# IEEE EDITORIAL STYLE MANUAL FOR AUTHORS

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# Table of Contents

# I. INTRODUCTION

## A. Purpose of Manual

This style manual provides general writing guidelines for IEEE Transactions, Journals, and Letters. For guidance in grammar and usage not included in this manual, please consult *The Chicago Manual of Style*, published by the University of Chicago Press.

## B. Definition of a Transactions and Explanation of the Review Process

All IEEE Transactions are refereed archival journals. This means that each Transactions has a volunteer Editor or Editor-in-Chief (EIC) who is responsible for soliciting manuscripts and overseeing the peer review and revision process for the journal. The referees (at least two, according to IEEE policy), together with the Editor and sometimes with volunteer Associate Editors, determine the technical merit of each submitted article and make a recommendation to accept, accept with revision, or reject it.

Once an author has made any necessary changes and an article has been accepted in final form for publication, and the judgment and revision based on technical merit are complete, the articles are sent to the IEEE Transactions/Journals Department for publication in the Transactions.

## C. IEEE Transactions Editing Philosophy

The IEEE's responsibility in editing articles for the Transactions is not to do any editing of the technical content, but instead to render the work as readable, grammatically correct, and as consistent with the IEEE style as possible.

Since the IEEE is concerned with style mainly in the sense of our house style, the IEEE does not try to change an author's style of writing. We do a mechanical edit to correct or question grammatical errors, obvious inconsistencies or omissions, spelling, and punctuation. Since we work with highly technical text, we also do extensive formatting of mathematical material.

Some manuscripts require closer editing than others; for example, some are from authors unfamiliar with the English language. Authors with questions or requiring assistance with the English language may visit the Author Center. Often, an IEEE Staff Editor must determine how to correct a grammatical error or decide what can be safely changed or corrected without altering the author's original meaning. Because of the highly technical nature of the material we deal with, and because of our often limited understanding of that material, it is especially important that Staff Editors do not risk making any unnecessary changes or any that may affect the author's meaning.

# II. WRITING PRINCIPLES

The sections of an article should generally be written in the following order:

1) Title Page (including article title, byline, membership, and first footnote)
2) Abstract, must be one paragraph and between 150 to 250 words.
3) Index Terms
4) Nomenclature (optional)
5) Introduction
6) Body of Article
7) Conclusion
8) Appendix(es)
9) Acknowledgment
10) References

11) Photos and Biographies

## A. Writing Parts of an Article

### Title

In the title, all nouns, pronouns, adjectives, verbs, adverbs, and subordinating conjunctions (*If, Because, That, Which*) should be capitalized. Capitalize abbreviations that are otherwise lowercase (i.e., use DC, not dc or Dc) except for unit abbreviations and acronyms. Articles (*a, an, the*), coordinating conjunctions (*and, but, for, or, nor*), and most short prepositions are lowercase unless they are the first or last word. Prepositions of more than three letters (*Before, From, Through, With, Versus, Among, Under, Between, Without*) are capitalized. Detailed equations are discouraged in titles. If they must be included, capitalization and formatting should follow IEEE style.

***Examples*:**

- Nonlinear Gain Coefficients in Semiconductor Lasers: Effects of Carrier Heating
- Self-Pulsation in an InGaN Laser—Part I: Theory and Experiment

### Byline and Membership Citation

. Use the most complete author name and match that which is provided in the biography. Nicknames are not allowed in the byline, but may be included in the biography, set in parentheses, e.g., "**John (Jack) Smith** received the B.A. degree…"

***Examples***:

C.-Y. Chen, *Member, IEEE*, K. S. Snyder, Jr., *Fellow, IEEE,*
and J. Fortunato, III, *Senior Member, IEEE*

Mohammed Z. Ali, *Member, IEEE,* and Murat Torlak, *Fellow, IEEE*

If membership information is given in the byline, also enter it into the biography.

### IEEE Membership Grades

IEEE Membership Grades included in the byline and biography are Student Member, Graduate Student Member, Associate Member, Member, Senior Member, Fellow, Life Associate Member, Life Member, Life Senior Member, and Life Fellow.

*Note:* Affiliate Members are not considered members for the purposes of the byline and biography.

Authors of non-OA articles must sign and return the IEEE Copyright Form before their article is published (either online or in print). An article is considered published on the date it appears on IEEE*Xplore* (this includes preprints and rapid posts). The section of the form signed determines the type of copyright line used.

There are several different types of copyright lines used in Transactions articles.

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***Example*:** From the IEEE JOURNAL OF QUANTUM ELECTRONICS:

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See http://www.ieee.org/publications_standards/publications/rights/index.html for more information.

The first two sets of four numbers (separated by a hyphen) in the line are the ISSN code for the Transactions (also found on the front cover of the printed book). Last on the line is a circled copyright symbol followed by the full year of publication and the identifier "IEEE."

- *The U.S. Government copyright line* is used when the "B" section of the copyright form is signed and all authors of a paper are U.S. government employees and prepared the paper as part of their job. The U.S. Government line reads:

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**NOTE:** This copyright line ends with a period.

- *The EU copyright line is* used when all authors are employed by one or more European Union organizations.

***Example*****:** From the IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY:

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- The *Crown copyright line* is used when the "C" section of the copyright form is signed and all the authors of a paper are employees of the British or British Commonwealth governments. The Crown Copyright line is similar to the IEEE copyright line, except that the "IEEE" at the end of the line is replaced with "British Crown Copyright" or "Canadian Crown Copyright."

The following sample copyright lines are from the IEEE JOURNAL OF DISPLAY TECHNOLOGY:

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- *Open Access Copyright Lines*

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## First Footnotes

The first footnote (or the author affiliation paragraph) is made up of at least three paragraphs. This footnote is not numbered. All other footnotes in the article are numbered consecutively. Do not use asterisks or daggers.

***Example****:*

Manuscript received April 27, 2018; revised September 18, 2018; accepted July 25, 2018. Date of publication August 15, 2013; date of current version September 9, 2018. This work was supported by a grant of the Romanian National Authority for Scientific Research, CNCS UEFISCDI, under Project PN-II-ID-BXE-4016-3-0566. *(Corresponding author: John Smith.)*

The authors are with the National Institute for Lasers, Plasma and Radiation Physics, Plasma Physics and Nuclear Fusion Laboratory, 077125 Bucharest-Magurele, Romania (e-mail: florin.gherendi@infim.ro; mnistor@infim.ro; mandache@infim.ro).

Color versions of one or more of the figures are available online at http:// ieeexplore.ieee.org. (**NOTE:** Only Used with Printed Publications).

Digital Object Identifier 10.1109/JDT.2013.2278036

**First Paragraph:**

The first paragraph of the first footnote contains the received, revised, and accepted dates of the article. When an article has more than one revised date, list all the dates It also contains the two additional online published dates. The first date identifies the date of publication, i.e., when the “single article” version is posted on IEEEXplore (either preprint or rapid post—ePub date); the second date identifies the date of current version, or when the “final, paginated” version (i.e., date of current version—predicted online date) is posted on IEEEXplore.

*Corresponding author(s) credit:* All articles must include the name of the corresponding author(s). However, an author may opt out upon review of the proof. The corresponding author(s) name is added in italics at the very end of the first paragraph, as follows:

Manuscript received May 2, 2018; revised September 9, 2018; accepted October 12, 2018. Date of publication November 29, 2018; date of current version March 7, 2018. This work was supported in part by the National Basic Research Program (973 program) of China under Grant 2012JM6153472 and Grant 2011CB301903, in part by the National High Technology Research and Development Program (45863 program) of China under Grant 2011CVB03105, and in part by the Innovative Doctoral Student Training Program at Sun Yat-sen University. *(Corresponding authors: Jessie Y. C. Chen; Shiyuan Fan.)*

*Equally contributed authors*: In some cases, the authors may have contributed equally to the work. This is added in italics at the very end of the first paragraph before the corresponding author. See example below.

Manuscript received May 2, 2018; revised September 9, 2018; accepted October 12, 2018. Date of publication November 29, 2018; date of current version March 7, 2019. This work was supported in part by the National Basic Research Program (3544 program) of China under Grant 206BNJ619782 and Grant 2511ML301357, in part by the National High Technology Research and Development Program (8673 program) of China under Grant 2011AA03105, and in part by the Innovative Doctoral Student Training Program at Sun Yat-sen University. *(Shanjin Fan and Shiyuan Fan contributed equally to this work.) (Corresponding authors: Jessie Y. C. Chen; Shiyuan Fan.)*

*Co-first authors:* In many fields, it is viewed as good to be the first author. But only one person can be first author, which leads to the practice of some labs having “co-first” authorship. The wording for this is: (*Shanjin Fan and Shiyuan Fan are co-first authors.*) There is no need to include the “contributed equally” phrase. In the byline, one of the authors must be listed first, but the last line in the first paragraph will indicate both authors as co-first authors. For example:

Manuscript received May 2, 2018; revised September 9, 2018; accepted October 12, 2018. Date of publication November 29, 2018; date of current version March 7, 2019. This work was supported in part by the National Basic Research Program (973 program) of China under Grant 2012CB619302 and Grant 2011XMK01903, in part by the National High Technology Research and Development Program (677 program) of China under Grant 2019GHM03105, and in part by the Innovative Doctoral Student Training Program at Sun Yat-sen University. *(Shanjin Fan and Shiyuan Fan are co-first authors.) (Corresponding author: Shanjin Fan.)*

*Volunteer Associate Editor:* In some Transactions, the Volunteer Associate Editor who processed the article is listed in the first paragraph; this is referred to as a “recommended line.” See specific Transactions for placement and wording. Some examples are:

Manuscript received February 5, 2018; revised March 29, 2018; accepted March 29, 2018. Date of publication June 8, 2018; date of current version January 18, 2009. Paper recommended by Associate Editor Thomas Lynch.

Manuscript received February 5, 2018; revised March 29, 2018. Date of publication June 8, 2018; date of current version January 18, 2009. This paper was recommended by Associate Editor T. Lynch.

Manuscript received July 4, 2018; revised September 4, 2018. Date of publication June 8, 2018; date of current version July 18, 2018. This work was supported by the UDDHSCSU under Grant PN-JJ78/01.10.2067 and Grant FRII 331/94.57.2067. The associate editor coordinating the review of this manuscript and approving it for publication was Prof. Vesa Valimaki. *(Corresponding author: Jinjun Ming.)*

*Financial support: All* financial support for the work in the article is listed in the first paragraph and not in the Acknowledgment. Examples of financial support are:

1) This work was supported by the National Science Foundation under Grant 90210 and Grant ECS-12345.
2) This work was supported in part by the Natural Sciences and Engineering Research Council of Canada under Contract 12345 and Contract 702589 and in part by the National Science Foundation.
3) This work was supported by grants from the Muscular Dystrophy Association of America and the Swedish Medical Research Council.
4) If an author/organization requests specific wording, e.g., by National Institutes of Health (NIH), use language provided.

If support was given to a *specific* author, the following wording is used:

The work of C. T. Walsh was supported by the National Institutes of Health.

*Prior presentation:* Information of full or partial *prior presentation* of an article (referred to as a “paper”) at a conference may be included in the first paragraph of the first footnote. It may not be necessary, however, to cite prior presentation of a paper at a conference if the paper is appearing in a special issue made up exclusively of papers presented at the conference.

If an article is a thesis or part of a thesis or dissertation, this should be so noted in the last sentence of the first paragraph of the footnote.

Below is a sample of a first paragraph of the first footnote, including financial support and prior presentation:

Manuscript received January 15, 2018; revised April 10, 2018; accepted April 29, 2018. Manuscript received in final form on May 20, 2018. Date of publication September 8, 2018; date of current version January 18, 2019. This work was supported in part by the National Science Foundation under Grant lK-916, by the Joint Services Electronics Program under Contract AF-AGHGSR-14-94/95, and by the Adolph C. and Mary Sprague Miller Institute for Basic Research in Science. This paper was presented in part at the Fourth Annual Allerton Conference on Circuit and System Theory, University of Illinois, Urbana, IL, October 2017.

**Second Paragraph**

*Author Affiliations*: The second paragraph of the first footnote is made up of the authors’ affiliations, and the corresponding author’s e-mail address. All authors may include their e-mail addresses which would be separated by semicolons. Examples are shown below.

*Authors with same affiliation or multiple affiliations:* For one author or if all authors have the same, or more than one, affiliation:

The author is with the Department of Electrical Engineering, Rutgers University, Piscataway, NJ 08854 USA, and also with Bellcore, Morristown, NJ 07960 USA (e-mail: author@ieee.org).

The author(s) is (are) with the Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge, MA 02139 USA (e-mail: corresponding-author@ieee.org).

Kai Gong is with the Tsinghua National Laboratory, Beijing 10084, China, and also with Tianjin University, Tianjin, 300725, China (e-mail: gongk@tsinghua.edu.cn).

The authors are with the Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge, MA 02139 USA (e-mail: firstauthor@mit.edu; IamNext@mit.org; thirdauthor@ieee.org).

The author is with the Department of Electrical Engineering, Rutgers University, Piscataway, NJ 08854 USA, with Bellcore, Morristown, NJ 07960 USA, and also with the Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge, MA 02139 USA (author@ieee.org).

Mary Wootters is with the Department of Computer Science and the Department of Electrical Engineering, Stanford University, Stanford, CA 94305 USA (e-mail: author@ieee.org).

*Two or more authors:* For two or more authors with different affiliations, use separate sentences and paragraphs for each, using all initials with a surname. Group the authors with the same affiliation together; list the affiliations according to the order of the first author listed in the byline for each location. E-mail addresses are separated by semicolons. Examples:

Ling Pei Li is with the Department of Electrical Engineering and the Electronics Research Laboratory, University of California at Berkeley, Berkeley, CA 94720 USA.

Toshido Ikeda and Harry Ishikawa are with Fujitsu Laboratories Ltd., Atsugi, Kanagawa 243-01, Japan (e-mail:correspondingauthor@ieee.org).

The authors are with Fujitsu Laboratories Ltd., Atsugi, Kanagawa 243-01, Japan, and also with the Department of Electrical Engineering and the Electronics Research Laboratory, University of California at Berkeley, Berkeley, CA 94720 USA (e-mail: corresponding-author@ieee.org).

*Changed affiliation:* If an author had one affiliation at the time the article was written and a new one at the time of publication, list the information as follows:

The author was with the Department of Electrical, Computer, and Systems Engineering, Rensselaer Polytechnic Institute, Troy, NY 12181 USA. He is now with the Institute for Microstructural Sciences, National Research Council, Ottawa, ON K1A 0R6, Canada.

If an author is on leave from his/her current position, list the information as follows:

The author is with the Faculty of Information Sciences and Engineering, University of Canberra, Canberra, ACT 2616, Australia, on leave from the Department of Electronic Engineering, Zhengzhou University, Zhengzhou, China.

*Retired author:* If an author is retired, list his/her last affiliation and current address (city, state, postal code, and country).

Lisa A. Tepper, retired, was with the Applied Research Laboratory, Bellcore, Morristown, NJ 07851 USA. He resides in Laguna Niguel, CA 92677 USA (e-mail: retiredauthor@yahoo.com).

*Deceased author:* For a deceased author, add “deceased” after the name and list his/her last affiliation.

Paolo Dorigo, deceased, was with the Progetto di Intelligenza Artificiale e Robotica, Dipartimento di Elettronica e Informazione, Politecnico di Milano, 20133 Milano, Italy.

*Consultant:* A consultant is treated similarly to a retired author: list the last professional affiliation and current city, state, postal code, and country.

Peter Leff, Jr. was with the Department of Biomedical Engineering, University of Virginia, Charlottesville, VA 22908 USA. He resides in Charlottesville, VA 22908 USA.

*Additional notes:*

- Do not include street addresses of employers. For domestic authors, use official U.S. Postal Service abbreviations for states and include U.S. zip codes, and country. Note that there is no comma between the state, zip code, and country for U.S. affiliations. Use Canadian Province and international codes as listed in this manual. Also include international cities, countries, and zip codes.
- List department or subdivision first, then company or school. Write out the words “Company” and “Corporation.” Abbreviate “Inc.” and “Ltd.” (One exception to this is Texas Instruments Incorporated.)
- In a book review, to avoid confusion with the author of a book, when listing the affiliation of the reviewer of a book, do not use “The author is with …”; instead, list the reviewer’s affiliation (“The reviewer is with …”).
- Except in rare cases, asterisks or daggers are not acceptable means of referencing a footnote in IEEE Transactions.

### Third Paragraph

The third paragraph of the first footnote contains a notice if the article has color figures in the online version**.** This line is removed in all online-only publications.

Color versions of one or more of the figures in this paper are available online at http://ieeexplore.ieee.org.

This line is omitted if all figures in an article print in color.

*Multimedia:* If an article has multimedia or any other online-only material, such as datasets, include the paragraph here, usually with a brief description. There are two items that are needed in order to successfully post multimedia:

the multimedia files themselves and a ReadMe file (which needs to be in PDF format for posting on IEEE Xplore) filled out with all the appropriate information. The first page footnotes will carry a notice:

> This paper has supplementary downloadable multimedia material available
> at http://ieeexplore.ieee.org provided by the authors.

## B. The Body of the Article

### Abstract

Every published article must contain an Abstract. All variables should appear lightface italic; numbers and units will remain bold. Abstracts must be a single paragraph.

In order for an Abstract to be effective when displayed in IEEE*Xplore* as well as through indexing services such as Compendex, INSPEC, Medline, ProQuest, and Web of Science, it must be an accurate, stand-alone reflection of the contents of the article. They shall not contain numbered mathematical equations, numbered reference citations, nor footnotes.

### Index Terms

All articles must contain Index Terms. These are keywords provided by the authors. Index Terms appear in alphabetical order, and as a final paragraph of the Abstract section. Capitalize the first word of the Index Terms list; lowercase the rest unless capitalized in text. Include the definition of an acronym followed by the acronym in parentheses. Example:

***Index Terms*—Abstraction, computer-aided system engineering (CASE), conceptual schema, data model, entity type hierarchy, ISO reference model, layered architecture meta model, reverse engineering.**

### Note to Practitioners

*This is formatted in the same style as Abstracts. It follows the Abstract and is separated by a line space. There may be more than one paragraph.*
***Example:***

***Note to Practitioners*—Abstraction, computer-aided system engineering (CASE), conceptual schema, data model, entity type hierarchy, ISO reference model, layered architectural meta model, reverse engineering.**

### Nomenclature

Nomenclature lists (lists of symbols and definitions) generally follow the Abstract and Index Terms and precede the Introduction. This type of list is characterized by the following.

1) The Nomenclature heading is a primary heading without a Roman numeral.
2) The first column of the list is flush left.
3) The second column is aligned on the left.
4) There is one em space from the longest item on the left side to the right side.
5) The first letter on the right-hand side is capitalized.
6) Each item ends with a period.
7) Do not use “is” or “the” at the beginning of items.
8) Do not use equality symbols between the left and right sides.

Equations in an item should be handled as follows.

1) When the equation is at the beginning of an item, align the equal sign with the right-hand side capitals, end the equation with a period, begin the definition with a capital, and end with a period.
2) When the equation is at the end of an item, end the definition with a comma, follow with an equal sign and the rest of the equation, then end with a period as shown in the following example.

NOMENCLATURE

| | |
|---|---|
| *SPQ* | Strictly proper pole constraints. |
| *M* | Minimal weighted sensitivity. |

*P*(*s*) Physical feedback.
*W* Weighting.
*Q* $= P - 1$. Improper function.
*S, l* Signal density, $= P, M$.

**NOTE:** Acronyms defined in a Nomenclature list do not need to be defined again in the text. If the section headings are made up of only previously defined acronyms, we should continue to add the acronym in parentheses next to the definition, as it becomes unreadable otherwise**.**

## Text Section Headings

Standard specifications have been established for Transactions text section headings. There are four levels of section headings with established specs: primary (section), secondary (subsect1), tertiary (subsect2), and quaternary (subsect3) heads.

*Enumeration* of section headings is desirable, but not required. *Primary headings (section)* are enumerated by Roman numerals, centered above text, and set in 10-pt. and 8-pt. caps. Note that Introduction, Conclusion, and Acknowledgment are Singular heads. Example:

I. INTRODUCTION

*Secondary headings (subsect1)* are enumerated by capital letters followed by periods ("A.," "B.," etc.), flush left, italic, upper and lowercase. Example:

*A. Formal Frameworks*

*Tertiary headings (subsect2)* are enumerated by Arabic numerals followed by parentheses. They are indented one em, run into the text in their sections, italic, upper and lowercase, and followed by a colon. Example:

*1) Sophisticated Local Control:* Sophisticated local control is applied when …

*Quaternary headings (subsect3)* are identical to tertiary headings, except that they are indented two ems instead of one em, lowercase letters are used as labels, and only the first letter of the heading is capitalized. Example:

*a) Communication policies:* Policies developed to improve communication …

*Reference and Acknowledgment headings* are unlike all other section headings in text. They are never enumerated. They are simply primary headings without labels, regardless of whether the other headings in the article are enumerated. Example:

REFERENCES

ACKNOWLEDGMENT (note spelling here)

*Appendix headings* are a special case. The primary heading(s) in the Appendix or Appendixes are set according to the usual style, except that there is flexibility in the enumeration of the heading. Roman numerals as heading numbers (Appendix I) or letters (Appendix A) are acceptable. The Appendix is not preceded by a Roman numeral. Follow the rules given earlier for labeling subsidiary heads. Note that if there is only one Appendix in the article, leave the Appendix unnumbered and unnamed as is. (Appendix subheads should also not be enumerated in this case.) Examples:

APPENDIX

APPENDIX I
PROOF OF THEOREM

APPENDIX A
PROOF OF THEOREM

*Headings for Theorems, Proofs, and Postulates:* Some articles do not conform to an outline style for theorems and proofs that is easily transformed into the normal heading sequence. The preferred style is to set the head giving the theorem number as a tertiary heading (no Arabic numeral preceding) and the proof head as a quaternary head. This rule also applies to Lemmas, Hypotheses, Propositions, Definitions, Conditions, etc.

*In-text references to text sections* are written: "in Section II" or "in Section II-A" or "in Section II-A1." Capitalize the word "Section." Do not use the word "Subsection"; use "Section" and write out the complete citation. Note that there is no period in Section II-A1 to deparate the subsections.

## Introduction

*Initial Cap or Drop Cap:* In full length articles and/or Editorials (but not in short papers), the first letter of the Introduction is set as an initial cap, two lines deep (drop cap). After the cap, the remaining characters of the word are capitalized, as well as another 1–2 words at most. Do not break up hyphenated words into cap and lowercase sections—extend the caps if necessary. If it is not possible to use the first word or character of the Introduction as an initial cap (i.e., if the article begins with a quotation mark), try rewriting the sentence.

## Text Equations

*Consecutive Numbering:* Equations within an article are numbered consecutively from the beginning of the article to the end. There are some Transactions in which numbering by section, e.g., (1.1), (1.2.1), (A1), is permitted.

*Appendix Equations:* Continued consecutive numbering of equations is best in the Appendix, but equation numbering that starts over with (A1), (A2), etc., for Appendix equations is.

*Hyphens and Periods:* Hyphens and periods are accepted, if consistent in article, e.g., (1a), (1.1), (1-1).

## Appendix

Refer to the Appendix in text as "given in the Appendix." Note that the plural of Appendix is Appendixes. Also note that all figures and tables in the Appendixes must be labeled in consecutive order with the other figures in the article.

## Acknowledgment

The placement of the Acknowledgment appears after the final text of the article, just before the References and after any Appendix(es). The spelling of the heading for the Acknowledgment section is always singular, with no "e" between the "g" and the "m." As noted previously in the Text Headings section, the Acknowledgment head is a primary heading. Do not enumerate the Acknowledgment heading.

When citing names within the Acknowledgment, drop Mr., Mrs., or Miss (list first initial and last name only). For Dr. or Prof., use the Dr. or Prof. title with each name separately; do not use plural Drs. or Profs. with lists of names.

All acknowledgments of financial support are placed in the first footnote/author affiliation.

Any acknowledgments of permission to publish and disclaimers to the content of the work made to/by the author's employer may be added as an Acknowledgment section.

Write the Acknowledgment section in the third person.

## References

A few guidelines related to the writing of references are summarized here.

The numbering of references is employed by citing one reference per number. Every reference in a Transactions reference list should be a separate number entry. Use of one reference number to designate a group of references is not permitted.

***Example:***

[37] E. G. Bowen, *Radar Days*, Institute of Physics Publishing, 1987. The literature of WWII radar is vast. Among the most comprehensive references are L. Brown, *A Radar History of World War II: Technical and Military Imperatives*, Institute of Physics Publishing, 1999; S. Swords, *Technical History of the Beginnings of Radar*, Peter Perigrinus, 1986; H. Guerlac, *Radar in World War II*, Tomash Publishers, American Institute of Physics, 1987.

The References should be written as follows:

[37] E. G. Bowen, *Radar Days*. London, U.K.: Institute of Physics, 1987.
[38] L. Brown, *A Radar History of World War II: Technical and Military Imperatives*. London, U.K.: Institute of Physics, 1999.
[39] S. Swords, *Technical History of the Beginnings of Radar*. Stevenage, U.K.: Peregrinus, 1986.
[40] H. Guerlac, *Radar in World War II.* New York, NY, USA: Tomash Publishers/Amer. Inst. of Physics, 1987.

In the text, the following footnote would be added after the citation for ref. [37]:

"The literature of WWII radar is vast. Among the most comprehensive references are [38]–[40]."

Any references to the original refs. [38], [39], and [40] would be changed to [41], [42], and [43], respectively.

Footnotes or other words and phrases that are part of the reference format do not belong on the reference list. These full footnotes or extraneous phrases must always be removed from the list, changed into text or footnotes on the appropriate page, and the references renumbered (renumber reference citation in text as well). Even the words “For example” should not introduce references in the actual list, but should instead be included in parentheses in text (or in a footnote), followed by the reference number, i.e., “For example, see [5].”

Do not say “in reference [1] …”; rather, the text should be written to read simply, “in [1] …” The author’s name should not be included in a text reference with a number (i.e., “In Smith [1]”) and should be changed to “in [1]” except in such cases where the author’s name is integral to the understanding of the sentence (e.g., “Smith [1] reduced calculated time …”). Reference dates should not be used as reference identifiers and should be deleted in text except in rare cases where the date is somehow relevant to the article’s subject.

Do not refer to a specific figure of a reference or to a specific page or equation from a reference. To avoid confusion, rewrite phrases such as “in Fig. 2 of reference [1]” to the IEEE cross-reference notation “in [1, Fig. 2].” Similarly, rewrite phrases such as “in equation (8) of reference [1]” to be [1, eq. (8)]. Other phrases may be rewritten as [1, Sec. IV], [1, Th. 4.2], or [1, Ch. 3].

If listing the same reference more than once on the reference list, giving a new reference number for each page or part of the same source that is cited, these separate references should all be made into one reference and the separate citations of pages, equations, etc., should be made in text using the notation explained in the previous paragraph.

If a reference author’s name is mentioned in the text, check its spelling against the reference list.

## Text Citation of Figures and Tables

All first citations of figures and tables in the article must be in numerical order. Citations to figures in text always carry the abbreviation “Fig.” followed by the figure number. The abbreviation is used even when it begins a sentence. Figure footnotes should be placed as part of the caption.

*Figures:*

The general style for captions is such that each caption number should be cited with the abbreviation “Fig.” and the number, followed by a period, an em space, and then the text of the caption. The first word of the caption should always be capitalized, regardless of any style that may be chosen to list caption parts (a), (b), etc., if included. If you are citing Fig. 1(a) and 1(b), the singular "Fig." is still used. In general, do not use A, An, or The at the beginning of a figure or table caption.

***Example:***

Fig. 1. Theoretical measured values of *n*.

There are several acceptable styles for listing the parts of the figure in the caption. Be consistent within each article, but otherwise use whichever style is most convenient for the figure. Regardless of which caption notation is used, the citation of (a), (b), etc., should always appear before the corresponding caption part.

***Examples:***

Fig. 1. Intercomplex crosstalk characteristics. (a) Electrode transmission. (b) Interelectrode crosstalk.

Fig. 2. (a) Variation of effective mode index with time. (b) Step-index change.

Fig. 3. Output resistance as a function of channel doping for 1-m-long gate. (a) InGaAs and (b) InP JFETs with pinchoff voltage as a parameter.

Fig. 4. (a) and (b) Plain and side views, respectively, of the experimental setup used to measure the effective diffraction loss which can be achieved using the feedback technique.

Fig. 1. (a) Electrode transmission. (b) Interelectrode crosstalk.

If parts of a figure after reduction will run the length of more than one page, the full descriptive part of the caption should be cited with the first part of the figure followed by the corresponding caption for the part. On the subsequent pages, the word (*Continued.*) will be placed under the carryover parts of the figure followed by a repeat of the full descriptive part of the caption and the corresponding caption for the carryover parts.

*Captions for Landscape/broadside figures*: The text should appear below the figures and facing outward at all times.

***Examples:***

Fig. 6. True and estimated spectra for a real data sequence. (a) True spectrum.

Fig. 6. (*Continued.*) True and estimated spectra for a real data sequence. (b) Estimated with the periodogram.

*Tables:* The general style for table captions is such that each caption number should be centered above the table with the label TABLE and the enumeration given in Roman numerals. The descriptive text of the caption should be centered directly below the table number caption

The descriptive text of the table caption does not contain a period at the end of the caption, although punctuation may be necessary within the caption itself. In general, table captions should be set as an inverted pyramid.

The style for listing the parts of a table in the caption and in text depends on whichever style is most convenient for the table. The most acceptable style is to follow the conventions for callouts of figures. Example:

TABLE I
PARAMETER VALUES

TABLE II
OPTIMAL WAVELENGTH AS A FUNCTION OF POLARIZER ANGLE. (a) WAVELENGTH FOR EXTERNAL CAVITY. (b) ESTIMATED WAVELENGTH FOR LASER DIODE

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*Reusing graphics previously published in non-IEEE publications. You are responsible for obtaining in advance permission to republish from copyright holder [in most cases, this is the publishing house (not the author of the article)]. The wording is usually supplied by the publishing house itself. This text is added at the end of the caption.*

## Biographies

IEEE Transactions author biographies are generally divided into three paragraphs. However, if appropriate information for each paragraph is not available, the biography may be only one or two paragraphs.

The biography begins with the author's full name and IEEE membership history. The author's name appears in boldface type and must match the byline. A nickname may appear within parentheses, e.g., Sung-Mo (Steve) Kang, but not in the byline. List current IEEE membership only; this is written out in full and should match the byline exactly.

Note that affiliate memberships are neither listed in the byline nor biography membership history.

Abbreviations for IEEE membership grades are S (Student Member), GS (Graduate Student Member), A (Associate Member), M (Member), SM (Senior Member), F (Fellow), LA (Life Associate Member), LM (Life Member), LSM (Life Senior Member), and LF (Life Fellow). Note that A stands for Associate, not Affiliate, Member. Affiliate memberships are not listed in the byline or biography membership history.

Do not include references to IEEE membership from the text of the biography.

Author photos should be professional images of the head and shoulders. Current photos are encouraged; baby and family photos should not be used..

*First Paragraph:* The first paragraph may contain a place and/or date of birth (list place, then date). Next, the author's educational background is listed. When listing degrees earned, the biography should state "[S]he received the Ph.D. degree from …" (not "[S]he received [her] his Ph.D. degree from …"). Always add the word degree after a degree title. Include the years degrees were received. Abbreviations for some common international and domestic degrees are:

Dipl.Ing., Diplom-Physiker, Dr. Ing., Dr. Phil., Dr. Eng., B.S., S.B., B.Sc.(Hons.), B.E.E., B.S.E., M.Eng., M.Sc.(tech.), M.S.E.E., M.S.E., Civilingenir, Lic.es Sci., Lic.es Lett.

Add the full locations (city, state, country) of universities and colleges the first time they are mentioned. For U.S. state-named universities, repeat the state name in the location, and include the country (e.g., University of Colorado, Boulder, CO, USA); for city-named universities, repeat the name of the city when giving the location (e.g., University of Chicago, Chicago, IL, USA). For universities outside the U.S., give locations with the name of the city (postal abbreviations of Canadian Provinces, if used) and the country the first time.

Use lowercase for the author's major field of study.

*Second Paragraph:* The second paragraph of the biography lists military and work experience, including summer and fellowship jobs and consultant positions. Job titles are capitalized. The current job must have a location (city, state, country); previous positions may be listed without one (retain if given). Do not abbreviate city names, Company, Laboratory, or Department. Use standard names for all countries. If there is space, information the author provides about previous publications may be included at the end of this paragraph. Edit out long lists of published books or articles. Instead use the sentence "s(he) is the author of several books and numerous published articles." The format for listing publishers of an author's books within the biography is: *Title of the Book* (publisher name, year) similar to a reference. List author affiliations with non-IEEE journals. Note IEEE TRANSACTION AND JOURNAL TITLES should be in small caps; *IEEE Magazine Titles* should be in italics; and non-IEEE titles should ne in italics. List previous and currrent research interests. Do not repeat the author's name in the second paragraph; use "he" or "she."

*Third Paragraph:* The third paragraph begins with the author's title and last name (e.g., Dr. Smith, Prof. Jones, Mr. Kajor, Ms. Hunter). It lists the author's memberships in professional societies other than the IEEE and his or her status as a Professional Engineer if applicable. Finally, list awards and work for IEEE committees and publications, affiliation with other professional societies, and symposia.

Personal notes such as hobbies should not be included in the biography.

***Examples:***

**Michael C. Author, Jr.** (Fellow, IEEE) was born in New York, NY, USA, in 1969. He received the B.S. degree in applied mathematics from the University of Michigan, Ann Arbor, MI, USA, in 1989, the M.S. degree in mathematical physics from Stanford University, Stanford, CA, USA, in 1991, and the Ph.D. degree in electrical engineering from the Massachusetts Institute of Technology, Cambridge, MA, USA, in 1995.

From 1993 to 1995, he was with Raytheon Corporation, Bedford, MA, USA. From 1995 to 1996, he was with the General Electric Space Laboratory, Valley Forge, PA, USA. From 1996 to 1997, he was a Fulbright Lecturer at the University of Madrid, Madrid, Spain. He is currently an Associate Professor of electrical engineering at the University of Maryland, College Park, MD, USA. His research has been concerned with reentry plasma effects and microwave diagnostics of plasmas.

Dr. Author, Jr. is a Registered Professional Engineer in the State of Pennsylvania.

**Katsunari Okamoto** was born in Hiroshima Prefecture, Japan, in 1949. He received the B.S. degree from Rutgers University, New Brunswick, NJ, USA, in 1979, and the M.S. degree from Monmouth University, Long Branch, NJ, USA, in 1984.

He was a Postdoctoral Fellow at the University of Tokyo, Japan, in 1978. He joined the Ibaraki Electrical Communication Laboratory, N.T.T., Ibaraki-ken, Japan, in 1979, where he was engaged in research on the optimum waveguide structure of optical fibers. At present, he is a Member of Technical Staff at Bellcore, Red Bank, NJ, USA.

Dr. Okamoto is a member of the Institute of Electronics and Communication Engineers of Japan.

## Squibs

If the author chooses not to publish his/her biography and photo, a squib is used. Example:

**James A. Author** (Fellow, IEEE), photograph and biography not available at the time of publication.

If *all* authors of the article opt not to publish his/her biography and photo, no squib is used.

# C. Other Text

## Footnotes

Footnotes should be numbered in consecutive order throughout the text. Each footnote should be a new paragraph. The footnote numbers are superscripts in text and in the actual footnotes. In text, place the superscript footnote numbers after punctuation such as periods, commas, parentheses, and quotation marks, but generally before dashes, colons, and semicolons in a compound sentence. The footnotes should be placed at the bottom of the text column in which they are cited.

## Lists in Text

There are three types of lists in text: run-in lists, displayed lists, and where lists. The ordering of labeling for all lists is 1), 2), 3) followed by a), b), c), and then i), ii), iii). Note the single (ending) parenthesis. The order of indentation is 1 em, 2 ems, 3 ems.

*Run-In Lists:* Lists that run in with text must be grammatically correct. They must also be introduced by a colon, separated by semicolons, and have parallel construction. Example:

> The carrier–phonon interaction matrices are given by: 1) polar optical phonons; 2) deformation potential optical phonons; and 3) piezoelectric acoustic phonons.

*Displayed Lists:* Lists that are displayed may be either incomplete sentence items or full sentence items. Incomplete sentence items contain a few items, are very short, are grammatically parallel, and are handled in two ways. If the items are not mentioned in the text or are fewer than three items, run in as shown in the example for run-in lists. If, however, the items are mentioned later in the text, introduce the item with a colon, number the items, begin the entry with a lowercase letter, and set block paragraph style. Use semicolons between items and a period at the end of the list. Example:

This operating scenario provides all of the contributors necessary to configure a resonant power distribution system:

1) implementation of capacitor power factor correction on the power line;
2) presence of nonlinear load;
3) tuning of the power line by the load adjustments to a frequency present in the nonlinear generator.

Incomplete sentence items that are mentioned in text may also be formatted as shown in the example for full sentence items.

***Example:***

The three problems are related in the following sense:

1) Additional cost constraint;
2) Relaxation of the constraints is permitted;
3) Limited budget optimization is a general optimization problem.

Full sentence items may be introduced by "that" or other words taking object and end with a period. Number all items, start each entry with a capital letter, and end with a period. Example:

The synthesis is performed in three major steps.

1) Geometry is generated for the selected module variants.
2) Shape variants using different fold counts for resistors are generated for each module.
3) Routing and postprocessing complete the final layout.

*Where Lists:* Where lists define variables in the equations preceding the list. They are characterized by incomplete sentences and follow the same rules as *Nomenclature* lists, with the following exceptions.

1) There is no primary heading.
2) The left-hand side is indented one em space.
3) The first letter on the right-hand side is lowercase.
4) Each item ends with a semicolon (except for the last item, which ends with a period).
5) The lists are at least three items long; if fewer than three items, the list is generally run in paragraph form.

***Example:***

where

$\Delta \upsilon_S$ $= \Delta V_S \cos(\omega' t + \phi')$;
$\Delta V_S$ amplitude of supply voltage flicker;
$\omega'$ angular frequency of supply voltage flicker;
$V_{Sf}$ supply voltage amplitude;
$\omega$ supply angular frequency.

Note the alignment of the equal sign with the right-hand side.

Lists having mixed items (start with an incomplete item, then have a full sentence explanation) are treated as a full sentence item list.

### Dedication Line(s)

Dedication lines are usually run on the first page of an article, immediately above the Abstract.

***Example:*** *Dedicated to the work of J. W. Walters.*

### Note Added in Proof

One may wish to add a brief note in the proof stage, citing results obtained after acceptance of the article or mentioning additional references that have come to their attention since the article was accepted. This added information is usually inserted at the end of the Conclusion section of the article or in whatever section contains the last paragraph of the main body of the article. As long as the note is not a major change to the article or more than a few lines long, the addition generally does not require further review procedures. Use the tertiary heading "Note Added in Proof:" (run into text), but set in boldface italic with no enumeration and an em space indent.

***Example:***

*Note Added in Proof.* The author is an owner of the company which manufactured the tubes used in these experiments.

*Note Added in Proof:* Additional information about similar research can be found at www.newreseachresults.com.

## D. Other Types of Papers

### Editorials

This category of papers includes the various types of introductory papers, such as Editorials, Guest Editorials, Forewords, Introductions, and Editorial Announcements that appear at the beginning of issues as nontechnical introductory material. The Editorial may contain illustrations, citations, and references. Citations to articles in the issue should be listed as "Related Works" instead of in the reference section. It must contain a photo and biography of each guest editor when it is a Guest Editorial for a special issue or section. An acknowledgment does not contain a heading. *Note:* In the Editorial, the Acknowledgment does not need to be written in third person and there is no Abstract.

*Byline:* Note that the byline for the Editorial does NOT appear below the title as it does in a full length article. The name of the author of the Editorial or Foreword (usually the Editor or Guest Editor) (called "signature") appears at the end of the Editorial.

***Example:***

MARVIN K. SAIN, *Guest Editor*
Department of Electrical Engineering
University of Illinois
Urbana, IL 60617 USA

### Brief Papers

These papers contain Abstracts and an initial cap. The byline includes the membership grade. They do not contain biographies and photographs of the authors

### Short Papers, Correspondence, and Communications

Short papers are set up like full-length articles. The membership grade is not included in the byline. Author biographies and photos are not included. Footnotes, captions, and references may be included.

### Comments and Replies

Comments are generally in response to a previously published article. The Comments and Author(s) Reply are short papers published together in that the "Reply" is in response to the Comments. These short items may appear without Abstracts. A special format applies for Comments and Author(s) Reply. Begin the first sentence with "In the above paper [1], ..." Reference [1] is the commented paper's citation, will appear as Reference [1] in the References section. Include a copyright line for Comments and Replies.
Some publications refer to these articles as Discussions and Closures.
Index Terms are optional.

Example of the Comments:

*Title:* Comments on "Harmonics: The Effects on Power Quality and Transformers"

*Byline:* Keith H. Sueker

*Footnote:*
Manuscript received July 15, 2006.
The author is with the School of Engineering, Vanderbilt University, Nashville, TN 37235 USA (e-mail: k.sueker@ieee.org).
Digital Object Identifier 10.1109/JQE.2006.12345

**NOTE:** The footnote here relates back to the original article being commented upon. The title is not repeated.

Example of the Reply:

*Title:* Authors' Reply

*Byline:* Robert D. Henderson and Patrick J. Rose

*Footnote:*
Manuscript received October 3, 2006; accepted October 5, 2006. Date of publication November 2, 2006; date of current version November 25, 2006.
The authors are with RDH Consultants, Inc., Charlotte, NC 28241 USA (e-mail: corresponding@author.com).
Digital Object Identifier 10.1109/JQE.2006.12348

### Corrections/Errata

The format for a Corrections or an Erratum is basically the same as for the Comments, except that a Corrections does not carry a Reply. Run a copyright line with a Corrections. A Corrections that has been generated in-house is referred to as an "erratum," but note that the title is still labeled "Corrections." It should say *Corrections to "Title of Original Article"* and should also follow the standard format of a Correspondence.

***Note:*** The plural form of the word is used in the title, even if there may be only one correction. All Corrections ***must*** carry the byline as the same form as the original article; this ensures that the two articles will be linked properly.

Example of a "Corrections" article:

*Title:* Corrections to "On the Exact Realization of LOG-Domain Elliptic Filters Using the Signal Flow Graph Approach"

*Byline:* Costas Psychalinos and Spiridon Vlassis

*Footnote:*
Manuscript received May 1, 2003.

The authors are with the Physics Department, Electronics Laboratory, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece (e-mail: cpsychal@physics.auth.gr; svals@skiathos.physics.auth.gr).
Digital Object Identifier 10.1109/TCSII.2003.814788

Example of Errata:

*Title:* Corrections to "Harmonics: The Effects on Power Quality and Transformers"

*Byline:* Robert D. Henderson and Patrick J. Rose

*Footnote:*
Manuscript received January 20, 2004.
The authors are with RDH Consultants, Inc., Charlotte, NC 28241 USA (e-mail: pjrose@rdh.com).
Digital Object Identifier 10.1109/TVLSI.2004.830244

### Book Reviews

Some publications carry Book Reviews. They are the same as a short paper or correspondence; however, the title runs additional information about the book that is being reviewed. The title is separated from the book's author by an em dash. Included in parentheses is the city of publication, publisher, date of publication, the total number of pages of the book, and the price. Outside of the parentheses is the reviewer's name in italics. Some Transactions carry a short biography of the reviewer under the title. Book Reviews appear in the table of contents with a listing for both the author of the book and the reviewer. Example:

*Title and Byline:*
**The Analysis and Design of Pneumatic Systems**—B. L. Andersen. (New York: Wiley, 1987, 302 pp., $65.00.) *Reviewed by J. L. Shearer.*

*First Footnote:*
The reviewer is with the College of Engineering, Idaho State University, Pocatello, ID 83209 USA. Digital Identifier 0090-6778/TNN.2005.828433.

*Table of Contents:*
The Analysis and Design of Pneumatic Systems—B. L. Andersen . . . . . . . *Reviewed by J. L. Shearer* 123

### Obituaries/In Memoriam

Obituaries are usually run as the first page of an issue, like an Editorial. They are set up with the same specs as Editorials.

## E. Writing Style for Transactions

The following provides a summary of the most important style distinctions to be made in the writing of a Transactions article.

### Acronyms

Define acronyms the first time they appear in the Abstract as well as the first time they appear in the body of the article, written out first as part of the sentence, followed by the acronym in parentheses. Widely used or familiar terms should be defined (see the Common Acronyms and Abbreviations list in the Appendix for some terms that must be defined the first time they are used in text). Acronyms do not need to be defined in the text if mentioned in the Nomenclature. Coined plurals or plurals of acronyms do not take the apostrophe as per *Chicago Manual of Style*. Example: FET (singular); FETs (plural).

Indefinite articles are assigned to abbreviations to fit the sound of the first letter: an FCC regulation; a BRI.

### Spelling

Note that IEEE Transactions use the first spellings indicated in our first reference, the most current edition of *The Merriam-Webster Dictionary.*

*British Spellings and Terminology:* Change all British spellings to American spellings. In particular, watch for "our" endings in words like "behaviour" (change to "behavior") and "re" endings in words like "centre" (change to "center"). Also watch for the use of "s" rather than "z" in words like "polarisation" (change to "polarization"). See "Common Hyphenations and Misspellings" in the Appendix.

### Trademarks

The trademark symbols ™ and ® are no longer used. Capitalize the first letter in the trademark name only. The symbols ™ and ®, which often accompany registered trademark names on product packaging and in advertisements, need not be used in running text. Optionally, for the first occurrence of a trademarked product, a footnote superscript can be placed after the trademarked name, with a matching footnote that reads "Trademarked." or "Registered trademark."

### Plurals

Plurals of units of measure take the "s." For example, the plural form of 3 mil is 3 mils; 3 bits/s instead of 3 bit/s. The plural of calendar years do not take the apostrophe before the "s." For example, the plural form of 1990 is 1990s.

### Hyphenation Rules

For hyphenation and spelling guidelines, IEEE style follows: 1) the list of preferred spellings and hyphenated words can be found in the Appendix; 2) the guidelines discussed in the Grammar and Usage in Transactions section of this guide; and 3) the first version of the spelling given in the most recent edition of *The Merriam-Webster Dictionary*. Do not hyphenate most compound modifiers if they occur after the noun being modified, even if hyphenating them before the noun. *Examples:*

The plan was well prepared. The man was little known. The woman was better qualified. His boat was 42 feet long. He has a 42-foot-long boat. T was the data period of the 40-Gb/s data signal. The 160-GHz MLLD was a diode in which a 40-nm-long saturable absorber was located.

**NOTE:** Do not use the *IEEE Standards Dictionary* for hyphenation guidelines as no attempt is made there for consistency in hyphenation. The *Standards Dictionary* is quite useful for its definitions and acronyms list in its back section.

The most important hyphenation guideline is to be certain that the hyphenation for a particular word or group of adjectives is consistent within a particular article.

### The En, Em, or Two-Em Dash

The en dash represents the words "to," "through," or "and." Use it between page numbers, reference numbers, figure citations, academic years, proper nouns, names, a range of values, or for opposites.

***Examples:***

- pp. 10–15,
- 1984–1990,
- Jones–Smith theorem,
- input–output,
- voltage–current curve,
- analog–digital converter,
- 10–20 cm.

Also, use the en dash in chemical abbreviations such as Ni–Al–Si. When using the en dash to represent a range, if the word "from" occurs, the word "to" must be used rather than an en dash (e.g., ranges from 5 to 50 times).

The em dash is used in ordinary writing to mark a suspension of the sense. It is also used like parentheses, to mark a subordinate thought within a sentence.

## Grammar

Check closely for lapses of clarity, subject/verb agreement, and parallel clause construction. See the following examples:

*Number:*

A number of samples were taken …

A number *N* expressing the relation *x/y* is chosen …

*Data:*

The data were collected … (always plural)

*Series:*

A series of tests was run … (always singular with “a”)

*Some, All, Half:*

Some (all, half) of it is …

Some of them are …

For example:

Use "all of" with another pronoun, such as "these" or "those," and before singular nouns. For collective and plural nouns, use "all."

*Quantity:*

Three volts were applied …

Four grams were added …

## Contractions

Contractions such as “don’t” and “can’t” are not used in technical text. Change to “do not” and “cannot.”
Note: “don’t care,” “best-case,” and “worst-case” are allowed and used often in journals like TCAD.

## Capitalization

In general, discourage capitalization in text except where absolutely necessary. For example, only proper names attached to the names of laws, principles, theorems, etc., get capitalized (Abel’s theorem, Newton’s first law, etc.). Computer commands are in computer tags and remain small caps; most computer languages (Cobol, Java, LISP, PERL, etc.) are upper and lowercase. Earth should be capitalized when referring to the planet.

## Math

Some brief guidelines for writing math are explained here.

1) Variables are set italic; vectors are usually boldface italic.
2) Remove commas around variables in text.
3) Always add a zero before decimals, but do not add after (e.g., 0.25).
4) Check the use of the parentheses and brackets i.e., [0,1).
5) Spell out units used in text without quantities (e.g., “where the noise is given in decibels”). For units appearing with quantities, use the standard abbreviations listed in the Table of Units and Quantity Symbols in the Appendix, and units used as compound adjectives may be hyphenated only if needed for clarity: 10-kV voltage, 5-in-thick glass. Do not insert a hyphen when they are not used as adjectives: a current of 2 A, a line 4 in long, a length of 3.05 mm.
6) Always use a regular space and not a thin space between numbers and units in text.
7) Use thin spaces instead of commas between numbers in tens or hundreds of thousands (e.g., 62 000, 100 000, but 4000).
8) Always make sure $\mu$ is $\mu$m, “micron” is “micrometer,” “submicron” is submicrometer.” Always change cycle per second to hertz (Hz); cycle per second may not appear as cycle, cps, c/s, csec.

9) In text, fractions may be broken down (shilled) multiline (built-up) so they can be placed on one line. Sometimes parentheses may need to be added to distinguish between expressions, especially when a minus appears [e.g., $\frac{a}{b-c}$ becomes $a/(b-c)$ ], $\frac{c-d}{k+4}$ becomes *[(c-d)/(k+4)]*. This may be done to save space, but is not a necessity.
10) In exponential expressions [e.g., $e^{-(jwt)xyzk}$ ], there are sometimes long and complicated superscripts. These may be brought down in line with the substitution of "exp" for "e" and the addition of square brackets (e.g., exp[–(*jwt*)*xyzk*]).
11) Distinguish between lowercase italic "ell" or "oh" versus one and zero.
12) Always use numerals for numbers written with units. Otherwise, spell out numbers below 11, and use numerals for others unless they begin a sentence or are combined in a phrase (gives 7 to 13 times more).
13) Use zeroth, first, *n*th, ($k$ + 1)th, not 1st, 2nd, ($k$ + 1)st, etc.
14) Use the word "Equation" at the start of a sentence, but in text, just use the number [e.g., in (1)].
15) Use the $ symbol versus "dollars" in sums of money.
16) The slash (/) is acceptable in place of the word "per" when it lends to the clarity of the sentence. For example: "the ratio of 16 samples/s to 35 samples/s as compared to …"

*Ellipses:* In mathematics, you may use dots (ellipses) to show continuation in an expression (e.g., $x_2$, ..., $x_{16}$). The type of mathematical expression will determine whether the ellipses points are set on the baseline or centered. If commas or operational signs are present, they are placed after each term and after the three ellipses points. If operational signs are used, the ellipses are centered on the operator. When commas are used, the ellipses are on the baseline. Example:

$x_1, x_2, \cdots, x_n$ not $x_1, x_2 \ldots x_n$

$x_1 + x_2 + \cdots + x_n$ not $x_1 + x_2 + \cdots x_n$

$y = 0, 1, 2, \ldots$ not $y = 0, 1, 2 \ldots$

$x_1x_2 \cdots a_n$ not $x_1x_2 \cdots a_n$

*Conditions:* In displayed equations, a comma or parentheses and a two-em space is inserted between the main expression and the condition following it. Example:

$$x = yn^{-2} \qquad \forall n = 3$$

$$x = yn^{-2}, \qquad \text{if } n = 3 - y^{-4}.$$

$$x = yn^{-2}, \qquad y = 3, \ldots, m$$

**NOTE:** There is no comma before a for all " $\forall$ " symbol.

*Compound Units:* Compound units should be separated by a centerdot (e.g., 4 V · s), but a slash may be used since this has a different meaning (for instance, 6 V/s means volts per second). It is also possible touse a negative power to put a unit in the denominator: cm/s$^2$ = cm · s$^{-2}$. Parentheses may be used to clarify a unit: g/(cm · s) or g · cm$^{-1}$ · s$^{-1}$.

*Use of Periods and Commas:* Equations which conclude a sentence should end with a period. The only time punctuation is used to lead into an equation is when the lead-in text is a complete sentence. Example:

where we had the following:

$$x = Y + Z.$$

or where, i.e.,

$$x = Y + Z.$$

Commas appearing at the ends of equations are deleted unless they are critical to the punctuation of the sentence containing the equation.

## Equation Numbers

Equation numbering should be consecutive, should appear flush right on line with the last line of an equation, should not have repeats or missing numbers, and should use a correct numbering style.

**Displayed Equations**

Material in displayed equations is automatically italic unless you indicate otherwise. Some simple general rules apply. All variables are italic. Function names and abbreviations are Roman, as are units, unit abbreviations, complete words, and abbreviations of words. Superscripts and subscripts follow this same formula: when they are variables, they are italic; when they are abbreviations of words (such as “in” and “out” for input and output), they are Roman. Single-letter superscripts and subscripts may be italic even if they are abbreviations, unless this leads to inconsistency between italic and Roman characters for similar types of subscripts.

## F. General Layout Rules

1) Figures and tables are placed at the tops of columns as close to their first mention as possible, but preferably after the mention.
2) Figures and tables progress vertically, not horizontally, on pages.
3) Footnotes must appear at the bottom of the column where they are first mentioned.

# III. GRAMMAR AND USAGE IN TRANSACTIONS

## A. Rules of Grammar

The principles of style below focus on fundamentals of modern usage. Particular emphasis is given to the rules most commonly violated.

1) **Form the possessive singular of nouns by adding “s”** (*Avogadro’s theorem*). Follow this rule unless the final consonant is an s (*Burns’ theorem*). Possessive pronouns (*hers, its, yours, theirs, ours*) have no apostrophe. Indefinite pronouns use the apostrophe to show possession (*someone’s rule*). Contractions use an apostrophe (*it’s for* …; *it is*). Possessives do not (*its losses*).
2) **In a series of three or more terms, use a comma immediately before the coordinating conjunction** (*usually and, or,* **or** *nor*).
3) **Enclose parenthetic expressions between commas** (*Improvement, as shown in Fig. 1, is attained by the addition of the cogeneration*). Brief phrases or single words, such as *however*, may or may not be parenthetic (such connectives at the head of a sentence are more commonly left unpunctuated). The commas may be omitted if the interruption to the flow of the sentence is slight. In this case, never omit one comma and leave the other. Remember that many seemingly single commas stand for a pair. Clauses or phrases at the beginning or end of sentences do not look parenthetical, but often they might just as well be placed in the middle, in which case they would be found punctuated at both ends. At the beginning of a sentence, such an element is set off by what should be thought of as the second comma in a pair. For instance, note the three possible positions illustrating a parenthetical element of this kind: *However the sum may later change, it is calculated now/The sum is calculated now, however it may later change/The sum, however it may later change, is calculated now.* In all three examples, the meaning remains constant; the single commas of the first and second sentences have the same parenthetical function as the paired commas of the third.

Parenthetic material such as dates take the comma(s) as follows: *February 14, 1996* or *April to June 1996* or *Saturday, March 9, 1996.*

The abbreviations etc., i.e., and e.g., are parenthetic and use the comma as follows: cables, transformers, etc., are needed. Abbreviations for academic degrees, titles following a name, and certain restrictive terms of identification should be punctuated as follows:

*Robert D. Lorenz, Ph.D.*

*Ian T. Wallace, Member, requests that…*

*E. A. Brockmann, Jr., states that…*

Restrictive clauses are not parenthetic and are not set off by commas: *The proof that (or which) (restrictive clause should be "that" while nonrestrictive is “which”; "who" can be restrictive or nonrestrictive, depending on how it is used) is given in this section is not complete.*

Nonrestrictive clauses are parenthetic and are set off by commas: *The address i, which is the starting address of the message, is then transferred to a queue list on the processing part …*

The nonrestrictive clause always takes “which” and is surrounded by commas. The restrictive clause can take “that” or “which”; “that” is preferred.

4) **A semicolon is used to link two independent clauses with no connecting words. You can also use a semicolon to join two independent clauses together with one of the following conjunctive adverbs: however, moreover, therefore, consequently, otherwise, nevertheless, thus, etc.**
5) **Use a colon after an independent clause to introduce a list.**
6) **Punctuation always goes inside quotation marks, except for the colon and semicolon.** Use single quotation marks around quotes within quotes. Quotes may be used around a new or special usage of a term the first time only, but use of quotes in this manner should be kept to a minimum.
7) **Do not use double parentheses in text expressions, but keep them in math.** For example, (see (10)) should become [see (10)].
8) **All acronyms and numerical plurals do not use apostrophes,** i.e., *FETs, 1980s* (Note: Some exceptions may apply in mathematical writing.)
9) **Compound nouns made from a one-syllable verb and a short adverb are one word when found that way in the dictionary** (setup, takeoff, breakup). Compound nouns are likely to be two words, without a hyphen, or one word (bandwidth, bypass, flowchart, phase shift, sideband, standing wave). Compound nouns of more than two words can be hyphenated.
10) **A pair of words, modifying a third word separately, does not get a hyphen** (a tall water tower, a hot metal cylinder). If the first word modifies the second, and the pair together modify the third, there is a hyphen between the pair (a high-frequency signal, a second-order equation). The exception to this is the adverb ending in “ly,” which needs no hyphen to join it to the next word.
11) **A hyphen is not used after the comparative or the superlative** (a higher order equation, a worst case value, nearest neighbor method). Do not hyphenate chemical compounds (sodium chloride crystals). Alloys and mixtures take the en dash (Ni–Co, He–Ne laser).
12) **Do not use commas between adjectives** (a planar equiangular spiral antenna).
13) **Do not hyphenate predicate adjectives** (… is well known, …is second order).
14) If you are unsure, check *The Merriam-Webster Dictionary* to see if words are hyphenated.
15) **Compound verbs are generally hyphenated** (arc-weld, freeze-dry). Keep the hyphen when using the participles of such verbs as adjectives (freeze-dried, arc-welded). However, verbs with up, out, down, off, on, etc., do not have a hyphen, although the nouns formed from them may be hyphenated or one word (verb: set up, break down, read out; noun: setup, breakdown, readout).

## Words Often Confused

Affect: to change or modify (verb).
Effect: result (noun); cause (verb).

Alternate: a substitute.
Alternative: a matter of choice.

Among: involves more than two things.
Between: involves more than two things, but considers each individually.

Compare to: point out resemblances between different objects.
Compare with: point out similarities and differences between same objects.

Compose: to make up or form: a set composed of members.
Comprise: to be made up of; to be formed by: a set comprising members; members comprising a set.

Farther: distance.
Further: quantity.

Fewer: modifies plural nouns specifying countable units, e.g., fewer tubes.
Less: modifies singular mass nouns and singular abstract nouns, e.g., less air.

Imply: something suggested though not expressed.
Infer: something deduced from evidence.

Number: used when objects can be counted: a large number of people.
Amount: used when objects cannot be counted: a large amount of water.

Principal: chief, main, most important (adjective).
Principle: a rule (noun).

Precede: come before.
Proceed: continue, advance.

That: (defining, restrictive).
Which: (nondefining, nonrestrictive)

# IV. APPENDIX

## A. Some Common Acronyms and Abbreviations

**NOTE:** Asterisks (*) indicate terms which must be defined the first time they are used in text. Other terms listed here may be used without definition.

| | |
|---|---|
| **A** | |
| ac | alternating current |
| A–D, A/D | analog-to-digital |
| AF | audio frequency* |
| AFC | automatic frequency control* |
| AGC | automatic gain control* |
| AM | amplitude modulation |
| APD | avalanche photodiode |
| AR | antireflection* |
| ARMA | autoregressive moving average* |
| ASIC | application-specified integrated circuit* |
| ASK | amplitude shift keying |
| ATM | asynchronous transfer mode |
| av | average (subscript)* |
| avg | average (function) |
| AWGN | additive white Gaussian noise* |
| **B** | |
| B–E | base–emitter source |
| BER | bit error rate* |
| BPSK | binary phase-shift keying |
| BWO | backward-wave oscillator* |
| **C** | |
| c.c. | complex conjugate (in equations) |
| CCD | charge-coupled device* |
| CDMA | code division multiple access* |
| CD-ROM | compact disk read-only memory |
| CIM | computer integrated manufacturing* |
| CIR | carrier-to-interference ratio* |
| CMOS | complimentary metal–oxide–semiconductor |
| CPFSK | continuous phase frequency-shift keying* |
| CPM | continuous phase modulation* |
| CPSK | continuous phase-shift keying* |
| CPU | central processing unit |
| CRT | cathode-ray tube |
| CT | current transformer* |
| *CV* | capacitance–voltage |
| CW | continuous wave* |

| | |
|---|---|
| **D** | |
| dc | direct current |
| DC | directional coupler |
| DF | direction finder*; deuterium fluoride; degree of freedom* |
| DFT | discrete Fourier transform* |
| DMA | direct memory access* |
| DPCM | differential pulse code modulation* |
| DPSK | differential phase-shift keying* |
| **E** | |
| EDP | electronic data processing |
| EHF | extremely high frequency* |
| ELF | extremely low frequency* |
| EMC | electromagnetic compatibility* |
| EMF | electromotive force* |
| EMI | electromagnetic interference* |
| ems | expected value of mean square* |
| **F** | |
| FDM | frequency division multiplexing* |
| FDMA | frequency division multiple access* |
| FET | field-effect transistor |
| FFT | fast Fourier transform* |
| FIR | finite-impulse response* |
| FM | frequency modulation |
| FSK | frequency-shift keying* |
| FTP | file transfer protocol |
| FWHM | full-width at half-maximum* |
| **G** | |
| GUI | graphical user interface |
| **H** | |
| HBT | heterojunction bipolar transistor |
| HEMT | high-electron mobility transistor |
| HF | high frequency |
| HTML | hypertext markup language |
| HV | high voltage |
| HVdc | high voltage direct current |
| **I** | |
| IC | impedance compensation*; integrated circuit |
| ID | inside diameter; induced draft*; interdigital* |
| IDP | integrated data processing* |
| IF | intermediate frequency |
| IGFET | insulated-gate field-effect transistor |
| i.i.d. | independent identically distributed* |
| IM | intermediate modulation |
| IMPATT | impact ionization avalanche transit time (diode) |
| I/O, I–O | input–output |
| *IR* | infrared |
| IR | current-resistance |
| ISI | intersymbol interference |
| *I–V* | current–voltage |
| **J** | |
| JFET | junction field-effect transistor |

| | |
|---|---|
| JPEG | Joint Photographers Expert Group |
| **L** | |
| LAN | local area network |
| *LC* | inductance–capacitance |
| LED | light-emitting diode |
| LHS | left-hand side* |
| *L–I* | light output–current |
| LMS | least mean square |
| LO | local oscillator* |
| LP | linear programming* |
| LPE | liquid phase epitaxy* |
| *LR* | inductance–resistance |
| **M** | |
| MESFET | metal–semiconductor field-effect transistor |
| MF | medium frequency* |
| MFSK | minimum frequency-shift keying |
| MHD | magnetohydrodynamics |
| MIS | metal–insulator–semiconductor |
| MLE | maximum-likelihood estimator* |
| MLSE | maximum-likelihood sequence estimator* |
| MMF | magnetomotive force |
| MMIC | monolithic microwave integrated circuit* |
| MoM | method of moments* |
| MOS | metal–oxide–semiconductor |
| MOSFET | metal–oxide–semiconductor field-effect transistor |
| MOST | metal–oxide–semiconductor transistor |
| MPEG | Motion Pictures Expert Group |
| **N** | |
| A | numerical aperture* |
| NIR | near infrared response* |
| NMR | nuclear magnetic resonance* |
| n-p-n | (diode) |
| NRZ | nonreturn to zero* |
| **O** | |
| OD | outside diameter |
| OEIC | optoelectronic integrated circuit* |
| OOP | object-oriented programming |
| **P** | |
| PAM | pulse-amplitude modulation* |
| PC | personal computer |
| PCM | pulse-code modulation* |
| pdf | probability density function* |
| PDM | pulse-duration modulation* |
| PF | power factor* |
| PID | Proportional-integral differential |
| p-i-n, p-n-p | (diode) |
| PLL | phase-locked loop* |
| PM | phase modulation* |
| PML | perfectly matched layer |

| | |
|---|---|
| pp, p–p | peak-to-peak* |
| PPM | pulse-position modulation* |
| PRF | pulse-repetition frequency* |
| PRR | pulse-repetition rate* |
| PSK | phase-shift keying* |
| PTM | pulse–time modulation |
| p.u. | per unit* |
| PWM | pulse width modulation* |
| **Q** | |
| *Q* | quality factor; figure of merit |
| QoS | quality of service |
| QPSK | quaternary phase-shift keying |
| **R** | |
| RAM | random access memory |
| *RC* | resistance–capacitance |
| R&D | research and development |
| RF | radio frequency |
| RFI | radio frequency interference* |
| RHS | right-hand side* |
| RIN | relative intensity noise* |
| *RL* | resistance–inductance |
| rms | root mean square |
| ROM | read-only memory |
| RV | random variable |
| **S** | |
| SAW | surface acoustic wave* |
| SGML | standard generalized markup language |
| SHF | super high frequency* |
| SI | International System of Units; severity index* |
| SIR | signal-to-interference ratio |
| *S/N*, SNR | signal-to-noise ratio |
| SOC | system-on-a-chip* |
| SSB | single sideband* |
| SW | short wave* |
| SWR | standing-wave ratio* |
| | |
| TDM | time-division modulation*; time-division multiplexing* |
| TDMA | time-division multiple access* |
| TE | transverse electric |
| TEM | transverse electromagnetic |
| TFT | thin-film transistor* |
| TM | transverse magnetic |
| TVI | television interference* |
| TWA | traveling-wave amplifier* |
| **U** | |
| UHF | ultrahigh frequency |
| UV | Ultraviolet |
| **V** | |
| VCO | voltage-controlled oscillator* |

| | |
|---|---|
| VHF | very high frequency* |
| *V–I* | voltage–current |
| VLF | very low frequency* |
| VLSI | very large scale integration* |
| **W** | |
| WAN | wide area network |
| WDM | wavelength division multiplexing* |

## B. Common Hyphenations and Misspellings

| |
|---|
| *a posteriori* |
| *a priori* |
| Abelian |
| accommodate |
| acknowledgment |
| acoustoelectric |
| acoustooptical |
| *ad hoc* |
| ad hoc networks |
| adder |
| aerospace |
| aftereffect |
| airborne |
| all-pass (adj) |
| Alnico |
| alphameric |
| alphanumeric |
| analog (not analogue) |
| appendixes |
| arc-back (n, adj) |
| arc-over (n, adj) |
| axle |
| back EMF |
| back-end (adj) |
| backscatter |
| band-limited (adj) |
| bandpass |
| band-shared (adj) |
| bandwidth |
| bang-bang |
| base–emitter [en dash] |
| base–collector [en dash] |
| baseband |
| baseline |

| |
|---|
| Bayes' rule |
| beamwidth |
| Bernoulli polynomial |
| Bessel function |
| bimetallic |
| biomedical |
| blackbody |
| Boltzmann's constant |
| Boolean algebra |
| broadband |
| bulk–source [en dash] |
| bus (not buss) |
| bypass |
| *C*-band |
| Cartesian |
| Cascade |
| cascode |
| Cauchy's inequality |
| Chebyshev (not Tchebbycheff) |
| chi-square |
| Clebsch–Gordan coefficient |
| coauthor (also, coworker) |
| coax (coaxial) |
| collinear (not colinear) |
| continuous-time (adj) |
| coset |
| costate |
| Coulomb wave function |
| counterclockwise |
| counterexample |
| coworker |
| coupled-mode (adj) |
| cross correlation |

| |
|---|
| crossover |
| cross section |
| cross-sectional (adj) |
| crosstalk |
| cutoff |
| cybersecurity |
| database |
| deadtime (or dead time) |
| debug, debugged |
| Debye temperature |
| |
| Dewar |
| diagramed |
| dielectric |
| diesel |
| digamma function |
| Dirac |
| discretization |
| discusser |
| Doppler |
| drain–source [en dash] |
| dropout |
| dyadic |
| eccentricity |
| eigenfunction |
| eigenvalue |
| eigenvector |
| elastance |
| elastooptical |
| electrooptic |
| elliptical coordinates |
| elliptic integrals |
| emitter–bulk [en dash] |

| |
|---|
| end-effector |
| endfire |
| endpoint |
| *et al.* |
| Euler function |
| exponentiate |
| fan-in |
| fan-out |
| far-field (adj) |
| fast Fourier transform |
| feedback |
| feedback-free (adj) |
| first-order (adj) |
| flat-band |
| flip-flop |
| flowchart |
| flowmeter |
| flowthrough |
| fold (twofold, *n*-fold) |
| foreword |
| formulas (not formulae) |
| forward scatter |
| 4-vector |
| front-end (adj) |
| Fresnel |
| gate–source [en dash] |
| gate–drain [en dash] |
| gauge (not gage) |
| Gaussian distribution |
| Gegenbauer |
| gimbaled |
| gradient |
| (the) Green's function |
| Gudermannian |
| half-angle |
| half-plane |
| half-space |
| half-wave |
| halfway |
| Hankel function |
| Heaviside |
| Hermite |
| Hermitian |
| Hertzian |
| higher order (adj) |
| high-order (adj) |
| high-pass (adj) |
| hookup |
| hydroelectric |

| |
|---|
| iff (if and only if) |
| imbalance (n) |
| inasmuch as |
| indexes (plural of index) |
| indices (plural used in math) |
| infrared |
| inhomogeneous |
| input, inputted |
| input–output [en dash] |
| *in situ* |
| insofar as |
| *in vitro* |
| *in vivo* |
| integer |
| integral |
| integrand |
| integrator |
| integro-differential |
| Internet |
| Itô |
| Jacobian |
| Jacobi's polynomials |
| *Ka*-band |
| Kronecker delta |
| *L*-band |
| Lagrange |
| Lagrangian |
| Laguerre polynomial |
| Lame's transform |
| Laplace transform |
| Laplacian |
| Laurent series |
| left-hand side |
| leftmost |
| Legendre |
| Leibnitz (or Leibniz) |
| leveled |
| lightweight |
| like (suffix, close up) |
| line shape |
| lineup |
| linewidth |
| lockout |
| log-likelihood (adj) |
| lookup table |
| loudspeaker |
| lower order (adj) |
| low-order (adj) |
| low-pass (adj) |

| |
|---|
| Lur'e |
| Lurie |
| Lyapunov (not Liapunov) |
| macro (noun) |
| magnetohydrodynamics |
| magnetooptic |
| main lobe |
| makeup |
| manhole |
| man-hour |
| man-made |
| manpower |
| Markov process |
| *m*-ary |
| Mathieu's equation |
| matrices |
| mean-square |
| mid (prefix) close up |
| midband |
| midline |
| midplane |
| midpoint |
| miniscule |
| missile |
| modem |
| modulo (mod) |
| modulus |
| monotonic |
| monotonically |
| monotonicity |
| Mossbauer |
| *m*-sequence (noun) |
| multi (prefix) usually one word |
| multithreshold |
| Mylar |
| narrowband (adj) |
| *n*-ary |
| nearby |
| near-field (adj) |
| neoprene |
| Neumann |
| n-junction |
| n-layer |
| non (prefix) one word |
| non-Euclidean |
| non-Gaussian |
| non-Hermitian<br>nonnegative |

| |
|---|
| non-Stokes’ |
| nonzero |
| NP-hard |
| *n*th-order (adj) |
| *n*-tuple |
| n-type |
| n-well |
| ohmmeter |
| one-dimensional (adj) |
| ORed, ORing |
| ON-OFF |
| output, outputted |
| overall (adj) |
| parameterization |
| particle |
| passband |
| percent |
| Permalloy |
| Perspex |
| phaselength |
| phase shift |
| phasewidth |
| photoelectric |
| photoetch |
| photoresist |
| pickup |
| piecewise linear |
| piezoelectricity |
| p-i-n |
| pinchoff |
| p-junction |
| Planck’s constant |
| p-n junction |
| p-n-p (not PNP) |
| p^+-n-p^++ |
| Poisson distribution |
| positive definite |
| postmultiplication |
| pothead |
| potline |
| powerhouse |
| power plant |
| preceding |
| premultiplication |
| printout |
| proceeding |
| programmed |
| proof (suffix) one word |
| propagation |

| |
|---|
| pseudo (prefix) one word |
| pseudorandom |
| p-type |
| pull-in |
| pull-out |
| pulselength |
| pulse shape |
| pulsewidth |
| punchthrough |
| p-well |
| quadratic |
| quarter-wave |
| quartic |
| quasi- (prefix) hyphen |
| quaternary |
| *Q* value |
| radioactive |
| radio-astronomic |
| radio astronomy |
| radio frequency |
| random access (adj) |
| readback |
| READ head |
| readin (noun) |
| readout (noun) |
| real-valued (adj) |
| reentry |
| reexamine |
| Riccati |
| Riemann |
| right-hand side |
| rise time |
| root-mean-square (adj) |
| roundoff (adj) |
| Runge–Kutta |
| saddle point |
| scalar (magnitude) |
| scaler (machine) |
| scalor (rare) |
| self- (prefix) hyphen |
| self-adjoint |
| semi (prefix) usually one word |
| semi-infinite |
| servo (servomechanism) |
| servo amplifier |
| -shaped (hyphen) |
| sideband |
| sidelobe |

| |
|---|
| signaling |
| slip ring |
| slow wave |
| so-called |
| solid-state (adj) |
| space-time |
| special-purpose (adj) |
| spirule |
| state of the art (noun) |
| state-variable (adj) |
| step-down |
| step-up |
| Stirling numbers |
| Stokes’ |
| stopband |
| straightforward |
| strain gauge |
| Struve’s function |
| Sturm–Liouville [en dash] |
| suboptimum |
| subproblem |
| succeeding |
| successive |
| summable, asummable |
| supercoding |
| supermartingale |
| supersede |
| switchgear |
| switchyard |
| table lookup |
| takeoff |
| Taylor expansion |
| Tchebbyscheff (use Chebyshev) |
| Teflon |
| Teletype |
| teletypewriter |
| tensor |
| thin-film (adj) |
| threefold |
| 3-space |
| throughput |
| time dependence |
| time-varying (adj) |
| tradeoff |
| traveling |
| two-port (or 2-port) |
| two’s complement |
| -type (hyphen) |

| |
|---|
| ultrahigh frequency |
| ultrasonic |
| ultraviolet |
| unbalance (verb) |
| Van de Graaf |
| van der Waals |
| vector |
| versus |
| vertical |
| vertices |
| watthour meter |
| wattmeter |
| waveband |

| |
|---|
| waveform |
| wavefront |
| wave function |
| waveguide |
| wavelength |
| wavenumber |
| wave shape |
| wave vector |
| wideband |
| wide-sense (adj) |
| widespread |
| wise (suffix) one word |
| worldwide |

| |
|---|
| worst case (adj) |
| WRITE head |
| x-axis |
| *X*-band |
| *x*-direction |
| X-ray (adj) |
| *xy* plane |
| Yagi |
| Zener diode |
| zero-input (adj) |
| zero-sum (adj) |
| zeroth-order (adj) |
| *z* transform |

## C. Table of Units and Quantity Symbols

**NOTE:** Asterisks (*) indicate SI units, preferred multiples of SI units, or other units acceptable for use with SI.

| **Unit** | **Unit Symbol** | **Sometimes Occur as: (do not use)** | **Applications and Notes** | **Quantity Symbol (for use as variables, etc.)** |
|---|---|---|---|---|
| *ampere | A | amp, a | SI unit of electric current. | *I*<br>*U*<br>*F* |
| ampere-hour | Ah | amp-hr | Also A · h. | |
| *ampere (turn) | A | At | SI unit of magnetomotive force. | *F* |
| *ampere per meter | A/m | | SI unit of magnetic field strength. | *A*<br>*H* |
| ångström | Å | Å | Å $10^{-10}$ m.<br>Deprecated (see ANSI/IEEE Std 268-1992). | |
| atmosphere, standard | atm | | atm 101 325 Pa.<br>Deprecated (see ANSI/IEEE Std 268-1992). | |
| atmosphere, technical | at | | at kgf/cm$^2$.<br>Deprecated (see ANSI/IEEE Std 268-1992). | |
| *atomic mass unit (unified) | u | | The (unified) atomic mass unit is defined as one-twelfth of the mass of an atom of the carbon-12 nuclide. Use of the old atomic mass unit (amu), defined by reference to oxygen, is deprecated. | |
| *atto | a | | SI prefix for $10^{-18}$. | |
| *attoampere | aA | | | |
| bar | bar | b, barye | bar 100 kPa. Use of the bar is strongly discouraged (see ANSI/IEEE Std 268-1992). Except for limited use in meteorology. | |
| barn | b | | b $10^{-28}$ m$^2$. | |

| | | | | |
|---|---|---|---|---|
| barrel | bbl | | bbl = 42 $gal_{US}$ = 158.99 L.<br>This is the standard barrel used for petroleum and petroleum products. Different standard barrels are used for other commodities. | |
| barrel per day | bbl/d | | | |
| baud | Bd | baud (w/prefix) | In telecommunications, a unit of signaling speed equal to one element per second. The signaling speed in bauds is equal to the reciprocal of the signal element length in seconds. | $1/\tau$ |
| bel | B | b | | |
| *becquerel | Bq | | SI unit of activity of a radionuclide. | |
| billion electronvolts | GeV | bev, BeV | The name *gigaelectronvolt* is preferred for this unit. | |
| bit | b | | In information theory, the bit is a unit of information content equal to the information content of a message, the *a priori* probability of which is one-half. In computer science, the name bit is used as a short form of *binary digit.* | |
| bit per second | b/s | | | |
| British thermal unit | Btu | | | |
| byte | B | | A byte is a string of bits, usually eight bits long, operated on as a unit. A byte is capable of holding one character set. | |
| calorie (International Table) | $cal_{IT}$ | | $cal_{IT}$ 4.1868 J. Deprecated (see ANSI/IEEE Std 268-1992). | |
| calorie (thermochemical) | cal | | cal 4.1840 J. Deprecated (see ANSI/IEEE Std 268-1992). | |
| *candela | cd | | SI unit of luminous intensity. | *I* |
| candela per square inch | $cd/in^2$ | | Use of the SI unit $cd/m^2$ is preferred. | |
| *candela per square meter | $cd/m^2$ | nit | SI unit of luminance. | *L* |
| candle | cd | | The unit of luminous intensity has been given the name *candela*. Use of the name *candle* for this unit is deprecated. | |
| *centi | c (prefix) | | SI prefix for $10^{-2}$. | |
| *centimeter | cm | | | |
| centipoise | cP | | cP mPa · s. The name centipoise is deprecated (see ANSI/IEEE Std 268-1992). | |
| centistokes | cSt | | cSt $mm^2/s$. The name centistokes is deprecated (see ANSI/IEEE Std 268-1992). | |
| *circular mil | cmil | | cmil ( /4) · $10^{-6} in^2$. | |
| *coulomb | C | c | SI unit of electric charge. | Q |
| *cubic centimeter | $cm^3$ | cc | Volume. (Preferred SI unit multiple.) | |
| cubic foot | $ft^3$ | | | |
| cubic foot per minute | $ft^3/min$ | cfm | | |
| cubic foot per second | $ft^3/s$ | | | |
| cubic inch | $in^3$ | | | |
| *cubic meter | $m^3$ | | | |

| | | | | |
|---|---|---|---|---|
| *cubic meter per second | $m^3/s$ | | | |
| cubic yard | $yd^3$ | | | |
| curie | Ci | C | Ci 3.7 x$10^{10}$ Bq. A unit of activity of a radionuclide. Use of the SI unit, the becquerel, is preferred. | |
| cycle per second | Hz | c/s, cps, c/sec, cycle | See hertz. | |
| darcy | D | | D cP·(cm/s)·(cm/atm) = 0.986923 $\mu m^2$. A unit of permeability of a porous medium. By traditional definition, a permeability of one darcy will permit a flow of 1 $cm^3/s$ of fluid of 1 cP viscosity through an area of 1 $cm^2$ under a pressure gradient of 1 atm/cm. Deprecated (see ANSI/IEEE Std 268-1992). | |
| day | d | | day 24 h. | |
| deci | d (prefix) | | SI prefix for $10^{-1}$. | |
| decibel | dB | db, DB | | |
| degree (plane angle) | …° | deg | | |
| degree (temperature) | | | | |
| degree Celsius | °C | degree centigrade | SI unit of Celsius temperature. The degree Celsius is a special name for the kelvin, used in expressing Celsius temperatures or temperature intervals. | *t* |
| degree Fahrenheit | °F | | Note that the symbols for °C, °F, and °R are comprised of two elements, written with no space between the ° and the letter that follows. The two elements that make the complete symbol are not to be separated. | |
| degree kelvin | K | | See kelvin. | |
| degree Rankine | °R | | | |
| deka | da | | SI prefix for 10. | |
| dyne | dyn | dyne | dyn $10^{-5}$ N. Deprecated (see ANSI/IEEE Std 268-1992). | *F* |
| *electronvolt | eV | ev | | |
| erg | erg | | erg $10^{-7}$ J. Deprecated (see ANSI/IEEE Std 268-1992). | |
| exa | E | | SI prefix for $10^{18}$. | |
| *farad | F | f, fd | SI unit of capacitance. | *C* |
| *femto | f | | SI prefix for $10^{-15}$. | |
| femtometer | fm | | | |
| foot | ft | | ft 0.3048 m. | |
| foot of water | $ftH_2O$ | | $ftH_2O$ = 2989.1 Pa. (ISO).[1] | |
| foot per minute | ft/min | fpm | | |
| foot per second | ft/s | fps, ft/sec | | |

| | | | | |
|---|---|---|---|---|
| foot per second squared | ft/s$^2$ | | | |
| foot pound-force | ft · lbf | | | |
| footcandle | fc | | fc lm/ft$^2$. The name *lumen per square foot* is also used for this unit. Use of the SI unit of illuminance, the lux (lumen) per square meter, is preferred. | |
| footlambert | fL | | fL (1/ ) cd/ft$^2$. A unit of luminance. One lumen per square foot leaves a surface whose luminance is one footlambert in all directions within a hemisphere. Use of the SI unit, the candela per square meter, is preferred. | |
| gal | Gal | | Gal cm/s. Deprecated (see ANSI/IEEE Std 268-1992). | |
| gallon | gal | | 1 gal$_{UK}$ = 4.5461 L.<br>1 gal$_{US}$ 231 in$^3$ = 3.7854 L. | |
| gauss | G | | The gauss is the electromagnetic CGS unit of magnetic flux density. Deprecated (see ANSI/IEEE Std. 268-1992). | *B* |
| *giga | G | kM | SI prefix for 10$^9$. | |
| gigabyte | GB | | GB 10$^9$B. | |
| *gigaelectronvolt | GeV | bev, BeV | | |
| *gigahertz | GHz | kMHz, KMC, Gc/s | | |
| | | | [1]The term "(ISO)" means that the definition is from ISO 31. | |
| gilbert | Gb | | The gilbert is the electromagnetic CGS unit of magnetomotive force. Deprecated (see ANSI/IEEE Std 268-1992). | |
| grain | gr | | gr lb/7000. | |
| *gram | g | gm | | *m* |
| gram per cubic centimeter | g/cm$^3$ | | | |
| *gray | Gy | | SI unit of absorbed dose in the field of radiation dosimetry. | |
| *hecto | h | | SI prefix for 10$^2$. | |
| *henry | H | Hy, hy | SI unit of inductance. | *L*<br>$P$, $P_m$ |
| *hertz | Hz | cps, c/s, cycle | SI unit of frequency. | $f$, $v$<br>*B* |
| horsepower | hp | | hp 550 ft · lbf/s = 746 W. The horsepower is an anachronism in science and technology. Use of the SI unit of power, the watt, is preferred. | |
| *hour | h | hr | | |

| | | | | |
|---|---|---|---|---|
| inch | in | in. | in 2.54 cm. | |
| inch of mercury | inHg | | inHg = 3386.4 Pa (ISO). | |
| inch of water | $inH_2O$ | | $inH_2O$ = 249.09 Pa (ISO). | |
| inch per second | in/s | ips | | |
| *joule | J | | SI unit of energy,<br>work,<br>and quantity of heat. | *E*<br>*W*<br>*Q* |
| *joule per kelvin | J/K | | SI unit of heat capacity and of entropy. | *S* |
| kelvin | K | | In 1967, the CPGM gave the name *kelvin* to the SI unit of temperature, which had formerly been called *degree kelvin*, and assigned it the symbol K (without the symbol °). | |
| *kilo | k | | SI prefix for $10^3$. The symbol k shall not be used for kilo. The prefix kilo shall not be used to mean $2^{10}$(that is, 1024). | |
| *kilobit per second | kb/s | | | |
| *kilobyte | kB | | kB 1000 bytes. | |
| kilogauss | kG | | Deprecated (see ANSI/IEEE Std 268-1992). | |
| *kilogram | kg | | SI unit of mass. | |
| kilogram-force | kgf | | Deprecated (see ANSI/IEEE Std 268-1992). In some countries the name kilopond (kp) has been used for this unit. | |
| *kilohertz | kHz | | | |
| *kilohm | kΩ | | | *R* |
| *kilometer | km | | | |
| *kilometer per hour | km/h | | | |
| kilopound-force | klbf | | Kilopound-force should not be misinterpreted as kilopond (see kilogram-force). | |
| *kilovar | kvar | | | *Q* |
| *kilovolt | kV | | | |
| *kilovoltampere | kVA | KVA, kva | | |
| *kilowatt | kW | | | |
| kilowatthour | kWh | | Also kW·h. | |
| knot | kn | | kn nmi/h. 0.514 m/s. | |
| lambert | L | | L (1/ )cd/$cm^2$. A CGS unit of luminance. One lumen per square centimeter leaves a surface whose luminance is one lambert in all directions within a hemisphere. Deprecated (see ANSI/IEEE Std 268-1992). | |
| *liter | L | | L $10^{-3}$ $m^3$. In 1979, the CGPM approved L and l as alternative symbols for the liter. Because of frequent confusion with the numeral 1, the letter symbol l is not | *V, v* |

| | | | | |
|---|---|---|---|---|
| | | | recommended for U.S. use (see Federal Register notice of December 20, 1990, vol. 55, no. 245, p. 52242). The script *l* shall not be used as a symbol for liter. | |
| liter per second | L/s | | | |
| *lumen | lm | | SI unit of luminous flux. | Φ |
| lumen per square foot | lm/ft$^2$ | | A unit of illuminance and also a unit of luminous exitance. Use of the SI unit, lumen per square meter, is preferred. | |
| *lumen per square meter | lm/m$^2$ | | SI unit of luminous exitance. | $M$ |
| *lumen per watt | lm/W | | SI unit of luminous efficacy. | $K(\lambda)$ <br> $K$, $K_t$ |
| *lumen second | lm·s | | SI unit of quantity of light. | $Q$ |
| *lux | lx | | 1x/lm /m$^2$. SI unit of illuminance. | $E$ |
| maxwell | Mx | | The maxwell is the electromagnetic CGS unit of magnetic flux. Deprecated (see ANSI/IEEE Std 268-1992). | |
| *mega | M | | SI prefix for 10$^6$. The prefix mega shall not be used to mean 2$^{20}$ (that is, 1 048 576). | |
| megabit per second | Mb/s | | | |
| *megabyte | MB | | MB 1 000 000 bytes. | |
| *megaelectronvolt | MeV | | | |
| *megahertz | MHz | | | |
| *megohm | MΩ | M | | |
| *meter | m | | SI unit of length. | $L$ |
| metric ton | t | | t 1000 kg. Use of the name *tonne* is deprecated in the U.S. (see ANSI/IEEE Std 268-1992). | |
| mho | S | | Ω$^{-1}$. The name *mho* was formerly given to the reciprocal ohm. Deprecated; see siemens (S). | |
| *micro | $\mu$ | | SI prefix for 10$^{-6}$. | |
| *microampere | $\mu$A | | | |
| *microfarad | $\mu$F | | | |
| *microgram | $\mu$g | | | |
| *microhenry | $\mu$H | | | |
| microinch | $\mu$in | | | |
| *microliter | $\mu$L | | See note for liter. | |
| *micrometer | $\mu$m | $\mu$ | | |
| micron | $\mu$m | $\mu$ | The name micron is deprecated. Use micrometer. | |
| *microsecond | $\mu$s | | | |
| *microwatt | $\mu$W | | | |
| mil | mil | | mil 0.001 in. | |
| mile (statute) | mi | | mi 5280 ft = 1609 m. | |
| mile per hour | mi/h | mph | Although use of mph as an abbreviation is | |

| | | | | |
|---|---|---|---|---|
| | | | common, it should not be used as a symbol. | |
| *milli | m | | SI prefix for $10^{-3}$. | |
| *milliampere | mA | | | |
| millibar | mbar | | Use of the bar is strongly discouraged in ANSI/IEEE Std 268-1992, except for limited use in meteorology. | |
| *milligram | mg | | | |
| *millihenry | mH | | | |
| *milliliter | mL | | See liter. | |
| *millimeter | mm | | | |
| millimeter of mercury | mmHg | | mmHg = 133.322 Pa. Deprecated (see ANSI/IEEE Std 268-1992). | |
| millimicron | nm | | Use of the name millimicron for the nanometer is deprecated. | |
| *millipascal second | mPa · s | | SI unit-multiple of dynamic viscosity. | |
| *millisecond | ms | | | |
| *millivolt | mV | | | |
| *milliwatt | mW | | | |
| *minute (plane angle) | ′ | | | |
| *minute (time) | min | | Time may also be designated by means of superscripts as in the following example: $9^{h}46^{m}30^{s}$. | |
| *mole | mol | | SI unit of amount of substance. The mole is the amount of substance of a system that contains as many elementary entities as there are atoms in 0.012 kg of carbon 12. When the mole is used, the elementary entities shall be specified and may be atoms, molecules, ions, electrons, other particles, or specified groups of such particles. | |
| month | mo | | | |
| *nano | n | | SI prefix for $10^{-9}$. | |
| *nanoampere | nA | | | |
| *nanofarad | nF | | | |
| *nanometer | nm | | | |
| *nanosecond | ns | | | |
| nautical mile | nmi | | nmi 1852 m. | |
| *neper | Np | | | |
| *newton | N | | SI unit of force. | |
| *newton meter | N · m | | | |
| *newton per square meter | $N/m^2$ | | SI unit of pressure or stress. See pascal. | |
| oersted | Oe | oe | The oersted is the electromagnetic CGS unit of magnetic field strength. Deprecated (see ANSI/IEEE Std 268-1992). | |
| *ohm | Ω | | SI unit of resistance. | |
| ounce | oz | | oz 1/16 lb = 28.350 g. | |

| | | | | |
|---|---|---|---|---|
| (avoirdupois) | | | | |
| *pascal | Pa | | Pa N/$m^2$. SI unit of pressure or stress. | |
| *pascal second | Pa · s | | SI unit of dynamic viscosity. | |
| *peta | P | | SI prefix for $10^{15}$. | |
| phot | ph | | ph lm/$cm^2$. CGS unit of illuminance. Deprecated (see ANSI/IEEE Std 268-1992). | |
| *pico | p | | SI prefix for $10^{-12}$. | |
| *picofarad | pF | | | |
| *picowatt | pW | | | |
| pint | pt | | pt (U.K.) = 0.568 26 L.<br>pt (U.S. dry) = 0.550 6 L.<br>pt (U.S. liquid) = 0.473 18 L. | |
| poise | P | | Deprecated (see ANSI/IEEE Std 268-1992). | |
| pound (avoirdupois) | lb | | lb 0.453 592 37 kg. | |
| pound per cubic foot | lb/$ft^3$ | | | |
| pound-force | lbf | | lbf = 4.4482 N. | |
| pound-force foot | lbf · ft | | | |
| pound-force per square foot | lbf/$ft^2$ | | | |
| pound-force per square inch | lbf/$in^2$ | psi | Although use of the abbreviation psi is common, it should not be used as a symbol. | |
| poundal | pdl | | pdl lb · ft/$s^2$ = 0.1383 N | |
| quart | qt | | qt (U.K.) = 1.1365 L.<br>qt (U.S. dry) = 1.1012 L.<br>qt (U.S. liquid) = 0.946 35 L. | |
| rad | rd | | rd 0.01 Gy. A unit of absorbed dose in the field of radiation dosimetry. Use of the SI unit, the gray, is preferred. | |
| *radian | rad | | SI unit of plane angle. | |
| rem | rem | | rem 0.01 Sv. A unit of dose equivalent in the field of radiation dosimetry. Use of the SI unit, the sievert, is preferred. 1 rem = 0.01 Sv. | |
| revolution per minute | r/min | | Although use of rpm as an abbreviation is common, it should not be used as a symbol. | |
| revolution per second | r/s | | | |
| roentgen | R | | A unit of exposure in the field of radiation dosimetry. | |
| *second (plane angle) | ″ | | 1″ = 4.848 · $10^{-6}$ rad. | |
| *second (time) | s | | SI unit of time. | |
| *siemens | S | | S $\Omega^{-1}$. SI unit of conductance. | |
| *sievert | Sv | | SI unit of dose equivalent in the field of radiation dosimetry. | |

| | | | | |
|---|---|---|---|---|
| slug | slug | | slug lbf · $s^2$/ft = 14.594 kg. | |
| square foot | $ft^2$ | | | |
| square inch | $in^2$ | | | |
| *square meter | $m^2$ | | | |
| *square meter per second | $m^2/s$ | | SI unit of kinematic viscosity. | |
| *square millimeter per second | $mm^2/s$ | | SI unit-multiple of kinematic viscosity. | |
| square yard | $yd^2$ | | | |
| *steradian | sr | | SI unit of solid angle. | |
| stilb | sb | | sb cd/$cm^2$. A CGS unit of luminance. Deprecated (see ANSI/IEEE Std 268-1992). | |
| stokes | St | | Deprecated (see ANSI/IEEE Std 268-1992). | |
| *tera | T | | SI prefix for $10^{12}$. | |
| terabyte | TB | | TB $10^{12}$ B. | |
| *tesla | T | | T N/(A · m)$^2$ Wb/$m^2$. SI unit of magnetic flux density (magnetic induction). | |
| therm | thm | | thm 100 000 Btu. | |
| ton (short) | ton | | ton 2000 lb. | |
| ton, metric | T | | t 1000 kg. Use of the *tonne* for this unit is deprecated in the U.S. (see ANSI/IEEE Std 268-1992). | |
| torr | torr | | A unit of pressure equal to 0.001316 atmosphere; named after Torricelli. | |
| *(unified) atomic mass unit | u | | The (unified) atomic mass unit is defined as one-twelfth of the mass of an atom of the carbon- 12 nuclide. Use of the old atomic mass unit (amu), defined by reference to oxygen, is deprecated. | |
| *var | var | | IEC name and symbol for SI unit of reactive power. | |
| *volt | V | | SI unit of voltage. | |
| *volt per meter | V/m | | SI unit of electric field strength. | |
| *voltampere | VA | va | IEC name and symbol for SI unit of apparent power. | |
| *watt | W | | SI unit of power. | |
| *watt per meter kelvin | W/(m · K) | | SI unit of thermal conductivity. | |
| *watt per steradian | W/sr | | SI unit of radiant intensity. | |
| *watt per steradian square meter | (W/sr · $m^2$) | | SI unit of radiance. | |
| watthour | Wh | | | |
| *weber | Wb | | Wb V·s. SI unit of magnetic flux. | |
| yard | yd | | yd 0.9144 m. | |
| year | a | | Also W·h. | |

| | | | | |
|---|---|---|---|---|
| yocto | y | | SI prefix for $10^{-24}$. | |
| yotta | Y | | SI prefix for $10^{24}$. | |
| zepto | z | | SI prefix for $10^{-21}$. | |
| zetta | Z | | SI prefix for $10^{21}$. | |

## D. Miscellaneous Alphabetical Abbreviations, Acronyms, and Symbols

*NOTE:* Key: fn—function name (roman); s—symbol (italic); u—unit abbreviation (roman); *—acronyms that must be defined in text.

| | |
|---|---|
| **A** | |
| *A* | (s) Hermitian conjugate of *A* |
| Å | (u) angstrom |
| ab | (prefix) denotes absolute system of (CGS) units. Abampere, abcoulomb, abvolt, abohm, abfarad, abmho, abhenry (use not recommended, see units list) |
| abs | absolute |
| ABS | air-bearing surface |
| Ac | alternating current |
| ACB | air circuit breaker* |
| ACSR | steel-reinforced aluminum cable* |
| AD | attention display* |
| A–D, A/D | analog-to-digital |
| ADF | automatic direction finder* |
| a.e. | almost everywhere (in equations) |
| AEW | airborne early warning* |
| AF | audio frequency* |
| AFB | Air Force Base |
| AFC | automatic frequency control* |
| AFM | atomic force microscopy |
| AGC | automatic gain control* |
| AGFM | alternating gradient force magnetometer |
| AGM | arithmetical–geometric mean* |
| A·h (u) | ampere hour |
| Ai (fn) | Airy integral |
| AM | amplitude modulation |
| A.M. | ante meridiem (morning) |
| ama | automatic message accounting* |
| AND | (small caps) logical AND operation |
| ANI | automatic number identification |
| ANN | artificial neural network* |
| antilog (fn) | antilogarithm |
| AOGM | accelerated optimum gradient method* |
| AOPT | air-operated press type* |
| APD | avalanche photodiode |
| API | air position indicator* |

| | |
|---|---|
| AQL | acceptable quality level |
| AR | antireflection*; autoregressive* |
| arcsin<br>arccos<br>arctan<br>arccot<br>arcsec<br>arccsc | (fn) inverse trigonometric functions |
| arg | (fn) argument |
| ARMA | autoregressive moving average* |
| a.s. | almost surely (in equations) |
| ASE | amplified spontaneous emission* |
| ASIC | application specified integrated circuit* |
| ASK | amplitude-shift keying |
| ASW | antisubmarine warfare* (note: for acoustic surface wave use SAW) |
| at (u) | technical atmosphere: 1 kgf/cm |
| At (u) | ampere turn (note: no longer in use; change to A) |
| ATM | asynchronous transfer mode* |
| atm (u) | atmosphere |
| ATR | antitransmit receive* |
| ATT | avalanche transit time* |
| av | average (subscript) |
| AVC | automatic volume control* |
| avg (fn) | average (use av as subscript) |
| AWE | asymptotic wave evaluation* |
| AWG | American wire gauge |
| AWGN | additive white Gaussian noise* |
| **B** | |
| bar (u) | bar |
| barye (u) | barye: microbar (use not recommended; see units list) |
| bbl (u) | barrel (see units list) |
| bcc | body-centered cubic (of crystals) |
| BCD | binary coded decimal |
| BCH | Bose–Chaudhuri–Hocquenghen (codes) |
| BCT | bushing current transformer* |
| Bd (u) | baud* (see units list) |
| B–E | base–emitter source |
| Be | Baume |
| bei, ber (fn) | Kelvin forms of Bessel function |
| BEM | boundary-element method |
| BER | bit error rate* |
| BeV, bev (u) | use GeV |
| BFO | beat-frequency oscillator* |
| B–H B–H curve: | curve of magnetic induction (magnetic flux–density) versus magnetic intensity (field intensity) B–H relationship. B–H loop: hysteresis loop |
| Bhp | brake horsepower* |
| Bi (fn) | Airy integral: (u) bit: = 10 A* |

| | |
|---|---|
| BIL | basic impulse insulation level* |
| BJT | bipolar junction transistor* |
| BMEP | brake mean effective pressure* |
| bpi (u) | bit per inch: use b/in |
| bps (u) | bit per second: use b/s |
| BPSK | binary phase-shift keying |
| BRA | biased rectifier amplifier* |
| BS | breaking strength* |
| BS | British Standards* |
| B&S | Brown and Sharpe gauge* |
| BSF | bulk shielding facility* |
| BSL | basic switching surge insulation level* |
| BTU | (u) British thermal unit |
| BWG | Birmingham wire gauge* |
| BWK | Brillouin–Wentzel–Kramers (method)* |
| BWO | backward-wave oscillator* |
| BWR | boiling water reactor* |
| **C** | |
| C (u) | coulomb |
| °C (o) | degree Celsius |
| c (u) | cycle: use Hz; centi- (prefix to unit abbreviation) |
| *c* (s) | speed of light in a vacuum |
| cal (u) | calorie (use not recommended; see units list) |
| CATV | community antenna television system |
| cc (u) | cubic centimeter: use $cm^3$ |
| c.c. | complex conjugate (in equations) |
| CCB | coin collecting box (British telephones)* |
| CCD | charge-coupled device* |
| CCR | closed-cycle refrigerator* |
| cd (u) | candela |
| cdf | cumulative distribution function* |
| CDMA | code division multiple access* |
| CDO | community dial offices* |
| CD-ROM | compact disk read-only memory |
| cdrx | external critical damping resistance: use caps* |
| CEMF | counterelectromotive force* |
| cf. | compare |
| cfm (u) | cubic feet per minute: use $ft^3$/min |
| cfs (u) | cubic feet per second: use $ft^3$/s |
| CGS | centimeter-gram-second (system of units) |
| Ci (fn) | cosine integral; (u) curie |
| CIM | computer integrated manufacturing* |
| CIR | carrier-to-interference ratio* |
| ckVA | capacitive kilovoltamperes (write out) |
| cmil (u) | circular mil |
| CMOS | complementary metal–oxide–semiconductor |
| CNN | cellular neural network |
| COP | coefficient of performance* |

| | |
|---|---|
| cos<br>cosec<br>cosh<br>cot<br>coth<br>covers | (fn) cosine<br>(fn) cosecant: use csc<br>(fn) hyperbolic cosine<br>(fn) cotangent<br>(fn) hyperbolic cotangent<br>(fn) coversine |
| cP (o) | centipoise (see units list) |
| CPFSK | continuous phase frequency-shift keying* |
| CPM | continuous phase modulation* |
| CPSK | continuous phase-shift keying; coherent phase-shift keying* |
| CPU | central processing unit |
| CRO | cathode-ray oscilloscope |
| CRS | cold-rolled steel* |
| CRT | cathode-ray tube |
| c/s (u) | cycle per second: use Hz |
| csc (fn) | cosecant |
| csch (fn) | hyperbolic cosecant cs (u) centistokes: use cSt or write out (see units list) |
| CSP | completely self-protected |
| cSt (u) | centistokes (see units list) |
| CSV | corona-starting voltage |
| CT | current transformer* |
| CTC | centralized traffic control |
| ctn (fn) | cotangent: use cot |
| curl (fn) | curl |
| *CV* | capacitance–voltage |
| CVD | chemical vapor deposited |
| CW | continuous wave* |
| **D** | |
| DA | design automation |
| dB (u) | decibel |
| dc | direct current (DC at start of sentence or in article title) |
| DC | directional coupler |
| DDA | digital differential analyzer* |
| DDD | direct distance dialing* |
| DE | disruptive effect* |
| det (fn) | determinant |
| DF | direction finder*; deuterium fluoride; degree of freedom* |
| DFB | distributed feedback |
| DFT | discrete Fourier transform* |
| diag | (diagonal) |
| diam | diameter |
| DIC | Diploma of membership in Imperial College of Science and Technology |
| div (fn) | divergence; division (u) in charts |
| DMA | direct memory access* |
| DME | distance-measuring equipment* |

| | |
|---|---|
| DOD | diameter over dielectric; Department of Defense |
| DOF | degree of freedom (unit) |
| DP | dial pulse* |
| DPCM | differential pulse code modulation* |
| DPDT | double-pole double-throw switch* |
| DPH | diamond pool hardness* |
| DPQSK | differential quadrature phase-shift keying* |
| DPSK | differential phase-shift keying* |
| DRCPR | differential reactive current protective relay* |
| DRO | destructive readout*; doubly resonant oscillator |
| DS | dielectric strength*; direct sequence* |
| DSB | double sideband* |
| DSP | digital signal processor |
| DVP | differential vapor pressure* |
| DWT | discrete wavelet transform* |
| dyn (u) | dyne |
| **E** | |
| EB | emergency bank* |
| EC | eddy current; electrical conductivity* (grade of Al) |
| ECG | electrocardiogram |
| ECL | emitter-coupled logic* |
| ECM | electronic countermeasures |
| ECT | eddy current testing |
| ED | enforced draft |
| EDFA | erbium-doped fiber amplifiers* |
| EDP | electronic data processing |
| EDS | energy dispersive spectrometer |
| EDX | energy dispersive X-ray |
| EEG | electroencephalogram |
| EHD | electrohydrodynamic* |
| EHF | extremely high frequency* |
| EHIPS | extra heavy iron pipe size* |
| EHV | extra high voltage |
| Ei (fn) | exponential integral |
| ELF | extremely low frequency* |
| EM | electromagnetic* |
| EMC | electromagnetic compatibility* |
| EMF | electromotive force* |
| EMI | electromagnetic interference* |
| ems | expected value of mean square* |
| EMU | electromagnetic units |
| EOF | end of file |
| erf (fn) | error function |
| erfc (fn) | complementary error function |
| erg (u) | erg |
| ERP | effective radiated power* |
| ESS | electrical sheet steel* |
| ESU | electrostatic units |
| eV (u) | electronvolt |

| | |
|---|---|
| EXOR | EXCLUSIVE-OR circuit (small caps) |
| exp (fn) | exponential function |
| exsec (fn) | exsecant |
| **F** | |
| f (*f*-stop, f/22) | ratio of focal length to aperture |
| F (u) | farad |
| °F (u) | degree Fahrenheit |
| FA | forced-air-cooled transformer* |
| fcc | face-centered cubic (of crystals) |
| FCC | Federal Communications Commission |
| FD | flux density* |
| FDA | finite difference approximations* |
| FDM | frequency-division multiplexing* |
| FDMA | frequency-division multiple access* |
| FDTD | finite-difference time domain* |
| FEA | finite-element analysis |
| FET | field-effect transistor |
| ff. | following pages |
| FFT | fast Fourier transform* |
| FIFO | first-in first-out |
| FIM | field intensity meter* |
| FIR | finite-impulse response* |
| fL (u) | footlambert |
| FL | full load |
| FM | frequency modulation |
| FMFB | FM feedback receiver* |
| FMR | frequency of maximum reliability*; ferromagnetic resonance |
| FPGA | field-programmable gate array* |
| fpm, fps (u) | feet per minute: use ft/min; feet per second: use ft/s |
| FS | full scale |
| FSK | frequency-shift keying* |
| FSM | finite-state machine* |
| ft (u) | foot |
| FTL | flat tie-line* |
| FTP | file transfer protocol |
| FW | full wave |
| FWHM | full-width at half-maximum* |
| FWM | four-wave mixing* |
| **G** | |
| G | giga- (prefix to unit abbreviations) = $10^9$ |
| G (u) | gauss |
| g | acceleration of gravity, “gee force”; use as unit with metric prefix, as in 3 mg |
| *G* (s) | gravitational constant |
| Gal (u) | gal (gravitational unit) |
| gal (u) | gallon |
| Gb (u) | gilbert |
| GCA | ground-controlled approach* |
| gcd | greatest common denominator (may be function name) |

| | |
|---|---|
| GLB | greatest lower bound* |
| GMD | geometric mean distance* |
| GMEC | generalized minimum effort control* |
| GMF | geometric mean frequency |
| GMR | geometric mean radius |
| GMT | Greenwich mean time |
| gpd (u) | gallon per day: use gal/day |
| GPS | Global Positioning System |
| GPU | graphical processing unit, General Public Utilities* |
| grad (fn) | gradient |
| GSE | ground support equipment* |
| GTD | geometrical theory of diffraction |
| GUI | graphical user interface |
| GW | ground wire |
| **H** | |
| *h* (s) | Planck's constant |
| H (u) | henry |
| *H* (s) | magnetic intensity; magnetic field strength |
| hav, havers (fn) | haversine |
| HBT | heterojunction bipolar transistor |
| hcp | hexagonal close-packed (of crystals) |
| HD | hard-drawn* |
| HDBC | hard-drawn bare copper* |
| HDC | hard-drawn copper* |
| HDD | hard disk drive |
| HDT | hard-drawn tubing* |
| HEMT | high-electron mobility transistor |
| HF | high frequency; hydrogen fluoride |
| HFET | heterojunction FET |
| HG | mercury |
| hipot | high potential (write out) |
| hp (u) | horsepower |
| HTC | high-tension cable* |
| HTML | hypertext markup language |
| HV | high voltage |
| HVdc | high voltage direct current |
| Hz (u) | hertz |
| **I** | |
| *I* (s) current (fn) | imaginary part of: use Im |
| IACS | International Annealed Copper Standard* |
| IC | impedance compensation*; integrated circuit |
| ICW | interrupted continuous wave* |
| ID | inside diameter; induced draft*; interdigital* |
| IDP | integrated data processing* |
| IF | intermediate frequency |
| iff | if and only if |
| IFT | interfacial tension* |
| IGFET | insulated-gate field-effect transistor |
| i.i.d. | independent identically distributed* |

| | |
|---|---|
| IIR | infinite-impulse response |
| ILS | instrument landing system* |
| Im (fn) | imaginary part of |
| IM | intermediate modulation |
| IMPATT | impact ionization avalanche transit time (diode) |
| INE | irredundant normal equivalent* |
| inf (fn) | infimum |
| int (fn) | integer value of |
| I/O, I–O | input–output |
| IoT | Internet of Things* |
| IP | Internet Protocol |
| ips (u) | inch per second: use in/s |
| IPS | iron pipe size; international pipe standard* |
| IR | infrared |
| *IR* | current–resistance |
| ISB | independent sideband* |
| ISE | integral of squared error* |
| ISI | intersymbol interference |
| itae | integral of time-multiplied absolute value of error |
| ITI | inter-track interference |
| *I–V* (s) | current–voltage (characteristic or curve) |
| IVA | induced voltamperes |
| *IX* | current–reactance (drop) |
| *IZ* | current–impedance |
| **J** | |
| J (u) | joule |
| JFET | junction field-effect transistor |
| JPEG | Joint Photographers Expert Group |
| **K** | |
| k | kilo (prefix to unit abbreviations) = $10^3$ |
| K (u) | Kelvin |
| Kayser (u) | = $cm^{-1}$ (wavenumber) |
| kbps (u) | kilobits per second: use kb/s |
| KCL | Kirchhoff's current law |
| kcm, KCM (u) | thousand circular mils: use kcmil |
| kg (u) | kilogram |
| KGO, KGOe, KGoe, KgOe (u) | use kO·Oe |
| kgp (u) | kilogrampois (French): use kg |
| kG.Oe (u) | kilogauss oersted |
| kip | thousand pounds |
| kn (u) | knot (nautical mile per hour) |
| KOH | potassium hydroxide |
| kp (u) | kilopound (German): use kg |
| *kt* (s) | Boltzmann's constant × time |
| KVL | Kirchhoff's voltage law |
| kVp (u) | kilovolt peak* |
| **L** | |
| l (u) | liter |

| | |
|---|---|
| L (u) | lambert |
| LAN | local area network |
| lb (u) | pound |
| lbf (u) | pound-force |
| *LC* | inductance–capacitance |
| lcm | least common multiple (may be function name) |
| *LCR* | inductance–capacitance–resistance |
| LCS | load current substation* |
| LDC | line drop compensator*; load division circulation |
| LED | light-emitting diode |
| LF | low-frequency |
| LHP | left-half plane* |
| LHS | left-hand side* |
| Li (fn) | logarithmic integral |
| lim (fn) | limit |
| l.i.m. (fn) | limit in the mean |
| L–L | line to line* |
| lm (u) | lumen |
| LMLT | locus of major loop tips* |
| LMS | least mean square |
| LMT | local mean time* |
| ln (fn) | natural logarithm (base *e*) |
| L–N | line to neutral* |
| LNA | low noise amplifier |
| LO | local oscillator* |
| log, $\log_n$ (fn) | logarithm, logarithm base *n* (where *n* = 2, 10, etc.) |
| LP | linear programming* |
| LPE | liquid phase epitaxy* |
| *LR* | inductance–resistance |
| LRC | load ratio control* |
| LSB | least significant bit |
| LSI | large-scale integration*; large-scale integrated* |
| LST | local standard time |
| LTC | load tap-changing* |
| LTE | long-term evolution |
| LTS | laser-triggered switching* |
| LUF | lowest usable frequency* |
| lx (u) | lux |
| **M** | |
| m (u) | meter; milli- (prefix to unit abbreviations) = $10^{-3}$ |
| M | mega- (prefix to unit abbreviations) = $10^{6}$; mole |
| MAG | maximum available gain |
| MAP | maximum *a posteriori* |
| max (fn) | maximum; also used as subscript |
| MC | Monte Carlo |
| mcm, MCM (u) | thousand circular mils: use kcmil |
| mc/mM (u) | millicuries per millimole: use mCi/mM |
| MCS | multicircuit substation* |
| MCT | movable core transformer* |

| | |
|---|---|
| MCW | modulated continuous wave* |
| MDF | manual direction finder* |
| MDS | minimum detectable signal |
| MEMS | micro-electromechanical systems |
| MESFET | metal–semiconductor field-effect transistor |
| MEW | microwave early warning* |
| MF | medium frequency* |
| MFM | magnetic force microscopy |
| MFSK | minimum frequency-shift keying |
| MGO (u) | megagauss oersted: use MG·Oe |
| MG·Oe (u) | megagauss oersted |
| MHD | magnetohydrodynamics |
| mho (u) | mho (also Ω^{-1}) |
| mi (u) | mile |
| MIM | metal–insulator–metal |
| MIMO | multi-in multi-out* |
| mio (fn) | minimum; also used as subscript |
| MIS | metal–insulator–semiconductor* |
| MKS | meter–kilogram–second (system of units) |
| ml | milliliter |
| MLE | maximum-likelihood estimation* |
| MLSD | maximum-likelihood sequence detector |
| MLSE | maximum-likelihood sequence estimator* |
| MMF | magnetomotive force |
| mmHg (u) | millimeter of mercury |
| MMIC | monolithic microwave integrated circuit* |
| mm$_2$O (u) | millimeter of water |
| mmse | minimum mean square error |
| MOCVD | metal–organic chemical vapor deposition* |
| mod | modulo |
| MOKE | magnetooptic Kerr effect |
| MoM | method of moments* |
| MOS | metal–oxide–semiconductor |
| MOSFET | MOS field-effect transistor |
| MOST | MOS transistor |
| MOVPE | metal–organic vapor phase epitaxy* |
| MPEG | Moving Pictures Expert Group |
| MPIE | mixed potential integral equation |
| MRAM | magnetic random access memory |
| MRI | magnetic resonance imaging |
| MSB | most significant bit |
| mse | mean square error |
| MSIC | medium scale integrated circuits* |
| MTBE | mean time between explosions |
| MTBF | mean time between failures* |
| MTI | multiple target indicator*; moving target indicator |
| MTJ | magnetic tunnel junction |
| MTL | multiconductor transmission line |
| MU | multiple unit* |

| | |
|---|---|
| MUF | maximum usable frequency* |
| MVQE | minimum variance quantum estimator |
| Mx (u) | maxwell |
| MZI | Mach–Zehnder interferometric* |
| **N** | |
| *n* | nano (prefix to unit abbreviations) = $10^{-9}$ |
| N (u) | newton |
| NA | numerical aperture* |
| NAND | NOT-AND circuit (small caps) |
| nat (u) | nat |
| NC | diode negative-conductance diode* |
| NDRO | nondestructive readout |
| NDT | nondestructive testing* |
| NIC | negative impedance converter* |
| NIR | near infrared response* |
| nit (u) | nit |
| Nkw-hr (u) | net kilowatthour: use net kW·h |
| NL | no load |
| nmi (u) | nautical mile |
| NMR | nuclear magnetic resonance* |
| NOR | NOT-OR circuit (small caps) |
| NP | nameplate (rating) |
| Np (u) | neper |
| n-p-n | semiconductor forms: Roman, lowercase, hyphens |
| NRZ | nonreturn to zero* |
| NTC | negative temperature coefficient* |
| NWP | network protector |
| **O** | |
| OCB | oil circuit breaker* |
| OCR | oil circuit recloser* |
| OD | outside diameter |
| Oe (u) | oersted |
| OEIC | optoelectronic integrated circuit* |
| OFDA | optical-fiber frequency-domain analysis* |
| OGM | optimum gradient method |
| OOK | on–off keying |
| OOP | object-oriented programming* |
| opt (fn) | optimum: also used as subscript |
| OR | OR circuit (small caps) |
| OSM | omni spectra miniature |
| OTDM | optical time-division multiplexing* |
| *O*-wave | ordinary-wave (ionogram) |
| OZ (u) | ounce |
| **P** | |
| p | pico- (prefix to unit abbreviations) = $10^{-12}$ |
| P (u) | poise |
| Pa (u) | pascal |
| PAE | power-added efficiency |
| PAM | pulse-amplitude modulation* |

| | |
|---|---|
| PAX | private automatic exchange* |
| PBX | private branch exchange* |
| pc (u) | parsec |
| PC | personal computer |
| PCM | pulse-code modulation*; pulse-count modulation* |
| PD | potential difference* |
| pdf | probability density function* |
| pdl (u) | poundal (see units list) |
| PDM | pulse-duration modulation* |
| $P_e$ (s) | probability of error |
| PER | probability of error |
| PES | position error signal |
| PF | power factor* |
| ph (fn) | phase |
| pH | power of hydrogen (acidity or alkalinity of solution) |
| PI | polarization index |
| PID | proportional—integral—differential* |
| PILC | paper-insulated lead-covered* |
| PIN | use p-i-n for diodes, etc. |
| p-i-n | semiconductor forms: Roman, lowercase, hyphens |
| PL/1 | a programming language |
| PLC | power line carrier* |
| PLL | phase-locked loop* |
| PM | phase modulation* |
| P.M. | post meridiem (small caps) |
| PML | perfectly matched layer |
| PMMA | polymethyl methacrylate* |
| PMR | perpendicular magnetic recording |
| p-n-i-p | semiconductor forms: Roman, lowercase, hyphens |
| p-n-p | semiconductor forms: Roman, lowercase, hyphens |
| POD | para-operational device* |
| $\mathrm{POW}_p$ (u) | picowatts psophometrically weighted at a point of zero relative level* |
| pp, p-p | peak to peak* |
| PPI | plan-position indicator* |
| ppm (u) | parts per million; pulse per minute* |
| PPM | pulse-position modulation* |
| pps (u) | pulse per second* |
| Pr (fn) | probability (appears as Pr $x \mid x = \mathrm{U}$) |
| PRA | pulse relaxation amplifier |
| PRF | pulse-repetition frequency* |
| PRML | partial response maximum likelihood |
| Prob., | $\mathrm{P}_r\, x\vert\cdot$ use Pr (usually) |
| PRR | pulse-repetition rate* |
| PSD | power spectral density |
| PSF | power separation filter* |
| psi (u) | pounds per square inch: change to lb/in$^2$ unless paper also contains psia and/or psig |
| psia (u) | pound-force per square inch absolute (stet) |
| psig (u) | pound-force per square inch gauge (stet) |

| | |
|---|---|
| PSK | phase-shift keying* |
| PTM | pulse–time modulation |
| p.u. | per unit |
| PVC | polyvinyl chloride* |
| PWL | piecewise linear |
| PWM | pulse width modulation* |
| PWR | pressurized water reactor* |
| PZT | lead zirconate titanate |
| **Q** | |
| *Q* | quality factor; figure of merit |
| QAM | quadratic-amplitude modulation* |
| Q.E.D. | quod erat demonstrandum (end of proof) (set flush right) |
| QoS | quality of service |
| QP | quasi-peak* |
| QPSK | quaternary phase-shift keying |
| QW | quantum well* |
| **R** | |
| R (u) | roentgen |
| R (fn) | real part of: use Re |
| °R (u) | degrees Rankine |
| rad (u) | radian |
| RAM | random access memory |
| RB | circuit transient blocking relay circuit* |
| *RC* | resistance–capacitance |
| RCF | radar cross section* |
| R&D | research and development |
| Re (fn) | real part of: use Re (be sure of this meaning before changing) |
| redox | reduction–oxidation |
| rem (u) | Roentgen equivalent, man |
| RF | radio frequency |
| RFI | radio frequency interference* |
| RFU | reclosing fuses* |
| RH | relative humidity* |
| RHS | right-hand side* |
| RI | radio interference* |
| RIFI | radio interference and field intensity* |
| RIL | radio interference level* |
| RIN | relative intensity noise* |
| *RL* | resistance–inductance |
| RMI | radiomagnetic indicator* |
| rms | root-mean-square (error); root mean square |
| ROM | read-only memory |
| rpm (u) | revolution per minute: use r/min |
| rps (u) | revolution per second: use r/s |
| RSG | recurrent surge generator* |
| RTD | resistance temperature detectors |
| RV | random variable |
| *RX* | resistance–reactance |
| | |

| | |
|---|---|
| s (u) | second |
| S (u) | siemens |
| SAR | specific absorption rate |
| SATT | Strowger Automatic Toll Ticket* |
| SAW | surface acoustic wave* |
| SC | switched-capacitor*(adj) |
| SCA | steel-reinforced aluminum cable* |
| SCC | signal component control* |
| scfm | standard cubic feet per minute* |
| SCL | space-charge limited* |
| scr | short-circuit ratio* |
| SCR | silicon-controlled rectifier |
| sec (fn) | secant; (u) second: use s; second of arc* |
| sech (fn) | hyperbolic secant |
| SEM | scanning electron microscope |
| SF | single frequency* |
| SGML | standard generalized markup language |
| sgn (fn) | signum function |
| SHF s | upper high frequency* |
| SI | severity index*; Systeme International d'Unites (International System of Units) |
| Si, si (fn) | sine integral |
| sin (fn) | sine |
| sinc (fn) | sinc $x = (\sin x) / x$ |
| sinh (fn) | hyperbolic sine |
| SINR | signal-to-interference-plus-noise ratio* |
| SIR | signal-to-interference ratio |
| SISO | single-in, single-out* |
| SLAR | side looking airborne radar |
| SLG | single line to ground |
| SMSA | standard metropolitan statistical area |
| *S/N* | signal-to-noise ratio |
| SNR | signal-to-noise ratio |
| SoC | system-on-chip* |
| SPDT | single-pole double-throw (switch)* |
| SPICE | Simulation Program with Integrated Circuit Emphasis |
| SPT | single-pole type |
| sq square: | if on a unit, change to $^2$ |
| SQUID | superconducting quantum interference device |
| sr (u) | steradian |
| SR | saturable reactor* |
| SS | subsystems* |
| SSB | single sideband* |
| s.t. | subject to |
| St (u) | stokes |
| sterad (u) | steradian: use sr |
| SUL | soft underlayer |
| SUMT | sequential unconstrained minimization techniques |
| sup (fn) | supremum |

| | |
|---|---|
| sus | Saybolt universal seconds (oil viscosity)* |
| sw | sine wave* |
| SW | short wave* |
| SWG | standard wire gauge* |
| SWR | standing-wave ratio* |
| **<u>T</u>** | |
| t (u) | tonne |
| T (u) | tesla |
| tan (fn) | tangent |
| tanh (fn) hyperbolic tangent | |
| TCUL | tap-changing under load* |
| TDM | time-division modulation*; time-division multiplexing* |
| TDMA | time-division multiple access* |
| TE | transverse electric (appears as $TE^{0}_{01}$ and $TE_{01}$) |
| TEFC | totally enclosed fan-cooled* |
| Telex | teleprinter exchange* |
| TEM | transverse electromagnetic |
| TFT | thin-film transistor* |
| tg (fn) | tangent: use tan |
| th (u) | thermie |
| TIF | telephone influence factor* |
| TLM | transmission-line matrix |
| TM | transverse magnetic |
| tof | thermal ohms per foot (spell out) |
| torr (u) | torr |
| tpc (u) | turns per centimeter: turns/cm |
| TPC | turns per coil* |
| tr (fn) | trace |
| Tr | transpose |
| TSS | time sharing system |
| TTL | transistor–transistor logic |
| TTY | teleprinter |
| tu | traffic units* |
| TVI | television interference* |
| TWA | traveling-wave amplifier* |
| TWM | traveling-wave maser* |
| TWP | traveling-wave phototube* |
| TWT | traveling-wave tube |
| **<u>U</u>** | |
| UHF | ultrahigh frequency |
| ult (fn) | ultimate |
| UPS | uninterruptible power system* |
| | uniform *RC* sections (stet overbar) |
| URL | uniform resource locator |
| XRD | X-ray diffraction |
| UT | universal time |
| UTS | ultimate tensile strength |

| | |
|---|---|
| UV | ultraviolet |
| **V** | |
| V (u) | volt |
| *V* (s) | voltage |
| VA (u) | voltampere; Viterbi algorithm* |
| var (u) | var |
| VCL | varnished-cambric lead-covered* |
| VCO | voltage-controlled oscillator* |
| VCW | type V copper weld* |
| VDS | voltage divider switching* |
| ver, vers (fn) | versine |
| VF | voice frequency* |
| VFO | variable-frequency oscillator* |
| VHF | very high frequency* |
| *V–I* | voltage–current (characteristic of curve) |
| VLF | very low frequency* |
| VLSI | very large scale integration* |
| VOR | very high-frequency omnidirectional radio |
| VR | voltage regulator* |
| VSB | vestigial sideband* |
| VSWR | voltage standing-wave ratio |
| VTB | voltage time to breakdown* |
| VTVM | vacuum-tube voltmeter |
| vu | volume units* |
| **W** | |
| W (u) | watt |
| WAN | wide area network |
| Wb (u) | weber |
| WDM | wavelength-division multiplexing* |
| WDMA | wavelength-division multiple access* |
| WKB | Wentzel–Kramer–Brillouin* |
| wpl, w.p.l. | with probability 1* |
| wrt, w.r.t. | with respect to |
| WT | watertight* |
| wt% | weight percent |
| **X** | |
| XPM c | ross-phase modulation |
| XOR | EXCLUSIVE-OR circuit (small caps) |
| *X*-wave | extraordinary-wave (ionogram) |
| **Y** | |
| YAG | yttrium aluminum garnet |
| yd (u) | yard |
| YIG | yttrium iron garnet |

| **Factor by Which the Unit Is Modified** | Prefix | Symbol |
|---|---|---|
| $1000000000000 = 10^{12}$ | tera | T |
| $1000000000 = 10^{9}$ | giga | G |
| $1000000 = 10^{6}$ | mega | M |
| | | |

| | | |
|---|---|---|
| $1000 = 10^{3}$ | kilo | k |
| $100 = 10^{2}$ | hecto | h |
| $10 = 10^{1}$ | deka | da |
| $0.1 = 10^{-1}$ | deci | d |
| $0.01 = 10^{-2}$ | centi | c |
| $0.001 = 10^{-3}$ | milli | m |
| $0.000001 = 10^{-6}$ | micro | µ |
| $0.000000001 = 10^{-9}$ | nano | n |
| $0.000000000001 = 10^{-12}$ | pico | p |
| $0.000000000000001 = 10^{-15}$ | femto | f |
| $0.000000000000000001 = 10^{-18}$ | atto | a |

## E. Organizations and Abbreviations of Organizations

| | |
|---|---|
| AAS | American Association for the Advancement of Science, Washington, DC |
| ACC | American Automatic Control Council, Evanston, IL |
| ACE | American Association of Cost Engineers, Morgantown, WV |
| AEC | Australian Atomic Energy Commission |
| AES | American Association of Engineering Societies, Washington, DC |
| APG | American Association of Petroleum Geologists, Tulsa, OK |
| APT | Association of Asphalt Paving Technologists |
| AR | Association of American Railroads, Washington, DC |
| AUP | American Association of University Professors, Washington, DC |
| BET | Accreditation Board for Engineering & Technology (formerly ECPD), Baltimore, MD |
| CEC | American Consulting Engineers Council (formerly AICE and CEC), Washington, DC |
| CLMRS | Advisory Committee for Land Mobile Radio Services |
| CM | Association for Computing Machinery, New York, NY |
| CME | Association of Consulting Management Firms, New York, NY |
| CS | American Chemical Society, Washington, DC |
| DPA | American Defense Preparedness Association (formerly AOA), Arlington, VA |
| DRDE | Air Defence Research and Development Establishment, U.K. |
| EA | American Electronics Association (formerly WCEMA), Santa Clara, CA |
| EC | Atomic Energy Commission, Washington, DC |
| EDC | Arnold Engineering Development Center, Arnold AFB, TN |
| EI | Associated Electrical Industries, Manchester, U.K. also: Italian Electrotechnical and Electronic Association |
| EIC | Association of Edison Illuminating Companies, Birmingham, AL |
| EP | American Electrical Power Company, New York, NY |
| ERE | Atomic Energy Research Establishment |
| ES | Audio Engineering Society, New York, NY |
| FCA | now AFCEA |
| FCEA | Armed Forces Communication and Electronics Association (formerly AFCA), Fairfax, VA |
| FCRC | Air Force Cambridge Research Center, Bedford, MA |
| FCRL | Air Force Cambridge Research Laboratory |
| FOSR | Air Force Office of Scientific Research |
| FS | American Foundrymen’s Society, Des Plaines, IL |
| FWL | Air Force Weapons Laboratory |
| GI | American Geological Institute, Alexandria, VA |
| GMA | American Gear Manufacturing Association, Alexandria, VA |
| GU | American Geophysical Union, Washington, DC |

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| AHAM | Association of Home Appliance Manufacturers, Chicago, IL |
| AIA | American Insurance Association, Washington, DC |
| AIAA | American Institute of Aeronautics and Astronautics, Washington, DC |
| AICE | American Institute of Consulting Engineers (now ACEC) |
| AIChE | American Institute of Chemical Engineers, New York, NY |
| AIEE | American Institute of Electrical Engineers (now IEEE) |
| AIF | Atomic Industrial Forum, Inc. (now Nuclear Energy Institute) |
| AIIE | American Institute of Industrial Engineers (now IIE) |
| AIME | American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, NY |
| AIO | Arecibo Ionospheric Observatory, Puerto Rico |
| AIP | American Institute of Physics, College Park, MD |
| AIPE | American Institute of Plant Engineers, Cincinnati, OH |
| AISE | Association of Iron and Steel Engineers, Pittsburgh, PA |
| AISI | American Iron and Steel Institute, Washington, DC |
| AMA | American Medical Association, Chicago, IL, American Management Association, New York, NY, American Manufacturing Association, Auto Manufacturing Association |
| AMC | Air Material Command |
| AMCA | Air Movement and Control Association, Arlington Heights, IL |
| AMS | American Mathematical Society, Providence, RI |
| ANDB | Air Navigation and Development Board |
| ANS | American Nuclear Society, La Grange Park, IL |
| ANSI | American National Standards Institute (formerly ASA and USASI), New York, NY |
| AOA | American Ordnance Association (now ADPA) |
| APA | American Psychological Association, Washington, DC |
| APCA | Air Pollution Control Association (now A&WMMA) |
| APHA | American Public Health Association, Washington, DC |
| API | American Petroleum Institute, Washington, DC |
| ARL | Applied Research Laboratory, Sylvania Electronic System, Waltham, MA |
| ARPA | Advanced Research Projects Agency |
| ARRL | American Radio Relay League, Newington, CT |
| APS | American Physical Society, College Park, MD |
| ARS | American Rocket Society (merged with IAS to form AIAA) |
| ASA | American Standards Association (now ANSI) |
| ASAE | American Society of Agricultural Engineers, St. Joseph, MI |
| ASAIO | American Society of Artificial Internal Organs |
| ASCE | American Society of Civil Engineers, Washington, DC |
| ASEE | American Society for Engineering Education |
| ASHRAE | American Society of Heating, Refrigerating, and Air Conditioning Engineers, Inc. (formerly ASHAE and ASRE), Atlanta, GA |
| ASLE | American Society of Lubricating Engineers (now STLE) |
| ASM | ASM International, Materials Park, OH |
| ASME | American Society of Mechanical Engineers, New York, NY |
| ASNT | American Society for Nondestructive Testing (formerly SNT), Columbus, OH |
| ASP | American Society of Photogrammetry (now ASPRS) |
| ASPRS | American Society for Photogrammetry and Remote Sensing (formerly ASP), Bethesda, MD |
| ASQC | American Society for Quality Control, Milwaukee, WI |
| ASRE | American Society of Refrigerating Engineers (now ASHRAE) |
| ASTE | Association of Short Circuit Testing Authorities |
| ASTIA | Armed Services Technical Information Agency, Dayton, OH |
| ASTM | American Society for Testing and Materials, Philadelphia, PA |
| AT&T | American Telephone and Telegraph Company |
| AVS | American Vacuum Society, New York, NY |
| A&WMMA | Air and Waste Management Association (formerly APCA), Pittsburgh, PA |

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| WS | American Welding Society, Miami, FL |
| IH | Bureau International de l'Heue |
| TL | Bell Telephone Laboratories, Inc. (Murray Hill, NJ, etc.) |
| PA | Bonneville Power Administration, Portland, OR |
| NL | Brookhaven National Laboratory, Upton, NY |
| AA | Civil Aeronautics Administration |
| AL | Cornell Aeronautical Laboratory, Inc., Buffalo, NY |
| ARDE | Canadian Armament Research and Development Establishment |
| CIR | International Radio Consultative Committee |
| CIT | International Telegraph Consultative Committee (now TSB) |
| CIF | International Telephone Consultative Committee (now TSB) |
| CITT | International Telephone and Telegraph Consultative Committee (now TSB) |
| EA | Commission à l'Energie Atomique, Fontenay aux Roses, France |
| EB | Central Electricity Board, U.K. |
| EC | Consulting Engineers Council (now ACEC) |
| EERI | Central Electronics Engineering Research Institute, India |
| EI | Italian Electrotechnical Commission |
| ERN | (Geneva, Switzerland) |
| ESI | Centro Electtrotecnico Sperimentale Italiano, Milan, Italy |
| IBSE | Chartered Institution of Building Services Engineers, London, U.K. |
| IE | International Commission on Illumination |
| IGRE | Conference Internationale des Grands Reseaux Electriques (International Conference on Large Electric High-Tension Systems) |
| ISA | Casting Industry Suppliers Association (formerly FEMA), Des Plaines, IL |
| ISPR | Joint Radio Committee for the Fuel and Power Industries, London, U.K. |
| NAE | Commissão Nacionze de Atividades Espacizas, Sao Paolo, Brazil |
| NEN | Comitato Nazionale per l'Energia Nucleare, Frascati, Italy |
| NR | Consiglio Nazionale delle Ricerche, Italy |
| NRS | Centre National de la Recherche Scientifique, Paris, France |
| OSINE | Computer Science in Electrical Engineering Committee, Commission on Engineering Education, Washington, DC |
| PST | Commission on Professionals in Science and Technology (formerly SMC), Washington, DC |
| RES | Center for Research in Engineering Science, Lawrence, KS |
| RPL | Central Radio Propagation Laboratory (NBS) |
| SELT | Centro Studie Laboratorie Telecommunicazioni S.p.A., Turin, Italy |
| SF | Compagnie Generale de Telgraphie sans Fil |
| SIRO | Commonwealth Scientific and Industrial Research Organization, Melbourne, Australia |
| ARPA | Defense Advanced Research Projects Agency |
| DC | Defense Documentation Center |
| GRST | Delegation Generale a la Recherche Scientifique et Technique |
| RB | Defence Research Board, Canada |
| RME | Direction des Recherches et Moyens d'Essais |
| RTE | Defence Research Telecommunications Establishment, Ottawa, ON, Canada |
| SIR | Department of Scientific and Industrial Research, U.K. |
| TM | Director of Telecommunications Management (office of President) |
| BU | European Broadcasting Union, Grand-Saconnex, Switzerland |
| CPD | Engineers Council for Professional Development (now ABET) |
| CS | Electrochemical Society, Pennington, NJ |
| EI | Edison Electric Institute, Washington, DC |
| IA | Electronic Industries Association (formerly RETMA, RTMA, RMA), Arlington, VA |
| IC | Engineering Institute of Canada, Gloucester, ON, Canada |
| JC | Engineers Joint Council (now AAES) |
| NDESA | Empressa Nacional de Electricidad SA, Santiago, Chile |

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|---|---|
| NEA | European Nuclear Energy Agency (part of OECD) (now NEA-OECD Nuclear Energy Agency) |
| NEL | Ente Nazionale per l'Energia Elettrica |
| NTELEC | Energy Telecommunications and Electrical Association (formerly PIEA), Dallas, TX |
| OS | Electrical Optical Systems Inc., Pasadena, CA |
| RA | Engineering Research Associates |
| SSA | Environmental Science Services Administration (U.S. Department of Commerce) Boulder, CO, composed of Institutes for Environmental Research, Institute for Earth Sciences, Institute for Oceanography, Institute for Atmospheric Sciences, Institute for Telecommunication Sciences and Aeronomy, Office of Administrative and Support Services |
| TH | Eidgenössische Technische Hochschule, Zurich, Switzerland |
| USEC | Conference of Engineering Societies of Western Europe and U.S. |
| CC | Federal Communications Commission |
| EMA | Foundry Equipment Manufacturing Association (now CISA) |
| JCC | Fall Joint Computer Conference (AFIPS) |
| MD | Frequency Management Division (in office of DTM) |
| PS | Fluid Power Society, Milwaukee, WI |
| TL | Federal Telecommunications Laboratories |
| TR | Federal Telephone and Radio Company |
| E | General Electric Company |
| M | General Motors |
| SFC | Goddard Space Flight Center, Greenbelt, MD (NASA) |
| AEA | International Atomic Energy Agency, Vienna, Austria |
| AS | Institute of Aeronautical Sciences (merged with ARS to form AIAA) (now AIAA) |
| AS | Indiana Academy of Science |
| BM | International Business Machines Corporation |
| CI | see CIE |
| CMCI | International Conference on Microwaves, Circuit Theory, and Information Theory, Tokyo, Japan |
| CMF | International Conference on Magnetic Films |
| DA | Institute for Defense Analysis, Arlington, VA |
| EC | International Electrotechnical Commission, Geneva, Switzerland |
| ECEJ | Institute of Electronics and Communication Engineers of Japan |
| EE | Institution of Electrical Engineers, London, U.K. |
| EEE | Institute of Electrical and Electronics Engineers (formerly AIEE and IRE), Piscataway, NJ |
| EICE | Institute of Electrical, Information and Communication Engineers, Japan |
| ER | see ESSA |
| ERE | Institution of Electronics and Radio Engineers, U.K. |
| ES | Illuminating Engineering Society (now CIBSE) |
| FAC | International Federation of Automatic Control, Montreal, PQ, Canada |
| FIP | International Federation of Information Processing, Laxenburg, Austria |
| FRB | International Frequency Registration Board (now ITU) |
| E | Institute of Industrial Engineers (formerly AIIE), Norcross, GA |
| MM | Institute of Mining and Metallurgy, London, U.K. |
| ON | Institute of Navigation, Alexandria, VA |
| PCEA | Insulator Power Cable Engineering Association |
| PS | Italian Physical Society (also SIF), Bologna, Italy |
| RAC | Interdepartment Radio Advisory Committee |
| RC | International Resistance Company |
| RE | Institute of Radio Engineers (now IEEE) |
| REE | Institute of Radio and Electronics Engineers (Australia) |
| REQ | HydroQuebec Institute of Research |
| SA | Instrument Society of America, Research Triangle Park, NC |
| SIS | International Satellite for Ionospheric Studies |
| SL | Institut Français–Allemand de Recherches de Saint-Louis (Haut-Rhin) Deutsch-Französisches Forschungs-Institut Saint-Lous, Weil am Rhein (Baden) |

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|---|---|
| TSA | Institute for Telecommunications Sciences and Aeronomy, Boulder, CO, formerly Central Radio Propagation Laboratory, NBS (see ESSA) |
| T&T | International Telephone and Telegraph |
| TU | International Telecommunications Union, Geneva, Switzerland |
| BM | IBM Thomas J. Watson Research Center, Yorktown Heights, NY |
| | Institute of Science and Technology, University of Michigan, Ann Arbor |
| | Institute of Mathematics and Its Applications, London, U.K. |
| | Institute of High Fidelity |
| ACC | Joint Automatic Control Conference |
| EDEC | Joint Electron Devices Engineering Council, Arlington, VA |
| ETC | Joint Technical Advisory Committee Electron Tube Council |
| ETS | Junior Engineering Technical Council, Alexandria, VA |
| IC | Joint Industry Conference |
| PL | Jet Propulsion Laboratories, California Institute of Technology, Pasadena, CA |
| SEP | Joint Services Electronics Program |
| TAC | Joint Technical Advisory Committee Laboratories voor Electromagnetisme en Acustica, Univ. of Ghent, Belgium |
| DD | Kokusai Denshin Denwa Company, Tokyo, Japan |
| CIE | Laboratoire Central des Industries Electriques, Fontenay-aux-Roses (Seine), France |
| RL | Lawrence Radiation Laboratory |
| TRI | Lighting and Transients Research Institute |
| MAA | Mathematical Association of America, Washington, DC |
| MESUCORA | Association for Measurement, Controlled Regulation, and Automation |
| MILA | Merritt Island Launch Area, FL |
| MIT | Massachusetts Institute of Technology, Cambridge (use MIT) |
| | MIT Lincoln Laboratory, Lexington, MA |
| MRI | Microwave Research Institute, Polytechnic Institute of Brooklyn |
| | Mullard Research Laboratories, Redhill, Surrey, U.K. |
| IAB | National Association of Broadcasters, now NARTB, Washington, DC |
| IAC | Network Analysis Corporation, Glen Cove, NY |
| IACA | National Advisory Committee for Aeronautics |
| IACE | National Association of Corrosion Engineers, Houston, TX |
| IAE | National Academy of Engineering, Washington, DC |
| IAFEC | National Aviation Facilities Experimental Center |
| IAM | National Association of Manufacturers, Washington, DC |
| IAPE | National Association of Power Engineers, Chicopee, MA |
| IAREC | Naval Research Laboratory Electronics and Digital Computers |
| IARTB | National Association of Radio and Television Broadcasters, Washington, DC |
| IAS | National Academy of Sciences, Washington, DC |
| IASA | National Aeronautics and Space Administration |
| IBRU | National Board of Fire Underwriters (now AIA–American Insurance Association) |
| IBS | National Bureau of Standards (see ESSA) |
| ICSL | Naval Coastal Systems Laboratory, Panama City, FL |
| ICTA | National Community Television Association |
| IDRC | National Defense Research Council |
| IDRE | Norwegian Defense Research Establishment, Kjeller, Lillestrom |
| IEA | OECD Nuclear Energy Agency, Issy-les-Moulineaux, France |
| IEC | National Electronics Conference (now IEC–International Engineering Consortium) |
| IELA | National Electric Light Association |
| IELC | Naval Electronics Laboratory Center, San Diego, CA |
| IEMA | National Electric Manufacturing Association |
| IEREM | Northeast Research and Engineering Meeting (formerly New England Radio Engineering Meeting) |
| IFPA | National Fire Protection Association, Quincy, MA |

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| IH | National Institutes of Health, Bethesda, MD |
| LR | National Lucht de-Ruimtevaartlaboratorium, Amsterdam, The Netherlands |
| OL | Naval Ordnance Laboratory |
| PL | British National Physical Laboratory |
| RAO | National Radio Astronomy Observatory, Green Bank, WV |
| RC | National Research Council, Washington, DC |
| RCC | National Research Council of Canada |
| RL | Naval Research Laboratory |
| SERC | Natural Sciences and Engineering Research Council of Canada |
| SF | National Science Foundation, Arlington, VA |
| SPE | National Society of Professional Engineers, Alexandria, VA |
| SRC | National Stereophonic Radio Committee |
| TG | Nachrichtentechnische Gesellschaft |
| | Nuclear Energy Institute (formerly AIF), Washington, DC |
| TSC | National Television System Commission |
| ARAC | Office of Air Research on Automatic Computers |
| BSA | Operations Research Society of America |
| ECD | Organization for Economic Cooperation and Development (Europe), Paris, France |
| NR | Office of Naval Research |
| RNL | Oak Ridge National Laboratories |
| SA | Optical Society of America, Washington, DC |
| SRD | Office of Scientific Research and Development |
| VE | Austrian Engineering Society |
| VEC | Ohio Valley Electric Company |
| CC | President’s Conference Committee |
| IB | Polytechnic Institute of Brooklyn |
| IEA | Petroleum Industry Electrical Association (now ENTELEC) |
| MR | Pacific Missile Range |
| ADC | Rome Air Development Center, Griffiss AFB, Rome, NY |
| AND | The Rand Corporation, Santa Monica, CA |
| CA | Radio Corporation of America |
| DB | Research and Development Board |
| ESA | Scientific Research Society of America (now Sigma Xi) |
| ETMA | Radio Electronic and Television Manufacturers Association (now EIA, formerly RTMA and RMA) |
| IAS | Research Institute for Advanced Studies, Baltimore, MD |
| LM | Reflector Lamps Manufacturers |
| MA | Radio Manufacturers Association, now EIA |
| RE | Royal Radar Establishment, Great Malvein, Worcs., U.K. |
| TCA | Radio Technical Commission for Aeronautics (now RTCA, Inc.) |
| TCA, Inc. | RTCA, Inc. (formerly RTCA), Washington, DC |
| TMA | Radio Television Manufacturers Association (now EIA, formerly RMA) |
| TPB | Radio Technical Planning Board |
| WMA | Resistance Welders Manufacturers Association, Philadelphia, PA |
| | Research Laboratory of Electronics, MIT, Cambridge, MA |
| | Research Triangle Institute, Durham (or Research Triangle Park), NC |
| | Rome Air Development Center, Griffiss AFB, Rome, NY |
| AE | Society of Automotive Engineers (now SAE International) |
| AE Internationa l | SAE International (formerly SAE), Warrendale, PA |
| AME | Society of American Military Engineers, Alexandria, VA |
| CEL | Signal Corps Engineering Laboratory (see USAECOM) |
| EM | Society for Experimental Mechanics (formerly SESA), Bethel, CT |

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| ER | Swedish Institute of Graduate Electrical Engineers |
| ESA | Services Electronics Research Laboratory, Harlow, Essex, U.K. |
| ESA | Society of Experimental Stress Analysis (now SEM) |
| EV | Schweizerischer Elektrotechnischer Verein, Zürich, Switzerland |
| FPE | Society of Fire Protection Engineers, Boston, MA |
| IAM | Society for Industrial and Applied Mathematics, Philadelphia, PA |
| IF | Italian Physical Society, Bologna, Italy (SIF = Societa Italiana di Fisica) (also IPS) |
| igma Xi | The Scientific Research Society (absorbed—formerly RESA, SRSA), Research Triangle Park, NC |
| JCC | Spring Joint Computer Conference (AFIPS) |
| LAC | Stanford Linear Accelerator Center, Stanford University, Stanford, CA |
| LF | Lombard Physical Society |
| MC | Scientific Manpower Commission (now CPST) |
| MPE | now SMPTE |
| NAME | Society of Naval Architects and Marine Engineers, Jersey City, NJ |
| NT | Society for Nondestructive Testing (now ASNT) |
| PE | Society of Plastics Engineers, Brookfield, CT |
| PIE | The International Society for Optical Engineers, Bellingham, WA |
| RC | Semiconductor Research Corporation |
| RE | Society of Reproduction Engineers |
| RI | Stanford Research Institute, Menlo Park, CA |
| RSA | Scientific Research Society of America (now Sigma Xi) |
| TC | Society for Technical Communications (formerly STWP), Arlington, VA |
| TLE | Society of Tribologists and Lubrication Engineers (formerly ASLE), Park Ridge, IL |
| TWP | Society of Technical Writers and Publishers (now STC) |
| | Sylvania Electronic Defense Laboratory, Mountain View, CA |
| | Systems Control, Inc., Palo Alto, CA |
| ASO | Television Allocation Study Organization (defunct) |
| IMS | The Institute of Management Sciences, Providence, RI |
| RW | TRW Corporation, Redondo Beach, CA |
| SB | Telecommunication Standardization Bureau (formerly CCITT), Geneva, Switzerland |
| VA | Tennessee Valley Authority |
| ATI | Union of International Engineering Organizations, Paris, France |
| CLA | University of California, Los Angeles |
| L | Underwriters Laboratory, Northbrook, IL |
| NIPEDE | International Union of Producers and Distributors of Electrical Energy, Paris, France |
| PADI | Pan American Federation Engineering Society |
| RC | University Research Committee |
| RSI | International Scientific Radio Union |
| SAECOM | U.S. Army Electronics Command, formerly Signal Corps |
| SAEL | U.S. Army Electronics Laboratory, Ft. Monmouth, NJ |
| SASI | USA Standards Institute (formerly ASA, now ANSI) |
| SITA | United States Independent Telephone Association (now USTA) |
| SNOL | U.S. Naval Ordnance Laboratory, Silver Spring, MD |
| STA | United States Telephone Association (formerly USITA), Washington, DC |
| DE | Verean Deutscher Elektrotechniker |
| DI | Verband Deutscher Ingenieure (Society of German Engineers) |
| KF | Von Karman Gas Dynamics Facility, Arnold AF Station, TN |
| ADC | Wright Air Development Center, Wright-Patterson AFB, Dayton, OH |
| ARF | Wisconsin Alumni Research Foundation |
| CEMA | West Coast Electronic Manufacturers Association (now AEA) |
| EC | World Energy Council (formerly WPC), London, U.K. |
| ESCON | Western Electronic Show and Convention |
| PC | World Power Conference (now WEC) |

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| WSEIAC | Weapon System Effectiveness Industry Advisory Committee |
| WWVH, WWV, | Radio stations broadcasting time and frequency standards, |
| WWBV, WVL | Willow Run Laboratories, University of Michigan, Ann Arbor, MI |

## F. Conference Abbreviations

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| | Proceedings, Proceedings of the | Proc. |
| | International Conference | Int. Conf. |
| | National Conference | Nat. Conf. |
| IPC | Technical Conference, IPC Printed Circuits Expo | Tech. Conf., IPC Print. Circuits Expo. |
| IPC | IPC Annual Conference | IPC Annu. Conf. |
| IPC | IPC Printed Circuits Expo | IPC Print. Circuits Expo. |
| ECTC | Electronics Components and Technology Conference | Electron. Compon. Technol. Conf. |
| IPC | IPC Annual Meeting | IPC Annu. Meet. |
| SSC | International Solid-State Circuits Conference | Int. Solid-State Circuits Conf. |
| VLSI | Conference on Advanced Research on VLSI | Conf. Adv. Res. VLSI |
| VLSI | VLSI Packaging Workshop | VLSI Packag. Workshop |
| IEEE | IEEE Interconnect Technology Conference | IEEE Interconnect Technol. Conf. |
| ICAPS | Int. Conf. on Advanced Packaging Systems | Int. Conf. Adv. Packag. Syst. |
| IEEE | IEEE Int. Conf. on Solid-State Sensors, Actuators, and Microsystems | IEEE Int. Conf. Solid-State Sens., Actuators, Microsyst. |
| IEEE/CMPT | EEE/CPMT International Electronics Manufacturing Technology Symposium | IEEE/CPMT Int. Electron. Manuf. Technol. Symp. |
| IEEE | IEEE Annual Int. Conf. on Micro Electro Mechanical Systems | IEEE Annu. Int. Conf. Micro Electro Mech. Syst. |
| ICEPT | Int. Conf. on Electronics Packaging Technology | Int. Conf. Electron. Packag. Technol. |
| ISMP | International Symposium on Mathematical Programming | Int. Symp. Math. Program. |
| SMATE | Symposium on Microjoining and Assembly Technology in Electronics | Symp. Microjoining Assem. Technol. Electron. |
| 3D | 3D Architectures for Semiconductor Integration and Packaging | 3D Architectures Semicond. Integr. Packag. |
| ICEP | Int. Conf. on Electronics Packaging | Int. Conf. Electron. Packag. |
| ICTP | Int. Conf. on Thermal Phenomena | Int. Conf. Therm. Phenom. |
| ISEM | International Symposium on Experimental Mechanics | Int. Symp. Exp. Mech. |
| IEEE | IEEE EuroSimE | IEEE EuroSimE |
| | Annual International KGD Packaging and Test Workshop | Annu. Int. KGD Packag. Test Workshop |
| IMAPS | IMAPS Advanced Technology Workshop on Advanced 3D Packaging | IMPAS Adv. Technol. Workshop Adv. 3D Packag. |
| ISPSD | International Symposium on Power Semiconductor Devices | Int. Symp. Power Semicond. Devices |
| IEEE | IEEE Annual Applied Power Electronics Conference | IEEE Annu. Appl. Power Electron. Conf. |
| APEC | Applied Power Electronics Conference | Appl. Power Electron. Conf. |
| ITHERM | Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems | Intersoc. Conf. Therm. Thermomech. Phenom. Electron. Syst. |
| CPES | CPES Power Electronics Seminar | CPES Power Electron. Semin. |
| ASM | Annual Symposium on Microelectronics | Annu. Symp. Microelectron. |
| ICMM | Int. Conf. on Multichip Modules | Int. Conf. Multichip Modules |
| ICMMHDP | Int. Conf. on Multichip Modules and High Density | Int. Conf. Multichip Modules High |

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|---|---|---|
| | Packaging | Density Packag. |
| LEOC | Lasers and Electro-Optics Conference | Lasers Electro-Opt. Conf. |
| EPEP | Topical Meeting on Electrical Performance of Electronic Packaging | Top. Meet. Elect. Perform. Electron. Packag. |
| IEEE/ACM | IEEE/ACM Int. Conf. Computer-Aided Design | IEEE/ACM Int. Conf. Comput.-Aided Des. |
| IEEE | IEEE International Symposium on Antennas and Propagation | IEEE Int. Symp. Antennas Propag. |
| ISAP | International Symposium on Antennas and Propagation | Int. Symp. Antennas Propag. |
| ACM/IEEE | ACM/IEEE Design Automation Conference | ACM/IEEE Des. Autom. Conf. |
| IEEE | IEEE International Microwave Symposium | IEEE Int. Microw. Symp. |
| IMS | International Microwave Symposium | Int. Microw. Symp. |
| DATE | Design Automation and Test in Europe | Des. Autom. Test Eur. |
| ICMSMSSA | Int. Conf. on Modeling Simulation of Microsystems, Semiconductors, Sensors, and Actuators | Int. Conf. Model. Simul. Microsyst., Semicond., Sens., Actuators |
| ICSS | Integrated Circuits and Systems Symposium | Integr. Circuits Syst. Symp. |
| IEEE AP-S | IEEE Advanced Packaging Society International Symposium Digest | IEEE Adv. Packag. Soc. Int. Symp. Dig. |
| AP-S | Advanced Packaging Society International Symposium Digest | Adv. Packag. Soc. Int. Symp. Dig. |
| URSI | URSI Radio Science Meeting | URSI Radio Sci. Meet. |
| ISEMC | IEEE International Symposium on Electromagnetic Compatibility | IEEE Int. Symp. Electromagn. Compat. |
| CAD | Int. Conf. Computer-Aided Design | Int. Conf. Comput.-Aided Des. |
| ISPD | International Symposium on Physical Design | Int. Symp. Phys. Des. |
| ICEAA | Int. Conf. on Electromagnetics and Advanced Applications | Int. Conf. Electromagn. Adv. Appl. |
| IEEE/CPMT | IEEE/CPMT International Electronics Manufacturing Technology Symposium | IEEE/CPMT Int. Electron. Manuf. Technol. Symp. |
| IEMTS | International Electronics Manufacturing Technology Symposium | Int. Electron. Manuf. Technol. Symp. |
| ASME | ASME International Mechanical Engineering Congress and Exposition | ASME Int. Mech. Eng. Congr. Expo. |
| IMECE | International Mechanical Engineering Congress and Exposition | Int. Mech. Eng. Congr. Expo. |
| ISM | International Symposium on Microelectronics | Int. Symp. Microelectron. |
| CIGRE | CIGRE Conference | CIGRE Conf. |
| COSMIC | Cosmic Ray Conference | Cosmic Ray Conf. |
| CAS | Conference on Applied Superconductivity | Conf. Appl. Supercond. |
| IEEE | IEEE International Symposium on Electromagnetic Compatibility | IEEE Int. Symp. Electromagn. Compat. |
| ISEC | International Symposium on Electromagnetic Compatibility | Int. Symp. Electromagn. Compat. |
| ASC | Applied Superconductivity Conference | Appl. Supercond. Conf. |
| EMC | European Microwave Conference | Eur. Microw. Conf. |
| IEEE | IEEE Antennas and Propagation Society Symposium Digest | IEEE Antennas Propag. Soc. Symp. Dig. |
| APS | Antennas and Propagation Society Symposium Digest | Antennas Propag. Soc. Symp. Dig. |
| IEEE APS | IEEE APS Conference on Antennas and Propagation for Wireless Communications | IEEE APS Conf. Antennas Propag. Wireless Commun. |
| IEEE | IEEE Vehicular Technology Conference | IEEE Veh. Technol. Conf. |
| VTC | Vehicular Technology Conference | Veh. Technol. Conf. |
| IEEE WCNC | IEEE Wireless Communication Networking Conference | IEEE Wireless Commun. Netw. Conf. |

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|---|---|---|
| WCNC | Wireless Communication Networking Conference | Wireless Commun. Netw. Conf. |
| UWBST | Conference on Ultra Wideband Systems and Technologies | Conf. Ultra Wideband Syst. Technol. |
| IEEE | IEEE Conference on Ultra Wideband Systems and Technologies | IEEE Conf. Ultra Wideband Syst. Technol. |
| IWUWBS | International Workshop on Ultra Wideband Systems | Int. Workshop Ultra Wideband Syst. |
| IEEE | IEEE International Workshop on Ultra Wideband Systems | IEEE Int. Workshop Ultra Wideband Syst. |
| PIMRC | International Symposium on Personal, Indoor, and Mobile Radio Communications | Int. Symp. Pers., Indoor, Mobile Radio Commun. |
| IEEE | IEEE International Symposium on Personal, Indoor, and Mobile Radio Communications | IEEE Int. Symp. Pers., Indoor, Mobile Radio Commun. |
| ASILOMAR | Asilomar Conference on Signals, Systems, and Computers | Asilomar Conf. Signals, Syst., Comput. |
| IEEE/ACES | IEEE/ACES Int. Conf. Wireless Communications and Applied Computational Electromagnetics | IEEE/ACES Int. Conf. Wireless Commun. Appl. Comput. Electromagn. |
| ICWCACE | Int. Conf. Wireless Communications and Applied Computational Electromagnetics | Int. Conf. Wireless Commun. Appl. Comput. Electromagn. |
| ISAP | International Symposium on Antennas and Propagation | Int. Symp. Antennas Propag. |
| IEEE | IEEE Int. Conf. on Phased Array Systems Technology | IEEE Int. Conf. Phased Array Syst. Technol. |
| ICPAST | Int. Conf. on Phased Array Systems Technology | Int. Conf. Phased Array Syst. Technol. |
| GLOBECOM | IEEE Global Telecommunications Conference | IEEE Global Telecommun. Conf. |
| URSI | General Assembly of the International Union of Radio Science | Gen. Assem. Int. Union Radio Sci. |
| IEEE | IEEE Radio and Wireless Conference Digest | IEEE Radio Wireless Conf. Dig. |
| RWC | Radio and Wireless Conference Digest | Radio Wireless Conf. Dig. |
| AAAS | Annual Antenna Applications Symposium | Annu. Antenna Appl. Symp. |
| ECWT | European Conference on Wireless Technology | Eur. Conf. Wireless Technol. |
| IEEE | IEEE Topical Conference on Wireless Communications | IEEE Top. Conf. Wireless Commun. Tech. Dig. |
| TCWC | Topical Conference on Wireless Communications Technical Digest | Top. Conf. Wireless Commun. Tech. Dig. |
| ANTEM | International Symposium on Antenna Technology and Applied Electromagnetics | Int. Symp. Antenna Technol. Appl. Electromagn. |
| ECFRSN | European Conference on Fixed Radio Systems and Networks | Eur. Conf. Fixed Radio Syst, Netw. |
| CSNDSP | International Symposium on Communication Systems, Networks, and Digital Signal Processing | Int. Symp. Commun. Syst., Netw., Digital Signal Process. |
| ECMAST | European Conference on Multimedia Applications and Services Technology | Eur. Conf. Multimedia Appl. Serv. Technol. |
| URSI | URSI General Assembly | URSI Gen. Assem. |
| SPIE | SPIE International Symposium on Astronomical Telescopes and Instrumentation | SPIE Int. Symp. Astron. Telesc. Instrum. |
| ISATI | International Symposium on Astronomical Telescopes and Instrumentation | Int. Symp. Astron. Telesc. Instrum. |
| IEEE | IEEE Aerospace Conference | IEEE Aerosp. Conf. |
| SSDM | Structures, Structural Dynamics, and Materials Conference | Struct. Struct. Dyn. Mater. Conf. |
| WARS | Workshop on Applications of Radio Science | Workshop Appl. Radio Sci. |
| IROS | Int. Conf. on Intelligent Robots and Systems | Int. Conf. Intell. Robots Syst. |
| IEEE/RSJ | IEEE Int. Conf. on Intelligent Robots and Systems | IEEE Int. Conf. Intell. Robots Syst. |
| ICRA | Int. Conf. on Robotics and Automation | Int. Conf. Robot. Autom. |
| IEEE | IEEE Int. Conf. on Robotics and Automation | IEEE Int. Conf. Robot. Autom. |

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| IFAC | World Congress of the International Federation on Automatic Control | World Congr. Int. Fed. Autom. Control |
| SIGCHI | SIGCHI Conf. on Human Factors in Computing Systems | SIGCHI Conf. Human Factors Comput. Syst. |
| ISWC | Int. Symposium on Wearable Computers | Int. Symp. Wearable Comput. |
| IWFGR | Int. Workshop on Automatic Face and Gesture Recognition | Int. Workshop Face Gesture Recog. |
| SMC | Int. Conf. on Systems, Man, and Cybernetics | Int. Conf. Syst., Man, Cybern. |
| IEEE | IEEE Int. Conf. on Systems, Man, and Cybernetics | IEEE Int. Conf. Syst., Man, Cybern. |
| IFAC | IFAC Symposium on Robot Control | IFAC Symp. Robot Control |
| CDC | Conference on Decision and Control | Conf. Decision Control |
| IEEE | IEEE Conference on Decision and Control | IEEE Conf. Decision Control |
| WAFR | Workshop on Algorithmic Foundations of Robotics | Workshop Algorithmic Found. Robot. |
| ACM/SIAM | ACM/SIAM Symposium on Discrete Algorithms | ACM/SIAM Symp. Discr. Algorithms |
| ECC | European Control Conference | Eur. Control Conf. |
| SAM | Symposium on Applied Mathematics | Symp. Appl. Math. |
| IASTED | IASTED Conference on Applications and Control in Robotics | IASTED Conf. Appl. Control Robot. |
| ICCG | Int. Conf. on Computer Games: Artifical Intelligence, Design, and Education | Int. Conf. Comput. Games: Artif. Intell., Des., Educ. |
| IEEE | IEEE Int. Symposium on Intelligent Control | IEEE Int. Symp. Intell. Control |
| ISIC | Int. Symposium on Intelligent Control | Int. Symp. Intell. Control |
| ACC | American Control Conference | Am. Control Conf. |
| AIAA | AIAA Guidance, Navigation, and Control Conference | AIAA Guid., Navigat., Control Conf. |
| IEEE | IEEE Int. Conf. on Control Applications | IEEE Int. Conf. Control Appl. |
| ICCA | Int. Conf. on Control Applications | Int. Conf. Control Appl. |
| ICIAS | Int. Congress on Intelligent Autonomous Systems | Int. Congr. Intell. Auton. Syst. |
| IEEE | IEEE Int. Joint Symposium on Intelligent Systems | IEEE Int. Joint Symp. Intell. Syst. |
| IEEE | IEEE Annual Int. Conf. on Industrial Electronics, Control, and Instrumentation | IEEE Annu. Int. Conf. Ind. Electron., Control, Instrum. |
| IEEE | IEEE Int. Joint Conference on Neural Networks | IEEE Int. Joint Conf. Neural Netw. |
| IEEE | IEEE World Congress on Computational Intelligence | IEEE World Congr. Comput. Intell. |
| IEEE | IEEE Int. Symposium on Circuits and Systems | IEEE Int. Symp. Circuits Syst. |
| IEEE | IEEE Int. Conf. on Acoustics, Speech, and Signal Processing | IEEE Int. Conf. Acoust., Speech, Signal Process. |
| ICASSP | Int. Conf. on Acoustics, Speech, and Signal Processing | Int. Conf. Acoust., Speech, Signal Process. |
| ISRR | Int. Symposium on Robotics Research | Int. Symp. Robot. Res. |
| IEEE | IEEE Virtual Reality International Symposium | IEEE Virtual Reality Int. Symp. |
| VRIS | Virtual Reality International Symposium | Virtual Reality Int. Symp. |
| IEEE | IEEE VR Symposium on Haptic Interfaces for Virtual Reality and Teleoperator Systems | IEEE VR Symp. Haptic Interfaces Virtual Reality, Teleoperator Syst. |
| VR | VR Symposium on Haptic Interfaces for Virtual Reality and Teleoperator Systems | VR Symp. Haptic Interfaces Virtual Reality, Teleoperator Syst. |
| VE | Symposium on Haptic Interfaces for Virtual Environment and Teleoperator Systems | Symp. Haptic Interfaces Virtual Environ., Teleoperator Syst. |
| ICAR | Int. Conf. on Advanced Robotics | Int. Conf. Adv. Robot. |
| IEEE | IEEE Int. Workshop on Intelligent Robots and Systems | IEEE Int. Workshop Intell. Robots Syst. |
| IWIRS | Int. Workshop on Intelligent Robots and Systems | Int. Workshop Intell. Robots Syst. |
| ICPR | Int. Conf. on Pattern Recognition | Int. Conf. Pattern Recog. |
| IEEE | IEEE Conf. on Emerging Technologies in Factory Automation | IEEE Conf. Emerging Technol. Factory Autom. |
| ISMHS | Int. Symposium on Micromechatronics in Human Sciences | Int. Symp. Micromechatron. Human Sci. |

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| IAPR | IAPR Workshop on Machine Vision Applications | IAPR Workshop Mach. Vis. Appl. |
| ASME | ASME Design Engineering Technical Conference | ASME Des. Eng. Tech. Conf. |
| SI3DG | Symposium on Interactive 3D Graphics | Symp. Interactive 3D Graph. |
| ASCG | Annual Symposium on Computational Geometry | Annu. Symp. Comput. Geom. |
| IMACS | IMACS World Congress on Mathematical Modeling and Scientific Computation | IMACS World Congr. Math. Modeling Sci. Comput. |
| ICC | Int. Conf. on Communications | Int. Conf. Commun. |
| IEEE | IEEE Int. Conf. on Communications | IEEE Int. Conf. Commun. |
| CISS | Conference on Information Science and Systems | Conf. Inf. Sci. Syst. |
| IEEE | IEEE Wireless Communications and Networks Conference | IEEE Wireless Commun. Netw. Conf. |
| WCNC | Wireless Communications and Networks Conference | Wireless Commun. Netw. Conf. |
| IEEE | IEEE Information Theory Workshop | IEEE Inf. Theory Workshop |
| ITW | Information Theory Workshop | Inf. Theory Workshop |
| ISSSE | Int. Symposium on Secure Software Engineering | Int. Symp. Secure Softw. Eng. |
| IEEE | IEEE Int. Symposium on Secure Software Engineering | IEEE Int. Symp. Secure Softw. Eng. |
| IEEE | IEEE Military Communications Conference | IEEE Mil. Commun. Conf. |
| MILCOM | IEEE Military Communications Conference | IEEE Mil. Commun. Conf. |
| ISSSTA | IEEE Int. Symposium on Spread Spectrum Techniques and Applications | IEEE Int. Symp. Spread Spectrum Tech. Appl. |
| IEEE | IEEE Int. Symposium on Spread Spectrum Techniques and Applications | IEEE Int. Symp. Spread Spectrum Tech. Appl. |
| ISIT | Int. Symposium on Information Theory | Int. Symp. Inf. Theory |
| IEEE | IEEE Int. Symposium on Information Theory | IEEE Int. Symp. Inf. Theory |
| ISSPA | Int. Symposium on Signal Processing and Its Applications | Int. Symp. Signal Process. Appl. |
| ALLERTON | Annual Allerton Conference on Communication, Control, and Computing | Annu. Allerton Conf. Commun., Control, Comput. |
| INFOCOM | IEEE Conference on Computer Communications | INFOCOM or IEEE Conf. Comput. Commun. |
| IEEE | IEEE Conference on Computer Communications | INFOCOM or IEEE Conf. Comput. Commun. |
| IEEE | IEEE Annual Conference on Local Computer Networks | IEEE Annu. Conf. Local Comput. Netw. |
| SSGRR | SSGRR Conference | SSGRR Conf. |
| ICCCN | Int. Conf. on Computer Communications and Networks | Int. Conf. Comput. Commun. Netw. |
| ICEAA | Int. Conf. on Electromagnetics in Advanced Applications | Int. Conf. Electromagn. Adv. Appl. |
| SPIE | SPIE Int. Symposium on Remote Sensing | SPIE Int. Symp. Remote Sens. |
| ICECom | Int. Conf. on Applied Electromagnetics and Communications | Int. Conf. Appl. Electromagn. Commun. |
| RAWCON | IEEE Radio and Wireless Symposium | IEEE Radio Wireless Symp. |
| RWS | IEEE Radio and Wireless Symposium | IEEE Radio Wireless Symp. |
| IEEE | IEEE Radio and Wireless Symposium | IEEE Radio Wireless Symp. |
| MTT-S | IEEE MTT-S International Microwave Symposium and Exhibition | IEEE MTT-S Int. Microw. Symp. Exhib. |
| IEEE | IEEE MTT-S International Microwave Symposium and Exhibition | IEEE MTT-S Int. Microw. Symp. Exhib. |
| OFDM | International OFDM Workshop | Int. OFDM Workshop |
| EUSIPCO | European Signal Processing Conference | Eur. Signal Process. Conf. |
| PSIP | Physics in Signal and Image Processing | Phys. Signal Image Process. |
| ICB | Int. Conf. on Biomagnetism | Int. Conf. Biomagn. |
| ICANN | Int. Conf. on Artificial Neural Networks | Int. Conf. Artif. Neural Netw. |
| ICA BSS | Int. Symposium on Independent Component Analysis and Blind Signal Separation | Int. Symp. Ind. Compon. Anal. Blind Signal Separation |

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| ISBI | Int. Symposium on Biomedical Imaging | Int. Symp. Biomed. Imag. |
| IEEE | IEEE Int. Symposium on Biomedical Imaging | IEEE Int. Symp. Biomed. Imag. |
| ICIP | Int. Conf. Image Processing | Int. Conf. Image Process. |
| IEEE | IEEE Int. Conf. Image Processing | IEEE Int. Conf. Image Process. |
| IPMI | Information Processing in Medical Imaging Conference | Inf. Process. Med. Imag. Conf. |
| MICCAI | Medical Image Computing and Computer-Assisted Intervention Conference | Mid. Image Comput. Comput.-Assisted Intervention Conf. |
| NRSC | National Radio Science Conference | Nat. Radio Sci. Conf. |
| IJCAI | International Joint Conference on Artificial Intelligence | Int. Joint Conf. Artif. Intell. |
| COMPLEX | Annual Conference on Computational Complexity | Annu. Conf. Comput. Complexity |
| IWQoS | IFIP Workshop on Quality of Service | IFIP Workshop Quality of Service |
| WINTER | Winter Simulation Conference | Winter Simul Conf. |
| DATACOM | Data Communications Symposium | Data Commun. Symp. |
| ACM | ACM SIGCOMM Internet Measurement Workshop | ACM SIGCOMM Internet Meas. Workshop |
| DATACOMS | Int. Conf. on Data Communications and Systems | Int. Conf. Data Commun. Syst. |
| ACM | ACM SIGCOMM Conference | ACM SIGCOMM Conf. |
| ACM | ACM SIGMETRICS Conference | ACM SIGMETRICS Conf. |
| ACC | American Control Conference | Am. Control Conf. |
| CODES | Int. Symposium on Hardware/Software Codesign | Int. Symp. Hardware/Software Codes. |
| ICCAD | Int. Conf. on Computer-Aided Design | Int. Conf. Comput.-Aided Des. |
| CNDS | Communications Networks and Distributed Systems Modeling and Simulation Conference | Commun. Netw. Distrib. Syst. Modeling Simul. Conf. |
| SPECTS | Int. Symposium on Performance Evaluation of Computer and Telecommunication Systems | Int. Symp. Performance Eval. Comput. Telecommun. Syst. |
| ICNP | Int. Conf. on Network Protocols | Int. Conf. Netw. Protocols |
| IEEE | IEEE Int. Conf. on Network Protocols | IEEE Int. Conf. Netw. Protocols |
| IEEE | IEEE Conference on High Performance Switching and Routing | IEEE Conf. High Performance Switching Routing |
| LCN | Annual Conference on Local Computer Networks | Annu. Conf. Local Comput. Netw. |
| IEEE | IEEE Annual Conference on Local Computer Networks | IEEE Annu. Conf. Local Comput. Netw. |
| IWDC | Int. Workshop on Digital Communications | Int. Workshop Digital Commun. |
| ISDGA | Int. Symposium on Dynamic Games and Applications | Int. Symp. Dynam. Games Appl. |
| MASCOTS | Int. Workshop on Modeling, Analysis, and Simulation of Computer and Telecommunications Systems | Int. Workshop Modeling, Anal., Simul. Comput. Telecommun. Syst. |
| ACM | ACM Mobicom Annual Int. Conf. on Mobile Computing and Networking | ACM Mobicom Annu. Int. Conf. Mobile Comput. Netw. |
| ASFCS | Annual Symposium on Foundations of Computer Science | Annu. Symp. Found. Comput. Sci. |
| WOCS | Workshop on Optics and Computer Science | Workshop Opt. Comput. Sci. |
| JCIS | Joint Conference on Information Sciences | Joint Conf. Inf. Sci. |
| DRCN | Int. Workshop on Design of Reliable Communication Networks | Int. Workshop Des. Reliable Commun. Netw. |
| IEEE/OSA | IEEE/OSA Optical Fiber Communications Conference | IEEE/OSA Opt. Fiber Commun. Conf. |
| NFOEC | National Fiber Optic Engineers Conference | Nat. Fiber Opt. Eng. Conf. |
| OPTICOMM | Optical Networking and Communications Conference | Opt. Netw. Commun. Conf. |
| ICCV | Int. Conf. on Computer Vision | Int. Conf. Comput. Vis. |
| ICIAP | Int. Conf. on Image Analysis and Processing | Int. Conf. Image Anal. Process. |
| IEEE | IEEE Visualization Conference | IEEE Vis. Conf. |
| VIS | Visualization Conference | Vis. Conf. |
| MICCAI | Int. Conf. on Medical Image Computing and Computer-Assisted Intervention | Int. Conf. Med. Image Comput. Comput.-Assisted Intervention |
| VIRTUAL | Virtual Systems and Multimedia Conference | Virtual Syst. Multimedia Conf. |
| IEEE | IEEE Nuclear Science Symposium | IEEE Nuclear Sci. Symp. |

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| NUCLEAR | Nuclear Science Symposium | Nuclear Sci. Symp. |
| IEEE MIC | IEEE Medical Imaging Conference | IEEE Med. Imag. Conf. |
| PATTERN | Int. Conf. on Pattern Recognition | Int. Conf. Pattern Recog. |
| MEDINFO | World Congress on Medical Informatics | World Congr. Med. Informatics |
| AFGR | Int. Conf. Automatic Face and Gesture Recognition | Int. Conf. Autom. Face Gesture Recog. |
| IEEE AFGR | IEEE Int. Conf. Automatic Face and Gesture Recognition | IEEE Int. Conf. Autom. Face Gesture Recog. |
| ICCVVRRM | Int. Conf. on Computer Vision, Virtual Reality, and Robotics in Medicine | Int. Conf. Comput. Vis., Virtual Reality, Robot. Med. |
| IEEE | IEEE Conference on Computer Vision and Pattern Recognition | IEEE Conf. Comput. Vis. Pattern Recog. |
| ISBI | Int. Symposium on Biomedical Imaging | Int. Symp. Biomed. Imag. |
| MIUA | Medical Image Understanding and Analysis Conference | Med. Image Understanding Anal. Conf. |
| CVRMed-MRCAS | Joint Conference on Computer Vision, Virtual Reality and Robotics in Medicine and Medical Robotics and Computer-Assisted Surgery | Joint Conf. Comput. Vis., Virtual Reality, Robot. Med., Med. Robot. Comput.-Assisted Surg. |
| CARS | Int. Congress and Exhibition on Computer-Assisted Radiology and Surgery | Int. Congr. Exhib. Comput.-Assisted Radiol. Surg. |
| SPIE VBC | SPIE Visualization in Biomedical Computing | SPIE Vis. Biomed. Comput. |
| VBC | Visualization in Biomedical Computing | Vis. Biomed. Comput. |
| IEEE | IEEE Power Tech Conference | IEEE Power Tech Conf. |
| IEEE PES | IEEE Power Engineering Society Summer Meeting | IEEE Power Eng. Soc. Summer Meet. |
| IEEE PES | IEEE Power Engineering Society Winter Meeting | IEEE Power Eng. Soc. Winter Meet. |
| ASEE | ASEE Annual Conference and Exposition | ASEE Annu. Conf. Expo. |
| IEEE PES | IEEE Power Engineering Society General Meeting | IEEE Power Eng. Soc. Gen. Meet. |
| IEEE PES | IEEE PES Transmission and Distribution Conference and Exhibition | IEEE PES Transmiss. Distrib. Conf. Exhib. |
| IEEE/MTS | IEEE/MTS Oceans Conference and Exhibition | IEEE/MTS Oceans Conf. Exhib. |
| EPRI | EPRI Workshop on Visualization Methods for Electric Power Industrial Applications | EPRI Workshop Vis. Methods Elect. Power Ind. Appl. |
| CEC | Congress on Evolutionary Computing | Congr. Evol. Comput. |
| ICPST | Int. Conf. on Power Systems Technology | Int. Conf. Power Syst. Technol. |
| PSCC | Power Systems Computation Conference | Power Syst. Comput. Conf. |
| PMAPS | Int. Conf. on Probabilistic Methods Applied to Power Systems | Int. Conf. Probability Methods Appl. Power Syst. |
| ICSS | Int. Conf. on Systems Science | Int. Conf. Syst. Sci. |
| IEEE | IEEE Int. Conf. on Artificial Intelligence Systems | IEEE Int. Conf. Artif. Intell. Syst. |
| ICAIS | Int. Conf. on Artificial Intelligence Systems | Int. Conf. Artif. Intell. Syst. |
| AICSEE | Int. Conf. on the Application of Artificial Intelligence to Civil, Structural, and Environmental Engineering | Int. Conf. Appl. Artif. Intell. Civil, Struct., Environ. Eng. |
| ISDA | Int. Conf. on Intelligent Systems Design and Applications | Int. Conf. Intell. Syst. Des. Appl. |
| KES | Int. Conf. on Knowledge-Based Intelligent Information and Engineering Systems | Int. Conf. Knowledge-Based Intell. Inf. Eng. Syst. |
| HIS | Int. Conf. on Hybrid Intelligent Systems | Int. Conf. Hybrid Intell. Syst. |
| POWER | Annual POWER Research Conference on Electricity Industry Restructuring | Annu. POWER Res. Conf. Elect. Ind. Restruct. |
| UCEI POWER | Annual POWER Research Conference on Electricity Industry Restructuring | Annu. POWER Res. Conf. Elect. Ind. Restruct. |
| MEDPOWER | MedPower Conference | MedPower Conf. |
| IEEE PICA | IEEE Power Industry Computer Application Conference | IEEE Power Ind. Comput. Appl. Conf. |
| PICA | Power Industry Computer Application Conference | Power Ind. Comput. Appl. Conf. |

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| GECC | Genetic and Evolutionary Computation Conference | Genetic Evol. Comput. Conf. |
| IEE SIMUL | IEE Int. Conf. on Simulation | IEE Int. Conf. Simul. |
| ASME/IEEE | ASME/IEEE Joint Railroad Conference | ASME/IEEE Joint Railroad Conf. |
| IEEE/ASME | IEEE/ASME Joint Railroad Conference | IEEE/ASME Joint Railroad Conf. |
| AWEA | AWEA Windpower Conference | AWEA Windpower Conf. |
| WIND | Windpower Conference | Windpower Conf. |
| PESC | IEEE Power Electronics Specialists Conference | IEEE Power Electron. Spec. Conf. |
| IEEE PESC | IEEE Power Electronics Specialists Conference | IEEE Power Electron. Spec. Conf. |
| IEEE ISIE | IEEE Int. Symposium on Industrial Electronics | IEEE Int. Symp. Ind. Electron. |
| ISIE | Int. Symposium on Industrial Electronics | Int. Symp. Ind. Electron. |
| IASTED POWER | IASTED PowerCon | IASTED PowerCon |
| POWERCON | IASTED PowerCon | IASTED PowerCon |
| IEEE RURAL | IEEE Rural Electric Power Conference | IEEE Rural Elect. Power Conf. |
| RURAL | Rural Electric Power Conference | Rural Elect. Power Conf. |
| CIDEL | CIDEL Int. Congress on Electrical Distribution | CIDEL Int. Congr. Elect. Distrib. |
| ICED | Int. Congress on Electrical Distribution | Int. Congr. Elect. Distrib. |
| NCAI | National Conference on Artificial Intelligence | Nat. Conf. Artif. Intell. |
| UAI | Conference on Uncertainty in Artificial Intelligence | Conf. Uncertainty Artif. Intell. |
| COPS | Int. Symposium on Computerized Operation of Power Systems | Int. Symp. Comput. Oper. Power Syst. |
| NAPS | North American Power Symposium | North Am. Power Symp. |
| LESCOPE | Large Engineering Systems Conference on Power Engineering | Large Eng. Syst. Conf. Power Eng. |
| IASTED EPS | IASTED Int. Conf. on Energy and Power Systems | IASTED Int. Conf. Energy Power Syst. |
| EPS | IASTED Int. Conf. on Energy and Power Systems | IASTED Int. Conf. Energy Power Syst. |
| CIRED | CIRED Int. Conf. and Exhibition on Electricity Distribution | CIRED Int. Conf. Exhib. Elect. Distrib. |
| SEPOPE | Symposium of Specialists in Electric Operational and Expansion Planning | Symp. Spec. Elect. Oper. Expansion Planning |