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IEEE Recommended Definitions of Terms for Automatic Generation Control on Electric Power Systems

Sponsor
**Power System Engineering Committee
of the
IEEE Power Engineering Society**

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IEEE Standards Board

Abstract: Commonly used terminology in the field of automatic generation control is defined for reference purposes. Control terms not specific to automatic generation control are not included.
Keywords: Terminology, definitions, control, electric power systems

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Foreword

(This Foreword is not part of IEEE Std 94-1991, IEEE Recommended Definitions of Terms for Automatic Generation Control on Electric Power Systems.)

The need for standard terminology in the field of automatic generation control (AGC) became apparent when it was noted that authors of technical papers covering this technology frequently used different terms to convey identical meanings. This inconsistency of terms and requests for standardization from operating organizations of interconnected power systems in both the United States and Canada led to the original development of these definitions. They were first published in 1965 after three years of work by the System Control Subcommittee of the Power System Engineering Committee of the IEEE Power Engineering Society. The first revision occurred in 1970.

This publication is the second revision of these terms. It illustrates the continuing need to standardize commonly used terminology unique to AGC. However, this publication does not include standard control terms not specific to AGC. In addition, term definitions are intended principally as references, not as tutorial substitutes for training in this control field. The definitions provide simplified, unambiguous meanings for individuals having a basic understanding of AGC technology.

Revision of this standard, as in the past, is expected to be a continuing process. As power system operations change and AGC technology improves to keep pace, new terms or the possibility of modifying existing ones remains a practical need. The System Control Subcommittee recognizes the reality of this situation and will keep its task force intact to address these needs. Suggestions for improvement to this standard by all interested parties are encouraged. These suggestions should be sent to the Secretary, IEEE Standards Board, as shown on the previous page.

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IEEE Recommended Definitions of Terms for Automatic Generation Control on Electric Power Systems

ACE. *See:* area control error.

AGC. *See:* automatic generation control.

area assist action. A control feature that bypasses economic control and that controls all available units while the area control error violates a preset limit.

area control error (ACE). A quantity reflecting the deficiency or excess of power within a control area.

automatic generation control (AGC). Any supplementary control that automatically adjusts the power output levels of electric generators within a control area. Automatic generation control schemes can include one or more control subsystem(s) such as load frequency control, economic dispatch control, environmental dispatch control, security dispatch control, and the like.

base load control. For an electric generating unit or station, a mode of operation in which the unit or station generation is held constant.

biased scheduled net interchange. The scheduled net interchange power plus the algebraic sum of frequency bias, time-error bias, and other control-area biases.

camshaft position. The angular position of the main shaft directly operating the governor-controlled valves.

command control. An automatic generation control methodology that reduces unit control error irrespective of area control error.

constant-frequency control. For a power system, a mode of operation under load-frequency control in which the area control error is directly proportional to the frequency error.

constant-net-interchange control. For a power system, a mode of operation under load-frequency control in which the area control error is proportional to the net interchange error.

control area. A power system, a part of a power system, or a combination of several power systems under common control for which a single area control error is defined.

control metering point. The actual or equivalent location of power flow measurement on an area tie line.

derivative control action. A control mode designed to provide a controller output proportional to the rate of change of the input.

economic dispatch. The optimization of the incremental cost of delivered power by allocating generating requirements among the on-control units with consideration of such factors as incremental generating costs and incremental transmission losses.

economic dispatch control (ED). An automatic generation control subsystem designed to allocate unit generation to minimize the incremental cost of delivered power.

ED. *See:* economic dispatch control.

energy metering point. For a tie line, the actual or equivalent location of a power flow measurement that is integrated to produce an energy transfer value.

environmental dispatch control. An automatic generation control subsystem that allocates unit generation levels within a control area based upon environmental considerations.

frequency bias. An offset of the scheduled net interchange that varies with frequency error.

frequency bias setting. A coefficient that, when multiplied by frequency error, yields the frequency bias component of the area control error.

frequency error. System frequency minus the scheduled frequency.

frequency standard. A device that produces a standard frequency.

frequency-response characteristic. The sum of an area's generation-frequency and load-frequency characteristics.

generation-frequency characteristic. The change in area generation of a utility or of a control area through governor action that results from a change in system frequency without supplementary control action.

governor speed changer. A device that adjusts the speed or power output of the turbine during operation.

governor-controlled gates (on a hydro turbine). Gates that control the power input to the turbine and that are actuated by the speed governor directly or through the medium of the speed-control mechanism.

governor-controlled valves (on a steam turbine). Valves that control the power input to the turbine and that are actuated by the speed governor directly or through the medium of the speed-control mechanism.

gross generation. The generated output power at the terminals of the generator.

inadvertent interchange energy. The time integral of a control area's net interchange error.

incremental cost of delivered power. The additional per-unit cost incurred when supplying another increment of power.

incremental cost of reference power. The additional per-unit cost incurred when supplying another increment of power to a designated reference point on a transmission system.

incremental delivered power. The percent of an increment of power delivered from a source to any specific point, such as the system load.

incremental generating cost. The additional cost of producing an increment of generation divided by the increment of generation.

incremental heat rate. For a steam turbine-generator unit, the rate of a change in heat input per unit of time to the corresponding change in power output.

incremental maintenance cost. The additional cost for maintenance per increment of power incurred by changing generation level.

incremental transmission loss. The change in power loss incurred when power flow within the transmission network is changed and/or redistributed.

incremental water rate. For a hydro turbine-generator unit, the ratio of a change in water input at a constant per unit of time (at a constant net head) to the corresponding change in power output.

integral control action. A control mode designated to provide a controlled output proportional to the time integral of the input.

interconnected system. Two or more power systems connected by transmission facilities.

lambda (λ). See: system incremental cost.

LFC. See: load frequency control.

load frequency control (LFC). An automatic generation control subsystem that changes control area generation in response to an area control error.

load limit changer. A device on the speed-governing system that prevents the governor-controlled valves from opening beyond a preset limit.

load-frequency characteristic. The change in power requirements of a control-area load

that is caused by a change in system frequency.

master controller. The central device that develops corrective action for execution at one or more generating units.

measurement devices. For an automatic control system, a device that measures physical and electrical quantities.

net generation. Gross generation minus station service or unit service power requirements.

net interchange. The algebraic sum of the power on the tie lines of a control area.

net interchange error. The net actual interchange power minus the scheduled net interchange.

nonconforming load. A load that has characteristics dissimilar to those of the system load and that, depending on the modeling and/or control methodologies, may require special treatment.

penalty factor. A factor that produces the incremental cost of delivered power from a source when multiplied by the incremental cost of power at the source. Mathematically, it is:

$$\frac{1}{(1 - \text{incremental transmission loss})^*}$$

* Expressed as a decimal.

permissible response rate. (A) *steam-generating unit.* The maximum allowable rate of change of generation under load control, which is based on the limitations of the turbine, boiler, combustion control, and/or auxiliary equipment. (B) *hydro-generating unit.* The maximum allowable rate of change of generation under load-control, which is based on the limitations of the water column, piping, turbine, and/or auxiliary equipment.

permissive control. An automatic generation control methodology that reduces generating unit control error only when unit change will reduce area control error.

power system. The generation resources and/or transmission facilities operated as an entity to meet load and/or interchange commitments.

proportional control action. A control mode designed to provide a linear relationship between the controller output and input, assuming both are within normal range.

rated frequency. (A) The frequency used in the specification of apparatus upon which test conditions and frequency limits are based. (B) The system frequency at which a power system normally operates.

regulating range. That range of power output within which a generating unit is permitted to respond to load frequency control.

scheduled frequency offset. Scheduled system frequency minus rated frequency. This offset is usually initiated to correct the system time error.

scheduled net interchange. The net power flow that a control area strives to maintain on its area tie lines in the absence of control biases.

scheduled system frequency. The frequency that a power system or an interconnected system attempts to maintain.

security dispatch control. An automatic generation control subsystem that allocates unit generation levels within a control area based upon system security considerations.

speed governor. A device that varies the governor-controlled valves to adjust energy input levels to maintain a uniform speed of a rotating machine.

speed-control mechanism. All equipment such as relays, servomotors, pressure or power-amplifying devices, levers, and linkages between the speed governor and the governor-controlled valves.

speed-governing system. The control system used to maintain the rotational speed of a

- turbine-generator unit. The system consists of the speed governor, the speed-control mechanism, and the governor-controlled valves on a steam turbine or gates on a hydro turbine.
- standard frequency.** A precise frequency source used as a frequency reference.
- station service power.** The power used to operate a station.
- station-control error.** The actual station generation minus assigned station generation.
- steady-state speed regulation (straight condensing and noncondensing steam turbines, nonautomatic extraction turbines, hydro turbines, and gas turbines).** The percent change in rated speed as the power output is gradually reduced from rated power to zero while all speed-governing system settings remain unchanged.
- supplementary control.** Any control action that is superimposed upon normal governor action.
- system frequency.** The prevailing frequency in hertz (Hz) of the alternating current and voltage throughout a power system.
- system incremental cost.** The additional cost of delivering another megawatt of power to the load center. This cost is commonly called lambda (λ).
- tie line.** A transmission line connecting two power systems.
- tie point.** The location of the switching facilities of a tie line.
- tie-line bias control.** A mode of load-frequency control in which the area control error is a function of the net interchange error and frequency related biases.
- IEEE RECOMMENDED DEFINITIONS OF TERMS FOR
- time bias setting.** A coefficient that, when multiplied by time error, yields time error bias.
- time error.** Power system time minus a reference time. This quantity is derived by integrating frequency error over time and dividing it by rated frequency.
- time error bias.** An offset of the scheduled net interchange of a control area that varies in proportion to time error and that assists in restoring time error to zero.
- transmission-loss coefficients.** Mathematically derived constants to be combined with source powers to provide incremental transmission losses from each source to the composite system load. These coefficients may also be used to calculate total system transmission losses.
- unit rate limiting controller.** A controller that limits rate of change of generation of a generating unit to an assigned value or values.
- unit service power.** The power used to operate a unit.
- unit-control error.** The unit generation minus assigned unit generation.
- valve point.** A camshaft (turbine input valve control mechanism) position at which point one of the turbine input valves is fully or near fully open and the next valve remains closed.
- valve point loading.** An economic control strategy that dispatches generation based on minimizing production costs by considering the effects of turbine input valve points on incremental heat rate.
- valve-point loading control.** A control means for making a unit operate in the more efficient portions of the range of the governor-controlled valves.

Table 1
Index of Nonstandard Terms

Nonstandard Terms	Standard Terms
Area requirement	Area control error
Base frequency	Scheduled system frequency
"B" or transmission loss constants	Transmission-loss coefficients
Economic loading	Economic dispatch
Feedback control system	Closed-loop control system
Flat frequency control	Constant-frequency control
Flat tie-line control	Constant-net-interchange control
Fringe control action	Proportional control action
Holding load	Base load control
Incremental production cost	Incremental generating cost
Mandatory control	Command control
Speed droop	Steady-state speed regulation
Station requirement	Station-control error
Sustained control action	Integral control action
Synchronizing device	Governor speed changer
System deviation	Area control error
Time deviation	Time error
Unintentional interchange	Inadvertent interchange energy
Unit requirement	Unit-control error