

The `steinmetz` package*

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1 Introduction

In electrotechnics it is common a notation for variables taking on complex values. First of all any nonzero complex number z admits a unique representation as

$$z = \varrho(\cos \alpha + i \sin \alpha)$$

where ϱ is a positive real number and α is a real number in the interval $[0, 2\pi)$. In technical applications α is expressed in degrees, with figures such as 30° . The conversion is very easy by considering $^\circ$ as the multiplicative constant $\pi/180$. By Euler formulas, we can write

$$z = \varrho(\cos \alpha + i \sin \alpha) = \varrho e^{i\alpha}$$

but Steinmetz, in the nineteenth century, started to express this in a simplified form:

$$z = \varrho \angle \alpha$$

which has however the disadvantage to be difficult to interpret when the angle is the result of some algebraic expression. This is where this package helps: indeed we can write

`z=\varrho\angle\phase{\alpha+\beta}`

which gives

$$z = \varrho \angle \alpha + \beta$$

making it clear what is the angle to consider. Some textbooks in electrotechnics use this notation and some users asked how to produce it in \LaTeX .

Dependencies

Note that this package requires `pict2e`, so a fairly recent version of \LaTeX is needed. In order to typeset this document, you have to generate the package file, by running \LaTeX on `steinmetz.ins`, unless it's already in your distribution.

Table 1: Results from the various choices of the optional argument to `\phase`

Command	Result
<code>A\phase{\alpha}</code>	A/α
<code>A\phase{30^\circ}</code>	$A/30^\circ$
<code>A\phase[0]{\alpha}</code>	A/α
<code>A\phase[1]{\alpha}</code>	A/α
<code>A\phase[2]{\alpha}</code>	A/α
<code>A\phase[3]{\alpha}</code>	A/α
<code>A\phase[0]{\frac{\alpha}{2}}</code>	$A/\frac{\alpha}{2}$
<code>A\phase[1]{\frac{\alpha}{2}}</code>	$A/\frac{\alpha}{2}$
<code>A\phase[2]{\frac{\alpha}{2}}</code>	$A/\frac{\alpha}{2}$
<code>A\phase[3]{\frac{\alpha}{2}}</code>	$A/\frac{\alpha}{2}$

2 Commands

`\phase` This package provides only one command, `\phase`, which takes as argument the angle to be enclosed in the Steinmetz symbol. It may receive also an optional argument, an integer number from 0 to 3 (default 1). This optional argument tells L^AT_EX to typeset the angle in the various mathematical styles, as exemplified in table 1.

Recall that the command `\phase` should be given only in math mode. Since the command is usually written in display or text style, it should be uncommon to need the optional argument, unless you have to force a particular style for fractions.

If you have more than one of these symbols in a row, it can help alignment to put `\mathstrut` in the argument.

3 Acknowledgments

The macro has been developed based on ideas of Stefano Di Gennaro (Università dell'Aquila, Italy) and his student Andrea Tonelli. Both have suffered from the earthquake of April 5, 2009: I wish them, their families and their university a prompt recover.

4 Implementation

`1 \RequirePackage{pict2e}[2004/07/06]`

*This document corresponds to `steinmetz v1.0`, dated 2009/06/14.

We need the extended slopes provided by pict2e.

```
\stm@phasebox We reserve some registers.
\stm@phasedp 2 \newsavebox{\stm@phasebox}
\stm@phaseht 3 \newlength{\stm@phasedp}
\stm@phasetot 4 \newlength{\stm@phaseht}
\stm@phasewd 5 \newlength{\stm@phasetot}
               6 \newlength{\stm@phasewd}
```

`\phase` This is the main (and unique) command provided at user level.

```
7 \newcommand\phase[2][1]{%
8   \sbox\stm@phasebox{%
9     $\ifcase#1\relax
10      \displaystyle\or\textstyle\or\scriptstyle\or\scriptscriptstyle
11      \fi#2$}
```

We set the box register to a formula containing the argument in the style chosen by the optional argument (default is text style).

```
12 \stm@phaseht=\ht\stm@phasebox
13 \stm@phasedp=\dp\stm@phasebox
14 \stm@phasetot=\stm@phasedp \advance\stm@phasetot .35ex
15   \advance\stm@phasetot\stm@phaseht
16 \stm@phasewd=\wd\stm@phasebox
17   \advance\stm@phasewd .5\stm@phasetot
```

We do some measuring; the name of the registers should be self-explaining.

```
18 \setbox\stm@phasebox=\vbox to\stm@phaseht{
19   \hbox{\setlength{\unitlength}{1pt}\linethickness{.6pt}%
20     \edef\ph@x{\strip@pt\stm@phasewd}\edef\ph@y{\strip@pt\stm@phasetot}%
21     \dimen@ .5\stm@phasetot \edef\ph@dx{\strip@pt\dimen@}}%
```

In the reserved box register we put a vbox and set inside it the unit length for the picture environment to 1 pt; since we have to use pure numbers, we strip the unit from the lengths.

```
22 \begin{picture}(\ph@x,\ph@y)
23   \put(0,0){\circle*{.4}}
24   \put(0,0){\line(1,0){\ph@x}}\put(0,0){\line(1,2){\ph@dx}}
25   \put(\ph@dx,1.5){\raise\stm@phasedp\vbox{\box\stm@phasebox}}
26 \end{picture}%
```

The picture environment draws the angle. In its vertex we put a small circle to masquerade the connections. Inside the angle we print the expression given as argument, freeing the box register so that it can be used again (by the macro itself).

```
27   }\vss}%
28   \advance\stm@phasedp .35ex \advance\stm@phasedp .6pt
29   \dp\z@=\stm@phasedp \box\stm@phasebox}
```

We close the vbox, correct its depth and print it.

5 An example

The following will generate an example file.

```
30 \documentclass[a4paper]{article}
31 \usepackage{steinmetz}
```

```

32
33 \begin{document}
34
35 We will indicate the amplitude and phase relationship through the use
36 of complex notation: a complex number is used to indicate only the
37 amplitude and phase of voltages and currents in the circuit (since the
38 sinusoidal time variation factor is common to all terms). For
39 example, a circuit described by the equation
40 \[
41 i(t)=I_{0}\cos(\omega t+\theta)
42 \]
43 can be written in complex exponential form as
44 \[
45 i(t)=\operatorname{Re}\{I_{0}e^{j(\omega t+\theta)}\}=
46 \operatorname{Re}\{I_{0}e^{j\theta}e^{j\omega t}\},
47 \]
48 and in polar complex form as
49 \[
50 i(t)=\operatorname{Re}\{I_{0}\operatorname{phase}\{\theta\}e^{j\omega t}\}.
51 \]
52 Finally, we can simplify the notation by dropping the implied
53  $e^{j\omega t}$  term and the  $\operatorname{Re}\{\sim\}$  operator, leaving the phasor
54 notation:
55 \[
56 \mathbf{I}=I_{0}\operatorname{phase}\{\theta\}=I_{0}e^{j\theta}=
57 I_{0}(\cos\theta+j\sin\theta),
58 \]
59 where the boldface  $\mathbf{I}$  reminds us that the phasor quantity
60  $\mathbf{I}$  is a complex number. The important advantage of this
61 approach is that the mathematics involves mostly simple algebraic
62 operations on the magnitudes and phases.
63
64 It is interesting to look at the complex ratio of phasor voltage and
65 phasor current,  $\mathbf{V}/\mathbf{I}$ , which is called the
66 impedance  $\mathbf{Z}$ . For the basic circuit elements we
67 find:
68 \begin{itemize}
69 \item Resistor,  $\mathbf{R}$ :  $\mathbf{Z}=R$ ,
70 \item Inductor,  $\mathbf{L}$ :  $\mathbf{Z}=j\omega L=
71 \omega L\operatorname{phase}\{90^{\circ}\}$ ,
72 \item Capacitor,  $\mathbf{C}$ :  $\mathbf{Z}=\frac{1}{j\omega C}=
73 -j\frac{1}{\omega C}=\frac{1}{\omega C}\operatorname{phase}\{-90^{\circ}\}$ .
74 \end{itemize}
75 \end{document}

```

Change History

v1.0
 General: Initial version 1

Index

Numbers written in *italic* refer to the page where the corresponding entry is described; numbers underlined refer to the code line of the definition; numbers in *roman* refer to the code lines where the entry is used.

Symbols	L	S
<code>\!</code> 65	<code>\line</code> 24	<code>\sin</code> 57
<code>\[</code> 40, 44, 49, 55	<code>\linethickness</code> 19	<code>\stm@phasebox</code> <u>2</u> , 8, 12, 13, 16, 18, 25, 29
<code>\{</code> 45, 46, 50, 53	M	<code>\stm@phasedp</code> <u>2</u> , 13, 14, 25, 28, 29
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