# IEEE EDITORIAL STYLE MANUAL

IEEE

*Advancing Technology for Humanity*

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# I. INTRODUCTION

**A. Purpose of Manual**

   This style manual provides general editing guidelines for IEEE Transactions, Journals, and Letters. For guidance in grammar and usage notincluded in this manual, please consult *The Chicago Manual of Style*, published by the University of Chicago Press.

**B. IEEE Transactions Editing Philosophy**

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

   Since we are concerned with style mainly in the sense of IEEE house style, we do 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. Some papers, for example, are from authors unfamiliar with the English language. Often, an IEEE Staff Editor must walk a fine line in determining how to correct a grammatical error or in deciding 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 we as Staff Editors do not risk making any unnecessary changes or any that may affect the author's meaning.

   Sometimes there are cases where it is simply not possible for us to decipher an author's meaning or to find a way to correct a sentence. In these cases, a judgment is made either to query the author on the proof about the passage in question, to directly contact the author, or in rare cases, to work with the Transactions Editor or Guest Editor to clarify the material.

   For a new Staff Editor, experience, familiarity with the material in this guide, and continued consultation with the training of IEEE Staff Editors will lead to an understanding of how much in a paper to change or question and what form those changes or questions should take.

**C. Preprinting (Pre-edit Rapid Posting)**

Preprinting is a term used to define the process of posting an author-submitted PDF of his/her manuscript online on the IEEEXplore site. This is done within a day or two of receipt at the IEEE. The author is required to include a signed copyright form with their submission package. If the form is not provided, the paper cannot be preprinted. On Xplore, it appears under "Early Access." This version of the paper has been accepted for publication by IEEE, but has not yet been edited and may not have been assigned to a print issue. A paper that has been preprinted is considered published.

In the blue-i, in WMS, journals that are set up to be preprinted will show **Preprint=Yes** in the **Production Tab**. Therefore, there is text in the first footnote of the final version that reflects this. The date the preprinted proof is available on Xplore is considered the **date of publication**. This date populates WMS in the **First Published Date** field under the **Production Tab**.

**D. Rapid Posting (Post-edit Rapid Posting)**

Rapid Posting is a term used to define the process of posting the author-approved edited version online. This is done within 3 weeks of receipt at the IEEE for a fully-edited article, and within 2 weeks of receipt for a moderately-edited article. The running head will contain only the publication title. The page numbers would contain generic numbers (e.g., 1 – 10). On Xplore, the article can be found under "Early Access." Once the article is assigned to a print issue, the article is paginated, and the running head is "opened up" and will contain the volume, issue, month , and year.

In the blue-i, journals that are set up to be rapid posted  will show **Rapid Post=Yes** in the **Production Tab**. A paper that has been preprinted is considered published. Therefore, there is text in the first footnote of the final version that reflects this. The date the preprinted proof is available on Xplore is considered the **date of publication**. This date populates WMS in the **First Published Date** field under the **Production Tab**.

**E. Continuous Pagination**

In a continuously paginated journal, each individual article goes through the entire workflow process, is assigned an issue, page numbers, and finally posted to Xplore. These articles may have been pre-printed or rapid posted already.

There is a running head; therefore in the article meta tag, RP must be set to "no." The proddate tages for "Current version…" are suppressed prior to author review, but unsupressed prior to posting to Xplore.

- **<u>Print Collections</u>** — In addition, several journals have ***Print Collections***. A print collection is a literal collection of online issues collected into one print edition. For this reason, additional concerns must be taken into considering when paginating. Each online issue will contain an Index of Contents listing of the papers in the issue. Due to postal requirements, a blank page MUST appear between issues, preceding the Index of Contents, in each print collection. The first article must begin on a verso page. Therefore, if the last page of one print collection ends on an even number (left-hand side), TWO blank pages must be left in order to start the next issue on the right-hand side.

- In Print Collections, Cover 1 may contain a graphic indicating which pages the TOCs appear on for each issue. Please refer to the "Table of Contents" section for more information.

**F. Article Numbering**

Article numbers are applied under the continuous pagination model. All papers in process are assigned article numbers and posted to Xplore as final, in the appropriate issue in which they are to appear. In the 7-digit article number, the first two digits within the subject category, the following three digits are the sequence number (for the year), and the last two are the page count. Example: 5701712

**G. Public Access**

If the government agency that funded this paper requires that the paper be deposited in an institutional repository in order to be made publicly available (there is not a consistent policy among government agencies), the author should comply with the requirement and submit the paper. We will send him the paper as accepted for publication, in PDF format through the Author Gateway, once the paper has been finalized. This is the version he should submit to the institutional repository. IEEE requires that the paper not be deposited before 12 months from the date of publication of the paper, unless the agency policy is different.

**H. Open Access**

**Open access** (**OA**) means unrestricted online access to peer-reviewed scholarly research. Open access comes in two degrees: *gratis* **OA**, which is free online access, and *libre* **OA**, which is free online access plus some additional usage rights. These additional usage rights are often granted through the use of various specific Creative Commons licenses.

The two ways authors can provide OA are: 1) by self-archiving their journal articles in an OA repository, also known as 'green' OA, or by 2) by publishing in an open access journal, known as 'gold' OA.

With green OA authors publish in any journal and then self-archive a version of the article for *gratis* public use in their institutional repository, in a central repository (such as PubMed Central), or on some other open access website.
With gold OA, authors publish in Open access journals, which provide immediate open access to all of their articles, usually on the publisher's website. ("Hybrid" gold OA journals are subscription journals that provide gold open access only for those individual articles for which their authors (or their author's institution or funder) pay an open access publishing fee).

# II. EDITING PRINCIPLES

The sections of a paper should generally be edited in the following order:

1) Title Page (including paper title, byline, membership, first footnote including Digital Object Identifier (DOI) information, running head, and copyright line)
2) Abstract, must be one paragraph, and no more than 250 words. A minimum of 150 words are suggested, but not mandatory.
3) Index Terms
4) Nomenclature (optional)
5) Introduction
6) Body of Paper
7) Conclusion
8) Appendix(es)
9) Acknowledgment
10) References
11) Figure and Table Captions
12) Biographies

## A. Editing the Parts of a Paper

### Paper Title

In the paper title, capitalize the first letter of the first and last word and all nouns, pronouns, adjectives, verbs, adverbs, and subordinating conjunctions (*If, Because, That, Which*). Capitalize abbreviations that are otherwise lower case (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 lower case unless they are the first or last word. Prepositions of more than three letters (*Before, Through, With, Versus, Among, Under, Between, Without.*) should be capitalized. Example:

- Nonlinear Gain Coefficients in Semiconductor Lasers: Effects of Carrier Heating
- Self-Pulsation in an InGaN Laser $\frac{1}{m}$ Part I: Theory and Experiment

### Byline and Membership Citation

Check authors' names against biographies and editorial correspondence (compare to *IEEE Membership Directory* listing if necessary). Use the longest and most complete name given in either the biography or byline. Use the same information in both places. Always defer to the author's wishes if changes are made in the proof stage. Nicknames are not allowed in the byline, but may be included in the biography. 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*

Check the manuscript byline and biographies to see if IEEE membership information has been provided by the author. If so, verify the information in the *IEEE Membership Directory* and enter it into the byline and into the biography.

### IEEE Membership Grades

Student Member, Graduate Student Member, Associate Member, Member, Senior Member, Fellow, Life Associate Member, Life Member, Life Senior Member, and Life Fellow. The highest grades other than Affiliate Members are listed in the byline. All grades are listed in the biography. Life Members carry the highest previous grade in their byline.

**NOTE:** Affiliate Members are not considered members for the purposes of the byline and biography. An affiliate of an IEEE Society is not an IEEE member, but rather an individual who has been admitted by a

Society with the special rights and privileges of that particular organization within the IEEE. In general, an affiliate must have attained stature in a related scientific and technical field, comparable to that for IEEE membership.

**Invited Paper**

If the EIC notes that a paper is an Invited Paper either directly on the hard copy, on the table of contents, or elsewhere, use an Invited Paper line between the byline and the text of the paper. Insert a 12-pt. space between the byline and the words "(Invited Paper)." Also be sure to include the Invited Paper line directly after the title on the table of contents. Example in a byline:

# Shadow Codes and Weight Enumerators

Steven T. Dougherty, *Fellow, IEEE*

*(Invited Paper)*

Example in a table of contents:

**Running Heads**

Transactions contain two types of running heads: issue and author. Running heads appear in 7-pt. capitals.

*Issue Running Heads* appear on all left-hand (verso) pages of full length papers, on all first pages of full length papers, and on both left and right pages of all other types of papers. Issue running heads consist of the full name of the Transactions, volume number, issue number, month, and year. Note that the volume number of a Transactions increases by one at the start of every calendar year. The format used is as follows:

IEEE TRANSACTIONS ON IMAGE PROCESSING,  VOL. 19,  NO. 3, MARCH 2010

*Author Running Heads* appear on all right-hand (recto) pages of full length papers (except the first page of papers). The author running heads are written by Staff Editors and should appear on the author's proof. Guidelines for writing author running heads are as follows.

- Use only the most important words; it should be the gist of the title.
- For a very long title, try to find the critical phrase or phrases.
- Frequently, it is possible to eliminate adjectives completely.
- If units of measure, chemical compounds, mathematical terms, etc., must be included in the running head, stet the use of lower case as determined by IEEE style.
- Use 7-pt. caps for all author names, e.g., SMITH, DIBENEDETTO, MCLEAN
- Do not include Jr., Sr., III, etc., in running heads.
- Do not exceed one line.

The format used for author running heads is as follows:
*For one author:*

SPINA: MODELING OF HIGHLY EFFICIENT GRATING FEEDBACK

*For two authors:*

BONIFAS AND RICCARDELLA: DYNAMICS OF AlGaAs SEMICONDUCTOR LASERS

MACGREGOR AND GROVER: ROUTING OF TRANSPORT NETWORK DEMANDS $\dfrac{1}{m}$ I

*For three or more authors:*

ANDERSEN *et al.*: DYNAMICAL MODEL OF DC WAVEGUIDE LASERS

**Note: A lower case acronym, e.g., "DC," is capped in the running head and title, even though it is lower case in text.**

*Note: Parts, e.g., part I,  is written only as "I" in the running head, preceded by an emdash. The subtitle is not included.*

### Copyright Lines

Authors must sign and return the IEEE Copyright Form before their paper is published. The section of the form signed determines the type of copyright line used.

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

The *IEEE copyright line* is by far the most commonly used line. The IEEE copyright line Copyright Clearance Center Code (or CCC code) is used at all times whenever the "A" section of the IEEE copyright form has been signed by the author. The author's signature on the "A" section of the IEEE copyright form and use of the IEEE copyright line indicate IEEE ownership of the paper's copyright.

The following is a sample IEEE copyright line from the IEEE JOURNAL OF QUANTUM ELECTRONICS:

The first two sets of four numbers (separated by an hyphen) in the line are the ISSN code for the Transactions (also found on the front cover of the printed book). (Note: the price information was omitted in 2013. This appeared before the copyright symbol representing the amount the IEEE charges per copy when permission is granted to use IEEE copyrighted material.) Last on the line is a circled copyright symbol followed by the full year of publication and the identifier "IEEE."

Other types of lines may be used when certain conditions are met.

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

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

*Rapid posted/pre-printed papers*: If you are posting papers in 2013 for a print issue in 2014, please note the year in the copyright line MUST be the year of online publication. Also, note the copyright line (year) information will NOT change when the article is printed in 2014.

Note this applies to all models of publication, rapid post, preprint, and continuous (e.g., JSEN, JQE, LPT).
That is, rapid-posted , preprinted, or continuously paginated articles that posted to IEEEXplore in 2013,
but will be printed in 2014, should carry a copyright year of 2013.

## Open Access

http://www.ieee.org/publications_standards/publications/authors/open_access.html
Do authors need to sign an IEEE copyright transfer form for an OA article?
Not in every case. The standard document for an author to authorize publication of an article supported by an article processing charge (APC) is the IEEE Open Access Copyright Form (OACF). This form transfers copyright to IEEE, while assuring that IEEE will make the article freely available to all visitors to IEEE *Xplore*. The OACF gives IEEE full authority to resolve any complaints of abuse (such as plagiarism) of the authors' content.

IEEE will make exceptions for authors who have special requirements from their funding agencies to publish their OA articles with a Creative Commons Attribution (CC BY) license. Two such funding agencies are the Wellcome Trust and the Research Councils of the United Kingdom (RCUK), both of which require authors to use the CC BY license. IEEE will accept use of the CC BY license in these cases. Authors with a funding requirement to use the CC BY license should not sign the OACF, but instead should request a CC BY license.

*Open Access copyright lines*

**OAPA:**

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*Crown Copyright lines* are used when the "C" section of the copyright form is signed and all the authors of a paper are employees of the British or Canadian 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" as follows:

<center>

0018-9197 © 2013 British Crown Copyright
0018-9197 © 2013 Canadian Crown Copyright

</center>

### First Footnote

The first footnote (or the author affiliation paragraph) is made up of three paragraphs. This footnote is not numbered. All other footnotes in the paper are numbered consecutively. Do not use asterisks or daggers.
An example follows:

> Manuscript received April 27, 2012; revised September 18, 2012; accepted July 25, 2013. Date of publication August 15, 2013; date of current version September 09, 2013. This work was supported by a grant of the Romanian National Authority for Scientific Research, CNCS UEFISCDI, under Project PN-II-ID-PCE-2011-3-0566.
> 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.
> Digital Object Identifier 10.1109/JDT.2013.2278036

The first paragraph of the first footnote contains the *received* and (possibly) *revised* dates, followed by the *accepted* dates of the paper. When a paper has more than one revised date, list all the dates given. Effective June 2008, it also contains the *two additional online published dates.* The first date identifies the date of publication, i.e., when the "single article" is posted on Xplore (either preprint or rapid post – ePub date); the second date identifies when the "final, paginated" version (date of current version – predicted online date) is posted on Xplore.

OnlyChina-affiliated authors may request the name of the corresponding author to be listed. This is added in italics at the very end of the first paragraph. An example of this is included here.

*Examples (**Traditional - articles not preprinted or rapid posted**):*

Manuscript received April 27, 2012; revised September 18, 2012; accepted July 25, 2013. Date of current version September 09, 2013.

*Examples (**print collections (continuous)----articles published online (continuously) with pagination, e.g., LPT, JQE:***

Manuscript received April 27, 2012; revised September 18, 2012; accepted July 25, 2013. Date of publication August 15, 2013; date of current version September 09, 2013. *(Corresponding author: J. Ming.)*

*Note:* There is only one final date. The "published" date here is acquired from IDAMS data.

*Examples (**preprinted or rapid posted articles**):*

Manuscript received November 19, 2007; revised March 12, 2008; accepted March 15, 2008. Date of publication June 25, 2008; date of current version September 10, 2008.

Manuscript received December 14, 2006; revised  November 8,  2007 and February 8, 2008; accepted February 20, 2008.  Date of publication June 8, 2008; date of current version January 29, 2009.

Manuscript received September 12, 2006; revised June 11, 2007, September 14, 2007, and January 25, 2008.  Date of publication  June 8, 2008; date of current version January 29, 2009.

Manuscript received February 22, 2009; accepted March 3, 2009.  Date of publication  June 8, 2009; date of current version August 29, 2009.

Manuscript received January 15, 2008; revised April 10, 2008; accepted April 29, 2008. Date of publication July 8, 2008; date of current version January 18, 2009.

Manuscript received January 15, 2008; revised April 10, 2008; accepted April 29, 2008.  Manuscript received in final form on May 20, 2008. Date of publication September 8, 2008; date of current version January 18, 2009.

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

Manuscript received February 5, 2007; revised March 29, 2007; accepted March 29, 2007.  Date of publication June 8, 2007; date of current version January 18, 2008. Paper recommended by Associate Editor Thomas Lynch.

Manuscript received February 5, 2007; revised March 29, 2007. Date of publication June 8, 2007; date of current version January 18, 2008. This paper was recommended by Associate Editor T. Lynch.

Manuscript received July 4, 2007; revised September 4, 2007. Date of publication June 8, 2007; date of current version July 18, 2008. This work was supported by the UEFISCSU under Grant PN-II 65/01.10.2007 and Grant PN-II 331/01.10.2007. The associate editor coordinating the review of this manuscript and approving it for publication was Prof. Vesa Valimaki. *(Corresponding author: J. Ming.)*

All *financial support* for the work in the paper is listed next in the first paragraph and not in the Acknowledgment at the end of the paper. Examples of financial support acknowledgment 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.

Information of full or partial *prior presentation* of 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 a paper 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:

Manuscript received January 15, 2008; revised  April 10, 2008; accepted April  29, 2008.  Manuscript received in final form on May 20, 2008. Date of publication September 8, 2008; date of current version January 18, 2009. This work was supported in part by the National Science Foundation under Grant GK-716, by the Joint Services Electronics Program under Contract AF-AFOSR-128-94/95, and by the Adolph C. and Mary Sprague Miller Institute for Basic Research in Science. This paper was presented in part at the Fourth *(or 4th)* Annual Allerton Conference on Circuit and System Theory, University of Illinois, Urbana, IL, October 1995.

The second paragraph of the first footnote is made up of the authors' affiliations, and the corresponding author's email address. There are instances when several authors may want their email addresses included. E-mail addresses are separated by semicolons. Examples are shown below.
.
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).

K. 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).

*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. Email addresses are separated by semicolons. Examples:

L. P. Li is with the Department of Electrical Engineering and the Electronics Research Laboratory, University of California at Berkeley, Berkeley, CA 94720 USA.
T. Ikeda and H. 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).

If an author had one affiliation at the time the paper 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 current position, list the information as follows:

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

Additional Examples:
*Retired author:*

L. 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:*

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

*Consultant:*

P. 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. 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.)
- At the request of some societies, most Transactions include e-mail addresses in the affiliation. The standard usage of e-mail addresses is to list the address at the end of the affiliation line for that particular author.

*E-mail listing for one author:*

R. A. Morgan is with the Department of Information Technology, Honeywell Corporation, Bloomington, MN 55420 USA (e-mail: r.morgan@empire.honeywell.com

*E-mail listing for more than one author:*

H. Saidi and P. S. Min are with the Department of Electrical Engineering, Washington University, St. Louis, MO 63130 USA (e-mail: saidi@rgit.wustl.edu; psm@ee.wustl.edu).

- 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 (e.g., IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING to indicate the corresponding author), asterisks or daggers are not acceptable means of referencing a footnote in IEEE Transactions.
- 

The third or final paragraph of the first footnote contains the Digital Object Identifier (DOI). (The DOI system m was conceived by the Association of American Publishers (AAP) in partnership with the Corporation for National Research Initiatives and is now administered by the International DOI Foundation. Essentially, the DOI system is a scheme for Web page redirection by a central manager.) In January 2004, the IEEE adopted the use of the Digital Object Identifier system to provide unique identification of documents and facilitate on-line publication. The purpose of the DOI is to describe the structure and assignment of an identification code for publication items (articles) within publication types (journals and books).

The DOI consists of the following:

- 10.1109 identifies IEEE Publication;
- the calendar year of the date of assignment;
- a number unique to the publication item within the publication type.

An example of the DOI as it appears in the first footnote is as follows:

Digital Object Identifier 10.1109/JQE.2004.834561

The DOI is the last line of the author affiliation paragraph.

**NOTE:** It is very important that this number appear correctly in print. It will be a permanent means of identifying the document. If the printed DOI number does not match the database assigned DOI number, errors will result when linking the electronic version of the document.

## C. Editing the Body of the Paper

### Abstract

Every published paper must contain an Abstract; request one immediately from the EIC and/or author if it is not provided with the manuscript. Abstracts appear in text in 8-point boldface type per Transactions specs. All variables should appear lightface italic; numbers and units will remain bold. Abstracts should be a single paragraph. By nature, Abstracts shall not contain numbered mathematical equations nor numbered references. Numbered reference citations are not allowed. If a citation is made, reword the sentence to exclude citation numbers.

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.

The abstract must be a concise yet comprehensive reflection of what is in your article. In particular:

- The abstract must be self-contained, without abbreviations, footnotes, or references. It should be a microcosm of the full article.
- The abstract must be between 150-250 words. Be sure that you adhere to these limits; otherwise, you will need to edit your abstract accordingly.
- The abstract must be written as one paragraph, and should not contain displayed mathematical equations or tabular material.
- The abstract should include three or four different keywords or phrases, as this will help readers to find it. It is important to avoid over-repetition of such phrases as this can result in a page being rejected by search engines.
- Ensure that your abstract reads well and is grammatically correct.

### Index Terms

All papers must contain Index Terms. These are keywords provided by the authors. Request them if they are not provided. Index Terms appear in bold type in the same style as the Abstract, in alphabetical order, and as a final paragraph of the Abstract section. Separate Abstract and Index Terms by a 6-pt. space. Capitalize the first word of

the Index Terms list; lower case 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. The text appears in boldface and in 8-point type. 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.**

*Note Added in Proof:* This added information is usually inserted at the end of the Conclusion section of the paper or in whatever section contains the last paragraph of the main body of the paper. (See  p. 18.)

### 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.

<div align="center">NOMENCLATURE</div>

| | |
|---|---|
| *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 the 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 is not required. Follow the author's preference. However, the choice must be consistent throughout the paper. That is, if an author enumerates some but not all section headings, the remaining headings in the paper should be labeled so that all headings and all levels of section headings in the paper are enumerated.

Author enumeration notation that is not in IEEE style should be changed to IEEE style. For example, if an author labels primary headings with capital letters, they should be changed to Roman numerals to match IEEE style. The remaining style rules for each level of section heading as listed below should also be followed.

*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:

<div align="center">I. I<small>NTRODUCTION</small></div>

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

<div align="center">R<small>EFERENCES</small></div>

<div align="center">A<small>CKNOWLEDGMENT</small> (note spelling here)</div>

*Appendix headings* are a special case. The primary heading(s) in the Appendix or Appendixes (note spelling of plural) are set according to the usual style, except that there is flexibility in the enumeration of the heading. The author may use Roman numerals as heading numbers (Appendix I) or letters (Appendix A). Either is 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 paper, leave the Appendix unnumbered and unnamed as is. (Appendix subheads should also not be enumerated in this case.) Examples:

<div align="center">A<small>PPENDIX</small></div>

<div align="center">A<small>PPENDIX</small> I<br>P<small>ROOF OF</small> T<small>HEOREM</small></div>

<div align="center">A<small>PPENDIX</small> A<br>P<small>ROOF OF</small> T<small>HEOREM</small></div>

*Headings for Theorems, Proofs, and Postulates:* Some papers 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.

**Introduction**

*Initial Cap or Drop Cap:* In full length papers 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 next 8–12 characters (1–2 words) are capitalized. (Do not break up hyphenated words into cap and lower case 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 paper begins with a quotation mark), try rewriting the sentence and query the author. See Section II-A of this guide for type specs of the initial cap.

### Text Equations

*Consecutive Numbering:* Equations within a paper are numbered consecutively from the beginning of the paper to the end. There are some Transactions in which an author's own numbering system such as 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 if an author starts equation numbering over with (A1), (A2), etc., for Appendix equations, it is permissible to leave the copy as is.

*Hyphens and Periods:* Hyphens and periods are accepted, if consistent in paper, e.g., (1a), (1.1), (1-1). This should be done consistently throughout the paper.

### 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 paper. Never start a separate numbering system or group of numbers for the figures or tables in the Appendix section.

### Acknowledgment

The placement of the Acknowledgment appears after the final text of the paper, 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, use first initials only, not full names. 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 must be removed from the Acknowledgment section and 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.

Rewrite the Acknowledgment section to be read in the third person. Rewrite it even if the paper is given in the first person.

### References

A few guidelines related to the editing of references are summarized here. See Section V of this manual for a more complete discussion of reference style.

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 preferred, and is discouraged. If the author-supplied reference list is unnumbered, the Staff Editor must provide numbers, or if the list contains multiple references, these should be separated and renumbered by the Staff Editor. If numbering or renumbering is necessary, then in-text references to the reference list must be checked and renumbered by the Staff Editor.

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 edited 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 paper's subject.

Sometimes an author will 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 an author lists 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 text, check its spelling against the reference list.

### Text Citation of Figures and Tables

All first citations of figures and tables in the paper must be in numerical order. If a figure is not mentioned or if the first text mentions are not in order, call or query the author and/or renumber the figures where necessary. 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.

*Figures:* If labeled, parts of figures (callouts) should be 8-pt. lower case Roman letters within parentheses. Whenever possible, all caption parts shown on the figure must be removed and keyed along with the caption.

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. 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 paper, 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.

Do not use:

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

If a figure after reduction will run more than one 21-pica column in width, the caption should be flush left on 43 picas.

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. Example:

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 (set in 8-pt. caps) and the enumeration given in Roman numerals. The descriptive text of the caption should be centered directly below the table number caption and is set in 8-pt. and 6-pt. caps. The captions are usually centered on 21 picas, unless the table will be wider than one column width, in which case the table caption should be centered on 43 picas.

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.

As in figures, labeled parts of tables should be 8-pt. lower case Roman letters within parentheses. 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

A single rule should be added above and below the table body. Use the **hrule** macro to create rules. The type specs for the text of a table is 8-pt. TR for full length papers, brief papers, and short papers.

The same rules as in figures apply for listing table part labels (callouts).

Table footnotes should be 8-pt. type and should be placed below the bottom rule of the table.

**Obtaining permission to reuse copyrighted material**

1) Reusing IEEE graphics previously published in IEEE publications. Author should email IEEE Intellectual property department at: *copyrights@ieee.org*. In mose cases, the only requirements will be to give full credit to the original source and to obtain the author's approval (as a courtesy to the author). At the end of the caption, add the reference number of the papers from which the graphics are being used.

2) *Reusing graphics previously published in non-IEEE publications.* Author must have obtained permission to republish from copyright holder (in most cases, this is the publishing house (not the author of the paper). The wording is provided by the author (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 provided by the author, the biography may be only one or two paragraphs.

The biography begins with the author's full name and IEEE membership history as listed in the *IEEE Membership Directory*. 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. The format for listing the IEEE membership history is to list each grade of membership attained followed by an apostrophe and the year it was attained, with each year and grade combination separated from the others by an en dash. Note that if an author attains the same membership grade in more than one year, list only the first year that it was reached. Check the current membership listed with the biography against the byline.

Abbreviations for IEEE membership grades are: S (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.

Delete all references to IEEE membership from the text of the biography.

*First Paragraph:* If provided by the author, 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 if it is not included. Include the years degrees were received. If the author was educated overseas, the names of the degrees earned may not be familiar. 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 locations of universities and colleges the first time they are mentioned if not included (*refer to the University website for location*). For U.S. state-named universities, repeat the state name in the location, and included the country (e.g., University of Colorado, Boulder, CO, USA); but 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 lower case for the author's major field of study.

*Second Paragraph:* The second paragraph of the biography should list military and work experience, including summer and fellowship jobs and consultant positions. Job titles are capitalized. The current job must have a location; 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 many 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. The author often notes current and sometimes previous research interests. If space is available, these may be retained; otherwise, edit out the prior interests and leave in the current. Any homepage of the author may be listed in the biography only.

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 given. Finally, list awards and work for IEEE committees and publications, affiliation with other professional societies, and symposia.

Personal notes such as hobbies should be deleted from the biography. Examples:

**Michael C. Author, Jr.** (S'87–A'89–SM'90–F'93) was born in New York, NY, USA, on March 2, 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, 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 the Raytheon Corporation, Bedford, MA, USA. From 1995 to 1996, he was with the General Electric Space Laboratory, Valley Forge, PA, USA. During 1996–1997, 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, on October 19, 1949. He received the B.S. degree from Rutgers University, New Brunswick, NJ, 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 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.

**NOTE:** If no photograph is available or the journal does not require them, the biography is set 8/9×21 picas.

### Squibs

If no biography or photograph is available, a squib is used. The phrase is run at 8/9 ×21 picas, flush left. Example:

**James A. Author,** (S'87–A'89–SM'90–F'93)  photograph and biography not available at the time of publication.

### D. Other Text to Edit

#### Footnotes

Footnotes should be numbered in consecutive order throughout the text. In full length, brief, and short papers, they are 8/9 TR ×21. 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, and parentheses, 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). All are Roman; note single 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 less than three items, run in as shown in the example for run-in lists. If, however, the items are mentioned later in text, introduce the item with a colon, number the items, begin

the entry with a lower case 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) the implementation of capacitor power factor correction on the power line;
2) the presence of nonlinear load;
3) the 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.

Full sentence items may be introduced by "that" or other words taking object and are rewritten to end with a period. If the items are introduced by a sentence ending with a colon, change the colon to 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 lower case.
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. Follow author preference for run-in or displayed lists. 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.


### Note Added in Proof

An author may wish to add a brief note in the proof stage, citing results obtained after acceptance of the paper or mentioning additional references that have come to the author's attention since acceptance. This added information is usually inserted at the end of the Conclusion section of the paper or in whatever section contains the last paragraph of the main body of the paper. As long as the note is not a major change to the paper 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:*


## E. 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 non-technical introductory material. A discussion of the papers in an editorial should follow the order of the table of contents. The editorial may contain illustrations, citations, and references. Follow general rules for editing. An acknowledgment does not contain a heading. If a heading is required, set as a separate section and follow the primary heading specs without enumeration. *Note:* In the Editorial, the Acknowledgment does not need to be in third person.

Procedures and style for Editorials include the following.

*General Specs:* Type specs are the same as for full length papers. The initial cap remains the same. The title of the Editorial is set in 24 pt. as in a full length paper title. There is no Abstract. There is a rule above the DOI.

**NOTE:** Editorials generally do not carry a section heading above the title. Center the word "Editorial" in 24-pt. type above the title.

*Byline:* Note that the byline for the Editorial does NOT appear below the title as it does in a full length paper. 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, 6 pts. below the end of text, in 10-pt. and 8-pt. caps. Stack and align the name or names with an identifier such as "Guest Editor" which should appear in italics next to the name. The affiliation should appear as a "list" under each name. The right edge of the longest of these aligned lines should then be flush right at the end of the last column of text. Example:

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

*Biographies and Photos:* Biographies and photographs that appear with Editorials are set differently from regular biographies and photos in the Transactions. They are, for example, not 8/9 type, but are the same type size as the text of the Editorial (normally 10/12). In addition, Editorial biographies are: first 13 lines ×32, rest at 43 picas. The photos are reduced to 9 1/2 ×12 picas.

*Copyright Line:* Run a copyright line for the Editorial, even if no copyright form is submitted by the Editor.

### Brief Papers

**Brief papers are set up like full length papers, except that the paper title is set in 16-pt. TR, centered on 43 picas. These papers do contain Abstracts and also take the initial cap. The byline includes the membership grade. See Section I-B. They do not contain biographies and photographs of the authors. Footnotes, references, and figure/table captions are 8/9 TR. The papers carry issue running heads on both left and right pages.**

### Short Papers, Correspondence, and Communications

Short papers are set up like full-length papers, except that usually they are 9/11 type and their titles and bylines are smaller type and run across only one column. Usually, short paper titles are 10/12 bold with bylines 9-pt. upper and lower case. These papers do contain Abstracts, but do not take the initial cap. The membership grade is not included in the byline. Author biographies and photos are not included. Footnotes, captions, references are 8/9 type.

### Comments and Replies

Comments are generally in response to a previously published paper. 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 even if no new forms are required from the author(s). 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, 1995.
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 paper 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, 2009; accepted October 5, 2009. Date of publication November 2, 2009; date of current version November 25, 2009.
The authors are with RDH Consultants, Inc., Charlotte, NC 28241 USA.
Digital Object Identifier 10.1109/JQE.2006.12348

### Corrections/Errata

The format for a Corrections is basically the same as for the Comments, except that a Corrections does not carry a Reply. Run a copyright line with a Corrections even if no new forms are received from the author(s). Corrections that has been generated in-house may be labeled "Erratum," and should also follow the standard format, although the byline may be omitted because the IEEE Transactions/Journals Department assumes authorship of the Corrections. *Note:* The plural form of the word is used in the title, even if there may be only one correction. 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:* Erratum

*Byline:* There is no byline for an erratum, as this is created if the department (staff/vendor) is responsible for the error.

*Footnote:*
Manuscript received January 20, 2004.
Digital Object Identifier 10.1109/TVLSI.2004.830244

### Book Reviews

Some publications carry Book Reviews. The type specs of the text are the same as for 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. Obituaries normally are formatted as one column, at 36 picas width. They may carry a photo of the person being memorialized, usually the same size as in Editorials (9-1/2 ×12 picas). The name appears above the

photograph in 12-pts., boldface. The photograph is generally centered above the text. The years of birth and death are generally cited at the bottom of the photo in 12-pts., boldface type in parentheses. The obituary is normally set as one column, across a 36-pica width.

## F.  Editing Style for Transactions

The following provides a summary of the most important style distinctions to be made in the final copy editing of a Transactions paper.

### Acronyms

Define acronyms the first time they appear in the Abstract as well as the first time they appear in the body of the paper, written out first as part of the sentence, followed by the acronym in parentheses. Widely used or familiar terms should be defined (see Section VIII-F of this manual 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

Obviously, in reading and editing a paper, misspellings and typographical errors are top priority for correction. Note that IEEE Transactions use the first spellings indicated in our first reference, the most current edition of *Webster's New Collegiate 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 Section VIII-E.

### Trademarks

The trademark symbol, ™ and ® are no longer used. Capitalize the first letter in the trademark name only. Follow the author's notation. The symbols ™ and ®, which often accompany registered trademark names on product packaging and in advertisements, need not be used in running text.

### 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 given at the end of this section; 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 *Webster's Tenth New Collegiate Dictionary*. Do not hyphenate most compound modifiers if they occur after the noun being modified, even if hyphenating them before the noun. Do not hyphenate most compound modifiers if they occur after the noun that is being modified, even though you may hyphenate them before the noun. *Example:*

**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-feet-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.

Follow the author's preference if the result is consistent and clear. 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 paper.

### 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 are: 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 (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 samples below and a more detailed discussion in the Grammar and Usage in Transactions section of this guide.

*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 …
*Quantity:*
   Three volts was applied …
   Four grams was 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 (Boyle's law, 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 lower case. In text, the names of IEEE publications are 10-pt. and 8-pt. caps: TRANSACTIONS, IEEE SPECTRUM, PROCEEDINGS OF THE IEEE.

### Math

Some brief guidelines for editing math are explained here. For further discussion, see Section IV of this guide.

1) Variables are set italic; vectors are usually boldface italic (if distinguished by the author).
2) Remove commas around variables in text.
3) If not included by the author, always add a zero before decimals, but do not add after (e.g., 0.25).
4) Stet the use of the author's parentheses and brackets (i.e., [0,1) may be correct).
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 Section VIII-G.
6) Numbers 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.
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 change $\mu$ to $\mu$m, "micron" to "micrometer," "submicron" to submicrometer." Always change cycle per second to hertz (Hz); cycle per second may not appear as cycle, cps, c/s, csec. See "Table of Units and Quantity Symbols" in Section VIII-G.

9) In text, break down (shill) multiline (built-up) fractions 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 $\left[(c-d/(k+4)\right]$.

10) In exponential expressions [e.g., $e^{-(jwt)xyzk}$ ], there are sometimes long and complicated superscripts. These may be brought down on line with the substitution of "exp" for "e" and the addition of square brackets (e.g., exp[–(jwt)xyzk]).

11) Distinguish between lower case 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 an author 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 (almost all expressions will use three 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 $y = 0, 1, 2 \ldots$

$x_1 x_2 \cdots a_n$ not $x_1 x_2 \cdots a_n$

*Conditions:* In displayed equations, there should be a comma or parentheses and a two-em space 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 multidot (e.g., 4  V · s), but leave the slash if the author uses it since this has a different meaning (for instance, 6 V/s means volts per second). It is also possible to use a negative power to put a unit in the denominator: $cm/s^2 = cm \cdot s^{-2}$. Parentheses may be used to clarify a unit: $g/(cm \cdot s)$ or $g \cdot cm^{-1} \cdot s^{-1}$.

*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

Check that equation numbering is consecutive, that it appears flush right on line with the last line of an equation, that there are no repeats or missing numbers, and that a correct numbering style has been used.

### Displayed Equations

Material in displayed equations is automatically italic unless otherwise indicated by the author. 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.

### Typical Problems

Which does the author mean: zero or "oh"? one or "ell"? subscript variable or on line? A general guideline to help resolve these questions before querying the author is to read carefully through the paper—does the author mention "O" for output or use a series of numbers like 0, 1, 2,?—and look through the illustrations—does $V_s$ appear in the figures or is it $Vs$? This may provide clues.

### G. General Layout Rules

1) Normal page depth for a Transactions is 60 picas (called even).
2) Pages may run one line long (61 picas) or short (59 picas), but facing pages (left and right) must be the same depth.
3) Transactions papers are set in a two-column format. Each column is 21 picas wide, with a 1-pica space between the two columns, giving a total page width of 43 picas.
4) Specifics of type area spacing are approximately 18 pts. between text and footnotes or figures and text, 6 pts. above and below equations and lists, 12 pts. above primary heads, at least 6 pts. above secondary heads, and 3 picas between biographies.
5) Figures and tables are placed at the tops of columns as close to their first mention as possible, but preferably after the mention.
6) Figures and tables progress vertically, not horizontally, on pages.
7) Footnotes must appear at the bottom of the column where they are first mentioned.
8) There must be at least two or three lines of text under a head at the bottom of a column.
9) Never leave widows at the tops of columns when breaking text. (A "widow" is any single last line of a paragraph, even if it is of full column width.) The exceptions are when widows are used to introduce equations or when they are in the Reference section.
10) Avoid breaking multiline equations so that one line appears at the bottom of a column and the others at the top of the next column.
11) The starting page number is determined by checking the previous issue—it is the next page number after the last page of the preceding issue, including any fillers. Issues beginning a new calendar year always start with page 1.
12) Obituaries/In Memoriam(s) are articles formatted on 36-pica width.

# III. GRAMMAR AND USAGE IN TRANSACTIONS

## A. Rules of Grammar

The principles of style given below aim to concentrate 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*).
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** (
4) **Use the semicolon, not the comma, to separate two complete sentences which form a compound sentence.**
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.*
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) **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).

## B. 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 differences between same objects.

Compose: a set composed of members.
Comprise: 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: a large number of people.
Amount: 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. EDITING MATHEMATICS

## A. The Language of Math

When editing technical publications it is important to remember that the mathematics often carries as much if not more meaning than the body of text itself. Therefore, it is critical that the grammar of an equation be taken into account when editing.

Most equations should read like a sentence. They should contain a noun and a verb and often contain adjectives, prepositional phrases, conjunctions, and conditions. Equations also contain punctuation. When math occurs along with text it shares the grammatical characteristics of the text. A displayed expression may be a main or subordinate clause, an expression in apposition, a direct object, an item in a list, or the object of a preposition. **Use comma at end of introductory sentences after: i.e., e.g., "Hence" or "That is." Use a colon after words such as "following" or "as follows."** There should be no punctuation after forms of the verb to be, or between a verb and its object or a preposition and its object. IEEE style dictates that the only punctuation used at the end of an equation is a period. There is, however, other punctuation permitted in the equation itself and between an equation and its condition. This interior punctuation contains mathematical meaning and must not be changed.

Some examples of interior punctuation are as follows.

*Mathematical Ellipses:*

$$I = 1, 2, 3, \ldots, n$$

**NOTE:** *Only three dots* are used and they are enclosed by commas and are on the baseline.

*Matrix:*

$$C_{\text{Eopt}} = \begin{bmatrix} -4.65\,E^{+0} & -1.07\,E^{-1} & -1.42\,E^{-1} & -9.50\,E^{-4} & 2.52\,E^{+1} & 3.36\,E^{+0} \\ 1.97\,E^{+0} & 1.44\,E^{-1} & 8.80\,E^{+0} & 5.88\,E^{-2} & 2.14\,E^{+1} & 1.46\,E^{+0} \\ -1.62\,E^{+0} & -1.10\,E^{-1} & 1.01\,E^{+1} & 6.27\,E^{-2} & -1.92\,E^{+1} & -1.37\,E^{+0} \end{bmatrix} \quad (1)$$

**NOTE:** There is a centered operator, equation number, and period.

*Parenthetic Statement:*

$$v(t) = u\,(t), \qquad t = 1, 2, \ldots, m.$$

**NOTE:** There is a 2em space after the comma and before the condition $t = 1, 2, \ldots, m$. Multiple conditions should be separated with a semicolon, with a comma at the end of the equation, a 2em space, and the condition aligned on the operator.

## B. In-Line Equations and Expressions

An inline equation is an equation within text or part of a paragraph. It is not displayed.

*Rule 1:* Equations appearing in text should be broken after a verb or an operator, meaning, if at all possible, the verb or operator should remain on the top line of text.

*Rule 2:* Fractions should not appear stacked in line. $\dfrac{(xy + 6\alpha)}{xy}$ should be written as $(xy + 6\alpha)/(xy)$.

*Rule 3:* Collective signs should not appear with limits to top and bottom, but to the side instead.

$\sum\limits_{i=0}^{i=\infty}$ should be written as $\sum_{i=0}^{i=\infty}$ .

*Rule 4:* Use Roman function exp instead of $e$ followed by a lengthy superscript. $e^{(zx^2 + y)\,(\alpha - 2yx) + zx}$ should be written as $\exp[(zx^2 + y)\,(\alpha - 2yx) + zx]$.

*Rule 5 (optional):* Avoid square roots (radical signs) having long bars. $\sqrt{(x + \alpha)}$ should be rewritten as $(x + \alpha)^{\frac{1}{2}}$.

## C. Break/Alignment Rules

*Rule 1:* Break equations at verbs and align on same when possible for a displayed equation.

$$A = (5\alpha + x) + (10y + \beta)^2$$
$$\geq (5x - \alpha + y + x^2)$$
$$\equiv B^2$$

*Rule 2:* In equations with one verb, break at operators and align to the right of verb.

$$A = (5\alpha + x)$$
$$+ (10y + \beta)^2$$
$$- (5x - \alpha + y + x^2)$$

*Rule 3:* Separate all equations with 1) an em quad if they fit on one line or 2) stack and align on verb.

$$x = (-b + 4ac) \quad y = (a - 2bc)$$
$$z = (-c + 3ab)$$

*Rule 4:* An equation that will fit conveniently on two lines without further breaks should be broken at the verb and aligned flush left/flush right over the column width.

$$2xy$$
$$= \frac{(-c + 3ab) + (a - bc)^2 - (b - 2c)}{(4ac + 3bc) - (2c + 3ab)}$$

*Rule 5:* When breaking an equation within fences, break at an operator and align inside the left-hand fence.

$$x = \left[\left(\frac{-c + 3ab}{-bc}\right) - (b - 2\alpha)\right.$$
$$\left. + \left(\frac{4ac + 3bc}{ac}\right) - (2c + 3ab)\right]$$

**NOTE:** Pairs of fences should match in size and be proportional to the math within.

*Rule 6:* A  period is placed at the end of a fraction, case equation, or closed delimiters, shown as

$$2xy = \frac{(-c + 3ab) + (a - bc)^2 - (b - 2c)}{(4ac + 3bc) - (2c + 3ab)}.$$

$$x = \left[\left(\frac{-c + 3ab}{-bc}\right) - (b - 2\alpha)\right.$$
$$\left. + \left(\frac{4ac + 3bc}{ac}\right) - (2c + 3ab)\right]$$

**NOTE:** Pairs of fences should match in size and be proportional to the math within.

## D. Exceptions and Oddities

*Right to Left Equations:* Equations in which the verb appears in the right half of the statement are broken before an operator and aligned to the left of the verb.

$$5\alpha + x + 10y$$
$$+ \beta^2 + z = x$$

*Solidus as Operator:* Break after a solidus and align the next line to the right of the verb.

$$A = [(2z - 5\alpha + x) (xy + 6\alpha)] /$$
$$[(xy + 6\alpha)]$$

*Implied Product:* When a set of fences is followed directly by another set of fences, the equation may be broken between them, provided a multiplication sign ($\times$, $\cdot$) is inserted. Alignment is to the right of the verb as for other operators.

$$x = (-b + 4ac) (a - 2bc)$$
$$\times (-c + 3ab)$$

*Integrals and Differentials:* If an equation containing an integral must be broken before the differential expression (see Section VIII-G: Glossary), break at an operator and align to the right of the integral. It is preferential not to break this type of equation until a differential occurs, then break after the differential expression.

Preferential

$$x = \int_1^0 \frac{1}{2} + \left(\frac{n-1}{n}\right) - dy\, A_0$$
$$+ (2x - 3zy)$$

If necessary

$$x = \int_1^0 \frac{1}{2}\left(\frac{n-1}{n}\right)$$
$$- dy\, A_0 + (2x - 3zy)$$

## E. Headings for Theorems, Proofs, and Postulates

Some papers 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.

## F. Text Equations

*Consecutive Numbering:* Equations within a paper are numbered consecutively from the beginning of the paper to the end. There are some Transactions in which an author's own numbering system such as 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 if an author starts equation numbering over with (A1), (A2), etc., for Appendix equations, it is permissible to leave the copy as is.

*Hyphens and Periods:* Hyphens and periods are usually removed from equation numbers, i.e., (1a) rather than (1-a) and (2a) rather than (2.a). This should be done consistently throughout the paper.

## G. Reminders

*Angle Brackets:* Angle brackets are not the same as greater than and less than signs.

*Vectors:* Vectors are usually made boldface italic (if distinguished by the author).

*Thin Spaces and Roman Functions and Differentials:* Thin spaces occur on either side of both functions and differentials.

Incorrect

$$\sin t_t = \log \mu r$$

Correct

$$\sin t_t = \log \mu r$$

Incorrect

$$x = \int_0^x dx A_0 + \partial z \beta$$

Correct

$$x = \int_0^x dx\, A_0 + \partial z\, \beta$$

However, a thin space is not necessary when functions and differentials are preceded or followed by verbs or an operator.

## H. Short Reference List of Italics, Roman, and Small Capitals

| Italics | Roman | Small Caps |
|---|---|---|
| RC | p-n | A.M., P.M. |
| RL | p-i-n | NOR |
| I-V | $p^+$-n-$p^{++}$ | OR |
| LC | and variations thereof | ORing |
| S/N | (don't forget the hyphen) | ORed |
| f/22 | SNR | AND |
| et al. | O ring | NAND |
| in situ | T junction | ADD |
| inter alia | Y-connected circuit | DIFFER |
| in toto | class-A amplifier | EXTRACT |
| in vivo | 2N5090 transistor | XOR |
| in vitro | ,e.g., | EXCLUSIVE OR |
| a priori | ,i.e., | DIMENSION |
| a posteriori | viz., | GO TO |
|  | Fortran IV | DO |
|  | Algol 60 | READ |
|  | Cobol | WRITE |
|  | Atlas Autocode | PRINT |
|  | PL/1 | CONTINUE |
|  | BAL | PAUSE |
|  | cf., | FORMAT |
|  | Tr | END |
|  | Ke | ON |
|  | Im | OFF |
|  |  | MOSFET |
|  |  | IGFET |
|  |  | IMPATT |
|  |  | TRAPATT |
|  |  | ONE |
|  |  | ZERO |
|  |  | BARITT |

## I. Functions and Operators Always Set in Roman Font

ad          (adjoint)
arg         (argument)
cos         (cosine)
cosh        (hyperbolic cosine)
cot         (cotangent; do not use ctg)
coth        (hyperbolic cotangent)
csc         (cosecant; do not use cosec)
csch        (hyperbolic cosecant)
curl        (curl)
det         (determinant)
diag        (diagonal)
dim         (dimension)
div         (divergence)
exp         (exponential)
hom         (homology)
Im          (Imaginary)
inf         (inferior)
ker         (kernel)
lim         (limit)

| | |
|---|---|
| liminf | (limit inferior) |
| limsup | (limit superior) |
| ln | (natural logarithm) |
| log | (logarithm) |
| lub | (least upper bound) |
| max | (maximum) |
| min | (minimum) |
| mod | (modulus) |
| Pr | (Probability) |
| Re | (real) |
| sec | (secant) |
| sin | (sin) |
| sinh | (hyberbolic sine) |
| tan | (tangent) |
| tanh | (hyperbolic tangent) |
| tr | (trace) |
| Tr | (transpose) |
| wr | (wreath) |

## K. The Greek Alphabet

| Name | Upper Case | Lower Case |
|---|---|---|
| Alpha | A | $\alpha$ |
| Beta | B | $\beta$ |
| Gamma | $\Gamma$ | $\gamma$ |
| Delta | $\Delta$ | $\delta$ |
| Epsilon | E | $\varepsilon$ |
| Zeta | Z | $\zeta$ |
| Eta | H | $\eta$ |
| Theta | $\Theta$ | $\theta$ |
| Iota | I | $\iota$ |
| Kappa | K | $\kappa$ |
| Lambda | $\Lambda$ | $\lambda$ |
| Mu | M | $\mu$ |
| Nu | N | $\nu$ |
| Xi | $\Xi$ | $\xi$ |
| Omicron | O | o |
| Pi | $\Pi$ | $\pi$ |
| Rho | P | $\rho$ |
| Sigma | $\Sigma$ | $\sigma$ |
| Tau | T | $\tau$ |
| Upsilon | Y | $\upsilon$ |
| Phi | $\Phi$ | $\varphi$ |
| Chi | X | $\chi$ |
| Psi | $\Psi$ | $\psi$ |
| Omega | $\Omega$ | $\omega$ |

# V.  EDITING REFERENCES

**A. Citing References**

*References in Text:* References need not be cited in the text. When they are, they appear on the line, in square brackets, *inside the punctuation.* Grammatically, they may be treated as if they were footnote numbers, e.g.,

as shown by Brown [4], [5]; as mentioned earlier [2], [4]–[7], [9]; Smith [4] and Brown and Jones [5]; Wood et al. [7]

**NOTE:** Use *et al.* when three or more names are given.

or as nouns:

as demonstrated in [3]; according to [4] and [6]–[9].

*References Within a Reference:* Check the reference list for *ibid.* or *op. cit.* These refer to a previous reference and should be eliminated from the reference section. In text, repeat the earlier reference number and renumber the reference section accordingly. If the *ibid.* gives a new page number, or other information, use the following forms:

[3, Th. 1]; [3, Lemma 2]; [3, pp. 5-10]; [3, eq. (2)]; [3, Fig. 1]; [3, Appendix I]; [3, Sec. 4.5]; [3, Ch. 2, pp. 5-10]; [3, Algorithm 5].

**NOTE:** Editing of references may entail careful renumbering of references, as well as the citations in text.

**B. Style**

Reference numbers are set flush left and form a column of their own, hanging out beyond the body of the reference. The reference numbers are on the line, enclosed in square brackets. In all references, the given name of the author or editor is abbreviated to the initial only and precedes the last name. Use commas around Jr., Sr., and III in names. IEEE publications must list names of all authors, up to six names. If there are more than six names listed, use *et al.* after the first author. For non-IEEE publications, *et al.* may be used if names are not provided. Abbreviate Conference titles  (see Section V-E and V-F). Note that when citing IEEE Transactions, if the issue number or month is not available, research IEEEXplore to update the information. Retain or request the day of the month when referencing a patent. References may not include all information; please obtain and include relevant information. Do not combine references. There must be only one reference with each number. If there is a URL included with the print reference, it can be included at the end of the reference (see style for On-line references).

*Periodicals*

Prior to 1988, the volume number of IEEE Transactions/Journals carried the acronym of the journal. For example, an issue of the IEEE TRANSACTIONS ON AUTOMATIC CONTROL would read: *IEEE Trans. Automat. Contr.,* vol. AC-26, no. 1, pp. 1–34, Jan. 1981. When referencing IEEE Transactions, both the issue number and month are included upon verification of frequency and starting month.

**NOTE:** The only exception to this rule is PROCEEDINGS OF THE IEEE, which never carried an acronym on the masthead.

*Basic Format:*

[1]   J. K. Author, "Name of paper," *Abbrev. Title of Periodical*, vol. *x,* no. *x,* pp. *xxx-xxx,* Abbrev. Month, year.

*Examples:*

[1]   R. E. Kalman, "New results in linear filtering and prediction theory," *J. Basic Eng.*, ser. D, vol. 83, pp. 95-108, Mar. 1961.

[2]   J. U. Buncombe, "Infrared navigation—Part I: Theory," *IEEE Trans. Aerosp. Electron. Syst.*, vol. AES-4, no. 3, pp. 352–377, Sept. 1944.

[3]   ____, "Infrared navigation—Part II: An assessment of feasibility," *IEEE Trans. Aerosp. Electron. Syst.*, vol. AES-4, no. 4, pp. 588–613, Nov. 1944.

[4]   H. Eriksson and P. E. Danielsson, "Two problems on Boolean memories," *IEEE Trans. Electron. Devices*, vol. ED-11, no. 1, pp. 32–33, Jan. 1959.

[5]  F. Aronowitz, "Theory of traveling-wave optical maser," *Phys. Rev.*, vol. 134, pp. A635–A646, Dec. 8, 1965.

[6]  Ye. V. Lavrova, "Geographic distribution of ionospheric disturbances in the F2 layer," *Tr. IZMIRAN*, vol. 19, no. 29, pp. 31–43, 1961 (Transl.: E. R. Hope, Directorate of Scientific Information Services, Defence Research Board of Canada, Rep. T384R, Apr. 1963).

[7]  E. P. Wigner, "On a modification of the Rayleigh–Schrodinger perturbation theory," (in German), *Math. Naturwiss. Anz. Ungar. Akad. Wiss.*, vol. 53, p. 475, 1935.

[8]  E. H. Miller, "A note on reflector arrays," *IEEE Trans. Antennas Propag.*, to be published.*** *Always use this style when the paper has been accepted or scheduled for a future publication, i.e., do not use "to appear in."***

[9]  C. K. Kim, "Effect of gamma rays on plasma," submitted for publication. *** *Always use this style when the paper has not yet been accepted or scheduled for publication, i.e., do not use "to appear in."***

[10]  W. Rafferty, "Ground antennas in NASA's deep space telecommunications," *Proc. IEEE*  vol. 82, no. 5, pp. 636-640, May 1994.

[11]  J. S. Turner, "New directions in communications," *IEEE J. Sel. Areas Commun.,* vol. 13, no. 1, pp. 11-23, Jan. 1995.

[12]  L. T. Wu *et al.*, "Real-time analytic sensitivity method for transient security assessment and prevent control," *Proc. Inst. Elect. Eng.,* vol. 135, pt. C, pp. 107-117, Mar. 1988. \****Authors may refer to this journal as Proc. IEE, but the abbreviation must be as listed above. Proc. IEE is printed in the U.K. and must not be confused with the Proc. IEEE.****

[13]  *Special Issue on Artificial Neural Network Applications, Proc. IEEE*, vol. 84, pp. 1353-1576, Oct. 1996.

*Article Referred to in the Same Issue:*

[1]  R. U. Aslip, "Surface and leaky wave antennas," *IEEE Trans. Circuits Syst. I, Fundam. Theory Appl.,* vol. 30, no.1, pp. 545–546, Jan. 2000.

**NOTE:** Handle it exactly as any other reference with no difference.

### Books

*Basic Format:*

[1]  J. K. Author, "Title of chapter in the book," in *Title of His Published Book, x*th ed. City of Publisher, Country if not USA: Abbrev. of Publisher, year, ch. *x*, sec. *x*, pp. *xxx–xxx.*

*Examples:*

[1]  B. Klaus and P. Horn, *Robot Vision.* Cambridge, MA: MIT Press, 1986.

[2]  L. Stein, "Random patterns," in *Computers and You,* J. S. Brake, Ed. New York: Wiley, 1994, pp. 55-70.

[3]  R. L. Myer, "Parametric oscillators and nonlinear materials," in *Nonlinear Optics*, vol. 4, P. G. Harper and B. S. Wherret, Eds. San Francisco, CA: Academic, 1977, pp. 47-160.

[4]   M. Abramowitz and I. A. Stegun, Eds., *Handbook of Mathematical Functions* (Applied Mathematics Series 55). Washington, DC: NBS, 1964, pp. 32-33.

[5]  E. F. Moore, "Gedanken-experiments on sequential machines," in *Automata Studies* (Ann. of Mathematical Studies, no. 1), C. E. Shannon and J. McCarthy, Eds. Princeton, NJ: Princeton Univ. Press, 1965, pp. 129-153.

[6]  Westinghouse Electric Corporation (Staff of Technology and Science, Aerospace Div.), *Integrated Electronic Systems*. Englewood Cliffs, NJ: Prentice-Hall, 1970.

[7]  M. Gorkii, "Optimal design," *Dokl. Akad. Nauk SSSR*, vol. 12, pp. 111-122, 1961 (Transl.: in L. Pontryagin, Ed., *The Mathematical Theory of Optimal Processes.* New York: Interscience, 1962, ch. 2, sec. 3, pp. 127-135).

[8]  G. O. Young, "Synthetic structure of industrial plastics," in *Plastics,* vol. 3, *Polymers of Hexadromicon*, J. Peters, Ed., 2nd ed. New York: McGraw-Hill, 1964, pp. 15-64.

### Reports

The general form for citing technical reports is to place the name and location of the company or institution after the author and title and to give the report number and date at the end of the reference.

*Basic Format:*

[1]  J. K. Author, "Title of report," Abbrev. Name of Co., City of Co., Abbrev. State, Rep. *xxx*, year.

*Examples:*

[1]  E. E. Reber, R. L. Michell, and C. J. Carter, "Oxygen absorption in the earth's atmosphere," Aerospace Corp., Los Angeles, CA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.

[2]  J. H. Davis and J. R. Cogdell, "Calibration program for the 16-foot antenna," Elect. Eng. Res. Lab., Univ. Texas, Austin, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.

[3]   R. E. Haskell and C. T. Case, "Transient signal propagation in lossless isotropic plasmas," USAF Cambridge Res. Labs., Cambridge, MA, Rep. ARCRL-66-234 (II), 1994, vol. 2.

[4]   M. A. Brusberg and E. N. Clark, "Installation, operation, and data evaluation of an oblique-incidence ionosphere sounder system," in "Radio Propagation Characteristics of the Washington-Honolulu Path," Stanford Res. Inst., Stanford, CA, Contract NOBSR-87615, Final Rep., Feb. 1995, vol. 1.

[5]   P. Diament, S. L. Richert, and W. L. Lupatkin, "V-line surface-wave radiation and scanning," Dept. Elect. Eng., Columbia Univ., New York, Sci. Rep. 85, Aug. 1991.

## *Handbooks*

*Basic Format:*

[1]   *Name of Manual/Handbook*, *x* ed., Abbrev. Name of Co., City of Co., Abbrev. State, year, pp. *xxx-xxx.*

*Examples:*

[1]   *Transmission Systems for Communications*, 3rd ed., Western Electric Co., Winston-Salem, NC, 1985, pp. 44–60.

[2]   *Motorola Semiconductor Data Manual*, Motorola Semiconductor Products Inc., Phoenix, AZ, 1989.

[3]   *RCA Receiving Tube Manual*, Radio Corp. of America, Electronic Components and Devices, Harrison, NJ, Tech. Ser. RC-23, 1992.

## *Published Conference Proceedings*

The general form for citing conference proceedings is to list the author and title of the paper, followed by the name (and location, if given) of the conference *in italics* using these standard abbreviations.

| | |
|---|---|
| Annals | Ann. |
| Annual | Annu. |
| Colloquium | Colloq. |
| Conference | Conf. |
| Congress | Congr. |
| Convention | Conv. |
| Digest | Dig. |
| Exposition | Expo. |
| International | Int. |
| Meeting | Meeting |
| National | Nat. |
| Proceedings | Proc. |
| Record | Rec. |
| Symposium | Symp. |
| Technical Digest | Tech. Dig. |
| Technical Paper | Tech. Paper |
| Workshop | Workshop |

First
Second
Third
Fourth/*n*th...
1st
2nd
3rd
4th/*n*th...

Write out all the remaining words, but omit most articles and prepositions like "of the" and "on." That is, *Proceedings of the 1996 Robotics and Automation Conference* becomes *Proc. 1996 Robotics and Automation Conf.*

**NOTE:** All published conference or proceedings papers have page numbers.

*Basic Format:*
[1] J. K. Author, "Title of paper," in *Abbreviated Name of Conf.*, (location of conference is optional), year, pp. *xxx-xxx.*

*Examples:*

[1] G. R. Faulhaber, "Design of service systems with priority reservation," in *Conf. Rec. 1995 IEEE Int. Conf. Commun.*, pp. 3–8. *** *If the year is given in the conference title, it may be omitted from the end of the reference as shown here.**** 
[2] S. P. Bingulac, "On the compatibility of adaptive controllers," in *Proc. 4th Annu. Allerton Conf. Circuit and Systems Theory*, New York, 1994, pp. 8–16.
[3] W. D. Doyle, "Magnetization reversal in films with biaxial anisotropy," in *1987 Proc. INTERMAG Conf.*, pp. 2.2-1–2.2-6.
[4] C. T. Meadow and D. W. Waugh, "Computer assisted interrogation," in *1991 Fall Joint Computer Conf., Proc. AFIPS Conf.,* vol. 29.   Washington, DC: Spartan, 1991, pp. 381–394. *** *There is an <emspace> between "vol. 29." and "Washington."****
[5] P. C. Parks, "Lyapunov redesign of model reference adaptive control systems," in *1993 Joint Automatic Control Conf., Preprints*, pp. 485–491.
[6] C. Janow, "Guidance and control components for space applications," in *Proc. Nat. Electronics Conf.*, 1994, vol. 24, pp. 30-35.
[7] T. S. Hsia, "System identification," in *IEDM Tech. Dig.*, 1993, vol. 2, no. 8, pp. 6–13.

### Papers Presented at Conferences

*Basic Format:*

[1] J. K. Author, "Title of paper," presented at the abbrev. Name of Conf., City of Conf., Abbrev. State, year.

*Examples:*

[1] M. Mayer, presented at the 4th Congr. Permanent Magnets, Grenoble, France, Mar. 1995.
[2] J. G. Kreifeldt, "An analysis of surface-detected EMG as an amplitude-modulated noise," presented at the 1989 Int. Conf. Medicine and Biological Engineering, Chicago, IL.
[3] G. W. Juette and L. E. Zeffanella, "Radio noise currents on short sections on bundle conductors," presented at the IEEE Summer Power Meeting, Dallas, TX, June 22-27, 1990, Paper 90 SM 690-0 PWRS. *** *PES Papers—For years prior to 1997, all Power papers were presented at a conference.****
[4] J. Arrillaga and B. Giessner, "Limitation of short-circuit levels by means of HVDC links," presented at the IEEE Summer Power Meeting, Los Angeles, CA, July 12–17, 1990, Paper 70 CP 637. ****Preprints are available before the conference from the IEEE Customer Services Department, at the conference from Paper Sales, and after the conference from ASK*IEEE.****

### Patents

*Basic Format:*

[1] J. K. Author, "Title of patent," U.S. Patent *x xxx xxx*, Abbrev. Month, day, year.

*Example:*

[1] J. P. Wilkinson, "Nonlinear resonant circuit devices," U.S. Patent 3 624 125, July 16, 1990.
**NOTE:** Use "issued date" if several dates are given.

### Theses (M.S.) and Dissertations (Ph.D.)

*Basic Format:*

[1] J. K. Author, "Title of thesis," M.S. thesis, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.
[2] J. K. Author, "Title of dissertation," Ph.D. dissertation, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

*Examples:*

[1] J. O. Williams, "Narrow-band analyzer," Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, 1993.

[2] N. Kawasaki, "Parametric study of thermal and chemical nonequilibrium nozzle flow," M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.

[3] N. M. Amer, "The effects of homogeneous magnetic fields on developments of tribolium confusum," Ph.D. dissertation, Radiation Lab., Univ. California, Berkeley, Tech. Rep. 16854, 1995. *** *The state abbreviation is omitted if the name of the university includes the state name, i.e., "Univ. California, Berkeley."* ***

[4] C. Becle, These de doctoral d'etat, Univ. Grenoble, Grenoble, France, 1968.

### Unpublished

These are the two most common types of unpublished references.

*Basic Format :*

[1] J. K. Author, private communication, Abbrev. Month, year.

[2] J. K. Author, "Title of paper," unpublished.

*Examples:*

[1] A. Harrison, private communication, May 1995.

[2] B. Smith, "An approach to graphs of linear forms," unpublished.

[3] A. Brahms, "Representation error for real numbers in binary computer arithmetic," IEEE Computer Group Repository, Paper R-67-85.

### Standards

*Basic Format:*

[1] *Title of Standard*, Standard number, date.

*Examples:*

[1] *IEEE Criteria for Class IE Electric Systems*, IEEE Standard 308, 1969.

[2] *Letter Symbols for Quantities*, ANSI Standard Y10.5-1968.

## C. On-Line Sources

The guidelines for citing electronic information as offered here are in modified illustration of the adaptation by the International Standards Organization (ISO) documentation system and the American Psychological Association style.

*Guidelines for Breaking URLs:*
- Break after slash or double slash.
- Break "before" hyphen that is part of an address, and do not break after; do not add hyphens; do not let addresses hyphenate.
- Break "before" a tilde (~), a hyphen, an underline (_), a question mark, or a percent (%) symbol.
- Break before or after an equals sign or an ampersand (follow the same rule for the "at" (@) symbol).

### Books, Monographs

*Basic Format:*

[1] J. K. Author. (year, month day). *Title* (edition) [Type of medium]. *volume(issue)*. Available: site/path/file

*Example:*

[1] S. Khutaina. (1995, Aug. 15). *EMBASE handbook* (3rd ed.) [Online]. *3(21)*. Available: Knowledge Index File: EMBASE Handbook (EMHB)

*FTP*

*Basic Format:*

[1] J. K. Author. (year). *Title* (edition) [Type of medium]. [Online] Available FTP: Directory: File:

*Example:*

[1]   R. J. Vidmar. (1994). *On the use of atmospheric plasmas as electromagnetic reflectors* [Online]. Available FTP: atmnext.usc.edu Directory: pub/etext/1994 File: atmosplasma.txt

*WWW*
*Basic Format:*

[1]   J. K. Author. (year, month day). *Title* (edition) [Type of medium]. Available: http://www.(URL)

*Example:*

*[1]*   J. Jones. (1991, May 10). *Networks (2nd ed.)* [Online]. Available: http://www.atm.com

*E-mail*
*Basic Format:*

[1]   J. K. Author. (year, month day). *Title* (edition) [Type of medium]. Available e-mail: Message:

*Example:*

[1]   S. H. Gold. (1995, Oct. 10). *Inter-Network Talk* [Online]. Available e-mail: COMSERVE@RPIECS Message: Get NETWORK TALK

*Telnet*
*Basic Format:*

[1]   J. K. Author. (year, month day). *Title* (edition) [Type of medium]. Available Telnet: Directory: File:

*Example:*

*Telnet*
*Basic Format:*

**V. Meligna. (1993, June 11). Periodic table of elements [Online]. Available Telnet: Library.CMU.edu Directory: Libraries/Reference Works File: Periodic Table of Elements**

**Full Text Databases—Periodicals**

*Journal Articles*

*Basic Format:*

[1]   J. K. Author. (year, month). Title. *Journal* [Type of medium]. *volume(issue)*, paging if given. Available: site/path/file

*Examples:*

[1]   J. Bourke. (1995, Mar.). A comparison of RF electrode models. *J. Phys.* [CD-ROM]. *32(4)*, RD2-RD3. Available: JPY File: Science Periodicals Ondisc Item: 95-76401

[2]   R. J. Vidmar. (1992, Aug.) On the use of atmospheric plasmas as electromagnetic reflectors. *IEEE Trans. Plasma Sci.* [Online]. *21(3)*, pp. 876–880. Available: http://www.halcyon.com/pub/journals/21ps03-vidmar

*FTP*
*Basic Format:*

[1]   J. K. Author. (year, month). Title. *Journal* [Type of medium]. *volume(issue)*, paging if given. Available FTP: Directory: File:

*Example:*

[1]   R. P. Drew. (1996, Jan.). All-digital oversampled front-end sensors. *Science Online* [Online]. *3(1)*. Available FTP: sci.mit.edu Directory: pub/journals/sci.online/issue12 File: 012bel5.txt

*WWW*
*Basic Format:*

[1]   J. K. Author. (year, month day). Title. *Journal* [Type of medium]. *volume(issue)*, paging if given. Available: http://www.(URL)

*Example:*

[1]  M. Semilof. (1996, July 15). Driving commerce to the Web—Corporate Intranets and the Internet: Lines blur. *Communications Week* [Online]. *6(19)*. Available: http://www.techweb.com/se/index.html.

*E-Mail*
*Basic Format:*

[1]  J. K. Author. (year, month). Title. *Journal* [Type of medium]. *volume(issue)*, paging if given. Available e-mail: Message:

*Example:*

[1]  J. Frasene. (1992, July/Aug.). Least squares theory. *The Electronic Journal of Automation* [Online]. *6(8)*. Available e-mail: listserv@nasum.cc.edu Message: Get [frasene 992] eja-f=mail

*Telnet*
*Basic Format:*

[1]  J. K. Author. (year, month). Title. *Journal* [Type of medium]. *volume(issue)*, paging if given. Available Telnet: Directory: File:

*Example:*

[1]  P. Darien. (1992, Jan.). Buying science. *Quantum* [Online]. *4(3)*. Available Telnet: gopher.tp.umn.edu Directory: Libraries/Newspapers, Magazines, and Newsletters/Technical Journals/Quantum/ASCII Issues/Volume V Issue 3 January 1992 File: "Buying Science" by P. Darien

**Magazine Articles**

*Basic Format:*

[1]  J. K. Author. (year, month day). Title. *Magazine* [Type of medium]. paging if given. Available: site/path/file

*Example:*

[1]  S. Fujii and Y. Mikami. (1991, Apr. 20). Construction aspects of intelligent buildings. *IEEE Communications Mag.* [CD-ROM]. pp. 50-57. Available: UMI File: IPO (IEEE/IEE Publications Ondisc) Item: 3939837

*FTP*
*Basic Format:*

[1]  J. K. Author. (year, month day). Title. *Magazine* [Type of medium]. paging if given. Available FTP: Directory: File:

*Example:*

[1]  R. Young. (1994, Dec. 2). Summary of meta fonts available. *TexMag* [Online]. Available FTP: sum.soe.clarkson.edu Directory: pub/tex/texmag File: texmag.4.06

*WWW*
*Basic Format:*

[1]  J. K. Author. (year, month day). Title. *Magazine* [Type of medium]. paging if given. Available: http://www.(URL)

*Examples:*

[1]  A. Stuart, Ed. (1996, Dec. 3). Business in the wake of the Web. *WebMaster Mag.* [Online]. Available: http://www.cio.com/cgi-bin/gate2?~
[2]  L. Brigman (1997, Feb.). The never-ending story. *WebMaster Mag.* [Online]. Available: http://www.cio/WebMaster/020197_field_content.html

*E-Mail*
*Basic Format:*

[1]  J. K. Author. (year, month day). Title. *Magazine* [Type of medium]. paging if given. Available e-mail: Message:

*Example:*

[1]  A. Harriman. (1993, June 28). Compendium of genealogical software. *Humanist* [Online]. *2*(41). Available e-mail: HUMANIST@NYVM Message: Get GENEALOGY REPORT

*Telnet*
*Basic Format:*

[1]   J. K. Author. (year, month day). Title. *Magazine* [Type of medium]. Available Telnet: Directory: File:

*Example:*

[1]   S. Bene. (1990, July 21). Queues at information desks. *Com* [Online]. Available Telnet: gopher.uet.edu Directory: Libraries/Newspapers, Magazines, Newsletters/EE/EECom File: V.2I.3Jul90

## Full Text Databases—Other Sources

### *Papers Presented at Conferences*

*Basic Format:*

[1]   J. K. Author. Title. presented at Conference title. [Type of Medium]. Available: site/path/file

*Example:*

[1]   Process Software Corp., MA. Intranets: Internet technologies deployed behind the firewall for corporate productivity. presented at INET'96 Annu. Meeting [Online]. Available: http://www.process.com/Intranets/wp2.htp

### *Reports and Handbooks*

*Basic Format:*

[1]   J. K. Author. (year, month). Title. Company. City, State or Country. [Type of Medium]. Available: site/path/file

*Examples:*

[1]   S. L. Talleen. (1996, Aug.). The IntraNet Architecture: Managing information in the new paradigm. Amdahl Corp, CA. [Online]. Available: http://www.amdahl.com/doc/products/bsg/intra/infra/html

[2]   Netscape Communications Corp. (1997, Dec.). The new way to share workgroup information. [Online]. Available: http://home.netscape.com/comprod/a

### *U.S. Government Documents*

*Basic Format:*

[1]   Legislative body. Number of Congress, Session. (year, month day). *Number of bill or resolution*, *Title*. [Type of medium]. Available: site/path/file

*Example:*

[1]   U.S. House. 102nd Congress, 1st Session. (1991, Jan. 11). *H. Con. Res. 1, Sense of the Congress on Approval of Military Action*. [Online]. Available: LEXIS Library: GENFED File: BILLS

### *Patents*

*Basic Format:*

[1]   Name of the invention, by inventor's name. (year, month day). *Patent Number* [Type of medium]. Available: site/path/file

*Example:*

[1]   Musical toothbrush with adjustable neck and mirror, by L.M.R. Brooks. (1992, May 19). *Patent D 326 189* [Online]. Available: NEXIS Library: LEXPAT File: DESIGN

## D. Common Abbreviations of Words in References

| | |
|---|---|
| Acoustics | Acoust. |
| Administration | Admin. |
| Administrative | Administ. |
| American | Amer. |
| Analysis | Anal. |
| Annals | Ann. |
| Annual | Annu. |
| Apparatus | App. |

| | |
|---|---|
| Applications | Appl. |
| Applied | Appl. |
| Association | Assoc. |
| Automatic | Automat. |
| British | Brit. |
| Broadcasting | Broadcast. |
| Business | Bus. |
| Canadian | Can. |
| Chinese | Chin. |
| Communications | Commun. |
| Computer(s) | Comput. |
| Conference | Conf. |
| Congress | Congr. |
| Convention | Conv. |
| Correspondence | Corresp. |
| Cybernetics | Cybern. |
| Department | Dept. |
| Development | Develop. |
| Digest | Dig. |
| Economic(s) | Econ. |
| Education | Edu. |
| Electrical | Elect. |
| Electronic | Electron. |
| Engineering | Eng. |
| Ergonomics | Ergonom. |
| European | Eur. |
| Evolutionary | Evol. |
| Foundation | Found. |
| Geoscience | Geosci. |
| Graphics | Graph. |
| Industrial | Ind. |
| Information | Inform. |
| Institute | Inst. |
| Intelligence | Intell. |
| International | Int. |
| Japan | Jpn. |
| Journal | J. |
| Letter(s) | Lett. |
| Machine | Mach. |
| Magazine | Mag. |
| Management | Manage. |
| Managing | Manag. |
| Mathematical | Math. |
| Mechanical | Mech. |
| Meeting | Meeting |
| National | Nat. |
| Newsletter | Newslett. |
| Nuclear | Nucl. |
| Occupation | Occupat. |
| Operational | Oper. |
| Optical | Opt. |
| Optics | Opt. |
| Organization | Org. |
| Philosophical | Philosoph. |
| Proceedings | Proc. |
| Processing | Process. |
| Production | Prod. |
| Productivity | Productiv. |
| Quarterly | Quart. |

| | |
|---|---|
| Record | Rec. |
| Reliability | Rel. |
| Report | Rep. |
| Research | Res. |
| Review | Rev. |
| Royal | Roy. |
| Science | Sci. |
| Selected | Select. |
| Society | Soc. |
| Sociological | Sociol. |
| Statistics | Statist. |
| Studies | Stud. |
| Supplement | Suppl. |
| Symposium | Symp. |
| Systems | Syst. |
| Technical | Tech. |
| Techniques | Techn. |
| Technology | Technol. |
| Telecommunications | Telecommun. |
| Transactions | Trans. |
| Vehicular | Veh. |
| Working | Work. |

## E. IEEE Abbreviations for Transactions, Journals, Letters

**NOTE:** * denotes past acronyms/abbreviations of journals (used for pre-1988 publications).

| Publication | Acronym | Reference Abbreviation |
|---|---|---|
| IEEE TRANSACTIONS ON AEROSPACE AND ELECTRONIC SYSTEMS | AES | *IEEE Trans. Aerosp. Electron. Syst.* |
| | ANE* | *IEEE Trans. Aeronaut. Navig. Electron.** |
| | ANE* | *IEEE Trans. Aerosp. Navig. Electron.** |
| | AS* | *IEEE Trans. Aerosp.** |
| | MIL* | *IEEE Trans. Mil. Electron.** |
| | AE* | *IEEE Trans. Airborne Electron.** |
| IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION | AP | *IEEE Trans. Antennas Propag.* |
| IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS | LAWP | *IEEE Antennas Wireless Propag. Lett.* |
| IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY | ASC | *IEEE Trans. Appl. Supercond.* |
| IEEE TRANSACTIONS ON AUTOMATIC CONTROL | AC | *IEEE Trans. Autom. Control* |
| IEEE TRANSACTIONS ON AUTOMATION SCIENCE AND ENGINEERING | ASE | *IEEE Trans. Autom. Sci. Eng.* (from July 2004) |
| IEEE TRANSACTIONS ON AUTONOMOUS MENTAL DEVELOPMENT | AMD | *IEEE Trans. Auton. Mental Develop.* |
| IEEE TRANSACTIONS ON BIG DATA | BD | *IEEE Trans. Big Data* |
| IEEE REVIEWS IN BIOMEDICAL ENGINEERING | RBME | *IEEE Rev. Biomed. Eng.* |
| IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING | BME | *IEEE Trans. Biomed. Eng.* |
| | BME* | *IEEE Trans. Bio-Med. Eng.** |
| | BME* | *IEEE Trans. Bio-Med. Electron.** |
| | PGME* | *IEEE Trans. Med. Electron.** |
| IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS | BCAS | *IEEE Trans. Biomed. Circuits Syst.* |
| IEEE TRANSACTIONS ON BROADCASTING | BC | *IEEE Trans. Broadcast.* |
| | BC* | *IEEE Trans. Broadcast. Technol.** |
| IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS—I: REGULAR PAPERS | CSI | *IEEE Trans. Circuits Syst. I, Reg. Papers* |
| IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS—II: EXPRESS BRIEFS | CSII | *IEEE Trans. Circuits Syst. II, Exp. Briefs* |
| IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS—I: FUNDAMENTAL THEORY AND APPLICATIONS | CAS1* | *IEEE Trans. Circuits Syst. I, Fundam. Theory Appl.* (1993–2003) |
| IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS—II: ANALOG AND DIGITAL SIGNAL PROCESSING | CAS2* | *IEEE Trans. Circuits Syst. II, Analog Digit. Signal Process.*(1993–2003) |
| | CAS* | *IEEE Trans. Circuits Syst.** (1974–1992) |
| | CT* | *IEEE Trans. Circuit Theory** (until 1973) |
| IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY | CSVT | *IEEE Trans. Circuits Syst. Video Technol.* |
| IEEE TRANSACTIONS ON COMMUNICATIONS | COM | *IEEE Trans. Commun.* |
| | COM* | *IEEE Trans. Commun. Technol.** (through 1971) |
| IEEE COMMUNICATIONS LETTERS | COMML | *IEEE Commun. Lett.* |
| IEEE TRANSACTIONS ON COMPONENTS, PACKAGING, AND MANUFACTURING TECHNOLOGY | CPMT | *IEEE Compon., Packag., Manuf. Technol.* |
| | ADVP | *IEEE Trans. Adv. Packag. (1999–2010)* |
| | EPM | *IEEE Trans. Electron. Packag. Manuf. (1999–2010)* |
| | CAPT | *IEEE Trans. Compon. Packag. Technol. (1999–2010)* |

| Publication | Acronym | Reference Abbreviation |
|---|---|---|
| | CPMTA* | *IEEE Trans. Compon., Packag., Manuf. Technol. A*\* (1994–1998) |
| | CPMTB | *IEEE Trans. Compon., Packag., Manuf. Technol. B*\* (1994–1998) |
| | CPMTC | *IEEE Trans. Compon., Packag., Manuf. Technol. C*\* (1996–1998) |
| | CHMT | *IEEE Trans. Compon., Hybrids, Manuf. Technol.*\* (1978–1993) |
| | MFT* | *IEEE Trans. Manuf. Technol.*\* (1972–1977) |
| | PHP* | *IEEE Trans. Parts, Hybrids, Packag.*\* (June 1971–1977) |
| | PMP* | *IEEE Trans. Parts, Mater., Packag.*\* (until 1971) |
| IEEE TRANSACTIONS ON COMPUTER-AIDED DESIGN OF INTEGRATED CIRCUITS AND SYSTEMS | CAD | *IEEE Trans. Comput.-Aided Design Integr. Circuits Syst.* |
| IEEE TRANSACTIONS ON COMPUTATIONAL INTELLIGENCE AND ARTIFICIAL INTELLIGENCE IN GAMES | CIAIG | *IEEE Trans. Comput. Intell. AI in Games.* |
| IEEE COMPUTER ARCHITECTURE LETTERS | | *IEEE Comput. Archit. Lett.* |
| IEEE TRANSACTIONS ON CONSUMER ELECTRONICS | CE | *IEEE Trans. Consum. Electron.* |
| IEEE TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY | CST | *IEEE Trans. Control Syst. Technol.* |
| IEEE TRANSACTIONS ON DEVICE AND MATERIALS RELIABILITY | DMR | *IEEE Trans. Device Mater. Rel.* |
| IEEE TRANSACTIONS ON DIELECTRICS AND ELECTRICAL INSULATION | DEI | *IEEE Trans. Dielectr. Electr. Insul.* |
| | EI* | *IEEE Trans. Electr. Insul.*\* (until 1993) |
| IEEE/OSA JOURNAL OF DISPLAY TECHNOLOGY | DT | *J. Display Technol.* |
| IEEE TRANSACTIONS ON EDUCATION | E | *IEEE Trans. Educ.* |
| IEEE TRANSACTIONS ON ELECTROMAGNETIC COMPATIBILITY | EMC | *IEEE Trans. Electromagn. Compat.* |
| | RFI* | *IEEE Trans. Radio Freq. Interference*\* |
| IEEE TRANSACTIONS ON ELECTRON DEVICES | ED | *IEEE Trans. Electron Devices* |
| IEEE ELECTRON DEVICE LETTERS | EDL | *IEEE Electron Device Lett.* |
| IEEE EMBEDDED SYSTEMS LETTERS | ES | *IEEE Embedded Syst. Lett.* |
| IEEE TRANSACTIONS ON ENERGY CONVERSION | EC | *IEEE Trans. Energy Convers.* |
| IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT | EM | *IEEE Trans. Eng. Manag.* |
| IEEE TRANSACTIONS ON EVOLUTIONARY COMPUTATION | EVC | *IEEE Trans. Evol. Comput.* |
| IEEE TRANSACTIONS ON FUZZY SYSTEMS | FUZZ | *IEEE Trans. Fuzzy Syst.* |
| IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING | GRS | *IEEE Trans. Geosci. Remote Sens.* |
| IEEE GEOSCIENCE AND REMOTE SENSING LETTERS | GRSL | *IEEE Geosci. Remote Sens. Lett.* |
| IEEE TRANSACTIONS ON IMAGE PROCESSING | IP | *IEEE Trans. Image Process.* |
| IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS | IE | *IEEE Trans. Ind. Electron.* |
| IEEE TRANSACTIONS ON INFORMATION FORENSICS AND SECURITY | IFS | *IEEE Trans. Inf. Forensics Security* |
| IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS | IINF | *IEEE Trans Ind. Informat.* |
| IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS | IA | *IEEE Trans. Ind. Appl.* |
| IEEE TRANSACTIONS ON INFORMATION TECHNOLOGY IN BIOMEDICINE | ITB | *IEEE Trans. Inf. Technol. Biomed.* |
| IEEE TRANSACTIONS ON INFORMATION THEORY | IT | *IEEE Trans. Inf. Theory* |
| IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT | IM | *IEEE Trans. Instrum. Meas.* |
| | I, PGI* | *IEEE Trans. Instrum.*\* |
| IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS | ITS | *IEEE Trans. Intell. Transp. Syst.* |

| Publication | Acronym | Reference Abbreviation |
|---|---|---|
| IEEE TRANSACTIONS ON KNOWLEDGE AND DATA ENGINEERING | KDE | *IEEE Trans. Knowl. Data Eng.* |
| IEEE/OSA JOURNAL OF LIGHTWAVE TECHNOLOGY | LT | *J. Lightw. Technol.* |
| IEEE Embedded Systems Letters | LES | *IEEE Embedded systems* |
| IEEE TRANSACTIONS ON MAGNETICS | MAG | *IEEE Trans. Magn.* |
| IEEE/ASME TRANSACTIONS ON MECHATRONICS | MECH | *IEEE/ASME Trans. Mechatronics* |
| IEEE TRANSACTIONS ON MEDICAL IMAGING | MI | *IEEE Trans. Med. Imag.* |
| IEEE/ASME JOURNAL OF MICROELECTROMECHANICAL SYSTEMS | MEMS | *J. Microelectromech. Syst.* |
| IEEE MICROWAVE AND GUIDED WAVE LETTERS | MGWL | *IEEE Microw. Guided Wave Lett.* (until 2002) |
| IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS | LMWC | *IEEE Microw. Wireless Compon. Lett.* |
| IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES | MTT | *IEEE Trans. Microw. Theory Techn.* |
| IEEE TRANSACTIONS ON MULTIMEDIA | MM | *IEEE Trans. Multimedia* |
| IEEE TRANSACTIONS ON MOBILE COMPUTING | MC | *IEEE Trans. Mobile Comput.* |
| IEEE TRANSACTIONS ON MULTIMEDIA | MM | *IEEE Trans. Multimedia* |
| IEEE TRANSACTIONS ON NANOBIOSCIENCE | NB | *IEEE Trans. Nanobiosci.* |
| IEEE TRANSACTIONS ON NANOTECHNOLOGY | NANO | *IEEE Trans. Nanotechnol.* |
| IEEE/ACM TRANSACTIONS ON NETWORKING | NET | *IEEE/ACM Trans. Netw.* |
| IEEE TRANSACTIONS ON NEURAL NETWORKS | NN | *IEEE Trans. Neural Netw.* |
| IEEE TRANSACTIONS ON NUCLEAR SCIENCE | NS | *IEEE Trans. Nucl. Sci.* |
| IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING | NSRE | *IEEE Trans. Neural Syst. Rehabil. Eng.* |
| IEEE TRANSACTIONS ON REHABILITATION ENGINEERING | RE* | *IEEE Trans. Rehabil. Eng.* * (1993–2000) |
| IEEE JOURNAL OF OCEANIC ENGINEERING | OE | *IEEE J. Ocean. Eng.* |
| IEEE JOURNAL OF OPTICAL COMMUNICATIONS AND NETWORKING | OCN | *IEEE J. Opt. Commun. Netw.* |
| IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS | PDS | *IEEE Trans. Parallel Distrib. Syst.* |
| IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE | PAMI | *IEEE Trans. Pattern Anal. Mach. Intell.* |
| IEEE PHOTONICS JOURNAL | PHOT | *IEEE Photonics Journal* |
| IEEE PHOTONICS TECHNOLOGY LETTERS | PTL | *IEEE Photon. Technol. Lett.* |
| IEEE PHOTONICS JOURNAL | PJ | *IEEE Photon. J.* |
| IEEE TRANSACTIONS ON PLASMA SCIENCE | PS | *IEEE Trans. Plasma Sci.* |
| IEEE TRANSACTIONS ON POWER APPARATUS AND SYSTEMS | PAS* | *IEEE Trans. Power App. Syst.* * (through 1985) |
| IEEE TRANSACTIONS ON POWER DELIVERY | PWRD | *IEEE Trans. Power Del.* |
| IEEE TRANSACTIONS ON POWER ELECTRONICS | PEL | *IEEE Trans. Power Electron.* |
| IEEE POWER ELECTRONICS LETTERS | LPEL | *IEEE Power Electron Lett.* |
| IEEE TRANSACTIONS ON POWER SYSTEMS | PWRS | *IEEE Trans. Power Syst.* |
| IEEE JOURNAL OF PRODUCT SAFETY ENGINEERING | | *IEEE J. Product Safety Eng.* |
| IEEE TRANSACTIONS ON PROFESSIONAL COMMUNICATION | PC | *IEEE Trans. Prof. Commun.* |
| IEEE JOURNAL OF QUANTUM ELECTRONICS | QE | *IEEE J. Quantum Electron.* |
| IEEE TRANSACTIONS ON RELIABILITY | R | *IEEE Trans. Rel.* |
| IEEE REVIEWS BIOMEDICAL ENGINEERING | RBME | *IEEE Reviews in Biomed. Eng.* |
| IEEE TRANSACTIONS ON ROBOTICS | RO | *IEEE Trans. Robot.* |
| IEEE TRANSACTIONS ON ROBOTICS AND AUTOMATION | RA* | *IEEE Trans. Robot. Autom.* * (1989–June 2004) |
| | RA* | *IEEE J. Robot. Autom.* * (1985–1988) |
| IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS IN REMOTE SENSING | STAERS | *IEEE J. Sel. Topics Appl. Earth Observ.* |
| IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS | SAC | *IEEE J. Sel. Areas Commun.* |
| IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS | STQE | *IEEE J. Sel. Topics Quantum Electron.* |
| IEEE TRANSACTIONS ON SMART GRID | SG | *IEEE Trans.  Smart Grid* |

| Publication | Acronym | Reference Abbreviation |
|---|---|---|
| IEEE TRANSACTIONS ON SUSTAINABLE ENERGY | STE | *IEEE Trans.  Sustainable Energy* |
| IEEE JOURNAL OF SELECTED TOPICS IN SIGNAL PROCESSING | STSP | *IEEE J. Sel. Topics Signal Process.* |
| IEEE TRANSACTIONS ON SEMICONDUCTOR MANUFACTURING | SM | *IEEE Trans. Semicond. Manuf.* |
| IEEE SENSORS JOURNAL | SEN | *IEEE Sensors J.* |
| IEEE TRANSACTIONS ON SIGNAL PROCESSING | SP | *IEEE Trans. Signal Process.* |
|  | ASSP* | *IEEE Trans. Acoust., Speech, Signal Process. * (1975–1990)* |
|  | AU* | *IEEE Trans. Audio Electroacoust. (until 1974)* |
| IEEE SIGNAL PROCESSING LETTERS | SPL | *IEEE Signal Process. Lett.* |
| IEEE SYSTEMS JOURNAL | SYS | *IEEE Syst. J.* |
| IEEE TRANSACTIONS ON SOFTWARE ENGINEERING | SE | *IEEE Trans. Softw. Eng.* |
| IEEE JOURNAL OF SOLID-STATE CIRCUITS | SSC | *IEEE J. Solid-State Circuits* |
| IEEE TRANSACTIONS ON SPEECH AND AUDIO PROCESSING | SAP | *IEEE Trans. Speech Audio Process.* |
| IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS—PART A: SYSTEMS AND HUMANS | SMCA | *IEEE Trans. Syst., Man, Cybern. A, Syst., Humans* |
| IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS—PART B: CYBERNETICS | SMCB | *IEEE Trans. Syst., Man, Cybern. B, Cybern.* |
| IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS—PART C: APPLICATIONS AND REVIEWS | SMCC | *IEEE Trans. Syst., Man, Cybern. C, Appl. Rev.* |
|  | SMC* | *IEEE Trans. Syst., Man, Cybern.* (1971–1995)* |
|  | SSC* | *IEEE Trans. Syst. Sci. Cybern.* (through 1970)* |
| IEEE TRANSLATION JOURNAL ON MAGNETICS IN JAPAN | TJMJ | *IEEE Transl. J. Magn. Jpn.* |
|  | MMS* | *IEEE Trans. Man-Mach. Syst.* (through 1970)* |
|  | HFE* | *Hum. Factors Electron. * (through 1968)* |
| IEEE JOURNAL ON TECHNOLOGY IN COMPUTER AIDED DESIGN | TCAD | *IEEE J. Technol. Computer Aided Design* |
| IEEE TRANSACTIONS ON ULTRASONICS, FERROELECTRICS, AND FREQUENCY CONTROL | UFFC | *IEEE Trans. Ultrason., Ferroelectr., Freq. Control* |
|  | SU* | *IEEE Trans. Sonics Ultrason.* (through 1985)* |
|  | UE* | *IEEE Trans. Ultrason. Eng.* * |
|  | PGUE* | *IEEE Trans. Ultrason. Eng.* * |
| IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY | VT | *IEEE Trans. Veh. Technol.* |
|  | VC* | *IEEE Trans. Veh. Commun.* * |
| IEEE TRANSACTIONS ON VERY LARGE SCALE INTEGRATION (VLSI) SYSTEMS | VLSI | *IEEE Trans. Very Large Scale Integr. (VLSI) Syst.* |
| IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS | VCG | *IEEE Trans. Vis. Comput. Graphics* |
| IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS | WC | *IEEE Trans. Wireless Commun.* |
| PROCEEDINGS OF THE IEEE |  | *Proc. IEEE* |
|  |  | *Proc. IRE* (through 1962)* |

## F. List of IEEE Magazines

| Magazines | Reference Abbreviation |
|---|---|
| IEEE Aerospace and Electronics Systems Magazine | *IEEE Aerosp. Electron. Syst. Mag.* |
| IEEE Annals of the History of Computing | *IEEE Ann. Hist. Comput.* |
| IEEE Antennas and Propagation Magazine | *IEEE Antennas Propag. Mag.* |
| IEEE ASSP Magazine (1984–1990) | *IEEE ASSP Mag.* |
| IEEE Circuits and Systems Magazine | *IEEE Circuits Syst. Mag.* |
| IEEE Circuits and Devices Magazine (1988–2006) | *IEEE Circuits Devices Mag.* |
| IEEE Communications Society Magazine (through 1978) | *IEEE Commun. Soc. Mag.* |
| IEEE Communications Magazine (1979–present) | *IEEE Commun. Mag.* |
| IEEE Computational Intelligence Magazine | *IEEE Comput. Intell. Mag.* |
| IEEE Computing in Science and Engineering Magazine | *IEEE Comput. Sci. Eng.* |
| IEEE Computer Applications in Power | *IEEE Comput. Appl. Power* |
| IEEE Computer Graphics and Applications Magazine | *IEEE Comput. Graph. Appl. Mag.* |
| IEEE Concurrency | *IEEE Concurrency* |
| IEEE Consumer Electronics Magazine | *IEEE Consum. Electron. Mag.* |
| IEEE Control Systems Magazine | *IEEE Control Syst. Mag.* |
| IEEE Design & Test | *IEEE Des. Test.* |
|  | *IEEE Des. Test. Comput.* (through 2012) |
| IEEE Electrical Insulation Magazine | *IEEE Elect. Insul. Mag.* |
| IEEE Electomagnetic Compatibility Magazine | *IEEE Electrmagn. Compat.* |
| IEEE Electrification Magazine | *IEEE Electrific. Mag.* |
| IEEE ElectroTechnology Review | *IEEE ElectroTechnol. Rev.* |
|  | *IEEE Eng. Med. Biol. Mag. (1982−2009)* |
| IEEE Engineering Management Review | *IEEE Eng. Manag. Rev.* |
| IEEE Expert (through 1997) | *IEEE Expert* |
| IEEE Geoscience and Remote Sensing Magazine | *IEEE Geosci. Remote Sens. Mag.(replaces Newsletter)* |
| IEEE Industrial Electronics Magazine | *IEEE Ind. Electron. Mag.* |
| IEEE Industry Applications Magazine | *IEEE Ind. Appl. Mag.* |
| IEEE Instrumentation and Measurement Magazine | *IEEE Instrum. Meas. Mag.* |
| IEEE Intelligent Systems (formerly IEEE Expert) | *IEEE Intell. Syst.* |
| IEEE Intelligent Transportation Systems Magazine | *IEEE Intell. Transp. Syst. Mag.* |
| IEEE Internet Computing Magazine | *IEEE Internet Comput.* |
| IEEE IT Professional | *IEEE IT Prof.* |
| IEEE Micro Magazine | *IEEE Micro* |
| IEEE Microwave Magazine | *IEEE Microw. Mag.* |
| IEEE MultiMedia | *IEEE Multimedia Mag.* |
| IEEE Nanotechnology Magazine | *IEEE Nanotechnol. Mag.* |
| IEEE Network | *IEEE Netw.* |
| IEEE Personal Communications | *IEEE Pers. Commun.* |
| IEEE Potentials | *IEEE Potentials* |
| IEEE Power Electronics Magazine | *IEEE Power Electron. Mag.* |
| IEEE Power and Energy Magazine | *IEEE Power Energy Mag.* |
| IEEE Power Engineering Review | *IEEE Power Eng. Rev.* |
| IEEE Pulse | *IEEE Pulse* |
| IEEE Robotics and Automation Magazine | *IEEE Robot. Autom. Mag.* |
| IEEE Signal Processing Magazine (1991–present) | *IEEE Signal Process. Mag.* |
| IEEE Solid-State Circuits Magazine | *IEEE Solid State Circuits Mag.* |
| IEEE Security and Privacy | *IEEE Security Privacy* |
| IEEE Software | *IEEE Softw.* |
| IEEE Spectrum | *IEEE Spectr.* |
| IEEE Technology and Society Magazine | *IEEE Technol. Soc. Mag.* |
| IEEE Vehicular Technology Magazine | *IEEE Veh. Technol. Mag.* |
| China Communications Magazine | *China Commun.* |
| Communications Surveys and Tutorials | *Commun. Surveys Tuts.* |
| Computer Magazine | *Computer* |
| Internet Computing | *Internet Comput.* |
| Pervasive Computing | *Pervasive Comput.* |
| Today's Engineer | *Today's Engineer* |
| Wireless Communications | *Wireless Commun.* |

## G. 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 complete list can be found in Section VIII-I.

| | |
|---|---|
| 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–E | base–emitter source |
| BER | bit error rate* |
| BPSK | binary phase-shift keying |
| BWO | backward-wave oscillator* |
| | |
| 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* |
| | |
| 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* |
| | |
| 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* |
| 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* |
| | |
| GUI | graphical user interface |
| | |
| HBT | heterojunction bipolar transistor |
| HEMT | high-electron mobility transistor |
| HF | high frequency |
| HTML | hypertext markup language |
| HV | high voltage |
| HVdc | high voltage direct current |
| | |
| 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 |
| | |
| JFET | junction field-effect transistor |
| JPEG | Joint Photographers Expert Group |
| | |
| 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 |
| | |
| 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 |

| | |
|---|---|
| NA | numerical aperture* |
| NIR | near infrared response* |
| NMR | nuclear magnetic resonance* |
| n-p-n | (diode) |
| NRZ | nonreturn to zero* |
| | |
| OD | outside diameter |
| OEIC | optoelectronic integrated circuit* |
| OOP | object-oriented programming |
| | |
| 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* |
| | |
| $Q$ | quality factor; figure of merit |
| QoS | quality of service |
| QPSK | quaternary phase-shift keying |
| | |
| 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 |
| | |
| 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* |
| | |
| UHF | ultrahigh frequency |
| UV | Ultraviolet |
| | |
| VCO | voltage-controlled oscillator* |
| VHF | very high frequency* |
| $V–I$ | voltage–current |
| VLF | very low frequency* |
| VLSI | very large scale integration* |
| | |
| WAN | wide area network |
| WDM | wavelength division multiplexing* |