



IEEE Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations

IEEE Power and Energy Society

Sponsored by the
Substations Committee
and the
Power Systems Relaying Committee

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Abstract: The definition and application of function numbers and acronyms for devices and functions used in electrical substations and generating plants and in installations of power utilization and conversion apparatus are covered. The purpose and use of the numbers and acronyms is discussed, and 95 numbers and 17 acronyms are assigned.

Function numbers or function acronyms for arc fault detection, high impedance fault detection, human machine interface, communications devices, digital fault and sequence of event recorders, power quality recorders, substation time sources and synchrophasor devices are among those that have been added. The use of prefixes and suffixes to provide a more specific definition of a function is defined. Device contact designations are also covered.

Keywords: control, designations, device functions, device function acronyms, device function numbers, function numbers, IEC 61850, relay, switchgear

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Introduction

This introduction is not part of IEEE Std C37.2-2008, IEEE Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations.

This standard applies to systems used for the monitoring, protection, switching, and controlling of electric apparatus in unattended and attended substations, generating stations, power utilization and conversion facilities, and equipment designed for automatic protection of power systems.

This standard is a revision of IEEE Std C37.2-1996. A definition for the previously unused Device Number 16 has been added, as well as acronyms for 17 new devices/functions. Acronyms were added for these functions, rather than utilizing numbers above 99, as those numbers are already in use in some installations. See Clause 3.4 for examples.

Definitions of some device functions have been improved for present applications, and additional suggested suffix letters/definitions have been added. An annex, cross-referencing IEEE Std C37.2 device function numbers to IEC 61850 logical nodes, has been added.

Previous revisions were approved and published as standards dated 1996, 1991, 1987, 1979, 1962, 1956, 1945, and 1937. The original work on this subject was approved in 1928 and published by the American Institute of Electrical Engineers (AIEE) as AIEE No. 26.

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IEEE Standard for Electrical Power System Device Function Numbers, Acronyms, and Contact Designations

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1. Overview

1.1 Scope

This standard applies to the definition and application of function numbers and acronyms for devices and functions used in electrical substations and generating plants and in installations of power utilization and conversion apparatus.

NOTE—Historically, device function numbers have typically represented individual or component devices. These numbers and acronyms may also be used to represent individual functions within multi-function devices or software programs, and that may contain both protection- and non-protection-oriented functions.¹

1.2 Purpose

A device function number, with an appropriate prefix and appended suffix (or an acronym), is used to identify the function(s) of each device installed in electrical equipment. These numbers and acronyms are to be used in drawings, elementary and connection diagrams, instruction books, publications, and specifications. The device number or acronym may be physically placed on, or adjacent to, each device on the assembled equipment.

¹ Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

NOTE—Most of these device function designations have been developed as a result of usage over many years, with the first version of this standard having been published in 1928. They may define the actual function the device performs in equipment or they may refer to the electrical or other quantity to which the device is responsive. Hence, in some instances, there may be a choice of the function number or acronym to be used for a given application. The preferable choice should be the function number or acronym that is recognized to have the narrowest interpretation in all cases. The choice should specifically identify a device or function in the minds of all individuals concerned with the design and operation of the equipment.

2. Normative references

There are no normative references in this standard.

3. Standard device /function number and function acronym descriptions

3.1 Standard device /function numbers

Each number, with its corresponding function name and a general description of the function, is listed in the subclauses that follow. Note that a function may be provided by means of a separate freestanding device (a device function), or as one of the functions in a multifunction device. The use of the word “relay” in the function names is intended to be generic, and does not necessarily imply a separate freestanding single function device. Additional functions are defined in 3.2. An index of device /function names consisting of the corresponding device /function numbers or acronyms and page numbers is provided in Annex E.

NOTE—When alternate names and descriptions are included under the function, only the name and description that applies to each specific case should be used. In general, only one name for each device, such as relay, contactor, circuit breaker, switch, or monitor, is included in each function designation. However, when the function is not inherently restricted to any specific type of device, and where the type of device itself is thus merely incidental, any one of the listed alternative names, as applicable, may be substituted. For example, if a device number 6—a contactor—is used to function as a circuit breaker, the function name should be specified as “starting contactor.”

For every application of device/function numbers and acronyms, the originator should provide a brief definition for all device/function numbers used in that application, including all combinations of prefixes, function numbers, and suffixes. Typical definitions are illustrated in the figures in Annex A and Annex B. These definitions should be included in the drawing where the device/function number or acronym is used, or in a separate drawing or list to which the other drawings refer. All instruction books and other documents shall also include the device/function number and acronym definitions.

Numbers from 95 through 99 should be assigned only for those functions in specific cases where none of the assigned standard device function numbers or acronyms are applicable.

3.1.1 Device number 1—master element

A device, such as a control switch, etc., that serves, either directly or through such permissive devices as protective and time-delay relays, to place equipment in or out of operation.

NOTE—This number is normally used for a hand-operated device, although it may also be used for an electrical or mechanical device for which no other function number is suitable.

3.1.2 Device number 2—time-delay starting or closing relay

A device that functions to give a desired amount of time delay before or after any point of operation in a switching sequence or protective relay system, except as specifically provided by device functions 48, 62, 79, and 82.

3.1.3 Device number 3—checking or interlocking relay

A device that operates in response to the position of one or more other devices or predetermined conditions in a piece of equipment or circuit, to allow an operating sequence to proceed, or to stop, or to provide a check of the position of these devices or conditions for any purpose.

3.1.4 Device number 4—master contactor

A device, generally controlled by device function 1 or the equivalent and the required permissive and protective devices, that serves to make and break the necessary control circuits to place equipment into operation under the desired conditions and to take it out of operation under abnormal conditions.

3.1.5 Device number 5—stopping device

A control device used primarily to shut down equipment and hold it out of operation. [This device may be manually or electrically actuated, but it excludes the function of electrical lockout (see device function 86) on abnormal conditions.]

3.1.6 Device number 6—starting circuit breaker

A device whose principal function is to connect a machine to its source of starting voltage.

3.1.7 Device number 7—rate-of-change relay

A device that operates when the rate-of-change of the measured quantity exceeds a threshold value, except as defined by device 63.

3.1.8 Device number 8—control power disconnecting device

A device, such as a knife switch, circuit breaker, or pull-out fuse block, used for the purpose of connecting and disconnecting the source of control power to and from the control bus or equipment.

NOTE—Control power is considered to include auxiliary power that supplies such apparatus as small motors and heaters.

3.1.9 Device number 9—reversing device

A device that is used for the purpose of reversing the field of a machine or for performing any other reversing function.

3.1.10 Device number 10—unit sequence switch

A device that is used to change the sequence in which units may be placed in and out of service in multiple-unit equipment.

3.1.11 Device number 11—multifunction device

A device that performs three or more comparatively important functions that could only be designated by combining several device function numbers. All of the functions performed by device 11 shall be defined in the drawing legend, device function definition list, or relay-setting record. See Annex A for further discussion and examples.

NOTE—If only two relatively important functions are performed by the device, it is preferred that both function numbers be used, as described in 3.7.

3.1.12 Device number 12—overspeed device

A device, usually direct-connected, that operates on machine overspeed.

3.1.13 Device number 13—synchronous-speed device

A device such as a centrifugal-speed switch, a slip-frequency relay, a voltage relay, an undercurrent relay, or any other type of device that operates at approximately the synchronous speed of a machine.

3.1.14 Device number 14—underspeed device

A device that functions when the speed of a machine falls below a predetermined value.

3.1.15 Device number 15—speed or frequency matching device

A device that functions to match and hold the speed or frequency of a machine or a system equal to, or approximately equal to, that of another machine, source, or system.

3.1.16 Device number 16—data communications device

A device that supports the serial and/or network communications that are a part of the substation control and protection system. This clause establishes the assignment of IEEE C37.2™ device number 16 for a data communications device handling protective relaying or other substation communication traffic. The following suffix list identifies specific functions of a component identified as device 16. The first suffix letter shall be either S (serial devices for RS-232, 422, or 485 communications) or E (for Ethernet components). The second and subsequent suffix letters shall be one or more of the following letters to further define the device:

- C Security processing function [Virtual Private Network (VPN), encryption, etc.]
- F Firewall or message filter function
- M Network managed function [e.g., configured via Simple Network Management Protocol (SNMP)]
- R Router
- S Switch (Examples: Port switch on a dial up connection is 16SS, and an Ethernet switch is 16ES)
- T Telephone component (Example: auto-answer modem)

See Annex B for a complete description of this function number and example usage of its unique suffix letters.

A device 16 may be a single function or a multifunction device.

3.1.17 Device number 17—shunting or discharge switch

A device that serves to open or close a shunting circuit around any piece of apparatus (except a resistor), such as a machine field, a machine armature, a capacitor, or a reactor.

NOTE—This excludes devices that perform such shunting operations as may be necessary in the process of starting a machine by devices 6 or 42 (or their equivalent), and also excludes device function 73 that serves for the switching of resistors.

3.1.18 Device number 18—accelerating or decelerating device

A device that is used to close or cause the closing of circuits that are used to increase or decrease the speed of a machine.

3.1.19 Device number 19—starting-to-running transition contactor

A device that operates to initiate or cause the automatic transfer of a machine from the starting to the running power connection.

3.1.20 Device number 20—electrically operated valve

An electrically-operated or -controlled device used in a fluid, air, gas, or vacuum line.

NOTE—The function of the valve may be more completely indicated by the use of suffixes as discussed in 3.3.

3.1.21 Device number 21—distance relay

A device that functions when the circuit admittance, impedance, or reactance increases or decreases beyond a predetermined value.

3.1.22 Device number 22—equalizer circuit breaker

A device that serves to control or make and break the equalizer or the current balancing connections for a machine field, or for regulating equipment, in a multi-unit installation.

3.1.23 Device number 23—temperature control device

A device that functions to control the temperature of a machine or other apparatus, or of any medium, when its temperature falls below or rises above a predetermined value.

NOTE—An example is a thermostat that switches on a space heater in a switchgear assembly when the temperature falls to a predetermined value. This should be distinguished from a device that is used to provide automatic temperature regulation between close limits, which would be designated as device function 90T.

3.1.24 Device number 24—volts per Hertz relay

A device that operates when the ratio of voltage to frequency is above a preset value or is below a different preset value. The relay may have any combination of instantaneous or time-delayed characteristics.

3.1.25 Device number 25—synchronizing or synchronism-check relay

A synchronizing device that produces an output that causes closure of a circuit breaker between two circuits whose voltages are within prescribed limits of magnitude, phase angle, and frequency. It may or may not include voltage or speed control. A synchronism-check relay permits the paralleling of two circuits that are within prescribed (usually wider) limits of voltage magnitude, phase angle, and frequency.

3.1.26 Device number 26—apparatus thermal device

A device that functions when the temperature of the protected apparatus (other than the load-carrying windings of machines and transformers as covered by device function number 49), or that of a liquid or other medium, exceeds a predetermined value; or when the temperature of the protected apparatus or that of a liquid or other medium, exceeds a predetermined value or decreases below a predetermined value.

3.1.27 Device number 27—undervoltage relay

A device that operates when its input voltage is less than a predetermined value.

3.1.28 Device number 28—flame detector

A device that monitors the presence of the pilot or main flame in such apparatus as a gas turbine or a steam boiler.

3.1.29 Device number 29—isolating contactor or switch

A device that is used expressly for disconnecting one circuit from another for the purposes of emergency operation, maintenance, or testing.

3.1.30 Device number 30—annunciator relay

A nonautomatically reset device that gives a number of separate visual indications upon the functioning of protective devices and that may also be arranged to perform a lockout function.

3.1.31 Device number 31—separate excitation device

A device that connects a circuit, such as the shunt field of a synchronous converter, to a source of separate excitation during the starting sequence.

3.1.32 Device number 32—directional power relay

A device that operates on a predetermined value of power flow in a given direction, such as reverse power flow resulting from the motoring of a generator upon loss of its prime mover.

3.1.33 Device number 33—position switch

A device that makes or breaks contact when the main device or piece of apparatus that has no device function number reaches a given position.

3.1.34 Device number 34—master sequence device

A device such as a motor-operated multi-contact switch (or the equivalent), or a programmable device, that establishes or determines the operating sequence of the major devices in equipment during starting and stopping, or during sequential switching operations.

3.1.35 Device number 35—brush-operating or slip-ring short-circuiting device

A device for raising, lowering, or shifting the brushes of a machine; short-circuiting its slip rings; or engaging or disengaging the contacts of a mechanical rectifier.

3.1.36 Device number 36—polarity or polarizing voltage device

A device that operates, or permits the operation of, another device on a predetermined polarity only, or that verifies the presence of a polarizing voltage in equipment.

3.1.37 Device number 37—undercurrent or underpower relay

A device that functions when the current or power flow decreases below a predetermined value.

3.1.38 Device number 38—bearing protective device

A device that activates upon excessive bearing temperature or on other abnormal mechanical conditions associated with bearings, such as undue wear, which may eventually result in excessive bearing temperature or failure.

3.1.39 Device number 39—mechanical condition monitor

A device that activates upon the occurrence of an abnormal mechanical condition (except conditions associated with bearings as covered under device function 38), such as excessive vibration, eccentricity, expansion, shock, tilting, or seal failure.

3.1.40 Device number 40—field (over /under excitation) relay

A device that activates upon a given or abnormally high or low value or failure of machine field current, or on an excessive value of the reactive component of armature current in an ac machine indicating abnormally high or low field excitation.

3.1.41 Device number 41—field circuit breaker

A device that functions to apply or remove the field excitation of a machine.

3.1.42 Device number 42—running circuit breaker

A device whose function is to connect a machine to its source of running or operating voltage. This function may also be used for a device, such as a contactor, that is used in series with a circuit breaker or other fault-protecting means, primarily for frequent opening and closing of the circuit.

3.1.43 Device number 43—manual transfer or selector device

A manually operated device that transfers control or potential circuits in order to modify the plan of operation of the associated equipment or of some of the associated devices.

3.1.44 Device number 44—unit sequence starting relay

A device that functions to start the next available unit in multiple-unit equipment upon the failure or non-availability of the normally preceding unit.

3.1.45 Device number 45—abnormal atmospheric condition monitor

A device that functions upon the occurrence of an abnormal atmospheric condition, such as damaging fumes, explosive mixtures, smoke, or fire.

3.1.46 Device number 46—reverse-phase or phase-balance current relay

A device in a polyphase circuit that operates when the polyphase currents are of reverse-phase sequence, or when the polyphase currents are unbalanced, or when the negative phase-sequence current exceeds a preset value.

3.1.47 Device number 47—phase-sequence or phase-balance voltage relay

A device in a polyphase circuit that functions upon a predetermined value of polyphase voltage in the desired phase sequence when the polyphase voltages are unbalanced, or when the negative phase-sequence voltage exceeds a preset value.

3.1.48 Device number 48—incomplete sequence relay

A device that returns the equipment to the normal or off position and locks it out if the normal starting, operating, or stopping sequence is not properly completed within a predetermined time.

3.1.49 Device number 49—machine or transformer thermal relay

A device that functions when the temperature of a machine armature winding or other load-carrying winding or element of a machine or power transformer exceeds a predetermined value.

3.1.50 Device number 50—instantaneous overcurrent relay

A device that operates with no intentional time delay when the current exceeds a preset value. The suffix TD should be used (e.g., 50TD) to describe a definite time overcurrent function. Use 50BF for a current-monitored breaker failure function.

3.1.51 Device number 51—ac inverse time overcurrent relay

A device that functions when the ac input current exceeds a predetermined value, and in which the input current and operating time are inversely related through a substantial portion of the performance range.

3.1.52 Device number 52—ac circuit breaker

A device that is used to close and interrupt an ac power circuit under normal conditions or to interrupt this circuit under fault or emergency conditions.

3.1.53 Device number 53—field excitation relay

A device that forces the dc machine field excitation to build up during starting or that functions when the machine voltage has built up to a given value.

3.1.54 Device number 54—turning gear engaging device

A device either electrically operated, controlled, or monitored that functions to cause the turning gear to engage (or disengage) the machine shaft.

3.1.55 Device number 55—power factor relay

A device that operates when the power factor in an ac circuit rises above or falls below a predetermined value.

3.1.56 Device number 56—field application relay

A device that automatically controls the application of the field excitation to a synchronous ac motor at some predetermined point in the slip cycle.

3.1.57 Device number 57—short-circuiting or grounding device

A device that functions to short-circuit or ground a circuit in response to automatic or manual means.

3.1.58 Device number 58—rectification failure relay

A device that functions if a power rectifier (diode) fails to conduct or block properly.

3.1.59 Device number 59—overvoltage relay

A device that operates when its input voltage exceeds a predetermined value.

3.1.60 Device number 60—voltage or current balance relay

A device that operates on a given difference in voltage, or current input or output, of two circuits.

3.1.61 Device number 61—density switch or sensor

A device that operates at a given density value or at a given rate of change of density.

3.1.62 Device number 62—time-delay stopping or opening relay

A device that imposes a time delay in conjunction with the device that initiates the shutdown, stopping, or opening operation in an automatic sequence. Example: 62BF = breaker failure function (with no current monitoring).

3.1.63 Device number 63—pressure switch

A device that operates at a given pressure value or at a given rate of change of pressure.

3.1.64 Device number 64—ground detector relay

A device that operates upon the insulation failure of a machine or other apparatus to ground.

NOTE—This function is not applied to a device connected in the secondary circuit of current transformers in a normally grounded power system where other overcurrent device numbers with the suffix G or N should be used; for example, 51N for an ac time overcurrent relay connected in the secondary neutral of the current transformers.

3.1.65 Device number 65—governor

A device consisting of an assembly of fluid, electrical, or mechanical control equipment used for regulating the flow of water, steam, or other media to the prime mover for such purposes as starting, holding speed or load, or stopping.

3.1.66 Device number 66—notching or jogging device

A device that functions to allow only a specified number of operations of a given device or piece of equipment, or a specified number of successive operations within a given time of each other. It is also a device that functions to energize a circuit periodically or for fractions of specified time intervals, or that is used to permit intermittent acceleration or jogging of a machine at low speeds for mechanical positioning.

3.1.67 Device number 67—ac directional overcurrent relay

A device that functions at a desired value of ac overcurrent flowing in a predetermined direction.

3.1.68 Device number 68—blocking or “out-of-step” relay

A device that initiates a pilot signal for blocking of tripping on external faults in a transmission line or in other apparatus under predetermined conditions, or cooperates with other devices to block tripping or reclosing on an out-of-step condition or on power swings.

3.1.69 Device number 69—permissive control device

A device with two positions that, in one position permits the closing of a circuit breaker, or the placing of a piece of equipment into operation, and in the other position, prevents the circuit breaker or the equipment from being operated.

3.1.70 Device number 70—rheostat

A device used to vary the resistance in an electric circuit when the device is electrically operated or has other electrical accessories, such as auxiliary, position, or limit switches.

3.1.71 Device number 71—liquid level switch

A device that operates at a given level value, or on a given rate of change of level of a liquid.

3.1.72 Device number 72—dc circuit breaker

A device that is used to close and interrupt a dc power circuit under normal conditions or to interrupt this circuit under fault or emergency conditions.

3.1.73 Device number 73—load-resistor contactor

A device that is used to shunt or insert a step of load limiting, shifting, or indicating resistance in a power circuit; to switch a space heater in circuit; or to switch a light or regenerative load resistor of a power rectifier or other machine in and out of circuit.

3.1.74 Device number 74—alarm relay

A device other than an annunciator, as covered under device function 30, that is used to operate, or that operates in connection with, a visual or audible alarm.

3.1.75 Device number 75—position changing mechanism

A device that is used for moving a main device from one position to another in equipment; for example, shifting a removable circuit breaker unit to and from the connected, disconnected, and test positions.

3.1.76 Device number 76—dc overcurrent relay

A device that functions when the current in a dc circuit exceeds a given value.

3.1.77 Device number 77—telemetry device

A transmitting device used to generate and transmit to a remote location an electrical signal representing a measured quantity; or a receiver used to receive the electrical signal from a remote transmitter and convert the signal to represent the original measured quantity.

3.1.78 Device number 78—phase-angle measuring relay

A device that functions at a predetermined phase angle between two voltages, between two currents, or between a voltage and a current.

3.1.79 Device number 79—ac reclosing relay

A device that controls the automatic reclosing and locking out of an ac circuit breaker.

3.1.80 Device number 80—flow switch

A device that operates at a given flow value, or at a given rate of change of flow.

3.1.81 Device number 81—frequency relay

A device that responds to the frequency of an electrical quantity, operating when the frequency or rate of change of frequency exceeds or is less than a predetermined value.

3.1.82 Device number 82—dc load-measuring reclosing relay

A device that controls the automatic closing and reclosing of a dc circuit interrupter, generally in response to load circuit conditions.

3.1.83 Device number 83—automatic selective control or transfer relay

A device that operates to select automatically between certain sources or conditions in equipment or that performs a transfer operation automatically.

3.1.84 Device number 84—operating mechanism

A device consisting of the complete electrical mechanism or servomechanism, including the operating motor, solenoids, position switches, etc., for a tap changer, induction regulator, or any similar piece of apparatus that otherwise has no device function number.

3.1.85 Device number 85—pilot communications, carrier or pilot-wire relay

A device that is operated, restrained, or has its function modified by communications transmitted or received via any media used for relaying.

3.1.86 Device number 86—lockout relay

A device that trips and maintains the associated equipment or devices as inoperative until it is reset by an operator, either locally or remotely.

3.1.87 Device number 87—differential protective relay

A device that operates on a percentage, phase angle, or other quantitative difference of two or more currents or other electrical quantities.

3.1.88 Device number 88—auxiliary motor or motor generator

A device used for operating auxiliary equipment, such as pumps, blowers, exciters, rotating magnetic amplifiers, etc.

3.1.89 Device number 89—line switch

A device used as a disconnecting, load-interrupter, circuit switcher, or isolating switch in an ac or dc power circuit. (This device function number is normally not necessary unless the switch is electrically operated or has electrical accessories, such as an auxiliary switch, a magnetic lock, etc.)

3.1.90 Device number 90—regulating device

A device that functions to regulate a quantity or quantities, such as voltage, current, power, speed, frequency, temperature, and load, at a certain value or between certain (generally close) limits for machines, tie lines, or other apparatus.

3.1.91 Device number 91—voltage directional relay

A device that operates when the voltage across an open circuit breaker or contactor exceeds a given value in a given direction.

3.1.92 Device number 92—voltage and power directional relay

A device that permits or causes the connection of two circuits when the voltage difference between them exceeds a given value in a predetermined direction and causes these two circuits to be disconnected from each other when the power flowing between them exceeds a given value in the opposite direction.

3.1.93 Device number 93—field-changing contactor

A device that functions to increase or decrease, in one step, the value of field excitation on a machine.

3.1.94 Device number 94—tripping or trip-free relay

A self-resetting device that functions to trip a circuit breaker, contactor, or piece of equipment; to permit immediate tripping by other devices; or to prevent immediate reclosing of a circuit interrupter if it should open automatically, even though its closing circuit is activated or energized.

3.1.95 Device numbers 95–99—used only for specific applications

These device numbers are used in individual specific installations if none of the functions assigned to the numbers from 1 through 94 in 3.1 or the acronyms in 3.2 are suitable.

3.2 Device /Function acronyms—

To be used in the same manner as the function numbers defined in Subclause 3.1

3.2.1 AFD—arc flash detector

A device/function that detects an unintentional electrical arc in air.

3.2.2 CLK—clock or timing source

A device / function that receives an accurate timing signal input and distributes an accurate timing signal output to other devices.

NOTE—An example of an accurate timing signal input is a signal received from a Global Positioning System (GPS) satellite clock. An example of an accurate timing output signal is Inter-Range Instrumentation Group Type B (IRIG-B).

3.2.3 DDR—dynamic disturbance recorder

A device/function that records incidents that portray power system behavior during low frequency (0.1 Hz to 3 Hz) oscillations, and abnormal frequency or voltage excursions.

3.2.4 DFR—digital fault recorder

A device/function that records, for analysis purposes, events on the power system. It records voltage and/or current waveforms replicating the primary power system voltages and currents when triggered by a sudden change in the waveforms or by an external event.

3.2.5 ENV—environmental data

A device/function that measures and stores variables relating to the environment, such as weather data, ice buildup conditions, geomagnetic disturbances, earthquakes, and other similar phenomena.

3.2.6 HIZ—high impedance fault detector

A device/function that detects high impedance faults on grounded or ungrounded systems.

3.2.7 HMI—human machine interface

A device/function that displays data/information to and allows control of a system by an operator. A HMI may also be local to a specific device for operator interaction specific to that device.

3.2.8 HST—historian

A device/function that continuously gathers states and values from a data concentrator or directly from protection and control Intelligent Electronic Devices (IEDs), and may also act as a recorder of data from which trends may be determined.

3.2.9 LGC—scheme logic

A device/function that provides the programmed logic for a multi-device control/protective relay scheme, such as a Remedial Action Scheme (RAS) or an interlocking scheme.

3.2.10 MET—substation metering

A device/function that is connected to CTs and VTs, and may calculate and store one or several of the following quantities—watts, vars, amps, volts, power factor, demand, energy.

3.2.11 PDC—phasor data concentrator

A device/function that collects phasor and discrete event data from PMUs (and from other PDCs) and transmits the data to other destinations. PDCs may buffer data for a short time period, but do not store the data.

3.2.12 PMU—phasor measurement unit

A device/function that samples voltage and current with very accurate time stamps and calculates phase angles vs. a GPS time reference (synchrophasors). See IEEE Std 1344™ [B5]².

3.2.13 PQM—power quality monitor

A device/function that monitors electrical parameters used in power quality measurements.

Parameters include (but are not limited to) RMS variations, frequency variations, unbalance, transients, harmonics, and inter-harmonics. The storage of historical values of these measurements may also be performed. See IEEE Std 1159™ [B4].

3.2.14 RIO—remote input/output device

A device/function interfacing between the power system process (analog or digital) and the substation automation system that serves as a substation data repository of control and protection system information, but without connection to a SCADA master station.

3.2.15 RTU—remote terminal unit/data concentrator

A device/function that serves as the primary interface (the data concentrator function) between a protection and control system and a SCADA system to provide operational data visibility to, and perform command operations from, the SCADA control center. See IEEE Std C37.1™ [B7].

3.2.16 SER—sequence of events recorder

A device/function that records events (changes of state of equipment or functions) with a time reference (commonly from a GPS or IRIG-B receiver).

3.2.17 TCM—trip circuit monitor

A device/function that monitors an associated circuit breaker's trip circuit for continuity and for the presence of tripping voltage, and sets an externally readable alarm when continuity or tripping voltage is lost (a surrogate for the traditional red light on relay and control panels).

3.3 Addition of prefixes and suffixes

Letters and numbers may be used as prefixes or suffixes to the device function numbers in 3.1 to provide a more specific definition of the function, as discussed below. They permit a manifold multiplication of

² The numbers in brackets correspond to those of the bibliography in Annex F.

available function designations for the large number and variety of devices used in the many types of equipment covered by this standard. They may also serve to denote individual or specific parts or auxiliary contacts of these devices or certain distinguishing features, characteristics, or conditions that describe the use of the device or its contacts in the equipment.

Prefixes and suffixes should, however, be used only when they accomplish a useful purpose. For example, when all of the devices in a piece of equipment are associated with only one kind of apparatus, such as a feeder, motor, or generator, it is common practice, in order to retain maximum simplicity in device function identification, not to add the respective suffix letters F, M, or G to any of the device function numbers.

In order to prevent any possible conflict or confusion, each letter suffix should preferably have only one meaning in individual pieces of equipment. To accomplish this, short, distinctive abbreviations or any appropriate combination of letters may also be used as letter suffixes where necessary. However, each suffix should not consist of more than three (and preferably not more than two) letters, in order to keep the complete function designation as short and simple as possible. The meaning of each suffix should be designated on the drawings or in the publications with which they are used, similar to TC-trip coil, V-voltage, or X-auxiliary relay.

In cases where the same suffix (consisting of one letter or a combination of letters) has different meanings in the same equipment depending upon the device function number with which it is used, then the complete device function number with its suffix letter or letters and its corresponding function definition should be listed in the legend in each case, i.e., 63V-vacuum relay, 70R-raising relay for device 70, 90V-voltage regulator.

3.4 Suggested prefixes

A similar series of numbers, prefixed by the letters RE (for *remote*) may be used for the interposing relays performing functions that are controlled directly from the supervisory system. Typical examples of such functions are RE1, RE5, and RE94.

In multiple-unit installations, it may be desirable to use a prefix number to distinguish between device functions associated with individual units. For example, in pipeline pump stations, the numbers 1–99 are applied to device functions that are associated with the overall station operation. A similar series of numbers, starting with 101 instead of 1, are used for those device functions that are associated with unit 1; a similar series starting with 201 for device functions that are associated with unit 2; and so on, for each unit in these installations. Some utilities use the 100 series for devices/functions connected to the primary side of a substation, and the 200 series for the secondary side—e.g., a circuit breaker on a primary bus is a 152 device, and a circuit breaker on a secondary bus is a 252 device.

3.5 Suggested suffix letters

Subclauses 3.5.1, 3.5.2, 3.5.3, 3.5.4, 3.5.5, and 3.5.6 describe letters that are commonly used and are recommended for use when required and as appropriate. In addition, there is a unique set of suffix letters applicable only to device number 16. See 3.1.16 and Annex D.

3.5.1 Auxiliary devices

These letters denote separate auxiliary devices, such as the following:

- C Closing relay/contactor
- CL Auxiliary relay, closed (energized when main device is in closed position)
- CS Control switch
- D “Down” position switch relay
- L Lowering relay

O	Opening relay/contactor
OP	Auxiliary relay, open (energized when main device is in open position)
PB	Push button
R	Raising relay
U	“Up” position switch relay
X	Auxiliary relay
Y	Auxiliary relay
Z	Auxiliary relay

NOTE—In the control of a circuit breaker with a so-called X-Y relay control scheme, the X relay is the device whose main contacts are used to energize the closing coil or the device that in some other manner, such as by the release of stored energy, causes the breaker to close. The contacts of the Y relay provide the anti-pump feature of the circuit breaker.

3.5.2 Actuating quantities

These letters indicate the condition or electrical quantity to which the device responds, or the medium in which it is located, such as the following:

A	Air/amperes/alternating
C	Current
D	Direct/discharge
E	Electrolyte
F	Frequency/flow/fault
GP	Gas pressure
H	Explosive/harmonics
I_0	Zero sequence current
I_-, I_2	Negative sequence current
I_+, I_1	Positive sequence current
J	Differential
L	Level/liquid
LR	Locked rotor
P	Power (real)/pressure
PF	Power factor
Q	Reactive power/oil
S	Speed/suction/smoke
T	Temperature
V	Voltage/volts/vacuum
VB	Vibration
W	Water/watts

3.5.3 Main device

The following letters denote the main device to which the numbered device is applied or is related:

A	Alarm/auxiliary power
AC	Alternating current
AN	Anode
B	Battery/blower/bus
BK	Brake
BL	Block (valve)

BP	Bypass
BT	Bus tie
C	Capacitor/condenser/compensator/carrier current/case/compressor
CA	Cathode
CH	Check (valve)
D	Discharge (valve)
DC	Direct current
E	Exciter
F	Feeder/field/filament/filter/fan
G	Generator/ground ³
H	Heater/housing
L	Line/logic
M	Metering/motor
MOC	Mechanism operated contact ⁴
N	Network/neutral ³
P	Phase comparison/pump
R	Reactor/rectifier/room/rotor
S	Secondary/stator/strainer/sump/suction (valve), synchronizing
T	Transformer/thyratron
TH	Transformer (high-voltage side)
TL	Transformer (low-voltage side)
TM	Telemeter
TOC	Truck-operated contact ⁵
TT	Transformer (tertiary-voltage side)
U	Unit

3.5.4 Main device parts

These letters denote parts of the main device, except auxiliary contacts, position switches, limit switches, and torque limit switches, which are covered in Clause 4.

BK	Brake
C	Coil/condenser/capacitor
CC	Closing coil/closing contactor
HC	Holding coil
M	Operating motor
MF	Fly-ball motor
ML	Load-limit motor
MS	Speed adjusting or synchronizing motor
OC	Opening contactor
S	Solenoid
SI	Seal-in
T	Target

³ The suffix N is preferred when the device is connected in the residual of a polyphase circuit, is connected across a broken delta, or is internally derived from the polyphase current or voltage quantities. The suffix G is preferred where the measured quantity is in the path to ground, or, in the case of ground fault detectors, is the current flowing to ground. See Figure C.2 in Annex C for examples.

⁴ MOC denotes a circuit breaker mechanism-operated auxiliary switch that is mounted on the stationary housing of a removable circuit breaker.

⁵ TOC denotes a circuit breaker truck-operated auxiliary switch that is mounted on the stationary housing of a removable circuit breaker.

TC	Trip coil
V	Valve
W	Winding

3.5.5 Other suffix letters

The following letters cover all other distinguishing features, characteristics, or conditions not specifically described in 3.5.1, 3.5.2, 3.5.3, and 3.5.4, which serve to describe the use of the device in the equipment, such as:

A	Accelerating/automatic
B	Blocking
BU	Back up
BF	Breaker failure
C	Close/cold
D	Decelerating/detonate/down/disengaged
DCB	Directional comparison blocking
DCUB	Directional comparison unblocking
DUTT	Direct underreaching transfer trip
E	Emergency/engaged
F	Failure/forward
GC	Ground check
GP	General Purpose
H	Hot/high
HIZ	High impedance fault ⁶
HR	Hand reset
HS	High speed
L	Left/local/low/lower/leading
M	Manual/master
O	Open/over
OFF	Off
ON	On
P	Polarizing
POTT	Permissive overreaching transfer trip
PUTT	Permissive underreaching transfer trip
R	Right/raise/reclosing/receiving/remote/reverse
S	Sending/swing
SHS	Semi-high speed
SOTF	Switch on to fault
T	Test/trip/trailing
TD	Time delay
TDC	Time-delay closing contact
TDDO	Time delayed relay coil drop-out
TDO	Time-delay opening contact
TDPU	Time delayed relay coil pickup
THD	Total harmonic distortion
U	Up/under
Z	Impedance

⁶ As a suffix for past usage only. For new applications, use the acronym HIZ (see 3.2.6).

3.5.6 Use of suffix letters

Lowercase (small) letters are used in practically all instances on electrical diagrams for the auxiliary, position, and limit switches, as shown in 4.1. Uppercase (capital) letters are generally used for all suffix letters in 3.5.5.

The letters in 3.5.1, 3.5.2, and 3.5.3, since they should generally form part of the device function designation, are usually written directly after the device function number; for example, 52CS, 71W, or 49D. When it is necessary to use two types of suffix letters in connection with one function number, it is often desirable for clarity to separate them by a slanted line or dash, as, for example, 20D/CS or 20D-CS.

The suffix letters in 3.5.4, which denote parts of the main device, and those in 3.5.5, which cannot or need not form part of the device function designation, are generally written directly below the device function number on the drawings, as shown in Figure 4.

3.6 Suffix numbers

If two or more devices with the same function number and suffix letter (if used) are present in the same piece of equipment, they may be distinguished by numbered suffixes, as, for example, 4X-1, 4X-2, and 4X-3, when necessary.

3.7 Devices performing more than one function

If one device performs two important functions in a piece of equipment so that it is desirable to identify both of these functions, a double function number and name, such as 50/51 instantaneous and time overcurrent relay, may be used. For more than two functions, use Function 11—multifunction device (see 3.1.11). Its contents may be identified using one of the methods shown in Annex A. Note that a device 11 may include relaying, control, data collection, and monitoring functions.

4. Device contacts

4.1 Auxiliary, position, and limit switch contacts

The letters *a* and *b* shall be used for all auxiliary, position, and limit switch contacts for such devices and equipment as circuit breakers, contactors, valves and rheostats, and contacts of relays as follows:

- a* Contact that is open when the main device is in the standard reference position, commonly referred to as the nonoperated or de-energized position, and that closes when the device assumes the opposite position
- b* Contact that is closed when the main device is in the standard reference position, commonly referred to as the nonoperated or de-energized position, and that opens when the device assumes the opposite position

The simple designation *a* or *b* is used in all cases where there is no need to adjust the contacts to change position at any particular point in the travel of the main device, or if the part of the travel where the contacts change position is of no significance in the control or operating scheme. Hence, the *a* and *b* designations usually are sufficient for circuit breaker auxiliary switches.

Standard reference positions of some typical devices are given in Table 1.

Table 1—Standard reference positions of devices

Device	Standard reference position
Adjusting means (see NOTE 1)	Low or down position
Clutch	Disengaged position
Contactator (see NOTE 2)	De-energized position
Contactator (latched-in type)	Main contacts open
Density switch	Standard reference
Disconnecting switch	Main contacts open
Flow detector (see NOTE 3)	Lowest flow
Gate	Closed position
Level detector (see NOTE 3)	Lowest level
Load-break switch	Main contacts open
Power circuit breaker	Main contacts open
Power electrodes	Maximum gap position
Pressure switch (see NOTE 3)	Lowest pressure
Recloser	Main contactor open
Relay (see NOTE 2)	De-energized position
Relay (latched-in type)	See 4.5.3
Rheostat	Maximum resistance position
Speed switch (see NOTE 3)	Lowest speed
Tap changer	Center tap
Temperature relay (see NOTE 3)	Lowest temperature
Turning gear	Disengaged position
Vacuum switch (see NOTE 3)	Lowest pressure that is highest vacuum
Valve	Closed position
Vibration detector (see NOTE 3)	Minimum vibration
<p>NOTE 1—These may be speed, voltage, current, load, or similar adjusting devices comprising rheostats, springs, levers, or other components for the purpose.</p> <p>NOTE 2—These electrically-operated devices are of the nonlatched-in type, whose contact position is dependent only upon the degree of energization of the operating, restraining, or holding coil or coils that may or may not be suitable for continuous energization. The de-energized position of the device is that with all coils de-energized.</p> <p>NOTE 3—The energizing influences for these devices are considered to be, respectively, rising temperature, rising level, increasing flow, rising speed, increasing vibration, and increasing pressure.</p>	

4.1.1 Auxiliary switches with defined operating position

When it is desired to have the auxiliary, position, or limit switch designation, it should be indicated at what point of travel the contacts change position, as is sometimes necessary in the case of valves and for other main devices. Then an additional letter (or a percentage figure, if required) is added (as a suffix to the *a* or *b* designation) for this purpose.

For a valve, the method of designating such position switches is shown in the diagram and legend in Figure 1. There are thus two points to consider in visualizing or describing the operation of these position switches. The first is whether the contact is *a* or *b* as indicated by the first letter. The second is where the contact changes position, either at or near:

- a) The closed position of the valve *c*,
- b) The open position of the valve *o*, or
- c) A specified percentage, such as 25% of the full open position; for example, a25.

When applied to devices other than valves, gates, circuit breakers, and switches for which the letters *o* and *c* are used for *open* and *closed*, respectively, it will be necessary to use other applicable letters. For example, for such devices as a clutch, turning gear, rheostat, electrode, and adjusting device, the letters *d*, *e*, *h*, *l*, *u*, and *d*, meaning *disengaged*, *engaged*, *high*, *low*, *up*, and *down*, respectively, are applicable. Also, other appropriate suffix letters may be used for special *a* or *b* position switches, when these are considered more appropriate and if their meaning is clearly indicated. For example, in the case of an early-opening auxiliary switch on a power circuit breaker that is adjusted to open when the breaker is tripped before the main contacts part, it may be thus described and then designated as an *ae* auxiliary switch.

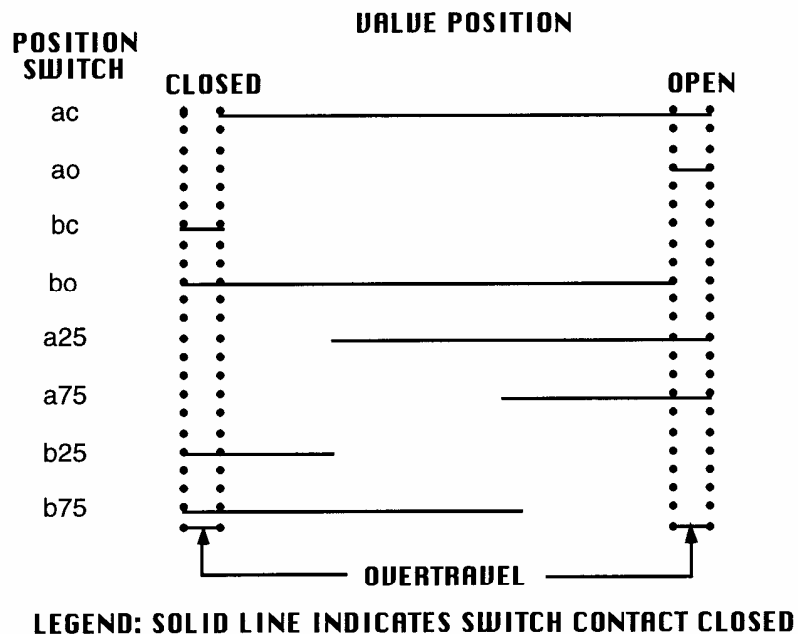
Example:

20BL/ac

designates an auxiliary switch, on a block valve, that is open only when the valve is fully closed.

20D/a10

designates an auxiliary switch, on a discharge valve, that is open except when the valve is 10% or more open.



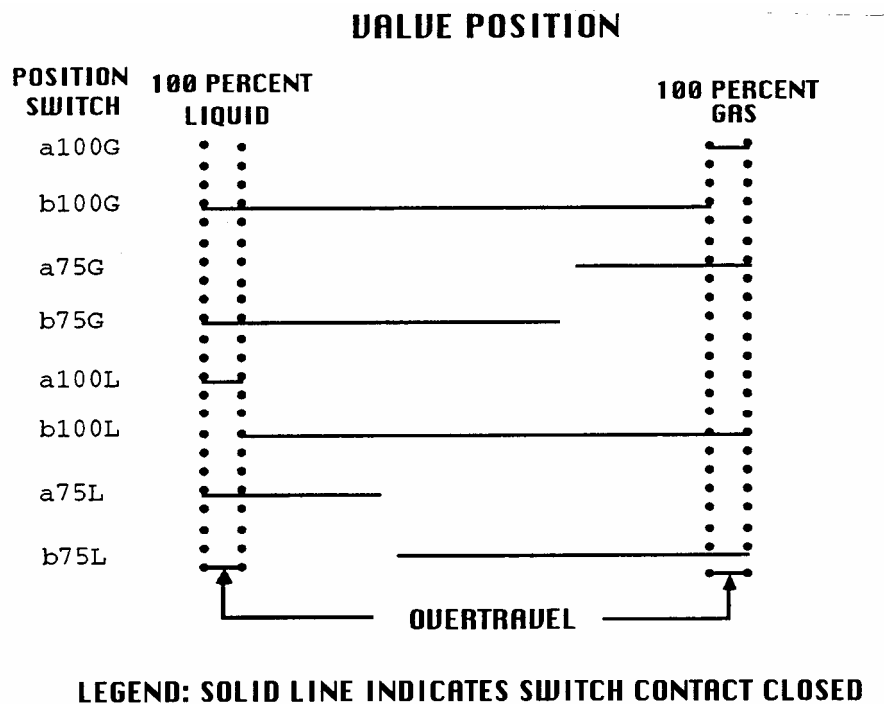
Each of the eight valve positions can be described as follows:

<i>ac, a</i>	contact that changes position at or near the closed position of the valve, that is, open only when the valve is fully closed
<i>ao, a</i>	contact that changes position at or near the open position of the valve, that is, closed only when the valve is fully open
<i>bc, b</i>	contact that changes position at or near the closed position of the valve, that is, closed only when the valve is fully closed
<i>bo, b</i>	contact that changes position at or near the open position of the valve, that is, open only when the valve is fully open
<i>a25, a</i>	contact that changes position when the valve is 25% open, that is, closed only when the valve is open 25% or more
<i>a75, a</i>	contact that changes position when the valve is 75% open, that is, closed only when the valve is open 75% or more
<i>b25, b</i>	contact that changes position when the valve is 25% open, that is, closed only when the valve is open less than 25%
<i>b75, b</i>	contact that changes position when the valve is 75% open, that is, closed only when the valve is open less than 75%

Figure 1—Valve

4.1.2 Auxiliary switches for devices without a standard reference position

In designating position switches for such a special device as, for example, a fuel transfer device, which has no standard reference or nonoperated position and may be placed at either extreme or any intermediate position for normal operation, *a* and *b* designations are still applicable. However, a percentage figure of the “full open” or “on” position should always be used, and, for the sake of consistency, this percentage should always be in terms of the position that is 50% or more of the “full open” or “on” position, as shown in Figure 2.



Each of the eight positions can be described as follows:

- a100G closed only when 100% of the fuel being supplied is gas
- b100G closed only when less than 100% of the fuel being supplied is gas
- a75G closed only when 75% or more of the fuel being supplied is gas
- b75G closed only when less than 75% of the fuel being supplied is gas
- a100L closed only when 100% of the fuel being supplied is liquid
- b100L closed only when less than 100% of the fuel being supplied is liquid
- a75L closed only when 75% or more of the fuel being supplied is liquid
- b75L closed only when less than 75% of the fuel being supplied is liquid

Figure 2—Fuel transfer device

4.2 Limit switches

LS designates a limit switch. This is a position switch that is actuated by a main device, such as a gate or valve, at or near its extreme end of travel. Its usual function is to open the circuit of the operating device, but it may also serve to give an indication that the main device has reached an extreme position of travel. The designations *ac*, *ao*, *bc*, and *bo*, given in Figure 1, are actually more descriptive for valve limit switches than such designations as LSC or LSO. Also, in the case of a fuel transfer device as covered in 4.1.2, designations such as a100G, b100G, a100L, and b100L are more descriptive than LS designations. In both cases they indicate whether the specific contact is an *a* contact or a *b* contact.

4.2.1 Auxiliary switches for circuit breaker operating mechanisms

For the mechanically trip-free mechanism of a circuit breaker:

- aa* Contact that is open when the operating mechanism of the main device is in the nonoperated position and that closes when the operating mechanism assumes the opposite position (sometimes called an “early a” contact)
- bb* Contact that is closed when the operating mechanism of the main device is in the nonoperated position and that opens when the operating mechanism assumes the opposite position (sometimes called an “early b” contact)

The part of the stroke at which the auxiliary switch changes position should, if necessary, be specified in the description. LC is used to designate the latch-checking switch of such a mechanism, which is closed when the mechanism linkage is re-latched after an opening operation of the circuit breaker.

4.3 Torque limit switches

This is a switch that is used to open an operating motor circuit at a desired torque limit at the extreme end of travel of a main device, such as a valve. It should be designated as follows:

- tqc* Torque limit switch, opened by a torque-responsive mechanism, that stops valve closing
- tqo* Torque limit switch, opened by a torque-responsive mechanism, that stops valve opening

4.4 Other switches

If several similar auxiliary, position, and limit switches are present on the same device, they should be designated with such supplementary numerical suffixes as 1, 2, 3, etc., when necessary.

4.5 Representation of device contacts on electrical diagrams

4.5.1 Contacts with defined reference position

On electrical diagrams, the *b* contacts of all devices as described in 4.1, 4.2, and 4.3, including those of relays and those with suffix letters or percentage figures, should be shown as closed contacts, and all *a* contacts should be shown as open contacts. The use of the single letters *a* and *b* with the contact representation is generally superfluous on the diagrams. However, these letters are a convenient means of reference in the text of instruction books, articles, and other publications (see Figure 3, Figure 4, and Figure 5, and IEEE Std 315™-1975 [B2] for representation of closed and open contacts on electrical diagrams).

4.5.2 Contact opening and closing settings

The opening and closing settings of the contacts and auxiliary, position, and limit switches, covered in 4.1, 4.2, and 4.3, should, when necessary for the ready understanding of the operation of the devices in the equipment, be indicated on the elementary diagram for each such contact. In the case of relay contacts, this indication would consist of the numerical settings; in the case of the switches, this indication would consist of a chart similar to those shown in Figure 1 and Figure 2, respectively.

4.5.3 Devices without a standard reference position

For those devices that have no de-energized or nonoperated position, such as manually-operated transfer or control switches (including those of the spring-return type), or auxiliary position indicating contacts on the housings or enclosures of a removable circuit breaker unit, the preferred method of representing these contacts is normally open. Each contact should, however, be identified on the elementary diagram as to

when it closes. For example, the contacts of the manual-automatic transfer switch, device 43, which are closed in the automatic position, would be identified with the letter A, and those that are closed in the manual position would be identified with the letter M; and the auxiliary position switches on the housing 52 TOC of a removable circuit breaker unit, which are open when the unit is not in the connected position, may be identified by

52TOC/a

and those that are closed when the unit is not in the connected position may be identified by

52TOC/b

as shown in IEEE Std C37.20.1™-2002 [B8].

In the case of latched-in or hand-reset relays, which operate from protective devices to perform the shutdown of a piece of equipment and hold it out of service, the contacts should preferably be shown in the normal, nonlockout position. In general, any devices, such as electrically-operated latched-in relays, which have no de-energized or nonoperated position and have not been specifically covered in the above paragraphs or under 4.1, should have their contacts shown in the position most suitable for the proper understanding of the operation of the devices in the equipment. Sufficient description should be present, as necessary, on the elementary diagram to indicate the contact operation.

4.5.4 Recommended representation of device functions and contacts on drawings

The typical elementary diagrams in Figure 3, Figure 4, and Figure 5 illustrate the recommended method of representing the contacts of typical devices on an elementary diagram. All other representations and features, except those specifically covered in other standards, are illustrative only and are not necessarily generally accepted practice or standard ratings.

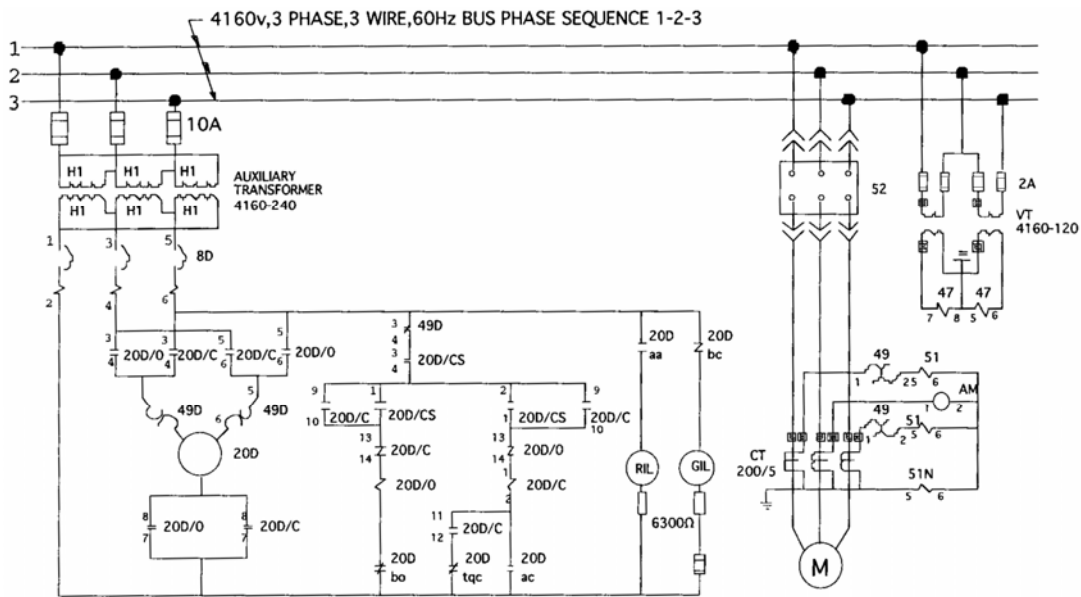


Figure 3—Typical AC elementary diagram

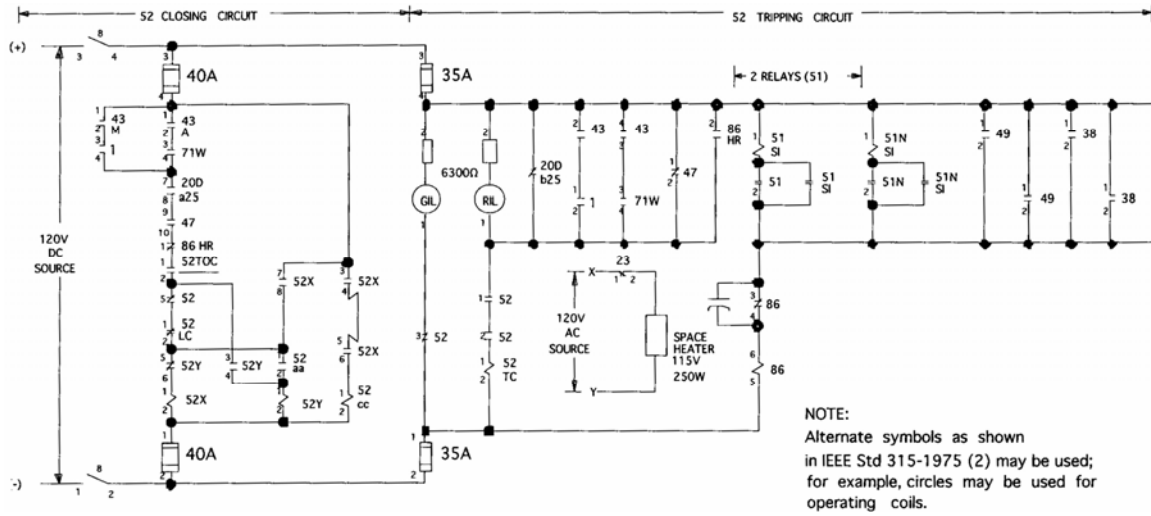


Figure 4—Typical DC elementary diagram—Independent trip and close fusing

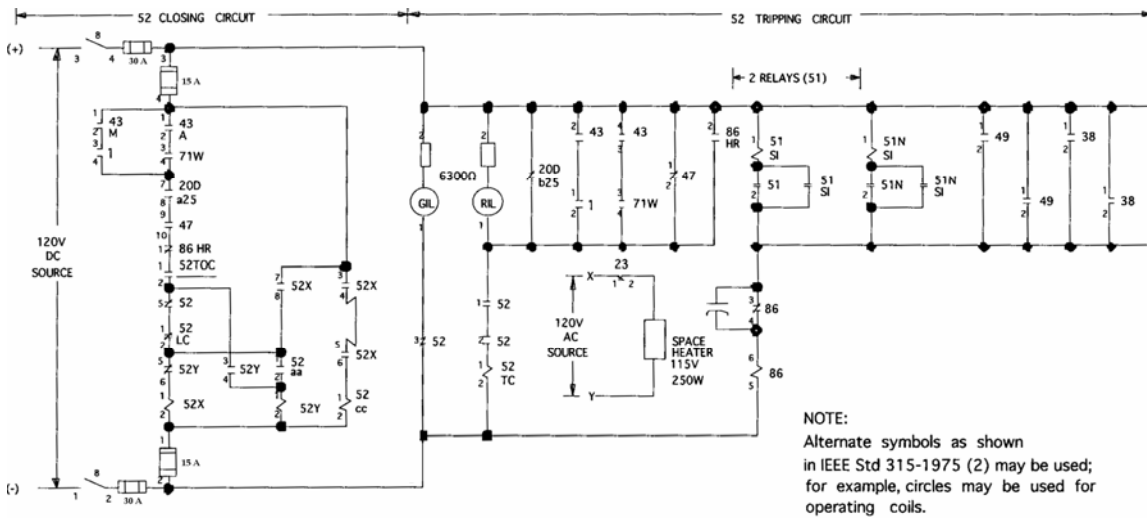


Figure 5—Typical DC elementary diagram with coordinated control fusing

Adapted from an IEEE Power System Relaying Committee Report “Relay Trip Circuit Design” [B9].

Annex A

(informative)

Device 11—Multi-function device representations

A.1 Introduction

Three commonly used representations of multi-function devices (such as protective relays) are shown for use on one-line meter relay and control diagrams. The user must determine which is best for the application. Recommended nomenclature for the multi-function relays are shown in these examples. No attempt is made to diagram the interconnection of the various elements inside the boxes in any of these methods, which can be very complex in modern multifunction devices. Disabling or enabling functions and software upgrades may require drafting changes.

In each of the three representation methods, 11L-xxxx is used where

- 11 denotes a multi-function device,
- L is the zone of protection: line (generator, bus, etc.),
- xxxx is the manufacturer's model designation

A.2 Device 11—First representation method—Empty box

The “empty box” method minimizes space requirements while showing all inputs and outputs from the relay. It does not require drafting changes when an element is removed or placed in-service or when a software upgrade adds additional capabilities. It does not give the user a visual indication of functions in use, but provides the relay model, which indicates function availability for those familiar with the relay model. See Figure A.1.

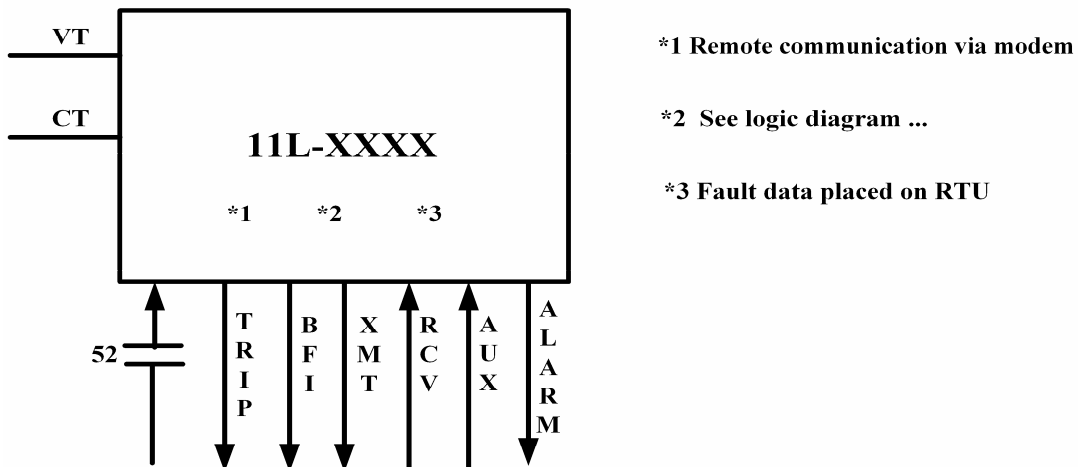
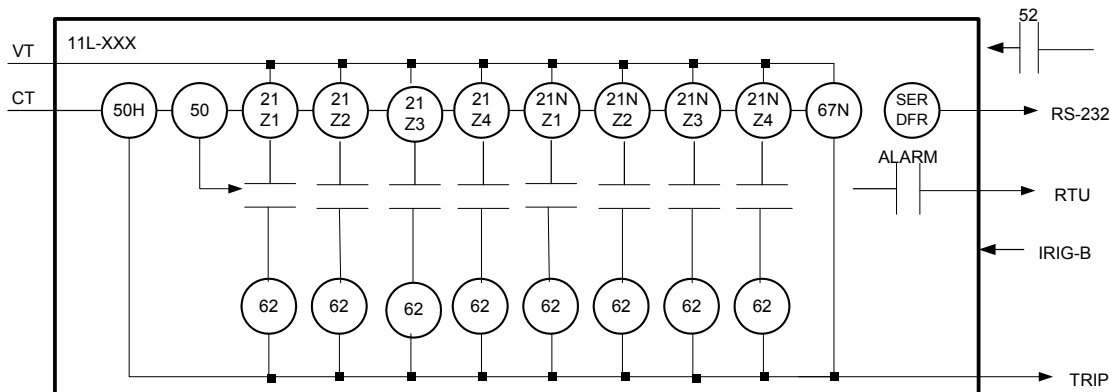


Figure A.1—Empty box method

A.3 Device 11—Second representation method—Filled box

The “filled box” method provides visual indication of the functions being used. Contiguous space requirements can become very large depending on functions in use. Disabling or enabling functions and software upgrades may require drafting changes. See Figure A.2.



21-Z1 through Z4	are the phase distance relays for zones 1 through 4
21N-Z1 through Z4	are the ground distance relays for zones 1 through 4
50H	is the high set instantaneous overcurrent relay
50	is the instantaneous overcurrent relay
62	is the time delay for tripping
67N	is the directional relay in neutral
SER/DFR	are the sequence of events recorder/digital fault recorder

Figure A.2—Filled box method

A.4 Device 11—Third representation method—List box

The “list box” method is a compromise between the **empty box** method, which forces the user of the diagram to go to other more detailed diagrams to determine what functions are provided in the protection and control system, and the **filled box** method, which can be cumbersome and difficult to generate. In the list box method, the functions in the multifunction device are simply listed. Figure A.3 is an example of the list box method as used in a highly integrated system. The zone of protection covered by this multifunction device 11 is line 1209. The line is connected to a breaker-and-a-half substation via bus breaker 108 and mid breaker 118. This device is the System A multifunction device for line 1209. There is also a System B multifunction device 11 on line 1209 as well, and it would have its own list box.

Shown in Figure A.3 are the major functions provided in this device for the protection, monitoring, and control of line 1209 and its associated breakers. It also shows how remote SCADA and local control is implemented in which specific device(s) (to maintain redundancy). Note that automatic reclosing (device 79) is implemented on a per-line basis and not on a per-breaker basis (otherwise it would have been listed as 79–108 and 79–118). The reclosing function is not redundant and thus does not have an A or B suffix. To maintain redundancy for the various close control functions, synch check (device 25) is redundant (it does have an A or B suffix). The binary I/O and communications connections (arrows on the right side of the box) are optional, and may be implied (not shown) to reduce the complexity of the diagram. XXXX is a placeholder for the manufacturer’s model number of this device 11.

Mid breaker 118 may also have a similar multifunction device 11 associated with the adjacent zone. It is important to know if common functions such as manual control, automatic reclosing, and breaker failure for breaker 118 also reside in that device. This is readily apparent using the list box method.

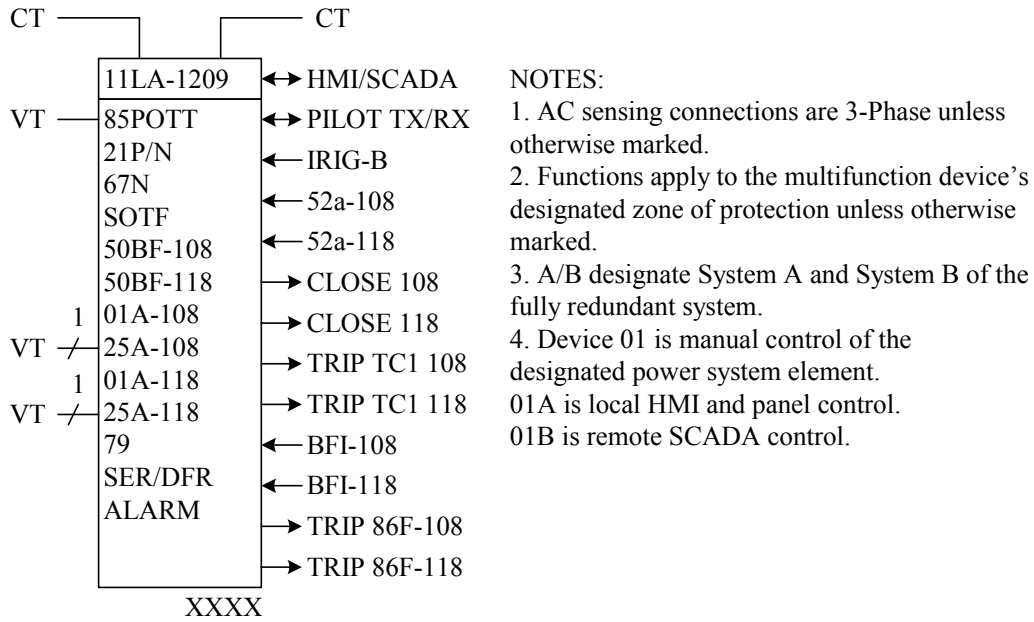


Figure A.3—List box method

Annex B

(informative)

Explanation of device 16 and its suffixes

In certain electric utility and industrial applications, data communications connections to protective relays are critical to the protection application. The data communications devices to which the relays connect are as important as auxiliary relays in protection system design and documentation.

For example, Ethernet local area networks (LANs) and wide area networks (WANs) are used for message transmission to carry out high-speed control and protection. A prime example for utilities is the use of IEC 61850 PART 8-1 [B1] GOOSE or GSSE messages in a substation Ethernet LAN environment to convey relaying element status, to provide interlocking, or to transmit a primary or backup trip command from one relay to another without conventional wiring. .

The Ethernet networks in substations are comprised of wired connections or fiber optic links, connecting protective relays and other IEDs in LANs based on managed Ethernet switches. The switch is, in fact, an elaborate message-processing computer with a list of settings that define how the protection messages are sent from one relay to another. Thus, Ethernet switches are the auxiliary relays for Ethernet-based protection and control systems. Furthermore, in some architectures, these substation LANs are connected to the utility enterprise WAN via Ethernet router(s) with broad functional capabilities and configuration settings. The configuration settings impact remote access to relays for monitoring, control, data collection, and wide-area protection, and are critical in the implementation of data communications security. See IEEE Std 1615™-2007 [B6] for more information.

Similarly, serial data communications devices are important for communicating with relays for fault data retrieval, settings access, configuration, and for condition monitoring as part of a formal maintenance program.

These suffixes can be combined to handle multifunctional networking devices as shown in the example figures on the following pages.

Figure B.1 shows four multifunctional microprocessor-based relays, each shown as device 11: Each of these relays has an RS-232 serial port. For integration of data communications, a substation might have the following:

- **16SS** – RS-232 serial switch. 16SS has a port through which a connected user can talk to the switch and request a connection to a particular end device—any one of the four relays shown as device 11 in the figure. The device performing the 16SS function may be a sophisticated communications processor with data storage, protocol translation, and information storage.
- **16SCT** – Encrypting modem. A conventional non-encrypting modem would be device 16ST, which depends on 16SS or 11 having a password for access security. Encryption provides strong cyber-security protection capability.

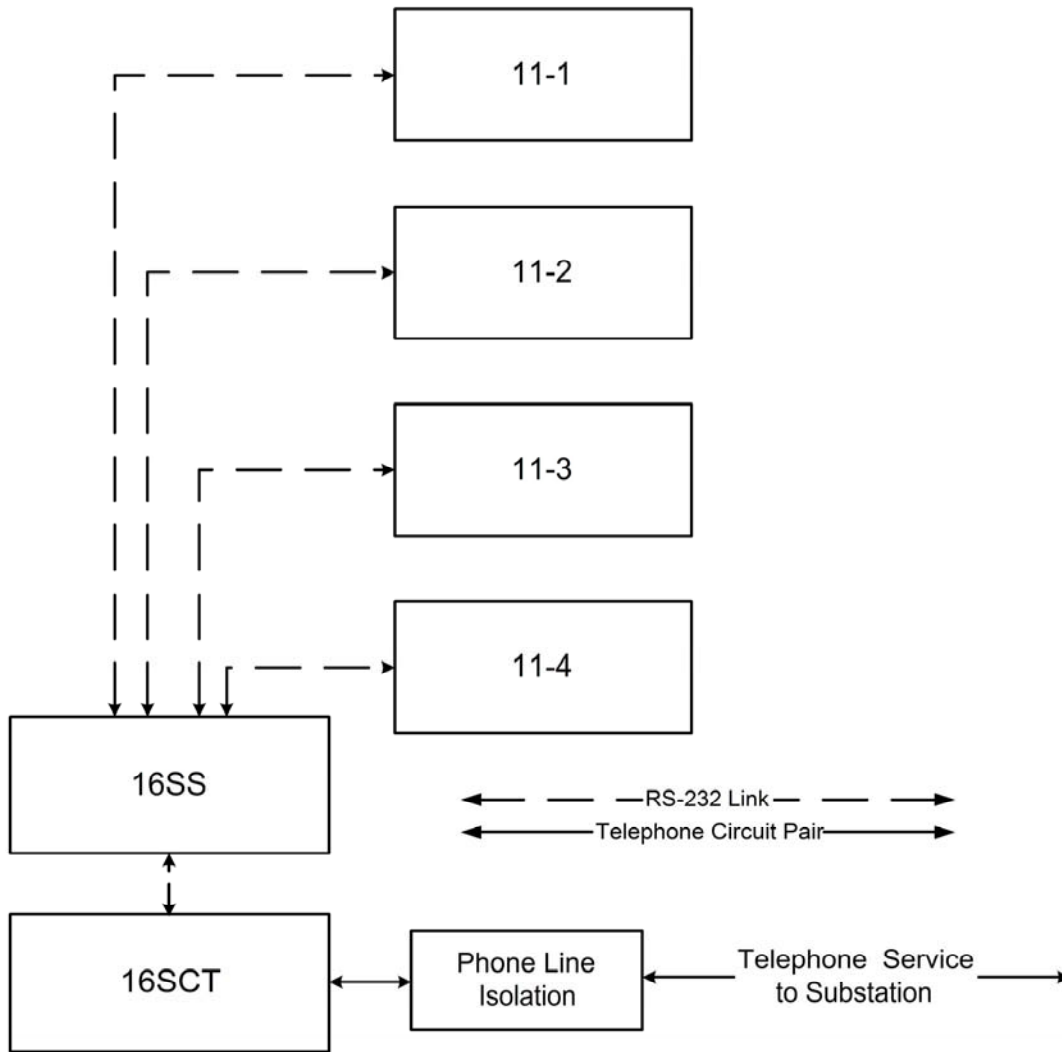


Figure B.1—Use of device 16 with protective relays and serial data communications

Figure B.2 shows an example of how the same group of relays might be integrated with an Ethernet LAN connected to the utility enterprise WAN. Each of the connections shown as one bidirectional arrow in Figure B.2 comprises a pair of noise-immune optical fibers for conveying Ethernet message packets in each direction. The communications components in Figure B.2 with device 16 designations are as follows:

- 16ESM – Ethernet managed switch. Each of the relay Ethernet network ports connects to a port on the Ethernet switch. The term “managed” refers to the fact that the switch operation itself can be monitored and controlled over the same network, and this is typically done from a remote location.
- 16ERFCM – Ethernet router, managed, with firewall and VPN for cyber-secured communications to the utility WAN.

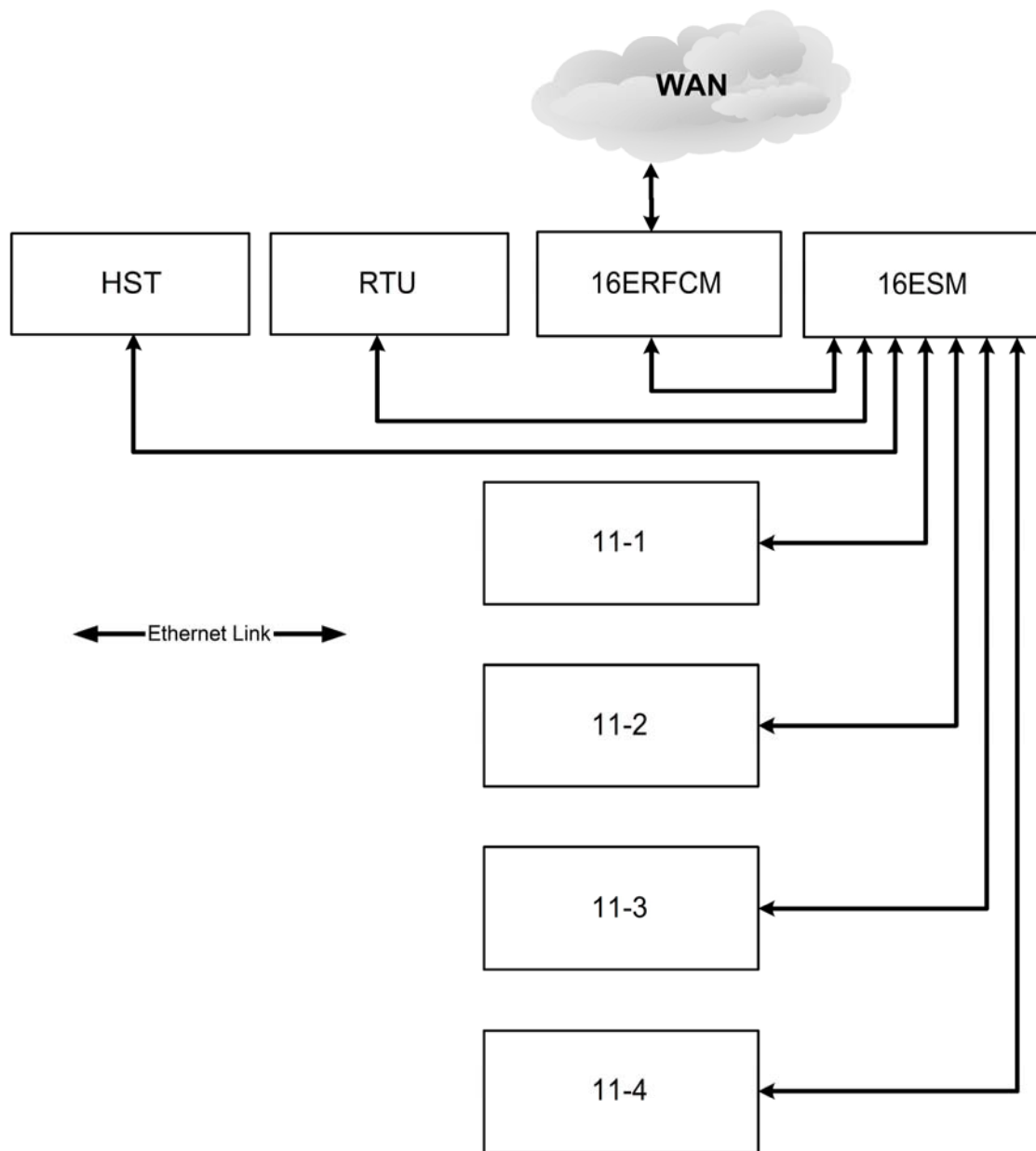


Figure B.2—Use of device 16 with protective relays and Ethernet data communications

Figure B.3 is an example of how dual redundant relays might be integrated with an Ethernet LAN connected to the utility enterprise WAN. Each of the linked Ethernet connections shown for System A and System B in Figure B.3 comprises a pair of noise-immune optical fibers for conveying Ethernet message packets in each direction. The communications components in Figure B.3 with device 16 designations are:

- 16ESM – Ethernet managed switch. The Ethernet network port of each device 11 relay is connected to its own port on an Ethernet switch. The term “managed” refers to the fact that the switch operation itself can be monitored and controlled over the same network, and this is typically done from a remote location.
- 16ERFCM – Ethernet router, managed, with firewall and VPN for cyber-secured communications to the utility WAN.

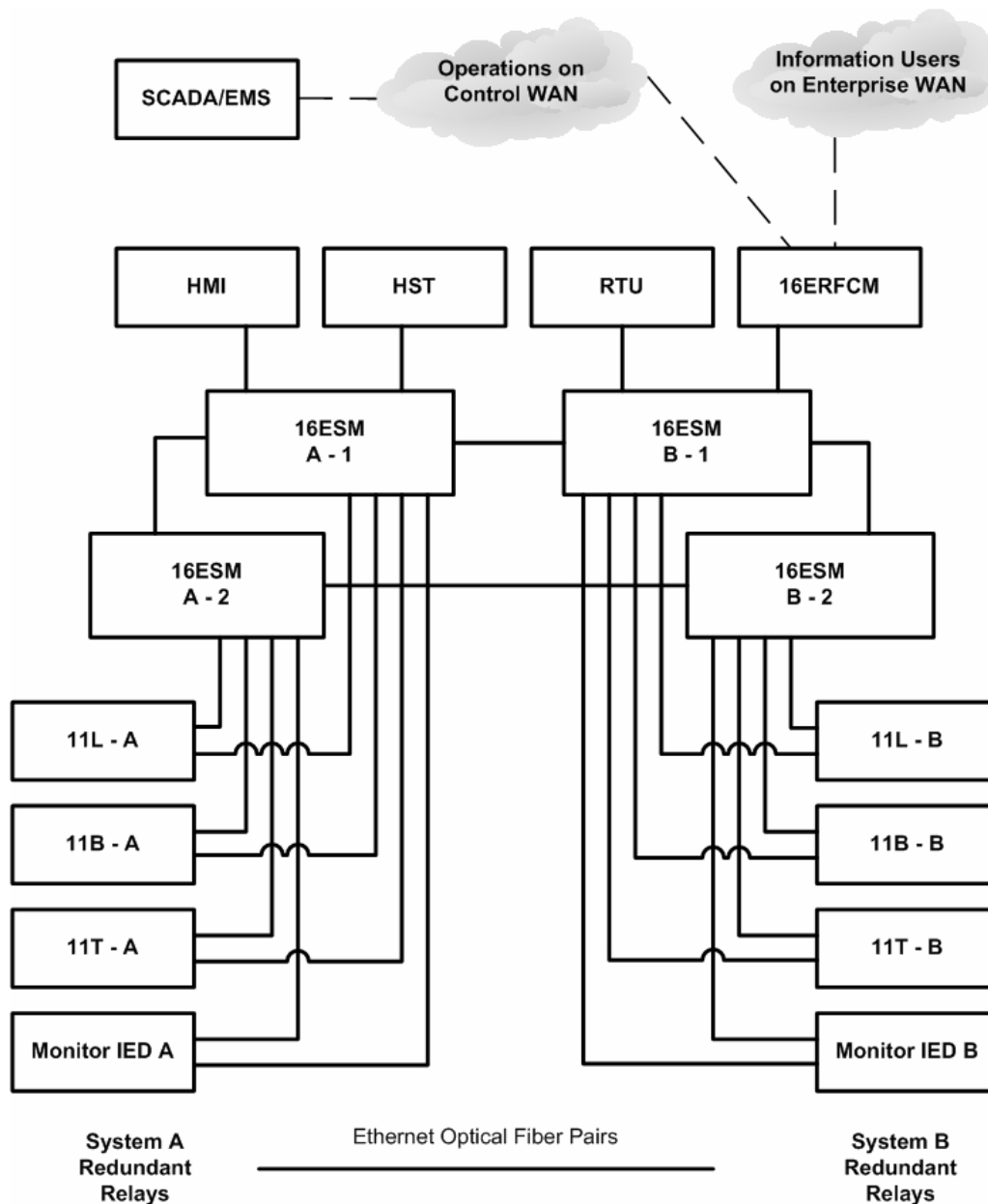


Figure B.3—Use of device 16 with dual redundant protective relays and redundant Ethernet networks

Annex C

(informative)

Device 64—Ground detector relay applications

Figure C.1, Figure C.2, Figure C.3, Figure C.4, Figure C.5, Figure C.6, and Figure C.7 are examples showing the preferred use of the suffixes N and G.

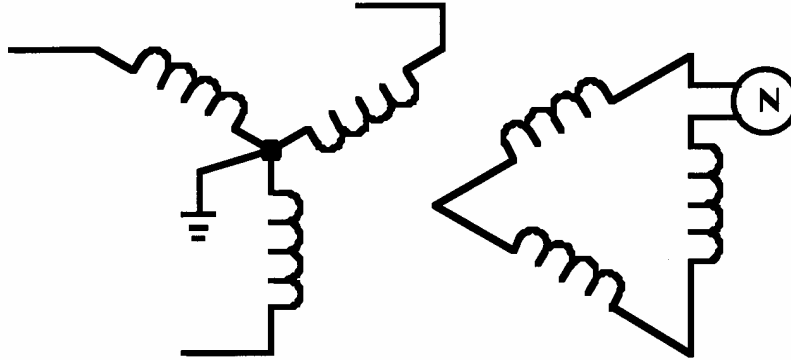
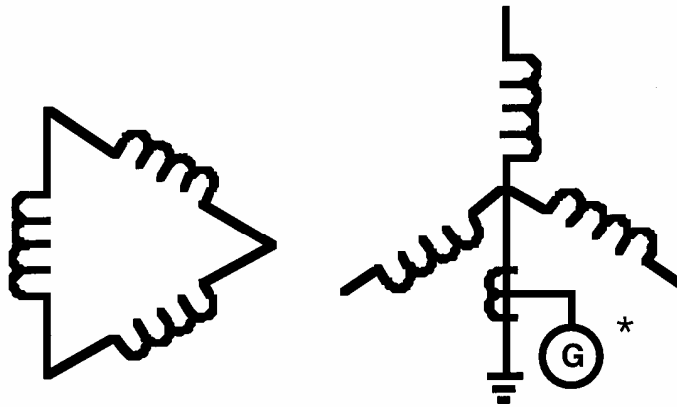


Figure C.1—Broken delta connection in VT secondary circuit



* While 'G' is preferred, past practice makes 'N' acceptable.

Figure C.2—Delta-wye transformer

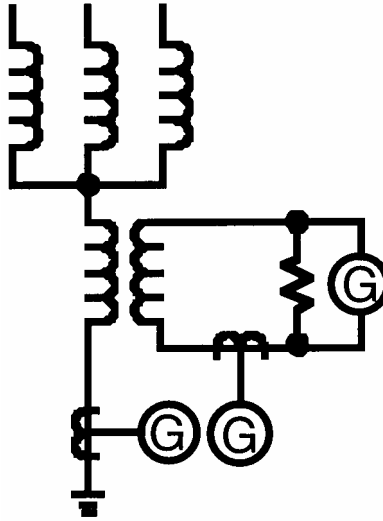


Figure C.3—Generator high-impedance ground

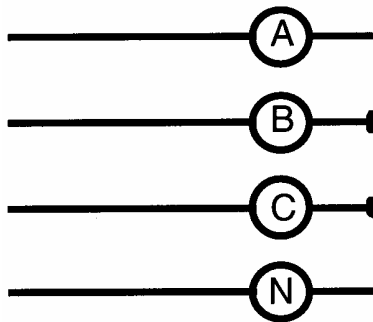


Figure C.4—Residual connection in CT secondary circuit (or internally derived by device)

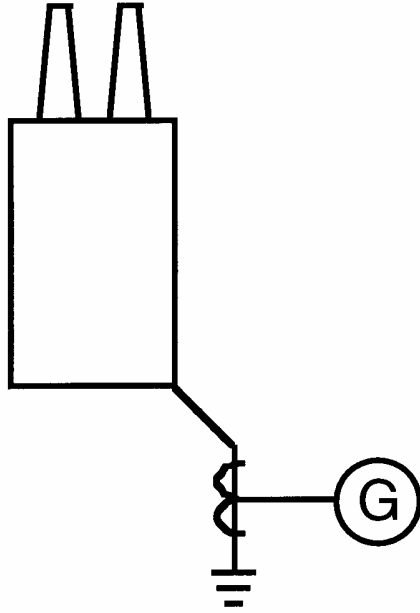


Figure C.5—Tank grounds (breaker, CT, etc.)

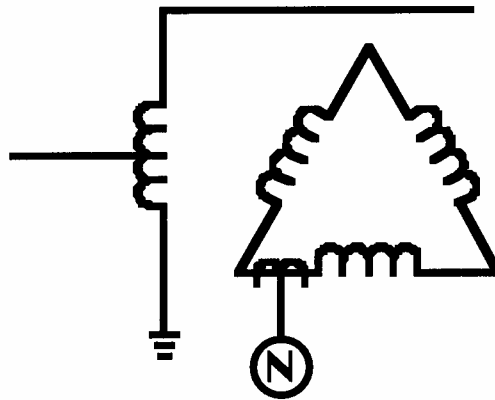


Figure C.6—Delta tertiary winding on autotransformer

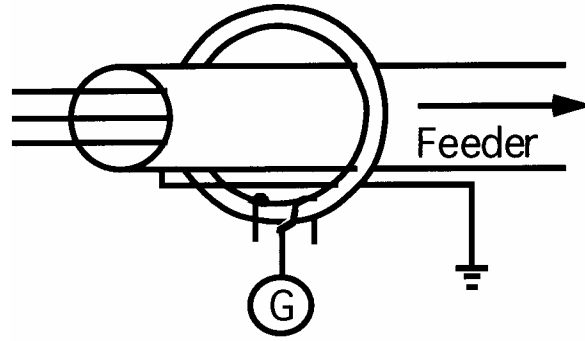


Figure C.7—Window (donut) current transformer

Annex D

(informative)

Relationship between IEEE C37.2 device function numbers and IEC 61850-7-4 logical nodes

Table D.1 shows the relationship between IEEE Std C37.2 device function numbers and IEC 61850-7-4 [B1] logical nodes.

Table D.1—Relationship between IEEE Std C37.2 device function numbers and IEC 61850-7-4 logical nodes

Functionality	IEEE Std C37.2 reference	Modeled in IEC 61850-7-4	Comments
Transient earth fault		PTEF	
Directional earth fault wattmetric protection		PSDE	Sensitive ground fault protection
Checking or interlocking relay	3	CILO	
Zero speed and under speed	14	PZSU	
Security processing function	16EC or 16SC		VPN, encryption module, etc.
Firewall	16EF		Or message filtering function
Network managed function	16EM		(e.g., configured via SNMP)
Router	16ER		
Switch	16ES or 16SS		Example: Ethernet switch is 16ES, dial-up port switch is 16SS
Ethernet managed switch	16ESM		
Ethernet router with firewall, VPN for secure communications	16ERFCM		See Annex B, Figure B.2
Serial encrypting modem	16SCT		See Annex B, Figure B.1
Other serial communications components	16ST		Example: 16ST = Auto-answer modem or telephone switch
Distance	21	PDIS PSCH	IEC uses one instance per zone to build line-protection schemes
Volts per Hz	24	PVPH	
Synchronism-check	25	RSYN	
(Time) Under voltage	27	PTUV	
Directional power/reverse power	32	PDOP or PDUP	Directional over power Directional underpower Reverse power modeled by PDOP plus additional mode “reverse”
Undercurrent/underpower	37	PTUC PDUP	Undercurrent Underpower
Loss of field/Under excitation	40	PDUP	Directional underpower

Functionality	IEEE Std C37.2 reference	Modeled in IEC 61850-7-4	Comments
Reverse phase or phase balance current	46	PTOC	Time overcurrent (PTOC) with three-phase information with sequence current as an input or even ratio of negative and positive sequence currents
Phase sequence voltage	47	PTOV	Three-phase information and processing
Motor start-up	49, 66 48, 51LR	PMRI PMSS	Motor restart inhibition Motor starting-time supervision
Thermal overload	49	PTTR	
Rotor thermal overload	49R	PTTR	Thermal overload
Stator thermal overload	49S	PTTR	Thermal overload
Instantaneous overcurrent or rate of rise	50	PIOC	
AC time overcurrent	51 (Inverse time) 50TD (Definite time)	PTOC	
Voltage controlled/dependent time overcurrent	51V	PVOC	
Circuit breaker	52	XCBR	
Power factor	55	POPF PUPF	Over power factor Under power factor
(Time) Over voltage	59	PTOV	Both for dc and ac
Voltage or current balance	60	PTOV PTUV	Over voltage or under voltage
Breaker failure protection	50BF or 62BF	RBRF	
Earth fault/ground detection	64	PHIZ	
Rotor earth fault	64R	PTOC	Time overcurrent
Stator earth fault	64S	PTOC	Time overcurrent
Inter-turn fault	64W	PTOC	Time overcurrent
AC directional overcurrent	67	PTOC	Time overcurrent
Directional earth fault	67G ^a	PTOC, RDIR	Time overcurrent
Power swing detection/blocking	68	RPSB	
DC overcurrent	76	PTOC	overcurrent for dc
Phase angle or out-of-step	78	PPAM	
AC auto reclosing	79	RREC	
Frequency	81	PTOF PTUF PFRC	Over frequency Under frequency Rate of change of frequency
DC load measuring reclosing	82		
Pilot communications, carrier, or pilot-wire relay	85		
Lockout relay	86		
Differential	87	PDIF	

Functionality	IEEE Std C37.2 reference	Modeled in IEC 61850-7-4	Comments
Phase comparison	87P	PDIF	
Differential line	87L	PDIF	
Restricted earth fault	87N	PDIF	
Differential transformer	87T	PDIF PHAR	Differential transformer Harmonic restraint
Differential bus bar	87B	PDIF or PDIR	Bus bar differential or Fault direction comparison
Motor differential	87M	PDIF	
Generator differential	87G	PDIF	
Circuit switcher, isolating switch	89	XSWI	
Directional element		RDIR	Directional element for modelling directed protection with Pxyz nodes
Arc flash detector	AFD		
Clock (or timing source in IEEE Std C37.2)	CLK	Clock	GPS or IRIG receiver
Non fault disturbance recording digital fault recording	DDR DFR	RDRE RADR RBDR	Basic functionality (IEC) Analogue channel (IEC) Binary channel (IEC)
Environmental data	ENV		Weather, ice, geomagnetic disturbances, earthquakes, etc.
Fault Locator		RFLO	Calculates the location of the fault
High impedance fault detector	HIZ		On grounded systems
Historian	HST		Stores data
Human machine interface	HMI		Displays for operator control
Logic, scheme	LGC		For interlocking or remedial action schemes
Substation metering	MET	MMTR, MMXU	Energy, amps, volts, watts, vars, power factor, demand
Phasor data concentrator	PDC		Assembles and forwards PMU data
Phasor measurement unit	PMU		Calculates and stores synchrophasors
Power quality monitor	PQM		RMS and frequency variations, transients, harmonics
Remote input/output device	RIO		Substation data repository
Remote terminal unit	RTU		Also serves as data concentrator
Router	16ER		
Sequence of events recorder	SER		Time tagged event data
Trip circuit monitor	TCM		

^a Per 3.5, “The suffix G is preferred where the measured quantity is in the path to ground, or in the case of ground fault detectors, is the current flowing to ground.”

Annex E

(informative)

Device index

This index lists the device/function names, their numbers or acronyms, and their corresponding clause numbers.

Device or function name	Device/Function number or acronym	Clause number
abnormal atmospheric condition monitor	45	3.1.45
ac circuit breaker	52	3.1.52
ac directional overcurrent relay	67	3.1.67
accelerating or decelerating device	18	3.1.18
arc flash detector	AFD	3.2.1
alarm relay	74	3.1.74
annunciator relay	30	3.1.30
apparatus thermal device	26	3.1.26
automatic selective control or transfer relay	83	3.1.83
auxiliary motor or motor generator	88	3.1.88
balance		
phase-balance current relay	46	3.1.46
voltage or current balance relay	60	3.1.60
bearing protective device	38	3.1.38
blocking or “out-of-step” relay	68	3.1.68
brush-operating or slip-ring short-circuiting device ⁷	35	3.1.35
carrier or pilot-wire relay	85	3.1.85
checking or interlocking relay	3	3.1.3
circuit breaker		
ac circuit breaker	52	3.1.52
dc circuit breaker	72	3.1.72
equalizing circuit breaker	22	3.1.22
field circuit breaker	41	3.1.41
running circuit breaker	42	3.1.42
starting circuit breaker	6	3.1.6
clock or timing source	CLK	3.2.2
contactor		
field-changing contactor	93	3.1.93
isolating contactor or switch	29	3.1.29
load-resistor contactor	73	3.1.73
master contactor	4	3.1.4
current		
voltage or current balance relay	60	3.1.60
directional overcurrent relay (ac)	67	3.1.67
instantaneous overcurrent relay	50	3.1.50
inverse time overcurrent relay (ac)	51	3.1.51
overcurrent relay (dc)	76	3.1.76

⁷ This function number is inactive for new projects or applications and may be reused in the next revision.

Device or Function name	Device/Function number or Acronym	Clause number
phase-balance current relay	46	3.1.46
reverse-phase current relay	46	3.1.46
time overcurrent relay (ac)	51	3.1.51
undercurrent or underpower relay	37	3.1.37
data concentrator/RTU	RTU	3.2.15
data communications device	16	3.1.16
dc circuit breaker	72	3.1.72
dc generator relay (see field excitation relay – 53)		
dc load-measuring reclosing relay	82	3.1.82
dc overcurrent relay	76	3.1.76
decelerating (or accelerating) device	18	3.1.18
density switch or sensor	61	3.1.61
differential protective relay	87	3.1.87
dynamic disturbance recorder	DDR	3.2.15
digital fault recorder	DFR	3.2.4
directional overcurrent relay (ac)	67	3.1.67
directional power relay	32	3.1.32
directional voltage relay	91	3.1.91
directional power and voltage relay	92	3.1.92
discharge or shunting switch	17	3.1.17
disconnecting device		
control power disconnecting device	8	3.1.8
distance relay	21	3.1.21
environmental data	ENV	3.2.5
equalizer circuit breaker	22	3.1.22
excitation		
field excitation relay	53	3.1.53
separate excitation device	31	3.1.31
field application relay	56	3.1.56
field -changing contactor	93	3.1.93
field circuit breaker	41	3.1.41
field relay	40	3.1.40
flame detector	28	3.1.28
flow switch	80	3.1.80
frequency or speed matching device	15	3.1.15
frequency relay	81	3.1.81
gear		
turning gear engaging device	54	3.1.54
governor	65	3.1.65
ground detector relay	64	3.1.64
grounding or short-circuiting device	57	3.1.57
hertz (also see frequency)		
volts per Hertz relay	24	3.1.24
high impedance fault detector	HIZ	3.2.6
historian	HST	3.2.8
human machine interface	HMI	3.2.7
incomplete sequence relay	48	3.1.48
instantaneous overcurrent relay	50	3.1.50
interlocking or checking relay	3	3.1.3
isolating contactor or switch	29	3.1.29

Device or Function name	Device/Function number or Acronym	Clause number
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line switch	89	3.1.89
load-measuring reclosing relay (dc)	82	3.1.82
load-resistor contactor	73	3.1.73
lockout relay	86	3.1.86
machine or transformer thermal relay	49	3.1.49
master contactor	4	3.1.4
master element	1	3.1.1
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mechanism		
operating mechanism	84	3.1.84
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liquid level switch	71	3.1.71
mechanical condition monitor	39	3.1.39
pressure switch	63	3.1.63
multifunction device	11	3.1.11
notching or jogging device	66	3.1.66
opening		
time-delay opening or stopping relay	62	3.1.62
operating mechanism	84	3.1.84
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phase-balance or reverse-phase current relay	46	3.1.46
phase-balance or phase-sequence voltage relay	47	3.1.47
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phasor measurement unit	PMU	3.2.12
power quality monitor	PQM	3.2.13
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position changing mechanism	75	3.1.75
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power factor relay	55	3.1.55
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pressure switch	63	3.1.63
rate-of-change		

Device or Function name	Device/Function number or Acronym	Clause number
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frequency relay (and rate-of-change)	81	3.1.81
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pressure switch (and rate-of-change)	63	3.1.63
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dc load-measuring reclosing relay	82	3.1.82
ac reclosing relay	79	3.1.79
rectification failure relay	58	3.1.58
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remote terminal unit/data concentrator	RTU	3.2.15
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load-resistor contactor	73	3.1.73
rheostat	70	3.1.70
reversing device	9	3.1.9
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selector		
manual selector or transfer device	43	3.1.43
automatic selective control or transfer relay	83	3.1.83
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unit sequence switch	10	3.1.10
master sequence device	34	3.1.34
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accelerating or decelerating device	18	3.1.18
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stopping device	5	3.1.5
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switch		
discharge or shunting switch	17	3.1.17
flow switch	80	3.1.80
isolating contactor or switch	29	3.1.29

Device or Function name	Device/Function number or Acronym	Clause number
liquid level switch	71	3.1.71
line switch	89	3.1.89
position switch	33	3.1.33
pressure switch	63	3.1.63
shunting or discharge switch	17	3.1.17
unit sequence switch	10	3.1.10
synchronizing or synchronism-check relay	25	3.1.25
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temperature control device	23	3.1.23
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time-delay stopping or opening relay	62	3.1.62
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undercurrent or underpower relay	37	3.1.37
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Annex F

(informative)

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