BANNER®

The Evolution of Wireless Sensor Networks

New standalone remote monitoring and control solutions enable a new class of wireless applications.

Wireless technology was once limited by factors that included inadequate bandwidth, early integrated circuit design, and insufficient power management technology. Improvements to today's wireless networks allow robust monitoring and control—even in remote and harsh applications or classified areas.

Features such as bidirectional communications, fully-acknowledged data transfer, and configurable default output conditions make remote and field-based monitoring and critical control a reality. These alternative power options have increased the usability of sensor networks because the systems are no longer limited only to locations wired for power. New systems enable cost-effective monitoring that is scalable down to a single point.

Today, these improvements to RF technology make wireless an ideal solution for a wide variety of applications such as field-based agribusiness and water management systems, which use wireless networks to improve water use, increase efficiencies, and reduce manual measurements. Process measurements such as operational status, level, temperature, and other crucial information can now be easily monitored and controlled remotely, even in locations not wired for data transfer or power.

Historically, wireless remote terminal unit (RTU) systems incorporated a number of different components, including an RTU, radio, solar panel and rechargeable battery pack, as well as input and output terminals. Once all these devices were selected, users had to purchase an outdoor enclosure and integrate the disparate components into a single, cohesive system. These older systems were difficult to install in part because of the number of components required to build the monitoring system.

Older monitoring systems were complicated to maintain over time. The diverse power requirements of the components frequently required large solar panels and batteries to operate. These traditional monitoring systems were too expensive, or too large, for small, single-point monitoring systems.

To be cost effective, installing these systems required wiring as many I/O points as possible back to each remote node. Ironically, it required a significant amount of conduit wire and time to connect a dozen or more I/O points to the traditional large wireless RTU panel. Once installed, these monitoring systems could not be easily relocated to accommodate changes in the application or the environment.

ANTENNA

ENCLOSURE
• Data Radio
• Data Logger
• RTU

SOLAR PANEL

FIXED
MOUNTING
LEGS

BATTERIES

POURED CEMENT PAD
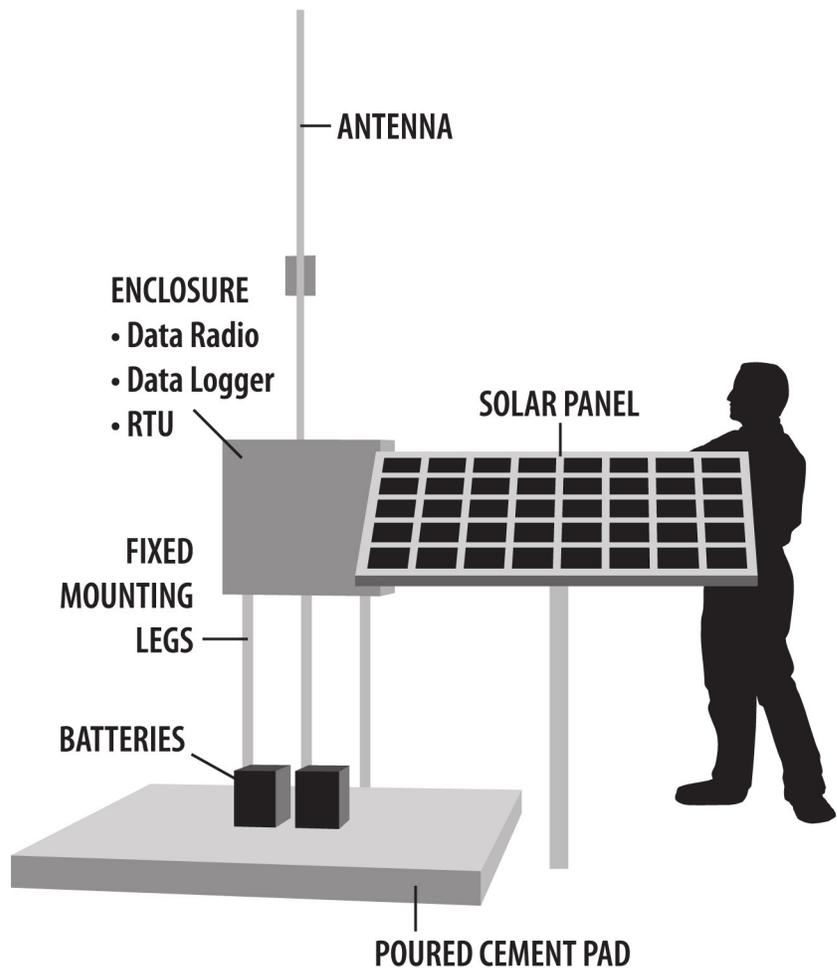
Today, many remote monitoring solutions are available that offer more reliable wireless communication while integrating many of these components into a single, inexpensive unit. A radio and I/O terminal contained within a single housing that is rated for outdoor use eliminates the need for an additional enclosure. Without this large, permanent enclosure, these new wireless industrial I/O devices are easy to install, and then uninstall and move to a new location as monitoring requirements change.

With the radio, power controller, I/O terminals, and RTU components included within a single, water-resistant housing, fewer mechanical and wiring issues need to be incorporated into a maintenance schedule, resulting in valuable time and cost savings—without sacrificing capabilities. A single wireless I/O device can collect both digital and analog sensor readings and forward this data to a central collection point for analysis.
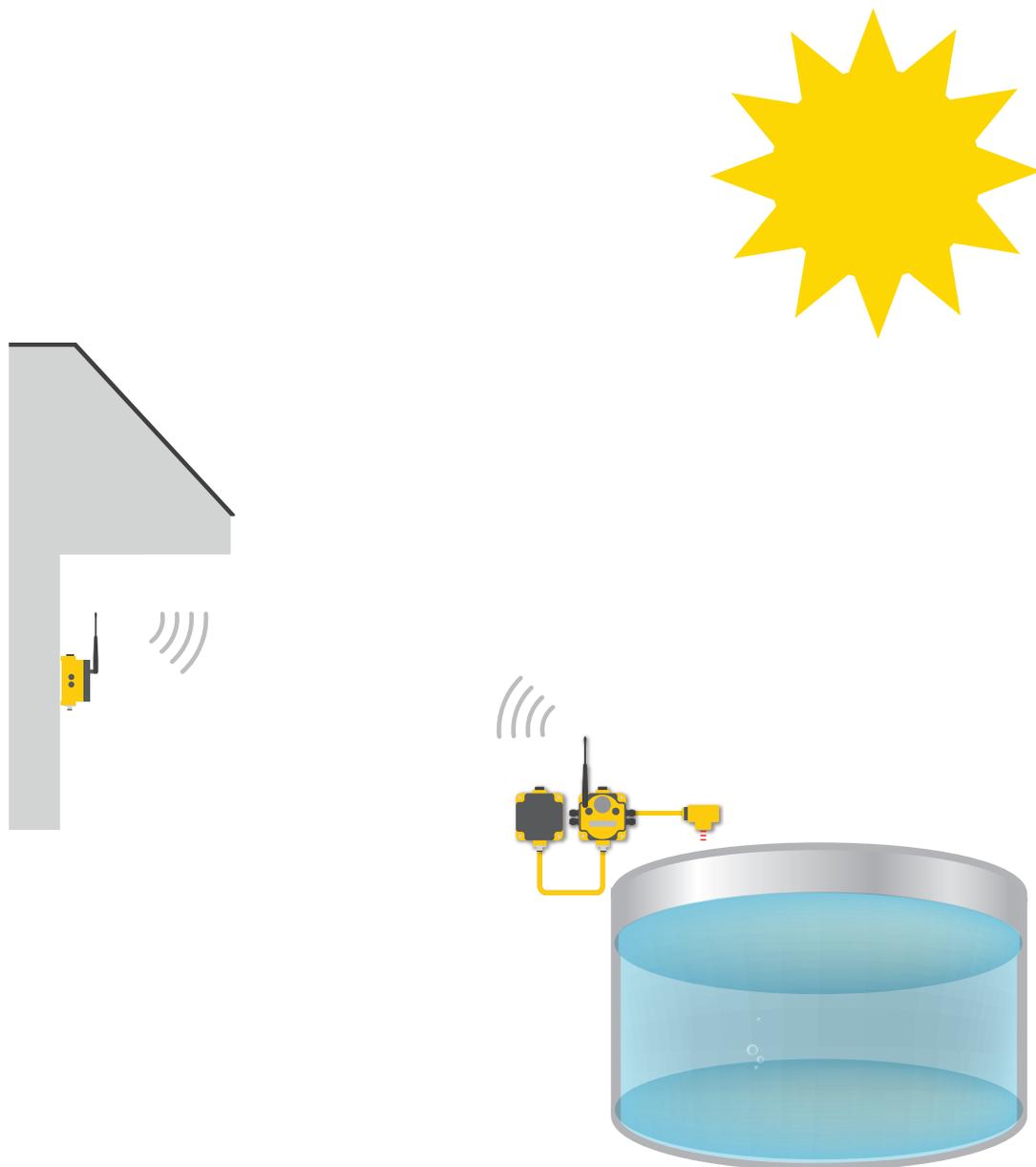
Evolution of RF Technology

Just as packaging improvements have made wireless monitoring systems easier to install, radio communication technologies including Frequency Hopping Spread Spectrum (FHSS) have improved network reliability. When using FHSS as a communication method, the frequency range is split into several channels. Data packets are transmitted using these channels randomly in a pattern known only to the master device, or gateway, and the nodes. If interference is detected on one channel, both radios hop to the next channel and resend the data packet, minimizing unsuccessful transmissions in high interference environments.

Another method of ensuring successful data transmission is by using Time Division Multiple Access (TDMA), which divides communication time into specific time slots for each node and guarantees that all devices within a radio network have time to transmit and receive data packets. When multiple radios are not trying to communicate with the master device at the same time, data collisions and radio interference are minimized. Using TDMA to avoid data collisions also prevents wasted power resources by minimizing resent data packets.

Bidirectional transceivers on both ends of a communications link ensure fully acknowledged data transmissions. Polling and site survey capabilities monitor communication integrity either at the radio master device (gateway) or locally at each radio node. A site survey is a signal strength analysis conducted by the gateway to determine the reliability of the radio signal received by the node. If a site survey is conducted before installing the devices, the test ensures each node is positioned at an optimal location.

Gateways poll their nodes at specific intervals to verify the radio communications are operating. If a gateway identifies a radio link that is not operational based on an unsuccessful poll, these new systems are capable of reacting deterministically. Deterministic response capabilities drive specific outputs to a defined output state in the event of a communications failure, ensuring control over the network outputs and system responses.

For example, a remote monitoring system is monitoring a tank level and controlling a valve based on the level readings. When the radio signal is disrupted, the valve may be automatically closed to prevent equipment damage, and then opened again when the radio communications resume operation.

Radio Link Lost

Gateway

Outputs set to defined states

Node

OFF

Node
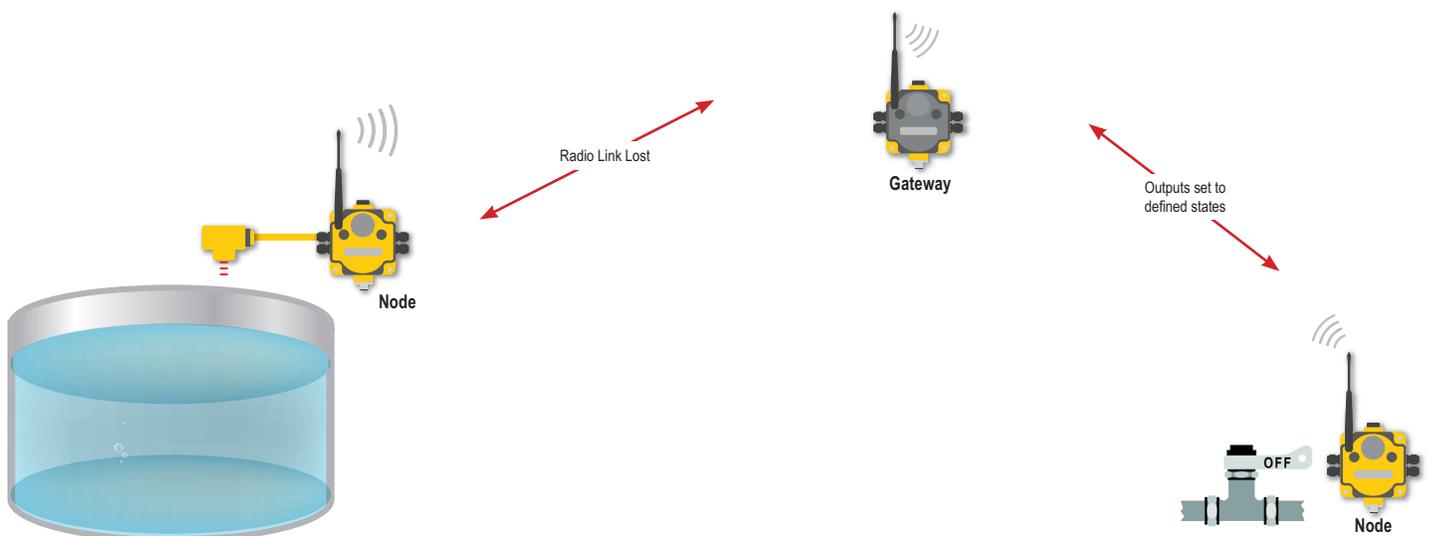
Power Management Systems

To accommodate remote monitoring needs in locations without power, optimized wireless I/O devices using advanced power management technology can operate from a single battery pack for several years. This extended life span is achieved by putting the entire system in low-power mode, allowing the system to consume almost no power.

The power management system can be configured to periodically sample the sensor and report data at defined intervals. These intervals can be set from a few samples per second to a few samples per hour with the longer sampling intervals corresponding to longer battery life. Often a five to ten year battery life can be achieved by optimizing the sample and report rates.

Integrated power management systems are also beneficial when using solar power. Typically, the entire solar panel system can be significantly smaller, less expensive, and easier to install. With power options that include solar panels or battery packs, radio devices can now be installed over a wide geographical area, extending the range of data collection for miles.

A growing class of power-managed sensors, including temperature, relative humidity, ultrasonic, and submersible pressure sensors take advantage of independent power sources to operate for years without replacing batteries. These flexible devices can even operate using line power in ideal conditions and then operate from a battery module if the line power fails, preventing costly crop or product losses during unplanned power failures.

Host System

Wireless master

Wireless I/O device powered from a battery pack

Wireless I/O device powered from a solar power assembly
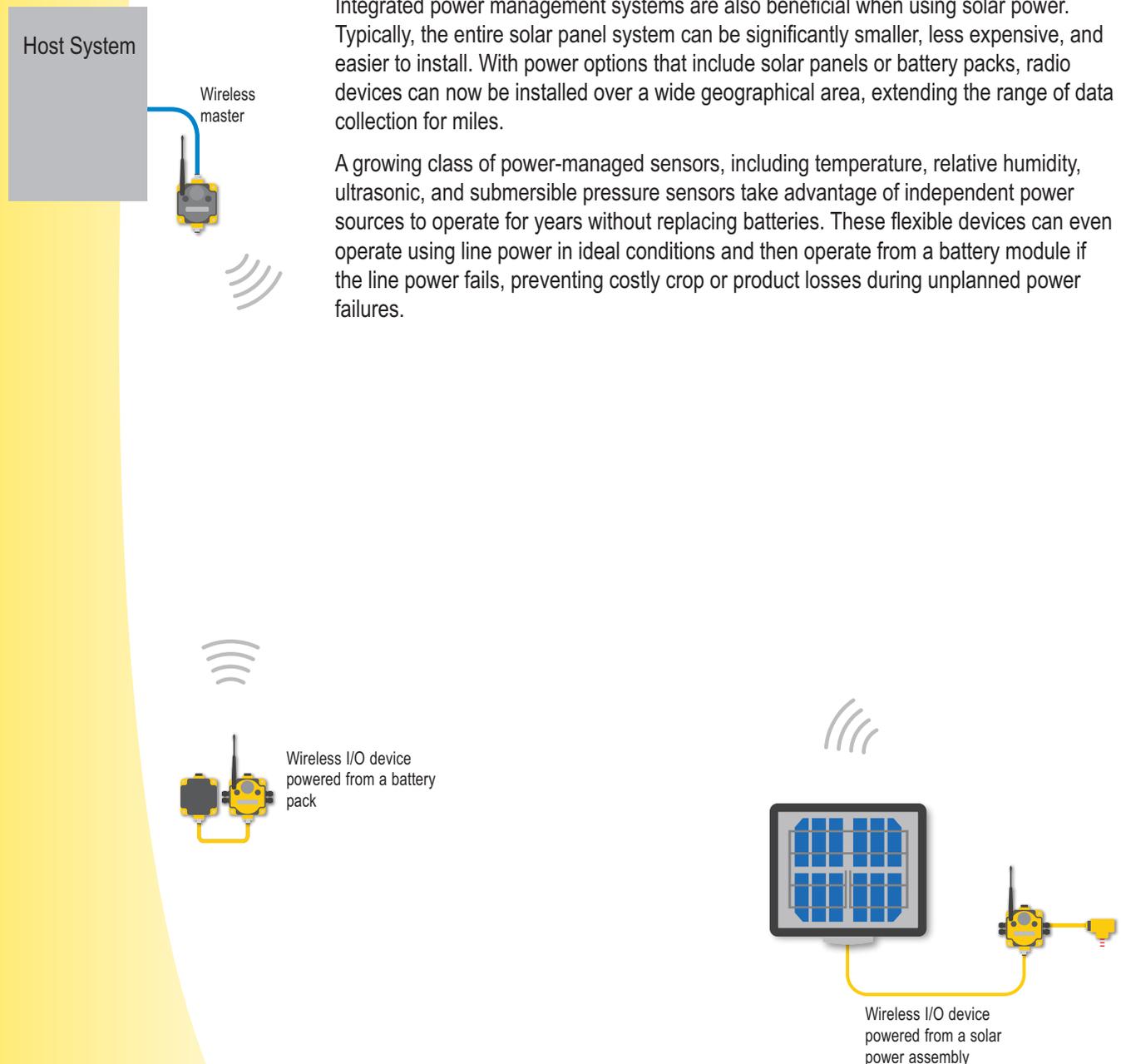
Cost Effective Scalability

Now that multiple sensors can be connected to a single radio node and dozens of radio nodes can exist within a single radio network, hundreds of sensor readings can be aggregated into a single gateway device before being forwarded to a host-controlled system for analysis.

Further extending this wireless I/O network are serial data radios—backhaul devices that receive serial data from another serial data radio, or a serial connection to a gateway, and forward the data to another serial device miles away. Chaining data radios can expand this network indefinitely.

This backhaul architecture enables limitless scaling for everything from single-point data collection to 10,000 data point applications while retaining the cost advantage associated with minimal wiring for power or I/O transmission.

New wireless technology enables remote monitoring solutions that were previously unaffordable or impractical to install. Compact, reliable, inexpensive wireless I/O monitoring devices can now be installed in isolated, low-signal count locations for data collection. These same compact devices can be easily relocated as the application environment changes in what is known as a peel-n-stick installation process.

Host System

Data radio

Data radio and wireless master device

Wireless I/O device powered by a battery pack
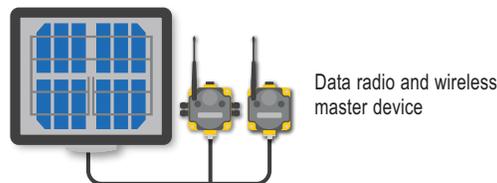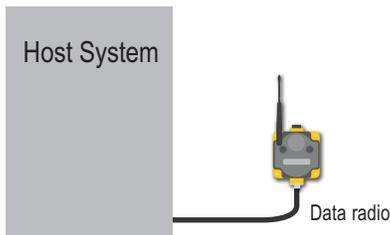
The new generation of wireless remote I/O monitoring is particularly suitable for small, single-point measurements. While previous remote monitoring technology was too expensive or too bulky to use for low-signal count applications, current technology makes these applications easy to install and use.

For example, a single wireless I/O device and power-optimized ultrasonic sensor can reliably monitor tank levels and report analog or digital inputs back to a central location. The peel-n-stick installation allows this device to be easily moved and reinstalled depending on the requirements of the application.

These devices can be installed in a broad range of environmental conditions ranging from outdoor installations exposed to weather to applications within hazardous or explosive locations. Because these devices are more compact than past systems and are certified for a wide variety of environments, they are easy to retrofit into existing applications, particularly on mobile assets such as trucks or boats that must enter and exit hazardous locations or areas rated to require intrinsically safe equipment.

In agribusiness, the most common reasons for adopting wireless monitoring systems are improving crop quality and reducing labor costs. Tasks that previously required constant human intervention can be replaced by installations of solar or battery powered sensors, nodes, and gateways. The most common use for wireless sensor networks is the monitoring of soil moisture levels to control irrigation systems. As more land is used for agriculture, water conservation will play a vital role in crop quality and profitability.

For these applications, remote sensors can be used to monitor and report the moisture levels of the soil back to a central control location, notifying personnel that irrigation is required before crops are damaged. With this constant automatic monitoring, wasted water is minimized without harming the crops.

To this end, vineyards are adopting wireless technology for a range of tasks that include monitoring environmental conditions such as soil moisture and pH levels in the fields, controlling the dispensing of fertilizers and insecticides, and detecting pests or mold. In the processing facilities, wireless sensor networks are used to gather tank level data, control flow of liquids, and analyze the relative humidity and temperature within the storage rooms.

Drip, flood, and center arm pivot irrigation systems are all suitable applications for wireless control and monitoring. Wireless nodes using pressure and flow sensors monitor the irrigation system and transmit data back to the gateway or control center. These wireless systems can notify personnel immediately when a component fails or when the irrigation system fails to meet established performance parameters, preventing crop damage or loss.

A single battery-powered node using a temperature and relative humidity sensor can reliably monitor environmental data within a greenhouse for years and transmit that data back to a central control system. Once the control system has calculated the corrective action, a wireless signal sent back to the node can turn on fans, open vents, cycle on heaters or coolers, or trigger a water misting system.

Whether your application needs to be a cost-effective solution for single-point monitoring or scalable up to 10,000 data points, the new generation of wireless products and sensors offer reduced installation time, multi-year battery life, reliable radio communications, and simple integration into existing systems. These new systems offer a simple solution to increase productivity and reduce labor costs without sacrificing ease of use.

Gateways

All Banner SureCross wireless networks consist of one Gateway and multiple Nodes. The Gateways are master devices within the wireless network, but can be either master or slave devices to a Modbus (host) network. Gateways communicate to host systems using Modbus RTU.

For protocol conversion, the Gateway Pro is used. A Gateway Pro is a Gateway without I/O, but with the ability to convert to Modbus/TCP or EtherNet/IP.

Nodes

Nodes collect data from sensors wired through their I/O connections and report the data back to the Gateway. The Nodes are always slave devices within the wireless network.

*Flex*Power™

*Flex*Power offers the flexibility of multiple power options. *Flex*Power devices may be powered by 10–30V dc, battery supply modules, or solar power assemblies.

Some *Flex*Power devices have internal batteries integrated into their housings and some *Flex*Power devices are designed for use only with specific sensors.

Hazardous Location and Intrinsically Safe Devices

DX99 models are intrinsically safe devices, certified for use in specific environments depending on the housing materials.

DX99 models in a polycarbonate housing are certified for operation in Class I, Division 1, Groups A, B, C, D; Class I, Zone 0, Group IIC; and Group IIC, Zone 0 environments.

DX99 models in a metal housing are certified for operation in in Class I, Division 1, Groups A, B, C, D; Class II, Division 1, Groups E, F, G; Class III, Division 1; Class I, Zone 0, Group IIC; Group IIC, Zone 0; and Dust, Zone 20 environments.

Devices with the external terminal blocks are Class I, Division 2 certified when they are installed in a suitable enclosure. DX91 models are Class I, Division 2 certified as sold.

Term	Definition
ACK	to acknowledge a radio signal
bandwidth	range of frequencies a radio channel broadcasts across and the amount of data that can be transmitted within that band
communication protocol	combination of modulation scheme and the rules and regulations governing the use of a frequency band
data collisions	situation in which two or more transmissions are made on a system that can only handle one transmission at a time
data radio	transmits a signal to every radio within its network; I/O capacity is not restricted
determinism	selected outputs of an I/O network are driven to a predetermined state during a communications failure
gateway	network device that translates between two incompatible communication protocols
Gateway	Banner's wireless network master device that converts the communication protocols of the wireless I/O network to the outside world
FHSS (Frequency Hop Spread Spectrum)	method for generating spread spectrum transmissions where the signal is switched between different frequency channels in a pseudorandom sequence known by both the transmitter and the receiver.
***Flex*Power**™	Banner's term for wireless I/O devices that can be powered from 10-30V dc, battery supply modules, or solar power assemblies
hazardous locations	locations requiring Class I, Division 2 certified devices
intrinsically safe	locations requiring Class I, Division 1 certified devices
network ID	identifier for every device in a given network
node	any point within a network
Node	Banner's wireless I/O network slave device that collects sensor data and forwards it to the Gateway
peel-n-stick installation	the ability to easily install or uninstall compact wireless I/O units; the ability to move an installation when the application changes

Term	Definition
polling	when the Gateway requests a response from one of its Nodes to verify the radio communications link is operating
radio link loss	loss of the signal between a transmitter and receiver
remote terminal unit (RTU)	remotely located unit for monitoring I/O
repeater	transmits the inputs from one device to the outputs of another device; I/O capacity limited to that of the repeater device
RF	radio frequency
single-point monitoring system	monitoring system that gathers data from only one I/O point
site survey	signal strength analysis conducted by the Gateway to determine the reliability of the radio signal received by the Node
TDMA (Time Division Multiple Access)	wireless network communication architecture that provides a given slot of time for each device on the network and provides guaranteed opportunity for each device to transmit to the gateway.
transceiver	integrated circuits (ICs) that incorporate both the transmitter and receiver in a single component