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Is It Time to Cut the Cable?

Written by Mark Arnold and Paul Craven as published in Hydraulics & Pneumatics, | Nov 12, 2019

The decision to go wireless for machine communication comes down to how much the benefits outweigh the challenges.

Wireless communication in our everyday electronic mobile devices has become so pervasive that it's difficult to remember when such connectivity didn't exist. Conversely, this level of connectivity has yet to dominate the factory floor. However, with the increased focus on IIoT, this may soon become a reality.

Pneumatic solenoid valves for many decades have been controlled through discrete wiring, with each solenoid individually wired and connected to a common cable, such as a 25-pin D-sub connector. This has progressed to fieldbus for quicker installation times, reduced wiring errors, and more importantly, diagnostic feedback capabilities.

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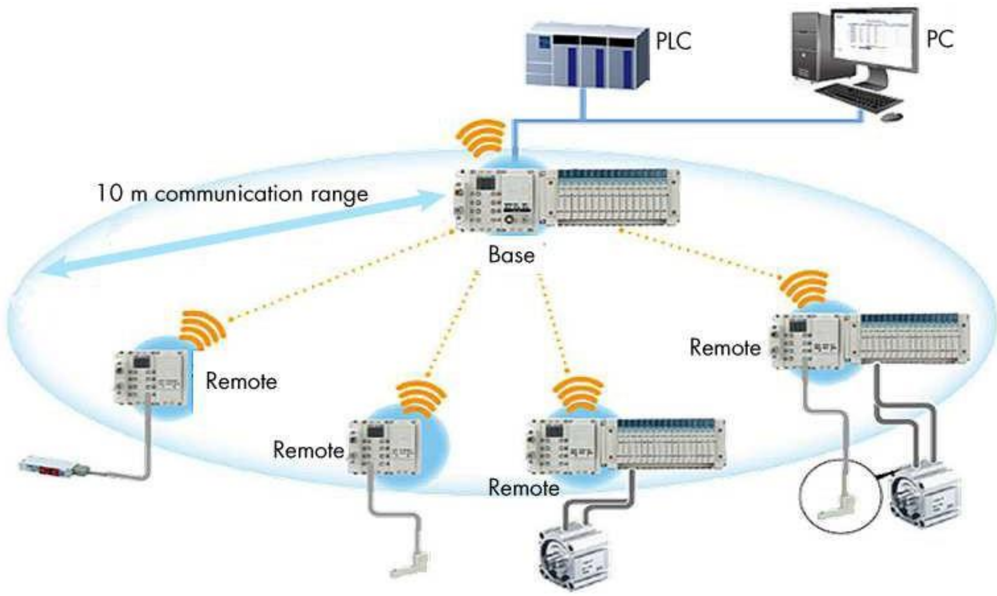
Wireless manifold technology allows a PC and PLC to communicate with a base unit to transmit data via a wireless network to remote valve manifold units that control air pressure to actuators or pilot valves. However, remote units still need to be connected to power through cables.



Wireless manifolds allow a PC and PLC to communicate with a base unit to transmit data via a wireless network to remote valve manifold units that control air pressure to actuators or pilot valves.

The immediate advantages are lower expenses for controls cables and less cable clutter. Additionally, going wireless removes the exposure of communication cables to the power cable's electrical noise when routed in the same cable bundle. This will protect the communication integrity while also increasing flexibility when allocating machine space within the factory.

Typical Applications for Going Wireless

Robotic arms and end effectors operate at very high speeds increasing productivity and throughput; this will increase the stress and wear to all components on or in physical contact with the robot's arm.

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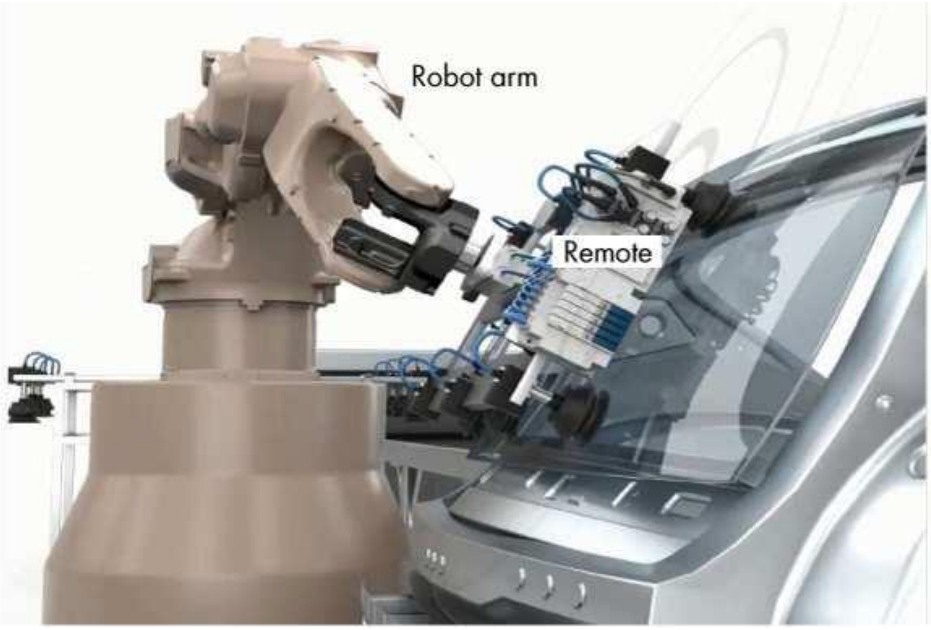
This high-speed, dynamic movement will subject all cables to repeated exposure to roll, bending, torsional, and variable flexing in or outside the robot's arm, making cable choice a factor in machine performance and component longevity.



Because robotic arms and end effectors operate at very high speeds, they subject all cables to repeated exposure to roll, bending, torsional, and variable flexing in or outside the robot's arm.

Eliminating all but the power cables and pneumatic tubing frees up more space inside the tight diameter of the robot's arm, facilitating an easier build and reducing installation times. In general, power cables can be made more robust than communication cables. Troubleshooting also becomes easier because a cable failure will be confined to a loss in power—no more hunting through bundles of communications cables to diagnose a problem, thus minimizing downtime.

Production equipment has steadily been transitioning from single-purpose to multi-purpose machines that offer greater versatility. One solution to this is automatic tool changers. Wireless valve manifolds

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will eliminate the communications plugs and pins that are vulnerable to bending and breaking as they are repeatedly subject to plugging and unplugging. Simplifying the tool end to only electric power and compressed air will increase the robustness of the system.

Rotary indexing or turntables will rotate a tabletop to a specified angle, stop and dwell motionless for a duration until work is completed, then continue angular rotation and stop for the next work operation. They are typically powered by electric motors, positioned by encoders and sensors, and mounted with pneumatic valves and actuators.

The tabletop components rely on slip rings to connect electric power, communications, and air pressure from the non-rotating base with the rotating tabletop. Some slip rings can be simple, off-the-shelf products, whereas others can be complex and specially designed.

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Wireless valve manifolds allow specifying simpler slip rings for rotary indexing tables by eliminating the need to transmit sensitive electronic signals.

Wireless valve manifolds will allow specifying simpler slip rings that transmit only electrical power and open space for more pneumatic channels. Because the wireless valve manifold is installed in closer proximity to the tabletop-mounted actuators, response times will improve, resulting in better cycle times. Also, there's an energy cost savings because shorter tubing lengths from manifold to actuators translates to less air volume wasted.

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Dedicated Frequency Band and Frequency Hopping

Wireless communication inside an enclosed space—densely populated with obstructive metal machinery and surrounded by electrical noise—creates challenges to quick, uninterrupted, and trustworthy data transmission for safe control, operation, and monitoring of production equipment. Cabled communication, however costly and bulky, has proven itself to be safe and secure, so why go wireless? Research and testing for wireless factory automation have identified and developed workable solutions to mitigate the anxiety surrounding the adoption of wireless technology.

The 2.4-GHz ISM (industrial, scientific, and medical) frequency band is easy to implement because no license is required, and is globally recognized and ruled by the FCC, CFR 47, Part 15. This limits transmission to 1 W when operating wireless communication with more than 75 frequency channels. The 2.4 GHz ISM isolates the frequency above the most common sources of industrial noise: ac and dc welding, motor starting, heater contacts, etc. Examples of devices typically used at 2.4 GHz include Bluetooth, wireless LAN, and various other RFID devices.

Why use 2.4 GHz where 5.8 GHz is less common, with less chance of interference? Some global markets require a license to operate equipment at 5.8 GHz, but more pragmatically, a 2.4-GHz signal better diffracts around solid objects and travels farther when transmitted at the same power rating.

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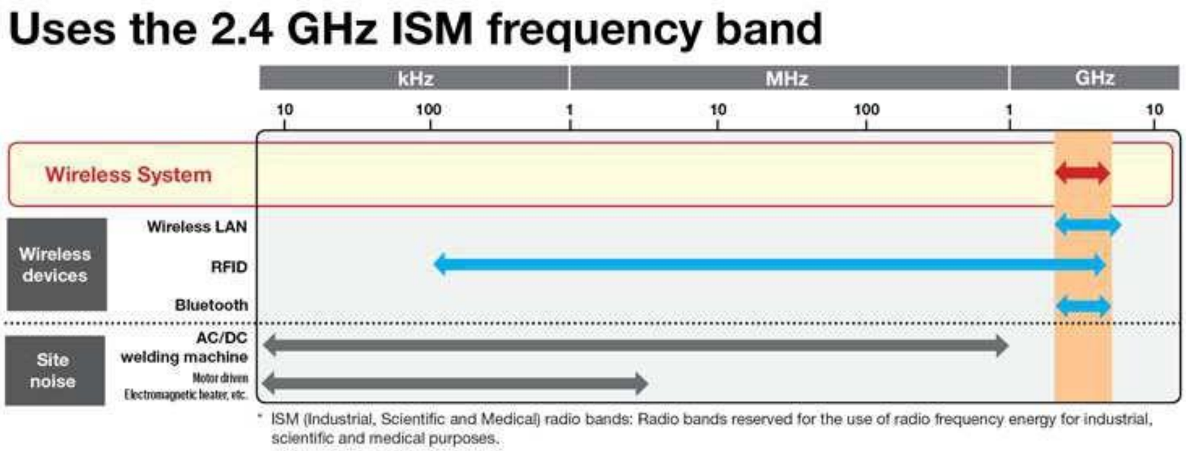
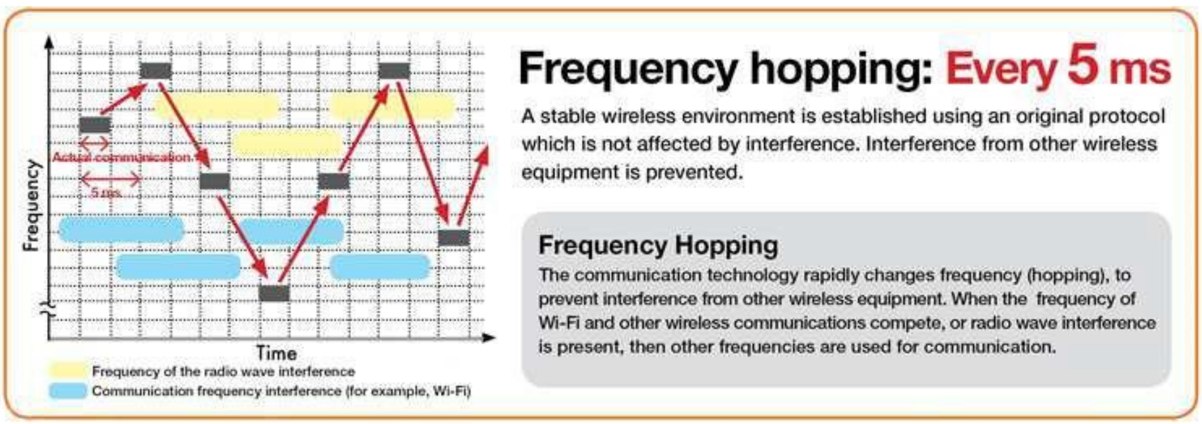


The 2.4 GHz ISM frequency band is easy to implement because no license is required, and it is globally recognized and ruled by the FCC.

An added measure to mitigate interference is to use a proprietary protocol within the 2.4-GHz ISM band and frequency hop among the available 79 channel frequencies. Frequency-hopping spread spectrum (FHSS) is a method of transmitting radio signals by rapidly switching a data channel among many frequency channels, using a sequence known to both transmitter and receiver. The data channel is changed automatically at predetermined time intervals (e.g., every 5 ms) to prevent being interfered with or interfering with other devices. Furthermore, because most other ISM devices will use a single fixed frequency, interference can only minimally impact the data transmission because a different clear channel will be hopped to and reconnected within 5 ms.

An additional backup measure to interference would be to have the base unit automatically attempt to reconnect to the remote units until wireless communication is reestablished. If after 31 retries connectivity is not reestablished, an alarm bit will be set. Once whatever interference present is removed, the unit will automatically reestablish communication. Also, limiting the radius of the communication distance (e.g., 10 m) between the base and remote units will help clear the airways of interference, mitigating the multipath effect and transmission delays.



Frequency hopping transmits radio signals by rapidly switching a data channel among many frequencies, using a sequence known to both transmitter and receiver to avoid interfering with other devices.

Secured Wireless Communication

Protection from willful malicious attacks with the intent to disrupt communications and corrupt data is a high concern for any production facility. How can factories safeguard from intentional or unintentional breaches? Recommended best practices when integrating wireless valve manifolds include:

- Limiting the distance between the manifold's base and remote units to 10 m by using a low powered transmitter, so no unauthorized entity can interfere from outside the facility to network traffic
- Creating unique product identification codes for all base and remote units to ensure exclusive peer-to-peer communication
- Using a proprietary communication protocol/algorithm between base and remote units with 128-bit encryption
- Using frequency hopping at 2.4 GHz ISM across 79 channels at 5-ms intervals

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A Reality Check

Aspiring for a 100% secured wireless communication system from an operational point of view is impractical. Any time new products are integrated into existing processes, all decision-makers and stakeholders must exercise due diligence, weighing the rewards, risks, and trade-offs when considering adopting wireless valve manifolds.

This new technology will greatly reduce the time spent troubleshooting and will help eliminate the age-old argument between electricians and maintenance: Is it an electronic problem or an airflow/pressure problem? Some of these machines will actually self-diagnose and point you in the right direction, virtually eliminating production losses. Remember, it is always more cost-effective to design-in reliability rather than to retrofit these instruments on the machine unit after it has already been installed.

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