides a transceiver radio that engineers can drop into a design for proprietary communications.

The Vishay RFW122L/RFW122M, RFW8M and RFW3M modules have a range of about 20M indoors and modules that include an RF amplifier have an indoor range of about 60M. The latter modules can operate at up to about 8 Mbits/sec., making them attractive for video and audio communications. "Developers treat these modules like black boxes," explained David Ben-Bassat, president of Vishay's RF Waves Division. "They do not need to know what goes on inside. They just interface a module to their digital circuits and get going. Treat a module properly on the digital side, and the RF side will do its job."
According to Ben-Bassat, the wireless market divides into standard and proprietary technologies. "By their nature, standard technologies carry a lot of overhead. On the other hand lean-and-mean proprietary technologies let engineers optimize cost and performance for an application."

In some cases, a proprietary approach provides another benefit: Equipment manufacturers may want to prevent their products from operating with those from other vendors. "Suppose you sell a home-security system," said Rodger Richey of

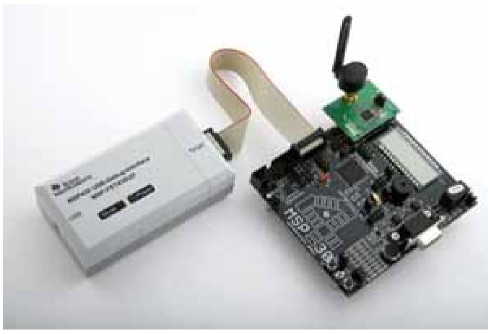
Microchip. "You want to 'capture' each home for yourself and you do not want another company to sell add-on products for your system." In that type of situation, a proprietary scheme protects your business.

Although radio vendors offer a variety of modules, chips and chipsets, many customers want to simplify designs and purchase a radio and an MCU in one IC. Ember, for example, provides a Cambridge Consultants XAP-2 MCU core in its EM250 ZigBee chip. "The chip looks like a standard MCU with I/O pins, a timer and a radio," said Andy Wheeler, Ember's chief technology officer. "You have an antenna on one side and digital I/O on the other." Engineers program the MCU in C and link their code to the Ember ZigBee library.

But that approach can lock engineers into one type of processor with a limited variety of peripherals and I/O ports. If you need, say, an Ethernet connection, you may have to add a second chip to provide that capability. Thus, Microchip, for one, continues on the two-chip path that separates radios and MCUs. "Customers can choose a radio and mate it with almost any of our MCUs," said Microchip's Richey. "Then, when they need an Ethernet port, a faster ADC or more memory, they pick a different MCU."

Engineers who want to move a step up from individual chips can select an all-in-one module that provides a radio, an MCU, I/O ports, and digital communications. Although this package might cost more than individual chips and components, modules offer at least one advantage --> low risk. "If chip vendors update their silicon or if protocol specifications change, we change our designs," said John Schwartz of MaxStream. "In many cases, the user does not know the difference. We assume the risk and guarantee our modules meet a given specification, regardless of the silicon in them."

What Do You Want to Do?



Developers can add a Texas Instruments ZigBee module to the company's MSP430 MCU Experimenter's Board to test concepts and programs. Software turns this type of setup into a ZigBee sniffer.

Before engineers jump on one wireless-communication technology, they must know

what they want their communication system to do. Often, engineers do not care about underlying technologies; they just want to solve a problem. "If someone needs a simple point-to-point link, they can use our CC2420 802.15.4 chip," explained Mark Grazier, business development manager for Texas Instruments' Low Power RF Products. "Many times, a short distance between devices means a simple radio will work well. In that case, engineers can start with a CC2430DK Development Kit, write some code and move data back and forth between two points."
But, if customers need a full-mesh or multi-hop network, they can buy TI's CC2430ZDK ZigBee Development Kit that comes with five nodes, a mother board and a "sniffer" that lets users examine transmitted data packets. (See sidebar: Give ZigBee the Sniffer Test.)

According to John Schwartz at MaxStream, almost all new applications require point-to-multipoint communications. "A few customers say they do not want a full-blown mesh network, but most like to have a limited mesh-network capability just in case they end up with a node they cannot communicate with in any other way. A mesh network offers a fall-back plan." MaxStream, a part of Digi International, offers a variety of radio development kits that can communicate from several hundred feet to 40 miles. Rabbit Semiconductor, also part of Digi, uses MaxStream XBee modules in its ZigBee/802.15.4 Application Kit.

Engineers always want to know how far radios can communicate. "Range depends on physics: materials between radios, how many paths and reflections you get from radio A to radio B and other effects," said Mark Grazier of Texas Instruments. Grazier also noted that engineers want to know how many nodes they can put in a ZigBee network. "We have run tests with over 200 nodes and have started to see companies deploy ZigBee products in large building-monitoring systems. Those applications will help us all determine what is practical."

"I have talked with people who assume their design will always achieve the spec sheet's line-of-sight range," noted John Schwartz of MaxStream. "So they do not run any tests and deploy prototypes only to find they have nodes they cannot talk to. In that situation, they cannot do anything but adopt a mesh network to overcome the range problem. But they may not have that type of modification in their plan or budget."

An InSight Development Kit from Ember includes hardware, development tools, and software for embedded-applications developers to help them design an intelligent decentralized device network.

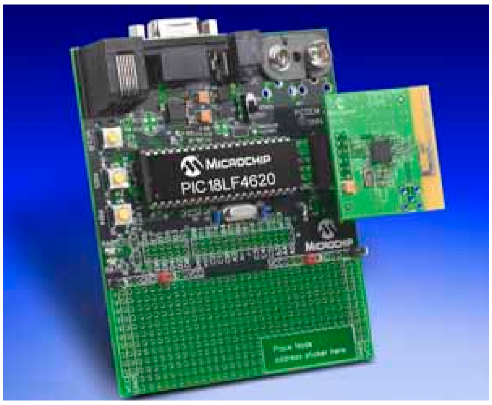
Schwartz recommends that engineers test their design in a typical operating environment -- say, an office building, a home, outdoors and so on. A module may have a specified indoor range of 300 feet, but in some indoor situations, the range may extend to only 60 feet. Radios that operate outdoors over a 1.5-mile clear path might have a range of 300 feet through trees. "When engineers test a product before they deploy it, they should understand how their system will to perform in the field," said Schwartz.
"We talk with engineers who know the type of wireless communication they need and with others who do not," said Tim Cutler of Cirronet. Because ZigBee has received so much press coverage, engineers say they want to use ZigBee, even though they might not need it. "We help them choose modules, operating frequencies, data rates and so on," explained Cutler. "Generally, small start-up companies create new wireless products and established companies add wireless capabilities to existing products," said Cutler.

Like other companies, Cirronet offers development kits for all its modules. First, engineers can set up a wireless link that connects two PCs and lets them communicate. This step helps engineers understand how to work with a kit's API and how to control basic module operations. Second, the engineers can use a kit as a known-good reference. If they run into trouble, they can move modules back to the development kit. Then they can determine if they have a wireless-network problem or a problem with the way they applied the modules in their design.

In addition to deploying individual nodes, system designers must establish a control point or base station that will collect data and send it to a central point. (ZigBee systems label this radio a coordinator.) "Generally, after customers design a module into a widget, they put a module in a box near a PC to serve as their base station," said Cirronet's Tim Cutler. "Instead of designing their own base station, we encourage them to buy one and concentrate on their widget design."

Some Experience Necessary

"We talk with two types of developers," said Nate Smith, product marketing manager in the Advanced Microcontroller Architecture Division at Microchip Technology. "Some engineers have a lot of RF experience and others have little or no experience with RF circuits, but they know a lot about embedded systems. Both groups want to put ZigBee capabilities in a design." According to Smith, many digital designers think they can just drop a module into a design and have wireless communications. Sometimes that approach works, but experience with RF circuitry always helps.



The PICDEM Z board from Microchip accepts an IEEE 802.15.4-compatible daughter module. The MCU chip runs the MiWi profile that operates much like ZigBee but takes less memory.

To some engineers, antenna design has the look of black magic. Like many companies, Vishay's RF Waves Division offers modules with and without antennas. "Our RFW122L modules come with a built-in loop antenna," explained David Ben-Bassat. "Application information tells engineers where to -- and where not to -- put the antenna so if they follow the directions, they should not have problems." RF Waves provides technical support in case developers run into a snag.
"Unless engineers have RF experience, they often have difficulty figuring out how to design an antenna in any RF product," noted Ben-Bassat. "If they attempt an antenna design on their own, they may get so-so wireless performance because they lose a lot of RF energy in a poorly designed antenna." Vishay's engineers can point customers to consultants and companies that can assist with antenna designs.

Cirronet's Tim Cutler wants to talk with engineers about antenna locations as soon as they start to investigate wireless designs. "If they plan to put an antenna inside their product, we can offer tips about the proper place to put it. They also need to think about the antenna's radiation pattern and how they will connect a module to their antenna. If they need to run a PCB trace for the RF signal, we tell them how to create a 50? conductor."

Texas Instruments' engineers ask developers two basic questions: First, have you designed with RF circuits before? And second, are you familiar with antenna layouts and RF matching circuits? "Engineers take our development kits and create a prototype so they know the boards work. Then they move on to their own design," said TI's Mark Grazier. "But many of these people have not created an antenna layout, so 50? terminations and the balun between the antenna and our IC can present a hurdle."

To help overcome antenna problems, TI provides a reference design (with an antenna) in a Gerber file that engineers can download and use without modifying it. So, engineers have a ready-to-use PCB design that will get them on the air quickly. "To ensure that the circuit works, they must use the parts we recommend," stressed Grazier. "We list specific components, such as inductors and capacitors, to make it easy for engineers to replicate our reference design."

After designing and testing a product, it may require some level of FCC certification. Although designs produced from chips may offer a price advantage over modules, chip-based designs must undergo thorough certification. Modules, though, may carry some FCC approvals with them. "All our modules have received FCC certification and we get certified by ETSI, the European Telecommunications Standards Institute," said Tim Cutler of Cirronet. "Our FCC certification removes the need for a company to get type acceptance for their end product. In Europe, products need the CE mark, but the ETSI certification removes the requirement to do some of the intentional-radiator tests."

According to Rodger Richey at Microchip, much of the heartburn during FCC compliance testing occurs when something fails. "Say engineers take a reference design from a data sheet and drop it on their PCB. Then suppose during testing, their product does not comply with the FCC's specifications. They may have no clue how to fix the problem. The big expense comes not from the FCC tests themselves, but from redoing a design again and again until it passes." Some pre-compliance testing and consulting with chip and module suppliers can help avoid or overcome problems meeting regulatory specifications.

SIDEBAR: Give ZigBee The Sniffer Test [2]

Wireless Chip and Module Resources [1]

Source URL (retrieved on *03/27/2015 - 3:06am*):
http://www.ecnmag.com/articles/2007/06/rf-modules-rule-waves

Links:

[1] http://www.ecnmag.com/article.aspx?id=141992
[2] http://www.ecnmag.com/article.aspx?id=142006