

How to Use the IEEEtran BIB_TE_X Style

Michael Shell, *Member, IEEE*

Abstract—This article describes how to use the IEEEtran.bst BIB_TE_X style file to produce bibliographies that conform to the standards of the publications of the Institute of Electrical and Electronics Engineers (IEEE).

Index Terms—bibliography, BIB_TE_X, IEEE, L^AT_EX, paper, style, template, typesetting.

I. INTRODUCTION

THE IEEEtran.bst BIB_TE_X style file described in this document can be used with BIB_TE_X to produce L^AT_EX bibliographies of high quality that are suitable for use in IEEE publications. Other potential applications include thesis and academic work, especially when such work is in the area of electrical and/or computer engineering.

This document applies to version 1.10 and later of the IEEEtran BIB_TE_X style. Prior versions do not have all of the features described here. IEEEtran.bst will display the version number on the user's console during execution. The most recent version of this package can be obtained on CTAN [1] and may also be mirrored at various places within IEEE's website [2].

It is assumed that the reader has a basic understanding of the operation and use of BIB_TE_X. Documentation for the use of BIB_TE_X includes the user's guide [3] as well as supplementary information which addresses frequently asked questions [4]. The large collection of sample bibliographies and string definitions at the T_EX User Group Bibliography Archive may also be of help [5]. General support for BIB_TE_X related questions can be obtained in the internet newsgroup comp.text.tex.

Note that the references section of this document is used for two purposes: (1) to provide information where additional information can be found; and (2) to provide examples of references created using the IEEEtran BIB_TE_X style. The first few citations above fall into the first category, while virtually all of the citations that follow will serve as examples and are not meant to be actually referred to. Hopefully, it will be clear from context which way a particular reference is used.

II. INSTALLATION

The IEEEtran BIB_TE_X package consists of the following files:

IEEEtran_bst_HOWTO.pdf: This documentation.

Manuscript created on June 20, 2002; revised September 27, 2002. The opinions expressed here are entirely that of the author. No warranty is expressed or implied. User assumes all risk.

M. Shell is with the Georgia Institute of Technology.
Email: mshell@ece.gatech.edu See [1] for current contact information.

IEEEtran.bst: The standard IEEEtran BIB_TE_X style file (unsorted, i.e., references will appear in the order in which they are cited).

IEEEtranas.bst: The IEEEtran BIB_TE_X style file, but with additional sorting code (similar to that of plain.bst) which sorts the entries based on the names of the authors, editors, organizations, etc. May be of interest for non-IEEE related work. Do not use for work that is to be submitted to the IEEE.

IEEEexample.bib: A BIB_TE_X database that contains the references shown in the references section of this document. Users can copy the entries therein to serve as starting templates. The entries also have comments which may be of additional help.

IEEEfull.bib: A file that contains a comprehensive set of BIB_TE_X string definitions for the full names of IEEE journals and magazines. Because IEEE's bibliography style uses abbreviated journal names, this file's intended use is for work that is not to be submitted to the IEEE.

IEEEabrv.bib: Same as above, but contains the abbreviated form of the journal and magazine names. Recommended for work that is to be submitted to the IEEE.

IEEEbcpat.bib: Older versions of IEEE BIB_TE_X style files usually provide several string definitions ("acmcs," "acta," etc.) for a few of the popular computer related journals. However, it is inappropriate to provide journal name definitions within .bst files as this prevents entries that use them from working with other .bst files (that may not contain the needed definitions). Furthermore, these older definitions are not abbreviated as needed for IEEE related work. IEEEtran.bst does not provide the older definitions as it is designed to work with the newer "external" IEEEabrv.bib definitions instead. To provide for backward compatibility, IEEEbcpat.bib contains these obsolete definitions and can be loaded prior to any existing database files that still depend on them. Do not use the IEEEbcpat.bib definitions for new entries, or work that is to be submitted to the IEEE.

BIB_TE_X .bst files can be accessed system-wide when they are placed in the

```
<texmf>/bibtex/bst
```

directory, where <texmf> is the root directory of the user's T_EX installation. Similarly, system-wide .bib files (IEEEfull.bib and IEEEabrv.bib) can be placed in

```
<texmf>/bibtex/bib
```

On some L^AT_EX systems, the directory look-up tables will need to be refreshed after making additions or deletions to the system files. For t_EX and f_PT_EX systems this is accomplished via executing

texhash

as root. Mik_TE_X users can run

```
initexmf -u
```

to accomplish the same thing.

Users not willing or able to install the files system-wide can make the copies local, but will then have to provide the path (full or relative) as well as the filename when referring to them in L_AT_EX.

III. USAGE

IEEEtran.bst is invoked using the normal L_AT_EX bibliography commands:

```
\bibliographystyle{IEEEtran}
\bibliography{IEEEabrv,mybibfile}
```

String definition files must be loaded before any database files containing entries that utilize them — so the file names within the `\bibliography` command must be listed in a proper order.

In standard BIB_TE_X fashion, new documents will require a L_AT_EX run followed by a BIB_TE_X run and then two more L_AT_EX runs in order to resolve all of the references. An additional series of runs will be required as citations are added to the document.

A. Resource Requirements

IEEE’s bibliography style has several unique attributes that increase the complexity of BIB_TE_X styles that attempt to mimic it. Because the primary design goal of IEEEtran.bst is to reproduce the IEEE bibliography style as accurately and as fully as possible, IEEEtran.bst will consume significantly more computation resources (especially memory) during execution than many other BIB_TE_X style files. Most modern BIB_TE_X installations will be able to meet these demands without problem. However, some earlier BIB_TE_X platforms, especially those running on the MS Windows operating system, may be unable to provide the required memory space. Such platforms often provide as an alternative the higher-capacity¹ “8-bit BIB_TE_X” in the form of a “bibtex8” executable which IEEEtran.bst is fully compatible with. Users who encounter BIB_TE_X resource limitations should upgrade their BIB_TE_X installation. More details on this topic can be found in [4].

B. Nonstandard Extensions

Another, related, issue is that IEEEtran.bst provides extensions beyond the standard BIB_TE_X entry types and fields. These additional features are necessary for IEEE style work and were designed to closely follow the existing as well as “probable future” releases of the standard BIB_TE_X styles. Nevertheless, users should be aware that many current BIB_TE_X styles may not be compatible with BIB_TE_X databases that employ advanced features of IEEEtran.bst. BIB_TE_X will generate an error

¹However, command options may be needed to obtain the higher capacity, e.g., `bibtex8 -H myfile`. Use `bibtex8 -help` to list the possible options.

if it encounters a (cited) entry type that the style file does not support, but unsupported fields within an entry will simply be ignored. For this reason, users are encouraged to keep all nonstandard entry types in a BIB_TE_X database (.bib) file of their own. The nonstandard IEEEtran.bst entry types are: (1) “electronic” which is used for internet references; (2) “patent” which is used for patents; (3) “periodical” which is used for journals and magazines; and (4) “standard” which is used for published standards.

The most important extensions to the supported fields will now be briefly mentioned.

1) *The URL Field*: Every entry type supports an optional URL entry field for documents that are available on the internet. URLs will appear at the end of the bibliography entry and preceded by the words “[Online]. Available:” as is shown in [1]. IEEE does not place any punctuation at the end of a URL as this could be mistaken as being part of the URL. URLs are notoriously difficult to break properly. IEEEtran.bst places all URL text within a `\url{}` command so as to provide “plug-and-play” use with packages that provide such a command. It is strongly suggested that, when using entries with URLs, the popular L_AT_EX package `url.sty` [6] is also loaded to provide some intelligence in URL line breaking. Alternatively, the `hyperref.sty` package [7] also provides a `\url` command. However, unless the user needs hyperlinks, `url.sty` might be a better approach because it is “lightweight” and less likely to exhibit compatibility issues.

Users should be aware that version 1.5 and prior of `url.sty` interacts with BIB_TE_X (version 0.99c and prior) in way that can result in the anomalous appearance of “%” symbols within the URLs. To avoid this problem, it is recommended that users modify (or possibly upgrade) their `url.sty` package if they are using version 1.5 or earlier. The following code,² when placed just after where the `url.sty` package (version 1.5) is loaded, or at the end of the definitions within the `url.sty` file (just before the `\endinput` line), will correct the problem by configuring `url.sty` to ignore “%” symbols that are immediately followed by line feeds within the `\url` command:

```
\begingroup
\makeatletter
\g@addto@macro{\UrlSpecials}{%
  \endlinechar=13 \catcode\endlinechar=12
  \do\%{\Url@percent}\do\^M{\break}}
\catcode13=12 %
\gdef\Url@percent{\@ifnextchar^M{\@gobble}{\mathbin{\mathchar`%}}}%
\endgroup %
```

If the T_EX system is used by others, the original `url.sty` should be retained and the modified version given a different name (e.g., “`url_15b.sty`”). Note that any renamed style file needs its “`\ProvidesPackage`” line updated to reflect the current filename or else L_AT_EX will issue a (harmless) warning.

The `\url` command from recent versions of `hyperref.sty` does not exhibit this problem. For more details, see [4].

Even with intelligent URL breaking, formatting an entry with a URL can still pose challenges as URLs may contain long segments within which breaks are not possible (or at least

²This T_EX code can also be obtained from [4].

strongly discouraged). In its publications, IEEE deals with this problem by allowing the interword space to stretch more than usual. To accomplish this, IEEEtran.bst automatically engages a “super-stretch” feature for every entry that contains a URL. The interword spacing within entries that contain URLs is allowed to stretch up to four times normal without causing underfull hbox warnings. Reference [1] illustrates this feature.

Section VII discusses how users can control the amount of allowed stretch in entries with URLs. Alternatively, the default value of this stretch factor can be adjusted via a \LaTeX command, which must be placed before the bibliography begins:

```
\providecommand\BIBentryALTinterwordstretchfactor{2.5}
```

However, these adjustment mechanisms are of limited use because reducing the stretch factor usually just results in underfull hbox warnings. Another way to handle problem URLs is to configure url.sty to allow more possible break points.

2) *The Language Field:* IEEEtran.bst supports an optional language field which allows alternate hyphenation patterns to be used for the title and/or booktitle fields when these fields are in language other than the default. For examples, see sections V-N and VI-B as they each contain a reference that uses the language field. This feature is especially important for languages that alter the spelling of words based on how they are hyphenated.

Unlike some other BIB_TE_X style files, the use of the Babel package is not required to use this feature. In fact, Babel.sty should *not* be loaded with IEEEtran.cls as the former can interfere with the latter. However, the names given in the language field must follow Babel’s convention for the names of the hyphenation patterns. See the Babel documentation for details [8].

It is a \TeX limitation that, to be available for use, a hyphenation pattern must be loaded within a “format file” (memory image) and, therefore, cannot be loaded when running a .tex file. A list of available patterns is displayed on the console each time \LaTeX is started. If a requested hyphenation pattern is not available, the default will be used and a warning will be issued. Users wishing to add hyphenation patterns will need to activate the desired ones in their

```
<texmf>/tex/generic/config/language.dat
```

file and rebuild their \LaTeX format file³. Adding hyphenation patterns does reduce the amount of memory available to \TeX , so it cannot be done with impunity.

3) *Expanded Use of the Howpublished Field:* The standard BIB_TE_X styles support the howpublished field for the booklet and misc entry types. IEEEtran.bst extends this to also include electronic, manual, standard and techreport. The rationale for doing this is because, with these entry types, there is often a need to explain *in what form* the given work was produced. The additional information provided by howpublished

³On $\text{te}\TeX$ (UNIX) and $\text{fp}\TeX$ systems this can be accomplished simply by running “fmtutil --all” as root. For $\text{MiK}\TeX$ users, the command “initexmf --dump” will do the trick.

is placed, as given, in normal font, just after the title (or booktitle, if used) of the entry.

IEEE exploits this feature most often for electronic references, but it has application with any entry whose exact form would be unclear without additional information (unlike optional notes which tend to be more “by the way” in nature). See section V for more details.

C. Use With Cross-referenced Entries

IEEE bibliographies do not normally contain references that refer to other references. Therefore, IEEEtran.bst does not format entries that use cross references (via the crossref field) any differently from entries that don’t. Nevertheless, it does allow the entries using the crossref field to silently inherit any missing fields from their respective cross-referenced entries in the standard BIB_TE_X manner. However, users who take advantage of this “parent/child” feature are cautioned that BIB_TE_X will automatically, and without warning, add a cross-referenced entry to the end of the bibliography if the number of references using the cross-reference is equal to or greater than “min-crossrefs.” Because such additional entries are unwanted in IEEE style, users who employ cross-referenced entries need to ensure that the cross-referenced entries are not added to the bibliography. The default value of min-crossrefs on most BIB_TE_X systems is two. Unfortunately, this value is set when BIB_TE_X is compiled and cannot be altered within .bst files. However, BIB_TE_X does offer a way to control it on the command line. Therefore, when using cross-referenced entries, users must remember to set min-crossrefs to a large value (greater than the number of bibliography entries) when invoking BIB_TE_X:

```
bibtex -min-crossrefs=900 myfile
```

Because cross-referenced entries must always appear after any entries that refer to them, it is recommended that the cross-referenced entries be kept in separate (.bib) file(s) so that they can be loaded after the other (.bib) database files:

```
\bibliography{IEEEabrv,mybibfile,myxrefbibs}
```

IV. EXAMPLES OF THE THREE MOST COMMONLY USED ENTRY TYPES

Journal articles, conference papers and books account for the vast majority of references in most IEEE bibliographies. It may be helpful to the user to briefly illustrate a simple example of each of these common entry types before divulging into ones with more complex or obscure details.

A typical journal article entry looks like

```
@article{IEEEexample:article_typical,
  author = "S. Zhang and C. Zhu and J. K. O. Sin
    and P. K. T. Mok",
  title = "A Novel Ultrathin Elevated Channel
    Low-temperature Poly-{Si} {TFT}",
  journal = IEEE_J_EDL,
  volume = "20",
  month = nov,
  year = "1999",
  pages = "569-571"
};
```

which is shown as reference [9]. Using an entry key prefix that is used only by the given database file (“IEEEexample” in the above entry) ensures that the entry key will remain unique even if multiple database files are used simultaneously. Although initials are used for the first names here, users are encouraged to use full names whenever they are known as IEEEtran.bst will automatically abbreviate names as needed (but BIBTEX styles that use full names will require them to be present). Likewise, it is a good idea to provide all the authors’ names rather than using “and others” to get “et al.” [10]. Section VII describes how IEEEtran.bst can be configured to force the use of “et al.” if the number of names exceeds a set limit.

Within the title, braces are used to preserve the capitalization of acronyms. The journal name is entered as a string that is defined in the IEEEabrv.bib file. Not only does this approach reduce the probability of spelling mistakes, but it allows the user to instantly switch to full journal names by using the IEEEfull.bib definitions instead (not for use with work to be submitted to the IEEE). In like fashion, the month is entered as a standard BIBTEX three letter code⁴ so that the month format can automatically be controlled by the string (macro) month name definitions provided within every .bst file.

It is generally a good idea to also provide the journal number, but many journal article references in IEEE publications do not show the number. Section VII discusses how the user can configure IEEEtran.bst to ignore journal numbers for articles.

A typical paper in a conference proceedings entry looks like

```
@inproceedings{IEEEexample:conf_typical,
  author   = "R. K. Gupta and S. D. Senturia",
  title    = "Pull-in Time Dynamics as a Measure
             of Absolute Pressure",
  booktitle = "Proc. {IEEE} International Workshop
             on Microelectromechanical Systems
             ({MEMS}'97)",
  address  = "Nagoya, Japan",
  month    = jan,
  year     = "1997",
  pages    = "290-294"
};
```

which is shown as reference [11].

IEEE typically prepends “Proc.” to the conference name (when forming the booktitle field):

```
booktitle = "Proc. {ECOC}'99",
```

IEEEtran.bst does *not* do this automatically as it may not be appropriate for every conference.

The conference entry type is also available as an alias for inproceedings. There is no functional difference between the two.

Finally, a typical book entry looks like

```
@book{IEEEexample:book_typical,
  author   = "B. D. Cullity",
  title    = "Introduction to Magnetic Materials",
  publisher = "Addison-Wesley",
  address  = "Reading, MA",
  year     = "1972"
};
```

⁴For reference, these are: jan, feb, mar, apr, may, jun, jul, aug, sep, oct, nov and dec.

which is shown as reference [12]. One of the unusual attributes of IEEE bibliography references is that, when formatting entries, they precede the publisher address with a period and a larger than normal space.

V. SUPPORTED ENTRY TYPES

The fields that are recognized by each entry type are shown at the beginning of each of the subsections below. A **bold** font indicates a required field, while a *slanted* font is used to indicate fields that are extensions that may not be supported by the standard BIBTEX styles for the given entry type.

The reader is reminded that IEEEexample.bib file contains the actual BIBTEX entries that were used to make the references demonstrated here.

A. Article

Supported fields: **author**, **title**, *language*, **journal**, volume, number, pages, month, **year**, note, *url*.

Another typical journal article is shown in [13]. Because the referenced journal was not published by the IEEE, the IEEEabrv.bib file will not contain the needed string definition. So, the user will either have to make his/her own supplementary string definition file, or enter the abbreviated journal name directly into the journal field. See published IEEE bibliographies for examples of how to properly abbreviate the journal name at hand. Note also how IEEE uses small spaces to divide page (and other) numbers with five digits or more into groups of three. As mentioned previously, the display of the number field for articles can be controlled (see section VII).

Sometimes it is desirable to put extra information into the month field such as the day, or additional months [14]. This is accomplished by using the BIBTEX concatenation operator “#”:

```
month = sep # "/" # oct,
```

1) *Articles Pending Publication:* Articles that have not yet been published can be handled as a misc type with a note [15]:

```
@misc{IEEEexample:TBPmisc,
  author   = "M. Coates and A. Hero and R. Nowak
             and B. Yu",
  title    = "Internet Tomography",
  howpublished = IEEE_M_SP,
  month    = may,
  year     = "2002",
  note     = "to be published"
};
```

(date information is optional) or they can be handled as an article type with the pending status in the year field [16]:

```
@article{IEEEexample:TBPparticle,
  author   = "N. Kahale and R. Urbanke",
  title    = "On the Minimum Distance of Parallel
             and Serially Concatenated Codes",
  journal  = IEEE_J_IT,
  year     = "submitted for publication"
};
```

B. Book

Supported fields: **author** and/or **editor**, **title**, *language*, edition, series, address, **publisher**, month, **year**, volume, number, note, *url*.

Books may have authors [12], editors [17] or both [18]. Note that the standard BIB_TE_X styles do not support book entries with both author and editor fields, but IEEEtran.bst does.

The standard BIB_TE_X way of entering edition numbers is in capitalized ordinal word form:

```
edition = "Second",
```

IEEEtran.bst can automatically convert up to the tenth edition to the “Arabic ordinal” form (e.g., “2nd”) that IEEE uses. For editions over the tenth in references that are to be used in IEEE style bibliographies, it is best to enter edition fields in the “Arabic ordinal” form (e.g., “101st”).

A book may also be part of a series and have a volume or number [19].

C. Inbook

Supported fields: **author** and/or **editor**, **title**, *language*, edition, series, address, **publisher**, month, **year**, volume, number, chapter, type, pages, note, *url*.

Inbook is used to reference a part of a book, such as a chapter [20] or selected page(s) [21]. The type field can be used to override the word chapter (for which IEEE uses the abbreviation “ch.”) when the book uses parts, sections, etc., instead of chapters

```
type = "sec.",
```

D. Incollection

Supported fields: **author**, **title**, **booktitle**, *language*, edition, series, editor, address, publisher, month, **year**, volume, number, chapter, type, pages, note, *url*.

Incollection is used to reference part of a book having its own title [22]. Like book, incollection supports the series [23], chapter and pages fields [24]. Also, the type field can be used to override the word chapter.

IEEE sometimes uses incollection somewhat like inproceedings when the book in question is a composition of articles from various conferences [25]. For such use, the differences between incollection and inproceedings are minor — one distinctive sign is that, with incollection, the volume number appears after the date, while with inproceedings it appears before. To better support such use, IEEEtran.bst, unlike the standard BIB_TE_X styles, does not require a publisher field for incollection entries.

E. Booklet

Supported fields: **author**, **title**, *language*, *howpublished*, *organization*, address, month, year, note, *url*.

Booklet is used for printed and bound works that are not formally published. IEEEtran.bst formats titles of booklets like

articles — not like manuals and books. A primary difference between booklet and unpublished is that the former is/was distributed by some means. Booklet is rarely used in IEEE bibliographies.

F. Manual

Supported fields: **author**, **title**, *language*, edition, *howpublished*, *organization*, address, month, year, note, *url*.

Technical documentation is handled by the manual entry type [26]. Note that the cited example places the databook part number with the title. Perhaps a more correct approach would be to put this information into the *howpublished* field instead [27]. However, other BIB_TE_X styles will probably not support the *howpublished* field for manuals.

G. Inproceedings/Conference

Supported fields: **author**, **title**, *intype*, **booktitle**, *language*, series, editor, volume, number, *organization*, address, publisher, month, **year**, *paper*, type, pages, note, *url*.

References of papers in conference proceedings are handled by the inproceedings or conference entry types. These two types are functionally identical and can be used interchangeably.

If desired, the days of the conference can be added to the month via the BIB_TE_X concatenation operator “#” [28]:

```
month = dec # " 5--9,",
```

Although not common with conference proceedings, the volume and number fields are also supported [29]. Note that, unlike the other entry types, IEEE places such information prior to the date. From IEEE’s viewpoint, the location and date of the conference may form the dividing point between information related to identifying which proceedings and information that pertains to the location of the information referenced therein (pages, etc.).

IEEEtran.bst supports a paper field (a nonstandard extension) for paper numbers [30]:

```
paper = "11.3.4",
```

The type field can be used to override the default paper type (“paper”) [31]:

```
type = "postdeadline paper",
```

Section VII describes how these extensions can be disabled if desired for journals with bibliographies that tend not to display such information (while allowing the user to retain such information in the database entries for those journals that do).

There are events that happen during conferences that may not be in the written proceedings record (speeches, etc.). Sometimes it is necessary to reference such things. For these occasions, IEEEtran.bst supports the *intype* field (a nonstandard extension) which can override the word “in” in the reference [32]:

```
intype = "presented at the",
```

Note that when using `intype`, the `booktitle` field is no longer italicized because the book that contains the written conference record is no longer what is being referred to.

H. *Proceedings*

Supported fields: `editor`, **`title`**, *language*, *series*, *volume*, *number*, *organization*, *address*, *publisher*, *month*, **`year`**, *note*, *url*.

It is rare to need to reference an entire conference proceedings, but, if necessary, the `proceedings` entry type can be used to do so.

I. *Mastersthesis*

Supported fields: **`author`**, **`title`**, *language*, *type*, **`school`**, *address*, *month*, **`year`**, *note*, *url*.

Master's (or minor) theses can be handled with the `mastersthesis` entry type [33]. The optional `type` field can be used to override the words "Master's thesis" if a different designation is desired [34]:

```
type = "M. Eng. thesis",
```

J. *Phdthesis*

Supported fields: **`author`**, **`title`**, *language*, *type*, **`school`**, *address*, *month*, **`year`**, *note*, *url*.

The `phdthesis` entry type is used for Ph.D. dissertations (major theses) [35]. Like `mastersthesis`, the `type` field can be used to override the default designation.

K. *Techreport*

Supported fields: **`author`**, **`title`**, *language*, *howpublished*, **`institution`**, *address*, *number*, *type*, *month*, **`year`**, *note*, *url*.

`Techreport` is used for technical reports [36]. The optional `type` field can be used to override the default designation "Tech. Rep." [37], [38].

L. *Unpublished*

Supported fields: **`author`**, **`title`**, *language*, *month*, *year*, **`note`**, *url*.

The `unpublished` entry type is used for documents that have not been formally published. IEEE typically just uses "unpublished" for the required `note` field [39].

M. *Electronic* (IEEE_{TR}AN.bst extension)

Supported fields: `author`, *month*, *year*, **`title`**, *language*, *howpublished*, *organization*, *address*, *note*, *url*.

IEEE_{TR}AN.bst provides the `electronic` entry type for internet references [40], [41]. IEEE_{TR}AN.bst also provides the aliases "online," "internet," and "webpage" for compatibility with some existing BIB_T_EX database and style files. However, "electronic" should be used for all new work. IEEE formats electronic references differently by not using italics or quotes and separating fields with periods rather than commas. Also, the date is enclosed within parentheses and is placed closer to

the title. This is probably done to emphasize that electronic references may not remain valid on the rapidly changing internet. Note also the liberal use of the `howpublished` field to describe the form or category of the entries.

The `organization` and `address` fields may also be used [42].

N. *Patent* (IEEE_{TR}AN.bst extension)

Supported fields: `author`, *title*, *language*, *assignee*, *address*, **`nationality`**, *type*, **`number`**, *day*, *dayfiled*, *month*, *monthfiled*, **`year`** or **`yearfiled`**, *note*, *url*.

Patents are supported by IEEE_{TR}AN.bst. The `nationality` field provides a means to handle patents from different countries [43], [44]

```
nationality = "United States",
```

or

```
nationality = "Japanese",
```

Note that, with the exception of the U.S., the word for the nationality of a patent is not usually the same as the word for the country that issued the patent. The nationality for a U.S. patent can be entered either as "U.S." or "United States." IEEE_{TR}AN.bst will automatically detect and convert the latter form to "U.S." as is done by IEEE. The nationality should be capitalized.

The `assignee` and `address` (of the assignee) fields are not used by IEEE or IEEE_{TR}AN.bst. However, they are provided, and proper values should be assigned to them (if known) for all patent entries as other BIB_T_EX styles may use them.

The `type` field provides a way to override the "patent" description with other patent related descriptions such as "patent application" or "patent request" [45]:

```
type = "Patent Request",
```

In order to provide full support for both patents and patent applications, two sets of date fields are provided. One set pertains to the date the patent was granted (`day`, `month` and `year`) the other pertains to the date the patent application was filed (`dayfiled`, `monthfiled` and `yearfiled`). There is a slight complication because IEEE displays only one date for references of patents or patent applications. IEEE_{TR}AN.bst looks for the presence of the `year` and `yearfiled` files. If the `year` field is present, the set pertaining to the date granted is used. Otherwise, IEEE_{TR}AN.bst uses the set pertaining to the date filed.

O. *Periodical* (IEEE_{TR}AN.bst extension)

Supported fields: `editor`, **`title`**, *language*, *series*, *volume*, *number*, *organization*, *month*, **`year`**, *note*, *url*.

The `periodical` entry type is used for journals and magazines [46].

P. *Standard* (IEEE_{TR}AN.bst extension)

Supported fields: `author`, **`title`**, *language*, *howpublished*, **`organization`** or **`institution`**, *type*, *number*, *revision*, *address*, *month*, *year*, *note*, *url*.

The standard entry type is used for formally published standards [47]. For the name of the issuing entity, either the organization or institution fields can be used based on whatever the preference of the issuing entity may be. IEEE (and thus IEEE_{TR}AN.bst) do not display the address of the issuing organization/institution, but this information should be provided as other BIB_T_EX styles might.

The type field can be used to override the default description “std.” while the optional revision field can be used to provide a revision number [48]:

```
type      = "Working Draft Proposed Standard",
revision = "5.2",
```

Alternatively, the misc entry type, along with its howpublished field, can be used to create references of standards [49].

Q. Misc

Supported fields: `author`, `title`, `language`, `howpublished`, `organization`, `address`, `pages`, `month`, `year`, `note`, `url`.

Misc is the most flexible type and can be used when none of the other entry types are applicable. The howpublished field can be used to describe what exactly (or in what form) the reference is (or appears as). Note that IEEE_{TR}AN.bst, unlike the standard styles, also supports the organization, address and pages fields.

Possible applications include technical-report-like entries that lack an institution [50], white papers [51] and data sheets [52].

VI. UNUSUAL TYPES OF REFERENCES

A. Private Communication

Private communication entries can be created using the misc type with a note indicating “private communication,” or “personal correspondence,” etc., [53].

B. Laws and Regulations

Legal documents and laws are probably best handled by the misc type [54]. The howpublished field can handle the regulation number/description, while the organization field can carry the issuing body. The cited example also uses the language field as it is written in German.

C. Internet RFCs

Internet “Request For Comments” (RFC) documents are usually handled via the misc entry type [55]. The howpublished field can contain the RFC number. Because of the online nature of RFCs, it is a good idea to provide a URL field if at all possible. Alternatively, RFCs can be handled as electronic entry types, albeit with less portability (under other .bst files).

D. Other References

When dealing with a reference that does not fit into any of the categories of the previous examples, the best strategy is to use the closest one that fits. If that fails, fall back on the misc entry type.

Sometimes the most difficult step is determining *what* a particular reference actually is. Consider [56] which appeared in an IEEE journal. Now, from the appearance of this reference, one could conclude that what is being cited is an article that appeared in a journal called “*Blue Book*.” However, CCSDS’s Blue Books are actually a series of books, number four of which is what is being referenced. So, it might be better to use the book entry type with a series field [57]. (Also, note in this reference how IEEE replaces author names that are identical to the previous reference with a long dash.) But, using the author field for organizations is not a good practice. Therefore, the manual entry type, which provides an organization field and does not require an author, might be even better [58]. The howpublished field is used for the Blue Book series and number.

Upon even closer inspection, one finds that Blue Book number four is actually a request for a standard! So, perhaps the best approach is to use the IEEE_{TR}AN.bst entry type for standards [59].

VII. THE IEEE_{TR}AN BST CONTROL ENTRY TYPE

IEEE_{TR}AN.bst provides a very special entry type that can be used to externally control some aspects of the bibliography style. By altering these controls, a user can make adjustments in order to (1) compensate for minor variations in the typical bibliography styles of the various IEEE journals; (2) tweak certain aspects of the produced bibliographies to better suit the particular taste of the author (within the bounds of IEEE’s standards); and (3) provide a limited means to implement changes that might be desirable in certain types of non-IEEE related work such as theses. IEEE_{TR}AN.bst is not a universal style — alterations beyond those described here are outside of the scope of IEEE_{TR}AN.bst’s design. Users are cautioned that changes to some of the controls can result in a bibliography style that is no longer compliant to IEEE’s style.

In order to access the IEEE_{TR}AN.bst controls, users must create an “IEEE_{TR}ANBSTCTL” entry in one of their database (.bib) files:

```
@IEEEtranBSTCTL{IEEEexample:BSTcontrol,
  CTLuse_article_number = "yes",
  CTLuse_paper          = "yes",
  CTLuse_forced_etal    = "no",
  CTLmax_names_forced_etal = "10",
  CTLnames_show_etal    = "1",
  CTLuse_alt_spacing    = "yes",
  CTLalt_stretch_factor = "4",
  CTLdash_repeated_names = "yes",
  CTLname_format_string = "{f.~}{vv~}{ll}{, jj}",
  CTLname_latex_cmd     = ""
};
```

The above example shows all of the available control fields and their default values. Only the fields that need to be changed have to be listed in a control entry — fields that are missing or empty will not be altered. The changes are activated by citing

the control entry type (in the user's .tex file) using a special cite command which is a modified version of `\nocite`:

```
\bstctlcite{IEEEexample:BSTcontrol}
```

This command is provided by the `IEEEtran.cls` L^AT_EX class as well as by the `IEEEtrantools.sty` package [1]. Users using other class or package files will have to manually define the command in the preamble of their document:

```
\makeatletter
\def\bstctlcite#1{\@bsphack
  \@for\@citeb=#1\do{%
    \edef\@citeb{\expandafter\@firstofone\@citeb}%
    \if@filesw\immediate\write\@auxout{\string\citation{\@citeb}}\fi}%
  \@esphack}
\makeatother
```

The source code of `\bstctlcite` can also be found in the comments near the top of the `IEEEtran.bst` file.

`\bstctlcite` is silent — it will not add any entry to, or affect the numbering of, the bibliography, nor will it place any citation numbers in the main text. There are two main limitations on its use:

- 1) For the unsorted BIB_TE_X style, it must be placed before any entries that it is to affect. Because the user will almost always want to apply the changes to all the bibliography entries, a good location is just after `\begin{document}`. For the sorting style, control entries will automatically be given a sort key value that will put them at the beginning of the references. If this is not desired, a control entry can be manually given a key field with a value that will result in the desired sort position.
- 2) operation is “one shot.” That is to say the same control entry cannot be used again. However, it is possible to call another control entry that uses a different key name. This behavior is directly related to the way BIB_TE_X allows a reference to be cited multiple times, yet still produces only one entry within the bibliography.

A. BST Control Entry Fields

Here is a brief description of each of the control entry fields. **CTLuse_article_number**: Setting this to “no” will turn off the display of the number field for articles. “yes” enables. This is useful for IEEE publications that tend not to show the number field for referenced articles, but the user wishes to include the number field in the database entries. Turning off the display of the number fields for articles can also help to give more consistent results if the database article entries are erratic in their inclusion of the number field. The default value is “yes.”

CTLuse_paper: Likewise, setting this to “no” turns off the display of paper and type fields for inproceedings entries. “yes” enables. The default value is “yes.”

CTLuse_forced_etal: Setting this to “yes” enables `IEEEtran.bst` to automatically truncate a list of author names and force the use of “et al.” if the number of authors in an entry exceeds a set limit. “no” disables. The default value is “no.”

CTLmax_names_forced_etal: This value is the maximum number of names that can be present beyond which “et al.”

usage is forced (if forced “et al.” is enabled). The default value is 10.

CTLnames_show_etal: The number of names that are shown with a forced “et al.” Must be less than or equal to `CTLmax_names_forced_etal`. The default value is 1.

CTLuse_alt_spacing: Setting this to “no” will shut off the alternate interword spacing for entries with URLs. This feature may be of use to those who do not want the entries in the bibliography files (.bbl) to contain the added L^AT_EX code required by this feature. The default value is “yes.”

CTLalt_stretch_factor: If alternate interword spacing for entries with URLs is enabled, this is the interword spacing stretch factor that will be used. For example, the default value of 4 means that the interword spacing in entries with URLs can stretch to four times normal. The given value does not have to be an integer.

CTLDash_repeated_names: Setting this to “no” turns off the use of dashes for entries with names that are identical to those of the previous entry (repeated names) [57]. May be useful for non-IEEE related work. IEEE normally does this, so the default value is “yes.”

CTLname_format_string: This is the BIB_TE_X name format string that controls the format of the author and editor names. See [60] for more information. Do not alter this control for work that is to be submitted to the IEEE.

CTLname_latex_cmd: If not empty, specifies a L^AT_EX command, that must use a single argument, which is to process each of the (formatted) author and editor names in all the entries. For example, using

```
CTLname_latex_cmd = "\textsc"
```

will result in all of the author and editor names being rendered in the small caps font. Because IEEE does not use a different font for names, this control should not be used for work that is to be submitted to the IEEE. The default is empty.

ACKNOWLEDGMENT

The author would like to thank Laura Hyslop of the IEEE for her help with obtaining the definitions for the IEEE journal and magazine names and abbreviations. Also deserving recognition are Patrick W. Daly, for producing the `makebst` package from which algorithms were borrowed; Howard Trickey, Oren Patashnik, Silvano Balemi and Richard H. Roy for their work on earlier versions of IEEE BIB_TE_X styles; and Javier Bezos for his helpful suggestions on the implementation of the language field. Oren also kindly reviewed the beta release and made many suggestions that improved the final version.

REFERENCES

- [1] M. Shell. (2002) IEEEtran homepage on CTAN. [Online]. Available: <http://www.ctan.org/tex-archive/macros/latex/contrib/supported/IEEEtran/>
- [2] (2002) The IEEE website. [Online]. Available: <http://www.ieee.org/>
- [3] O. Patashnik. (1988, Feb.) BIB_TE_Xing. `btldoc.pdf`. [Online]. Available: <http://www.ctan.org/tex-archive/biblio/bibtex/contrib/doc/>
- [4] D. Hoadley and M. Shell. (2002, Oct.) BIB_TE_X tips and FAQ. `btFAQ.txt`. [Online]. Available: <http://www.ctan.org/tex-archive/biblio/bibtex/contrib/doc/>
- [5] N. H. F. Beebe. (2002, May) T_EX user group bibliography archive. [Online]. Available: <http://www.math.utah.edu:8080/pub/tex/bib/index-table.html>

- [6] D. Arseneau. (1999, Mar.) The url.sty package. [Online]. Available: <http://www.ctan.org/tex-archive/macros/latex/contrib/other/misc/>
- [7] S. Rahtz and H. Oberdiek. (2002, July) The hyperref.sty package. [Online]. Available: <http://www.ctan.org/tex-archive/macros/latex/contrib/supported/hyperref/>
- [8] J. Braams. (2001, Feb.) The Babel package. [Online]. Available: <http://www.ctan.org/tex-archive/macros/latex/required/babel/>
- [9] S. Zhang, C. Zhu, J. K. O. Sin, and P. K. T. Mok, "A novel ultrathin elevated channel low-temperature poly-Si TFT," *IEEE Electron Device Lett.*, vol. 20, pp. 569–571, Nov. 1999.
- [10] F. Delorme *et al.*, "Butt-jointed DBR laser with 15 nm tunability grown in three MOVPE steps," *Electron. Lett.*, vol. 31, no. 15, pp. 1244–1245, 1995.
- [11] R. K. Gupta and S. D. Senturia, "Pull-in time dynamics as a measure of absolute pressure," in *Proc. IEEE International Workshop on Microelectromechanical Systems (MEMS'97)*, Nagoya, Japan, Jan. 1997, pp. 290–294.
- [12] B. D. Cullity, *Introduction to Magnetic Materials*. Reading, MA: Addison-Wesley, 1972.
- [13] A. Castaldini, A. Cavallini, B. Fraboni, P. Fernandez, and J. Piqueras, "Midgap traps related to compensation processes in CdTe alloys," *Phys. Rev. B*, vol. 56, no. 23, pp. 14 897–14 900, 1997.
- [14] Y. Okada, K. Dejima, and T. Ohishi, "Analysis and comparison of PM synchronous motor and induction motor type magnetic bearings," *IEEE Trans. Ind. Appl.*, vol. 31, pp. 1047–1053, Sept./Oct. 1995.
- [15] M. Coates, A. Hero, R. Nowak, and B. Yu, "Internet tomography," *IEEE Signal Processing Mag.*, May 2002, to be published.
- [16] N. Kahale and R. Urbanke, "On the minimum distance of parallel and serially concatenated codes," *IEEE Trans. Inform. Theory*, submitted for publication.
- [17] J. C. Candy and G. C. Temes, Eds., *Oversampling Delta-Sigma Data Converters Theory, Design and Simulation*. New York: IEEE Press., 1992.
- [18] S. M. Metev and V. P. Veiko, *Laser Assisted Microtechnology*, 2nd ed., R. M. Osgood, Jr., Ed. Berlin, Germany: Springer-Verlag, 1998.
- [19] J. Breckling, Ed., *The Analysis of Directional Time Series: Applications to Wind Speed and Direction*, ser. Lecture Notes in Statistics. Berlin, Germany: Springer, 1989, vol. 61.
- [20] H. E. Rose, *A Course in Number Theory*. New York, NY: Oxford Univ. Press, 1988, ch. 3.
- [21] B. K. Bul, *Theory Principles and Design of Magnetic Circuits*. Moscow: Energia Press, 1964, p. 464, (in Russian).
- [22] W. V. Sorin, "Optical reflectometry for component characterization," in *Fiber Optic Test and Measurement*, D. Derickson, Ed. Englewood Cliffs, NJ: Prentice-Hall, 1998.
- [23] J. B. Anderson and K. Tepe, "Properties of the tailbiting BCJR decoder," in *Codes, Systems and Graphical Models*, ser. IMA Volumes in Mathematics and Its Applications. New York: Springer-Verlag, 2000.
- [24] P. Hedelin, P. Knagenhjelm, and M. Skoglund, "Theory for transmission of vector quantization data," in *Speech Coding and Synthesis*, W. B. Kleijn and K. K. Paliwal, Eds. Amsterdam, The Netherlands: Elsevier Science, 1995, ch. 10, pp. 347–396.
- [25] R. M. A. Dawson, Z. Shen, D. A. Furst, S. Connor, J. Hsu, M. G. Kane, R. G. Stewart, A. Ipri, C. N. King, P. J. Green, R. T. Flegal, S. Pearson, W. A. Barrow, E. Dickey, K. Ping, C. W. Tang, S. V. Slyke, F. Chen, J. Shi, J. C. Sturm, and M. H. Lu, "Design of an improved pixel for a polysilicon active-matrix organic LED display," in *SID Tech. Dig.*, 1998, vol. 29, pp. 11–14.
- [26] *FLEXChip Signal Processor (MC68175/D)*, Motorola, 1996.
- [27] *FLEXChip Signal Processor, MC68175/D*, Motorola, 1996.
- [28] M. S. Yee and L. Hanzo, "Radial basis function decision feedback equaliser assisted burst-by-burst adaptive modulation," in *Proc. IEEE Globecom '99*, Rio de Janeiro, Brazil, Dec. 5–9, 1999, pp. 2183–2187.
- [29] M. Yajnik, S. B. Moon, J. Kurose, and D. Towsley, "Measurement and modeling of the temporal dependence in packet loss," in *Proc. IEEE INFOCOM'99*, vol. 1, New York, NY, Mar. 1999, pp. 345–352.
- [30] M. Wegmuller, J. P. von der Weid, P. Oberson, and N. Gisin, "High resolution fiber distributed measurements with coherent OFDR," in *Proc. ECOC'00*, 2000, paper 11.3.4, p. 109.
- [31] B. Mikkelsen, G. Raybon, R.-J. Essiambre, K. Dreyer, Y. Su., L. E. Nelson, J. E. Johnson, G. Shtengel, A. Bond, D. G. Moodie, and A. D. Ellis, "160 Gbit/s single-channel transmission over 300 km nonzero-dispersion fiber with semiconductor based transmitter and demultiplexer," in *Proc. ECOC'99*, 1999, postdeadline paper 2-3, pp. 28–29.
- [32] S. G. Finn, M. Médard, and R. A. Barry, "A novel approach to automatic protection switching using trees," presented at the Proc. Int. Conf. Commun., 1997.
- [33] N. C. Loh, "High-resolution micromachined interferometric accelerometer," Master's thesis, Massachusetts Institute of Technology, Cambridge, 1992.
- [34] A. Karnik, "Performance of TCP congestion control with rate feedback: TCP/ABR and rate adaptive TCP/IP," M. Eng. thesis, Indian Institute of Science, Bangalore, India, Jan. 1999.
- [35] Q. Li, "Delay characterization and performance control of wide-area networks," Ph.D. dissertation, Univ. of Delaware, Newark, May 2000. [Online]. Available: <http://www.ece.udel.edu/~qli>
- [36] R. Jain, K. K. Ramakrishnan, and D. M. Chiu, "Congestion avoidance in computer networks with a connectionless network layer," Digital Equipment Corporation, MA, Tech. Rep. DEC-TR-506, Aug. 1987.
- [37] J. Padhye, V. Firoiu, and D. Towsley, "A stochastic model of TCP Reno congestion avoidance and control," Univ. of Massachusetts, Amherst, MA, CMPSCI Tech. Rep. 99-02, 1999.
- [38] D. Middleton and A. D. Spaulding, "A tutorial review of elements of weak signal detection in non-Gaussian EMI environments," National Telecommunications and Information Administration (NTIA), U.S. Dept. of Commerce, NTIA Report 86-194, May 1986.
- [39] T. J. Ott and N. Aggarwal, "TCP over ATM: ABR or UBR," unpublished.
- [40] V. Jacobson. (1990, Apr.) Modified TCP congestion avoidance algorithm. end2end-interest mailing list. [Online]. Available: <ftp://ftp.isi.edu/end2end/end2end-interest-1990.mail>
- [41] V. Valloppillil and K. W. Ross. (1998) Cache array routing protocol v1.1. Internet draft. [Online]. Available: <http://ds1.internic.net/internet-drafts/draft-valloppillil-carp-v1-03.txt>
- [42] D. H. Lorenz and A. Orda. (1998, July) Optimal partition of QoS requirements on unicast paths and multicast trees. Dept. Elect. Eng., Technion, Haifa, Israel. [Online]. Available: <ftp://ftp.technion.ac.il/pub/supported/ee/Network/lor.mopq98.ps>
- [43] R. E. Sorace, V. S. Reinhardt, and S. A. Vaughn, "High-speed digital-to-RF converter," U.S. Patent 5 668 842, Sept. 16, 1997.
- [44] U. Hideki, "Quadrature modulation circuit," Japanese Patent 152 932/92, May 20, 1992.
- [45] F. Kowalik and M. Isard, "Estimateur d'un défaut de fonctionnement d'un modulateur en quadrature et étage de modulation l'utilisant," French Patent Request 9 500 261, Jan. 11, 1995.
- [46] *IEEE Personal Commun. Mag., Special Issue on Wireless ATM*, vol. 3, Aug. 1996.
- [47] *Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification*, IEEE Std. 802.11, 1997.
- [48] *Fiber Channel Physical Interface (FC-PI)*, NCITS Working Draft Proposed Standard, Rev. 5.2, 1999.
- [49] I. Widjaja and A. Elwalid, "MATE: MPLS adaptive traffic engineering," IETF Draft, 1999.
- [50] L. Roberts, "Enhanced proportional rate control algorithm PRCA," ATM Forum Contribution 94-0735R1, Aug. 1994.
- [51] "Advanced QoS services for the intelligent internet," White Paper, Cisco, May 1997.
- [52] "PDCA12-70 data sheet," Opto Speed SA, Mezzovico, Switzerland.
- [53] S. Konyagin, private communication, 1998.
- [54] "Messung von Störfeldern an Anlagen und Leitungen der Telekommunikation im Frequenzbereich 9 kHz bis 3 GHz," Meßvorschrift Reg TP MV 05, Regulierungsbehörde für Telekommunikation und Post (Reg TP).
- [55] K. K. Ramakrishnan and S. Floyd, "A proposal to add explicit congestion notification (ECN) to IP," RFC 2481, Jan. 1999.
- [56] Consultative Committee for Space Data Systems (CCSDS), "Telemetry channel coding," *Blue Book*, no. 4, 1999. [Online]. Available: <http://www.ccsds.org/documents/pdf/CCSDS-101.0-B-4.pdf>
- [57] —, *Telemetry Channel Coding*, ser. Blue Book. Newport Beach, CA: CCSDS, 1999, no. 4. [Online]. Available: <http://www.ccsds.org/documents/pdf/CCSDS-101.0-B-4.pdf>
- [58] *Telemetry Channel Coding*, ser. Blue Book, No. 4, Consultative Committee for Space Data Systems (CCSDS), Newport Beach, CA, 1999. [Online]. Available: <http://www.ccsds.org/documents/pdf/CCSDS-101.0-B-4.pdf>
- [59] *Telemetry Channel Coding*, ser. Blue Book, No. 4, Consultative Committee for Space Data Systems (CCSDS) Recommendation for Space Data System Standard 101.0-B-4, May 1999. [Online]. Available: <http://www.ccsds.org/documents/pdf/CCSDS-101.0-B-4.pdf>
- [60] O. Patashnik. (1988, Feb.) Designing B_{IB}T_EX styles. btxhak.pdf. [Online]. Available: <http://www.ctan.org/tex-archive/biblio/bibtex/contrib/doc/>