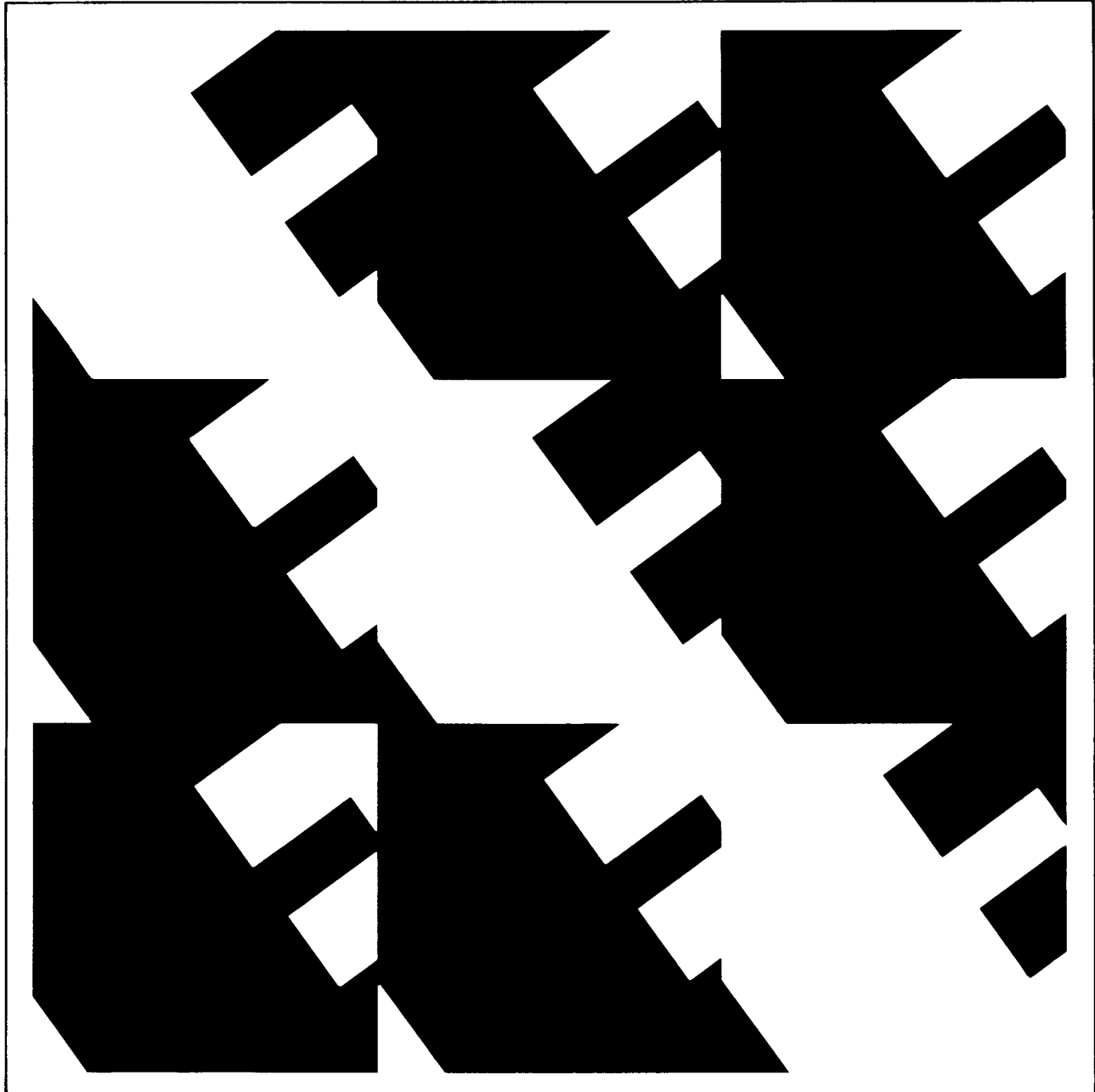


IEEE Standard Glossary of Mathematics of Computing Terminology

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**IEEE Standard Glossary of
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Sponsor
**Standards Coordinating Committee
of the
IEEE Computer Society**

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IEEE Standards Board

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Foreword

(This Foreword is not a part of ANSI/IEEE Std 1084-1986, IEEE Standard Glossary of Mathematics of Computing Terminology.)

The computer field is continuing to expand. New terms are being generated, and new meanings are being adopted for existing terms. The IEEE Computer Dictionary project was undertaken to document this vocabulary. Its purpose is to identify terms currently in use in the computer field and to establish standard definitions for these terms. The dictionary is intended to serve as a useful reference for those in the computer field and for those who come into contact with computers either through their work or in their everyday lives.

The completed dictionary will contain terms from seven areas: Computer Hardware, Software Engineering, Mathematics of Computing, Theory of Computation, Computer Applications, Computing Methodologies, and the Computing Environment. This increment of the dictionary contains those terms related to the Mathematics of Computing. The remaining six areas will be covered in other increments of the dictionary. All areas will be covered in the overall Computer Dictionary.

Every effort has been made to use definitions from established standards in this dictionary. When existing standards were found to be incomplete, unclear, or inconsistent with other entries in the dictionary, however, new or composite definitions have been developed.

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An American National Standard

IEEE Standard Glossary of Mathematics of Computing Terminology

1. Scope

This dictionary defines terms in the field of Mathematics of Computing. Topics covered include Boolean algebra, number systems, computer arithmetic, complementation, shifts, arithmetic errors, error detection and correction, number conversions, numeric codes, mathematical notation, and basic mathematics.

Every effort has been made to include all terms in general usage in this field. A term was excluded, however, if it was considered to be:

- (1) Parochial to one particular group or organization
- (2) A company proprietary or trademarked term
- (3) A multi-word term whose meaning could be inferred from definitions of the component words
- (4) A term whose meaning in the computer field could be directly inferred from its standard English meaning

2. Dictionary Structure

Entries in the dictionary are arranged alphabetically. An entry may consist of a single word, such as Boolean, a phrase, such as Boolean algebra, or an abbreviation, such as BCD. Phrases are given in their natural order (Boolean algebra) rather than reversed (algebra, Boolean).

Blanks are taken into account in alphabetizing. They precede all other characters. Hyphens and slashes are treated as blanks. Alternative spellings are shown in parentheses, for example, octad (octade).

A distinction is made between acronyms, which are pronounced as words (for example, ASCII), and other abbreviations which are pronounced as letters (for example, BCD).

If a term has more than one definition, the definitions are listed with numerical prefixes. In general, noun meanings appear first, followed by verb meanings, then adjective meanings, if applicable. This ordering does not imply preference, and the authors have deviated from it when clarity could better be served by a different ordering. Where necessary, examples and notes have been added to clarify the definitions.

The following cross-references are used to show a term's relationship to other terms in the dictionary:

- (1) *Contrast with* refers to a term with an opposite or substantially different meaning.
- (2) *Syn* refers to a synonymous term.
- (3) *See also* refers to a related term.
- (4) *See* refers to a preferred term or to a term whose definition serves to define the term that has been looked up.

The word "deprecated" indicates a term or definition whose use is discouraged because such use is obsolete, misleading, or ambiguous.

3. Sources

In those cases in which a definition is directly quoted from an existing dictionary or glossary, the source is designated in brackets following the definition. Each of these sources granted us permission to use their definitions. A list of all sources used on the Computer Dictionary project is given at the conclusion of the glossary.

4. Definitions for Mathematics of Computing Terms

absolute error. (1) The amount of error expressed in the same units as the quantity containing the error. *Contrast with: relative error.* [67]

(2) Loosely, the absolute value of the error; i.e., the magnitude of the error without regard to its algebraic sign. [67]

absolute value. The magnitude of a quantity without regard to its algebraic sign.

abstract symbol. A symbol whose meaning and use have not been determined by a general agreement but have to be defined for each application of the symbol. [34]

accuracy. A qualitative assessment of correctness, or freedom from error. *Contrast with: precision.*

addend. A number to be added to another number (the augend) to produce a result (the sum).

addition without carry.* *See: exclusive OR.*
*Deprecated.

algebraic manipulation. The processing of mathematical expressions without concern for the numeric values of the symbols that represent numbers. [67]

algorithm. A finite set of well-defined rules for the solution of a problem in a finite number of steps; for example, a complete specification of a sequence of arithmetic operations for evaluating $\sin x$ to a given precision. [67]

American National Standard Code for Information Interchange (ASCII). A binary code in which 128 letters, numbers, and special characters are represented by seven-bit numerals. *Note:* Some systems make use of an eight-bit binary code, called ASCII-8, in which 256 symbols are represented.

amphiboly. A logical expression that has more than one meaning. For example, the expression $A \text{ OR } B \text{ AND } C$ might mean $(A \text{ OR } B) \text{ AND } C$ or $A \text{ OR } (B \text{ AND } C)$ depending upon the rules of interpretation used.

analog. Pertaining to data in the form of continuously variable physical quantities. *Contrast with: digital.*

analog representation. The representation of numerical quantities by means of continuous physical variables such as translation, rotation, voltage, or resistance. *Contrast with: digital representation.*

AND. A Boolean operator having the property that if P is a statement, Q is a statement, R is a statement,..., then the AND of $P, Q, R, \dots$ is true if and only if all statements are true. *Note:* $P \text{ AND } Q$ is often represented by $P \cdot Q$, $P \& Q$, $P \wedge Q$, or PQ . *Syn: Boolean multiplication; collation; conjunction; intersection; logic multiply; logical multiply; meet.*

P	Q	$P \wedge Q$
0	0	0
0	1	0
1	0	0
1	1	1

AND truth table

AND-NOT.* *See: exclusion.*
*Deprecated.

arithmetic check. *See: mathematical check.*

arithmetic expression. An expression containing any combination of variables and constants joined by one or more arithmetic operators such that the expression can be reduced to a single numerical result.

arithmetic operation. An operation that is performed in accordance with the rules of ordinary arithmetic.

arithmetic overflow. *See: overflow.*

arithmetic point. *See: radix point.*

arithmetic shift. A shift that affects all digit positions in a register, word, or numeral but does not affect the sign position. For example, +231.702 shifted two places to the left becomes +170.200. *Note:* The result is equivalent to multiplication or division by an integral power of the radix, except for the

- truncation effects. *Syn:* **numerical shift**. *Contrast with:* **logical shift**.
- arithmetic underflow.** *See:* **underflow**.
- ASCII.** Acronym for **American National Standard Code for Information Interchange**.
- assumed binary point.** The position in a binary numeral at which the binary point is assumed to be located; usually at the right unless otherwise specified. *Syn:* **implied binary point**.
- assumed decimal point.** The position in a decimal numeral at which the decimal point is assumed to be located; usually at the right unless otherwise specified. *Syn:* **implied decimal point**.
- assumed radix point.** The position in a numeral at which the radix point is assumed to be located; usually at the right unless otherwise specified. *Syn:* **implied radix point**.
- augend.** A number to which another number (the addend) is added to produce a result (the sum).
- balanced error.** (1) A set of error values in which the maximum and minimum are opposite in sign and equal in magnitude. [61]
(2) A set of error values whose average is zero. *Contrast with:* **unbalanced error**.
- base.** *See:* **radix**.
- base complement.** *See:* **radix complement**.
- base-minus-one complement.** *See:* **diminished-radix complement**.
- base notation.** *See:* **radix notation**.
- base number.** *See:* **radix**.
- base point.** *See:* **radix point**.
- BCD.** Abbreviation for **binary-coded decimal**.
- bias.** (1) A systematic deviation of a value from a reference value. [67]
(2) The amount by which the average of a set of values departs from a reference value. *Syn:* **bias error**. [67]
- bias error.** *See:* **bias** (2).
- biased exponent.** In floating-point arithmetic, the sum of the exponent and a constant (bias) chosen to make the biased exponent's range nonnegative. [132]
- binary.** (1) Pertaining to a selection in which there are two possible outcomes.
(2) Pertaining to the numeration system with a radix of two. *Syn:* **natural binary**; **normal binary**; **ordinary binary**; **pure binary**; **regular binary**; **standard binary**; **straight binary**. [1]
- binary arithmetic operation.** An arithmetic operation in which the operands and the results are represented in the binary numeration system.
- binary Boolean operation.*** *See:* **dyadic Boolean operation**.
*Deprecated.
- binary code.** A code that uses exactly two symbolic characters, usually 0 and 1. [1]
- binary-coded decimal (BCD).** Pertaining to a number representation system in which each decimal digit is represented by a unique arrangement of binary digits (usually four); for example, the number 23 is represented as 0010 0011, whereas in binary notation, 23 is represented as 10111. *Syn:* **coded decimal**. [1]
- binary-coded digit.** A digit of any number representation system that is represented as a fixed number of binary digits. For example, the decimal digit 9 is represented as 1001.
- binary-coded octal.** Pertaining to a three-bit binary code in which the octal digits 0–7 are represented by the binary numerals 000–111.
- binary digit bit.** A numeral used to represent one of the two digits in the binary numeration system; zero (0) or one (1).
- binary element.** A data element that can assume either of two possible values or states. *See also:* **binary variable**.
- binary element string.** A string consisting solely of binary elements. [34]

binary incremental representation. An incremental representation system in which the value of an increment is plus one or minus one. *Syn:* **incremental binary representation.**

binary notation. Any notation that uses the binary digits and the radix 2. *Syn:* **binary scale; two-scale.**

binary number. (1) A quantity that is expressed by using the binary numeration system.
(2) Loosely, a binary numeral. [1,67]

binary number system.* *See:* **binary numeration system.**
*Deprecated.

binary numeral. A numeral in the binary numeration system. For example, the binary numeral 101 is equivalent to the decimal numeral 5.

binary numeration system. The numeration system that uses the binary digits and the radix 2. *Syn:* **binary system; pure binary numeration system.**

binary one. The "true" binary state, usually represented as 1 or T. *Contrast with:* **binary zero.**

binary operation.* (1) *See:* **Boolean operation.**
(2) *See:* **dyadic operation.**
*Deprecated.

binary operator. *See:* **dyadic operator.**

binary point. The radix point in the binary numeration system.

binary scale. *See:* **binary notation.**

binary-state variable. *See:* **binary variable.**

binary system. *See:* **binary numeration system.**

binary-to-decimal conversion. The process of converting a binary numeral to an equivalent decimal numeral. For example, binary 10001011.01 is converted to decimal 139.25.

binary-to-hexadecimal conversion. The process of converting a binary numeral to an equivalent hexadecimal numeral. For example, binary 10001011.01 is converted to hexadecimal 8B.4.

binary-to-octal conversion. The process of converting a binary numeral to an equivalent octal numeral. For example, binary 10001011.01 is converted to octal 213.2.

binary variable. A variable that can assume either of two values or logic states: binary zero (false) or binary one (true). *Syn:* **binary-state variable; Boolean variable; two-state variable; two-valued variable.**

binary zero. The "false" binary state, usually represented as 0 or F. *Contrast with:* **binary one.**

biquinary. Pertaining to a two-part representation of decimal digits consisting of a binary portion with values 0 or 5, and a quinary portion with values 0 through 4. For example, the decimal digit 7 is coded as 12, which implies $5 + 2$.

biquinary code. A two-part representation of decimal digits consisting of a binary portion with values 0 or 5 and a quinary portion with values 0 through 4. For example, decimal digit 7 is coded as 12.

biquinary-coded decimal. Pertaining to a number representation system in which each decimal digit is represented by a biquinary code.

biquinary notation. Any notation that uses the biquinary code to represent numbers.

biquinary numeration system. A numeration system that alternately uses 2 and 5 as bases. *Note:* The abacus uses a biquinary system.

bit. Acronym for **binary digit.**

block parity. A parity check system capable of detecting and correcting a single error in a binary message. *See also:* **parity check.**

Boolean. Pertaining to the rules of logic for-

ulated by the Irish mathematician George Boole in 1847. [55]

Boolean add. *See:* **OR.**

Boolean algebra. The binary system of algebra formulated by George Boole, dealing with binary variables and employing the basic logical operators AND, OR, NOT, etcetera. *Syn:* **Boolean logic; Boolean math.**

Boolean calculus. An extension of Boolean algebra that includes time-dependent operators such as BEFORE, DURING, AFTER.

Boolean complementation. *See:* **NOT.**

Boolean connective. *See:* **Boolean operator.**

Boolean function. A switching function in which the number of possible values of the function and each of its independent variables is two. [34]

Boolean logic. *See:* **Boolean algebra.**

Boolean math. *See:* **Boolean algebra.**

Boolean multiplication. *See:* **AND.**

Boolean operation. Any operation in which each of the operands and the result take one of two values. [34]

Boolean operation table. *See:* **truth table.**

Boolean operator. An operator whose operands and results are binary variables. *Syn:* **Boolean connective.**

Boolean value. The value of a binary variable; either binary zero or binary one.

Boolean variable. *See:* **binary variable.**

borrow. (1) A mathematical process used in subtraction, in which, when the difference in a digit place would be arithmetically negative, the subtraction in that digit place is preceded by increasing the digit in the minuend by the value of the radix, and decreasing the digit in the next higher digit place by one.
(2) The value added to the digit place in (1).
(3) To perform the process defined in (1).

byte. A group of adjacent binary digits operated upon as a unit and usually shorter than a computer word (frequently connotes a group of eight bits). [3]

C. Abbreviation for **centi.**

carry. (1) A mathematical process used in addition and subtraction, in which a value is generated when a sum or product in a digit place exceeds the largest number that can be represented in that digit place, and the value is transferred to the next higher digit place for processing there. *See also:* **cascaded carry; complete carry; end-around carry; half carry; high-speed carry; partial carry; standing-on-nines carry.**

(2) The value generated in (1).

(3) To perform the process defined in (1).

cascaded carry. A carry process in which the addition of two numerals results in a partial-sum numeral and a carry numeral that are in turn added together, this process being repeated until no new carries are generated. *Contrast with:* **high-speed carry.** *See also:* **partial carry; partial sum.** [1]

Augend	289594
Addend	320607
First Partial Sum	509191
First Partial Carry	101010
Second Partial Sum	600101
Second Partial Carry	010100
True Sum	610201

Example of cascaded carry

casting out nines. A method of checking addition, subtraction, or multiplication results by dividing decimal values by nine and comparing the remainders. *Syn:* **nines check.**

ceiling. The result obtained by rounding a number up to the nearest integer. For example, the ceiling of 5.3 is 6. *Contrast with:* **floor.**

centi (C). A prefix indicating one hundredth.

chain. A sequence of bits used to construct a binary code. *See also:* **chain code.** [61]

chain code. An arrangement in a cyclic sequence of some or all of the possible different n-bit words in which adjacent words are related such that each word is derivable from