

# **IEEE EDITORIAL STYLE MANUAL FOR AUTHORS**

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# I. INTRODUCTION

## A. Purpose of Manual

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

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

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

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

## C. IEEE Transactions Editing Philosophy

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

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

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

# II. WRITING PRINCIPLES

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

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

## A. Writing Parts of an Article

### Title

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

#### Examples:

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

### Byline and Membership Citation

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

#### Examples:

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

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

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

### IEEE Membership Grades

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

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

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

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### First Footnotes

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

**Example:**

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

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

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

Digital Object Identifier 10.1109/JDT.2013.2278036

**First Paragraph:**

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

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

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

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

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

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

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

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

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

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

Manuscript received July 4, 2018; revised September 4, 2018. Date of publication June 8, 2018; date of current version July 18, 2018. This work was supported by the UDDHSCSU under Grant PN-JJ78/01.10.2067 and Grant FR11 331/94.57.2067. The associate editor coordinating the review of this manuscript and approving it for publication was Prof. Vesa Valimäki. (*Corresponding author: Jinjun Ming.*)

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

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

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

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

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

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

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

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

## Second Paragraph

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

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

The author is with the Department of Electrical Engineering, Rutgers University, Piscataway, NJ 08854 USA, and also with Bellcore, Morristown, NJ 07960 USA (e-mail: [author@ieee.org](mailto: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](mailto: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](mailto: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](mailto:firstauthor@mit.edu); [lamNext@mit.org](mailto:lamNext@mit.org); [thirdauthor@ieee.org](mailto:thirdauthor@ieee.org)).

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

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

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](mailto: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](mailto:corresponding-author@ieee.org)).

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

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

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

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

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

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](mailto:retiredauthor@yahoo.com)).

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

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

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

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

### **Third Paragraph**

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

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

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

*Multimedia:* If an article has multimedia or any other online-only material, such as datasets, include the paragraph here, usually with a brief description. There are two items that are needed in order to successfully post multimedia: the multimedia files themselves and a ReadMe file (which needs to be in PDF format for posting on IEEE Xplore) filled out with all the appropriate information

This paper has supplementary downloadable multimedia material available at <http://ieeexplore.ieee.org> provided by the authors. This includes a power point file, which shows the background introduction, compliant mechanism design, kinematics, dynamics, finite element analysis, prototype fabrication, experimental study, and conclusion. This material is 13.8 MB in size.



## B. The Body of the Article

### Abstract

Every published article must contain an Abstract which must be one paragraph and between 150 to 250 words. By nature, Abstracts shall not contain numbered mathematical equations nor numbered references. Numbered reference citations are not allowed.

In order for an abstract to be effective when displayed in IEEE*Explore* 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.

### Index Terms

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

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

### Note to Practitioners

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

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

### Nomenclature

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

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

Equations in an item should be handled as follows.

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

#### NOMENCLATURE

<i>SPQ</i>	Strictly proper pole constraints.
<i>M</i>	Minimal weighted sensitivity.
<i>P(s)</i>	Physical feedback.
<i>W</i>	Weighting.
<i>Q</i>	$= P - 1$ . Improper function.
<i>S, l</i>	Signal density, $= P, M$ .

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

## Text Section Headings

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

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

### I. INTRODUCTION

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

#### A. Formal Frameworks

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

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

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

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

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

### REFERENCES

### ACKNOWLEDGMENT (note spelling here)

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

### APPENDIX

#### APPENDIX I PROOF OF THEOREM

#### APPENDIX A PROOF OF THEOREM

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

*In-text references to text sections* are written: “in Section II” or “in Section II-A” or “in Section II-A1.” Capitalize the word “Section.” Do not use the word “Subsection”; use “Section” and write out the complete citation.

## Introduction

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

## Text Equations

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

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

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

## Appendix

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

## Acknowledgment

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

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

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

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

Write the Acknowledgment section in the third person.

## References

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

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

### Example:

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

The References should be written as follows:

[37] E. G. Bowen, *Radar Days*. London, U.K.: Institute of Physics, 1987.

[38] L. Brown, *A Radar History of World War II: Technical and Military Imperatives*. London, U.K.: Institute of Physics, 1999.

[39] S. Swords, *Technical History of the Beginnings of Radar*. Stevenage, U.K.: Peregrinus, 1986.

[40] H. Guerlac, *Radar in World War II*. New York, NY, USA: Tomash Publishers/Amer. Inst. of Physics, 1987.

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

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

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

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

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

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

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

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

## Text Citation of Figures and Tables

All first citations of figures and tables in the article must be in numerical order. Citations to figures in text always carry the abbreviation "Fig." followed by the figure number. The abbreviation is used even when it begins a sentence.

### *Figures:*

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

### *Example:*

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

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

### *Examples:*

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

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

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

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

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

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

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

**Examples:**

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

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

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

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

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

TABLE I  
PARAMETER VALUES

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

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*Reusing IEEE graphics previously published in IEEE publications. You will need to request permission directly from IEEEExplore. In most 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 articles from which the graphics are being used.*

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

## Biographies

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

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

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

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

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

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

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

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

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

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

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

#### **Examples:**

**Michael C. Author, Jr.** (S'87–A'89–SM'90–F'93) was born in New York, NY, USA, in 1969. He received the B.S. degree in applied mathematics from the University of Michigan, Ann Arbor, MI, USA, in 1989, the M.S. degree in mathematical physics from Stanford University, Stanford, CA, USA, in 1991, and the Ph.D. degree in electrical engineering from the Massachusetts Institute of Technology, Cambridge, MA, USA, in 1995.

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

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

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

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

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

## **Squibs**

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

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

## **C. Other Text**

### **Footnotes**

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

### **Lists in Text**

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

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

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

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

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

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

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

**Example:**

The three problems are related in the following sense:

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

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

The synthesis is performed in three major steps.

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

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

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

**Example:**

where

$$\Delta v_S = \Delta V_S \cos(\omega' t + \phi');$$

$\Delta V_S$  amplitude of supply voltage flicker;  
 $\omega'$  angular frequency of supply voltage flicker;  
 $V_{Sf}$  supply voltage amplitude;  
 $\omega$  supply angular frequency.

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

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

### Dedication Line(s)

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

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

### Note Added in Proof

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

**Example:**

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

*Note Added in Proof:* Additional information about similar research can be found at [www.newresearchresults.com](http://www.newresearchresults.com).

## D. Other Types of Papers

### Editorials

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

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

**Example:**

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

### Brief Papers

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

### Short Papers, Correspondence, and Communications

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

### Comments and Replies

Comments are generally in response to a previously published article. The Comments and Author(s) Reply are short papers published together in that the “Reply” is in response to the Comments. These short items may appear



without Abstracts. A special format applies for Comments and Author(s) Reply. Begin the first sentence with “In the above paper [1], ...” Reference [1] is the commented paper’s citation, will appear as Reference [1] in the References section. Include a copyright line for Comments and Replies.

Some publications refer to these articles as Discussions and Closures.

Index Terms are optional.

Example of the Comments:

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

*Byline:* Keith H. Sueker

*Footnote:*

Manuscript received July 15, 2006.

The author is with the School of Engineering, Vanderbilt University, Nashville, TN 37235 USA (e-mail: k.sueker@ieee.org).

Digital Object Identifier 10.1109/JQE.2006.12345

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

Example of the Reply:

*Title:* Authors’ Reply

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

*Footnote:*

Manuscript received October 3, 2006; accepted October 5, 2006. Date of publication November 2, 2006; date of current version November 25, 2006.

The authors are with RDH Consultants, Inc., Charlotte, NC 28241 USA (e-mail: corresponding@author.com).

Digital Object Identifier 10.1109/JQE.2006.12348

## Corrections/Errata

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

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

Example of a “Corrections” article:

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

*Byline:* Costas Psychalinos and Spiridon Vlassis

*Footnote:*

Manuscript received May 1, 2003.

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

Digital Object Identifier 10.1109/TCSII.2003.814788

Example of Errata:

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

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

*Footnote:*

Manuscript received January 20, 2004.

The authors are with RDH Consultants, Inc., Charlotte, NC 28241 USA (e-mail: pjrose@rdh.com).

Digital Object Identifier 10.1109/TVLSI.2004.830244

## Book Reviews

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

*Title and Byline:*

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

*First Footnote:*

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

*Table of Contents:*

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

## Obituaries/In Memoriam

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

## E. Writing Style for Transactions

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

### Acronyms

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

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

### Spelling

Note that IEEE Transactions use the first spellings indicated in our first reference, the most current edition of *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-H, p. 22.

### Trademarks

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

## Plurals

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

## Hyphenation Rules

For hyphenation and spelling guidelines, IEEE style follows: 1) the list of preferred spellings and hyphenated words can be found in the Appendix; 2) the guidelines discussed in the Grammar and Usage in Transactions section of this guide on p. 22; and 3) the first version of the spelling given in the most recent edition of *Webster’s New Collegiate Dictionary*. Do not hyphenate most compound modifiers if they occur after the noun being modified, even if hyphenating them before the noun. *Examples:*

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

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

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

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

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

### *Examples:*

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

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

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

## Grammar

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

### *Number:*

A number of samples were taken ...

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

### *Data:*

The data were collected ... (always plural)

### *Series:*

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

### *Some, All, Half:*

Some (all, half) of it is ...

Some of them are ...

For example:

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

*Quantity:*

Three volts were applied ...

Four grams were added ...

## Contractions

Contractions such as "don't" and "can't" are not used in technical text. Change to "do not" and "cannot."

Note: "don't care," "best-case," and "worst-case" are allowed and used often in journals like TCAD.

## Capitalization

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

## Math

Some brief guidelines for writing math are explained here.

- 1) Variables are set italic; vectors are usually boldface italic.
- 2) Remove commas around variables in text.
- 3) Always add a zero before decimals, but do not add after (e.g., 0.25).
- 4) Check the use of the parentheses and brackets i.e., [0,1).
- 5) Spell out units used in text without quantities (e.g., "where the noise is given in decibels"). For units appearing with quantities, use the standard abbreviations listed in Section VI, Appendix, J, p. 29, and units used as compound adjectives may be hyphenated only if needed for clarity: 10-kV voltage, 5-in-thick glass. Do not insert a hyphen when they are not used as adjectives: a current of 2 A, a line 4 in long, a length of 3.05 mm.
- 6) Use thin spaces instead of commas between numbers in tens or hundreds of thousands (e.g., 62 000, 100 000, but 4000).
- 7) Always make sure  $\mu$  is  $\mu\text{m}$ , "micron" is "micrometer," "submicron" is submicrometer." Always change cycle per second to hertz (Hz); cycle per second may not appear as cycle, cps, c/s, csec.
- 8) In text, fractions may be broken down (shilled) multiline (built-up) so they can be placed on one line. Sometimes parentheses may need to be added to distinguish between expressions, especially when a minus appears [e.g.,  $\frac{a}{b-c}$  becomes  $a/(b-c)$ ],  $\frac{c-d}{k+4}$  becomes  $[(c-d)/(k+4)]$ . This may be done to save space, but is not a necessity.
- 9) In exponential expressions [e.g.,  $e^{-(j\omega t)xyzk}$ ], there are sometimes long and complicated superscripts. These may be brought down in line with the substitution of "exp" for "e" and the addition of square brackets (e.g.,  $\exp[-(j\omega t)xyzk]$ ).
- 10) Distinguish between lowercase italic "ell" or "oh" versus one and zero.
- 11) 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).
- 12) Use zeroth, first,  $n$ th,  $(k+1)$ th, not 1st, 2nd,  $(k+1)$ st, etc.
- 13) Use the word "Equation" at the start of a sentence, but in text, just use the number [e.g., in (1)].
- 14) Use the \$ symbol versus "dollars" in sums of money.
- 15) The slash (/) is acceptable in place of the word "per" when it lends to the clarity of the sentence. For example: "the ratio of 16 samples/s to 35 samples/s as compared to ..."

*Ellipses:* In mathematics, you may use dots (ellipses) to show continuation in an expression (e.g.,  $x_2, \dots, x_{16}$ ). The type of mathematical expression will determine whether the ellipses points are set on the baseline or centered. If

commas or operational signs are present, they are placed after each term and after the three ellipses points. If operational signs are used, the ellipses are centered on the operator. When commas are used, the ellipses are on the baseline. Example:

$$x_1, x_2, \dots, x_n \text{ not } x_1, x_2 \dots x_n$$

$$x_1 + x_2 + \dots + x_n \text{ not } x_1 + x_2 + \dots x_n$$

$$y = 0, 1, 2, \dots \text{ not } y = 0, 1, 2 \dots$$

$$x_1 x_2 \dots a_n \text{ not } x_1 x_2 \dots a_n$$

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

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

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

$$x = yn^{-2}, \quad y = 3, \dots, m$$

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

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

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

$$x = Y + Z.$$

or where, i.e.,

$$x = Y + Z.$$

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

## Equation Numbers

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

## Displayed Equations

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

## F. General Layout Rules

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

## III. GRAMMAR AND USAGE IN TRANSACTIONS

### A. Rules of Grammar

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

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

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

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

*Robert D. Lorenz, Ph.D.*

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

*E. A. Brockmann, Jr., states that...*

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

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

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

- 4) **A semicolon is used to link two independent clauses with no connecting words. You can also use a semicolon to join two independent clauses together with one of the following conjunctive adverbs: however, moreover, therefore, consequently, otherwise, nevertheless, thus, etc.**
- 5) **Use a colon after an independent clause to introduce a list.**
- 6) **Punctuation always goes inside quotation marks, except for the colon and semicolon.** Use single quotation marks around quotes within quotes. Quotes may be used around a new or special usage of a term the first time only, but use of quotes in this manner should be kept to a minimum.
- 7) **Do not use double parentheses in text expressions, but keep them in math.** For example, (see (10)) should become [see (10)].
- 8) **All acronyms and numerical plurals do not use apostrophes**, i.e., *FETs, 1980s* (Note: Some exceptions may apply in mathematical writing.)
- 9) **Compound nouns made from a one-syllable verb and a short adverb are one word when found that way in the dictionary** (setup, takeoff, breakup). Compound nouns are likely to be two words, without a hyphen, or one word (bandwidth, bypass, flowchart, phase shift, sideband, standing wave). Compound nouns of more than two words can be hyphenated.
- 10) **A pair of words, modifying a third word separately, does not get a hyphen** (a tall water tower, a hot metal cylinder). If the first word modifies the second, and the pair together modify the third, there is a hyphen between the pair (a high-frequency signal, a second-order equation). The exception to this is the adverb ending in “ly,” which needs no hyphen to join it to the next word.

- 11) **A hyphen is not used after the comparative or the superlative** (a higher order equation, a worst case value, nearest neighbor method). Do not hyphenate chemical compounds (sodium chloride crystals). Alloys and mixtures take the en dash (Ni–Co, He–Ne laser).
- 12) **Do not use commas between adjectives** (a planar equiangular spiral antenna).
- 13) **Do not hyphenate predicate adjectives** (... is well known, ...is second order).
- 14) If you are unsure, check *Webster's New Collegiate Dictionary* to see if words are hyphenated.
- 15) **Compound verbs are generally hyphenated** (arc-weld, freeze-dry). Keep the hyphen when using the participles of such verbs as adjectives (freeze-dried, arc-welded). However, verbs with up, out, down, off, on, etc., do not have a hyphen, although the nouns formed from them may be hyphenated or one word (verb: set up, break down, read out; noun: setup, breakdown, readout).

### Words Often Confused

Affect: to change or modify (verb).

Effect: result (noun); cause (verb).

Alternate: a substitute.

Alternative: a matter of choice.

Among: involves more than two things.

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

Compare to: point out resemblances between different objects.

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

Compose: to make up or form: a set composed of members.

Comprise: to be made up of; to be formed by: a set comprising members; members comprising a set.

Farther: distance.

Further: quantity.

Fewer: modifies plural nouns specifying countable units, e.g., fewer tubes.

Less: modifies singular mass nouns and singular abstract nouns, e.g., less air.

Imply: something suggested though not expressed.

Infer: something deduced from evidence.

Number: used when objects can be counted: a large number of people.

Amount: used when objects cannot be counted: a large amount of water.

Principal: chief, main, most important (adjective).

Principle: a rule (noun).

Precede: come before.

Proceed: continue, advance.

That: (defining, restrictive).

Which: (nondefining, nonrestrictive)