Precision Writing

Dennis S. Bernstein
Aerospace Engineering Department
The University of Michigan
Ann Arbor, MI 48109
dsbaero@umich.edu

What is Precision Writing?

Precision writing is a style of written communication in which the primary objective is to convey information. This style of writing is an appropriate mode of writing for technical communication, but can also be used in nontechnical situations.

Precision writing is distinct from fiction writing, where the main objective is story telling. In addition, precision writing is distinct from persuasive writing, which is appropriate for political, legal, and commercial objectives.

Precision writing is appropriate for documents that convey technical information, such as reports and articles. Instructions are also encompassed by precision writing, including directions (how to get to some place) and manuals (how to build, fix, repair, or operate something).

In a nutshell, the key characteristics of precision writing are 1) clarity and 2) conciseness. To achieve clarity, fuzziness and ambiguity must be avoided. Conciseness refers to the minimal number of words needed to convey the information without sacrificing clarity while providing fault tolerance as explained below.

How Can You Learn to Write Precisely?

With lots of practice. Here are some guidelines.

Audience and framework. All writing must take place with the audience in mind. Every audience requires that a framework be established so that your readers understand what you are talking about. You need to establish some background, assumptions, and terminology to set the stage for conveying information.

Signal-to-noise ratio. Every communication channel involves a signal and noise. The goodness of the channel is measured by the signal to noise ratio. Your objective in writing precisely is to optimize the signal-to-noise ratio by minimizing ambiguity and fuzziness.

Redundancy. Redundancy involves excess information that is included to decrease the possibility of miscommunication. Example: "Go 2.3 miles and turn left at the red house."

Fault tolerance and diagnostics. Unlike a personal conversation, you cannot receive immediate feedback from the reader on what you have written. The next best thing is to include diagnostics in your writing. Example: "Go three blocks and turn left. You will see a white barn on the right. If you do not, then go back to step 3."

Terminology. Choose good terminology and use it consistently. Choosing terminology means that you are giving names to things or ideas. These names must be easy to use, logical, and memorable. Poor or inconsistent terminology can be a significant barrier to precision communication.

Compression and expansion. Like a fluid, writing is compressible. You can be terse or long winded. Both extremes are bad. Sometimes you can compress ideas, while at other times more wordy or detailed expansion is needed.

Spatial precision. It can be challenging to use only words (that is, without images) to describe spatial ideas. Example: "Face the center of east wall at a distance of 6 feet. Turn right, and go 10 feet. Look in the third box from the right. Inside you will find some gold." Another example, "At the fourth stoplight, turn left. Go one block. You will see a 5-way intersection, which you enter at 6 o'clock and exit at 11 o'clock. Go 1 mile. My house is on the left." Another example: "Face the center of the east wall. Viewing yourself from above, turn clockwise 45 degrees. You will now see the money on the table."

Avoiding ambiguity. Example: Take the sine of the angle. That is, the trigonometric sine, not the algebraic sign." Additional ambiguous words include right/right, current/current/current, sign/sine, amp/amp (current/amplifier), plane/airplane, and tangent/tangent. Pronouns are a scourge when it comes to ambiguity especially when it is not clear what "it" or "this" refer to.

Negative information. Negative information refers to what not to do, again a device to improve reliability of the information you are providing. Example: "Pour the red liquid into the beaker. Do not touch the flame." Another example: "Go three miles. At the stop sign, turn left, that is, do not turn right." Note that the words "that is" signify equivalence.

Binary information. Some information is of the yes/no type, whereas other information is a matter of degree. This distinction is digital (binary) versus analog. Example: "The toaster is on. When the toaster is on, the coils are hotter than boiling water." Do not say "relative" or "advantage" without saying relative to what or advantage over what.

Negative questions. Questions of this type are often confusing. I do not know how to answer the question: "You don't want the money?"

Conciseness. Do not use many words when a few words suffice. Example: Change "The computer is able to make use of the software." to "The computer can use the software."

Summary

Establish frame of reference—so the reader knows what you're talking about
Terminology--important things, one name, use consistently
No ambiguity—minimize confusion
Fault diagnosis—check for errors
Fault tolerance—in case errors occur
Conciseness—not wordier than necessary, but not excessively compact
Compression and expansion—when to be terse and when to be wordier for clarity
Spatial location, movement, and orientation—describe with precision

Writing Style

The guidelines below were developed for the *IEEE Control Systems Magazine* to support the goal of precision writing.

Sentences and Paragraphs

First, and most importantly, write simply and clearly. Use clear and simple sentences, and arrange them in logical order. Order is crucial.

A good rule of thumb is to try to minimize the use of colons, semicolons, quotation marks, and parentheses. Strive for a smooth, linear writing style.

Carefully introduce terminology, and use your terminology precisely and consistently. Write with precision and clarity.

A long, complex sentence can often be divided into two shorter sentences that are easier to read. Do not try to do too much in a single sentence.

When a sentence has multiple clauses, arrange the clauses carefully. Try to keep each clause close to the noun that the clause modifies.

Organize sentences into coherent paragraphs of reasonable length. A paragraph can be as short as one or two sentences but usually not longer than half of a page. Start a new paragraph when you change thoughts or topics.

Organize paragraphs into sections, subsections, and subsubsections with common themes. Give careful consideration to the section/subsection/subsubsection structure of your article. The paper should have a natural flow and organization that can help the reader understand your thought process.
The ideal maximum length of a paragraph is 1/3 to 1/2 of a page. Try to avoid paragraphs that are longer than 3/4 of a page.

Unlike the document you are reading, indent every paragraph **without exception**.

Like the document you are reading, leave an extra blank line between successive paragraphs so that the reader of your article can see precisely where each paragraph begins and ends.

Wording Suggestions

Use “that” for essential (defining) clauses and “which” for nonessential (non-defining) clauses. This rule, *which* is useful, may take some practice to master. The rules *that* are given here are often useful. The relative pronoun “which,” which is distinct from the adjective “which,” should always be preceded by a comma except when used in the phrases “in which,” “for which,” and “from which.”

Try starting some sentences with “Although.” Try connecting clauses with “while,” which essentially means “and,” or “whereas,” which essentially means “and, however,”.

Since x and y are real, it follows that $x+y$ is real. It follows from (3) that x is negative.

The function f, whose domain is a closed set, is continuous.

For clarity, if often helps to couple the word “or” with the word “either.”

Replace “Our goal is to determine if x is real.” with “Our goal is to determine whether x is real.” Some writers use the phrase “whether or not.”

It is sometimes helpful to write “A is true whether or not B is true.”

Replace “If the temperate is high, then the ice melts.” with “When the temperature is high, the ice melts.” In other words, “when” is more appropriate than “if” when the focus is on events rather than logic.

Multiple “and’s” can be confusing. For example, replace “The simulation uses linear and nonlinear models and variable-step integration.” with “The simulation uses linear and nonlinear models as well as variable-step integration.” Synonyms for “and” include “as well as” and “together with.”

Watch out for misplaced “only.” You can *only* enroll in four courses. You can enroll in *only* four courses.

Do not say “so-called.” Instead of saying “The controller uses the so-called Smith method for stability analysis.” you could say “The controller uses a stability technique known as the Smith method.” Or, more simply, “The controller uses the Smith method discussed in [2] for stability analysis.”

Whenever using technical terms that might not be well known to a wide audience, try to write in such a way that either the meaning can be inferred from context or a definition is embedded in the sentence. For example, “The controller is based on feedback linearization, that is, inversion of the nonlinearities.”

Be careful of "could," "would," and "should," since these words have subtle and ambiguous meanings in referring to status or contingency. The word "must" is often more precise than "should." In fact, the word "should" is ambiguous, and it is advisable to avoid this word. It should rain today. He should win a Nobel prize.

Be careful of "generally," which means "often" or "usually" but is otherwise imprecise.

Control engineers *might* find alternative software helpful. Many writers use the word "may" to mean "might," and this usage is acceptable but suboptimal. Possibilities: The software may be useful. The software might be useful. The software is potentially useful. Not good: The software could be useful. The software should be useful.

Rewrite "In order to be a control engineer, you need to know calculus." as "To be a control engineer, you need to know calculus." Rewrite "The Bode plot is needed in order to find the gain margin." as "The Bode plot is needed to find the gain margin."

Avoid using *very* common words that might exaggerate and provide little information. *Many* writers use *quite* a lot of these words, which might appear to be *extremely* helpful. Write factually, and err on the side of understatement. Avoid hype, that is, hyperbole. Use the words "extremely, "many," "quite," and "very" sparingly. Write neutrally when your goal is to convey information.

Avoid repetition. Do not repeat what you have already said. However, a major exception to this rule is that some repetition provides fault tolerance in the event that the reader misses crucial information.

Avoid non sequiturs. In particular, be sure that successive sentences follow in a logical, coherent manner, with clear and logical flow. Avoid jumpiness between sentences. Try to hook sentences together.

Avoid subjective statements, which have no firm basis, as well as rhetorical questions, for which answers are not expected. For example, do not say "It is important for engineers to develop teraflop computers that cost less than US$100." or ask "What could be more important than solving this problem?"

Avoid vague statements based on hypothetical situations. Write with specifics.

Avoid using the vague word "one" as the subject of a sentence. OK: We expect to find that… Not OK: One expects to find that…

Try not to use more words than are needed to make your points. Avoid excessive verbiage.

Avoid starting sentences with "There are" or "There is." Weak: "There are many models that are ill conditioned." Stronger: "Many models are ill conditioned." For clarity, begin a sentence with the subject of the sentence.

Splitting infinitives is fine. Sounds awkward: "To prove easily Theorem 3, we use the Nyquist test." Sounds much better: To easily prove Theorem 3, we use the Nyquist test."

The correct use of "a," "the," and "this" is challenging, especially for non-native speakers of English. Think of "a" as meaning "some," while "the" refers to a specific or unique object. The word "this" refers to an object that has already been specified. Omit "the" when used twice in a row such as in "The inverse and [the] transpose of the matrix A are given by (3) and (4), respectively." Despite these simple rules, subtle cases can arise, although with some thought the correct usage usually becomes evident. In some cases, it is best to use neither "the" nor "a."

An example: "The algorithm is based on a colored noise model. A noise term is included in the state equation. The noise process *w* has stationary statistics. Noise is known to degrade the performance of estimation algorithms."

Tense

Imagine that your article is unfolding in the present. Therefore, write in the present tense as much as possible. Past tense is needed only for describing truly historical events. Try to avoid excessive reportorial writing. In fact, experimental or computational results can be described as if they are unfolding in the present.

Furthermore, it is usually possible to avoid the use of the future tense. Replace "We will investigate this problem." with "We plan to investigate this problem." Replace, "This approach will solve many difficult problems." with "This approach is expected to solve many problems." Or "This approach can solve many problems."

Examples: These rules *are* written for the benefit of this journal. The experimental results *show* the validity of the method. The pressure variable, shown in Figure 3, *indicates* increased drag due to surface roughness. The results of [7] *suggest* that saturation can degrade performance. It *is shown* in [6] that *x* is real. The results given in the next section *show* that the plant is nonlinear. We *plan* to solve this problem next year. This project *is expected* to begin next year.

Equations

Punctuate every equation as a smooth, integral part of the sentence, using commas and periods as appropriate. Punctuate each equation as part of a sentence in a grammatically correct manner. Therefore, most equations have a comma or period at the end.

Be absolutely sure that every symbol in every equation is precisely defined with appropriate dimensions or units.

Good: It follows from Newton's second law

$$f = ma,$$

where a denotes acceleration, that force is proportional to mass. Hence,

$$a = f/m.$$

Do not precede equations with a colon. Do not use the word "following" to introduce an equation. The first equation above is an appositive. The second equation provides the verb to the sentence.

A comma is used at the end of every equation in a list. Use a comma at the end of an equation that is followed by "where."

Do number all equations that you need to refer to. A clean style is to equations as (1), (2), (3). It is usually not necessary to number equations that are not referenced. However, it is preferable to number an equation and refer to the equation by its number rather than writing "the above equation." In other words, number equations so that you can refer to them easily, and use the numbers.

Do not use a single number to reference multiple equations. It is better to give a separate number to each equation. Avoid numbering equations as (1a), (1b).

Center every displayed equation.

Try to avoid including words on the same line as a displayed equation. An exception is "for all."

Definitions

Italics can be used when a word or phrase is first defined:

> The *predictive update law*, given by (1)-(3), is nonlinear. We now show that the predictive update law yields Lyapunov stability.

Define acronyms at the first opportunity, and then use the acronym consistently:

> In this article we use a model reference adaptive controller (MRAC) for stabilization. This MRAC can be used to control uncertain, minimum phase plants.

Punctuation

Avoid the excessive use of parentheses, colons (:), semicolons (;), and dashes (—). Simple, clear sentences are the most effective. Not desirable: "The equation has three real solutions: A, B, and C." Better: "The equation has three real solutions, namely, A, B, and C."

Avoid bulleted lists, that is, lists that use bullets (•), which are more appropriate for presentations. In most cases, try to write in text form.

Italics are appropriate for defining *technical language* that has specific meaning. Italics *can* be used for emphasis, but only rarely. Use italics for all mathematical variables such as x in $y = f(x)$.

Quotation marks can be used sparingly to indicate that a word such as "dog" is singled out for discussion.

Include the comma preceding "and" when referring to multiple items, such as x, y, and z. Likewise, x, y, or z.

A comma is needed to separate clauses in compound sentences, and this rule is universally followed. Note the comma before "and."

If an introductory phase is especially long, then insert a comma. If not then don't.

Omit the pair of commas surrounding a short appositive. For example, "the state variable, x, is a vector" should be written as "the state variable x is a vector."

Hyphens

The rules for hyphens are reasonably logical, but somewhat involved. Unfortunately, the use of hyphens is not universally agreed upon.

Use hyphens for multiple modifiers such as "computer-based synthesis" or "Lyapunov-function analysis" to show that the first word modifies the second word. However, the hyphen is usually omitted in common phrases such as "control system design" or "distributed parameter system," where no ambiguity is possible.

There is no hyphen in the phrase "higher order system," but there is a hyphen in "highest-order system." There is no simple reason for this convention, which varies among continents.

The use of hyphens is a little more logical when adverbs are involved. The hyphen is omitted in "fully developed theory" since "fully" is an "ly" adverb, and thus it is clearly an adverb. There usually *is* a hyphen between the adverb and the adjective when the adverb does not end in "ly." For example, "a well-known person" or "ill-posed problem" or "best-selling car" is hyphenated.

Be sure to note that "John is well known" does *not* have a hyphen since "is well known" is the predicate. Likewise, a "positive-definite matrix" is hyphenated, whereas "The matrix is positive definite" is not hyphenated.

Hyphens often disappear as a word comes into more common usage. For example: online, setpoint, and tradeoff.

The following verbs have no hyphen: back up, build up, close up, look up, ramp up, scale up, set up, shut down, speed up, spin up, start up, trade off.

Prefixes such as anti, bi, co, counter, de, inter, intra, multi, non, off, on, over, post, pre, proto, pseudo, quad, quasi, re, self, semi, sub, super, trans, tri, under, and uni might or might not warrant a hyphen.

Likewise, suffixes such as by, down, ite, less, and up might or might not warrant a hyphen. When in doubt, do not use a hyphen.

A hyphen is optional in coauthor, cochair, codirector, coeditor, cosupervisor, coworker, cofounder, cooperate, and coordinate. Do use a hyphen in co-owner.

Note the following distinction: The engineer ran a real-time simulation. The simulation runs in real time.

Likewise: The positive-definite matrix satisfies the Riccati equation. The solution of the Riccati equation is positive definite.

However, some phrases require a hyphen in all situations. The student is self-confident. The self-confident student passed the exam.

The system has three degrees of freedom (DOFs). A six-degree-of-freedom (6DOF) robotic arm is used for the experiment.

The testbed uses a 3-foot-long table. The table is 3-feet long.

Capitalization

When in doubt, use lower case letters.

Do not capitalize names of technical items. For example, write "linear-quadratic," but do not write "Linear-Quadratic." Always capitalize acronyms as in "linear-quadratic (LQ)."

Write "Figure 3" and "Chapter 4," but also write "figures 3 and 4" and "chapters 5 and 6." Likewise for "Section 3," "Theorem 3," and Example 3," as well as "sections 3 and 4 4," "theorems 3 and 4," and "examples 3 and 4."

Units

Write units without italics and with a space after the number. Correct: "3.57 mm". Wrong: "3.57mm". Wrong: "3.57*mm*".

Use "s" for second and "h" for hour. Also, use "l" (ell) for liter, but be sure that "l" is distinguishable from the number "1" in the font that you are using. It is best to use "ℓ" (script lower case "ell") for liter if possible.

Note the use of a hyphen in the units N-m and kg-m^2. Some publications use a raised dot instead of a hyphen.

Be sure that every axis of every plot is labeled with units.

Acronyms

Acronyms are useful in streamlining the discussion, but must not be overused.

Rule 1: Define all acronyms except those that represent names of commercial products. Although MIMO, SISO, and PID are widely used, it is usually a good idea to define these acronyms.

Rule 2: To define an acronym, use the words first, followed by the acronym. "The nonlinear backstepping (NBS) controller stabilizes the system."

Rule 3: Do not introduce an acronym that is not used subsequently.

Rule 4: Consider not introducing an acronym that is subsequently used only once.

Rule 5. Be conservative in introducing acronyms. The sentence "The MV for the ODE is used in the MIMO PID FLC." is unpleasant to read.

Rule 6: Do not use acronyms in a figure caption unless an acronym appears in the figure itself, in which case, redefine the acronym in the caption.

Spelling

English has some tricky spellings and a few tricky verbs. In addition, some spellings are not uniform among English-speaking countries.

Leaders *lead,* and plumbers work with *lead*. Last week the *leader led* the group.

I *read* a book every day. Yesterday, I *read* a book. Yesterday, the *reader read* a *red* book.

Today, I *lay* down the book. Yesterday, I *lay* down the book. Last week, I had *laid* down the book.

Today, I *lie* down on the floor. Yesterday, I *lay* down on the floor. Last week, I had *lain* down on the floor.

Noise can *affect* the performance of the algorithm. The noise has an *effect* on the performance of the algorithm. A good leader can *effect* change in an organization. Verb, noun, verb.

Toward, towards. Upward, upwards. Downward, downwards. Backward, backwards.

Watch out for double "ells." The system was *modeled*, and *modeling* is useful. The figure is *labeled*, and *labeling* is helpful. The system was *controlled*, and the poles were *canceled*. There is no logic to these spellings.

You *assure* someone who is anxious, you *insure* your car, and you *ensure* stability by using a Lyapunov function.

"Cannot" is one word except in very rare instances such as "the controller can not only stabilize the system but also reject disturbances."

"Parameterize" and "parameterization," but not "parametrize" and "parametrization."

Dependent versus descendant.

Some Stylistic Guidelines

Never use "this" and "these" as nouns. Wrong: *This* is the main idea. Correct: *This* rule applies to all functions. Wrong: *These* are relevant points. Correct: *These* points are relevant.

Likewise, do not use "It" or "They" as the subject of a clause. Wrong: *It* is a stabilizing controller. OK: *It* turned out that the error converged to zero. Similar comments apply to "its."

Replace "via" with "by means of." Replace "get" and "got" with "obtain" and "obtained." Replace "like" with "such as." Do not use "etc." or "and so forth."

Try "however" instead of "but." Better yet, try starting the sentence with "Although."

Do not use "as" when you mean "since."

Do not use "e.g." or "i.e." Replace "e.g." with "for example," "for instance," or "such as," and replace "i.e." with "that is."

Do not use "w.r.t." Rather, use "with respect to."

OK: *It* turned out that the phase margin was smaller than expected.

Not OK: *It* was 20 degrees.

"We recorded experimental data, which are given in Table 1." Note that "data" is a plural word.

Do not use the mathematical symbols upside-down A to denote "for all" or backwards E to denote "there exists." Do not use double arrows for "implies." Use English words in mathematical statements.

In mathematics, the word "or" is an *inclusive or*. That is, the statement "Either A or B is true" does not preclude the possibility that both A and B are true. Do not use "and/or," which presumably denotes inclusive or (in English, the word "or" is sometimes interpreted as an exclusive or, which motivates writers to use "and/or" as an inclusive or). If you require an exclusive or, write "Either A or B is true, but not both." If you followed all of this, you are doing well!

Do not use "or" to mean "that is."

Note the difference between the statements "I do not have a house and a car." and "I do not have a house or a car."

Replace “based upon” and “depend upon” with “based on” and “depend on.”

The word “any” is sometimes problematic in writing mathematics since “any” sometimes means “all” while other times “any” means “some.” Try to avoid using this word in mathematical statements.

Note the difference between “alternate,” which refers to switching, and “alternative,” which refers to a different choice.

“The new method has the advantage of speed.” “Advantage” compared to what other methods?

“The new method is relatively easy to apply.” Relative to what?

Replace “has the ability to,” “is able to,” and “is capable of” with “can.”

Change “utilizes” and “makes use of” to “uses.”

Do not use the exceedingly vague phrase “a number of.” The word “several” is fine.

Control engineers *can* analyze control systems. Control engineers *may* use MATLAB. Control engineers *may* or *might* become famous.

Consider replacing the word “other” with one of the words “alternative,” “additional,” or “remaining.”

Be aware and beware of the words “actual,” “still,” “even,” and “such,” which sometimes are used to compensate for weak sentence structure.

What Are Some Writing Exercises?

Instructions. Practice writing instructions for something or anything. Give the instructions to someone and find out whether your instructions are clear. You will be surprised.

Write one sentence. Yes, write one good sentence. Then rewrite the sentence a different way. Repeat 5 times. How many different ways can you say the same thing? What improvements can you make?

Write one paragraph. Write one really good paragraph, short or long. Make sure the paragraph has unity of thought, with a good opening sentence and a good closing sentence. Make sure the sentences follow one another logically and smoothly (even hooked together) without any jumpiness.

Write something a little longer. Write 2 or 3 coherent paragraphs that follow a logical development, with well-organized ideas.

Shorten. Write one page. Shorten it to 2/3 of a page. Shorten it to ½ page. Then shorten to ¼ of a page. You will be surprised at how short you can make something before you lose much of the information.

Learn to edit. Edit the writing of other writers so that you improve what they have written. Do this many times with many different people. Write something, put it away for 3 days, then edit it yourself. (Who wrote *that*?, you will ask.)

Find good examples. Find writing that you like and try to mimic it. There is no shame in that.

Annotated Bibliography

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