Wireless IO in the Oil and Gas Industry

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Historically, in the oil and gas industry hardwiring has been the only option available for users to connect remote instrumentation assets in the field. However, new technology in the shape of spread spectrum radios gives companies the ability to connect remote instrumentation in the field without the need for a costly wired infrastructure. In fact, asset information is now available from applied and embedded sensory points enabling sophisticated diagnostics, remote monitoring and control and plant optimization. Companies can now realize the true potential of their production assets with the emergence of this wireless field infrastructure by having dependable access to real-time information that provides excellent situational awareness of their operations.

With the prospect of being able to solve virtually any remote monitoring or control application, many people throughout the industry are viewing wireless IO as an exciting innovation for addressing issues previously deemed cost prohibitive, not technically feasible, or lacking in sufficient reliability.

What is Wireless IO?

Wireless IO (input/output) is basically a mechanism by which analog (4-20mA, 1-5VDC, etc.), discrete and other raw signals are transmitted via radio to and from a central processing device, such as a Distributive Control System (DCS), Programmable Logic Controller (PLC), or other Remote Terminal Unit (RTU). Specifically, the data transmitted includes level, pressure, flow, temperature, alarms and signals generated to actuate final control elements, such as valves.

In the simplest of terms, wireless IO is wire replacement, where the wireless communication link emulates wire in an existing application. No changes are required to the system architecture. Rather, wireless links are used to transmit the same data that the physical wire once carried.

Foundation of Wireless IO

The foundation of Wireless IO is license-free 900MHz spread spectrum radio technology designed specifically for integration into remote assets and SCADA systems. This technology has been widely used in oil and gas field automation for close to 20 years and has proven to be very reliable.

The FCC allows two methods for building a spread spectrum radio: Direct Sequence Spread Spectrum (DSSS) or Frequency Hopping Spread Spectrum (FHSS).

Unlike fixed frequency radio, FHSS radios pseudo-randomly vary carrier frequency, quickly hopping through multiple channels while sending data. Interference is avoided by hopping over different frequencies, each of which has a different interference effect or characteristic. This provides FHSS with collision-free access by allocating a specific time slot and frequency for its transmission. A frequency-hopping scheme, combined with error detection and automatic repeat requests ensures that the data is delivered reliably. Furthermore, since the frequency hopping patterns are proprietary to the radio manufacturer, industrial FHSS radios are inherently secure and less prone to interference. These characteristics make FHSS the preferable choice for oil and gas wireless IO applications, such as simple analog and digital signals.

FHSS is very different from DSSS, which spreads its signal over a larger spectral segment and maintains error-free transmission of its data until the interferer goes over the top of its jamming margin, at which point the throughput of the DSSS quickly drops to zero making it inappropriate for mission-critical, industrial wireless IO.

Figure 1 illustrates the difference between Frequency Hopping and Direct Frequency Spread Spectrum in terms of signal. FHSS, the image on the left, has short bursts of data and quickly hops (50-1000/second) pseudo-randomly to another frequency within the band. Whereas DSSS, the image on the right, combines its information signal with a spreading signal which occupies a much wider bandwidth.

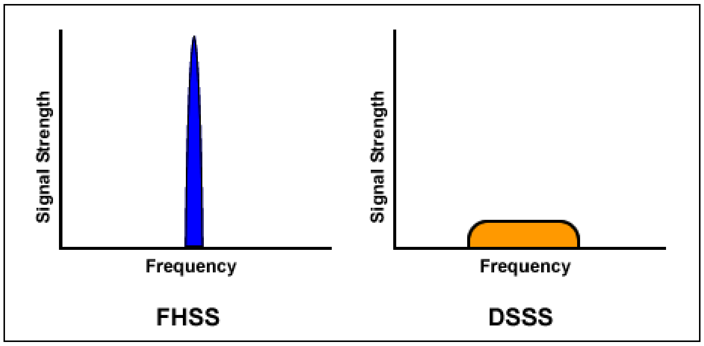

Figure 1. FHSS vs. DSSS signal strength

Latest Advancements in Wireless IO

Now, wireless IO Expansion offers an ideal way to increase IO count without having to add radios. Expansion modules can be attached onto an existing wireless IO radio, thus dramatically increasing the IO count at the end point (Figure 2).

Figure 2.

A single Expansion Module will increase the IO count dramatically. Universally configurable IO channels on the module allow the user to customize the Expansion Module for any application. For example, a base radio can be configured for up to four analog inputs (AI), two analog outputs (AO), four digital inputs (DI) and two digital outputs for a maximum of eight IO channels. Adding one expansion module will provide up to eight AIs, four AOs, 10 DIs and six DOs up to a maximum of 12 IO channels. Up to 15 Expansion Modules can be stacked on a base radio allowing for up to 192 total IO points at a single wireless endpoint.

The benefits of IO Expansion Modules extend beyond the wireless connection. Users can benefit from Expansion Modules in applications where the RTU or PLC has limited IO capacity. Expansion Modules are added to the RTU or PLC to meet the IO count required for the application. Users can re-use knowledge and experience gained in integrated wireless IO to solve the problem of monitoring and control as more sensors are added to a PLC or RTU locally.

IO Expansion Trends for Oil and Gas Technology

Traditionally, oil and gas wells were drilled straight down and each well needed its own pad (the location where the well head is located). In most cases, the company will lease the land at the location of the well pad. Recently, there have been advancements in drilling technology that enable directional drilling. Directional drilling allows one pad to host multiple wells because the drill can be snaked through the earth and go to different oil and gas pockets from the same surface location.

There are many economic and environmental benefits to drilling multiple wells on a single pad. When the wells are being drilled, using only one access road and pad site for many wells reduces the time and expense of moving drilling equipment from one well pad to another and minimizes environmental impact. During production, multiple well pads provide economies of scale for automation and control because of the close proximity and number of sensors and control points. Production engineers require several pressure readings from multiple casing and tubing strings to safely and efficiently operate high pressure gas wells. Marginally producing wells are retro-fitted with plunger lift technology to increase and optimize production. The plunger lift process increases the amount of gas extracted from the well by continuously monitoring casing and tubing pressure while waiting for a plunger to arrive at the top of the well head. Controlling all these inputs and outputs over one wireless link enables the simplest and most cost-effective solution to automate each well. Finally, as the wells are depleted, cost savings are achieved in the remediation of one pad site instead of several pad sites.

Like the density of wells on one pad, IO Expansion provides multiple IO points over a single wireless link while interfacing with the production company’s choice of sensors and controllers.

Advantages over wired alternatives

Installation Savings

The most intuitive of all the advantages is the reduction of labor and material costs required to hardwire the remote assets. Installation costs are a growing concern for company managers as labor rates continue to rise. Furthermore, if these applications are located in hazardous environments, isolation would be required from potential contact with chemicals and run inside of conduit with the necessary seals to reach the instrumentation deployed throughout the facility or field.

In addition to the sheer costs associated with hardwiring instrumentation, one of the other advantages with respect to installation is the speed of deployment. Wired systems can take days or weeks to be properly installed, isolated and commissioned. Wireless IO networks generally require only the end points to be installed and configured, saving substantial time for projects with aggressive schedules.

Economies of Scale

Any network, wired or wireless, should scale gracefully as the number of endpoints increases. Following installation savings, scalability is the next biggest advantage of wireless IO over hard-wired alternatives.

Deploying additional points in a wireless IO network is incremental. Instead of installing spare conductors, additional IO slaves may share a common IO master (as shown in Figure 3). Capacity is increased as required by simply installing additional IO slaves. In effect, this is a “pay-as-you-go” architecture instead of a difficult tradeoff between initial cost and installed spare capacity.

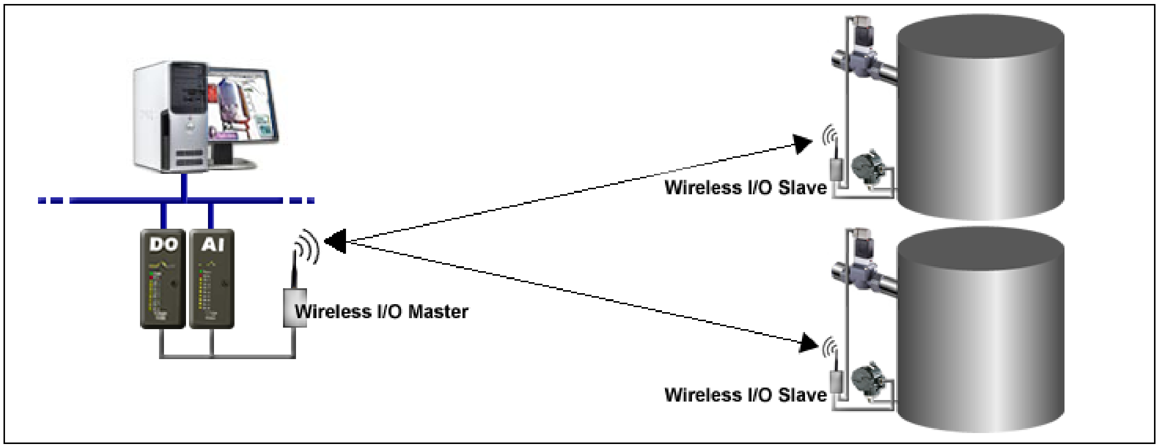

Figure 3. Utilizing a single wireless IO master for multiple wireless IO slaves

Fail Safe

No system is completely immune to signal loss. Wired systems are prone to having wires cut during construction or even routine maintenance. Rust, corrosion, steam, dirt, dust and water all can affect a wired instrumentation system. The difference is that wire can not alert a user of a problem.

Communication link alarms let the user know that data is no longer being received from the instrument due to a loss of signal between an IO slave and the IO master. Additionally, in the event of a communication failure, the IO slave will control its outputs based on the fail-safe default condition that was pre-programmed in the radio during the configuration of the system. In other words, should the link between the wireless IO master and slave be compromised, the outputs of the IO slave will default to its pre-programmed fail-safe position of on, off, or remaining in the last position.

Flexibility

Wireless IO also means that users are not required to replace existing legacy infrastructure. Wireless IO can be implemented slowly and integrated into existing systems.

In terms of flexibility, another benefit is the ease of reconfiguration and expansion. Should the need arise to relocate instruments, there is no expensive conduit to be demolished, relocated, or added. Moreover, if mobile instrumentation is to be used within the company. wireless IO offers an attractive solution.

Creating even more flexibility is the advent of Modbus wireless IO. Whereas traditional wireless IO is limited by the IO count on the master radio, Modbus wireless IO delivers data to a central control point via a serial port, exponentially increasing the IO count and thus eliminating the need for hardwiring the IO master to the control system's IO.

With Modbus wireless IO, each Modbus IO slave is given a unique Modbus device ID and the central control system is configured to poll Modbus registers of the specific Modbus address for a given slave. Typically, a Modbus register map is provided by each vendor for their device.

<u>Reliability</u>

For oil and gas applications, reliability is crucial: wireless systems must be just as reliable as traditional copper wire. Depending on the specific application, corrupted data can result in anything from a disruptive glitch to a devastating failure.

Three factors determine the signal reliability: path loss, RF interference, and transmit power. In order to identify and ultimately maximize signal reliability, it is recommended that an RF site survey or path study be performed. Although extremely useful, one of the major drawbacks has been the cost associated with the process as it requires highly skilled labor. However, certain manufacturers now are providing this as a value-added service helping customers realize precise and accurate network designs in a multitude of applications.

<u>Diagnostic Monitoring</u>

Another advantage is the diagnostic monitoring of the signal reliability within the radio system. The diagnostic activity occurs outside the normal transmission of IO data and can be fed into a diagnostics software package which will notify the system user of any abnormal operation of the system.

In the case of wireless IO, an additional signal is extracted and analyzed during the course of normal operation of the sensor. As the sensor operates, the signal is monitored for abnormalities in terms of signal, noise, voltage, temperature, reflected power, etc. The user may determine at what levels a warning occurs and at what levels an alarm is triggered.

<u>Low Power Consumption</u>

Although not necessarily a specific advantage over wired alternatives, but one of the most important considerations for remote site operation, is low DC power consumption. Low power consumption translates into smaller batteries and solar panels making remote site deployment feasible in areas previously considered impractical for monitoring and control.

Typical IO kit hardware consists of a weather tight enclosure with an antenna and solar panel. The enclosure houses a battery, battery charger and the wireless IO slave. An example of this configuration is shown in Figure 6. These types of kits provide up to 14 days of autonomy with multiple readings per second.

Figure 4. Wireless IO Kit

Conclusion

Wirelessly enabled IO solutions offer an evolutionary opportunity for oil and gas operators to turn more information into knowledge across geographically dispersed assets, leading to optimized productivity, improved safety and asset reliability. This information is vital to companies who want to create and maintain a significant competitive advantage.

As the advantages defined here have illustrated, wireless IO is positioned to meet specific challenges beyond just wiring costs. As a result, oil and gas companies can make better decisions with real-time information. In fact, suffice it to say that those who ignore embracing the technology risk are missing an enormous opportunity. Shedding the wires provides unmatched freedom and flexibility to creatively solve difficult challenges and allows adopters to deliver a major, positive impact to their respective company's bottom line.