Adaptable Embedded Wireless Design with Cypress's CyFi Low-Power RF

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Embedded systems designers are quickly realizing the benefits of going wireless, including reductions in cable costs, aesthetics and ease of installation. These benefits are seen across a multitude of applications, to include: low-power wireless sensor networks, industrial process monitoring and automation, home automation, automatic meter reading and many other applications. Unfortunately, wireless solutions often come with barriers or challenges such as reliability of wireless connectivity, distance limitations due to signal range, complexity of designing-in or attaching a wireless solution, and the dire need for low-power consumption to maximize battery life. In response, a plethora of wireless technologies have evolved. Data encoding techniques such as Direct Sequence Spread Spectrum (DSSS) are used to maximize reliability (figure 1). Channel hopping is used to avoid interference (figure 2). Signal amplification, through both on-chip and off-chip amplifiers address range issues. And extremely low-power transceivers that have low sleep, receive and transmit power ratings have evolved to extend battery life.

While many wireless solutions in the market today address one or two of these design challenges, the problem for designers has been finding a single solution that incorporates all of these technologies. For example, many proprietary 2.4-GHz wireless solutions focus on providing ultra low transceiver power ratings, but these solutions fall short in terms of reliability and/or range.

Cypress's new CyFi Low-Power RF solution, however, addresses all of these challenges in an uncompromising way. It provides a highly reliable, longer range solution that is extremely simple to design and operate, and offers the best system power-efficiency in the market.

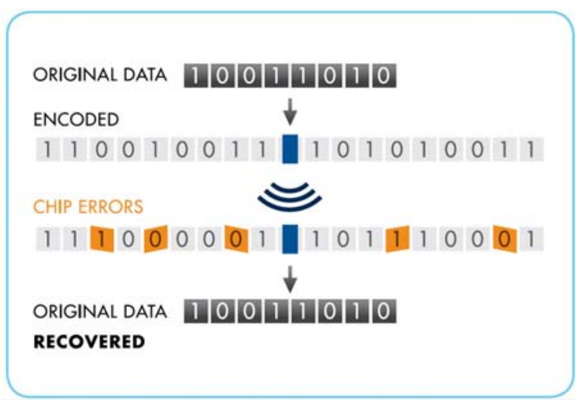

Figure 1 - Direct Sequence Spread Spectrum

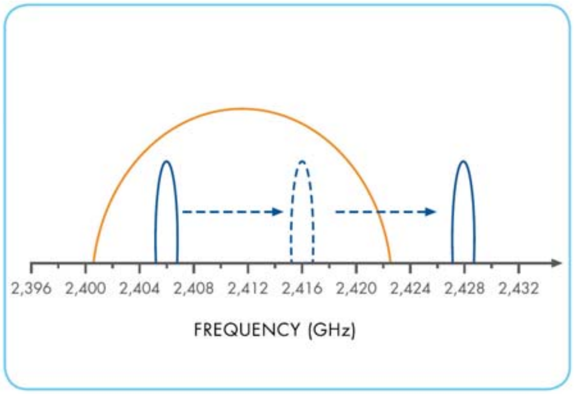

Figure 2 - Channel Hopping

Reliability Technologies

DSSS and hopping technologies have evolved to directly address the challenge of wireless reliability. DSSS is a radio transmission technology that essentially applies a robust forward error correction scheme to the data-in-transit in order to minimize the effect of data loss due to signal interference. Specifically, DSSS encodes a set of data into a larger bit stream, or chips. As you can see in figure 1, 8 bits of data is encoded into 32 chips. The chips are then modulated onto the RF signal and transmitted. The receiver demodulates the chips from the received signal and then reverses the DSSS encoding scheme. Even with demodulation errors due to signal noise or interference, the original data can still be recovered.

Channel hopping is an often complex technique of moving around the available RF spectrum to avoid interference. Some technologies are designed to constantly hop following an established and shared hopping algorithm, while others hop only as needed, or when facing overwhelming signal noise or interference. Finally, the smaller the channel size the greater the number of channels to hop to and, thus, the greater the spectrum agility to avoid interference. Cypress's CyFi Low-Power RF solution, for example, enables high frequency agility with 80 1-MHz channels that its built-in protocol can dynamically and smartly choose from. When moving channels the CyFi hub application activates a channel selection algorithm that moves across a network-predictable channel sequence and measures each channels' level of noise and settles on the channel it first reaches that is optimal for its operation. Once relocated, nodes within the hub's network follow the same network-predictable channel sequence and rejoin the hub with minimal latency resulting in fewer retransmissions because they relocate to a quiet operating environment.

These benefits in reliability directly correlate to system power savings: the higher the reliability, the less power-intensive retransmits are required, and the more time spent in power conserving sleep modes. In addition, the higher the reliability, the further the signal can transmit and still be clearly deciphered, boosting the signal range.

Power-Efficiency vs. Low-Power

The driving feature in the world of embedded wireless has long been minimizing sleep, transmit and receive power ratings of the transceivers. This focus has been so great that the efforts to minimize these power ratings have come at the expense of system reliability, which adversely affects the system's power rating. A wireless system with low reliability will result in many more inefficient re-transmits when compared to a reliable system and thus will expend more energy despite having lower per-component power ratings—thus the push to focus on system-level power consumption, or "power efficiency."

Power-Efficiency is the power savings contributed to by all of the different features and components of the wireless solution. The transceiver and its low sleep, transmit and receive current are only one of the many variables within the overall measure of system power efficiency. Other attributes include the level of system reliability (average number of transmits and retransmits) and any power management controls embedded in the solution's protocol.

Cypress's new CyFi Low-Power RF solution uniquely conserves power using Active Power Management functions. CyFi dynamically switches DSSS reliability on or off depending on the interference levels present—with DSSS on it provides reliable but reduced-throughput transmission and less retransmissions; with DSSS off it minimizes on-air time using the fastest available system throughput (see figure 3). CyFi also dynamically manages power output by measuring receive signals and using bi-directional communication to minimize output power to only what is required (see figure 4).

How do these features maximizing power-efficiency result in less power consumption? In a typical industrial sense and control application, the CyFi Low-Power RF solution can extend battery life from months to multiple years. For example, with a reporting period of once every 5 minutes, the CyFi Low-Power RF node can survive for **4 YEARS** on just two AA batteries. With the rate of improvements in the sense and control applications that exist, you are more likely to end-of-life the product and replace it then you are to change its batteries. Further, with the low-power consumption of these CyFi Low-Power applications, you can also better take advantage of energy harvesting technologies that can extend your applications survivability to decades vs. years.

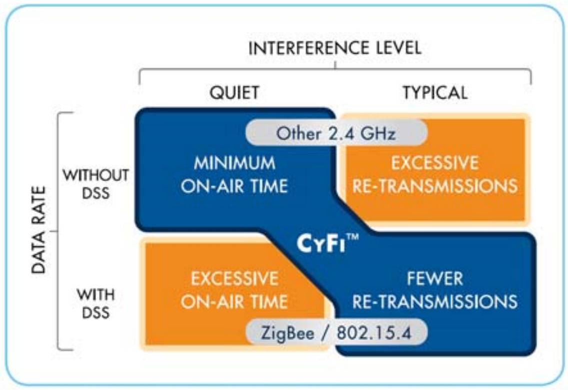

Figure 3 - CyFi Low-Power RF & Active Power Management

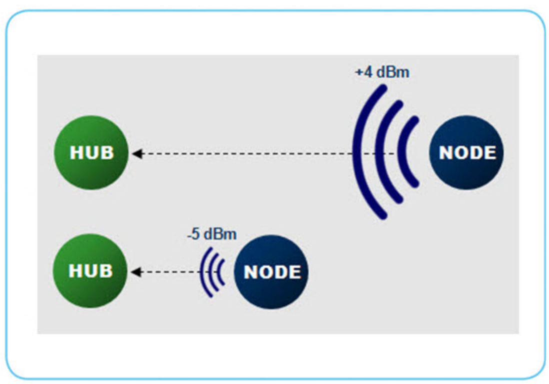

Figure 4 – Dynamic output power management

Cypress's CyFi Solution Adapts to Your Application's Environment

Adaptation, in the context of wireless technologies, is the ability of a system to measure and respond to the hostilities that face them—mainly, RF interference. CyFi Low-Power RF can detect RF interference and appropriately apply countermeasures to respond. For example, the CyFi solution can measure the receive signal strength of a communication transaction. Based on this signal strength and known baselines for ideal and harsh environments, it then *knows* what the environment looks like and how ideal or harsh the environment is.

The CyFi solution can also adapt to its environment by changing power output levels—talking softer or louder, activating a more robust means of communicating—talking clearer, boosting the speed of communicating—talking faster; or by moving to a quieter environment to communicate. The first response of changing the output power in response to the environment makes clear logical sense in terms of reducing power outputs in a quiet RF environment, but can be counter-intuitive in terms of the reverse. In a noisy environment and in an embedded wireless application where power is like gold, the act of using more power to get the same communications across sounds costly. But let's review what happens if you don't. Assuming all other factors the same and constant, a radio that is transmitting at lower-than-needed power levels to complete a communications transaction will repeatedly try to transmit the data over a short period of time and more-than-likely, burn more power than a solution that immediately transmits the same data in fewer attempts at a higher power output. Let's throw some math into this example to help explain this counter-intuitive approach. First, the configuration: one radio is configured to transmit at +4dBm, or 34.1mA, per transaction and a second radio is configured to transmit at -5dBm, or 20.8mA, per transaction. Power required to transmit the data is defined as the number of attempts multiplied by the power per transaction for each of the radios. In this case, it's very clear that if the +4dBm radio can transmit the data in one pass while the other, -5dBm radio, takes more than one attempt; the +4dBm radio burned less power to get the same data across. What's important here though; is that CyFi Low-Power RF has the capability to dynamically increase **or** decrease the power required in response to its environment—use more power when needed and conserve when not needed.

Another means of responding to the RF environment is the ability to speak slower & clearer or, its inverse, faster. In a harsh environment, the CyFi solution can dynamically activate a slower but more robust means of communicating whereby improving its ability to deal with the impacts of the interference without impacting its communication. The inverse of this method of adaptation is to know when interference is less of a concern and to take advantage of the quieter environment by transmitting at a faster yet less robust means. Again, and unique to Cypress's CyFi solution is the means to adapt to its environment by dynamically switching between these two approaches.

Finally, the CyFi solution can also respond by physically moving to a quieter environment in the presence of noise. As previously described, the method the CyFi solution undertakes is the more efficient move when needed and ensure the move results in a quieter environment and not to move at random or to a noisier environment. This results in a predictable move across the spectrum that nodes within the network can then follow and re-join as well as minimizing the number of moves and maximizes network stability.

Reliability and Power Efficiency Made Easy

Cypress also makes the most reliable low-power RF solution in the world simple to use and commission in end customer applications through the use of PSoC programmable system-on-chip devices and software. With PSoC Software, the CyFi solution is as simple as a drag-and-drop of the pre-characterized firmware and protocol. This PSoC Designer user module also includes an extensive and easy-to-use API library enabling the embedded designer to get a wireless application online with as little as eight API calls. In addition to ease-of-development, the protocol stack for a typical hub or node application adds a feature-packed 5-8 KB of flash to your PSoC application—enabling lower cost solutions through the use of smaller PSoC chip-sets or further maximizing BOM integration or system capability by leaving room for additional functionality. This CyFi Star Network Protocol, which is made available freely in the PSoC Designer IDE software (which is also freely available), contains a set of highly robust and complex algorithms under the hood that support up to 250 wireless nodes per network, support multiple power-schemes for nodes (such as coin-cell battery powered devices that require maximum sleep times as well as wall-powered devices that can idle in receive-mode), and make up the active power and link management algorithms that further reduce the number of system retransmissions and ultimately save years of battery-life for CyFi applications. Finally, with starter, expansion and development kits, Cypress makes it easy to quickly and easily evaluate and integrate CyFi solutions for designer's applications.

PSoC Programmable System-on-Chip

PSoC devices combine dynamic, configurable analog and digital blocks and an 8-bit MCU on a single chip, enabling designers to build complete wireless embedded systems with fewer components and shorter design cycles. PSoC programmability adds flexibility to wireless CyFi designs enabling change up to the last minute as well as the ability to integrate hundreds of different discrete peripherals reducing cost and board-level power-consumption. Finally, the programmable analog available in PSoC devices also enables a complete CyFi wireless sensing application with minimal chip counts.

Learn more about Cypress's CyFi Low-Power RF solution and how to get started today by visiting www.cypress.com/CyFi.

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