Basics of Industrial Control System and the Use of PLC

The components of industrial control system (ICS) can be roughly divided into two categories according to their location: control center equipment and remote site equipment.

The control center equipment is located in the system control center, including human machine interface (HMI), engineer workstation and historian.

Remote site equipment is a kind of equipment which is resident in the production site and directly connected to actuators and sensors. Its main function is to supervise and control the physical process.
Although field devices usually do not interact with people directly, they are more likely to be attacked and damaged because the production site is not as secure as the control center.

Human machine interface (HMI), sometimes called SCADA system, is a system that allows the operator to monitor and control the process.
Human machine interface (HMI) program is usually a pure software application program running on a general purpose computer, which generally runs in Microsoft Windows operating system environment. Common HMI programs in industrial field include Wonderware, WinCC of Siemens, RSView of Rockwell and Areva E-terra.

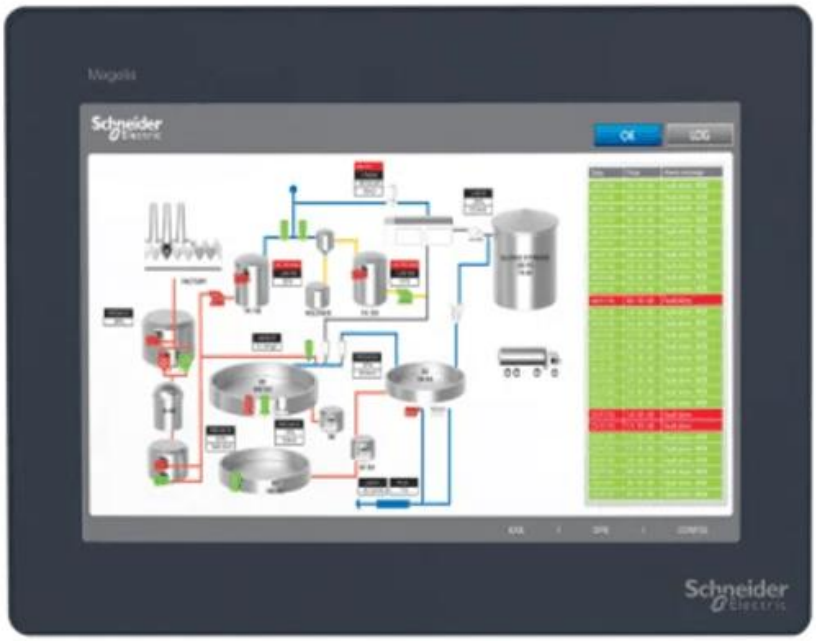

Figure 1: Schneider HMI HMIDT551

Historian is a database server that records the state history of process control system. In some cases, if the function of historian is powerful enough, it can also be used as HMI of control system. Historian, a history server, usually runs on mainstream operating systems and common hardware devices, and usually has image backup in the enterprise network.

Remote station equipment includes PLC, RTU, IED and relay. Although the functions of these devices are quite different, they can be roughly combined according to their location and similarity.
In addition, the hardware structures used in these devices are similar, generally providing analog or digital I / O and control functions. They read data directly from sensors and send operating instructions to actuators. In some cases, they are connected with other field devices.

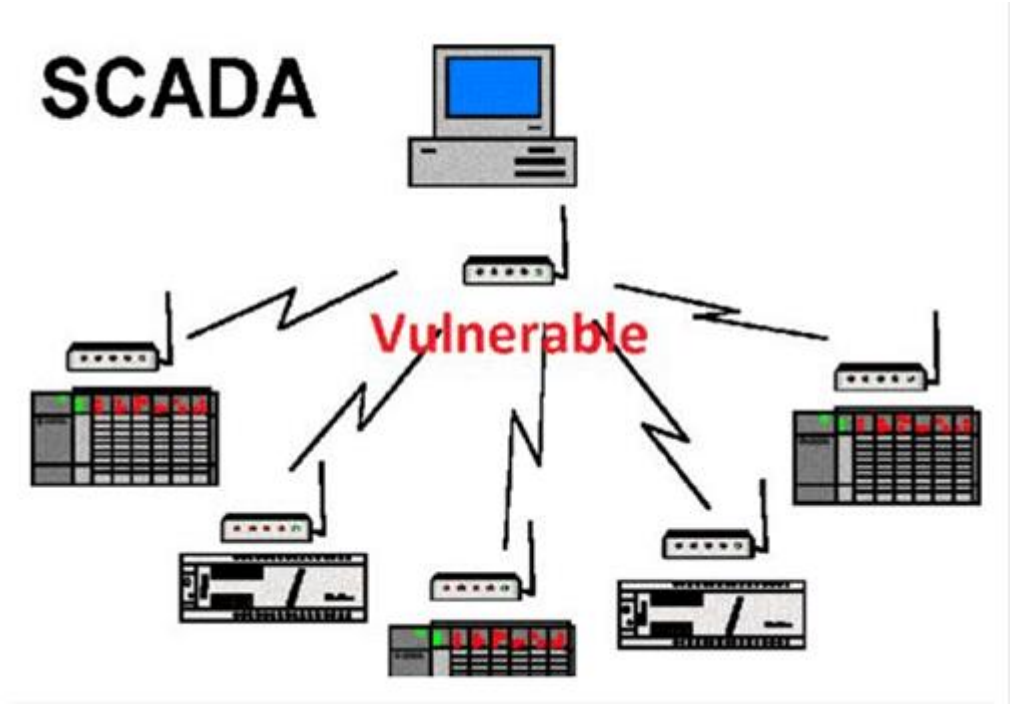

Figure 2: A cartoon of SCADA system structure.

In this article, the equipment is simplified. In fact, these devices mentioned above (PLC, RTU, IED and electronic relay) perform a certain function subset in the object relationship model (ORM) of control system.
For example, RTU is usually SCADA system, which only provides the function of field I / O control. Sampling is carried out by field I / O sensor. In individual cases, RTU will generate trigger for actuator.

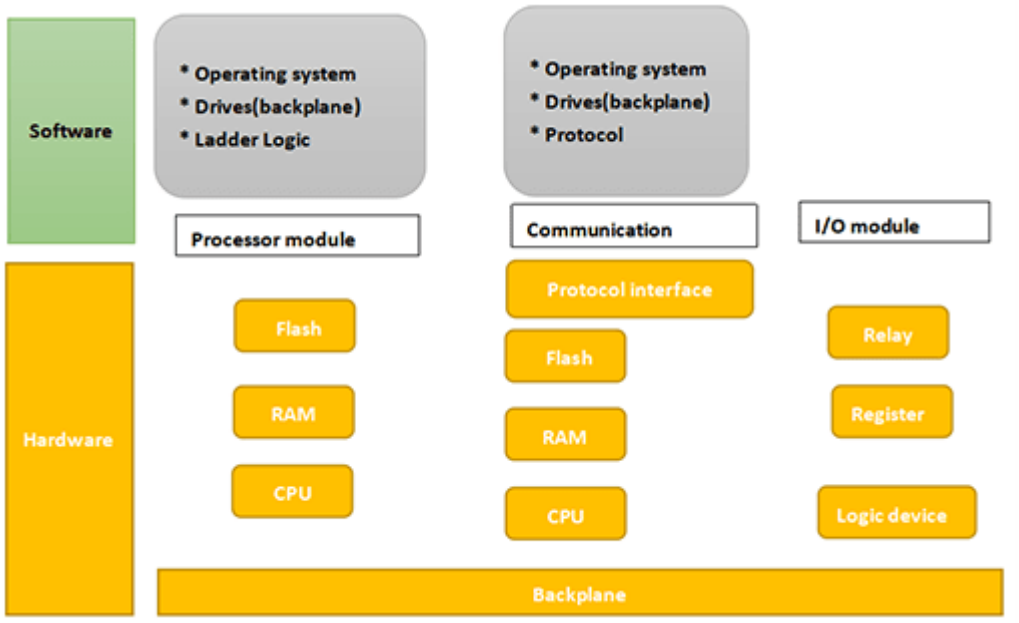

Figure 3: Industrial control system

The electronic relay will always perform the sampling and triggering functions. RTU will generate status data field points and sometimes process command data field points. The relay will generate status data field points, but it is unlikely to process the data field points of the command. RTU generally has no local control function, but relay has this function. In addition to communication with sensors, actuators and upper control functions, PLC also has important local control functions. These functions seem similar, but they are very different in ORM.

The common commercial PC running HMI communicates with field devices such as PLC through standard network protocol (such as Ethernet). Engineer station and historical database are also common commercial PC or server, which communicate with field equipment through standard network protocol. Field bus and other industrial control protocols based on Ethernet are used to connect field devices to other field devices. Some field devices use RS232 or RS485 standard serial bus communication protocol to connect with intelligent devices. Some field devices are directly connected with sensors, I / O devices and machine devices.

PLC is a field device that can be directly connected to sensors and actuators or other field devices. PLC is controlled locally by logic program (the format is generally defined according to IEC 61131-3 standard), and can receive control command and query request from HMI through control system communication protocol. PLC can be modular or combined into compact fixed shape, but the two types basically use the same underlying components.

Figure 4: Schneider PLC 170DNT11000

Pressure transmitter is a kind of pressure measuring instrument widely used in many transmitters. It is widely used in petroleum, chemical, metallurgy, food, electric power, medicine, papermaking, textile and other industries. It is mainly used to detect the differential pressure, pressure, absolute pressure and liquid level of fluid.

Figure 1: Different models of pressure transmitters.

1. Components of Pressure Transmitter

It is mainly composed of load cell sensor, module circuit, display meter, case and process connector.
It can convert the received gas, liquid and other pressure difference signals into standard current and voltage signals to supply secondary instruments such as indicating alarm instrument, recorder and regulator for measurement, indication and process regulation.

2. Measurement Principle of Pressure Transmitter

The process pressure and the reference pressure act on both ends of the integrated silicon pressure sensitive element respectively, and the differential pressure deforms the silicon wafer (displacement is very small, only μ m level), so that the full dynamic Wheatstone bridge made of semiconductor technology on the silicon wafer can output mv level voltage signal proportional to the pressure driven by an external current source.

Because of the excellent strength of silicon material, the linearity and variation index of output signal are very high. When working, the pressure transmitter converts the measured physical quantity into mv level voltage signal and sends it to a differential amplifier with high magnification and mutual cancellation of temperature drift.

The amplified signal is transformed into the corresponding current signal by voltage and current conversion, and then through nonlinear correction, the standard current and voltage signal which is linear with the input pressure is generated.

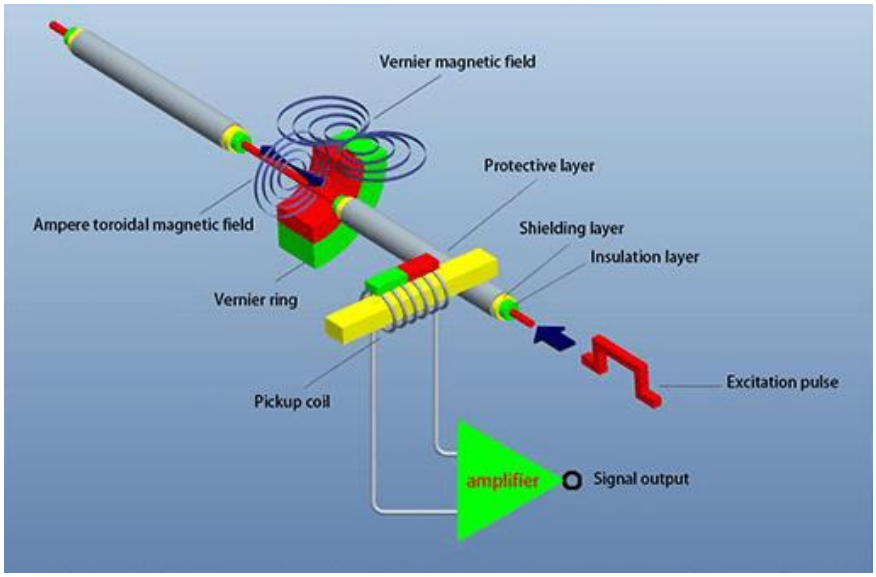

Figure 2: Illustration of pressure transmitter components.

3. Types of Pressure Transmitter

It mainly includes capacitive pressure transmitter, diffused silicon pressure transmitter, ceramic pressure transmitter, strain type pressure transmitter, etc.

3.1 Capacitive Type

When the pressure acts directly on the surface of the measuring diaphragm, the diaphragm will deform slightly.
The high-precision circuit on the measuring diaphragm transforms the tiny deformation into a voltage signal which is highly linear and proportional to the pressure and also proportional to the excitation voltage, and then a special chip is used to convert the voltage signal into an industrial standard 4-2oma current signal or 1-5V voltage signal.

Because the measuring diaphragm adopts the standardized integrated circuit, which contains the linear and temperature compensation circuit, it ensures the high accuracy and high stability of the pressure transmitter. The special two-wire system chip is used in the transmission circuit, which can ensure the output of 4-2oma current signal of two-wire system, which is convenient for field wiring.

Figure 3: ABB Transmitter 266DSH.A.S.H.A.3.A.1.L1.B1.TB

3.2 Diffused Silicon Type

The pressure of the measured medium acts directly on the diaphragm of the sensor (stainless steel or ceramic), which makes the diaphragm produce a micro displacement proportional to the medium pressure and changes the resistance value of the sensor. And the electronic circuit detects the change and converts and outputs a standard measurement signal corresponding to the pressure.

Figure 4: ABB Transmitter 266DSH-A-S-H-A-1-A-H-V1-E1-L1-B1

3.3 Ceramic Type

The ceramic pressure acts directly on the front surface of the ceramic diaphragm, causing a slight deformation of the diaphragm. The thick film resistor is printed on the back of the ceramic diaphragm and connected to form a Wheatstone bridge (closed bridge). Because of the piezoresistive effect of the varistor, the bridge produces a voltage signal which is highly linear and proportional to the pressure and also proportional to the excitation voltage.

Figure 5: DREAM Transmitter DMP-2088WS

3.4 Strain Type

The resistance strain gauge is a kind of sensitive device which converts the strain change on the measured part into an electrical signal. It is one of the main components of piezoresistive strain transducer.
The most widely used resistance strain gauge are metal resistance strain gauge and semiconductor strain gauge.
There are two kinds of metal resistance strain gauges: wire strain gauge and foil strain gauge. Usually, the strain gauge is tightly bonded to the matrix which produces mechanical strain by special adhesive. When the stress of the matrix changes, the resistance strain gauge also deforms together, which changes the resistance value of the

strain gauge, thus changing the voltage applied to the resistance.

Figure 6: Danfoss Transmitter 060N1008

4. How to Select Pressure Transmitter

The selection of pressure transmitter is based on its application. According to the following points to choose, respectively, is the accuracy, range, output signal, medium temperature, measurement medium, explosion-proof grade.

4.1 Accuracy Class

Every kind of electronic measuring meter will have accuracy error. When using, you should choose the transmitter according to the actual accuracy requirements.

4.2 Range

Generally, it is best that the maximum measurement range of the sensor is 70% of the full scale of the sensor. For example, if we want to measure the pressure of 7MPa, we should choose 10MPa as the range of the pressure transmitter.

4.3 Output Signal

At present, due to the needs of various acquisition, there are many kinds of output signals of pressure transmitter on the market. There are mainly 4 ~ 20mA, 0 ~ 20mA, 0 ~ 10V, 1 ~ 5V and so on.
4 ~ 20mA is commonly used. Among the above output signals, only 4 ~ 20mA is a two-

wire system. We say the output is several wire system, not including grounding or shielding wire. The others are three wire system.

4.4 Medium Temperature

As the signal of the pressure transmitter is partially converted by the electronic circuit, the temperature of the measuring medium of the pressure transmitter is generally - 30 to + 100 degrees. If the temperature is too high, we generally use the condensing bend to cool the medium. Relative to let the manufacturer specially produce a high temperature pressure transmitter for you, the cost of doing so will be reduced a lot.

4.5 Measuring Medium

If the measurement is relatively clean fluid, we can directly use the standard pressure transmitter. If the medium you measure is easy to crystallize or viscous, we usually use the external diaphragm or use it together with the chemical seal, which will effectively prevent the medium from blocking the pressure measuring hole.

4.6 Other Info

After determining the above five parameters, we also need to confirm the process connection interface of your pressure transmitter and the power supply voltage of the pressure transmitter. If it is used in special occasions, explosion-proof and protection grade should also be considered.

Figure 7: Pressure transmitter in a dusty place.

5. Summary

Among all kinds of instruments, pressure transmitter is widely used. Commonly used to measure pressure, differential pressure, etc. Different from the sensor, the transmitter can not only convert the non electric quantity into the measurable electric quantity, but also has a certain amplification effect.

In today's industrial world, pressure transmitter plays an important role in industrial control system. It not only displays the pressure of the system on the control screen, but also participates in important logic calculation and parameter alarm functions.