
Glossary of Terms used in Programmable Controller-based Systems

**From
Industrial Text and Video Co.
the leader in Electrical, Motor
Control and PLCs
Video Training Programs**

GLOSSARY

- A**
- AC/DC I/O interface.** A discrete interface that converts alternating current (AC) voltages from field devices into direct current (DC) signals that the processor can use. It can also convert DC signals into proportional AC voltages.
- action.** A set of control instructions prompting a PLC to perform a certain control function during the execution of a sequential function chart step.
- acyclic message.** An unscheduled message transmission.
- A/D.** *See* **analog-to-digital converter.**
- address.** (1) The location in a computer's memory where particular information is stored. (2) The alphanumeric value used to identify a specific I/O rack, module group, and terminal location.
- addressability.** The total number of devices that can be connected to a network.
- address field.** The sequence of eight (or any multiple of eight) bits immediately following the opening flag sequence of a frame, which identifies the secondary station that is sending (or is designated to receive) the frame.
- AI.** *See* **artificial intelligence.**
- algorithm.** A set of procedures used to solve a problem.
- alphanumeric code.** A character string consisting of a combination of letters, numbers, and/or special characters used to represent text, commands, numbers, and/or code groups.
- ambient temperature.** The temperature of the air surrounding a device.
- American National Standards Institute (ANSI).** A clearinghouse and coordinating agency for voluntary standards in the United States.
- American Wire Gauge (AWG).** A standard system used to designate the size of electrical conductors. Gauge numbers have an inverse relationship to size; larger gauges have a smaller diameter.
- analog device.** An apparatus that measures continuous information signals (i.e., signals that have an infinite number of values). The only limitation on resolution is the accuracy of the measuring device.
- analog input interface.** An input circuit that uses an analog-to-digital converter to translate a continuous analog signal, measured by an analog device, into a digital value that can be used by the processor.
- analog output interface.** An output circuit that uses a digital-to-analog converter to translate a digital value, sent from the processor, into an analog signal that can control a connected analog device.
- analog signal.** A continuous signal that changes smoothly over a given range, rather than switching suddenly between certain levels as discrete signals do.
- analog-to-digital converter (A/D).** A device that translates analog signals from field devices into binary numbers that can be read by the processor.
- AND.** A logical operator that requires all input conditions to be logic 1 for the output to be logic 1. If any input is logic 0, then the output will be logic 0.
- ANSI.** *See* **American National Standards Institute.**

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- application.** (1) A machine or process monitored and controlled by a PLC. (2) The use of computer or processor-based routines for specific purposes.
- application memory.** The part of the total system memory devoted to storing the application program and its associated data.
- application program.** The set of instructions that provides control, data acquisition, and report generation capabilities for a specific process.
- arithmetic instructions.** Computer programming codes that give a PLC the ability to perform mathematical functions, such as addition, subtraction, multiplication, division, and square root, on data.
- artificial intelligence (AI).** A subfield of computer science dealing with the development of computer programs that solve tasks requiring extensive knowledge.
- ASCII.** For *American Standard Code for Information Interchange*. A seven-bit code with an optional parity bit used to represent alphanumeric, punctuation, and control characters.
- ASCII I/O interface.** A special function interface that transmits alphanumeric data between peripheral equipment and a PLC.
- assembly language.** A symbolic programming language that can be directly translated into machine language instructions.
- asynchronous.** Recurrent or repeated operations that occur in unrelated patterns over time.
- AWG.** *See American Wire Gauge.*
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- B**
- back plane.** A printed circuit board, located in the back of a chassis, that contains a data bus, power bus, and mating connectors for modules that will be inserted into the chassis.
- backup.** A device or system that is kept on hand to replace a device or system that fails.
- backward chaining.** A method of finding the causes of an outcome by analyzing its consequents to obtain its antecedents.
- bandwidth.** The range of frequencies expressed in Hertz over which a system is designed to operate.
- base.** The maximum number of digits used to represent values in a number system.
- baseband coaxial cable.** A communication medium that can send one transmission signal at a time at its original frequency.
- BASIC module.** An intelligent I/O interface capable of performing computational tasks without affecting the PLC processor's computing time.
- battery backup.** A battery or set of batteries that will provide power to the processor's memory in the event of a power outage.
- baud.** (1) The reciprocal of the shortest pulse width in a data communication stream. (2) The number of binary bits transmitted per second during a serial data transmission.
- Baye's theorem.** An equation that defines the probability of one event occurring based on the fact that another event has already occurred.
- BCC.** *See block check character.*
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BCD. *See* **binary coded decimal**.

binary coded decimal (BCD). A binary number system in which each decimal digit from 0 to 9 is represented by four binary digits (bits). The four positions have a weighted value of 1, 2, 4, and 8, respectively, starting from the least significant (right-most) bit.

binary number system. A base 2 number system that uses only the numbers 0 and 1 to express all values. Each digit position of a binary number has a weighted value of 1, 2, 4, 8, 16, 32, 64, and so on, starting with the least significant (right-most) digit.

bit. For *binary digit*. The smallest unit of binary information. A bit can have a value of 1 or 0.

bit rate. *See* **baud**.

bit-wide bus network. An I/O bus network that interfaces with discrete devices that transmit less than 8 bits of data at a time.

blackboard architecture. The distribution of knowledge inferencing, as well as global and knowledge databases, in a control system through the use of several subsystems containing local, global, and knowledge databases that work independently of each other.

block. A group of words transmitted as a unit.

block check character (BCC). A character, placed at the end of a data block, that corresponds to the characteristics of the block.

block diagram. A schematic drawing.

block length. The total number of words transmitted at one time.

block transfer. A programming technique used to transfer up to 64 words of data to or from an intelligent I/O module.

Boolean action. A set of control instructions that assigns a discrete value to a variable during a sequential function chart step.

Boolean language. A PLC programming language, based primarily on the Boolean logic operators, that implements all of the functions of the basic ladder diagram instruction set.

Boolean operators. Logical operators, such as AND, OR, NAND, NOR, NOT, and exclusive-OR, that can be used singly or in combination to form logical statements that have output responses of TRUE or FALSE.

Boolean variable. A single-bit variable whose value is transmitted in the form of 1s and 0s.

Bourdon tube. A pressure transducer available in spiral, helical, twisted, and C-tube configurations that converts pressure measurements into displacement.

branch. A parallel logic path within a rung.

breadth-first search. A method of rule evaluation that evaluates each rule in the same level of a decision tree before proceeding downward.

bridge circuit. A mechanism found in transducer circuits that uses resistors to change the parameters (e.g., voltage and current) of an incoming signal.

broadband coaxial cable. A communication medium that can transmit two or more transmission signals at one time via frequency division multiplexing.

burn-in procedure. The process of operating a device at an elevated temperature to identify early-failing parts.

bus. (1) A group of lines used for data transmission or control. (2) Power distribution conductors.

bus topology. A network configuration in which all stations are connected in parallel with the communication medium and all stations can receive information from any other station on the network.

bypass/control station. A device that allows a process to be switched to either PLC or manual control.

byte. A group of eight adjacent bits that are operated on as a unit, such as when moving data to or from memory.

byte-wide bus network. An I/O bus network, which interfaces with discrete and small analog devices, that can transmit between 1 and 50 or more bytes of data at a time.

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- C**
- cascade control.** The use of two controllers to regulate a process so that the feedback loop of one controller is the set point of the other controller.
- center of gravity method.** A method of calculating the final output value of a fuzzy logic controller by finding the value that corresponds to the center of the mass under the control output curve.
- centralized control.** A PLC control system organization in which a central PLC controls several machines or processes.
- central processing unit (CPU).** The part of a programmable controller responsible for reading inputs, executing the control program, and updating outputs. Sometimes referred to as the *processor*, the CPU consists of the arithmetic logic unit, timing/control circuitry, accumulator, scratch pad memory, program counter, address stack, and instruction register.
- centroid.** The point in a geometrical figure whose coordinates equal the average of all the other points comprising the figure.
- channel.** A designated path for a signal.
- channel capacity.** The amount of information that can be transmitted per second on a given communication channel depending on the medium, line length, and modulation rate.
- character.** One symbol of a set of elementary symbols, such as a letter of the alphabet or a number.
- chassis.** A hardware assembly that houses PLC devices, such as I/O modules, adapter modules, processor modules, power supplies, and processors.
- checksum.** A transmission verification algorithm that adds the binary values of all the characters in a data block and places the sum in the block check character position.
- chip.** A very small piece of semiconductor material that holds electronic components. Chips are normally made of silicon and are typically less than 1/4 inch square and 1/100 inch thick.
- closed loop.** A control system that uses feedback from the process to maintain outputs at a desired level.
- coaxial cable.** A transmission medium, consisting of a central conductor surrounded by dielectric materials and an external conductor, that possesses a predictable characteristic impedance.

code. (1) A binary representation of numbers, letters, or symbols that have some meaning. (2) A set of programmed instructions.

coil. A ladder diagram symbol that represents an output instruction.

cold junction compensation. A compensation factor that allows a thermocouple to operate as though it has an ice-point reference.

collision detection (CSMA/CD). A network access method in which each node waits until there is no traffic on the network then transmits its message. If the node detects another transmission on the network, it will disable its transmitter and wait until the network clears before retransmitting the message.

combined error. *See propagation error.*

common bus topology. A network configuration in which individual PLCs connect to a main trunkline in a multidrop fashion.

compatibility. (1) The ability of various specified units to replace one another with little or no reduction in capability. (2) The ability of units to be interconnected and used without modification.

complement. A logical operation that inverts a signal or bit.

conditional probability inferencing. The conditional probability of an event happening in an artificial intelligence system.

constant voltage transformer. A transformer that maintains a steady output voltage (secondary) regardless of input voltage (primary) fluctuations.

contact. A ladder diagram symbol that represents an input condition.

contact output interface. A discrete interface, which does not require an external power source, that is triggered by the change in state of a normally open or normally closed contact.

contact symbology. A set of symbols used to express a control program through conventional relay symbols (e.g., normally open contacts, normally closed contacts, etc.).

continuous-mode controller. A process controller that sends an analog signal to a process control field device.

control element. The output field device that regulates the actual control variable level in a process control system.

control logic. The control plan for a given system.

control loop. The method of adjusting the control variable in a process control system by analyzing process variable data and then comparing it to the set point to determine the amount of error in the system.

control panel. A panel that contains instruments used to control devices.

control program checkout. A final review of a PLC's control program prior to starting up the system.

control program printout. A hard copy of the control logic program stored in a PLC's memory.

control strategy. The sequence of steps that must occur during a process or PLC program to produce the desired output control.

control task. The desired results of a control program.

control variable. The independent variable in a process control system that is used to adjust the dependent variable, the process variable.

- convergence.** A point in a sequential function chart where many elements flow into one element.
- counter.** An electromechanical device that counts the number of times an event occurs.
- counter instructions.** Computer programming codes that allow a PLC to perform the counting functions (count up, count down, counter reset) of a hardware counter.
- CPU.** *See* **central processing unit.**
- CRC.** *See* **cyclic redundancy check.**
- critically damped response.** A second-order control system response in which the damping coefficient equals 1, causing the response to overshoot the set point and then quickly settle back to it.
- CSMA/CD.** *See* **collision detection.**
- current loop.** A two-wire communication link in which the presence of a 20 milliamp current level indicates a binary 1 (mark) and its absence indicates no data, a binary 0 (space).
- CX-ORC.** *See* **cyclic exclusive-OR checksum.**
- cyclic exclusive-OR checksum (CX-ORC).** An error detection method in which the words in the data block are exclusive-ORed with the checksum word and then rotated to the left. This action is repeated until all of the words in the block have been operated on.
- cyclic message.** A scheduled message transmission.
- cyclic redundancy check (CRC).** An error detection method in which all the bits in a block are divided by a predetermined binary number. The remainder becomes the block check character.

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- D** **D/A.** *See* **digital-to-analog converter.**
- data.** A general term for any type of information.
- data link layer.** Layer 2 of the OSI network protocol. This layer provides functional and procedural means for establishing, maintaining, and releasing data link connections among network entities.
- data manipulation instructions.** Computer codes that provide a PLC with the ability to compare, convert, shift, examine, and operate on data in multiple registers.
- data table.** The part of a processor's memory, containing I/O values and files, where data is monitored, manipulated, and changed for control purposes.
- data transfer instructions.** Computer codes that allow a PLC to move numerical data within a controller, either in single register units or in blocks of registers.
- DC I/O interface.** A discrete module that links a processor with direct current field devices.
- dead time.** The delay between the time a control system's control variable changes and the time the process variable begins to respond to the change.
- debouncing.** The act of removing intermediate noise from a mechanical switch.
- decimal number system.** A base 10 number system that uses ten numbers—0, 1, 2, 3, 4, 5, 6, 7, 8, and 9—to represent all values. Each digit position has a weighted value of 1, 10, 100, 1000, and so on, beginning with the least significant (right-most) digit.

- defuzzification.** The process of converting a fuzzy logic controller's output conclusions into real output data and sending the data to the field device.
- depth-first search.** A rule evaluation method that evaluates all the rules in a downward branch of a decision tree before proceeding to the next branch.
- derivative controller.** A continuous-mode controller whose output to the control field device is proportional to the rate of change of error in the system.
- device bus network.** A network that allows low-level input/output devices that transmit relatively small amounts of information to communicate directly with a PLC.
- diagnostic AI system.** The lowest level of artificial intelligence system. This type of system primarily detects faults within an application but does not provide information about possible solutions.
- diagnostics.** The detection and isolation of an error or malfunction.
- differential input/output.** A signal transmission system where inputs and outputs have individual return lines for each channel, as opposed to all data running through one line.
- digital device.** A device that processes and sends discrete (two-state) electrical signals.
- digital signal.** A noncontinuous signal that has a finite number of values.
- digital-to-analog converter (D/A).** A device that translates binary numbers from a processor into analog signals that field devices can understand.
- direct-acting controller.** A closed-loop controller whose control variable output increases in response to an increase in the process variable.
- direct action I/O interface.** A special I/O interface that detects, preprocesses, and transmits low-level and fast-speed signals.
- discrete input interface.** An input circuit that allows a PLC to receive data from digital field devices.
- discrete-mode controller.** A controller that sends a noncontinuous signal to the field device controlling a process.
- discrete output interface.** An output circuit that allows a PLC to send data to digital field equipment.
- displacement transducer.** A device that measures the movement of an object.
- distributed control.** A PLC control system organization in which factory or machine control is divided into several subsystems, each managed by a separate PLC, yet all interconnected to form a single entity.
- distributed I/O processing.** The allocation of various control tasks to several intelligent I/O interfaces.
- divergence.** A point in a sequential function chart where one element flows into many elements.
- documentation.** An orderly collection of recorded hardware and software information about a control system. These records provide valuable reference data for installing, debugging, and maintaining the PLC.
- double-precision arithmetic.** Arithmetic instructions that use double the number of registers than single-precision arithmetic to hold the operands and result (i.e., two registers each for the operands and two or four registers for the result).
- downtime.** The time when a system is not available for use.

dynamic system checkout. The process of verifying the correct operation of a control program by actually implementing it.

- E**
- EAROM.** *See* **electrically alterable read-only memory.**
- EEPROM.** *See* **electrically erasable programmable read-only memory.**
- EIA.** *See* **Electronic Industries Association.**
- electrically alterable read-only memory (EAROM).** A type of nonvolatile, programmable, read-only memory that can be erased completely by applying the proper voltage to the memory chip.
- electrically erasable programmable read-only memory (EEPROM).** A type of nonvolatile, programmable, read-only memory that can be erased by electrical pulses.
- Electronic Industries Association (EIA).** An agency that sets electrical/electronic standards.
- encoder/counter module.** An interface, which is used in positioning applications, that links encoders and high-speed counter devices with programmable logic controllers.
- enhanced ladder language.** A PLC language that implements basic ladder language instructions, as well as more sophisticated functional block instructions, which can perform multiple operations in a single instruction.
- EPROM.** *See* **erasable programmable read-only memory.**
- erasable programmable read-only memory (EPROM).** A type of nonvolatile, programmable, read-only memory that can be erased with ultraviolet light.
- error.** The difference between the set point and the process variable in a control system.
- error-correcting code.** A code in which each acceptable expression conforms to specific rules of construction that also define one or more nonacceptable expressions, so that if certain errors occur, they can be detected and corrected.
- error deadband.** The amount that the process variable can fluctuate from the set point before the control system provides corrective action.
- error-detecting code.** A code in which each expression conforms to specific rules of construction, so that if an error occurs in an expression, it can be detected.
- exclusive-OR (XOR).** A logical operation, which has only two inputs, that yields a logic 1 output if only one of the two inputs is logic 1 and a logic 0 output if both inputs are the same, either logic 1 or logic 0.
- execute.** To perform a specific operation by processing either one instruction, a series of instructions, or a complete program.
- execution time.** The time required to perform one specific instruction, a series of instructions, or a complete program.
- executive memory.** The part of the system memory that permanently stores a system's supervisory programs, as well as instruction software. This area of memory is not accessible to the user.
- expert AI system.** The highest level of AI systems. This type of system detects process faults, provides information about possible causes of the faults, and makes complex decisions about resulting actions based on statistical analysis.

- F** **FALSE.** As related to PLC instructions, a reset logic state associated with a binary 0.
- fast-input interface.** An intelligent I/O module that functions as a pulse stretcher, detecting very fast input pulses that regular I/O modules cannot read.
- fast-response interface.** A special I/O module designed to detect fast inputs and respond with an output.
- FBD.** *See function block diagram.*
- feedback.** The signal or data transmitted to a PLC from a controlled machine or process to denote its response to the command signal.
- fiber-optic cable.** A communication medium composed of thin fibers of glass or plastic enclosed in a material with low refraction.
- first-order response.** A process response to a rapid change in the control variable characterized by one lag time and a process response curve that slowly approaches the set point.
- floating-point math.** A data manipulation format, which is used to express a number by expressing the power of the base, that usually involves the use of two sets of digits. For example, in a floating decimal notation where the base is 10, the number 8,700,000 would be expressed as 8.7(10)⁶ or 8.7E6.
- flowchart.** A graphical representation of the definition or solution of a task or problem.
- flowcharting.** A method of pictorially representing the operation of a process in a sequential manner.
- flow transducer.** A device that measures the amount of solid, liquid, or gaseous materials flowing through a process by measuring either weight, differential pressure, or fluid motion.
- forward chaining.** A method for determining all possible outcomes for a given set of inputs.
- frequency shift keying (FSK).** A signal modulation technique that offers a high amount of noise immunity in which a carrier frequency is shifted to high or low to represent a binary 1 or 0, respectively.
- FSK.** *See frequency shift keying.*
- full-duplex line.** A communication line used to simultaneously transmit data in two directions.
- function block diagram (FBD).** A graphical PLC programming language in which instructions are programmed as blocks that are then used as needed to control process elements.
- fuzzification.** The translation of input data into fuzzy logic membership sets.
- fuzzy logic.** The branch of artificial intelligence that deals with reasoning algorithms used to simulate human judgment.
- fuzzy logic interface.** A special I/O interface that provides intelligent, closed-loop process control by analyzing input data according to specified mathematical algorithms and then providing a correlating output response.
- fuzzy processing.** The interpretation of fuzzy input data to determine an appropriate outcome based on user-programmed IF...THEN rules.
- fuzzy set.** A group of membership functions.

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- G**
- gate.** A circuit having two or more input terminals and one output terminal, where an output is present only when the prescribed inputs are present.
 - gateway.** A device or pair of devices that connects two or more communication networks. This device may act as a host to each network and may transfer messages between the networks by translating their protocols.
 - global database.** The section of an AI system that stores data measurements from the controlled process.
 - grade.** A measure of how well a value fits into a given membership function.
 - Grafcet.** A PLC programming language that uses an object-oriented, flowchart-like framework, along with steps, transitions, and actions, to define the control program.
 - Gray code.** A cyclic code, similar to a binary code, in which only one bit changes as the counting number increases.
 - gross error.** An error resulting from human miscalculation.
 - ground loop.** A condition in which two or more electrical paths exist within a ground line.
 - guarantee error.** A value of error derived from a known specification that defines the amount that a product or material will arithmetically deviate from the mean.
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- H**
- half-duplex line.** A communication line that can transmit data in two directions, but in only one direction at a time.
 - Hamming code.** An error-detecting code that combines parity and data bits to generate a byte containing a value that identifies the erroneous bit.
 - hard copy.** A printed document.
 - hardware.** All the physical components of a programmable controller, including peripherals, as opposed to the software components that control its operation.
 - hardwired logic.** Logic control functions that are determined by the way a system's devices are physically interconnected.
 - hexadecimal number system (hex).** A base 16 number system that uses the numbers 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 and the letters A, B, C, D, E, and F to represent numbers and codes.
 - host.** A central computer in a network system.
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- I**
- IEC 1131 programming standard.** A standardized set of PLC programming guidelines, set forth by the International Electrotechnical Commission, that includes general PLC information, equipment and test requirements, programming languages, user guidelines, and communication standards.
 - IEEE 802.** A family of standards specified by the Institute of Electrical and Electronic Engineers for data communication over local and metropolitan area networks.
 - IL.** *See* instruction list.
 - image table.** An area in a PLC's memory dedicated to I/O data where 1s and 0s represent ON and OFF conditions, respectively.
 - individual control.** A PLC control system organization in which a PLC controls a single machine or process.
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inference engine. The section of an AI system where all decisions are made using the knowledge stored in the knowledge database.

input. Information sent to the processor from connected devices.

input device. Any connected equipment, such as control devices (e.g., switches, buttons, and sensors) or peripheral devices (e.g., cathode ray tubes and manual programmers), that supply information to the central processing unit. Each type of input device has a unique interface to the processor.

input/output system. A collection of plug-in modules that transmit control data between a PLC and field devices.

input table. The area of a PLC's memory where information about the status of input devices is stored.

instruction list (IL). A low-level, text-based PLC programming language that uses assembly language–like mnemonics to represent the control program.

integer variable. A nondiscrete variable whose value is transmitted in the form of a whole number.

integral controller. A continuous-mode controller whose output to the control field device changes according to how the error signal changes over time.

integral of time and absolute error open-loop tuning method (ITAE). A method used to determine the proper tuning constants for a controller based on the minimization of the integral of time and the absolute error of the response.

integral windup. The situation in which the control variable in a system remains at its maximum level even though the amount of error in the system starts to decrease.

intelligent I/O interface. A microprocessor-based module that can perform sophisticated processing functions independently of the central processing unit.

interface. A circuit that permits communication between a central processing unit and a field input or output device. Different devices require different interfaces.

interlock. A device actuated by the operation of another device to which it is linked to govern the succeeding operation of the same or allied devices.

internal output. A program output that does not drive a field device and is used for internal purposes only. It provides interlocking functions like a hardwired control relay. An internal output may also be referred to as an *internal storage bit* or an *internal coil*.

internal storage address assignment document. A document that identifies the address, type, and function of every internal used in a control program.

International Standards Organization (ISO). An organization established to promote the development of international standards.

interrupt. The act of redirecting a program's execution to perform a more urgent task.

I/O address. A unique number, assigned to each input/output device, that corresponds to the device's location in the rack enclosure. The address number is used when programming, monitoring, or modifying a specific input or output.

I/O address assignment document. A document that identifies every field device by address, type of input/output module, type of field device, and the function the field device performs.

I/O bus network. A network that lets input and output devices communicate directly to a PLC through digital communication.

I/O bus network scanner. A device connected to a PLC that reads and writes to field devices connected to an I/O bus network, as well as decodes the data in the network information packet.

I/O module. A plug-in assembly, containing two or more identical input or output circuits, that provides the connection between a processor and connected devices. Normal I/O module capacities are 2, 4, 8, and 16 circuits.

I/O scan time. The time required to update all local and remote I/O.

I/O update scan. The process of revising the bits in a PLC's I/O tables based on the latest results from reading the inputs and processing the outputs according to the control program.

I/O wiring connection diagram. A drawing that shows the actual connections of the field I/O devices to a PLC, including power supplies and subsystem connections.

ISO. *See International Standards Organization.*

isolated I/O interface. An input module in which each input has a separate return line. Isolated I/O interfaces can connect field devices powered from different sources to one module.

isolation transformer. A transformer that protects its connected devices from surrounding electromagnetic interference.

ITAE. *See integral of time and absolute error open-loop tuning method.*

K **K.** ²¹⁰. Used to denote memory size in either bits, bytes, or words.

knowledge AI system. A mid-level AI system that detects faults based on resident knowledge and also makes decisions about the cause of the fault and ensuing process actions.

knowledge database. The section of an AI system that stores information extracted from the expert.

knowledge inference. A decision-making methodology used to gather and analyze process data in order to draw conclusions.

knowledge representation. The way an artificial intelligence system strategy is organized.

L **label.** A name given to a membership function.

ladder diagram. An industry standard for representing relay logic control systems.

ladder diagram language (LD). A graphical set of instructions that implements basic relay ladder functions in a PLC.

ladder relay instructions. Computer codes that implement relay coils and contacts and their corresponding functions in a PLC.

ladder rung matrix. A rectangular array that defines the maximum number of contacts that can be programmed in a ladder rung, along with the maximum number of parallel branches allowed in the rung.

lag time. The delay between the initial response of the process variable to a change in the control variable and the process variable's optimal response to it.

LAN. *See local area network.*

language. A set of symbols and rules for representing and communicating information between people and machines.

Laplace transform. A mathematical function used to convert differential equations from the time domain into the frequency domain so that they become easy-to-manage algebraic equations.

LCD. *See* liquid crystal display.

LD. *See* ladder diagram language.

lead resistance compensation. A factor that compensates for signal loss due to resistance present in electrical wires.

least significant bit (LSB). The bit representing the smallest value in a nibble, byte, or word.

least significant digit (LSD). The digit representing the smallest value in a byte or word.

LED. *See* light-emitting diode.

light-emitting diode (LED). A semiconductor diode whose junction emits light when current passes through it in a forward direction.

limit switch. An electrical switch actuated by the motion of a machine or equipment.

linear variable differential transformer (LVDT). An electromechanical mechanism that provides a voltage reference that is proportional to the movement or displacement of a core inside a coil.

liquid crystal display (LCD). A display device consisting of a liquid crystal hermetically sealed between two glass plates.

load. The power used by a machine or apparatus.

load cell. A force or weight transducer that is based on a direct application of a bonded strain gauge.

local area network (LAN). An ensemble of interconnected processing elements (nodes), which are typically located within a few miles of each other.

local rack. An enclosure, placed in the same area as the master rack, that contains a local I/O processor, which sends data to and from the central processing unit.

location. A storage position or register in memory identified by a unique address.

logic. The process of solving complex problems through the use of simple functions that can be either true or false.

logic diagram. A drawing that uses interconnected AND, OR, and NOT logic symbols to graphically describe a system's operation or control.

longitudinal redundancy check (LRC). An error-checking technique based on an accumulated exclusive-OR of transmitted characters. LRC characters are accumulated at both the sending and receiving stations.

loop tuning. The process of determining the proportional, integral, and derivative constants that will allow a PID controller to perform optimally.

LRC. *See* longitudinal redundancy check.

LSB. *See* least significant bit.

LSD. *See* least significant digit.

LVDT. *See* linear variable differential transformer.

M **MAC.** *See* medium access control.

macrostep. A small sequential function chart program embedded as an action within a larger sequential function chart.

- mask.** A logical function used to set certain bits in a word to an established state.
- master.** A device used to control other devices.
- master control relay (MCR).** A hardwired or softwired relay instruction that will de-energize its associated I/O devices when the instruction is de-energized.
- master rack.** The enclosure containing the CPU or processor module.
- master/slave bus topology.** A network configuration in which one master controller manages several slave controllers.
- maximum value method.** A method of calculating the final output value of a fuzzy logic controller by finding the rule output value with the highest membership function grade.
- MCR.** *See* **master control relay.**
- mean.** The average value of a set of data readings.
- mean-time-between-failures study.** A study, which contains data about the average time between equipment failures, that provides information about the reliability of a product.
- median.** The middle value of a set of data readings organized in ascending order.
- medium access control (MAC).** A technique that ensures that only one device is transmitting on a network at any given time.
- membership function.** A group of fuzzy logic rules used to divide input data into sets, which are then analyzed to provide reasoned control of a field device.
- memory.** The part of a programmable controller that stores data, instructions, and the control program either temporarily or semipermanently.
- memory map.** A diagram showing a system's memory addresses, as well as which programs and data are assigned to each section of memory.
- message.** A group of data and control bits transferred as an entity from a data source.
- microprocessor.** A digital, electronic logic package (usually on a single chip) capable of performing the program execution, control, and data-processing functions of a central processing unit. A microprocessor usually contains an arithmetic logic unit, temporary storage registers, instruction decoder circuitry, a program counter, and bus interface circuitry.
- miniprogrammer.** A portable device used for programming, changing, and monitoring a PLC's control logic.
- mode.** The most frequently occurring value in a set of data readings.
- module.** An interchangeable, plug-in item containing electronic components.
- most significant bit (MSB).** The bit representing the greatest value of a nibble, byte, or word.
- most significant digit (MSD).** The digit representing the greatest value of a byte or word.
- MSB.** *See* **most significant bit.**
- MSD.** *See* **most significant digit.**
- multidrop link.** A cable that terminates at more than one point.
- multiplexing.** The act of channeling two or more signals to one source using the same channel.
- multiprocessing.** Concurrent execution of two or more tasks residing in memory.

- N**
- NAND.** A logical operator that yields a logic 1 output if any input is logic 0 and a logic 0 output if all inputs are logic 1. This operator is a negated AND function, the result of negating the output of an AND gate by following it with a NOT symbol.
- negative logic.** The use of binary logic so that logic 0 represents the voltage level normally associated with logic 1 (i.e., logic 0 = +5 V, logic 1 = 0 V).
- network.** A series of points (or devices) connected by some type of communication medium.
- network communications instructions.** Computer codes that allow a PLC to share data with other PLCs connected to a local area network.
- network interface module.** A special function interface that allows PLCs and other intelligent devices to communicate and transfer data over a high-speed local area communication network.
- network layer.** Layer 3 of the OSI protocol. This layer routes information in the network.
- nibble.** A group of four bits.
- node.** A station, such as a personal computer or a PLC, that is connected to a network and can thereby send and receive messages through the network.
- nonreturn to zero invert on ones (NRZI).** A self-clocking pulse code used to establish reliable synchronous transmission.
- nonvolatile memory.** A type of memory whose contents are not lost or disturbed if operating power is lost.
- NOR.** A logical operator that yields a logic 1 output if all inputs are logic 0 and a logic 0 output if any input is logic 1. This operator is a negated OR function, the result of negating the output of an OR gate by following it with a NOT symbol.
- normal action.** A set of IEC 1131-3 instructions that is executed continuously for the duration of an SFC step's activity.
- normally closed contact.** (1) A relay contact pair that is closed when the coil of the relay is not activated and open when the coil is activated. (2) A ladder program symbol that allows logic continuity (flow) if the referenced input is logic 0 when evaluated.
- normally open contact.** (1) A relay contact pair that is open when the coil of the relay is not activated and closed when the coil is activated. (2) A ladder program symbol that allows logic continuity (flow) if the referenced input is logic 1 when evaluated.
- NOT.** A logical operator that yields a logic 1 output if a logic 0 is entered at the input and a logic 0 output if a logic 1 is entered at the input. The NOT function, also called an *inverter*, is normally used in conjunction with AND and OR functions.
- NRZI.** See **nonreturn to zero invert on ones.**
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- O**
- octal number system.** A base 8 number system that uses eight numbers—0, 1, 2, 3, 4, 5, 6, and 7—to represent all values.
- off-line.** The state of not being in continuous direct communication with the processor.
- one's complement.** An operation that represents the negative value of a binary word by assigning the most significant bit of the word with a value equal to its normal value minus one.

- one shot.** A programming technique that sets a storage bit or output to a certain state for only one scan.
- on-line.** The state of being in continuous communication with the processor.
- open loop.** A control system that does not receive process feedback in order to perform self-correcting actions.
- optical coupler.** A device that couples signals from one circuit to another by means of electromagnetic radiation.
- OR.** A logical operator that yields a logic 1 output if any input is logic 1 and a logic 0 output if all inputs are logic 0.
- orifice plate.** A transducer that measures fluid flow by measuring the pressure differential between two points.
- OSI model.** A description of network communications functions organized in seven layers to promote open system interconnections.
- output.** Information sent from the processor to connected field devices.
- output device.** Any connected equipment, such as control devices (e.g., motors, solenoids, and alarms) or peripheral devices (e.g., line printers, disk drives, and color displays), that receives information or instructions from the central processing unit. Each type of output device has a unique interface to the processor.
- output table.** The area of a PLC's memory where information about the status of output devices is stored.
- overdamped response.** A second-order control system response in which the damping coefficient is greater than 1, causing the response to overshoot the set point and then slowly settle back to it.

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- P** **packet.** Data and sequences of control bits arranged in a specified format and transferred as an entity during data transmission.
- panel enclosure.** The physical enclosure that houses a PLC's hardware and components.
- parallel circuit.** A circuit in which two or more of the connected components or contact symbols in a ladder program are connected to the same pair of terminals so that current may flow through all the branches.
- parity.** The even or odd characteristic of the number of 1s in a byte or word of memory.
- parity bit.** A bit added to a memory word as a means of error detection.
- parity check.** A check for a certain number of 1s and 0s in a memory word to ensure data integrity.
- peripherals.** External devices, such as line printers, disk drives, recorders, etc., that are connected to a PLC.
- PID interface.** *See* **proportional-integral-derivative interface.**
- PLC.** *See* **programmable logic controller.**
- polling.** A network access method where a master controller manages the communication process by interrogating each slave controller under it to determine whether the slave has any information to send.
- positive logic.** The conventional use of binary logic in which logic 1 represents a positive logic level (e.g., logic 1 = +5 V, logic 0 = 0 V).

potentiometer. A simple transducer that measures displacement based on resistance changes due to the movement of a wiper arm.

power supply. The unit that supplies the necessary voltage and current to a system's circuitry.

presentation layer. Layer 6 of the OSI protocol. This layer communicates data while resolving syntax differences between network devices.

pressure transducer. A transducer that measures pressure by transforming exerted force into an electrical signal.

process. (1) Continuous and regular production executed in a definite, uninterrupted manner. (2) One or more entities threaded together to perform a requested service.

process bus network. A network that allows high-level analog input/output devices that transmit large amounts of information to communicate directly with a PLC.

process control. The regulation of process parameters to within specified target parameters through the manipulation of the control variable.

process gain. The ratio between a process's output and its input. In an ideal process control situation, the process gain equals one.

process variable. A process control system's dependent variable, which is controlled by its independent variable, the control variable.

program. A planned set of instructions stored in memory and executed in an orderly fashion by the central processing unit.

program coding. The process of translating a logic or relay diagram into PLC ladder program form.

program/flow control instructions. Computer codes that give a PLC the ability to direct the flow of operation and alter the order of execution of a control program.

programmable logic controller (PLC). A solid-state control device that can be programmed to control process or machine operations. It consists of five basic components: the processor, memory, input/output modules, the power supply, and the programming device.

programmable read-only memory (PROM). A read-only memory that can be programmed once and never altered again.

programming device. A device that is used to enter the control program into memory and make changes to the stored program.

program scan. The time required by the processor to evaluate and execute the control logic. This time does not include the I/O update time. The program scan repeats continuously while the processor is in the run mode.

PROM. *See programmable read-only memory.*

propagation error. A combined error caused by the interaction of two or more independent variables, each causing a different error.

proportional controller. A continuous-mode controller whose output to the control field device is proportional to the change in error.

proportional-derivative controller. A continuous-mode controller that uses both proportional and derivative actions to determine the control variable output based on both the amount of error and its rate of change.

proportional-integral controller. A continuous-mode controller that uses both proportional and integral actions to determine the control variable output based on the amount of error and its change over time.

proportional-integral-derivative controller. A continuous-mode controller that uses proportional, integral, and derivative actions to determine the control variable output based on the amount of error, its change over time, and its rate of change. This type of controller provides the optimum type of control in most process applications.

proportional-integral-derivative (PID) interface. An intelligent I/O module that provides automatic, closed-loop control of multiple, continuous-process control loops.

protocol. A formal definition of how communication will occur in a network.

pulse action. A set of IEC 1131-3 instructions that is executed only once after a step becomes active.

Q **quarter-amplitude response.** A process variable response whose amplitude diminishes by one-fourth during each cycle.

R **rack enclosure.** The location in a PLC that physically houses plug-in devices, such as I/O modules and supplementary power supplies.

RAM. *See* **random-access memory.**

random-access memory (RAM). A volatile, alterable memory that provides storage for the application program and data.

random error. An error resulting from an unexpected action in a process line.

read. (1) To acquire data from a storage device. (2) The transfer of data between devices, such as a peripheral device and a computer.

read-only memory (ROM). A type of memory that permanently stores an unalterable program or set of instructions.

real variable. A nondiscrete variable whose value is transmitted in the form of fractional and floating-point data.

register. A temporary storage device for data and information (e.g., timer/counter preset values). A PLC register is normally 16 bits wide.

register/BCD I/O interface. A multibit module that uses thumbwheel switches to interface between discrete devices and a programmable controller.

relay. An electrically operated device that mechanically switches electrical circuits.

relay logic. The representation of a control program or other logic in relay form (i.e., using electrically operated devices to mechanically switch electrical circuits).

remote I/O subsystem. A system where some or all of the I/O racks are mounted away from the PLC.

remote rack. An enclosure, containing I/O modules and a remote I/O processor, located away from the CPU.

resistance temperature detector (RTD). A temperature transducer composed of conductive wire elements typically made of platinum, nickel, copper, or nickel-iron.

resistance temperature detector (RTD) interface. An intelligent I/O module that interprets temperature information from RTD devices.

resolution. The smallest detectable increment of measurement.

response time. The time, including terminal delay, network delay, and service node

delay, between the transmission of the last character of a network node's message and its receipt of the first character of the reply.

reverse-acting controller. A closed-loop controller whose control variable output decreases in response to an increase in the process variable.

ring topology. A network architecture where signals from one node are relayed through all the other nodes in the network.

ROM. *See* **read-only memory.**

RTD. *See* **resistance temperature detector.**

RTD interface. *See* **resistance temperature detector interface.**

rule. An algorithm consisting of IF conditions and THEN actions that a fuzzy logic module uses to interpret input data and respond with a corresponding output value.

rule-based knowledge representation. A method of expressing an expert's knowledge in an AI system using IF...THEN rules that determine the actions and decisions to be made.

rung. A ladder program term that refers to the programmed instructions that drive one output. A complete control program may have several rungs.

S **safety control relay (SCR).** A hardwired or softwired relay instruction that will de-energize its associated I/O devices when de-energized.

scaling. Changing analog output data to reflect engineering units.

scan. The process of reading all inputs, executing the control program, and updating all outputs.

scan time. The time required to complete the scan. Effectively, this is the time required to activate an output that is controlled by programmed logic.

SCR. *See* **safety control relay.**

scratch pad memory. A temporary storage area used by the CPU to store a relatively small amount of data used for interim calculations or control. Data that is needed quickly is stored in this area to avoid the extra access time involved in retrieving data from the main memory.

second-order response. A process response to a rapid change in the control variable characterized by two lag time and a process response curve that either oscillates around the set point or overshoots the set point before settling to it.

sequential function charts (SFC). An object-oriented programming framework that organizes actions written in IEC 1131-3 programming languages (ladder diagram, instruction list, function block diagram, and structured text) into a unified sequential control program.

series circuit. A circuit in which the components or contact symbols are connected end to end. All components must be closed to permit current flow.

servo motor interface. An intelligent I/O module used in applications requiring position control via a servo drive controller, which translates the rotational movement of a servo motor into linear displacement.

set point. The target process variable value in a process control system.

SFC. *See* **sequential function charts.**

SFC action. A set of IEC 1131-3 instructions, organized as an SFC program, that is activated when a certain step in the main SFC program becomes active.

- single-ended input/output.** An analog I/O connection in which the commons are electrically tied together resulting in only one return line.
- single-precision arithmetic.** Arithmetic instructions that use one register each to hold the operands and one or two registers to hold the result of the operation.
- sinking configuration.** An electrical configuration that causes a device to receive current when the device is ON.
- slave.** A remote system or terminal whose function is controlled by a master device.
- software.** The programs that control the processing of data in a system.
- solenoid.** A transducer that converts a current into linear motion through the use of one or more electromagnets that move a metal plunger.
- solid-state.** Circuitry designed using only integrated circuits, transistors, diodes, etc., without any electromechanical devices, such as relays.
- sourcing configuration.** An electrical configuration that causes a device to provide current when the device is ON.
- special function instructions.** Computer codes that allow a PLC to perform special operations, such as sequencing, diagnostics, and PID control.
- ST.** *See structured text.*
- stand-alone action.** A set of IEC 1131-3 programming instructions, not attached to the SFC program itself, that directs the program to jump to a particular step when the action's logical conditions are satisfied.
- standard deviation.** A measure of the dispersion of a set of data readings about the mean.
- star-shaped ring topology.** A network architecture in which signals from one node are relayed through all the other nodes in the network, yet a node can be bypassed in the event of its failure to avoid a break in the ring.
- star topology.** A network architecture in which all network nodes are connected to a central device that routes the nodes' messages.
- static input wiring check.** A procedure performed with power applied to the PLC and input devices that verifies that each input device is connected to the proper input terminal and is operating properly.
- static output wiring check.** A procedure performed with power applied to the PLC and output devices that verifies that each output device is connected to the proper output terminal and is operating properly.
- steady state.** The situation in which the error in a process control system is at zero or within the error deadband.
- step.** A stage in a control process as defined by the process's sequential function chart.
- stepper motor interface.** A positioning interface that controls a stepper motor, which translates incoming pulses into mechanical motion, by generating a pulse train indicating distance, rate, and direction commands to the motor.
- step response.** The process variable's response to a sudden change in the process input (i.e., the control variable).
- step test.** A forced, sudden change in the control variable used to elicit a response from the process.
- storage area.** The area of a PLC's memory that stores blocks of input/output data, as well as data about the status of internal bits.

storage register assignment document. A document that lists the storage registers used in a control program, including their contents and a description of their function.

strain gauge. A mechanical transducer that measures body deformation (or strain) due to the force applied to a rigid body.

structured text (ST). A high-level, text-based PLC programming language, resembling the BASIC and PASCAL computer languages, that allows a control program or any other complex task to be broken down into smaller tasks.

subprogram. A semi-independent program, embedded in a larger, main control program, that executes a specialized control sequence when activated by the main program.

subroutine. A program segment in a ladder diagram that performs a separate task.

subsystem. A part of a larger system having the properties of a system in its own right.

sum-of-the-weights method. A method of changing values from other number systems into their decimal equivalents by multiplying each digit by the weighted value of its position and then summing the results.

synchronous. A type of serial transmission that maintains a constant time interval between successive events.

syntax. Rules governing the structure of a language.

system. A set of one or more PLCs, I/O devices and modules, computers, associated software, peripherals, terminals, and communication networks that together provide a means of performing information processing to control a machine or process.

system abstract. A definition of the process to be controlled including a clear statement of the control problem, a description of the design strategy, and a statement of objectives.

system configuration diagram. A drawing of the PLC control system that shows the location, simplified connections, and minimum details of the system's major hardware components.

system error. An error resulting from an instrument or from the environment.

system layout. The planned approach to placing and connecting PLC components to satisfy the control strategy and to provide system reliability and ease of maintenance.

T **tap.** A device that provides mechanical and electrical connections to a trunk cable. A tap allows the signals on the trunk to be passed to a station and the signals transmitted by the stations to be passed to the trunk.

task. A set of instructions, data, and control information capable of being executed by a CPU to accomplish a specific purpose.

TCP/IP. *See* **transmission control protocol/internet protocol.**

termination. (1) The load connected to the output end of a transmission line. (2) A provision for ending a transmission line and connecting to a bus bar or other terminating device.

thermal transducer. A device that measures changes in temperature.

thermistor. A temperature transducer made of semiconductor material, such as oxides of cobalt, nickel, manganese, iron, and titanium, that exhibits changes in internal resistance proportional to changes in temperature.

thermocouple. A bimetallic temperature transducer that provides a temperature value by measuring the voltage differential caused by joining together two different metals at different temperatures.

thermocouple input module. A module that amplifies, digitizes, and converts the input signal from a thermocouple into a digital signal equivalent to the temperature reading.

thermopile. The connection of several thermocouples in series to enhance their resolution.

three-position controller. A discrete-mode controller that provides three output levels—ON, 50% ON, and OFF.

throughput. The speed at which an application or part of an application is performed. Throughput depends on the transmission speed, medium, protocol, packet size, and amount of data handled by a network.

thumbwheel switch. A rotating switch used to input numeric information into a controller.

time base. A unit of time generated by the system clock and used by software timer instructions. Typical time bases are 0.01, 0.1, and 1.0 seconds.

timer instructions. Computer codes that allow a PLC to perform the timing functions (ON-delay energize/de-energize, OFF-delay energize/de-energize, reset) of a hardware timer.

token. (1) A signal that grants bus transmission rights to a node on a network. (2) A signal that enables a transition or action in a sequential function chart.

token passing. A network transmission technique in which a token is passed along the bus and each node has a set amount of time to receive it and respond to it.

topology. The way in which a network or system is physically structured.

transducer. A device used to convert physical parameters, such as temperature, pressure, and weight, into electrical signals.

transfer function. The unique characteristics of a process that determine its output due to changes over time.

transient response. The behavioral response of a process.

transistor-transistor logic (TTL). A semiconductor logic family characterized by high speed and medium power dissipation in which the basic logic element is a multiple-emitter transistor.

transition. A variable input, action result, conditional statement, or other program element that signals a sequential function chart to progress from one step to another.

transmission control protocol/internet protocol (TCP/IP). A network protocol developed by the U.S. Department of Defense.

transmission medium. The physical device used to transfer data in a transmission system (e.g., coaxial cable, fiber-optic cable, etc.).

transmitter. A device that amplifies a voltage signal.

tree topology. A network architecture in which the network has many nodes located in many branches of the network.

triac. A semiconductor device that functions as an electrically controlled switch for AC loads.

TRUE. As related to PLC instructions, a set logic state associated with a binary 1.

truth table. A table that shows the state of a given output as a function of all possible input combinations.

TTL. *See transistor-transistor logic.*

TTL I/O interface. A discrete interface that allows a controller to accept signals from TTL field devices, which are 5 VDC-level semiconductor devices.

turbine flow meter. A flow transducer that measures fluid flow by measuring the fluid's motion through the meter's multibladed rotor.

twisted-pair conductor. A communication medium used mainly for point-to-point applications that can transmit data up to 4000 feet at transmission rates as high as 250 kbaud.

two-position controller. A discrete-mode controller that provides two output levels—ON and OFF.

two's complement. A numbering system, used to express negative binary numbers, in which all numbers from right to left are inverted after the first 1 is detected.

U **underdamped response.** A second-order control system response in which the damping coefficient is less than 1, causing the response to oscillate around the set point before settling to it.

user program memory. The memory section where the application control program is stored.

V **variable.** A factor that can be altered, measured, and controlled.

Venturi tube. A transducer that measures fluid flow by measuring the pressure differential between two points.

vertical redundancy check (VRC). An error-detecting method in which a parity bit is added to each character in a message so that the number of bits in each character, including the parity bit, is either odd or even.

vibration transducer. A device that measures the vibration of a body by measuring its displacement, velocity, or acceleration.

volatile memory. A type of memory whose contents are irretrievable after operating power is lost.

VRC. *See vertical redundancy check.*

W **watchdog timer.** A timer that monitors the logic circuits controlling a PLC. If a watchdog timer ever times out, it will disconnect the processor from the process because it will assume that the processor is faulty.

weighted value. The numerical value assigned to any single bit as a function of its position in a word.

weight input module. A special analog interface designed to read data from load cells, which convert force and weight values into electrical signals.

wire bundling. The technique of grouping an I/O module's wires according to their characteristics (e.g., input, output, power).

wire input module. A special input interface designed to detect short-circuit or open-circuit connections between a module and its input devices.

word. The number of bits that the central processing unit operates on at one time when it is performing an instruction or operating on data. A word is usually composed of a fixed number of bits.

write. The process of putting information into a storage location.

X **XOR.** *See* **exclusive-OR.**

Z **Ziegler-Nichols closed-loop tuning method.** A method for determining a controller's tuning constants by finding the value of the proportional gain that will cause the control loop to oscillate indefinitely at a constant amplitude when it is in a closed-loop system.

Ziegler-Nichols open-loop tuning method. A method for determining the tuning constants for a controller by testing the process variable's response to a change in the control variable output in an open-loop system.