TEKON ELECTRONICS

TOP 5 BLOG POSTS FROM 2019

BLOG

SEEBECK EFFECT

The user familiar with the application of industrial thermocouples has certainly already studied and evaluated the relationship of Seebeck thermoelectric effect with the voltages recorded at these terminals. Thermoelectric effects involve the conversion of temperature differences into electrical voltage.

Seebeck effect was discovered in 1821 by the Estonian physicist Thomas Johann Seebeck. The phenomenon indicates that the temperature difference between two electrical conductors or semiconductors from distinct material nature produces a voltage between these two materials.

When heat is applied to one of the two conductors or semiconductors, the electrons became dynamic by the heat. Since only one side of the connection is subjected to heat, the electrons begin to move toward the cooler side of the two conductors. If the two conductors are connected in the form of a circuit, a direct current will flow through the circuit.

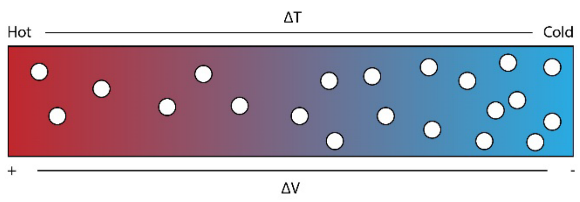


Figure 1 – Electrons movement

The voltages derived from the Seebeck effect are reduced. The voltage range produced is usually in the order of microvolts (millionth of volt) by temperature unit.

If the temperature difference is significant enough, some devices may produce a few millivolts. Several devices can be connected in parallel to increase the power supply capacity. These devices have been shown to provide a small-scale level of electrical power if a large temperature difference is maintained between the junctions.

SEEBECK COEFFICIENT

The voltage produced is proportional to the temperature difference between the junctions. The proportionality constant, represented by S, is known as the Seebeck coefficient. Mathematically, the Seebeck coefficient is represented by the following formula:

$$S = -\frac{\Delta V}{\Delta T} = \frac{V_{hot} - V_{cold}}{T_{hot} - T_{cold}}$$

Figure 2 – Seebeck coefficient calculation formula of a conductive material

In the Seebeck coefficient equation, ΔV is the voltage difference generated between the two conductive metals and ΔT is the temperature difference between the hot and cold sides.

The result of calculating the Seebeck coefficient is directly related to another factor. If the semiconductor material is n-type, the carriers are electrons. In this case the ΔV will be positive and in turn the Seebeck coefficient will be negative. If the semiconductor material is of type p, the potential difference will be negative and therefore the Seebeck coefficient will be positive.

The amount of conductive metals is relatively large. These metals have different thermoelectric sensitivities, i.e. different Seebeck coefficients.

Material	Seebeck Coefficient*
Aluminium	3,5
Bismuth	-72
Copper	6,5
Gold	6,5
Iron	19
Nickel	-15
Platinum	0
Silver	6,5
Tungsten	7,5

Source: eFunda

* units in ΔV/°C. Data registered at 0°C.

TRANSMITTERS WITH THERMOCOUPLES CONNECTIONS

Tekon Electronics has been developing thermocouple temperature monitoring solutions that meet the most recurring needs in the head transmitter temperature control market.

The diverse and expanding family of head transmitters for extreme environment applications are characterized by their wide measuring range with a degree of accuracy tailored to the needs of each application, with support for a broad set of thermocouples.

Learn more about compatible thermocouple head transmitters here.

BLOG

INCONEL SHEATHED THERMOCOUPLE PROBES

Inconel is a set of nickel and chromium alloys with properties of high resistance to high temperatures, oxidation and corrosion.

Thermocouples remain one of the most versatile systems used in temperature measurement processes. The characteristic operating range of these solutions is very inclusive and extensive to several industries. The sheath applied on this equipment has a strong influence on their durability, mechanical stability and toughness. Among the various materials available today, we look at a set of metal alloys with distinctive characteristics, namely the melting points and chemical resistance: Inconel coating alloys.

Inconel is a set of nickel and chromium alloys with properties of high resistance to high temperatures, oxidation and corrosion. Regardless of being a metal, it has no magnetic properties and has excellent mechanical properties. Inconel heating forms a thick and stable layer of oxide, which strengthens the surface of the material. This set of alloys was designed to operate at temperatures ranging from cryogenic level (< 150°C) to continuous temperatures in the 1100°C range typically applied to Inconel 600.

The application of Inconel coated thermocouples in environments with temperatures below 600°C has tended to reduce their degree of ductility (degree of deformation) as well as their physical resistance. Sulphurous environments are typically detrimental to the resistive capacities of these alloys. The mechanical properties of this alloy offer great resistance when subjected to different pressures. The pressure to which thermocouple is exposed is one of the factors that interferes on its durability. In cold work, the pressure exerted exponentially reduces the thermocouple's service life.

The correct production of Inconel sheathed probes has a high degree of dependence on the knowledge of the environment in which the equipment will be installed. Gathering as much information about the variables arranged in this environment is a critical step in producing the right probe type. This preliminary check makes it possible to prevent certain flaws in the temperature measurement process. The diameter of Inconel coated probes is one of the aspects where the standard for its choice will impact some variables directly related to the operation of thermocouples: duration, exposure temperatures and temperature drifts. In the XXI IMEKO World Congress, a **study** was presented demonstrating the interference of Inconel 600 thermocouple diameters on temperature drifts over the time of exposure to high temperatures..

CHEMICAL COMPOSITION

Inconel metal alloys have distinct chemical compositions in each type, with unequal percentages between each element, but constantly maintaining nickel as the main element and chromium as the secondary element.

	Chemical elements (%)														
Inconel	**Ni**	**Cr**	**Fe**	**Mo**	**Nb & Ta**	**Co**	**Mn**	**Cu**	**Al**	**Ti**	**Si**	**C**	**S**	**P**	**B**
600	≥ 72	14 to 17	6 a 10	-	-	-	≤ 1	≤ 0,5	-	-	≤ 0,5	≤ 0,15	≤ 0,015	-	-
617	44,2 to 61	20 to 24	≤ 3	8 to 10	-	10 to 15	≤ 0,5	≤ 0,5	0,8 to 1,5	≤ 0,6	≤ 0,5	0,05 to 0,15	≤ 0,015	≤ 0,015	≤ 0,006
625	≥ 58	20 to 23	≤ 5	8 to 10	3,15 to 4,15	≤ 1	≤ 0,5	-	≤ 0,4	≤ 0,4	≤ 0,5	≤ 0,1	≤ 0,015	≤ 0,015	
718	50 to 55	17 to 21		2,8 to 3,3	4,75 to 5,5	≤ 1	≤ 0,35	≤ 0,3	0,2 to 0,8	0,65 to 1,15	≤ 0,35	≤ 0,08	≤ 0,015	≤ 0,015	≤ 0,006

Table 1 - Chemical composition of different types of Inconel

MINERAL INSULATION

The use of Inconel sheathed thermocouples is mostly directed to applications where procedures / phenomena subject to high temperature ranges occur. The distinction of these thermocouples from conventional ones also lies in their mineral insulation. The mineral insulation does not set itself on fire making it ideal for high temperature.

Even exposed to temperatures above 1000°C, mineral insulation retains all its electrical insulation properties, which distinguishes it in the chapter on resilience to electromagnetic interference.

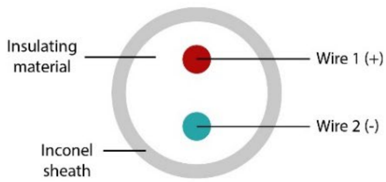


Figure 1 - Thermocouple top view

The probes flexibility is also dependent on the materials used in the insulation between the thermocouple and the sheath that covers it. The characteristics of the atmosphere in which the thermocouple will be installed play an influential role in the choice of insulating material. Their different compositions and operating temperatures affect the strength and durability of the solution and should offer the physical and chemical stability required to operate in extreme environments.

Elements used in mineral insulation have a susceptibility to temperature and relative humidity conditions that restrain their application and perfect thermocouple insulation. These materials exhibit rapid humidity absorption and therefore require strict environmental control in the production process of Inconel sheathed probes. Humidity is a major cause of mineral insulation deterioration and may turn the thermocouple unusable by reducing insulation resistance. Thermocouple accuracy is thus directly conditioned by the probe's mineral filling process. More often, we find insulation materials with the following attributes:

Denomination	Chemical formula
Magnesium oxide	MgO
Aluminum oxide	Al_2O_3
Hafnium oxide	HfO_2

Table 2 - Chemical formula of the most common mineral insulation

INCONEL PROBES AND THERMOCOUPLE TRANSMITTERS

Tekon Electronics, as an organization focused on the production of temperature transmitters is complemented by its business model, a department with increased capacity for the development of level and temperature probes with the guarantee of a unique service complementary to customer needs.

The production of Inconel sheathed temperature probes is a demanding process that must take place in controlled environments. At Tekon Electronics, the facilities are well-prepared to provide right storage and production conditions for Inconel sheathed thermocouples. Cold frame equipment is properly monitored in real time to provide a thorough level of quality, where temperature and humidity are extremely influential variables in the production of this type of probes, as previously mentioned. The welding process with Inconel is performed by dedicated equipment that values and certifies the quality required for this procedure.

Continued use of thermocouples in temperature measurement procedures is complemented at Tekon Electronics by the development of transmitters capable of supporting connection with these sensors (thermocouples). The communication methods of temperature transmitters have been developed in wired and wireless segments in order to leave their application open to different environments. The output signal of head transmitters is characterized by its mA format, in a range of 4 to 20, via **Modbus RTU** communication protocols for wired models, and via **Tinymesh™** protocol for wireless models.

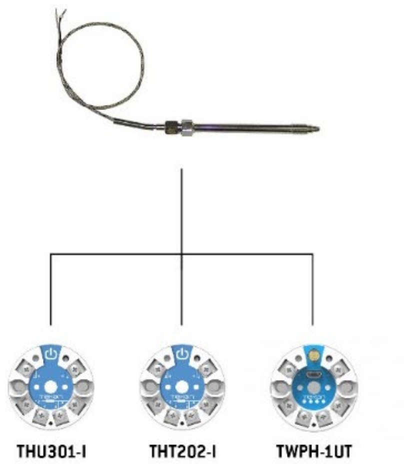
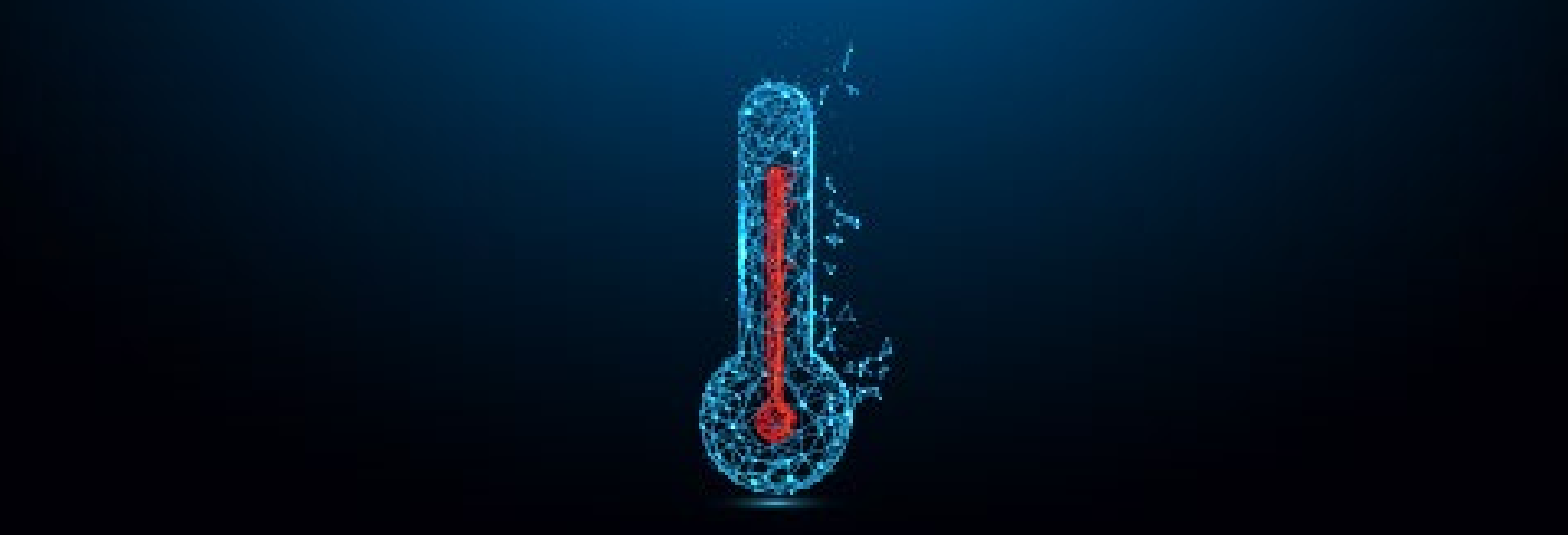


Figure 2 - Tekon Electronics in head transmitters with thermocouple connection



BLOG

RTD'S - 2, 3 OR 4-WIRE CONNECTIONS?

RTD’s are extremely useful instruments for process temperature measurement. The accuracy/temperature range ratio drives its use in singular business areas, from less demanding to more rigorous processes.

RTD means *Resistance Temperature Detectors*, also known in their application environments as resistance thermometers. The operation of this temperature measurement system is supported by the physical relationship between metal and temperature. The temperature oscillation of a metal is proportionally related to the variation of the metal’s resistance to electric flow. Similarly, as the RTD resistance element temperature increases, the electrical resistance, measured in ohms, decreases.

Traditional RTD’s are manufactured with a small coil of platinum, copper or nickel wire wrapped around a precise strength value around a ceramic or glass coil. Recently, RTDs are also being manufactured using a thin film of platinum metal or nickel iron placed on a ceramic substrate and then laser cut to obtain the desired reference strength. The most evident advantage in this construction is that thin film elements can achieve higher strength with less metal and less space. This makes them smaller, cheaper and more thermally dynamic than traditional elements.

The strength of the materials used has direct influence on the temperature measurement range. The different compounds offer operating ranges with different ranges.

RTD Material	Relative temperature range
Platinum	-260ºC a 650ºC
Nickel	-100ºC a 300ºC
Copper	-75ºC a 150ºC
Nickel/iron	0ºC a 200ºC

Figure 1 - Temperature range of RTD materials

RTD CONNECTION CONFIGURATION

RTD connections are made in three different ways: 2, 3 or 4 wires.

Choosing the most appropriated configuration is a rigorous process that involves considering several factors that can lead to significant errors throughout the temperature measurement process.

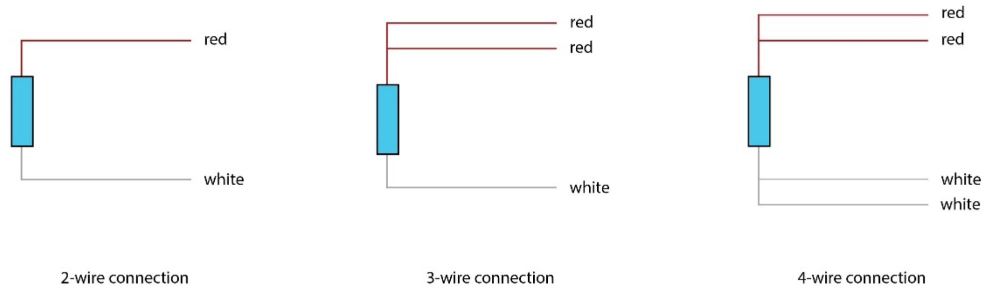


Figure 2 - RTD connections diagram

2-wire connection

The 2-wire connection is the simplest of all. The circuit has no mechanism to counterbalance, delete or calculate conductor resistance. The accuracy of this connection is much lower when compared to 3 or 4 wire connections. The application of this solution is suitable for projects where the length of the connecting wires is necessarily short and where there is no need to perform a measurement with a high degree of accuracy.

3-wire connection

RTDs with 3-wire connections are the most used of the 3 solutions presented. The presence of an additional wire in relation to the above system is precisely to fill the main flaw it has…remove the resistance of the sensor measurement cable. This setting provides a compensation loop that can be used to remove the resistance from the measurement cable.

4-wire connection

The need to choose this type of connection is due to the accuracy required in the temperature measurement process. It is the most complex solution to install and therefore the costliest. In this system, a pair of wires (white and red) are used to carry the excitation current to the sensor and the remaining two wires to measure the ohmic value of the RTD. Since the latter two do not carry the excitation current responsible for introducing errors associated with wire resistance, the actual resistance of each wire can be eliminated by returning the measurement system to the exact resistance of the RTD sensor.

RTD's CLASSIFICATION

The RTD classification has a direct involvement with their error tolerance at the time of their production. Parameter normalization allows manufacturers to develop solutions that ensure widespread operation.

Within the context of RTD's, due to their physical characteristics, platinum elements have maintained a high level of popularity and number of applications. Internationally defined standards divide these elements into two distinct classes, A and B, with values set at a temperature/tolerance ratio.

	Tolerance			
Temperature	Class A		Class B	
	ºC	Ω	ºC	Ω
-200	± 0,55	± 0,24	± 1,30	± 0,56
-100	± 0,35	± 0,14	± 0,80	± 0,32
0	± 0,15	± 0,06	± 0,30	± 0,12
100	± 0,35	± 0,13	± 0,80	± 0,30
200	± 0,55	± 0,20	± 1,30	± 0,48
300	± 0,75	± 0,27	± 1,80	± 0,64
400	± 0,95	± 0,33	± 2,30	± 0,79
500	± 1,15	± 0,38	± 2,80	± 0,93
600	± 1,35	± 0,43	± 3,30	± 1,06
650	± 1,45	± 0,46	± 3,60	± 1,13
700	-	-	± 3,80	± 1,17
800	-	-	± 4,30	± 1,28
850	-	-	± 4,60	± 1,34

Figure 3 – Temperature/tolerance value table for PRTD's by IEC 751

FINAL CONCLUSIONS

RTD's are extremely useful instruments for process temperature measurement. The accuracy/temperature range ratio drives its use in singular business areas, from less demanding to more rigorous processes. The 2, 3 or 4-wire connection configurations make it possible to distinguish applicability by the process to be monitored. Resistance thermometers guarantee accuracy and stability in temperature measurement from cryogenic processes to metal melting levels.

BLOG

ARE YOU MEASURING CARBON DIOXIDE WITH A 14% ERROR?

Researchers concluded that inhaling carbon dioxide at high levels, may dilate brain blood vessels, reducing neuronal activity.

Researchers concluded that inhaling carbon dioxide at high levels, may dilate brain blood vessels, reducing neuronal activity and triggering the consequent decreasing of communication quality between different brain regions.

A study performed in 2017, “The Ventilation problem in schools”, by W.J. Fisk, revealed that, by increasing school’s ventilation, children can achieve better results and perform all the tasks quickly, avoiding distraction moments.

In this way, carbon dioxide levels measurement equipment are essential tools to ensure the correct ventilation, by monitoring carbon dioxide levels and communication with ventilation systems, performing level readings throughout the day, to ensure the best practices that ensure the high performance of professionals in meeting rooms, offices, or business intelligence, to ensure the fastest and best purchase decisions in retail or shopping centers, increasing likelihood better results.

However, the use of data collection and monitoring equipment requires an in-depth knowledge of measurement methodologies, variables interpretation and other variables that may impact the collected data quality.

Carbon dioxide sensors use a Non-Dispersive Infrared (NDIR) technology. Although this technology is effective, attending to gas measurement, it is directly related to the atmospheric pressure and temperature at which sensor is at the time of measurement.

Considering an air volume whose dioxide concentration is 1000 ppm (parts/million), this air volume consists in the mixture of 999 000 air molecules and 1000 carbon dioxide molecules. However, the volume needed to hold this same number of particles depends on atmospheric pressure and air temperature.

As altitude increases, atmospheric pressure decreases. The atmospheric pressure decreasing makes the air more rarefied, and for the same air volume, there will be fewer molecules. The fact that it contains fewer molecules doesn't mean that carbon dioxide concentration decreases, keeping unchanged the factor between carbon dioxide molecules and air. Temperature increase also triggers a similar behaviour too. With a higher temperature or a lower atmospheric pressure there will be less air molecules in the sample chamber, so there will also be fewer CO2 molecules, although CO2 concentration hasn't decreased in PPM.

That way few carbon dioxide molecules mask the sensor readings leading to a lower carbon dioxide concentration than exists because sensors consider a standard atmospheric pressure at 1013 mbar.

Since the dependence of the density of air molecules depends on two facts, temperature and atmospheric pressure, is not possible to compensate the acquisition only from one of them. Since atmospheric pressure is directly related with altitude, although it doesn't depend exclusively on altitude, it is possible to reduce it from altitude, including the temperature influence on a single expression. Note that at sea level, 0m altitude, temperature has no effect on atmospheric pressure. The calculation of atmospheric pressure value is directly related to altitude and temperature variation.

On other side, when featured, the sensor acquisition dependency it is possible to compensate. For example, the probe used in **DUOS CO2** transmitter presents an acquisition dependency, can be described by the following equation:

$$CO_{2_{effective}} =$$

$$CO_{2_{measured}} \times \left(1 + \Delta p_{[mbar]} \times 0.14\%\right)$$

Calculation formula supplied by the manufacturer

Where:

$$\Delta p_{[mbar]} = 1013 - p_{local}$$

p_{local}: local probe atmospheric pressure.

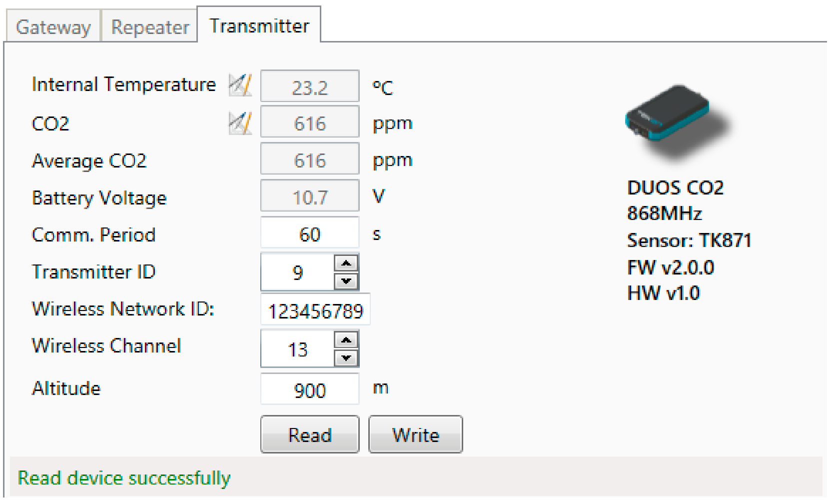
The probe dependency on atmospheric pressure can cause a substantial error. For example, if the probe is installed in the Guarda city (1056m altitude), Portugal, at 25°C temperature, the site atmospheric pressure will be approximately 900 mbar, following a physical calculation formula. Considering that the value measured by the probe is 1000pp, the acquisition error is calculated by:

$$\Delta p_{[mbar]} = 1013 - 900 = 113\ mbar$$

$$CO_{2_{effective}} = 1000 \times (1 + 113 \times 0.14\%)$$
$$\Leftrightarrow CO_{2_{effective}} = 1160ppm$$

So, a 113 mbar variation causes a -13.8% error in the probe acquisition. The local atmospheric pressure is difficult to establish without additional tools. However, at which it is located is relatively simple, using, for example, a mobile phone with GPS technology.

Temperature is another variable required to the compensation available on the **DUOS CO2** transmitter. Inserting the altitude value at which probe is installed, through the Tekon Configurator software, the transmitter has the necessary information to apply the calculation equation and thus obtain the atmospheric pressure to which the probe is subjected with a reduced error range. With this information can apply the calculation formula and perform the measurement compensation for each sample. Below example:



Carbon dioxide monitoring requires a deep knowledge not only of what the gas itself can cause, also about the technology used for its measurement and dependence on the thermodynamic behaviour of air and atmosphere.

Learn more about **DUOS CO2** here.

BLOG

MORE DATA, LESS MAINTENANCE

Industrial maintenance has undergone a revolution with the emergence of Industry 4.0. The status of production process and the equipment requires the monitoring of influencing variables in this process.

Every day, industrial environments are affected by failures and stops in the production process. It is a reality present in the equipment that perform repetitive tasks for a scaled production. A delay in production due to a forced break for maintenance can jeopardize the productive goals, lead to the increase of operational costs and non-fulfilment of deadlines. **The industries aim to reach more profitable levels of efficiency** and tend to adopt by the implementation of maintenance systems that help to reduce the rates of interventions of much needed industrial maintenance. The service significance is to ensure the upkeep the correct functioning of a production unit providing the necessary assistance to the manufacturing equipment.

Industrial maintenance has undergone a revolution with the emergence of **Industry 4.0** concept. The idealization of intelligent systems integrated in the industrial process allowed to take advantage of the operational data surrounding the industrial environment and impact the productive stages making its elements more informed and proactive. The maintenance comes with new methods and more complex aspects arising from this change as is the case of predictive maintenance.

Predictive maintenance bases its intervention on the indications resulting from the monitoring of the equipment in order to trigger preventive actions to ensure the correct operation of the industrial plant. The consequent actions appear as preventive measures and not as corrective measures resulting from unexpected events that have already led to production chain breaks and increased operating and maintenance costs.

Predictive maintenance offers advantages that span the entire industrial system:

- **Decrease machine downtime;**
- **Reduction in the number of unexpected interventions;**
- **Equipment life-time increased;**
- **Reduced maintenance costs;**
- **Productivity improvement;**
- **Increased workplace security;**
- **Reduction of industrial plant operating costs;**

Internet of Things (IoT) come up as a technology to help this present of maintenance. The technological concept is linked to **Industry 4.0** in the use of production data for a reliable monitoring of the productive system. The status of production process and the equipment requires the monitoring of influencing variables in this process – **conductivity, pH, vibration, flow, humidity, level, pressure, temperature among others.**

PLUS – from analog to IoT

Tekon Electronics has developed the **PLUS** wireless solution suit that streamlines the entire process of monitoring typical voltage and current analog variables.

The main feature of the PLUS wireless family is the collection of data from sensors. All this information generated by the sensors will soon be available online, in real time, for consultation and remote analysis through the **Tekon IoT Platform**.

How is data transmission processed? The **TWP4AI** transmitter supports the connection of up to 4 configurable analog inputs, turning traditional sensors in wireless smart sensors.

One of the major breakthroughs in the reliability of communication available in the wireless PLUS system is the versatility of the TWP4AI transmitter also be able to play the repeater role.

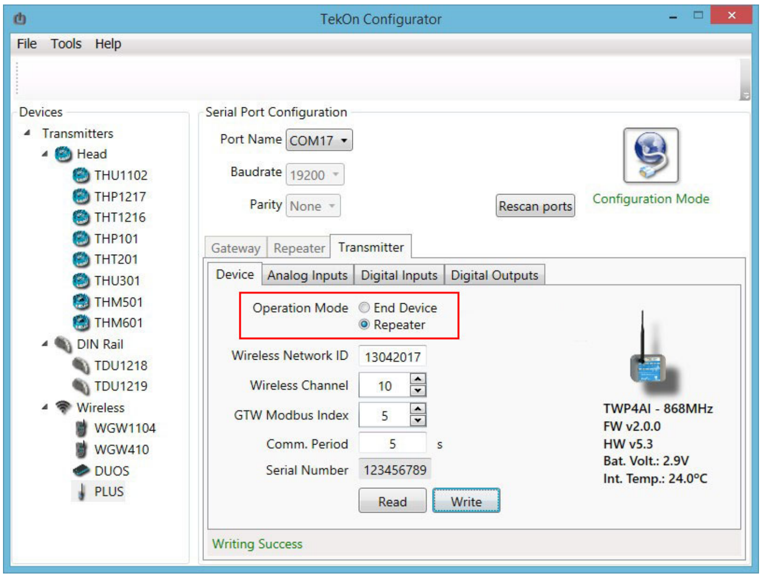


Figure 1 - Tekon Configurator window with the TWP4AI transmitter double configuration

The encrypted data transmission range of this solution although extensive is limited, so the **WRP001** repeater allows to extend the radius of action with the interconnection of up to 12 network repeaters in order to enhance the trust in data communication. Providing the correct data transmission also depends on the signal reliability. The transmitter and repeater of the PLUS product family carry out constant monitoring of the connection signal, data that is also stored and can be monitored on the Tekon IoT Platform.

The **WGW420** gateway assumes the central role of this entire network solution, collecting information from up to 55 devices simultaneously, extending all this data to the query and analysis on the Tekon IoT Platform.

The operational methodology of the PLUS wireless system focuses on a mesh type network typology. Benefits? This network typology redoubles the confidence in the connection to the users by the following indicators:

• **Self-forming**: seamless installation for the user. The network protocol performs all the necessary network input negotiation operations and chooses the information path between the TWP4AI transmitter and the WGW420 gateway;

• **Auto healing**: in case of data link breakage between devices, the network can search for and establish new connections between devices in order to maintain the correct operation of the network, all transparently and automatically without the need for user intervention;

• **Multipath**: the routing of a link becomes adaptable among several alternative paths within the network, causing greater security and reliability of the data package.

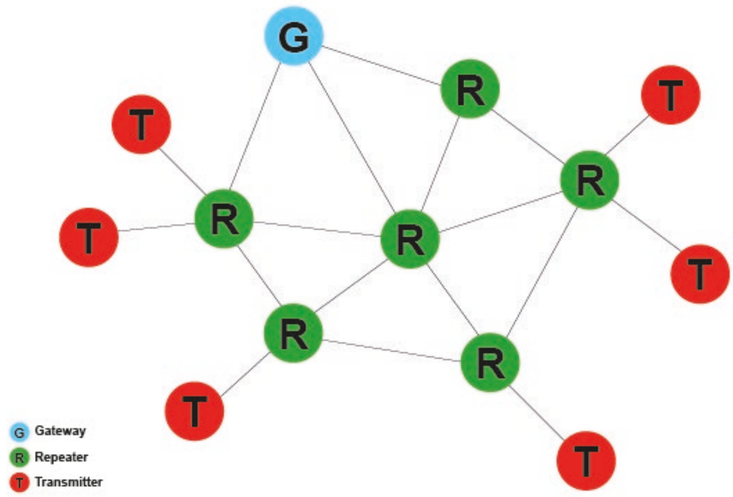


Figure 2 - Mesh network typology

PLUS wireless system features:

- **Low power consumption;**
- **Supply voltage monitoring;**
- **Communication of devices located up to 4km (LoS) from each other;**
- **Supports up to 12 repeaters in series;**
- **Supports up to 55 transmitters in the same network;**
- **Mesh network typology;**

FINAL CONCLUSIONS

In **Industry 4.0**, also known as the Fourth Industrial Revolution, with the emergence of new technologies, new maintenance processes emerged and drove the reformulation of past methods. The advances allowed the compilation of data to be translated into a more assertive response to the different difficulties in machines and production lines. The maintenance procedures culminated with an increase in the availability of equipment in industrial plants and in a greater control of cost of these processes.