Romanian Journal of Petroleum & Gas Technology
VOL. VI (LXXVII) • No. 2/2025

AUTOMATIC SYSTEM WITH PLC FOR MONITORING THE PARAMETERS OF A GAS WELL

Alexandru Vasile [1], Gabriela Bucur [1*]

[1] Petroleum-Gas University of Ploiesti, Romania
* email (corresponding author): gbucur@upg-ploiesti.ro

DOI: 10.51865/JPGT.2025.02.03

ABSTRACT

Monitoring gas well parameters is essential to ensure the efficient, safe and compliant operation of natural gas extraction and transportation facilities. By monitoring critical values in real time, any anomalies can be quickly detected and corrective measures can be implemented to prevent incidents and optimize production. The monitored parameters typically include: pressure (at the wellhead and in the column), gas flow, temperature, water content or other impurities, sand or solid particle level (if applicable). Modern monitoring systems use digital sensors, data transmission through SCADA networks and analysis algorithms for rapid data interpretation. This provides complete visibility into the performance of each well and contributes to extending the life of the equipment and increasing operational efficiency.

The paper presents aspects of the design and implementation of an automatic PLC monitoring system for gas well parameters. Based on the block diagram of the monitoring system, a new configuration of the placement of transducers on the well eruption head is proposed. The system's electrical diagrams are provided, along with the PLC programming steps and the operating specifications. Additionally, details are included regarding the HMI interface, highlighting how users can easily navigate, set transducer measurement intervals, perform calibrations, or activate alarms.

Keywords: PLC, monitoring system, gas well, critical parameters, transducer

INTRODUCTION

Growing global energy demand highlights the essential role of natural gas in meeting energy needs in a sustainable and cost-effective manner. Natural gas is often considered a bridge fuel in the transition to a more sustainable energy future. As a cleaner alternative to other fossil fuels, such as coal and oil, natural gas produces significantly lower carbon dioxide emissions when burned, making it a greener option for power and heating generation.

However, to fully realize these benefits, it is necessary that the extraction and production processes associated with natural gas are optimized. This optimization is vital to ensure the responsible use of resources and to minimize any negative effects on the environment. In this context, the implementation of high-performance gas well monitoring systems is becoming increasingly important. These systems allow real-time tracking of operational parameters, which helps to identify inefficiencies, mitigate risks and quickly address environmental concerns.

Thanks to revolutionary drilling techniques, such as horizontal directional drilling, which consists of directing the drill bit on a trajectory oriented at almost ninety degrees from the vertical to reach the desired gas reservoir [18], natural gas extraction and production have evolved substantially over the past century. As natural gas production has increased, so have the challenges associated with managing gas wells.

From the analysis of the specialized literature in the field, the following aspects were highlighted:

- Monitoring well parameters is a fundamental element for the safety and efficiency of natural gas field exploitation. Works [17] and [4] highlight the essential role of monitoring in preventing losses, optimizing production and reducing environmental or technological risks in gas exploitation.
- Process automation through PLC (programmable logic controller) and SCADA (Supervisory Control and Data Acquisition) has become the technological standard in the gas industry. Sources [1], [12], [17] and [21] emphasize the efficiency of these systems in controlling industrial processes, collecting real-time data and reacting quickly to anomalies.
- Emerging technologies, such as IoT and AI, are transforming the monitoring paradigm. The study presented in [6] shows how IoT and intelligent data analysis contribute to predictive surveillance, reducing downtime and enabling preventive maintenance.
- Reliability and security of SCADA and PLC systems are essential for hostile industrial environments [5, 20]. The papers [8] and [22] emphasize the need for robust design of these systems to operate in underground, toxic or extreme environments, as well as the importance of redundancy and cyber protection. The integration of SCADA systems with databases, smart sensors and human-machine interfaces (HMI), as suggested by the platforms and manufacturers listed [25–30], supports the digital transformation process and ensures more responsible management of resources.

Therefore, this paper focuses on the study, design and development of a monitoring system that uses an industrial PLC.

EVOLUTION OF NATURAL GAS PRODUCTION AND CONSUMPTION

Globally, natural gas exploitation and transportation technologies have advanced considerably. With the development of gas fields in Algeria, the North Sea, the Dutch coast, as well as in the eastern part of England, in Asia and in West Texas, in the Delaware Basin at depths exceeding 6000 m, challenges have arisen that require high-performance technology [23]. In addition, some recently discovered deposits in Romania are located at depths greater than 5000 m and face high pressures. In some cases, the deposits contain compounds such as hydrogen sulfide, carbon dioxide and water vapor, which creates major difficulties for monitoring and extraction systems [17].

In Romania, organized activity in the natural gas sector began at the beginning of the 20th century. The discovery of methane gas took place in 1909, at well 2 Sărmăsel, Mures County (Figure 1). Thus, following the first discoveries, commercial reserves were exploited. This allowed for the delivery of natural gas for domestic and industrial uses, including heating and street lighting [4]. Thus, from 1909 onwards, natural gas has been an important strategic sector for Romania, playing a significant role in the country's economy. The average annual production of natural gas in recent years has been approximately 11 billion cubic meters [19]. At the same time, it is important to emphasize that part of the natural gas requirement is imported, which proves Romania's dependence on external sources to satisfy domestic demand.

Figure 1. *The first gas well in Romania* [3].

According to the National Energy Regulatory Authority (ANRE), in October 2024, Romania recorded a domestic production of natural gas of 5,613,613.009 MWh (Figure 2). This quantity represents approximately 74.28% of the total natural gas consumed during that month, thus highlighting the country's domestic production capacity to satisfy a significant part of the national demand. It is also important to note that, in the same month, Romania imported a quantity of 1,944,171.808 MWh of natural gas, which constitutes 25.72% of the total consumption.

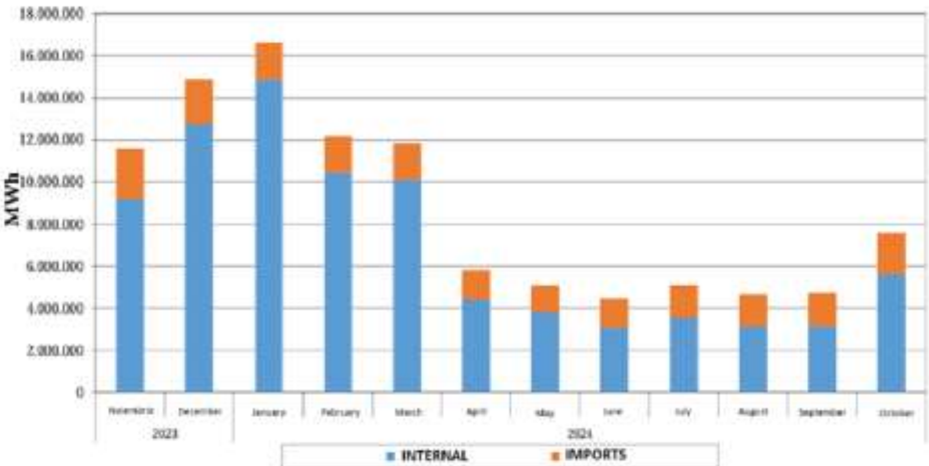


Figure 2. *Monthly structure of natural gas consumption over a 12-month period according to ANRE* [24].

Domestic natural gas production in Romania is dominated by two large companies that contribute significantly to meeting domestic demand. Romgaz, with a market share of 51.19%, plays a key role in securing gas resources, being one of the largest producers in the country. OMV-Petrom follows with a contribution of 34.55%, thus consolidating its position on the natural gas market. Together, these two companies cover a considerable percentage of the total domestic production, while the other producers contribute to the remaining 13.50%, having a smaller influence on the market [3].

In the early stages of their operational life, gas wells often exhibited a natural flow of gas to the surface, commonly known as free-flowing wells. This phenomenon occurs when the pressure at the bottom of the well is high enough to overcome the pressure losses accumulated along the flow path to the eruption head. When this critical pressure threshold is not reached, the well naturally stops bringing gas to the surface. The principle of "Gas Lift" (artificial lifting of gas to the surface) involves the use of compressed natural gas, which is injected at a certain depth into the well.

In the Gas Lift system with continuous gas injection, a constant flow of compressed gas is introduced into the well tubing, aerating the liquid and reducing pressure losses along the tubing to the blowout head (Figure 3). This decrease in flow resistance allows the original bottom hole pressure to become sufficient to lift the gas/liquid mixture to the surface, thus resuming well production [7]. Also, in practice, the intermittent injection method with compressed gas is used. The gas injection is done periodically and with a larger volume depending on the accumulation of a volume of liquid at the bottom of the well, thus the so-called "packages" of gas and liquid will reach the surface, and the injection is suspended until new packages form in the well.

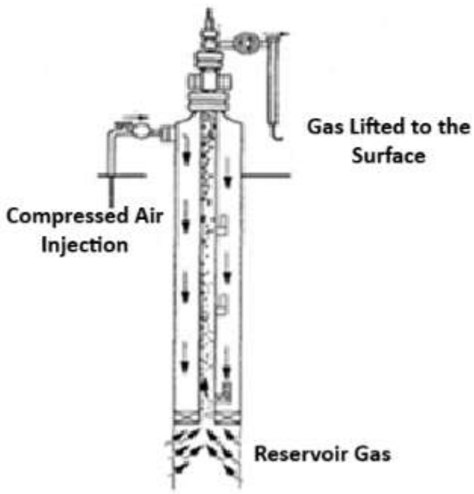


Figure 3. *Compressed gas injection* [7]

Monitoring gas well parameters (Figure 4), such as temperature, pressure, and flow, has become increasingly important for optimizing operational performance and ensuring system safety [2,14,15]. An example of a solution implemented in the past consists of using controllers with external communication modules, individual motherboards for analog and digital inputs that were finally connected to the main motherboard where there were complex algorithms for calculating and finally displaying the parameters.

During operation, interactions between these components could lead to unexpected malfunctions. For example, voltage variations or a short delay in a parameter could affect calculations, generating incorrect data. Also, physical wear on components, such as corrosion of connectors and circuits, could lead to signal loss or even complete system shutdown. Thus, integration problems frequently occurred during the replacement of defective hardware parts and this could also lead to additional costs caused by the downtime of the monitoring system.

Figure 4. *Weatherford gas well monitoring system* [9].

The configuration and placement of transducers and sensors on the blowout head of a gas well have remained relatively unchanged over the years. This consistency in system design is the result of previous optimizations that have demonstrated effectiveness in monitoring parameters (Figure 5).

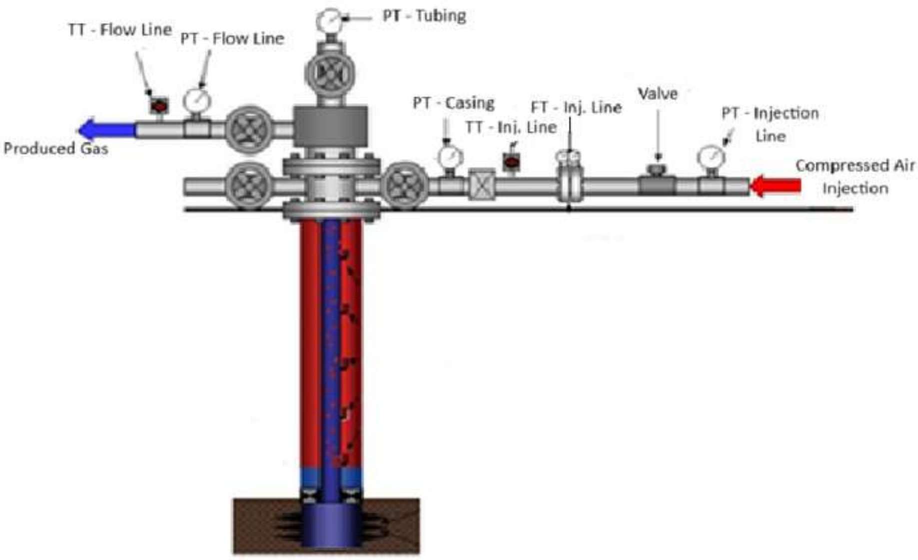


Figure 5. *Transducer placement* [9].

Although technology has advanced significantly in many areas, the transducers and sensors used to monitor gas well parameters such as temperature, pressure, and flow have not undergone significant changes to date. Many of these measuring devices based on older technologies continue to be used today, demonstrating the reliability and accuracy of the measurement methods used in the past [10,11,13].

An example of a PLC monitoring system used in the petroleum industry is a SCADA system, which uses a PLC to monitor and control gas pipeline parameters in real time. This system implements an Allen-Bradley 1400 Series A PLC, which collects data from temperature, flow, and pressure transducers, processes them, and enables remote control. Operators can thus monitor and adjust pipeline parameters through control valves and compressors [26]. The most important aspect of this system is its ability to detect leaks, using algorithms that analyze pressure and flow variations. The results show that the system can maintain pipeline parameters within prescribed limits, improving safety and operational efficiency (Figure 6). Thus, this monitoring system offers a high-performance and relatively easy-to-implement solution that does not require high costs, and can minimize financial losses and pipeline maintenance costs.

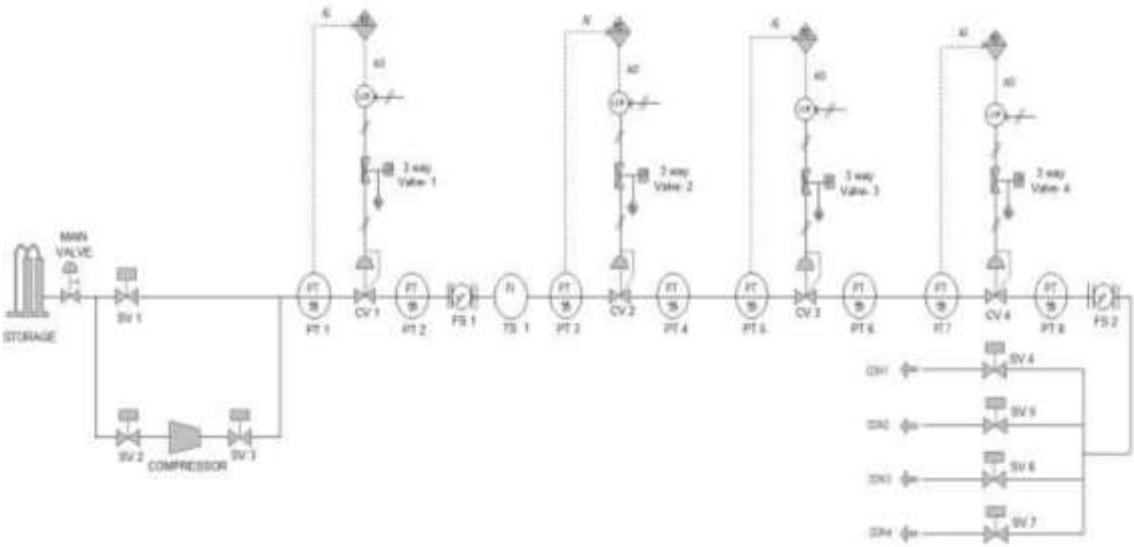


***Figure 6**. P&ID diagram of the gas pipeline monitoring and control system* [26].

DESIGN AND IMPLEMENTATION OF A MONITORING SYSTEM

The automatic system for monitoring the parameters of a gas well, developed in this work, aims to monitor in real time some essential operating parameters: the pressure in the tubing, column, production line and injection line, the flow rate and temperature in the production and injection lines, the temperature in the tubing at the upper level of the well's eruption head, as well as the position of the main valve (Master Valve) and the safety valve, which can stop the gas flow to the production line and which has the role of closing in the event of a failure. Although the main valve (Master Valve) is manually operated, requiring operator intervention to open or close it completely, the safety valve is hydraulically operated, by means of a solenoid connected to an emergency button located outside the safety box of the gas well. Given the possibility of solenoid failures, which can lead to an unintentional shutdown of the production line, constant monitoring of its position is preferred.

Thus, inductive sensors with normally-open contacts were chosen to be mounted on the two valves at the maximum and minimum positions of the internal stem and to transmit a digital signal 0 or 1 to the PLC to detect and signal both the fully open and fully closed positions of the two valves. The block diagram of the system is shown in figure 7.

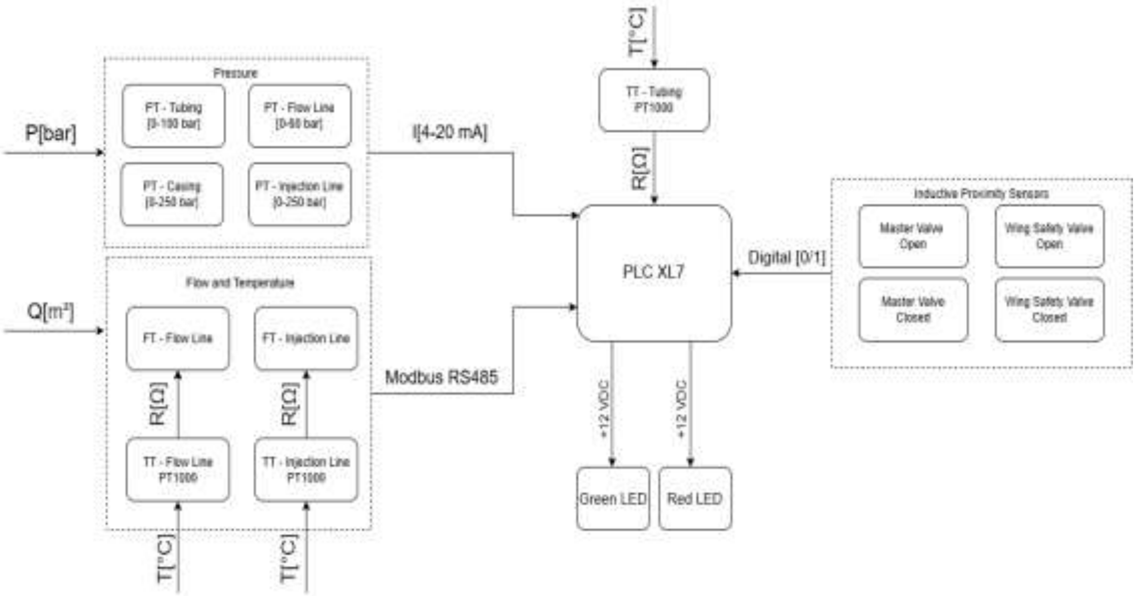


Figure 7. Block diagram of the system.

Based on the system block diagram, a new representation of the placement of transducers on the eruption head of a gas well was made. This diagram highlights in an indicative way the positioning of each transducer and the mechanical elements, such as the main valve and the safety valve, without showing the exact distances between the elements (Figure 8). This diagram of the placement of transducers was made in AutoCAD and later detailed in Adobe Photoshop.

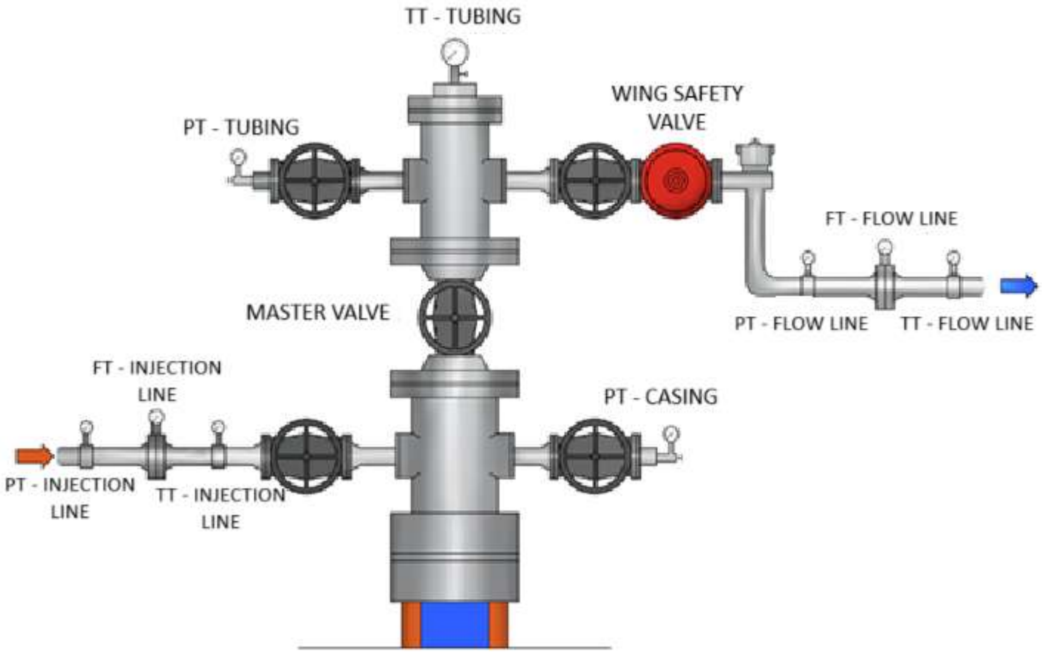


***Figure 8**. New location of the transducers*

A mono bloc eruption head can be seen, provided with a single arm on the main production line, an arm that is also equipped with a mechanical valve, but also with the safety valve. To the right of the safety valve is also present an adjustable nozzle that allows, by adjusting it, a different section of gas passage to the production line. Thus, the flow rate, pressure and temperature of the gas are measured after it passes through the adjustable nozzle. Also, in this figure, one can tentatively observe the injection of compressed gas into the well column in case it requires the artificial lifting of the gas to the surface.

The most important element of the monitoring system is the XL7 programmable controller from Horner Automation which has an integrated human-machine interface (HMI) (Figure 9). It is programmed using the industry-recognized Cscape software from Horner APG and can control a wide range of different processes. It can communicate with other equipment via the Modbus protocol. This feature makes it possible to integrate it into existing networks, allowing it to easily communicate with different devices. Using the Modbus protocol, the PLC collect and transmit data in real time, which helps improve process management. To achieve serial communication, it is necessary to use a UTP cable, which is designed to prevent interference between electrical fields caused by data transmission at higher frequencies. Interference can be caused by electrical fields induced by other wires inside the same cable, or by external sources such as motors or cables carrying high voltages [16].

Figure 9. *Horner Automation XL7 PLC [15] and HDR-60-12 power supply* [17]

PLC operation depends on the existence of a power source. Thus, in the design process of the monitoring system, a power source capable of providing an output voltage of 12 V DC and a current of up to 4.5 A was selected (Figure 9). In any system that includes electrical components, it is necessary that they be protected against excessive electrical currents and voltages, which could lead to equipment damage or even serious accidents. To prevent such situations, electrical fuses are used, which play an important role in circuit protection.

To indicate the operating status of the monitoring system, two 12 V LEDs will be used, one green and one red. The green LED will signal normal system operation. Conversely, the red LED will indicate the occurrence of an alarm or fault, alerting operators to a possible problem that requires intervention. This method of visual signaling allows for quick visual identification of the system status.

After choosing the hardware components of the system, the electrical diagrams were developed to reflect the system architecture, including power supply, necessary protections, connections between PLCs, sensors, transducers and signaling LEDs.

This process took into account the technical requirements of each component and the optimization of electrical routes to minimize consumable resources, such as cables, connection clamps and cable terminal pins. For each cable in the diagram, both its current position and final destination are indicated, thus making it easier to navigate the electrical diagrams.

In this first page of the electrical diagram (Figure 10.a), you can see the circuit being powered through the electrical terminal X1 with alternating current, which passes through the automatic fuse F1. After this, the current feeds a Schuko-type socket and the power supply A1, which converts the alternating current into direct current. The positive (+) and negative (-) direct current outputs of the source are connected to the terminals X2 and X3, respectively. You can also see the fuses FSB1 and FSB2, which were previously discussed, used to protect the PLC power circuit. Present in this first electrical diagram is the three-position key, which will help change the operating state of the monitoring system, a key that is made up of two normally open contacts for the MANUAL and AUTOMATIC states and a normally closed contact for the OFF state. The contacts of the three-position key are connected directly to the PLC, to its first three digital inputs.

On the second page of the electrical diagram (Figure 10.b), the central element is the XL7 PLC, presenting how the connections are made to its terminals. It is shown that terminal X5 is reserved exclusively for four digital inputs, which are connected together with the three-position key contacts to terminal J1A of the XL7 PLC, using inputs I1 to I7. Terminal X4 is reserved for analog inputs, and in most cases these are accompanied by a (-) output from terminal X3. The only exception is the input to terminal A4, which, according to the manufacturer's specifications, can also be used to connect a resistance thermometer.

Therefore, a "bridge" is formed between terminals A4A and A4B for the first pair of resistance thermometer cables, and terminal A4C will be used for the second pair of cables. The connection in terminal J2 is also shown, a terminal dedicated to digital outputs, which will be used to light the warning LEDs.

Two RJ45 ports can be seen, each with distinct functions. The first port is used for the Ethernet connection with the PLC, allowing communication via the TCP/IP protocol. The second RJ45 port, MJ3, is intended for serial communication via the Modbus protocol with other devices connected to the system. In case of using RS485 serial communication, according to the function table of the MJ3 port in the electrical diagram, pin pairs 1-3 and 2-4 of the UTP cable will be used to make the appropriate connection.

The MJ3 port is also capable of transmitting data in both Half Duplex and Full Duplex modes, which allows serial communication with different equipment. Half Duplex mode allows data to be transmitted in both directions, but not simultaneously, meaning that at a given time, the PLC is either transmitting data or receiving data. In contrast, Full Duplex mode allows data to be transmitted and received at the same time as the equipment it is communicating with, providing a bidirectional communication channel. Thus, the MJ3 port is suitable for use in Modbus networks or other serial communication systems.

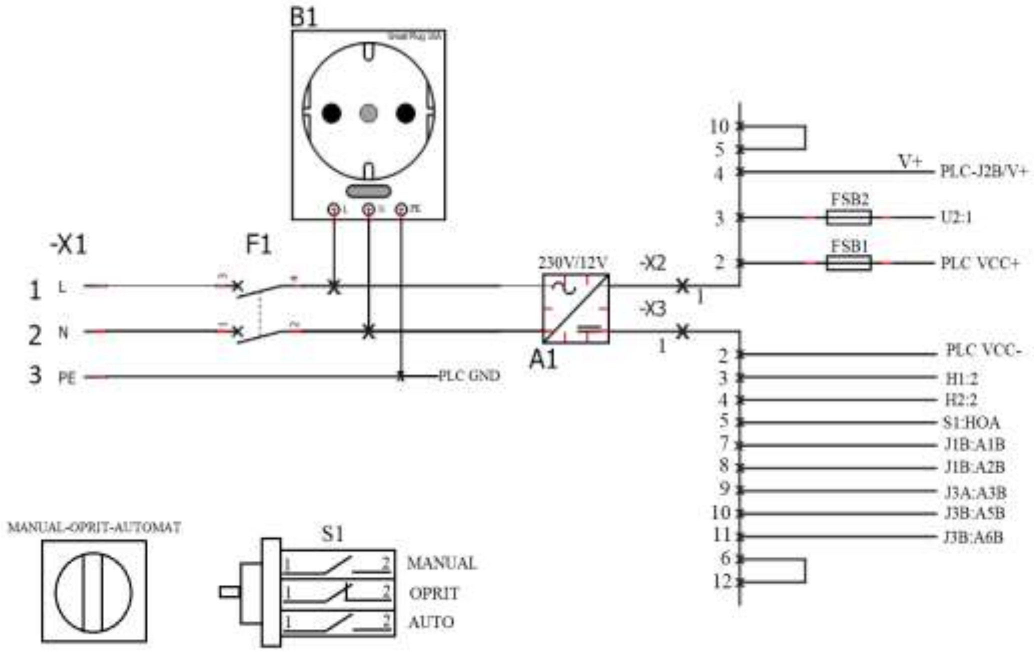


Figure 10.a. *Electrical diagram - page 1.*

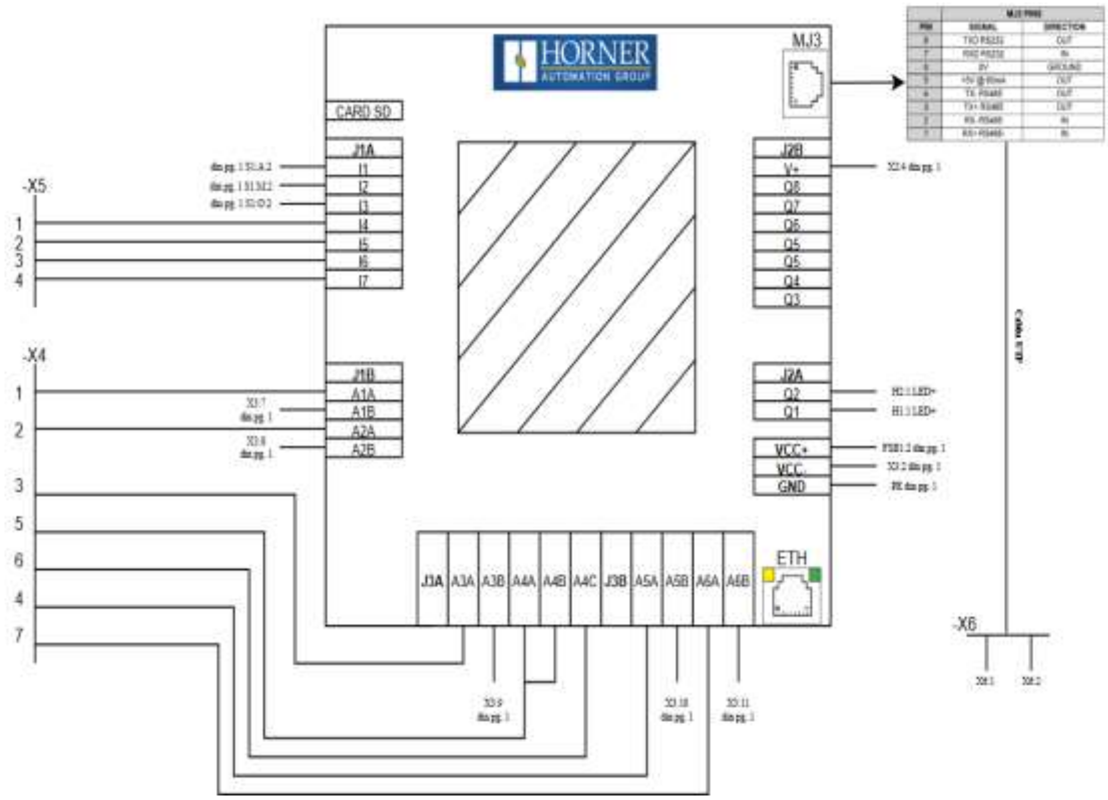


Figure 10.b. *Electrical diagram - page 2.*

In Figure 11, the picture on the left, a general view of the monitoring system is presented, in which the warning LEDs, the HMI interface and the three-position actuation key, used to change the system operating mode, are visible. The cutouts necessary to mount these components in the front panel were made using a self-tapping screw and an electric circular saw.

a) b) c)

***Figure 11**. Electrical connections between hardware components: (a) general view of the monitoring system; (b) protection system components; (c) PLC mounted on the box door*

The central picture illustrates the protection system components, including fuses and circuit breakers, the power supply, the Schuko socket, along with the X1 connection terminals for the AC power supply, the X2 clamp for connecting to the positive (+) DC terminal, the X3 clamp for the negative (-) terminal and the terminals dedicated to analog, digital and serial communication inputs.

The picture on the right shows how the PLC was mounted on the box door and the electrical connections that enter its terminals, as well as the UTP cable in the MJ3 port. Also in this figure, you can see how the LEDs and the two normally-open contacts and one normally-closed contact are attached to the back of the actuating key.

XL7 PLC PROGRAMMING

To program the PLC, the Cscape 10 software, developed by the manufacturer Horner Automation, will be used, using the Ladder Logic programming method. First, the connection between the computer and the device is made via a USB cable, with a type A connector on the end connected to the computer and a mini-B connector on the end connected to the PLC, and the appropriate communication port is selected in the Cscape program (Figure 12). Thus, after establishing the connection between the PLC and the computer, the actual hardware configuration follows (Figure 13).

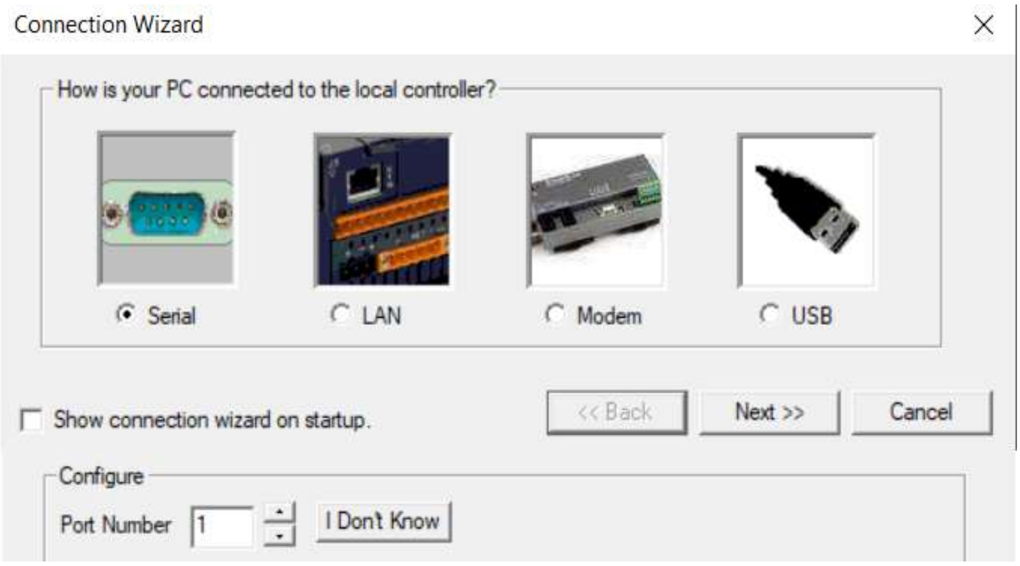


Figure 12. *Connection window*

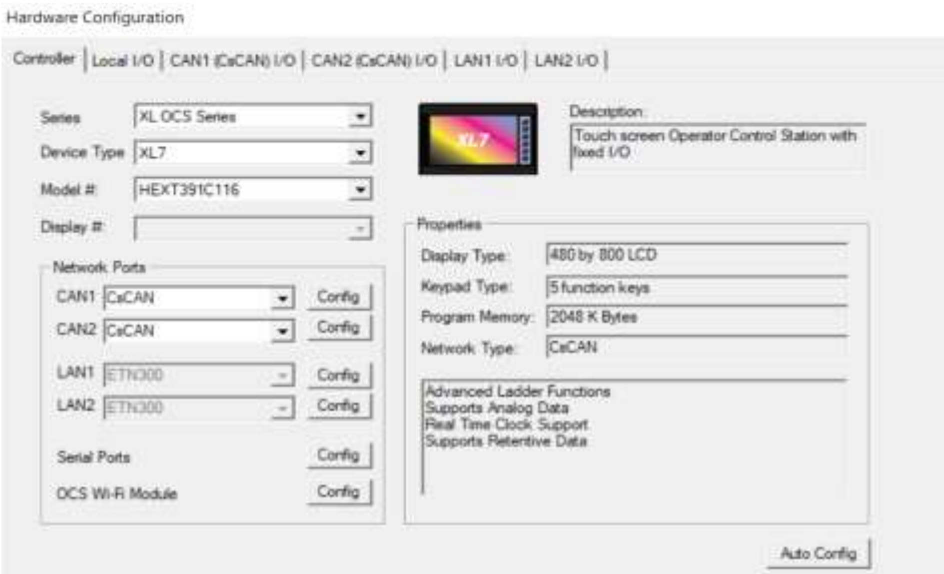


Figure 13. *Hardware configuration*

This window allows the complete configuration of the PLC hardware components, in which the programmer can set the parameters for digital and analog inputs and outputs, depending on the signal type and the role of each channel in the application. Also, in this window, the serial communication configuration is performed, by choosing the appropriate port, setting the transmission speed, the transmission type, RS-232 or RS-485, and selecting the protocol used, such as Modbus RTU. Also from this window, the Ethernet ports can be configured, by assigning the IP addresses necessary for the integration of the entire system into a network and its communication with other systems.

Following these initial steps of hardware configuration and establishing the connection with the PLC, we can proceed to develop the code steps in Ladder Logic language, which make the system possible. The first step is to read the analog data (Figure 14).

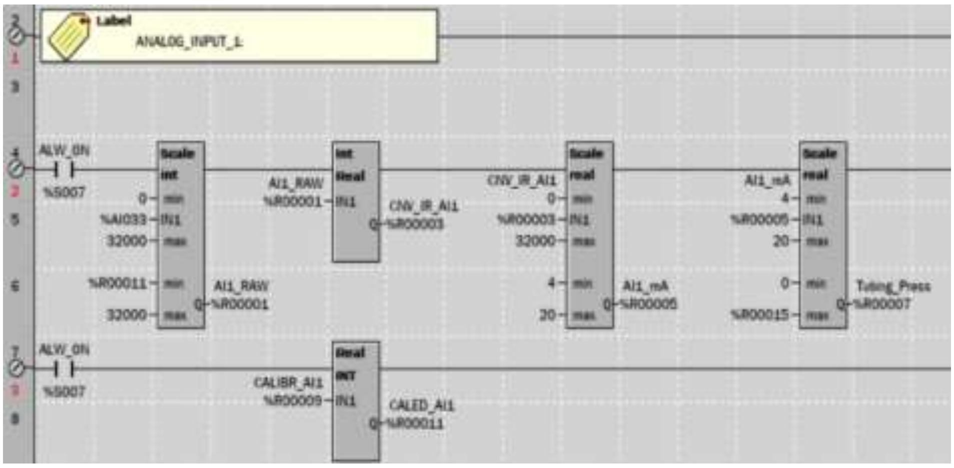


Figure 14. *Reading analog inputs*

After configuring the analog channel, the signal is read as a raw value in the %AI033 register, expressed in an integer variable (INT), corresponding to a range from 0 to 32000. To trigger alarms for each analog input, comparison blocks will be used depending on the values read (Figure 15).

Figure 15. *Conditions for triggering alarms.*

The real format comparison functions LT_REAL, which checks if a value is less than another value, and GT_REAL, which checks if a value is greater than another value, will be used. These comparison functions are activated by %M type registers, which are one-bit registers, enabled or disabled by the user from the configuration screens of each analog input and which have the ability to retain their last state even after a power failure. After implementing all the comparison functions for each analog input and for each flow transducer that communicates serially with the PLC and the alarm conditions in case of complete closure of the valves mounted on the eruption head, the logic steps were created to trigger alarms on the HMI screen and to activate the warning LEDs (Figure 16).

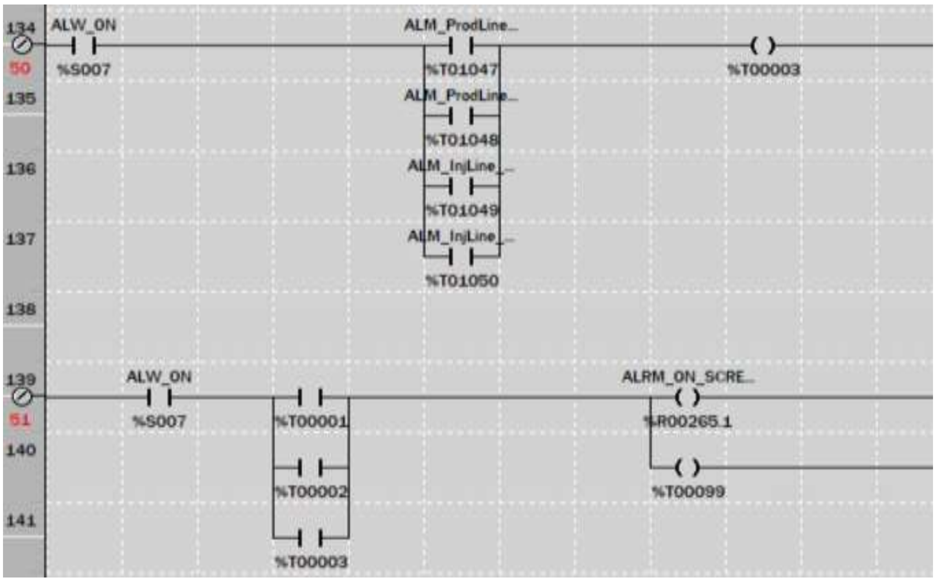


Figure 16. *Triggering alarms*

Each triggered alarm will switch the system to warning mode by turning off the green LED and turning on the red LED, mounted on the front panel of the system. Next, the MJ3 port was opened and configured for the PLC's serial communication with the flow transducers using the internal register %S001, which has the role of scanning the communication port at each program initialization to recognize its proper functioning (Figure 17). Immediately after configuring the port, it and the Ethernet port were opened in the main program (Figure 18).

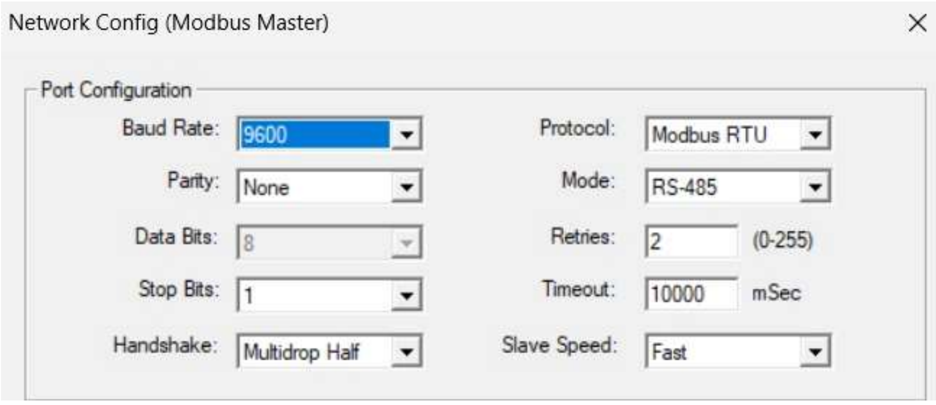


Figure 17. *Configuring the MJ3 port.*

The Ethernet port will be active only when the system key on the main panel is switched to AUTO, and it will operate with a transmission speed of 19200 bits per second and the Modbus RTU protocol. After opening and configuring the MJ3 port, it was possible to configure the serial communication via the Modbus protocol, allowing the definition of a list of registers to be read from the flow transducers.

These registers were read using the data sheets provided by the manufacturer. In this case, flow transducers from the 266MODBUS series from the manufacturer ABB were used, whose register addresses were entered into the Cscape program to allow the values provided by the transducers to be taken over.

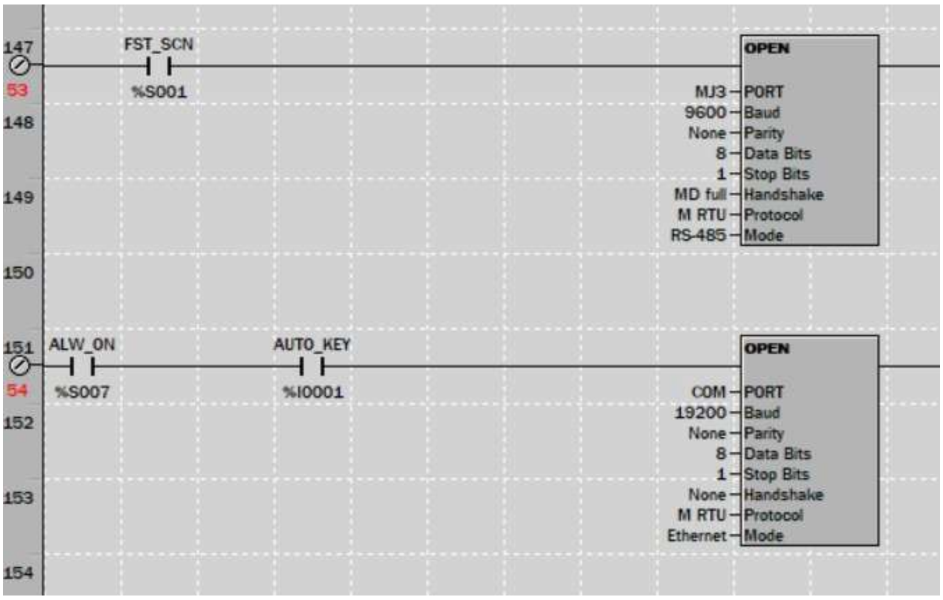


Figure 18. *Opening ports in ladder logic*

Figure 19 shows an example of a register from the manufacturer, which will show the value of the static pressure measured by the transducer. In this case, it is the register with address 22 of 32 bits, of read-only type, which means that the information contained can only be read and cannot be modified by the user.

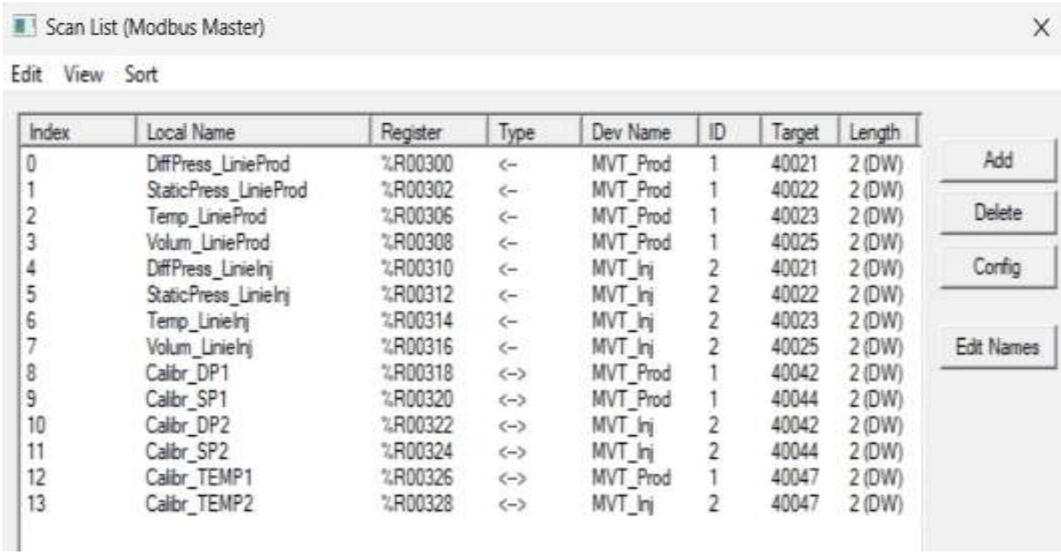
Register Address		Data Type	Object description	Read/ Write
32 bit	16 bit			
22	403 – 404	F	Static Pressure (Damping, Calibration and Units applied) floating point, 403 is high word, 404 is low word	RO

Figure 19*. Register provided by the manufacturer* [20].

Thus, in the register list, the ID of each transducer (ID 1 and ID 2) can be identified and both read-only parameters, such as differential pressure, static pressure, temperature and gas volume, as well as read-write parameters, which allow the modification of values, such as pressure and temperature calibration (Figure 20), can be observed. These parameters are found in the main program starting from %R300 to %R328, each occupying two positions, due to the 32-bit length.

OPERATION OF THE MONITORING SYSTEM

After completing the actual programming of the PLC, it was possible to program the HMI interface and organize each screen so that their use and understanding were as easy and intuitive as possible (Figure 21). When the system is turned on and switched to either MANUAL or AUTO, the user will first see the configuration of the location of the sensors, transducers and the values of the parameters measured by them. The user can interact with the touch screen by selecting each transducer individually or by navigating through the screens dedicated to the menu, alarms or graphs of the gas probe behavior.



Index	Local Name	Register	Type	Dev Name	ID	Target	Length
0	DiffPress_LinieProd	%R00300	<-	MVT_Prod	1	40021	2 (DW)
1	StaticPress_LinieProd	%R00302	<-	MVT_Prod	1	40022	2 (DW)
2	Temp_LinieProd	%R00306	<-	MVT_Prod	1	40023	2 (DW)
3	Volum_LinieProd	%R00308	<-	MVT_Prod	1	40025	2 (DW)
4	DiffPress_LinieInj	%R00310	<-	MVT_Inj	2	40021	2 (DW)
5	StaticPress_LinieInj	%R00312	<-	MVT_Inj	2	40022	2 (DW)
6	Temp_LinieInj	%R00314	<-	MVT_Inj	2	40023	2 (DW)
7	Volum_LinieInj	%R00316	<-	MVT_Inj	2	40025	2 (DW)
8	Calibr_DP1	%R00318	<->	MVT_Prod	1	40042	2 (DW)
9	Calibr_SP1	%R00320	<->	MVT_Prod	1	40044	2 (DW)
10	Calibr_DP2	%R00322	<->	MVT_Inj	2	40042	2 (DW)
11	Calibr_SP2	%R00324	<->	MVT_Inj	2	40044	2 (DW)
12	Calibr_TEMP1	%R00326	<->	MVT_Prod	1	40047	2 (DW)
13	Calibr_TEMP2	%R00328	<->	MVT_Inj	2	40047	2 (DW)

Figure 20. *List of registers*

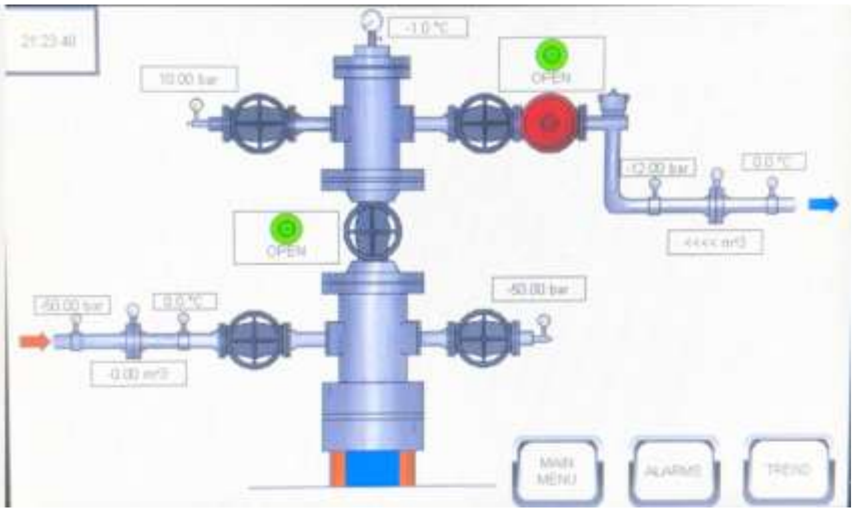


Figure 21. *Main navigation screen*

Thus, from the main menu screen, the user is required to access the authentication page if they wish to change a transducer operating range or alarm limit. This screen was designed to add an additional level of local security to the system, thus preventing unwanted changes to it.

After user authentication, the user can easily access the screens for individual configuration of analog inputs (Figure 22) and flow transducers (Figure 23). The screens for configuring analog inputs will display important information about each transducer, such as the measured value, the signal transmitted by the transducer, and the raw value from the input to the analog channel. Also, the user, once authenticated, has the possibility to set the measurement range of the transducer used, to calibrate the transducer in the event of a failure and to configure the limits for triggering alarms, as well as to activate or deactivate these alarms.

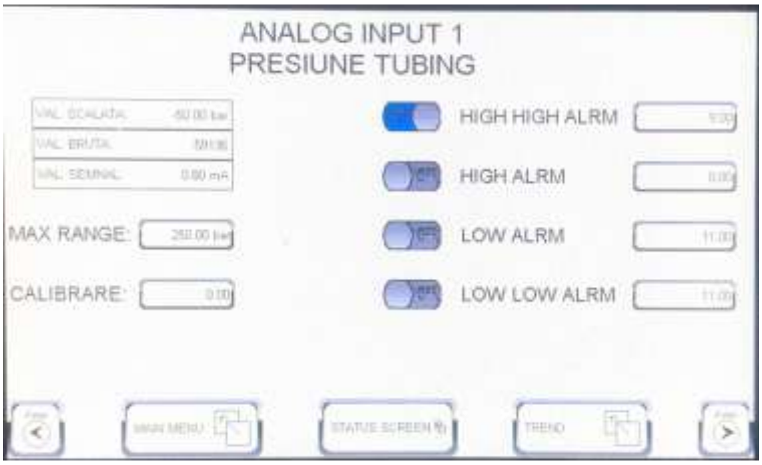


Figure 22. *Analog inputs configuration screen*

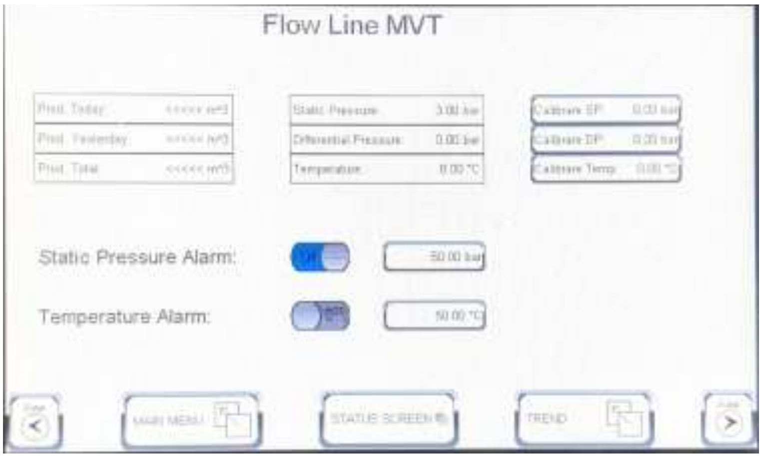


Figure 23*. Flow transducer configuration screen*

Similar to the analog input configuration screens, the flow transducer configuration screen displays important information such as the total gas production of the well, static and differential pressure, temperature, as well as the option to set alarms for static pressure and temperature. The daily gas production is automatically reset every day at 07:00 in the morning, at which time the meter returns to the value of 0 cubic meters. The value recorded the previous day is saved and displayed separately under the name "Prod. Yesterday", to allow easy tracking of the daily evolution of the gas well. In parallel, the system calculates and displays the total gas production, which represents the cumulative amount of gas extracted since the system was put into operation, without being influenced by the daily resets.

When an alarm occurs, the user can access the “Alarms” screen to acknowledge them or completely clear the alarms (Figure 24). This screen provides information on when each alarm was triggered and acknowledged. Although alarms can be cleared from the list, the red warning LED will remain lit until the alarm is completely disabled from the configuration screens or until the condition that triggered it is no longer met.

Figure 24. *Alarm display screen*

Finally, the user can access the screen dedicated to the gas well behavior graph, where he can view the evolution over time of all measured parameters (Figure 25). This allows the comparison of values recorded over time and provides an easy method for making the best decisions regarding production optimization and identifying possible anomalies in operation.

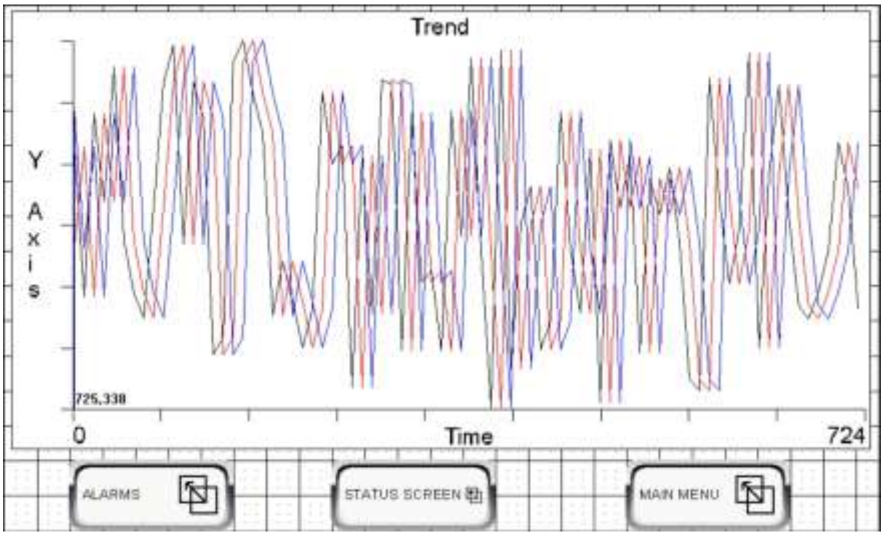


Figure 25. *Gas well chart*

CONCLUSIONS

The objective of this work was to design and implement an automatic system for monitoring the operational parameters of a gas well, with a focus on safety, reliability and operational efficiency. The proposed system responds to current requirements in the natural gas industry, where continuous monitoring and precise process control are essential for preventing failures, optimizing production and protecting personnel and equipment.

The system implementation included monitoring critical parameters such as pressure, temperature and flow on the production and injection lines, as well as supervising the position of the main and safety valves. By using inductive sensors and the Horner XL7 programmable controller, the system ensures reliable detection of critical positions of mechanical elements and allows real-time data transmission via the Modbus protocol.

Important components of the system are the electrical fuses, the dedicated power supply, and the human-machine interface (HMI), all designed to ensure operation in maximum safety conditions and to allow rapid intervention by operators in the event of a breakdown. The simplicity of interaction with the system, through the three-position switch and the visual LED signaling, contributes to the ergonomics of operation and the reduction of reaction time in critical cases. The detailed technical documentation, such as electrical diagrams and functional diagrams, provides a solid framework for the maintenance, expansion and subsequent adaptation of the system, depending on the application requirements or technological developments.

As development prospects, the system can be expanded with additional functionalities, such as: transmitting data to a SCADA platform for centralized monitoring; implementing a remote alarm module (SMS/email); integrating automatic diagnostic algorithms or artificial intelligence for fault prediction; installing additional sensors for monitoring vibrations, humidity or gas composition.

Therefore, the designed system not only meets the current requirements of a modern gas well, but also constitutes a solid foundation for future improvements, supporting the transition to safer, more efficient and digitalized operations in the oil and gas industry.

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Received: July 2025; Revised: September 2025; Accepted: September 2025; Published: September 2025