PlantWeb University – Wireless 207

Power Management

15 minutes

In this course:

Overview

Wireless networks are rapidly finding their way into industrial environments. Although eliminating wires avoids the cost and inconvenience of running cables to every instrument on the network, it also removes the traditional path for delivering power to those devices.

So how do you provide the power needed for each field device's radio, sensor, and embedded electronics? And what's the most efficient way to provide that power, so you're not constantly replacing batteries?

The answer lies in choosing technologies that offer **energy efficiency** and advanced **power management**.

In this course you'll learn how to reduce the energy consumption of wireless devices used in wireless field networks by selecting the most efficient power sources, wireless technologies, and sensor types. You will also learn about new energy harvesting techniques that extract energy from the environment to power wireless devices.

The course also discusses how low-power design techniques, tradeoffs between energy consumption and system performance, and selecting the right vendor – one who incorporates energy-awareness into every stage of design and operation – can help reduce the energy consumption of a wireless network.

(This course does not cover battery concerns related to PDAs and tablet PCs that mobile workers use to access the plant control network. Because these devices can be easily recharged when workers return to the control room or maintenance shop, battery life is generally less of a concern than with field-mounted instruments. Manufacturers of these devices also continue to make improvements that impact energy consumption and battery life.)

Hint

As you go through the topics in this course, watch for answers to these questions:

- What are the sources for power for wireless field devices?
- What is energy scavenging?
- Which wireless technologies and hardware options are most energy efficient?
- What best practices can make a wireless field network system more energy efficient?

Power sources

There are three common ways to power wireless field devices:

- Local power supply
- Batteries
- Energy scavenging

Let's take a close look at each one.

Power sources
Local power supply

Providing a local, wired power supply for each device can be costly. However, it may make sense in some situations:

- When local power is easily available
- When the sensor has high power requirements
- When extra power is needed to support frequent transmissions
- When you're transmitting data over long distances

Power sources
Batteries

Batteries are simple, inexpensive, and easy to install. But they also have to be replaced periodically, and frequent replacement increases labor, downtime, and stocking costs.

Batteries are therefore best suited for applications where low power consumption allows longer battery life. That means low-power sensors and radios, and short transmission distances.

You can also increase battery life by operating the system in a way that frequently reduces – or even shuts off – the instrument's power draw. This is often referred to as going into "sleep mode."

Battery life should typically be measured in years. Lithium-ion batteries are usually a good choice because of their long life and high power-to-size ratio.

Rechargeable batteries are not generally recommended because of the need for a recharging mechanism. They also self-discharge rapidly, and their capacity degrades over time.

However, rechargeable batteries may make sense if you have a low-cost, constantly renewed source of power for recharging. That's what we'll cover next.

Power sources
Energy scavenging

Energy scavenging or harvesting generates power by converting energy in the environment into electricity – decreasing or eliminating the need for battery power. *

Energy harvesting dates back to the water wheel and windmill, and methods for scavenging energy from waste heat or vibration have been around for many decades. It's now becoming increasingly important as an option for powering small, widely dispersed, low-power electronics – such as wireless sensors.

Most plants have a variety of energy sources that can be harnessed to produce small – but sufficient – amounts of electricity for low-power wireless devices, including

- **Solar power** – Photovoltaic cells convert energy from the sun into electrical energy
- **Vibration** – Physical motion such as pipe or equipment vibration can also be converted into electrical energy.
- **Thermal power** – Thermoelectric materials can convert excess heat or temperature variations into electrical energy.

These solutions do have some limitations. For example, solar power isn't available at night or on cloudy days. And, in general, energy-harvesting solutions are more costly than their battery-powered counterparts. Energy scavenging may also require a complicated installation of the scavenging device.

Despite its limitations, more and more vendors are working to combine power management techniques with low-power devices that can successfully operate with the limited energy they can harvest.

* Portions of this section are based on Joseph Paradiso and Thad Starner's *Energy Harvesting & Conservation: Energy Scavenging for Mobile and Wireless Electronics.*

The Emerson Advantage

Emerson is a leader in using energy scavenging techniques for wireless devices. For example, the Rosemount 753R Smart Wireless solution for web-based monitoring offers a solar power option. A solar panel continuously recharges the 753R's internal battery so that the device can operate up to 37 days without any sun. Depending on climate, the estimated battery life of the 753R is up to six years – compared to other solutions that provide only several days of runtime without solar recharge.

Now that we've looked at potential power sources for wireless devices, let's consider the other side of the issue: using the right technologies and methods to minimize power requirements.

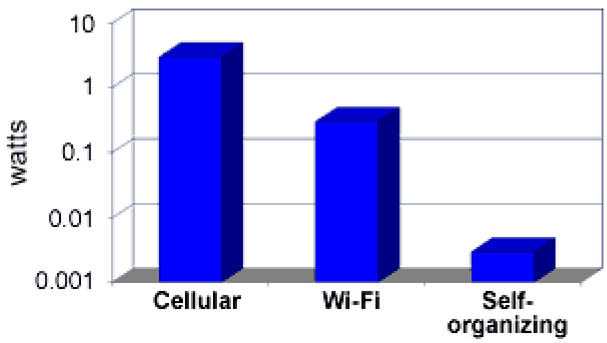
Network technology

Your choice of wireless field network technology can affect power consumption.

Devices whose radios transmit data over cellular networks have the highest power requirements – up to 3 watts – because the data travels over long distances to a cell tower.

Wi-Fi radios also require high power, ranging from 100mW to 1w, to transmit large packets of data.

Radios in self-organizing networks are, by far, the most energy efficient. They require less than 1mw of power because most transmissions cover only short distances (to the next network node), and update rates are generally low – about one per minute.



Network technology is a factor in power consumption.

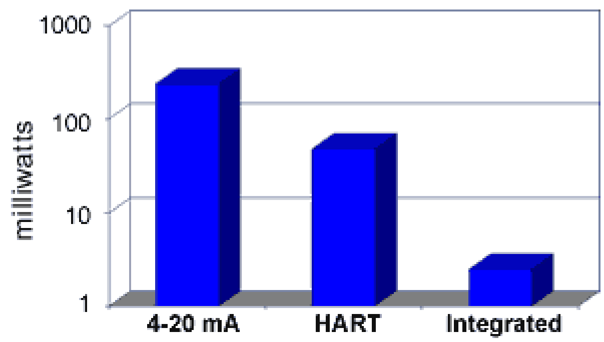
For more about these network technologies, see the courses on

- *Self-organizing networks*
- *Wi-Fi networks*
- *Cellular networks*
- *Technology selection*

Wireless devices

You have three options in choosing wireless devices – each with different power requirements:

- A wireless device that transmits a 4-20mA analog signal requires 240mw of power (20mA at 12 volts) to power the sensor.
- A wireless device transmitting digital HART data from a traditional measurement sensor requires 48mw of power (4mA at 12 volts) to power the sensor.
- An integrated radio/sensor device – using HART technology and recent advances in low-power electronics – requires only 2.5mw of power (0.5mA at 5 volts) to power the sensor.



Integrated radio/sensor devices take advantage of low-power electronics to reduce energy consumption.

If extended battery life is important to you as a way to minimize related maintenance requirements, the integrated device is clearly the optimal choice.

The other two choices can be appropriate if you want to add wireless technology to existing devices and need to transmit small packets of data over short distances and at slow update rates.

Duty cycling

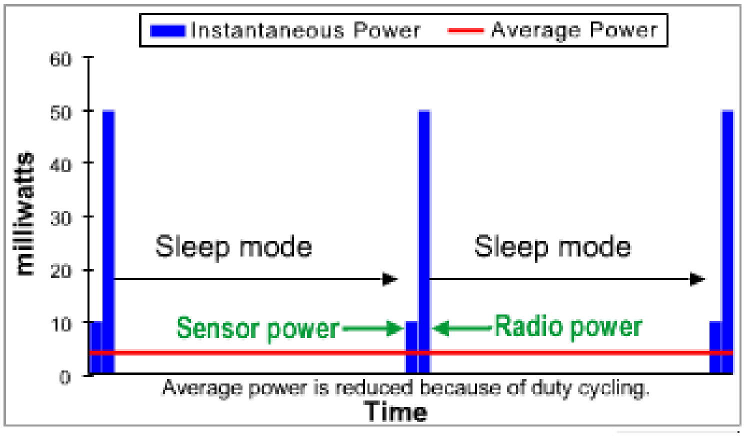
So far, you've learned that by choosing the right wireless technologies, sensors, and power source for your network, you can significantly reduce power consumption. And the less power the device consumes, the longer your batteries will last. That's important because you don't want ongoing battery-replacement costs to eat up your initial savings on wiring and installation.

But energy isn't just about power. It's also about how often – and for how long – the power is used:

Energy = power * on-time

You can therefore make huge strides towards energy efficiency by **duty cycling** the electronics between power-on and "sleep" modes.

In duty cycling, the sensor electronics and radio are not powered continuously. First the sensor is powered up just long enough to make a measurement. It then goes into a sleep mode that reduces power to almost zero. Then the radio is turned on for a very short time – just long enough to transmit the data. After the data is sent, the unit turns itself off and goes into sleep mode until it's time for the next scheduled measurement.



Duty cycling helps reduce average power consumption.

You can further improve energy efficiency by extending the time between measurements. Unless you're willing to replace batteries every few months or hard-wire a power source, measurement update rates for wireless devices will be less than wired systems.

To help you optimize measurement frequency for your application, some device suppliers provide a chart showing the relationship between battery life and update rate. With a well-designed device, you should expect battery life under installed conditions to be measured not in months, but years.

Synchronization

Battery life is also affected by the technology you use to synchronize communications in wireless field networks. There are two fundamental methods: **CSMA** (Collision Sensing Multiple Access) and **TDMA** (Time Division Multiple Access).

With CSMA, all devices in the network wake up at the same time and try to communicate. If two messages "collide" on the network, each device sends its message again and again until it gets through.

The key disadvantage of CSMA is that increasing network size means increased message traffic and therefore more collisions. The more collisions, the more power is needed for resending collision messages. And higher power consumption means shorter battery life. That's why CSMA is appropriate only for the smallest battery-powered networks typically found in residential or perhaps commercial environments.

With TDMA, each set of wireless devices knows exactly when and how often they will communicate within the network. The advantage is that each message has a specific time slot to travel through the network, so messages don't collide with each other.

As a result, TDMA provides the most robust method for achieving true scalability in a plant while using less energy than CSMA.

*For more about this topic, see the course on **Self-organizing Networks**.*

Vendor selection

Vendors of wireless devices and networks are familiar with the power-management techniques and tradeoffs we've covered in this course. Most work hard to offer products that will help their customers balance energy usage with application requirements.

As you evaluate suppliers, ask about each of these areas:

- Self-organizing network technology with TDMA
- Products built around low-power electronics, especially integrated radio/sensor instruments designed to minimize power consumption
- Instruments that can put themselves into sleep mode when they're not measuring/transmitting – and "wake up" quickly without power-intensive warmup periods
- User-configurable update rates
- Energy-scavenging options to supplement or replace battery power

The Emerson Advantage

Energy efficiency is a key consideration in the development of every Emerson wireless device and network component, with the goal of maximizing the period before maintenance is required. Our designers treat power like gold – a scarce commodity to be collected and conserved at every opportunity, and spent only on functionality valued by the user, such as diagnostics.

As a result, users get the benefits of our **SmartPower**™ capabilities, which include advanced power management techniques, fast device wakeup times, low-power electronics, and energy scavenging technologies.

We've also thought about what happens when circumstances cause a battery to drain more quickly than expected. That's why our **AMS™ Suite: Intelligent Device Manager** predictive maintenance software can be configured to alert you with ample warning that a battery will need replacing.

Summary

In this course you learned that you can significantly reduce power requirements – and related maintenance costs, such as for changing batteries – by choosing the right technologies, sensors, power sources, and power-management techniques for your wireless network.

Key points covered in the course include

- Energy scavenging can greatly reduce or even eliminate the need for battery power.
- Self-organizing networks are more energy-efficient than cellular or Wi-Fi networks.
- In wireless field networks, TDMA message-synchronization is more energy-efficient and scalable than CSMA.
- Duty cycling (powering instruments only when needed) further reduces energy usage.