Unplugged but connected

Part 2: Wireless sensors and effectors in industrial control

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Wireless technologies are rapidly gaining a foothold in industrial automation. Their application leads to gains in productivity and flexibility: Complex wiring solutions can be dispensed with, device design can be simplified and setup and commissioning time reduced.

In the first part of this article [1], ABB's WISA (Wireless Interface to Sensors and Actuators) was presented and the system architecture and wireless power supply discussed. This second part of the article concentrates on ensuring the reliability of wireless technology in hostile production environments and presents examples of how this technology was applied at customer facilities.

ABB has conducted extensive field testing of wireless communication in industrial environments (process plants, power plants, and manufacturing facilities). These are characterized by

1) **Industrial environment:** Extreme temperature, vibration, steel constructions, and obstructions. Issues facing wireless communication in such environments are heavy multi-path fading, fast/slow fading, coverage quality (due to reflection), and local variations in received power.
2) **EMI:** Electromagnetic Interference from electrical activity such as drives and welding which cause noise in radio frequency bands.
3) **Other Users:** Occupation of frequencies by other radio users over time (WLAN, Bluetooth, ZigBee, etc)

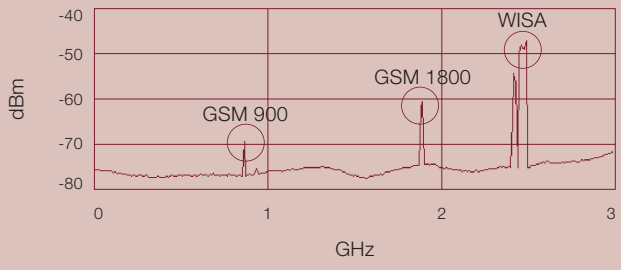
ABB's WISA technology is the only wireless technology designed to cope with these conditions and utilizes a novel frequency hopping scheme. This is combined with an error detection mechanism and automatic retransmission in case of failure. Messages are reliably delivered from the sensors/actuators, even in the presence of interference or interfering systems such as Bluetooth and WLANs. Multiple antennas and antenna switching (send/receive mode) are used to reduce the effects of multi-path fading and shadowing [2].

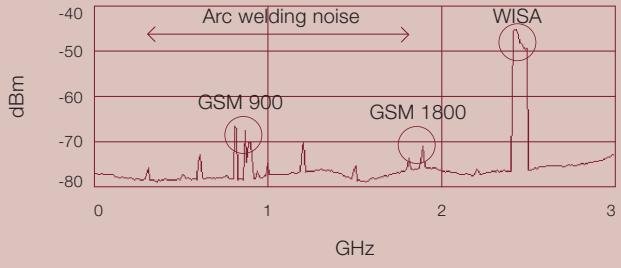
The design of WISA-com has been shown to be extremely robust, even in highly demanding environments such as welding applications. A spot welding gun used in induction welding operates at up to 20 kA and generates very strong electromagnetic fields. However, most of the frequency noise fades out above 1 GHz and therefore has a minimal impact on WISA-com (which operates in the 2.4 GHz band). The wireless proximity switches (WPS) have been tested in both spot welding and arc welding installations, where the sensors have been positioned only a few centimeters away from the welding gun. The tests showed no measurable impact on the communication performance 1.

Users are often concerned with interference by other wireless devices operating in the same frequency band. These include neighboring WISA systems ("self interference"), WLANs and Bluetooth. As WISA was especially designed for a high node density and minimal usage of frequency over time, there is no self interference in practical WISA applications, even at very high node densities. The short telegram length and suitable retransmit strategy are important for minimal disturbance by other systems. ABB has performed tests in worst case arrangements by setting up other wireless systems in very close proximity of WISA setups. A WLAN node, for example, consumes a large part of the available bandwidth in the 2.4 GHz band, typically one third (or 22 MHz). The tests however showed that this had a marginal effect on WISA performance, with very few telegrams having to be retransmitted.

1 Broad band frequency spectrum plots show no measurable impact of welding on the WPS system.

The plot above shows the frequency spectrum without any welding activity. The plot below shows the same spectrum during an arc welding sequence. Disturbances can be distinguished in the lower frequency band (300-1800 MHz) while the 2.4 GHz band, where WISA operates, is not affected.





WISA products at work

Since its market introduction in early 2004, the wireless proximity switch (WPS) and WISA technology have been deployed in a variety of applications and have undergone extensive field testing in industrial environments 2 3.

J. A. Krause in Bremen has a WPS system in its powertrain assembly. This line handles motor cylinder heads. A conveyor belt and a three-axis portal gripper for transferring the cylinder heads are controlled entirely with wireless proximity switches. The main benefit of this installation, besides lifetime savings and simplified construction of the moving gripper, was the short setup and commissioning phase. Normally, much of this work has to be done twice, first during the initial assembly in the supplier's factory, and then again at the customer's site for final commissioning.

Potential customers often ask ABB whether the company uses WPS in its own

production facilities. The question is justified. In fact, one of the first WPS system installations ever implemented is in an ABB production facility for motor starters. The setup has been running in production for nearly three years without any disturbances. "Wiring costs have been substantially reduced, and the hazard of broken wires on sensor-equipped moving components has been eliminated," says Olaf Maus, project manager responsible for integrating the switches into the production process. *"Plant extension using this innovative solution has made the production substantially simpler and safer. The switches also simplify construction and reduce installation time."*

Another WISA technology installation at the ABB High Voltage Cable factory in Karlskrona, Sweden uses 156 WPS in a single machine. This installation is a good example of the industrial robustness of WISA as the high wireless node density, their movement and large rotating steel parts present a highly challenging environment for standard wireless communication technologies. High voltage Cable's head of control engineering, Jan-Olov Sandberg, says "no other technology I have looked into in the last years was able to solve this task reliably and cost efficiently: 156 steel wire drums, rotating in all three dimensions in the large production machine have to be surveyed."

Future WISA products – disentangling robots

In robotics, an end-effector is attached to a robot, eg, a gripper used to move a part. In a conventional system, the robot is "dressed" with communication and power cables. Since the robot is capable of moving the end-effector in very complex patterns, the cabling is subject to heavy wear and tear and therefore requires frequent maintenance interventions. External cabling also limits the movement of the robot - hanging cables can easily get entangled in other automation equipment. This makes offline programming of the robot motion very difficult.

Messages are reliably delivered from the sensors/actuators, even in the presence of interference or interfering systems such as Bluetooth and WLANs.

ABB tackled this challenge by replacing the wired communication between the robot controller and the gripper by WISA, and powering the end-effector with a contactless power supply 4.

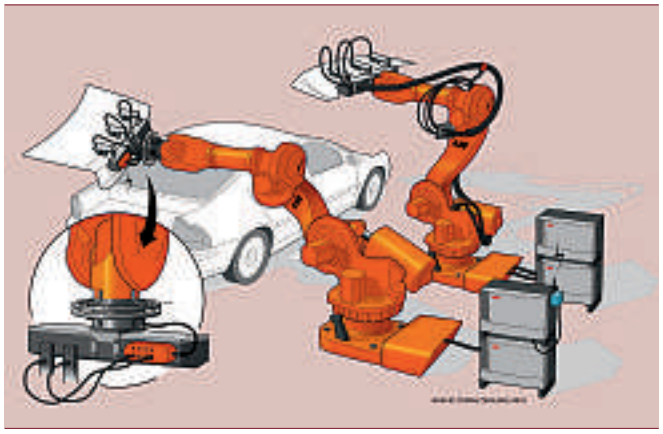
A prototype wireless input/output (I/O) module mounted on the end-effector connects the sensors and actuators of the end-effector with the control system of the robot. It uses the future I/O profile of WISA-com and shares its base station with the wireless proximity switches.

As the wireless I/O module needs to drive several outputs to control the actuators of the end-effector (pneumatic valves), it requires much higher power levels (10-50 W) than a single sensor. The solution was to eliminate the electrical connection between the robot and the end-effector. This interface represents the trickiest area for the cabling of the robot, as it is subject to the most bending and twisting. A medium-power contactless energy supply system was mounted between the robot and the effector. The primary winding (a circular coil) was attached to the robot and the secondary winding to the effector. Since the movement of the last axis no longer has any impact (strain) on the cabling, the supply cable of the transformer circuit can easily be mounted inside the mechanical arm of the robot, resulting in a robot system without external cabling and a dramatically improved life time.

A pilot system of the wireless I/O and contactless power transfer was installed at Volvo Cars in Olofström, Sweden. "When we first started this project, our aim was to evaluate whether radio communication could be used in our type of environment",

2 Example installations of the Wireless Proximity Switch (WPS). Left: Installation at J.A. Krause, Bremen Germany (powertrain assembly station) Center: Installation at ABB High Voltage Cable, Karlskrona, Sweden (High Voltage Cable Production Machine). Right :Installation of the WPS system at ABBs production facility for motor starters, Heidelberg, Germany.

3 Pilot installation of a wireless I/O and contactless power transfer in the production cell for the front wheel house assembly of the Volvo S80, XC70, and V70.



4 In the wireless solution, no external cabling is required. The communication is accomplished via a wireless input/output module that is attached to the tool.

says Ove Jösok, responsible for control systems at Volvo Cars in Olofström. To really put the technology to the test, one of the toughest applications conceivable was selected, namely a welding cell. The production cell for the front wheel house assembly of the Volvo S80, XC70, and V70, was picked as pilot application. The system was first installed in parallel with the existing wired solution and tested extensively. "The result was clear; no measurable impact on the wireless communication or contactless power supply could be detected. Volvo therefore decided to switch full production to the wireless system. It has been running successfully for more than two years now", says Ove Jösok.

Redefining automation

Since its introduction with the WPS products [3] – the concept received the Wall Street Journal Europe Innovation Gold Award in 2002 [4] – WISA technology has been extended with new profiles that support real-time communication with composite automation devices such as input/output (I/O) modules. The principle of the WISA-power technology can be extended to cover larger power ranges in a contactless fashion, opening up completely new application areas for wireless solutions.

No measurable impact on the wireless communication or contactless power supply could be detected.

Wireless installations clearly illustrate the potential for improvement this technology offers in terms of installation, engineering and life time cost. They also show that in order to achieve these benefits, both the communication and power supply must be considered. Exhaustive testing under harsh conditions, as well as customer feedback confirmed the high reliability of the WISA technology, and reinforced that existing wireless standards are not suited for real-time manufacturing automation.

Removing cables undoubtedly saves cost, but often the real cost gains lie in the radically different design approach that wireless solutions permit. For example, if the cabling in a part of the system can be eliminated, a simpler mechanical construction can often be adopted because strains on and movement of cables no longer need to be taken into account. This can translate into considerably more substantial savings than just the couple of meters of cable that are no longer required. In order to fully benefit from wireless technologies, a rethink of existing automation concepts and the complete design and functionality of an application is required.

The WISA technology platform has shown that wireless technologies can provide substantial benefits, and has the potential to redefine existing automation concepts completely.

References

[1] Jan-Erik Frey, Andreas Kreitz, Guntram Scheible; "Unplugged but connected: Part1 Redefining wireless", ABB Review 3/2005.

[2] Dacfey Dzung, Jan Endresen, Christoffer Apneseth, Jan-Erik Frey; "Design and Implementation of a Real-Time Wireless Sensor/Actuator Communication System" In: "ETFA05, Catania, 19–22 September 2005".

[3] Christoffer Apneseth, Dacfey Dzung, Snore Kjesbu, Guntram Scheible, Wolfgang Zimmermann; "Wireless, Introducing wireless proximity switches", ABB Review 4/2002, page 42.

[4] "The Hidden World" In: "Technology Innovations" a supplement of the Wall Street Journal Europe, 22–24. November 2002.

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