

American National Standard

**definition, specification, and analysis of
manual, automatic, and supervisory
station control and data acquisition**

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An American National Standard

IEEE Standard

Definition, Specification, and Analysis of
Manual, Automatic, and Supervisory
Station Control and Data Acquisition

Sponsor

Substations Committee of the
IEEE Power Engineering Society

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Secretariat

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American National Standard

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Foreword

(This Foreword is not a part of ANSI/IEEE C37.1-1979, IEEE Standard Definition, Specification, and Analysis of Manual, Automatic, and Supervisory Station Control and Data Acquisition.)

This standard applies to devices used for protection, switching, and controlling electric apparatus in unattended or attended generating stations or substations. It does not apply to equipment designed for communication circuit switching purposes. The requirements of this standard are in addition to those contained in standards relating to the individual devices.

This significantly revised standard was originally a section of ANSI C37.2-1970 which contained also device function numbers. ANSI C37.2-1970 has now been revised into two standards: Standard Definition, Specification, and Analysis of Manual, Automatic, and Supervisory Station Control and Data Acquisition, ANSI/IEEE C37.1-1979, and Electrical Power System Device Function Numbers, ANSI/IEEE C37.2-1979. Previous editions were approved by the Standards Institute in 1962, 1956, 1945, and 1937. The original work on this subject was done by the American Institute of Electrical Engineers (now the Institute of Electrical and Electronics Engineers) and published in 1928 as AIEE Publication No 26.

The standard applies to a rapidly changing technology. It is anticipated, therefore, that frequent revision may be desirable. Electrical Power System Device Function Numbers on the other hand have changed very little over the years. This revision, prepared by the Automatic and Supervisory System Subcommittee of the IEEE Substation Committee, was an attempt to bring the standard up to date and further broaden its applicability with respect to control, supervisory, and telemetering, for greater use in many industries.

The Standards Committee on Power Switchgear, C37, which reviewed and approved this standard, had the following personnel at the time of approval:

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When this standard was approved June 2, 1977, the IEEE Standards Board had the following membership:

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An American National Standard

IEEE Standard

**Definition, Specification, and Analysis of
Manual, Automatic, and Supervisory
Station Control and Data Acquisition**

1. Scope

This standard applies to the definition, specification, performance, analysis, and application of equipment in manual, partial automatic, automatic, and supervisory control and data acquisition systems used with electric substations and generating stations and with installations of power utilization and conversion apparatus.

This standard is intended to provide a basis for the definition, specification, and analysis of equipment described above.

2. References

The following American National Standards Institute standards and Institute of Electrical and Electronics Engineers standards and other publications are listed in this section and are referenced in the text of this standard.

- [1] ANSI/IEEE C37.90a-1974, Guide for Surge Withstand Capability (SWC) Tests (Supplement to ANSI/IEEE C37.90-1978).
- [2] ANSI C37.100-1972, Definitions for Power Switchgear.
- [3] ANSI/IEEE C37.2-1979, Electrical Power System Device Function Numbers.
- [4] ANSI C83.9-1972, Racks, Panels, and Associated Equipments.
- [5] ANSI X3.1-1969, Synchronous Signaling Rate for Data Transmission.

[6] ANSI X3.12-1970, Vocabulary for Information Processing.

[7] ANSI X3.24-1968, Signal Quality at Interface Between Data Processing Terminal Equipment and Synchronous Data Communication Equipment for Serial Data Transmission.

[8] ANSI X3.4-1968, Code for Information Interchange.

[9] ANSI X3.5-1970, Flowchart Symbols and Their Usage in Information Processing.

[10] ANSI Y10.5-1968, Letter Symbols for Quantities Used in Electrical Science and Electrical Engineering.

[11] ANSI Y14.15-1966 (R1973), Electrical and Electronic Diagrams, including Supplements Y14.15a-1970 (R1973) and Y14.15b-1973.

[12] ANSI/IEEE Std 91-1973, Graphic Symbols for Logic Diagrams (Two-State Devices)

[13] ANSI/IEEE Std 200-1975, Reference Designations for Electrical and Electronic Parts and Equipments.

[14] ANSI/IEEE Std 315-1975, Graphic Symbols for Electrical and Electronic Diagrams.

[15] ANSI Z-24-21-1957 (R1971), Methods for Specifying the Characteristics of Pickups for Shock and Vibration Measurements.

[16] ANSI/IEEE Std 344-1975, Recommended Practices for Seismic Qualifications of Class 1E Equipment for Nuclear Power Generating Stations.

[17] IEEE Std 422-1977, Guide for the Design and Installation of Cable Systems in Power Generating Stations.

[18] IEEE Std 525-1978, Guide for Selection and Installation of Control and Low Voltage Cable Systems in Substations.

[19] Bulletins 1–10, Designers Guide on Electromagnetic Compatibility. (EIA)¹

[20] EIA Std RS-232-C, Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange (Aug 1969).

[21] EIA Std RS-363, Standard for Specifying Signal Quality for Transmitting and Receiving Data Processing Terminal Equipment Using Serial Data Transmission at the Interface with Nonsynchronous Data Communication Equipment (May 1969).

[22] EIA Std RS-404, Standard for Start-Stop Signal Quality Between Data Terminal Equipment and nonsynchronous Data Communication Equipment (Mar 1973).

[23] ANSI/NEMA ICS6-1978, Enclosures for Industrial Controls and Systems.

[24] IEC TC No 65, Industrial Process Measurement and Control.²

[25] Mil Std 471, Maintainability Verification/Demonstration/Evaluation.³

[26] Mil Std 1472B, Human Engineering.

[27] Mil Std MIL-HDBK-217, Reliability Stress and Failure Rate Data for Electronic Equipment.

[28] Lloyd and Lipow, *Reliability, Management, Methods, and Mathematics*. Englewood Cliffs, NJ: Prentice-Hall, 1962.

¹EIA documents are available from the Electronic Industries Association, 2001 Eye Street NW, Washington, DC 20006.

²For information about this technical committee contact the American National Standards Institute, 1430 Broadway, New York, NY 10017.

³Military documents are available from Navy Publications and Forms Center, 5801 Tabor Ave, Philadelphia, Pa. 19120.

3. Definitions

The definitions of terms contained in this standard, or in other American National Standards referred to in this standard, are not intended to embrace all legitimate meanings of the terms. They are applicable only to the subject treated in this American National Standard.

Supervisory control and data acquisition systems may use computers. For standard definition of computer terms refer to ANSI X3.12-1970, Vocabulary for Information Processing.

Definitions in this standard may also be listed in ANSI C37.100-1972, Definitions for Power Switchgear.

alarm condition. A predefined change in the condition of equipment or the failure of equipment to respond correctly. Indication may be audible or visual, or both.

analog device. A device that operates with variables represented by continuously measured quantities such as voltages, resistances, rotations, and pressures.

analog-to-digital (A/D) conversion. Production of a digital output corresponding to the value of an analog input quantity.

analog quantity. A variable represented by a scalar value.

automatic. Pertaining to a process or device that, under specified conditions, functions without intervention by a human operator.

automatic control equipment. An equipment that provides automatic control of power apparatus in response to predetermined conditions.

automatic circuit recloser. A self-controlled device for automatically interrupting and reclosing an alternating-current circuit, with a predetermined sequence of opening and reclosing, followed by resetting, hold-closed, or lockout operation.

automatic line sectionalizer. A self-contained circuit-opening device that automatically opens the main electrical circuit through it after sensing and responding to a predetermined number of successive main current impulses equal to or greater than a predetermined magnitude. It opens while the main electrical circuit is deenergized. It may also have provision to be manually operated to interrupt loads.

automatic load throwover equipment (transfer or switchover). An equipment that automatically transfers a load to another source of power when the original source to which it has been connected fails, and that automatically restores the load to the original source under desired conditions.

NOTE: The restoration of the load to the preferred source from the emergency source upon reenergization of the preferred source after an outage may be of the continuous circuit restoration type or interrupted circuit restoration type.

(1) *Equipment of the Nonpreferential Type.* Equipment that automatically restores the load to the original source only when the other source, to which it has been connected, fails.

(2) *Fixed Preferential Type.* Equipment in which the original source always serves as the preferred source and the other source as the emergency source. The automatic transfer equipment will restore the load to the preferred source upon its reenergization.

(3) *Selective Preferential Type.* Equipment in which either source may serve as the preferred or the emergency source of preselection as desired, and which will restore the load to the preferred source upon its reenergization.

(4) *Semiautomatic Load Throwover Equipment.* An equipment that automatically transfers a load to another (emergency) source of power when the original (preferred) source to which it has been connected fails, but requires manual restoration of the load to the original source.

automatic reclosing equipment. Equipment which initiates automatic closing of a switching device under predetermined conditions without operator intervention.

automatic opening (tripping). The opening of a switching device under predetermined conditions without operator intervention.

availability. The ratio of uptime and uptime plus downtime. (See 7.3, Availability.)

backup. Provision for an alternate means of operation in case the primary system is not available.

backup, degraded. A backup capability that does not perform all of the functions of the primary system.

baud. The term "baud" defines the signaling speed, that is, keying rate of the modem.

The signaling speed in baud is equal to the reciprocal of the shortest element duration in seconds to be transmitted.

For example, in the table below, the signaling speed is calculated from the signaling element duration. In addition, the distinction between bit rate and baud for two different types of modems is illustrated.

Signaling Technique		
	Modem One	Modem Two
Signaling element duration	0.833 ms	
Signaling speed	1200 baud	
Information transmitted per element duration	1 bit	2 bits
Bit rate	1200 bits per second	2400 bits per second

The bit rate and baud are not synonymous and shall not be interchanged in usage. Preferred usage is bit rate, with baud used only when the details of a communication modem or channel are specified.

bit, least significant. In an n bit binary word its contribution is (0 or 1) toward the maximum word value of $(2^n - 1)$.

bit, most significant. In an n bit binary word its contribution is (0 or 1 times $2^{(n-1)}$) toward the maximum word value of $(2^n - 1)$.

bit rate. The number of bits transferred in a given time interval. Bits per second is a measure of the rate at which bits are transmitted.

buffer (buffer storage). (1) A device in which data are stored temporarily, in the course of transmission from one point to another; used to compensate for a difference in the flow of data, or time of occurrence of events, when transmitting data from one device to another. (2) An isolating circuit used to pre-

vent a driven circuit from influencing a driving circuit.

burn in. A period, usually prior to on-line operation, during which equipment is continuously energized for the purpose of forcing infant mortality failures.

calibration. Adjustment of a device such that the output is within a specified range for particular values of the input.

cathode ray tube (CRT). A display device in which controlled electron beams are used to present alphanumeric or graphical data on an electroluminescent screen.

checkback message. The response from the receiving end to the initiating end of a coded signal or message.

(1) *Partial.* Message from the initiating end is mirrored by the receiving end back to the initiating end to verify error-free transmission of the message.

(2) *Complete.* Message from the initiating end is interpreted by the receiving end. A new message is sent to the initiating end to verify both error-free transmission and proper interpretation of the message. (See 7.4, Security.)

common equipment. That complement of either the master or remote station supervisory equipment that interfaces with the interconnecting channel and is otherwise basic to the operation of the supervisory system, but is exclusive of those elements that are peculiar to and required for the particular applications and uses of the equipment.

console. That component of the system which provides facilities for control and observation of the system. Examples include operator's console, maintenance console. (See **panel, control**)

contention. An operational condition on a data communication channel in which no station is designated a master station. In contention, each station on the channel must monitor the signals on the channel and wait for a quiescent condition before initiating a bid for circuit control.

control. The execution of a system change by manual means, remote means, automatic means, or partially automatic means.

control, automatic. An arrangement of electrical controls that provides for switching or

controlling, or both, of equipment in an automatic sequence and under predetermined conditions.

control, closed loop. A type of automatic control in which control actions are based on signals fed back from the controlled equipment or system.

control, open loop. A form of control without feedback.

control, manual. Control in which the system or main device, whether direct or power-aided in operation, is directly controlled by an attendant.

control, partial automatic. Control which is a combination of manual and automatic control.

control, remote. Control of a device from a distant point.

data. Any representation of a digital or analog quantity to which meaning has been assigned.

data acquisition. The collection of data.

data acquisition system. A centralized system which receives data from one or more remote points. A telemetering system. Data may be transported by either analog or digital telemetering. (See **telemetering**)

data rate. The rate at which a data path (for example, channel) carries data, measured in bits per second (b/s).

data logging. The recording of selected data on suitable media.

dead band. The range through which an input can be varied without initiating response.

device (electrical equipment). An operating element such as a relay, contactor, circuit breaker, switch, valve, or governor used to perform a given function in the operation of electrical equipment.

digital quantity. A variable represented by coded pulses (for example, bits) or states.

digital-to-analog (D-A) conversion. Production of an analog signal whose instantaneous magnitude is proportional to the value of a digital input.

disable. A command or condition which prohibits some specific event from proceeding.

display, graphic. A hardware device (CRT, plasma panel, arrays of lamps, or light emitting diodes) used to present pictorial information.

downtime. The time during which a device or system is not capable of meeting performance requirements.

electromagnetic compatibility (EMC). A measure of equipment tolerance to external electromagnetic fields.

electromagnetic interference (EMI). A measure of electromagnetic radiation from equipment.

enable. A command or condition which permits some specific event to proceed.

expandability. The capability of a system to be increased in capacity or provided with additional functions. (See 7.5.)

event. A discrete change of state (status) of a system or device.

failure. An event that may limit the capability of an equipment or system to perform its function(s).

(1) *Critical.* Causes a false or undesired operation of apparatus under control.

(2) *Major.* Loss of control or apparatus which does not involve a false operation.

(3) *Minor.* Loss of data relative to power flow or equipment status.

failure distribution. Is the manner in which failures occur as a function of time; generally expressed in the form of a curve with the abscissa being time.

failures, infant mortality. A characteristic pattern of failure, sometimes experienced with new equipments which may contain marginal components, wherein the number of failures per unit of time decrease rapidly as the number of operating hours increase. A burn-in period may be utilized to age (or mature) an equipment to reduce the number of marginal components.

failures, random. The pattern of failures for equipments that have passed out of their infant mortality period and have not reached the wear-out phase of their operating lifetime. The reliability of an equipment in this

period may be computed by the equation:

$$R = e^{-\lambda t}$$

where λ is the failure rate and t is the time period of interest.

failures, wear out. The pattern of failures experienced when equipments reach their period of deterioration. Wear-out failure profiles may be approximated by a Gaussian (bell curve) distribution centered on the nominal life of the equipment.

firmware. Hardware used for the non-volatile storage of instructions or data that can be read only by the computer. Stored information is not alterable by any computer program. (See *station, remote*.)

function check. A check of master and remote station equipment by exercising a predefined component or capability.

(1) *Analog.* Monitor a reference quantity

(2) *Control.* Control and indication from a control-check relay

(3) *Scan.* Accomplished when control function check has been performed with all remotes

(4) *Poll.* Accomplished when analog function is performed with all remotes

(5) *Logging.* Accomplished when results of the control function check are logged.

hard copy. A permanent record of information in readable form for human use, for example, reports, listings, displays, logs, charts, etc.

hardwired. The implementation of processing steps within a device via the placement of conductors between components within the device. The processing steps are not alterable except by modifying the conducting paths between components.

indication. A light or other signal (audio or visual) provided by the man/machine interface that signifies a particular condition.

inhibit. To prevent a specific event from occurring.

log. A record of data.

master terminal unit (MTU). Refers to the master station of a supervisory control system (See *station, master*).

mean time between failure (MTBF). The time interval (hours) that may be expected between failures of an operating equipment.

mean time to repair (MTTR). The time interval (hours) that may be expected to return a failed equipment to proper operation.

offset. A predetermined value modifying the actual value so as to improve the integrity of the system, for example, the use of a 4 mA signal to represent zero in a 4 to 20 mA system.

panel, control. An assembly of man machine interface devices. (See 5.5.)

point equipment (point). Elements of a supervisory system, exclusive of the basic common equipment, which are peculiar to and required for the performance of a discrete supervisory function. (See **supervisory control functions**).

(1) **Alarm Point.** Station (remote or master, or both) equipment(s) that input a signal to the alarm function.

(2) **Accumulator Point.** Station (remote or master, or both) equipment(s) that accepts a pulsing digital input signal to accumulate a total of pulse counts.

(3) **Analog Point.** Station (remote or master, or both) equipment(s) that inputs an analog quantity to the analog function.

(4) **Control Point.** Station (remote or master, or both) equipment(s) that operate to perform the control function.

(5) **Indication (Status) Point.** Station (remote or master, or both) equipment(s) that accepts a digital input signal for the function of indication.

(6) **Sequence of Events Point.** Station (remote or master, or both) equipment(s) that accepts a digital input signal to perform the function of registering sequence of events.

(7) **Telemetry Selection Point.** Station (remote or master, or both) equipment(s) for the selective connection of telemetry transmitting equipment to appropriate telemetry receiving equipment over an interconnecting communication channel. This type of point is more commonly used in electromechanical or stand alone type of supervisory control.

(8) **Spare Point.** Point equipment that is not being utilized but is fully wired and equipped.

(9) **Wired Point.** Point for which all common equipment, wiring, and space are provided. To activate the point requires only the addition of plug-in hardware.

(10) **Space Only Point.** Point for which cabinet space only is provided for future addition or wiring and other necessary plug-in equipments.

NOTE: A point may serve for one or more of the purposes described above, for example, when a supervisory system is used for combined control and supervision of remotely operated equipment, point for supervisory control and point for supervisory indication may be combined into a single control and indication point.

polling (data request). The process by which a data acquisition system selectively requests data from one or more of its remote terminals. A remote terminal may be requested to respond with all, or a selected portion of, the data available.

programmable equipment. A remote or master station having one or more of its operations specified by a program contained in a memory device.

protocol. A strict procedure required to initiate and maintain communication.

quantization error. The amount that the digital quantity differs from the analog quantity. (See **analog-to-digital (A/D) conversion**.)

quiescent supervisory system. (See **supervisory system, quiescent**).

refresh rate. The number of times each second that the information displayed on a non-permanent display, for example, CRT, is rewritten or reenergized.

relay, interposing. A device which enables the energy in a high-power circuit to be switched by a low-power control signal.

remote terminal unit (RTU). Refers to a remote station equipment of a supervisory system. (See **station, remote**.)

repeatability. The measure of agreement among multiple readings of an output for the same value of input made under the same operating conditions, approaching from the same direction using full-range traverses.

reproducibility. The measure of agreement among multiple readings of the output for the same value of input, made under the same operating conditions, approaching from either direction using full range traverses.

resolution. The least value of the measured quantity which can be distinguished.