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Industrial Control Systems

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ABSTRACT
In light of the great global competition between manufacturers, the interest in high quality and the lowest price has become a basic requirement, so that each company acquires a part of the global market, so the interest in industrial control systems has become very high to obtain these requirements for various products. This paper deals with three types of control systems used in industry and differences between them, the first system, programmable logic controllers (PLCs), second, distributed Control System or Decentralized Control System (DCS) and third system is Supervisory Control and Data Acquisition (SCADA), also include some peripheral devices such as, Remote Terminal Units (RTUs), Human machine interface(HMI).
Keywords **–** Control System, PLCs, DCS, SCADA, RTUs, HMI

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I. INTRODUCTION

The theory of modern automatic control is one of the most important theories used in the management of technological and production processes. Modern industry is characterized by the steady increase in the productivity of machines and units, as well as the rise in the quality of products and their low cost, as it needs complete safety to avoid any undesirable conditions. The high speeds in production processes and the high requirements for the accuracy of maintaining them have led to the widespread use of automatic control systems, the automatic control system maintains some of the variable characteristics of the controlled quantities at a certain level or changes them according to a known law without human participation, by means of different types of technical equipment.

II. INDUSTRIAL CONTROL SYSTEM

Industrial control systems are a specific term used to define the combination of software, hardware, networks, and controls to operate and control simple and complex industrial processes for all industries of all kinds. Thus, it is generally an information system used to control various industrial processes such as product processing, manufacturing, production and distribution. These mechanisms include data acquisition and supervisory control systems for all units. Industrial control systems are classified into several types depending on the function and complexity of the control procedure. Here is a list of the most common control systems used.

2.1 Programmable Logic Controllers (PLCs)

Initially, PLC was an alternative to Relay control circuits. But this system consumes a lot of time and constitutes a challenge, and if we want to make a change in the work of the circuit or the operation of the machine, it requires a radical change in the system of connecting the units with each other. it is a complex process and a waste of time, effort and money. Relay control circuits have a short life span, and frequent failures due to relays breakdown frequently unlike computer components with long life and few failures, so the relay control system requires more downtime to keep it running

compared to the latest PLC-based controls. Relays also consume a lot of electricity, produce a lot of heat, and take up a lot of space.

Fig1: relay control system

The PLC consists of a central control unit and input and output units known as I/O (they may be integrated with the central control unit for limited use or separate for large use). In some applications, the input and output units are miles away from the CPU and connected to data cables. These units may be analog or digital. Several PLCs can also be connected by cables, depending on the manufacturer. Most manufacturers seem to have settled on Ethernet and/or USB, PROFIBUS. The industrial process control elements can also be connected to the PLC by means of these cables, for example, Micro_ Master is connected by PROFIBUS produced by Siemens, and there is like it in other manufacturers such as ABB, Allan_ Bradly.

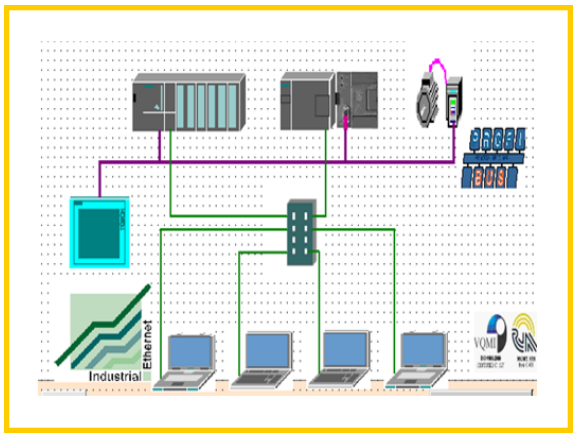

Fig2: PLC control system

PLC is called Programmable Logic Controller, we need to program it. Most PLCs are programmed using an application running on a standard desktop or laptop computer. Most manufacturers use Ladder Logic as a programming language that differs in its details from company to company. One attempt to achieve some system and interoperability for companies' compatibility in programming languages is the IEC 61131 standard from the American National Standards Institute (ANSI). This IEC 61131 standard contains a part containing standards for programmable controllers (PLCs) and associated peripheral devices such as programming and debugging tools (PADTs), human-machine interfaces (HMIs), etc., which are intended to use the control and control of machines and processes industrial. Among the purposes of this standard is that it defines the main definitions and characteristics relevant to the selection and application of programmable controllers and associated peripherals; defines equipment requirements and related tests for PLCs and associated peripherals; and defines for each of the most frequently used programming languages, main areas of application (grammatical and semantic rules, sets of commands from programming elements and applicable tests and means by which manufacturers can extend or adapt these elements with their own programmable controllers; also provides general information and instructions for the end user PLC.

2.2 Remote Terminal Unit (RTUs)

RTU stands for remote terminal unit, sometimes called telemetry unit or remote-control unit. It can be defined as a microcontroller that monitors and controls field operations and communicates with a SCADA or DCS system. The PLC and the peripherals share the same level and perform almost the same function. Both systems control operations at the same level, but the terminal units have a greater number of inputs and outputs, and many consider them to be more powerful than PLC. The price of PLC programmed controllers is cheaper, but RTU terminal units withstand harsh environmental conditions such as oil platforms in the seas and mountainous areas and operate over very long distances. about the central system. Some RTUs have a battery backup and charging circuit, such as solar, which will allow the RTU to continue

operating even when AC power is lost. As for programming languages, the PLC needs special programs to design control programs or RTU units that can be programmed through a web window, or they can be programmed in languages like PLC languages such as Ladder Logic or Structured Text. Arguably there are not many differences between modern RTUs and PLCs. An RTU consists of a central control unit (CPU), and one or more of the following: (AI) analog input, (DI) digital input, (DO/CO) digital (or control relay) output, or (AO) output analog.

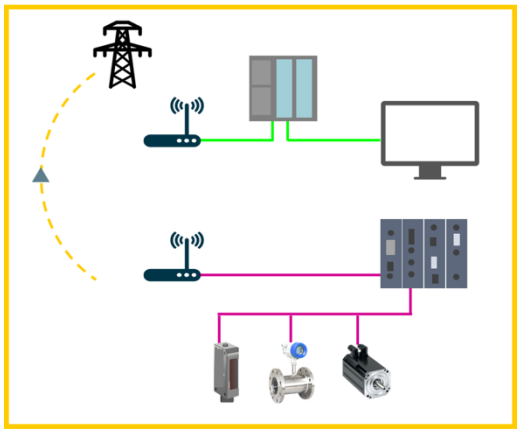

Fig 3: RTU control system

2.3 A Human-Machine Interface (HMI)

In light of the large number of controlling different processes within a single industrial facility, it has become necessary to help operators to see the details of these processes, the HMI unit provides this feature. Human Machine Interface (HMI) is a touch screen in which various industrial processes are designed using software specific to the manufacturer. For example, Siemens uses the WINCC software to program these processes. This software acts as an intermediary between the operator and the controlled process. PROFIBUS, INDUSTRIAL ETHERNET, or other communication network systems. Then the operator can see the whole industrial process as in reality. The status of valves, pumps and actuators can be seen, the measured values can be seen and the values necessary for operation and control (e.g.: starting the engine, reversing its movement, stopping it) and giving an alarm when the process exceeds the permissible limits These alarms can also be recorded, and reports printed at the end of the day. These screens are connected to PLC or RTU programmed industrial controllers, and all operations that are controlled by programmable units can be programmed, each process represented by one of the screens. The figure bellow shows a speed control

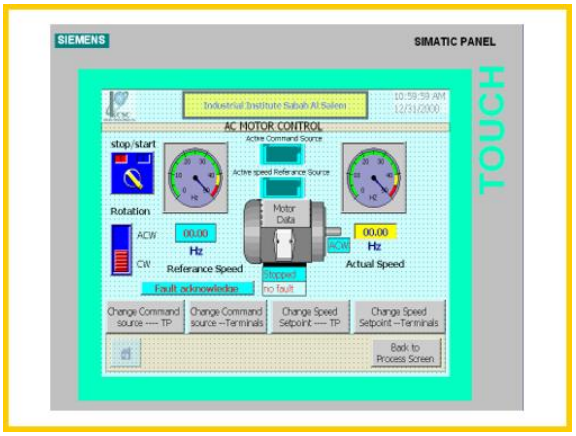

Fig 4: HMI Unit

system using PLC_S7 AND HMI. we are using the symbol table of PLC as tags for HMI. We can start, stop and reverse direction of the motor. We can control the engine speed by setting the desired value via the keyboard and reading the actual value from. the screen**.** As if the engine malfunctions, we can see the indication of this malfunction on the screen as shown in the figure above.

As a practical example of HMI programming, it is done by Wincc flexible program, where it is confirmed that the plc programmed controllers connect with HMI and that appears in the connection screen as shown in the figure below.

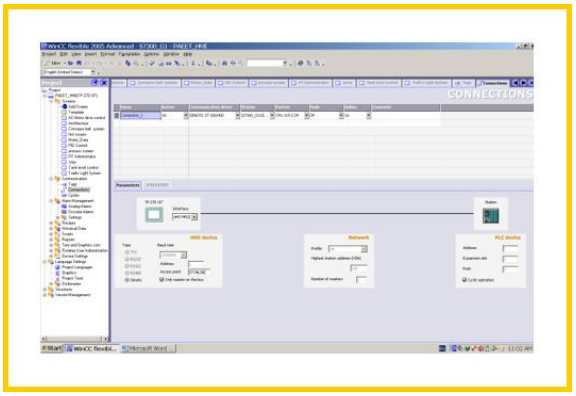

Fig 5: connection between HMI and PLC

Also, tags are used as in the symbol table in the Sematic Manger or TIA portal program at programming different operations. That is, the HMI cannot work without the PLC programmed controllers, as shown below.

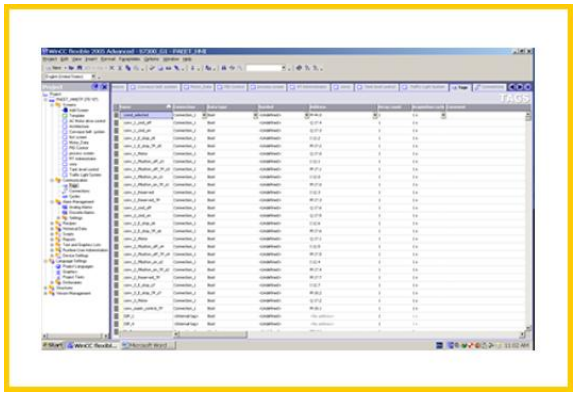

Fig 6: Tags of HMI

Then the operations are designated, and the tags are determined by the Wincc flexible program, as shown in the **Fig 6**.

2.3 distributed Control System (DCS)

The term DCS is called distributed control system or decentralized control system. It is a system that coordinates and supervises an entire plant for many different processes, unlike PLCs, which are used to handle individual processes and primarily for discrete repetitive control.

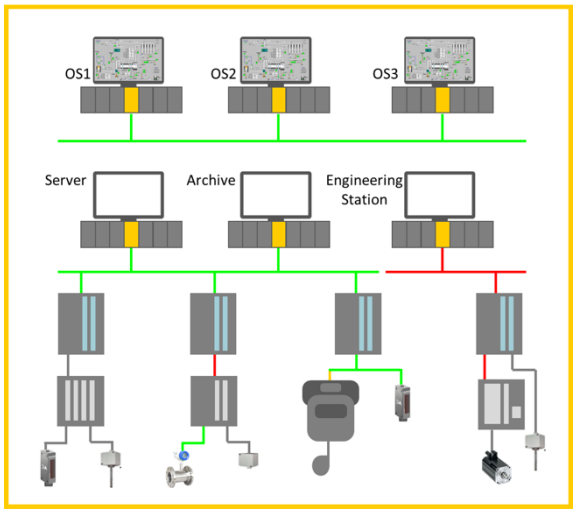

Fig 7: DCS control system

The DCS system consists of several levels. **Level one** operator stations, are the heart of the system in which the operator can monitor plant operations, display process-specific warnings and alarms, monitor production, and more.

Second level servers, computers, archiving and engineering stations. Communications with the operator's station level are usually industrial Ethernet. Servers are used to collect data from processors. They are responsible for the data transmitted between the operator's station and the processors that control the various production processes. Archiving computers are used to store data that can be used for study, development, or comparison of controlled processes. Engineering stations are used to create projects on which operations are working. This includes hardware configurations, task logic, player interaction graphic displays, and management of all these tasks through the installed software package.

Third level, Master controllers that supervise individual processors as well as I/O units, it is also responsible for providing data to servers, which in turn provide the history of the graphical interface. At this level, the processor implements the logic and does what it takes to control the process. Industrial Ethernet is usually used to communicate with the previous level.

Forth level, Field device level. The connections between this level and the processor level can be almost any type that the components may be compatible with. These include industrial Ethernet, Profibus DP, EtherCAT, optical fiber, or other proprietary communication protocols. Components at this level will be devices such as transmitters, switches, valves, actuators, remote or distributed I/O modules, etc. DCS can be best used to control processes where there are many I/O operations with many continuous processes, processor failure in one section of the plant is not a problem for production, or a risk assessment has determined that an integrated package would be the best choice.

2.3 Supervisory control and Data Acquisition (SCADA).

Supervisory Control means Comprehensive monitoring of all operations and control units in the industrial plant, determining the operating and control values, the maximum and minimum values of the operations, observing the warnings and determining the locations of malfunctions, meaning that the whole plant is under the operator's eyes and has the ability to control all operations in the plant.

Data Acquisition means collect data from instrumentation of the plant with time and date and stored it in the server or solid-state drive. We can read and analysis the old data in any time and data.

SCADA stands for Supervisory Control and Data Acquisition. It is a system that collects data (values from process with date and time, trending and logging) and This data helps the operator to analyze and make decisions that affect the system, which improves the performance of operations.

It is a system consisting of the combination of software and hardware that allows for the supervision and control of plants, both locally and remotely. A standard SCADA system consists of remote terminal units (RTUs) or programmable logic controllers (PLCs). RTUs and PLCs are microprocessors that control field devices such as valves and pumps, and HMIs can be connected to programmable logic controllers.

This communication data from the processors is routed to SCADA computers, where the software interprets and displays the data allowing operators to analyze and interact with system events. With the advent of local area network or LAN, and HMI software, SCADA systems were able to communicate with related systems. With the adoption of modern IT standards such as SQL and web-based applications, today SCADA allows access to real-time plant information from anywhere in the world. Having this data at the operator's fingertips facilitates industrial process optimization and allows SCADA queues to be responded to based on field-collected data and system analysis.

It is also possible to add control systems from different manufacturers, meaning that this system is considered an open system.

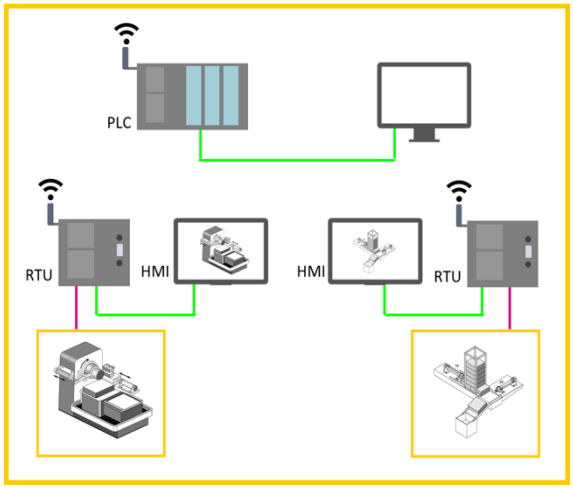

fig 8: SCADA control system

III. COMPARISON OF CONTROL SYSTEMS

3.1 Comparison of DCS System and PLCs System.

It can be said that the DCS system and the PLC system have the same field of use and are very similar in the current times except for the integrated monitoring and control. However, the differences can be summarized in the following points:

1- PLC is primarily used to control simple and repetitive industrial units, unlike DCS that controls large and complex industrial operations such as oil refineries.

2- PLC is considered the least expensive.

3- The PLC uses multiple communication protocols, unlike DCS, which uses limited communication protocols.

4- The PLC system is an open system, unlike the DCS system, which is considered a closed system.

5- PLC programming is simple and smooth and does not require much experience, unlike DCs needs programmers with experience, because it is a complex system.

6- The DCS control system is characterized as an integrated monitoring and control system similar to the current SCADA systems.

7- The advantage of the DCS is that the entire tag base is already in place, already created to control the process, and available for use on the monitoring and control screens.

8- The DCS system also features functional block programming. But the plc currently has the same feature.

9- DCS has independent control units scattered throughout the entire plant. If the control unit fails, the entire plant will not necessarily be affected.

10- Processing times are somewhat slower in DCS than in plc.

3.2 Comparison of DCS System and SCADA System.

Control systems SCADA and DCS are very similar. The SCADA system consists of a set of programs and controllers PLCs, RTUs to control industrial processes and uses wide communication protocols and works to collect data and present it to operators to make decisions with the help of operator input and control the facility based on these decisions. The DCS system It consists of microcontrollers to perform the same function as SCADA. What are the differences:

1- SCADA is an open system that can use controllers or computers from other manufacturers, unlike a closed DCS system.

2- The DCS system uses one him/plc software package, but the SCADA system needs more than one plc software package and him software package.

3- DCS has many pre-defined functions that can be customized and deployed for different applications unlike SCADA system, which was not available at the same level, but it is approaching in the recent period.

4- Processing times are somewhat slower in DCS vs PLC/RTU SCADA environment.

5- Communication within the SCADA system is extensive and has adapted to changing technologies while DCS has adapted to a lesser level

6- If safety is a priority, DCS is better than SCADA.

IV. CONCLUSION

Each of the previous control systems has a field of use and has advantages and disadvantages that depend mainly on the type of industrial processes to be controlled. Each system has significant advantages in certain industrial applications and disadvantages in others. All manufacturers of these systems are trying to combine the advantages of other systems to develop their own system. For example, PLC control systems are approaching control systems using SCADA by adding HMI and WINCC program. They also use different networks such as PROFIBUS, ETHERNET PROFNET, and so on. And mixed control systems that combine PLC with SCADA, which combine the advantages of the two systems by adding the advantage of data collection and storage and the breadth of controlled operations, corresponding to control systems using DCS, which is characterized by control of integrated and continuous operations, an advantage over the mixed system. That is, it can be said that most manufacturers tend to form one complete control system that combines all the advantages and avoids the defects of all control systems currently used in the field of large and expensive industries. As for the simple and medium industries, PLC remains the best in terms of price and performance.

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