

Wireless Systems: Frequently Asked Questions



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The purpose of this document is to cover some of the most common questions customers ask about wireless systems and the answers to these questions.

1. Why choose wireless over wired communication solutions?

The biggest advantages of wireless are installation cost and convenience. Wireless communication systems can be installed in industrial applications at a fraction of the cost of laying cable. To install (or repair) a wired system, the expense and effort of laying cable or conduit, buying permits, hiring labor, renting machines, trenching, backfilling and more can add up. Wireless systems are easy to install and configure, saving up to 90% in project costs and drastically reducing project completion time.

Wireless solutions are also a convenient choice for unpredictable industrial environments. Systems can be tested in advance, prior to purchase and installation, to ensure suitability for a chosen application. That means you can be sure you get a solution that meets your particular needs. In applications where devices may be mobile or may be moved, wireless systems are ideal.

2. What is Line of Sight (LOS)?

Radio Frequency (RF) LOS is different than visual LOS. Visual LOS is present when one can stand next to one antenna and use binoculars to view the other antenna. RF LOS requires visual sight line between the antennas plus it also requires that a football shaped area between the two antennas be free of obstructions. This football shaped area is called the Fresnel Zone (pronounced "fray-nell" zone). The fresnel zone is an area that is larger in diameter at the center and smaller in diameter at either end. Also, the greater the distance between the antennas, the larger the diameter of the fresnel zone in the center.

Any obstructions that enter into the fresnel zone will reduce the communication range. This includes buildings, vegetation, the ground, etc. As the antennas get further apart and the diameter of the fresnel zone also increases. At longer distances the ground can begin to obstruct the fresnel zone, so in order to keep the entire fresnel zone free of obstructions it is necessary to raise the antennas.

The diameter of the fresnel zone is a function of the RF frequency and the distance between the antennas. For reference here is a table to use as a guideline (Rule of Thumb: Add BOTH Antenna Heights > Fresnel Zone diameter):

Distance Between Antennas	Fresnel Zone Diameter (900Mhz)
1000 ft (300 m)	16 ft (4.9 m)
1 Mile (1.6 km)	32 ft (9.7 m)
5 miles (8 km)	68 ft (20.7 m)
10 miles (16 km)	95 ft (29 m)
20 miles (32 km)	138 ft (42 m)

3. What is Received Signal Strength Indication (RSSI)?

RSSI is a way for the radio to report the strength of the radio signal it is receiving from the transmitting unit. This is an important indication of radio link quality, or how reliable the radio link is. All ioSelect industrial radios have RSSI indication. For example, the ioPro WDL has two RSSI LEDs on the front. They have the following meaning:

Received signal greater Than -80 dB	2 x LED Excellent Signal (> 20dB Fade Margin)
Received signal greater Than -90 dB	1 x LED Good Signal (> 10dB Fade Margin)
Received signal less Than -90 dB	0 x LED Poor Signal (< 10dB Fade Margin)

4. What is Fade Margin?

The fade margin is the extra signal strength beyond what is minimally necessary for reliable reception. This extra margin is needed because the environment the radios are in is dynamic. Trees can grow, leaves can fall and re-grow, and buildings can be built in the path of a radio signal. The only way to fight this is to have enough extra signal strength at the receiver so that even if these things come to pass there is still enough signal to maintain a reliable link. We suggest 10 to 20 dB of fade margin.

5. Do I always need LOS?

No, but it helps. The radio waves used by ioSelect's industrial radios pass through all kinds of obstructions just like your AM/FM radios. Wood, drywall, concrete and steel all affect the propagation properties of radio waves differently. Wood structures are the easiest to pass through, and steel structures sometimes act as shields. With this in mind, to ensure radio waves penetrate or escape a conductive metal enclosure such as a steel electrical enclosure, or to get the signal into or out of a robustly build steel building, we recommend mounting the antenna on an external surface and connecting it to the radio inside with an appropriate RF cable.

6. How far will a typical 1 Watt ioSelect radio go?

That depends on the gain of the antennas used and the nature or density of obstructions in the path. But here are some guidelines:

- 1000' (1/5 of a mile) in a heavily obstructed industrial or municipal setting using 1/4 wave 0dB gain omni-directional antennas
- 1000' (1/5 of a mile) to 1 mile in mildly obstructed industrial or municipal settings using 1/4 wave 0dB gain omni-directional antennas and appropriate 'common sense' antenna placement
- 1-2 miles LOS with 1/4 wave 0dB gain omni antennas
- 1 mile through a dense forest of hardwood trees or across an industrial plant using 6dB gain antennas (on both ends)
- From 2 to 20+ miles if you have LOS and you increase the antenna height as the distance increases (higher the better)

7. How to know if the ioSelect radios will work and which antennas to specify?

We recommend using the following guidelines:

- If the distance to be covered is less than 1000' (1/5 of a mile), no test is required. In a very high percentage of applications the radios will work out-of-the-box with a simple 0dB gain omni antenna (like simple rubber whip antenna) regardless of what is in the radio's path. Essentially anyone can make an ioSelect radio work under these conditions.
- From 1/2 to 3 miles, test the link with a demo system or the actual radios to be installed. By monitoring the Receiver RSSI LEDs on the units it can be determined where the antennas need to be mounted for the maximum RSSI and/or check if a higher gain antenna would be helpful.
- Beyond 3 miles, get the GPS co-ordinates of your radio sites from Google Earth and conduct a pathloss study. (ioSelect can perform a pathloss study for you, if required.)

8. How far can the antenna be located from an ioSelect radio?

Generally 200 feet is a practical maximum. Like all cable, as the length of your coaxial RF cable increases so does signal loss. Similarly, there are several types of coaxial RF cable which vary in attenuation properties depending on quality and price. Rule of thumb: running antenna cable is very similar to running 120V wire, as the length increases you must increase the cable diameter to compensate for the voltage (signal) loss.

9. How close together can antennas be placed?

Separate the antennas either 6 feet vertically or 10 feet horizontally.

10. When is the best time to test a radio link?

Under conditions when the most obstructions are in place. This means in the spring/summer if there are leaf bearing trees (add a 5-10dB of additional signal attenuation if testing in the winter) or when the doors to a facility are closed (if transmitting from outside to inside a building).

11. Does rain affect reception at 900MHz?

Typically, radio designers ignore the effects of precipitation at frequencies below 1GHz. However, practical experience has shown some receive signal strength variations in heavy rain storms – possibly due to water vapor

in the path or antenna connections not being watertight. This is why we recommend that all installations have a 10-20dB fade margin.

12. Does snow affect reception?

Snow flakes themselves will not attenuate a 900MHz radio signal, however snow and ice build-up on an antenna can change its shape and therefore change its propagation characteristics. To overcome this, most antennas have a fiberglass radome that prevents snow from contacting the metal radiating elements. Yagi antennas are mounted with vertical polarization (cross bars vertical) to minimize snow build-up. These preventative measures have allowed radio based SCADA systems for water/waste water utilities and oil & gas applications to be used reliably in the most northerly cities and outlying areas for decades.

13. What happens if a building is erected or trees/bushes grow up between two radios?

Adding more molecules for radio waves to pass through (i.e. air being replaced by a building or trees) will naturally cause attenuation of the signal. This is why we recommend that radios be installed with a 10-20dB fade margin.

14. How many ioSelect radios can operate in the same area?

Hundreds of units.

15. How many independent systems can be in a given area?

Let's take the example of multiple "Back to Back" or Mirrored IO systems in close proximity, but it depends how independent they need to be:

- Hopping Channel (0 – 9): By setting each independent system to a unique Hopping Channel will mean that each system will not even know the other exists and they will not interact with each other in any way. This is the most independent they can be, but there is only 10 different Hopping Channels available.
- Unique Addressing: Even if units are all on the same Hopping Channel then can still be set with different source and destination addresses so the communication will only occur between these specific units. Unlike using the Hopping Channel method above, theoretically any number of units could be in the same location using this method, but they would all be using the same radio frequency resources and as more units are added they would start to have an effect on each other.

By combining the use of different Hopping Channels first and then Unique Addressing if needed easily dozens of independent systems can occupy the same area reliably.

16. What is multipath and why don't ioSelect radios have two antennas like most WiFi?

Multipath is a condition where radio waves leaving a transmitter take different paths to a receiver (due to reflections off of obstacles) and end up reaching the receiving antenna out of phase with one another. As a result, if two or more radio waves arrive out of phase at one antenna, chances exist that the opposing waves could cancel each other and result in a reduction of the radio signal possibly to the point of no reception.

WiFi radios use two antennas to try to overcome such nulls by placing the receive antennas in two physically different paths. Rather than physically changing the path, frequency hopping radios overcome multi-path null conditions by constantly changing frequencies. This works because different radio frequencies have different wave characteristics, so signals sent on different radio frequencies will not behave the same in any given environment. This means that a null occurring at one frequency, in a highly reflective refinery for example, will not occur on another frequency because the wave properties are different. So multipath may affect the overall data throughput of a Frequency Hopping Spread Spectrum (FHSS) radio, but not stop it.

17. Are these radios susceptible to interference from cell phones, two-way radios, etc?

No. Cell phones operate on frequency bands – typically 860-890MHz and 1.8GHz – outside the ISM 900MHz where the ioSelect industrial radios operate. The fixed frequency voice radios that plant personnel use often operate in the 450MHz range. In terms of off-band interference, the ioSelect Industrial radios use narrowband filters to keep unwanted signals out. That said, other ISM band radios operating within the 900MHz band do

have the potential to cause interference, but because of the nature of frequency hopping radios, if a collision occurs on one frequency, milliseconds later the radios hop to other frequencies where data can be updated.

18. What is the I/O update or response time?

A good rule of thumb is 750 msec per remote radio node worst case. So in the case of:

- A Back-to-Back system a change on an input at one end will be "Mirrored" to the output at the other end in at most 750msec.
- A master radio and 10 remote radios an input of on of the remote radios will be read by the host computer connected to the master radio in at most 7.5 sec.

19. Do the RF emissions affect pH or Cl2 sensors? What about VFD's?

More than a decade of field experience and testing has proven that these radios will not produce the same false alarms in sensitive instrumentation that voice radios do. Likewise, experience has shown that the ioSelect Industrial radios are not affected by VFD's nor to they interfere with the performance of such drives. They are quite happy to co-exist side by side.

20. Is my data secure with ioSelect radios?

Though the case can be made that nothing is really safe against a determined intruder, in the case of ioSelect's frequency hopping spread spectrum military-type radios, proprietary software, pseudo random hopping sequences, short single frequency dwell times and a host of other proprietary security features make signal interception and interpretation very difficult. To 'break in' to an ioSelect FHSS system, an intruder would have to:

- Be technically competent
- Have detailed knowledge of the inner workings of both the hardware (frequencies, bandwidths, hop and synchronization sequences and timing) and software (data packet construction, time tracking, synchronization strategy, etc.).
- Be very tenacious, own military-type equipment and have lots of time and money

Also, for extra security 256 bit Advanced Encryption Standard (AES) encryption (FIPS-197 certified) is available on the units and can be easily enabled when desired.