IEEE Standard Dictionary of Electrical and Electronics Terms

Frank Jay
Editor in Chief

An American National Standard

Approved July 20, 1984

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Third Edition

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Third Edition

IEEE Standard Dictionary of Electrical and Electronics Terms

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Introduction

From their earliest years, both the American Institute of Electrical Engineering (AIEE) (1884) and the Institute of Radio Engineers (IRE) (1912) published standards defining technical terms. They have maintained this practice since they were combined in 1963 to become the IEEE (Institute of Electrical and Electronics Engineers).

In 1928 the AIEE organized Sectional Committee C42 on Definitions of Electrical Terms under the procedures of the American Standards Association, now the American National Standards Institute. In 1941 AIEE published its first edition of *American Standard Definitions of Electrical Terms* in a single volume. However, by the time a second edition was ready, the highly accelerated development of new terms made it impracticable to publish in a single volume, and 17 separate documents, each limited to a specific field, were published from 1956 to 1959.

Over the years, IRE published a large number of standards that either included definitions or were devoted entirely to definitions. In 1961 it published all of its then-approved definitions in an alphabetically arranged single volume.

The 1972 edition of the IEEE Standard Dictionary of Electrical and Electronics Terms included all terms and definitions that had been standardized previously by IEEE, as well as many American National Standards and IEC terms. The 1977 edition derived the bulk of its new definitions from standards published between 1968 and 1977. Most of the definitions that were continued from the 1972 and 1977 editions have been reaffirmed because of their inherent usefulness. The committees responsible for the definitions originally, still consider them to be equally appropriate at the present time.

The current 1984 edition includes terms from Standards generated since 1977.

Acknowledgements

The 1984 IEEE Dictionary was produced almost completely by electronic means. The Secretariat of the Standards Coordinating Committee 10 (Terminology) is grateful for the assistance of the Purdue University School of Electrical Engineering and of Dr. Benjamin J. Leon who pointed us in the direction of automation originally. We wish also to thank Dr. Melvin Ferentz, Director of Computer Services at Rockefeller University, and Arden Phillips who maintained our data base, along with Dr. Banvir Chaudhary, Dr. Armand Gazes, and Elizabeth Gores.

We also acknowledge the conscientious efforts of Alan J. Eisenberg, Assistant Editor, the Standards Publication Department, and Jack Goetz, Acting Chairman of SCC 10.

We appreciate as well the good work of our typesetter, Black Dot, and the services of its representatives R. Ricci, A. McGurn, and S. Nardulli.

How to Use This Dictionary

The terms defined in this dictionary are listed in alphabetical order. Terms made up of more than two words appear in the order most familiar to the people who use them. In some cases cross-references are given.

Some terms take on different meanings in different fields. When this happens the different definitions are numbered, identified as to area of origin, coded, and listed under the main entry.

If a reader wants to know the source of a definition he need only look up the code number following the definition in the SOURCES section that appears at the back of the book between pages 1035 and 1039.

Foreword

It is globally realized that energy-deficient regions are weak regions. One of the primary concerns of the last decade has, therefore, been the development of energy sources other than oil. The enormous potential of nuclear power generation is being supplemented by a return on a large scale to coal as a primary source of energy. In the nuclear field considerable research has resulted in the development of standards dealing with the use of late model computer systems being used now in conjunction with instrumentation, control, and quality assurance guidelines.

The widespread use of coal, unfortunately, has produced the phenomenon known as "acid rain", destructive of biosystems. It will be necessary to eliminate this unwelcome after-effect in the very near future, and to that end research is going forward.

Coal, a derivative of the photosynthesis process, represents only one aspect of solar power. Although wind and water have long been used as energy sources, current interest centers on solar-heat collection panels, and conversion of the sun's power directly into electricity through the sophistications of photovoltaics.

Major advances have been made also, in many other areas of interest to those who will use this book. In the field of communications, the United States has seen a major restructuring of the telephone industry. Fiber optics have been replacing the slower, more expensive copper-wire circuits. In-plant microwave radio is being used to bypass the traditional suppliers of telephone services, and large privately-owned or community-sponsored dish antennas are being installed to pull program signals out of satellites.

If it is accurate to say that every era gets its own appropriate tag, then surely the present decade should be called the age of information. Semiconductor memory has increased hugely on tinier and tinier silicon chips. Miniaturization has advanced to such a point that a slim hand-held calculator of the 1980's can perform the functions that would have taken a large roomful of vacuum tubes to perform less than twenty years ago. In addition, the phenomenon of computer games has come and run its course. Children of the 1980's, unimpressed by what looks like magic to their parents, are growing up with hands-on computer experience from the nursery onward. Computer software has become increasingly complex, and a new form of data burglary has evolved in which "computer hackers" have worked out techniques that enable them to ramble almost at will through classified files of research institutions, business, and government.

In medical research, diagnostic tools such as the CT scanner, known commonly as the "cat scanner" and the nuclear magnetic resonance scanner, called the "N.M.R." have made it possible to scrutinize the interior of the human body and identify anomalies that in the past might have resulted in incorrect diagnoses.

Knowledge continues to multiply, and the IEEE Dictionary continues trying to keep its readers abreast of the necessary new nomenclature.

Just as Cervante's mad old knight, Don Quixote, stood between the phantasmagorical Middle Ages and the practical realities of the Earth-centered Renaissance, so we stand trying to capture the new semi-mystical languages of our time, with one foot on a file case of 3 x 5 index cards and the other on a floppy disk.

F.J.

List of Contributing Engineers

The following list is made up of the names of engineers who, over the years, have chaired the many committees that have generated standards. To a large extent the definitions in this compilation come from those standards.

IEEE has profound appreciation for the work that these people so willingly undertook and so carefully fulfilled.

We regret that the limitations of space do not allow us to list the names of the thousands of committee-and subcommittee members without whose painstaking efforts this dictionary would never have been possible.

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York, J. W.
Younkin, G. W.

Zucker, M.

A

aa auxiliary switch. *See:* **auxiliary switch; aa contact.** 103

aa contact (power switchgear). A contact that is open when the operating mechanism of the main device is in the standard reference position and that is closed when the operating mechanism is in the opposite position. 103

***A* and *R* display (radar).** An *A* display, any portion of which may be expanded. *See:* **navigation.** 13

***a* auxiliary switch.** *See:* **auxiliary switch; a contact.** 103

abampere. The unit of current in the centimeter-gram-second (cgs) electromagnetic system. The abampere is 10 amperes. 172

abandoned call (telephone switching systems). A call during which the calling station goes on-hook prior to its being answered. 55

***A* battery.** A battery designed or employed to furnish current to heat the filaments of the tubes in a vacuum-tube circuit. *See:* **battery (primary or secondary).** 328

abbreviated dialing (telephone switching systems). A feature permitting the establishment of a call with an input of fewer digits than required under the numbering plan. 55

abbreviation. A shortened form of a word or expression. *See:* **functional designation; graphic symbol; letter combination; mathematical symbol; reference designation; symbol for a quantity; symbol for a unit.** 173

abnormal decay (charge-storage tubes). The dynamic decay of multiply-written, superimposed (integrated) signals whose total output amplitude changes at a rate distinctly different from that of an equivalent singly-written signal. *Note:* Abnormal decay is usually very much slower than normal decay and is observed in bombardment-induced conductivity type of tubes. *See:* **charge-storage tube.** 174

abnormal glow discharge (gas tube). The glow discharge characterized by the fact that the working voltage increases as the current increases. *See:* **discharge.** 175

abort (software). To terminate a process prior to completion. *See:* **process.** 434

ABS (cable systems in power generating stations). Conduit fabricated from Acrylonitrile-Butadiene-Styrene. 35

absolute accuracy. Accuracy as measured from a reference that must be specified. 224, 207

absolute address (computing machines). (1) An address that is assigned by the machine designer to a physical storage location. (2) A pattern of characters that identifies a unique storage location without further modification. *See:* **machine address.** 255, 77

absolute altimeter (electronic navigation). A device that measures altitude above local terrain. 13, 187

absolute block (automatic train control). A block governed by the principle that no train shall be permitted to enter the block while it is occupied by another train. 328

absolute capacitivity (absolute dielectric constant) (permittivity). Of a homogeneous, isotropic, insulating material or medium, in any system of units, the product of its relative capacitivity and the electric constant appropriate to that system of units. *See:* **electric constant.** 210

absolute delay (loran). The interval of time between the transmission of a signal from the master station and transmission of the next signal from the slave station. *See:* **navigation.** 13, 187

absolute dielectric constant. *See:* **absolute capacitivity.**

absolute dimension. A dimension expressed with respect to the initial zero point of a coordinate axis. *See:* **coordinate dimension word.** 224, 207

absolute error. (1) The amount of error expressed in the same units as the quantity containing the error. (2) Loosely, the absolute value of the error, that is, the magnitude of the error without regard to algebraic sign. 255, 77, 54

absolute gain. *See:* **gain.** 111

absolute luminance threshold (illuminating engineering). Luminance threshold for a bright object like a disk on a totally dark background. 167

absolute machine code (software). Machine language code that must be loaded into fixed storage locations at each use and may not be relocated. *See:* **machine language code; relocatable machine code.** 434

absolute measurement (system of units). Measurement in which the comparison is directly with quantities whose units are basic units of the system. *Notes:* (1) For example, the measurement of speed by measurements of distance and time is an absolute measurement, but the measurement of speed by a speedometer is not an absolute measurement. (2) The word absolute implies nothing about precision or accuracy. 210

absolute permissive block (automatic train control). A term used for an automatic block signal system on a track signaled in both directions. For opposing movements the block is from siding to siding and the signals governing entrance to this block indicate STOP. For following movements the section between sidings is divided into two or more blocks and train movements into these blocks, except the first one, are governed by intermediate signals usually displaying STOP: then proceed at restricted speed, as their most restrictive indication. 328

absolute photocathode spectral response (diode-type camera tube). The ratio of the photocathode current, measured in amperes, to the radiant power incident on the photocathode face, measured in watts, as a function of the photon energy, frequency, or wavelength. Units: amperes watt^{-1} (A W^{-1}). 380

absolute refractory state (medical electronics). The

portion of the electrical recovery cycle during which a biological system will not respond to an electric stimulus. 192

absolute steady-state deviation (control). The numerical difference between the ideal value and the final value of the directly controlled variable (or another variable if specified). *See:* **deviation (control); percent steady-state deviation.** 219, 206

absolute system deviation (control). At any given point on the time response, the numerical difference between the ideal value and the instantaneous value of the directly controlled variable (or another variable if specified). *See:* **deviation.** 219, 206

absolute threshold. The luminance threshold or minimum perceptible luminance (photometric brightness) when the eye is completely dark adapted. *See:* **visual field.** 167

absolute transient deviation (control). The numerical difference between the instantaneous value and the final value of the directly controlled variable (or another variable if specified). *See:* **deviation; percent transient deviation.** 219, 206

absolute value (number). The absolute value of a number u (real or complex) is that positive real number vert*u vert* given by

$$|u| = + (u_1^2 + u_2^2)^{1/2}$$

where u_1 and u_2 are respectively the real and imaginary parts of u in the equation

$$u = u_1 + ju_2.$$

If u is a real number, u_2 , 0. 210

absolute-value circuit (analog computers). A transducer or circuit that produces an output signal equal in magnitude to the input signal but always of one polarity. 9

absolute-value device. A transducer that produces an output signal equal in magnitude to the input signal but always of one polarity. *See:* **electronic analog computer.** 9, 77

absorptance, $\alpha = \Phi_a/\Phi_i$. (illuminating engineering). The ratio of the absorbed flux to the incident flux. *Note:* The sum of the hemispherical reflectance, the hemispherical transmittance, and the absorptance is one. 167

absorption (1) (fiber optics). In an optical waveguide, that portion of attenuation resulting from conversion of optical power into heat. *Note:* Intrinsic components consist of tails of the ultraviolet and infrared absorption bands. Extrinsic components include (a) impurities, for example, the OH^- ion and transition metal ions and, (b) defects, for example , results of thermal history and exposure to nuclear radiation. *See:* **attenuation.** 433

(2) (illuminating engineering). A general term for the process by which incident flux is converted to another form of energy, usually and ultimately to heat. *Note:* All of the incident flux is accounted for by the processes of reflection, transmission, and absorption. 167

(3) (laser-maser). The transfer of energy from a radiation field to matter. 363

(4) (radio wave propagation). The irreversible conversion of the energy of an electromagnetic wave into another form of energy as a result of its interaction with matter. 146

absorption current (or component) (1) (rotating machinery). A reversible component of the measured current, which changes with time of voltage application, resulting from the phenomenon of "dielectric absorption" within the insulation when stressed by direct voltage. *See:* **IEEE Std 62-1958, Guide for Making Dielectric Measurements in the Field, Section 6.** 6

(2) (power cable systems). Current resulting from charge absorbed in the dielectric as a result of polarization. 437

absorption frequency meter (reaction frequency meter) (waveguide). A one-port cavity frequency meter that, when tuned, absorbs electromagnetic energy from a waveguide *See:* **waveguide.** 179

absorption loss (data transmission). The loss of signal energy in a communication circuit that results from coupling to a neighboring circuit or conductor. 59

absorption modulation. A method for producing amplitude modulation of the output of a radio transmitter by means of a variable-impedance (principally resistive) device inserted in or coupled to the output circuit. 145, 211

absorptive attenuator (waveguide). *See:* **resistive attenuator.**

abstraction (software). (1) A view of a problem which extracts the essential information relevant to a particular purpose and ignores the remainder of the information. (2) The process of forming an abstraction. 434

abstract machine (software). (1) A representation of the characteristics of a process or machine. (2) A module which processes inputs as though it were a machine. *See:* **module; process.** 434

abstract quantity. *See:* **mathematico-physical quantity.**

ac. *See:* **alternating current.**

ACA. *See:* **adjacent channel attenuation.**

ac, analog computer (analog computers). An analog computer in which electrical signals are of the form of amplitude-modulated suppressed carrier signals where the absolute value of a computer variable is represented by the amplitude of the carrier and the sign of a computer variable is represented by the phase (0 to 180 degrees) of the carrier relative to the reference ac signal. 9

ac breakdown voltage (gas tube surge-protective device). The minimum root-mean-square value of sinusodial voltage at frequencies between 15 Hz and 62 Hz that results in arrester sparkover. 370

AC cable (armored cable) (National Electrical Code). A fabricated assembly of insulated conductors in a flexible metallic enclosure. 256

accelerated life test (1) (cable). A test in which certain factors such as voltage, temperature, etcetera, to which a cable is subjected are increased in magnitude

above normal operating values to obtain observable deterioration in a reasonable period of time, and thereby afford some measure of the probable cable life under operating voltage, temperature, etcetera. 64

(2) (test, measurement and diagnostic equipment). A test in which certain factors, such as voltage, temperature, and so forth, are increased or decreased beyond normal operating values to obtain observable deterioration in a reasonable period of time, and thereby afford some measure of the probable life under normal operating conditions or some measure of the durability of the equipment when exposed to the factors being aggravated. *See:* **power distribution, underground construction.** 54

accelerated test (reliability). A test in which the applied-stress level is chosen to exceed that stated in the reference conditions, in order to shorten the time required to observe the stress responses of the item, or magnify the response in a given time. To be valid, an accelerated test shall not alter the basic modes and.or mechanisms of failure, or their relative prevalence. *See:* **reliability.** 182, 164

accelerating (rotating machinery). The process of running a motor up to speed after breakaway. *See:* **asynchronous machine; direct-current commutating machine.** 63

accelerating electrode. An electrode to which a potential is applied to increase the velocity of the electrons or ions in the beam. 190, 117, 125

accelerating grid (electron tubes). *See:* **accelerating electrode.**

accelerating or decelerating device (18) (power system device function numbers). A device that is used to close or to cause the closing of circuits which are used to increase or decrease the speed of a machine. 402

accelerating relay (power switchgear). A programming relay whose function is to control the acceleration of rotating electrical equipment. 103

accelerating time (control) (industrial control). The time in seconds for a change of speed from one specified speed to a higher specified speed while accelerating under specified conditions. *See:* **electric drive.** 219, 206

accelerating torque (rotating machinery). Difference between the input torque to the rotor (electromagnetic for a motor or mechanical for a generator) and the sum of the load and loss torques: the net torque available for accelerating the rotating parts. *See:* **rotor.** 63

accelerating voltage (oscilloscope). The cathode-to-viewing-area voltage applied to a cathode-ray tube for the purpose of accelerating the electron beam. *See:* **oscillograph.** 185

acceleration (electric drive). Operation of raising the motor speed from zero or a low level to a higher level. *See:* **electric drive.** 206

acceleration factor (reliability). The ratio between the times necessary to obtain the same stated proportion of failures in two equal saples under two different sets of stress conditions involving the same failure modes and mechanisms. 164

acceleration-insensitive drift rate (gyro). That component of systematic drift rate which has no correlation with acceleration. 46

acceleration, programmed. A controlled velocity increase to the programmed rate. 224, 207

acceleration-sensitive drift rate (gyro). Those components of systematic drift rates that are correlated with the first power of linear acceleration applied to the gyro case. The relationship of these components of drift rate to acceleration can be stated by means of coefficients having dimensions of angular displacement per unit time per unit acceleration for accelerations along each of the principal axes of the gyro, for example, drift rate caused by mass unbalance. 46

acceleration space (velocity-modulated tube). The part of the tube following the electron run in which the emitted electrons are accelerated to reach a determined velocity. *See:* **velocity-modulated tube.** 244, 190

acceleration-squared-sensitive drift rate (gyro). Those components of systematic drift rates that are correlated with the second power or product of linear acceleration applied to the gyro case. The relationship of these components of drift rate to acceleration squared can be stated by means of coefficients having dimensions of angular displacement per unit time per unit acceleration squared for accelerations along each of the principal axes of the gyro and angular displacement per unit time per the product of accelerations along combinations of two principal axes of the gyro for example, drift rate caused by anisoelasticity. 46

acceleration, timed (industrial control). A control function that accelerates the drive by automatically controlling the speed change as a function of time. *See:* **electric drive.** 219, 206

accelerator, electron, linear. *See:* **linear electron accelerator.**

accelerator, particle. *See:* **particle accelerator.**

accelerometer (1) (electronic navigation). A device that senses inertial reaction to measure linear or angular acceleration. *Note:* In its simplest form, an accelerometer consists of a case-mounted spring and mass arrangement where displacement of the mass from its rest position relative to the case is proportional to the total nongravitational acceleration experienced along the instrument's sensitive axes. *See:* **navigation.** 13, 187

(2) (gyro). A device that senses the inertial reaction of a proof mass for the purpose of measuring linear or angular acceleration. 46

accent lighting (illuminating engineering). Directional lighting to emphasize a particular object or draw attention to a part of the field of view. 167

acceptable (class 1E equipment and circuits). Demonstrated to be adequate by the safety analysis(-ses) of the station. 1, 102, 428, 99, 131

acceptance angle (1) (fiber optics). Half the vertex angle of that cone within which optical power may be coupled into bound modes of an optical waveguide.