Expertise – Passion – Automation

The role of wireless in modern production

The case and considerations of wireless serial interfaces in industrial environments

Contents

Taking the wires out of connectivity

It has been roughly a decade since the phrase Industry 4.0 was first uttered to fanfare at Germany's Hannover Fair in 2011. The concept is now entering a phase of maturity. Digital technologies are becoming increasingly common in industrial environments, and wireless serial communication is an integral part of that.

For many industrial businesses, the rise of smart factories has brought with it a renewed focus on industrial networking possibilities. This has meant a wealth of newer communications protocols and technologies, such as EtherNet/IP™, RFID and Bluetooth, making their presence felt on the factory floor. However, the fundamental drivers behind field-level communication remain the same as they always have been: to reduce the need for extensive cabling of production applications, to improve the effectiveness of maintenance and to simplify control and monitoring of devices on the factory floor.

Wireless is invaluable in any industry or application that makes regular use of motion applications with communication cables. Among these, one area where this is particularly valuable is parts assembly, whether that is in automotive, electronics production or any industry where rotary tables and robotic systems are commonly used. These systems make trailing communications cables problematic for two core reasons: first, the motion of the systems means the cables are often damaged or disconnected during operations, leading to frequent maintenance or replacement and higher operating expenditure (OPEX). Second, the design of many systems means communications cables run in close proximity to high voltage power cables, which can cause interference with communications signals.

It's in these areas that wireless communications devices offer a viable, cost-effective solution.

SMC Corporation has developed the EX600-W wireless fieldbus system in response to this ever-growing need for reliable, wireless communications technologies on the factory floor. The system allows industrial businesses to achieve consistent, noise-free communication of encrypted data that is quick to connect and modify. This flexibility means more possibilities for businesses, and less cables, maintenance, breakage and disconnection for engineers on the factory floor.

Wireless is invaluable in any industry or application that makes regular use of motion applications with communication cables.

Going wireless

Modern wireless communication technology can be traced back to one man, German physicist Heinrich Hertz. In 1888, Hertz proved the existence of radio waves – something that until that point had been merely theorised by James Clerk Maxwell's theory of electromagnetism, or Maxwell's equations. Hertz was modest in his reaction to the confirmation of airborne electromagnetic waves, reportedly stating,

> "*It's of no use whatsoever… we just have these mysterious electromagnetic waves that we cannot see with the naked eye. But they are there.*"

Six years later, Guglielmo Marconi began experimenting with what were then, and until 1910, known as Hertzian waves to develop long-distance wireless transmission systems. This led to the development of a wireless telegraph system and laid the groundwork for the eventual development of radio broadcast transmission.

100 years later, in the 1990s, the world witnessed a wireless boom. This rise came from a perfect storm of cellular communication developments, extensive commercialisation of vital electronic components like MOSFETs and legal rulings that made industrial, scientific and medical (ISM) radio frequency bands available for unlicensed use. The Institute of Electrical and Electronics Engineers (IEEE) promptly set about developing a new standard for wireless technology, called IEEE 802.11. The initial framework was established in 1997, specifying throughput bitrates of 1-2 megabits per second (Mbit/s) by either using frequency hopping spread spectrum (FHSS) or direct-sequence spread spectrum (DSSS) in the 2.4 GHz ISM radio frequency band.

FHSS, as the name suggests, involves the transmitted signals rapidly hopping between different frequencies in a spectral band. The order and structure of the frequency changes is known by both the transmitter and receiver device, and this is done to make interception of signals and interference of communication more difficult. On the other hand, DSSS modulates the transmitted signal with a pseudorandom bit sequence to make it wider in bandwidth, which is descrambled by receivers.

> *The IEEE's standard took a few years to gain traction, but this came in 1999 with IEEE 802.11-b, which increased the throughput to as much as 11 Mbit/s using the same 2.4 GHz band. This substantial increase in throughput capability was a catalyst in the rise of what we now know as Wi-Fi.*

Meanwhile, industrial networking technology has its own illustrious past. In the 1960s, telemetry systems began being applied to industrial processes to provide monitoring functionality, which led the way to supervisory control and data acquisition (SCADA) systems and distributed control systems (DCSs) coming to the fore. These systems involve a base device, which collects and processes data from a series of field devices connected with serial communication cabling. The main difference between the two, initially, was mostly that of user interface and device spread; today, however, there are many more similarities between the two system types.

A modern need

Similarly, the latter half of the 21st century brought automated systems to the factory floor, ranging from pneumatic rotary tables in automotive manufacturing and conveying systems to cartesian manipulators and industrial robots. These systems remain staples of modern industrial settings, particularly in applications such as automotive sub-assembly, electronics manufacturing and welding.

All these systems – the control systems and the physical automated systems – have two things in common: they are tools for enhancing productivity, and they must communicate data to operate effectively.

Cables: types and challenges

Cabling choices

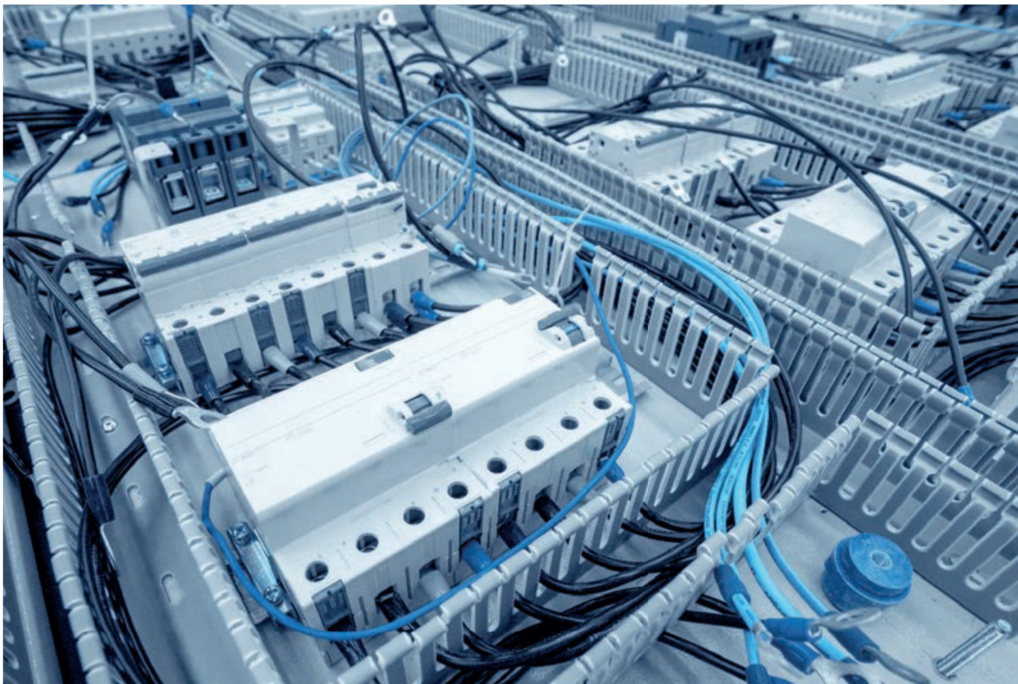
Generally speaking, there are two main types of cabling used in modern industrial settings: copper and fibre optic (FO).

Traditionally, copper cabling has been dominant in industry. It's typically able to run to lengths of 100 metres and, depending on the category of cabling used, allows for data transmission of up to and around 1 Gbps. This type of wiring has found popularity predominately due to its low cost, ease of installation and general reliability with the right sheathing and protection, which makes it initially an attractive proposition to industrial manufacturers.

However, it has numerous disadvantages. First, it is limited in the volume of data flow that it can allow – something that will become increasingly troublesome as Industry 4.0 technologies continue to develop and enter the factory floor. Second, it can present a spark risk if damaged, which makes it generally unsafe for certain industries such as oil and gas. Finally, it is inherently susceptible to electromagnetic interference (EMI) from other industrial applications unless it is properly shielded and protected.

FO cabling overcomes many of these problems. It boasts a data transmission speed of up to 10 Gbps and can be used for much longer runs of up to around 2 km. Of course, the transmission speed deviates depending on the length of the cable run – a 2 km run might only achieve speeds of approximately 100 Mbps, whereas a 500 m run may allow speeds of closer to 10 Gbps. In addition, FO cables overcome the disadvantages of copper cabling in that they do not pose spark risks and they are immune to EMI. However, this all comes at a higher price point and typically requires specialist installation, both of which deter manufacturers with a lot of cabling to install.

However, all cabling is limiting in its application. It hinders the movement of motion applications, and rotary tables and industrial robotics commonly experience faults because of this. Rotary applications are considered to be heavy loads for most cables, especially FOs, because the twisting motion causes significant attenuation – or decline in signal strength – of cables and can cause connection faults. Maintenance engineers are undoubtedly familiar with the frequent need to maintain or replace cabling in these cases,



and the cost of the planned downtime that comes with that.

In these cases, businesses are forced to spend ongoing amounts of money maintaining and replacing cabling. The alternative is investing in expensive rotary connectors and joints, or extra flexible cabling that will, in reality, still face the same challenges over time.

And as Industry 4.0 continues to accelerate the adoption of new automation, electrical and pneumatic systems, these problems will only amplify in cost and impact. Looking at industrial robotic systems alone, research firm McKinsey predicted in its 2018 Industrial robotics report that global industrial robot sales would reach 421,000 for that year, marking a 10.5 per cent increase from the 381,000 sold in 2017.

In late 2019, the International Federation of Robotics (IFR) reported that 422,000 were shipped in 2018 – outstripping McKinsey's estimate by 1,000. At that pace, the world is on track for 630,000 in 2021, although the IFR did note it expected a slight recession in numbers for 2019.

However, this new wave of robotic installations poses troubles for cabling. Not only in terms of a higher number of rotating applications causing cable attenuation, but also due to more sources of EMI.

Signal interference

EMI is a mounting problem in the modern industrial environment for several reasons. Most pieces of equipment that are electrically powered will generate electromagnetic emissions under normal use – a by-product of the electrical conversion process for mains AC power, and an increasing problem due to the advent of high-frequency power supplies. This is why proper care should be taken with the design of systems to mitigate the impact of these emissions interfering with one another.

Electric motors, which are understandably common in industrial environments, are prime culprits for causing harmful EM emissions that can radiate and interfere with nearby electrical and communications networks. For communications, this interference can mean data degradation and signal loss, which makes the performance of affected equipment become unreliable – not ideal for high value or precision manufacturing.

Of course, this problem hasn't been left unabated. EMI filters are commonly used in electrical networks to attenuate EM radiation, and copper cables are shielded to prevent interference. However, the threat remains for cabled applications.

Similarly, high voltage electrical cables can affect communications cables. Engineers should typically avoid running communication cables parallel to high voltage power cables, as the noise induced can cause communication loss or component damage. Yet this is the case for some industrial applications such as some industrial robotics, where wiring is confined to a set space.

Clearly, there is a pressing need for wireless technologies to revolutionise serial communication in industrial environments.

The trouble with cables

In a perfect world, the solution would be to use only systems that are designed and installed following good electromagnetic compatibility (EMC) design and installation practices.

Wireless worries

Wireless communications are not an entirely new concept in industrial environments and have risen in popularity in recent years. But for every benefit, there are some concerns about the security and robustness of wireless communications systems.

Security can be addressed through effective transmitter-receiver or base-remote data encryption, by using FHSS and ensuring a modest range to minimise the ability for external agents from 'listening in' to the frequency.

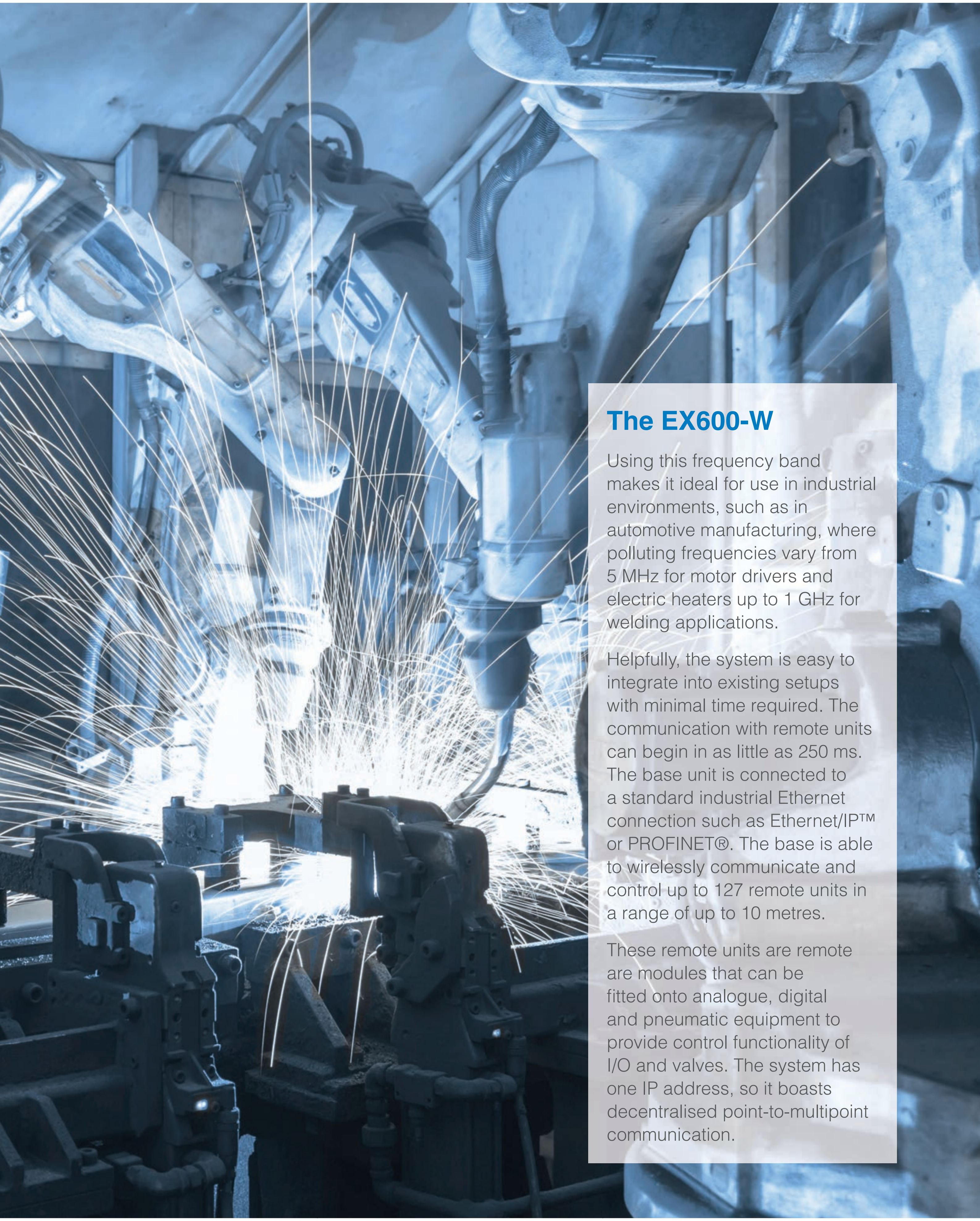
Concerns about interference can be more difficult to manage in industrial environments, which are generally rich in electrical and electromagnetic noise. In a perfect world, the solution would be to use only systems that are designed and installed following good electromagnetic compatibility (EMC) design and installation practices. Luckily, we can tackle this with a combination of using a base frequency band that is outside the normal noise frequency of industrial settings and employing FHSS to hop around that frequency range to reduce the chance of interfering with other devices.

Traditionally, another major shortcoming of wireless standards used in industrial environments has been response times. Latency is somewhat acceptable for slow moving processes, but fast response times are critical for real-time networks such as a bottling plant where the bottle, dispenser and cap need to align at very high speed. This is one reason why manufacturers have been reluctant to adopt wireless technologies and have opted to remain cabled in. The high-speed wireless networks have, until now, not been available, but that is changing.

A modern solution

At SMC Corporation, we work closely with businesses in a wide range of sectors to understand their concerns and challenges. This prompted the development of a first-of-its-kind product: the EX600-W.

The EX600-W is a decentralised wireless fieldbus system that bypasses the need for network cables. The system uses the 2.4 GHz ISM frequency band and uses a FHSS across 79 channels in that frequency range, changing channel every 5 ms to avoid interference with other objects and industrial noise.



The EX600-W

Using this frequency band makes it ideal for use in industrial environments, such as in automotive manufacturing, where polluting frequencies vary from 5 MHz for motor drivers and electric heaters up to 1 GHz for welding applications.

Helpfully, the system is easy to integrate into existing setups with minimal time required. The communication with remote units can begin in as little as 250 ms. The base unit is connected to a standard industrial Ethernet connection such as Ethernet/IP™ or PROFINET®. The base is able to wirelessly communicate and control up to 127 remote units in a range of up to 10 metres.

These remote units are remote are modules that can be fitted onto analogue, digital and pneumatic equipment to provide control functionality of I/O and valves. The system has one IP address, so it boasts decentralised point-to-multipoint communication.

Bringing wireless to European industry

The EX600-W has already started helping businesses through Europe to achieve more with less cables.

Lower maintenance

One business, a supplier of parts to the worldwide automotive industry, uses many rotary tables to produce cross beams. These tables are notorious in industry for being troublesome with fibreoptic communication cables, with the rotary motion leading to connection faults. Every time this occurs, the maintenance team must visit the rotary table, check the cabling and, usually, change the whole cable line.

As a solution to avoid this problem from continuing, SMC Europe offered its WiFi solution with the solenoid valves in the facility. The production line consists of several working cells, and the media supply for those cells is done via hall installation plate (HIP) and robot installation panel (RIP). We exchanged the standard fibreoptic unit on the HIP with an EX600-W base, and this WiFi base controls the remote units directly within the working cell area.

In total, four bases and 18 remote units, with 12 different valve manifold configurations, are now installed on the production line. The remote units are mounted directly at rotary tables. These units are still in place and allowing operations to proceed with a significantly reduced need for maintenance. In addition, the customer says that the wireless system emphasises the sense of innovation in the company – something that leaves a lasting, positive impression on their potential customers.

It can be calculated using a series of equations based on these figures:

Availability
(Planned production time – stop time)/planned production time

Performance
(Ideal cycle time/total count)/run time

Quality
Good count/Total count

OEE can then be equated to be
Availability × Performance × Quality, or (Good Count × Ideal Cycle Time)/ Planned Production Time

Achieving OEE

For another customer, the influencing factor that drove them to consider wireless was the company's measure of overall equipment effectiveness (OEE). OEE is a good practice manufacturing metric that is a simple way of evaluating the performance of production processes, by focussing on the losses in production and dividing them into three categories: availability, performance and quality.

For this customer, they had analysed the OEE of several production lines and found that the machine availability was affecting their operations. It needed to have higher machine availability to improve its OEE, which would allow the company to be more competitive and avoid repetitive breakdowns.

In addition to the time lost in stops for maintenance, the level of communication failure was very high.

Inside the production cell, there were several robot units, a turning table where the robots deposited and collected the different parts and assemblies to be installed and tested and a Cartesian manipulator YZ-Z (double Z arm). The customer had tried using some wireless products before, but the project was unsuccessful because the industrial environment had a lot of electromagnetic noise. The wireless system used previously was not equipped to handle this, because it lacked the FHSS technology as used by the EX600-W. As with many businesses that experience such difficulties, the customer's first reaction was incredulous and negative. That soon changed when we demonstrated the results.

After an initial test on the cartesian Y-ZZ resistance welding cell system, it became clear that the communication between EX600-W wireless devices was not affected at all by the environmental noise. The customer then decided to install wireless equipment on each of the robots, eliminating costly power packages and eliminating the problems associated with them. Communication between the base and the three robot remotes remained stable and robust. The robots' repeaters could be eliminated. The tooling change that was performed on one of them was improved to have a reconnection time of 250 ms, instead of the 19 seconds that is was costing. This change alone meant that production ratio increased by 15 per cent.

The last step was to retrofit the turning table where the assemblies and assembly tests were carried out. The expensive rotary joints with communication were eliminated by much simpler and cheaper ones. In the 18 months that the whole installation has been working, no communication failures have occurred again.

The customer had estimated the economic losses due to the production downtime resulting from cell communication failures totalled approximately 125,000 euros per year, signifying a substantial return on investment in the wireless system.

All the challenges faced by this company are indicative of those encountered in many industrial sectors, whether it's automotive subassembly or food and beverage processing. Not all wireless systems in the industrial sector work the same way and have the same behaviour. In fact, it is common that the customer has already tested one of these systems and is reluctant to try another one.

As proven in this case, customers that see the EX600-W wireless system working realise that the technology is not the same, and that the robustness of our equipment is much greater than what they had previously tested. In fact, it's common for customers to replicate the same solution in other parts of the factory following the first installation. Many of them even specify it in their requirements to machine suppliers.

Cost savings

We also have several cases of companies reducing costs with wireless in industrial environments. One customer benefited from wireless simultaneously demonstrated the EX600-W's ability to operate successfully in noisy industrial environments and achieve cost savings.

The company, an integrator, was tasked with solving a rotary table project on behalf of an end user. This table is used for metal sheet feeding at an arc welding device.

The table moves itself in one direction, and our CKZT series clamps are used to hold the sheets.

During this project, the integrator had to solve the problem with signal transmission from auto-switches to a control unit. Having priced up the cost of using a multifunctional rotary connector and a valve manifold, the company established that wireless might offer a more cost-effective investment. The integrator selected the EX600-W unit with the new SY series valves, which generated both investment savings and solved the problem with rotary connection. Our team also helped to ensure worker safety by adding VP544 series safety valves to the final product.

Eight months later, the system has been working tirelessly without problems or faults.

Wireless systems such as the EX600-W overcome the traditional problems with wireless and mark a revolutionary step forward, over the trailing cables that have limited industry to date.

Future proof

As Industry 4.0 enters a period of maturity, the need for wireless technology will only increase. From our extensive experience around European industry, we've seen that the growing adoption of automated systems means that flexibility, availability and durability are vital in modern communications networks.

Wireless systems such as the EX600-W overcome the traditional problems with wireless and mark a revolutionary step forward, over the trailing cables that have limited industry to date. By making use of these systems, industry can finally begin to realise the true possibilities of Industry 4.0 technologies.

Expertise – Passion – Automation