Tyco Electronics Corporation
Crompton Instruments
1610 Cobb International Blvd., Unit #4
Kennesaw, GA 30152
Tel. 770-425-8903
Fax. 770-423-7194

Process automation

General

Superior productivity is one of the keys to business success in the manufacturing sector nowadays. The secret to modern manufacturing is flexibility. Factories, such as those assembling automobiles, need integrated production lines that can produce individual items to order, whenever they are needed. To be flexible and efficient, the factory needs to be well automated. This kind of system can bring best productivity ith least costs. In an industrial plant, physical process systems consist of machinesand process equipment. They are individual devices or largersubsystems of their own. Manufacturing systems are inherently distributed and heterogeneous. Products are designed and manufactured by a range of people with different skills using a variety of systems specialized for different functions. More recently, significant effort has gone into bridging the islands of automation to a single large systems. In such an environment, system reliability is of utmost importance. One weak link can interrupt the entire chain of events and delay the delivery of the product. Manufacturers have traditionally planned down time for preventive maintenance of machines and had back up machines for those in need of repair. There has been many steps in automation systems devellopment. During the 1960s and throughout the 1970s, the machine control industry made the transformation from relay-based logic to programmable logic controllers, commonly referred to as PLC controllers. This transformation let the control engineer create systems with extremely high productivity, flexibility and reliability, and revolutionized the machine control market. PLC controller changed the way standard machine control logic was accomplished. Distributed devices interconnected bymeans of a communication network.Earlier generationsof digital control systems have beencombinations of existing automationIn an industrial plant, physicalprocess systems consist of machinesand process equipment. They areindividual devices or largersubsystems of their own.Most small process autiomation system components are installed to DIN rails and larger systems built to equipment racks (19" rack being the most common). There are few variations of standardized rail types:

- DIN 15 = EN 50 045 (15 mm wide)
- DIN 35 = EN 50 022 (35 mm wide)

The rail types are standardized in Europe and USA. DIN cased devices just snap the cases on to the rail. There are two variations of those rail models. There is assymmetical rail ('G' profile) and symmetrical rail (Top hat profile, sometimes referred as 'T' profile). There are DIN railtelnials and other equipment which plug to those DIN rails. When selecting the rail type, check that the components you plan to instal can plug to that specific rail type. Many components connect only to one rail type, but the ones with "universal mount" mount nicely to more than one rail type.Most common type nowadays seems to be 35 mm top hat profile rail. This DIN rail type is commonly used for example in modern electrical power distribution panels and used there to mount DIN rail mountable electrical wiring components like terminals and miniature circuit breakers.Investing in an industrial automation system requires the built-in flexibility that allows your system to cope with your expanding requirements, and with new technologies: the system must grow as you grow. Despite years of activity, truly open and intelligentcontrol systems seem still to be a promise of the future. Currently, industry is striving towardsproduct quality, safety andenvironmental protection. Tight profitmargins and networked manufacturingemphasise the need for integration andglobal optimisation of productionfacilities. The role of informationtechnology in achieving these goalshas become critical.The term "real-time" is often mentioned when talking about industrial autiomation systems. What exactly is industrial real-time ? The discussion can go forever what it is, because different fields can have different real-time needs. The most stringent requirements for motion control involve cycle times of around 50 microseconds and permissive jitter (deviation from the desired cycle time) of around 10 microseconds. Special applications with requirements tighter than this must be handled with application specific special hardware; normal industrial fieldbus based systems can't handle those applications. Typical cycle times for for position control lie in the 1 to 4 milliseconds range, but have very short jitter times, usually less than 20 microseconds. Pure PLC sequential logic usually doesen't require less than 10 milliseconds cycle times and jitter can be in milliseconds range. Communication with higher level computers will be in the seconds range.

Programmable Logic Controller (PLC)

A Programmable Logic Controller (PLC) is a ruggedized special purpose computer that reads input signals, runs control logic, and then writes output signals. They are used in factory production line automation mostly, but can be used in very many other applications also.A PLC (i.e. Programmable Logic Controller) was invented to replace the necessary sequential relay circuits for machine control. The PLC works by looking at its inputs and depending upon their state, turning on/off its outputs. The user enters a program, usually via software, that gives the desired results. PLCs are used in many "real world" applications, like industrial control. If you are involved in machining, packaging, material handling, automated assembly or countless other industries you are probably already using them. Almost any application that needs some type of electrical control of machine has a need for a PLC. A PLC works by continually scanning a program. First the PLC takes a look at each input to determine if it is on or off. Next the PLC executes your program one instruction at a time. Finally the PLC updates the status of the outputs. It updates the outputs based on which inputs were on during the first step and the results of executing your program during the second step. In the beginning all PLC implementations were proprietary, but nowadays there is standardization in this field going on. Noadays there are still many people relearning different plc systems all because the systems have a different editing suite or lack some instruction or simply MODIFY a timer or counter in some way. Ladder logic is great when it's an efficient medium for solutions, some more advanced solutions are sometimes needed. IEC 61131-3 is the first real endeavor to standardize programming languages for industrial automation in Programmable Logic Controllers (PLCs). The standard was IEC 1131 before renumbering. IEC 61131-3 is the global standard for industrial control programming. It harmonizes the way people design and operate industrial controls by standardizing the programming interface. IEC 61131-3 systems are a development that purports to provide a 'suite' of 6 lanquages that are syntactically standard irrespect of specific implementation. A person can learn these six lanquages and write control code that always works if it was written in the correct fashion for the application. With IEC 61131-3 you can write your PLC software using the Standard set of commands and operations. In programming using IEC 61131 standards one is able to mix programming methods [Structured Text, Ladder Diagram, Function Block Diagram and Instruction List] for each program function block. In some cases these may even be mixed within the same function block.There is no doubt that some instructions [for example array handling, complex calculations] are not efficiently handled with conventional ladder instructions, they are better handled using one of the alternate programming tools. This is a definite advantage. However it would seem that this begins to migrate away from a the very advantages that conventional ladder programming offered - namely a language/method that is readily understood and accepted by all parties involved in it implementation and use. This seems to be the ultimate goal of the IEC 61131 standard. The standard is well accepted and being used in Europe. The primary goals are to "standardize" the programming language and provide cross-platform software migration. In practice is apparent that each vendor includes a library of standardized IEC compliant instructions/functions and file tools. However they are free to provide platform/software specific libraries and tools. This means that you get standard 'plus' environment where a product provides the STANDARD plus their optimized extra solutions. The push towards standardized PLC programming was two-fold, it simplifies the I/O interfacing and dare I say it lowered the cost of necessary programming skills. This meant that a wider audience [from programmer to end-user maintenance folks] were able to work with the control devices. On-site changes, program downloads, on-line debugging etc. etc. all became a less painful and simpler process. Programmable logic controllers have been around forever (in technology years). Their proven reliability in harsh environments and design to handle many inputs and outputs has made them the foundation of many factory automated systems.PLCs can be combined with most other technologies to provide a sophisticated control and monitoring system.There are a lot of alternatives to the traditional PLC for a control engine. Some of which include Soft PLCs, personal desktop computers running Visual Basic or C, and embedded controllers. A lot of I/O manufacturers are embedding controllers in their I/O. For good programmers, control engines (Soft PLCs) can offer advantages over traditional PLCs. The standard interfaces used in PLCs are most typicallydigital input (24V binary input), digital output (solid state or relay),analog input (4..20 mA current loop) and analog output (4..20 mA current loop).Digital inputs are quite often24V DC current sinking binary input (IEC 61131-2 type 2):input current is typically 6 mA @ 24V (allowed 4-7 mA). This will mean that the input has around 3.5-6 kohm input impedance. The input current maximum is 30 mA on Type 2 DC input. Logic 0 is 0..+5V and logic 1 is +11..+30V according IEC 61131-2 (in some systems locgic 1 can be +15V or more). IEC 61131-2 type 1 is a lower current input version. Type 1 uses the same voltage levels as type 2, but the input current is typically 3 mA @ 24V.The maximum input current for type 1 input is 15 mA.Solid state digital outputs (transistor outputs) are generally current sourcing NPN outputwith 100 mA drive capacity and operation at 24V voltage(those 100 mA digital outputs ae directly compatible with DC inputs).Relay outputs are generally normal relay outputs (typically 1-2A 240V AC, can vary from device to device). (sometimes open collector outputs are used).Analogue inputs are genrally current loop type or voltage type.Current loop input generally convert current to voltage through around100-250 ohm resistor (maximum 300 ohms). Other possible inputs areDC inputs -10V..+10V, 0..+10V and +1..+5V (typically 4..20mA through 250 ohm resistor).Analogue current outputs are typically 4..20 mA current loops(less than 600 ohm output impedance) or DC outputs.IEC 601131-2 standard recommends 4..20 mA range to be used in future designs. Today the 2-wire 4..20 mA solution in sensors/transmitters is much more common than the 3-wire 0..20 mA solution. Á typical PLC controlling system is not lighting fast in operation. Pure PLC sequential logic applications usually doesen't require less than 10 milliseconds cycle times and jitter can be in milliseconds range. In many applications much slower controlling cycle times could be used, typically in the range from tens of milliseconds up to 100 milliseconds.

Automation buses

More than any technology on the horizon today, process fieldbus will have the most impact on the way we look at control systems and will forever change the dynamics of the process control and instrumentation marketplace. First conceived as a simple digital replacement for 4-20mA communications (or ven older 0-10V, 0-20mA, 0-5V etc.), the concept of fieldbus was hastened by the introduction of smart field devices in the 1980s.Nowadays information technology (IT) is increasingly determining growth in the world of automation. After it changed hierarchies, structures and flows in the entire office world, it now covers all the sectors from the process and manufacturing industries to logistics and building automation. The communications capability of devices and continuous, transparent information routes are indispensable components of future-oriented automation concepts. The IT revolution in automation technology is opening up new savings potentials in the optimization of system processes. Communication in automation is becoming increasingly direct, horizontally at field level as well as vertically through all hierarchy levels. Depending on the application and the price, graduated, matching industrial communication systems such as the Ethernet-based PROFInet, the fieldbus PROFIBUS, LON, and other systems like the sensor/actuator bus AS-Interface offer the ideal preconditions for transparent networking in all areas and levels of the automation process. At sensor/actuator level the signals of the binary sensors and actuators are transmitted via a sensor/actuator bus. Sensor/actuator level interfaces use simple, low-cost installation technique, through which data and a 24-volt power supply for the end devices are transmitted using a common medium using cyclical communications.At field level the distributed peripherals, such as I/O modules, measuring transducers, drive units, valves and operator terminals communicate with the automation systems via an efficient, real-time communication system cyclically (with option for acyclical alarms).At cell level, the programmable controllers such as PLC and IPC communicate with each other using large information packets. Network infrastructures for industrial communications are complex. The importance of a high-performance plant network is growing dramatically.

BACnet

on BACnet - A Data Communication Protocol for Building Automation and Control Networks is a communications network developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). BACnet is an American national standard, a European pre-standard, and an ISO global standard. BACnet is "a data communication protocol for building automation and control networks." A data communication protocol is a set of rules governing the exchange of data over a computer network. The rules take the form of a written specification (in BACnet's case they are also on compact disk) that spells out what is required to conform to the protocol. Everything from what kind of cable to use to how to form a particular request or command in a standard way. What makes BACnet special is that the rules relate specifically to the needs of building automation and control equipment, i.e., they cover things like how to ask for the value of a temperature, define a fan operating schedule, or send a pump status alarm. The trick is that BACnet provides a standard way of representing the functions of any device, as long as it has these functions. Examples are analog and binary inputs and outputs, schedules, control loops, and alarms. This standardized model of a device represents these common functions as collections of related information called "objects," each of which has a set of "properties" that further describe it. Each analog input, for instance, is represented by a BACnet "analog input object" which has a set of standard properties like present value, sensor type, location, alarm limits, and so on. Some of these properties are required while others are optional.

CAN

CAN (Controller Area Network) is an automation bus used in automotive applications and in industrial automation.The CAN standard, popular in automotive applications, defines a simple broadcast serial network that works well for real-time short range communications. Controller Area Network (CAN) is a fast serial bus that is designed to provide an efficient, reliable and very economical link between sensors and actuators. CAN uses a twisted pair cable to communicate at speeds up to 1Mbit/s with up to 40 devices. Originally developed to simplify the wiring in automobiles.CAN supports operation up to 40m at 1 Mbps speed without repeaters, and up to1 km at 20 kbps speed. Can uses twisted pair wiring. Can uses CSMA bus arbitration. CAN data packets are 8 bytes long and use 11-bit packet identifier.Bosch developed the "Controller Area Network" (CAN), which has since been standardized internationally (ISO11898) and has been "implemented in silicon" by several semiconductor manufacturers. Using CAN, peer stations (controllers, sensors and actuators) are connected via a serial bus. The bus itself is a symmetric or asymmetric two wire circuit, which can be either screened or unscreened. The electrical parameters of the physical transmission are also specified in ISO 11898. Suitable bus driver chips are available from a number of manufacturers. The CAN protocol, which corresponds to the data link layer in the ISO/OSI reference model, meets the real-time requirements of automotive applications. CAN is the basis of several sensor buses such as Device-NET of Allen Bradley, CAN Application Layer (CAL) from CAN in Automation, or HoneywellÂ?s SDS. CAN specifies well the low layers, but there are few rules at the upper layers. Although CAN provides a reliable communication channel, the application developer still must perform a substantial network design to make a CAN application work. Several standardized higher-layer CAN protocols are available, such as CANKingdom, CANopen, DeviceNet, J1939, and Smart Distributed System. Most of these protocols were designed for specific applications, including use in trucks or industrial automation. When implementing a CAN-based application, developers have to make a choice to either use an existing, standardized higher-layer CAN protocol or invent a proprietary protocol. Developers working on systems consisting of only a few nodes and a few network variables fear that a higher-layer CAN protocol is overkill and has a large learning curve. On the other hand, developing and maintaining an inhouse standard can be expensive, especially considering the lack of development tools. Many monitors, analyzers, configurators, and other tools available support the standardized higher-layer protocols. For embedded applications that don't require all the functionality of a "full-grown" higher-layer CAN protocol, CANopen is a popular choice, because with it you can implement only the functionality required by your particular application. MicroCANopen is an "entry-level" alternative to CANopen that works well in systems with embedded applications with limited resources. CAN bus is also pushign to safety related application. Conventional fieldbus technology is generally prohibited for safety-related use, unless the bus system is designed to meet the requirements of a safety system. Using a fieldbus to carry safety-related data is a major development, replacing traditional parallel hardwiring used in many existing safety systems. With the introduction of IEC 61508 (Functional safety of electrical/electronic/programmable electronic safety-related systems) new safety-related technologies are no longer held back, allowing the utilisation of machine safety fieldbus, such as SafetyBUS p from Pilz, which already has a proven installed base. Pilz has led the market with the introduction of SafetyBUS p in 1998, which now has a significant installed base and has achieved market acceptance of safety fieldbus in an understandably cautious market sector.

MAP

Manufacturing Automation Protocol (MAP) is a communication bus standardised in Standard 802.4. IEEE 802.4 defines a token-passing bus running at either 5 or 10 Mbps. The network is a classic broadband using frequency shift keying as the modulation method.

MODBUS

MODBUSÂ® Protocol is a messaging structure, widely used to establish master-slave communication between intelligent devices. Modbus devices communicate over a serial network in a master/slave(request/response) type relationship using one of two transmission modes:ASCII (American Standard Code for Information Interchange) mode or RTU(Remote Terminal Unit) mode.A MODBUS message sent from a master to a slave contains the address of the slave, the "command" (e.g. "read register" or "write register"), the data, and a check sum (LRC or CRC). MODBUS is traditionally implemented using RS232, RS422, or RS485 over a variety of media (e.g. fiber, radio, cellular, etc.). MODBUS TCP/IP uses TCP/IP and Ethernet to carry the MODBUS messaging structure. The MODBUS protocol comes in 2 flavours: ASCII transmission mode and RTU transmission mode. In ASCII mode, eight-bit bytes of information are sent as two ASCIIcharacters. The primary advantage of ASCII mode is the flexibility of thetiming sequence. Up to a one second interval can occur between charactertransmissions without causing communication errors. ASCII mode uses only ASCII character for datacoding and can be used with any dummy modem like communicationinterface, even ones with with 7bit communication channel. In RTU mode, data is sent as two four-bit, hexadecimal characters,providing for higher throughput than in ASCII mode for the same baudrate. Modbus RTU is a binary protocol and more time delay critical than the ASCII protocol. This means that RTU protocol does not always transfer well over modemsthat tend to buffer and error correct data. Both ASCII and RTU work nicely with direct wire connection and with 2-/4-wire short haul modems. For long distance connections where there are lots of communication devices in the communication route,the ASCII protocol is preferred, because it is less sensitive to delays and can be transported also over 7-bit communication channels.

Profibus

PROFIBUS is an international, vendor-independent, open fieldbus standard, under the European fieldbus standard EN 50170 and EN 50254. In manufacturing, industrial process and building automation applications, serial fieldbuses can act as the communication system, exchanging information between automation systems and distributed field devices. Both high-speed time critical data transmission and complex communication tasks can utilize PROFIBUS. The standard also allows devices from multiple vendors to communicate without special interface adjustments. Development and administration of PROFIBUS technology is handled by the User Organization known as the PTO in North America. PROFIBUS is an open standard. It was originally standardised in Germany in 1989 as DIN 19245 and in July 1996 as EN 50 170. The EN 50 170 specification is available through any of the national standards bodies of CENELEC / IEC and the PROFIBUS Specification can be supplied by any of the Regional PROFIBUS Associations. PROFIBUS is a polled protocol, with a layered architecture designed specifically for industrial control networks. Operations specific to industrial controls (such as Fail-Safe operation and globally coordinated Device Updates) are included in the protocol specification. Reliable operation is augmented by powerful error detection algorithms (CRC or Cyclic Redundancy Checking) and Watchdog timers.PROFIBUS uses a twisted-pair transmission medium and industry standard RS-485in manufacturing applications or IEC 1158-2 in process control. Profibus canalso use Ethernet/TCP-IP.Profibus DP is the Profibus running on standard RS-485 interface.Profibus PA (Process Automation) was developed by the Profibus User Organization (PNO) as a lower-speed intrinsically safe counterpart to Profibus DP for applications in process environments. Profibus PA is essentially Profibus DP technology superimposed on the standard IEC 1158-2 standard fieldbus physical layer. Several extensions were added to Profibus DP to make it appropriate for process applications in the form of Profibus PA (extensions include acyclic read or write of process data, confirmation of diagnostic and alarm messages, transmission of device status, bus power and intrinsic safety).PROFIBUS is a Fieldbus network designed for deterministic communication between computers and PLCs. Based on a real-time capable asynchronous token bus principle, PROFIBUS defines multi-master and master-slave communication relations, with cyclic or acyclic access, allowing transfer rates of up to 500 kbit/s (or 1.5 Mbps or up to 12 Mbps in some application). The maximum bus distance without repeaters is 200 m and if repeaters are used the maximum distance is 800m.Maximum number of nodes is 32 witout repeters and 127 if repeaters are used. PROFIBUS-DP is designed for high-speed data communication at the device level. In this case, central controllers (e.g., PLCs/PCs) communicate with their distributed field devices (I/O, drives, valves, etc.) via a high-speed serial link. Most of the data communication with these distributed devices is done in a cyclic manner. The functions required for these communications are specified by the basic PROFIBUS-DP functions in accordance with EN 50 170. PROFIBUS DP uses RS-485 on twisted pair or fiber. The communication speed can be 9.6 Kb-12 Mbit/s. The number of devices is max 125 slaves (according the PROFIBUS). The PROFIBUS standard specifies that twisted pair implementations use9 pin D-SUB connector (female on the device, male on the cable). The PROFIBUS Standard does not specify an alternative to the 9 pin D-SUB connectors. Alternative connectors may be used. PROFIBUS-DP bus should be properly installed, terminated and shielded to work reliably in process automation environment, The right cable type to use is shielded twisted pair cable with impedance of around 120 ohms. The RS485-line must be terminated to get rid of reflections and define state of lines when no device is transmitting. Termination of a bus line is done to prevent signal reflections on thePROFIBUS-DP cable. Wrong or missing termination of the line results in lowerefficiency due to transmission errors or in worst case that the communication link does not work at all. In addition to to traditional termination at right cable impedance (to avoid signal reflections), PROFIBUS-DP termination also provides a defined idle level on the cable.Ideally, termination is only implemented in the two devices by the twoends of the line. Typical applications use 390ohm for biasing resistors (one from line to ground and other from +5V to another signal wire) and 150..220 ohm for line terminating resistor (value depends on cable impedance used). It is recommended to connect the shield on both sides low inductively withthe protective ground in order to achieve optimal electromagneticcompatibility. In case of separate potentials the shieldshould be connected only at one side of the bus cable to the protectiveground. Preferably the connection between shield and protective ground ismade via the metal cases and the screw top of D-sub connector. If this isnot possible the connection can be made via pin 1 of the D-sub connector (9-pin connector). Is is also possible to bare the cable shield at an appropriate point and toground with a cable as short as possible to the metallic structure of thecabinet. To ensure easy handling an additional signal ground/reference wire is not used by PROFIBUS. It is recommended to isolate the interface circuit from the local ground (e.g. by opto couplers). This reduces a possible common mode voltage between transceivers to a minimum. PROFIBUS-PA is a PROFIBUS version specially designed for process automation. . It permits sensors and actuators, which can be connected through one common bus line even in intrinsically-safe areas. PROFIBUS-PA allows data communication and power transmission across a bus using 2-wire technology in accordance with the international standard IEC 1158-2. The physical media is IEC 1158-2 twisted pair or fiber. Baud rate is 9.6 Kb-12 Mbit/s.There can be max 31 devices/PROFIBUS-PA segment. PROFIBUS-PA uses the same communications protocol as PROFIBUS-DP; therefore their communication services and telegrams are identical. The difference is that in the PROFIBUS-PA, the RS 485 transmission system used for PROFIBUS-DP has been replaced with a transmission system based on the IEC 1158- 2. This system is internationally standardized to be used for intrinsically-safe applications. PROFIBUS-PA = PROFIBUS-DP communications protocol + IEC 1158-2 transmission system. PROFIBUS-PA's information and the power supply are transmitted along two-wire cable. When used in explosive surroundings, the PA bus and all connected devices must be designed with the "Intrinsicallysafe" type of protection. Up to 31 field devices in the nonhazardous area and up to 10 field devices in hazardous zone 1 can be connected to a PROFIBUS-PA segment.

Profinet

PROFInet is a cross-vendor communications, automation and engineering model, optimized for automation systems with distributed intelligence. PROFInet incorporates the current PROFIBUS solution.PROFInet uses DCOM for basic communication between components. PROFInet defines a runtime object model which must be implemented in every PROFInet device. The runtime software was developed to be strictly independent of operating systems. PROFInet also defines an engineering model on which configuration tools will be based using components from different vendors.

Fieldbus

Fieldbus is a "New Language" for digital process control instrumentation in the 21st Century.Fieldbus is a generic-term which describes a new digital communications network which will be used in industry to replace the existing 4 - 20mA analogue signal. The network is a digital, bi-directional, multidrop, serial-bus, communications network used to link isolated field devices, such as controllers, transducers, actuators and sensors. Fieldbus is much more than a replacement for the 4 - 20mA analogue standard.The fieldbus technology promises to improve quality, reduce costs and boost efficiency.

Interbus

INTERBUS is an open systems approach to a high performance, ring-based, distributed device network for manufacturing and process control.An INTERBUS system consists of a controller board installed into a computer (PC, VME, etc.) or PLC that communicates to a variety of I/O devices.INTERBUS is supported by over 300 third-party I/O device manufacturers worldwide.

Ethernet in industrial automation

Ethernet is the most popular and widely accepted communications network, and it works at all enterprise levels. Use of Ethernet communcations is entering to industrial automation.Ethernet is entering to factories to the human-machine interface (HMI)/SCADA automation applications.The addition of industrial grade components as well as the availability of several media types, including fiber optics, gives Ethernet unmatched momentum. As a result, the Internet is now a part of human-machine interface (HMI)/SCADA automation applications. Combining Ethernet and TCP/IP allows users to control and monitor their industrial systems from anywhere in the world. Using HMI/SCADA and other software that has Web interface, one can monitor statistical process control and other process information. When applying Ethernet technology to process industry, the devices used in the plant needs to be somewhat differently built than their office environment counterparts. Industrial Ethernet products generally have more rugged heavy-duty design, can use redundant voltage supply, feature reliable no-fan operation, offer flexible topology structures (line-ring-star), can be easiily installed on a standard DIN rail, have signaling contacts for function control, operate from from O degree C to +60 degree C, operate from 24V DC industrial power supply, operate at 10% to 95% non condensing humidity and had good enough protection level in case (for example IP30). Here are some considerations on Industrial Ethernet network

- when installign twisted pair cabling use at least CAT5 cable, preferably CAT6 cable
- Install twisted pair cable enough far away from power carrying wires (at least 15 cm from 230 VAC and at least 20 cm from 400 VAC cables).
- Use shielded cable on all noisy places (for example near welding machines and variable speed motor controls). The shielded cable should be grounded only from one end (cable with telescopic shielding ie even better). On very noisy places use fiber optics because it is immune to EMI.
- You must take environment in consideration when selecting the connectors. In some places you need protection classes IP56 or IP67. Most RJ45 connectors on the market do no meet the needs of industrial Ethernet on reliabity on hard conditions.
- The cables and connectors in industrial environment need often withstand the following conditions: dirt, mechanical stress, oil, moisture/water, varuing temperatures (-20..+60 typical, can be harder)
- At low temperatures the normal office Ethernet cable insulation breaks.

- Industrial Ethernet switches need typically to be able to operate in temperature range 0..60 C and run on 24V DC power. (Typical office switches use fans and are designed to operate at +10..+50 C and run from 110-120V or 220-240V AC power).

Most control system providers steer away from from discussions about Ethernet at the I/O bus level, because of its perceived speed and determinism. Ethernet can, on its own, provide very high speed, microsecond-level communication interchanges. The communication in full-duplex switched networks can be made also very deterministic with a well working Ethernet switch. The real-time problem is not with Ethernet, but with higher level protocols like TCP/IP and UDP/IP. When they are layered on top of Ethernet, the overall communications speed goes down into the millisecond range. From those protocols TCP was never designed to be very fast real-time protocol, but meterly a protocol that works well in congested networks to carry large amounts of data, so is not ideal for rela-time. The UDP protocol pretty simple protocol for simply sending and receiving packets over different networks. This protocol itself does not limit the real-time or speed in any way, but how it is implemented in many operating systems can have it's limitations. For those reasons the Ethernet's high-speed and real-time potential has gone unnoticed by many control systems vendors. Using an instrument as a Web server is a new aspect in industrial automation. Web-server technology is particularly well-suited to instruments that connect to Ethernet networks and that use TCP/IP (Transfer Control Protocol/Internet Protocol). It's true that Web-server technology has become so compact and inexpensive that individual sensors costing no more than a few hundred dollars each can transmit Web pages that users can view via the browser software of any Web-enabled PC. This works well on small systems, but can have it's downsides on large systems. Web server on each sensor approach quickly becomes unmanageable in applications that involve more than a few sensors.Applications involving hundreds and even thousands of sensors are common. To aggregate the multiple device outputs into a Web page that portrays the data in a form that users can understand, these applications need software that can't reside within individual sensors. Then sonfiguring the devices, programmable logic devices and such generally support BootP service to se their IP address, network mask and default gateway. DHCP is a newer version of this protocol, but it is not yet widely supported. Some traditional Internet protocols that might be found on industrial devices are DNS (Domain Name Service), SMTP (Simple Mail Transfer Protocol) and SNMP (Simple Network Manegement Protocol). Typical use of TCP/IP and UPD/IP in automation is the following: TCP/IP is used for communication between the controllers and the controlling room. This communication is typically not time critical. UPD/IP is used for time-critical data, because it is light and simple. Because UDP/IP does not provide reliable transport, the errors in data transfer needs to be handler on application layer (different manufacturers have developed different protocols for this). Industrial Automation for open Networking Allance (IAONA) is working on to advance the use of Ethernet in automation.

4-20 mA Current loop interface

4-20mA is an analog current loop protocol which has become the defacto U.S. standard for supplying DC power to a field transducer, and receiving a scaled return signal. DC power is typically supplied via an unregulated +10 to +30Vdc supply. Many industrial current-loop data acquisition systems operate on a 24V or 28V single supply. The field transducer controls the current flow, and is often referred to as a 2-wire "transmitter". You can easily receive 4-20 mA signals by passing the current through 100 ohm resistor, so you get 0.4-2V voltage over the resistor. 4-20mA current signals can be also quite easily opto-isolated using optocouplers. There are many reasons why current loop was chosen in automation instrumentation applications. Current-based signal systems are much more stable and resistant to outside influences than voltage based. For transmitting low-amplitude low-frequency signals over several hundred yards in a noisy industrial-control environment, current is preferred over voltage, because the current at any instant is constant over the entire length of the cable. Voltage transmission is not recommended, because the voltage at any point depends on line resistance and capacitance, which change with the cable's length. Current transmission also allows a single 2-wire cable to carry power and signals at the same time. Also it is actually fairly difficult to create unwanted CURRENT flows in a signal wire due to crosstalk or other induced voltages. Typical induced voltages are small, and easily swamped out by the loop driving voltage. At the end of the transmission line, a precise termination resistor converts the loop current to an accurate voltage. This resistor (typically 50 to 750) establishes the current-loop receiver's input impedance. A high signal-source impedance minimizes voltage fluctuations across the termination resistor caused by variations in line resistance, but it also picks up more EMI and other industrial interference. Large-valued bypass capacitors reduce EMI pickup by helping to lower the signal-source impedance. To summarize, current loops offer four major advantages:

- Long-distance transmission without amplitude loss
- Detection of offline sensors, broken transmission lines, and other failures
- Inexpensive 2-wire cables
- Low EMI sensitivity

In fact, the driving voltage of a typical 4-20mA system can vary from about 10Vdc to 35Vdc with the current signal still under control. Thus the poor electrical connection which would ruin a voltage signal might work fine with a current signal. There is one truly remarkable thing about 4-20mA communication: the ability of the sensor transmitter to be powered by the same two wires that carry the loop signal! Lowered wiring cost may be the single biggest reason for the dominance of 4-20mA. No separate viring is need to supply power to the transducer! You can feed a 4 to 20 mA signal to an a channel in two separate modules signal processing, connected in a series loop in some special cases. First the oputs of those modules need to be "floating" (isolated from ground) in at least one of the modules receiving the signal. Also the transmitter will have to be capable of driving the 4 to 20mA signal into the total resistance of the two modules. When receiving the 4-20 mA signal, there are different possible circuits. One of the simplest approach to convert 4-20 mA current to voltage signal is the following: feed the current through a known resistor and measure the voltage over the resistor. For example a 250 ohms resistor will nicely convert 4-20 mA current loop signal to 1-5V voltage range (you can feed this nicely to 0-5V ADC input). Many current loop sensors/transmitters are configurable to send currents out of allowed 4-20 mA range in case of sensor failure. In those applications the current ie either considerably more than 20 mA (typically 22-23 mA) or considerably less than 4 mA (3 mA or less). The 4-20 mA current loop was not the only system proposed. A 10-50mA standard was around before 4-20mA, but lost the long-term battle for dominance. Also 0-20 mA has been used in some applications, but it lacks the ability to supply power to the sensor through the same wire. 4-20mA has won the battle, andit is predicted that 4-20mA will be around for a long, long time.

HART

HART® is a digital communications protocol using a 1200 baud Frequency Shift Keying (FSK) digital signal which is superimposed over a conventional 4-20mA analog signal. HART is the de-facto digital communications standard for the process industries using conventional 4-20mA analog loops. With HART system a single twisted pair of wire (plus shield), can supply power to the transducer, carry the output signal, and with HART® also carry setup, calibration and transducer integrity information between the transducer and the control system.HART® is an industry standard with over 5 million HART® field instruments installed in more than 100,000 plants worldwide, it is the most widely used digital communications protocol in the process industry.

PID controlling

PID (Proportional-Integral-Derivative) control action allow the process control to accurately maintain setpoint by adjusting the control outputs. Proportioning control continuously adjusts the output dependent on the relative positions of the process temperature and the setpoint. PID (Proportioning/Integral/Derivative) are control functions commonly used together in today's controls. These functions when used properly allow for the precise control of difficult processes. Please note that there is no single PID algorithm. Different fields using feedback control have probably used different algorithms ever since math was introduced to feedback control. Also there is no standard terminology. Presently there are three basic forms of the PID algorithm. Expressed by their Laplace transforms the three forms are:

First form: Kc(1 + 1/Tis)(1 + Tds)/(1 + Tds/Kd)Second form: Kc'(1 + 1/Ti's + Td's)Third form: Kc" + 1/Ti"s+Td"s

where

Kc, Kc' and Kc" relate to the P part of PIDTi, Ti' and Ti" relate to the I part of PIDTd, Td' and Td" relate to the D part of PIDs is the Laplace notation for derivative with respect to timeKd is the derivative gain

This first form is called "series" or "interacting" or "analog" or "classical". The variables are:

Kc = controller gain = 100/proportional bandTi = Integral or reset time = 1/reset rate in repeats/timeTd = derivative timeKd = derivative gain

Early pneumatic controllers were probably designed more to meet mechanical and patent constraints than by a zeal to achieve a certain algorithm. Later pneumatic controllers tended to have an algorithm close to this first form. Electronic controllers of major vendors tended to use this algorithm. It is what process industry control users were used to at the time. Most major vendors of digital controllers provide first algorithm as basic, and many provide also provide the second form as well. Also, many provide several variations.If you are unsure what algorithm is being used for the controller you are tuning, find out what it is before you start to tune. Different algorithms behave differently.

Lonworks

LonWorks technology allows you to build a network of intelligent devices from different manufacturers for many applications including home, building, and factory automation. You can monitor and control these networks remotely. Lonworks networks can can range in size from two to 32,000 devices. Devices in a LonWorks network communicate using LonTalk, the standardized language of the network. LonTalk consists of a series of underlying protocols that allow intelligent communication among various devices on a network. The protocol provides a set of services that allow the application program in a device to send and receive messages from other devices over the network without needing to know the topology of the network or the names, addresses, or functions of other devices. LonTalk uses per to peer (P2P) network architechture. LonTalk protocol is defined in ANSI approved standard EIA/CEA-709.1-A-1999. LonTalk and thus LonWorks networks can be implemented over basically any medium, including power lines, twisted pair, radio frequency (RF), infrared (IR), coaxial cable and fiber optics.

EIB

The EIB is an intelligent building control system which is able to control, regulate, measure, switch, service and monitor. Its basis is a communications bus which lies in parallel with the 230V mains network. Intelligent system components, operating by distributed control, are coupled to this communications bus. Connection of the bus can be in linear, star or tree configurations which allows flexibility in the applications in all forms of modern electrical installation. EIB signals can be transmitted through twisted pair wiring and also through mains power network.Each system component can be programmed to perform prescribed functions in combination with other system components, either from controlling elements within the system or via PC control. Together, these form the infrastructure of the basic functional level of the system. Two types of system component are used: Sensors (Transmitters) and Actuators (receivers).