

Documentation of the `graphpaper` L^AT_EX class

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Abstract

This document describes how to use the L^AT_EX document class `graphpaper`. It allows to print several types of graph papers: bilinear, semilogarithmic, bilogarithmic, polar, Smith charts.

1 Legal terms

This file is part of the `graphpaper` bundle.

This work may be distributed and/or modified under the conditions of the L^AT_EX Project Public License, either version 1.3c of this license or (at your option) any later version. The latest version of this license is at: <http://www.latex-project.org/lppl.txt>

This work has the LPPL maintenance status “maintained”.

This work consists of this file `graphpaper.dtx`, and the derived files `graphpaper.cls` and `graphpaper.pdf`.

The list of derived (unpacked) files belonging to the distribution and covered by the LPPL is contained in the README file.

2 Installation

The simplest way to install `graphpaper` is by the package manager of your T_EX distribution (T_EX Live or MiK_TE_X). For manual installation see the README file.

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3 How to use graphpaper

Graphpaper is a \LaTeX class and it is loaded as usual:

```
\documentclass[options]{graphpaper}
```

It has three class options to specify the paper format: `a4paper` (default), `a3paper`, `letterpaper`. The paper orientation cannot be changed and it is always set to landscape.

`Graphpaper` provides the following commands (to be used inside the body of the document) in order to compose graph papers. At the end of the execution of these commands, a new page is always started.

```
\bilinear
\semilogx{decades along x}
\semilogy{decades along y}
\loglog[0/1]{decades along x}{decades along y}
\polar
\logpolar{decades along radius}
\smith
```

The commands `\bilinear`, `\semilogx`, and `\semilogy` are self explanatory. The optional parameter in the `\loglog` command chooses whether the decade length along the abscissa and ordinate axes must have the same dimension. It can assume the value 0 (free dimensions) or 1 (same dimensions), 0 being the default. The commands `\polar`, `\logpolar`, `\smith` are used to plot polar, logpolar, and Smith chart graph papers. The mandatory argument of `\logpolar` specifies the number of decades.

There are several commands to change the appearance of the graph papers. They must be inserted before the graph paper command which we want they affect.

The following ones are specific to bilinear, semilog and loglog papers only:

```
\setxside{length}
\setyaside{length}
\setminimumdistance{length}
```

`\setxside` and `\setyaside` allow to specify the dimensions of the rectangle of the grid. The default values are (260 mm, 180 mm) for A4 paper, (250 mm, 190 mm) for letter paper, and (380 mm, 280 mm) for A3 paper.

`\setminimumdistance` specifies the minimal optical distance between two lines. Default is 1 mm. In this way, the number of subdivision is automatically composed.

The following commands are instead general settings for all graph papers:

```
\setgridcolor{color}
\setmajorlinethickness{length}
\setmediumlinethickness{length}
\setminorlinethickness{length}
\customcode[0/1]{picture environment commands}
```

`\setgridcolor` sets the color of the grid. The argument must be a color defined or predefined by the `color` or `xcolor` package. The default color is the typical red-orange color used in many graph papers, Pantone 2011 U corresponding to RGB (250,153,89).

`\setmajorlinethickness`, `\setmediumlinethickness`, `\setminorlinethickness` can be used to change the thickness of the lines. The default values are 1 pt, 0.6 pt, 0.25 pt, respectively.

`\customcode` accepts all the commands accepted by the `picture` environment. This snippet of code is inserted inside the `picture` environment used to draw the subsequent graph paper. The origin of the coordinate system in the case of rectangular graph papers is the lower left vertex. The `\unitlength` is set to 1 mm. For circular plots (both polar and Smith) the origin is in the center of the circle and the `\unitlength` is set to 1/140 of the paper height currently in use.

The `\customcode` command can be used, for example, to add a logo or to draw on the graph paper. Its optional argument is by default set to 0. If it is set to 1, the content of the `\customcode` is erased after its usage in a graphpaper.

4 The implementation

This class file has been already identified by the commands extracted by the `DocStrip` package, during the `.dtx` file compilation. Therefore the commands `\NeedsTeXFormat` and `\ProvidesClass` are already present in the `.cls` file.

4.1 Loaded packages, class options, and initial settings

The `xkeyvalue` package is used in order to define the class options:

```
1 \RequirePackage{xkeyval}
```

Three class options are implemented and they allows only to change the paper format (A4, A3, letter). The orientation of the paper is fixed to landscape.

```
2 \def\GP@paper{1}
3 \define@key[GRP]{a4paper}[]{\PassOptionsToPackage{a4paper}{geometry}}
4 \define@key[GRP]{letterpaper}[]{\PassOptionsToPackage{letterpaper}{geometry}}%
5 \def\GP@paper{2}
6 \define@key[GRP]{a3paper}[]{\PassOptionsToPackage{a3paper}{geometry}}%
7 \def\GP@paper{3}
8 \DeclareOptionX*{\ClassError{graphpaper}{Option '\CurrentOption'%
9 \MessageBreak is not valid}{Remove '\CurrentOption' %
10 from class options}}
11 \ProcessOptionsX[GRP]<>
```

The class is based on the `article` class. The default paper is A4.

```
12 \LoadClass[a4paper,11pt]{article}
```

Some packages are loaded. *euclideangeometry* loads *curve2e* which in turns loads *pict2e*; all of them are *picture* environment extensions.

```
13 \RequirePackage[landscape]{geometry}
14 \RequirePackage{euclideangeometry,graphicx,xcolor}
```

Default line color (Pantone 2011 U).

```
15 \definecolor{gridcolor}{RGB}{250,153,89}
```

Default thickness of the lines used for main divisions and subdivisions. The ISO-UNI standards prescribe a geometric progression with $\sqrt{2}$ ratio, but it is not respected here. It must be keep in mind also that a safe minimum thickness for an offset monochromatic printer is about 0.25 pt, whereas a safe minimum thickness for a laser printer is about 0.5 pt.

```
16 \newlength\lwa
17 \setlength{\lwa}{1pt}
18 \newlength\lwb
19 \setlength{\lwb}{0.6pt}
20 \newlength\lwc
21 \setlength{\lwc}{0.25pt}
```

Minimum distance between two subdivision lines. A necessary parameter for automatic choice of number of subdivisions. Default 1 mm.

```
22 \newlength\mindistanceunit
23 \setlength{\mindistanceunit}{1mm}
```

Definition of the width and height of the main rectangle within which the bilinear, semilog and loglog grid is composed.

```
24 \newlength\xsideunit
25 \newlength\ysideunit
26 \if\GP@paper1
```

```

27 \setlength{\xsideunit}{260mm}
28 \setlength{\ysideunit}{180mm}
29 \fi
30 \if\GP@paper2
31 \setlength{\xsideunit}{250mm}
32 \setlength{\ysideunit}{190mm}
33 \fi
34 \if\GP@paper3
35 \setlength{\xsideunit}{380mm}
36 \setlength{\ysideunit}{280mm}
37 \fi

```

4.2 Rectangular graph papers

As we will see below, the commands to compose the bilinear, semilog and loglog graph papers are just proper calls of the low-level command `\carta`.

4.2.1 Service macros for rectangular graph papers

First of all, four macros are defined. They are used by the `\carta` service command only.

Two of them are simply two identical classical `whiledo` commands: the first cycles on the counter `\J` while the second one on the counter `\K`. They are two because in this way two nested `whiledo` commands can be implemented. These `\WhileDo` commands have four parameters: 1. the incremental step of the counter between cycles (default 1); 2. the initial value of the counter; 3. the final value of the counter; 4. the code to execute at each cycle.

```

38 \newcount\J
39 \newcount\K
40
41 \newcommand\WhileDoOne[4][1]{%
42 \J=#2 \fpdowhile{\J<=#3 }{#4\advance\J by #1\relax}}
43
44 \newcommand\WhileDoTwo[4][1]{%
45 \K=#2 \fpdowhile{\K<=#3 }{#4\advance\K by #1\relax}}

```

The other two commands are used to draw a periodic set of equidistant lines in log scale. These two commands are practically identical, the only difference is that they act on different axes. These commands have six parameters: 1. number of lines to draw (distance between these lines is the fifth parameter); 2. value at which the first line must be drawn (x-value for vertical lines, y-value for horizontal lines); 3. thickness; 4. tick length; 5. distance between two lines (typically the length of a decade: y-decade for horizontal lines, x-decade for vertical lines); 6. line length (typically the length of the graph paper sides: x-side for horizontal lines and y-side for vertical lines).

```

46 \newcommand\hlines[6]{%
47 \multiput(-#4,\fpeval{\ln(#2) * #5 / \ln(10)})(0,#5){#1}%
48 {\linethickness{#3}\line(1,0){\fpeval{#6 + 2*#4}}}%
49 }
50
51 \newcommand\vlines[6]{%
52 \multiput(\fpeval{\ln(#2) * #5 / \ln(10)},-#4)(#5,0){#1}%
53 {\linethickness{#3}\line(0,1){\fpeval{#6 + 2*#4}}}%
54 }

```

4.2.2 Command for rectangular graph papers

Here starts the definition of the `\carta` command. Its syntax is

```
\carta[⟨0 or 1⟩]{⟨no. x decades⟩}{⟨no. of y decades⟩}
```

If an axis has zero decades, the scale is linear. For example, `\carta{0}{0}` composes a bilinear graph paper, `\carta{2}{0}` composes a semilog graph paper with linear y-axis and two decades along x-axis, and so on. Its optional argument can be 0 or 1. If it is set to 0, and both the numbers of decades are greater than zero (which means the resulting graph paper is loglog), then the length of x-axis and y-axis decades are set to be equal.

Declaration of the command and its arguments.

```
55 \NewDocumentCommand{\carta}{0{0} m m}{%
```

Typographical settings and definition of the main features of the graphpaper. `\xlength` and `\ylength` represent the lengths, expressed in mm, of the rectangle dimensions. `\minimumdistance` is the minimum distance at which two subdivision lines can be drawn.

```
56 \newpage
57 \parindent=0pt
58 \pagestyle{empty}%
59 \color{gridcolor}%
60 \setlength{\unitlength}{1mm}%
61 \def\ticklength{2}
62 \def\minorticklength{1.2}
63 \def\minimumdistance{\fpeval{(\mindistanceunit/1mm)}}
64 \def\xlength{\fpeval{round(round(\xsideunit/1cm) * 10)}}
65 \def\ylength{\fpeval{round(round(\ysideunit/1cm) * 10)}}

```

`\xlinsq` and `\ylinsq` represent the number of big divisions (cm) on horizontal and vertical axes for linear scales, respectively.

```
66 \def\xlinsq{\inteval{\xlength/10}}
67 \def\ylinsq{\inteval{\ylength/10}}

```

Implementation of the same decade length between x-axis and y-axis for loglog graph paper. This is obtained properly changing the values of `\xlength` and `\ylength`, making them equal.

```
68 \edef\decx{#2}% decades along x
69 \edef\decy{#3}% decades along y
70 \unless\ifnum#2=0 \unless\ifnum#3=0 \ifnum#1=1%
71 \fptest{\decx/\decy < \xlength/\ylength}%
72 {\def\xlength{\fpeval{\ylength*\decx/\decy}}}
73 {\def\ylength{\fpeval{\xlength*\decy/\decx}}}
74 \fi\fi\fi

```

Using the values of the paper width and height together with the length of the graph paper rectangle sides, the margins are calculated and passed to the geometry package in order to center the grid with respect to the page.

```
75 \ifcsname ml\endcsname\relax\else\newlength\ml\fi
76 \ifcsname mr\endcsname\relax\else\newlength\mr\fi
77 \ifcsname mt\endcsname\relax\else\newlength\mt\fi
78 \ifcsname mb\endcsname\relax\else\newlength\mb\fi
79 \unless\ifcsname mr\endcsname\newlength\mr\fi
80 \unless\ifcsname mt\endcsname\newlength\mt\fi
81 \unless\ifcsname mb\endcsname\newlength\mb\fi
82 \setlength\ml{\fpeval{(\paperwidth/1mm - \xlength)/2}mm}

```

```

83 \setlength{\mr}{\fpeval{(\paperwidth/1mm - \xlength)/2}mm}
84 \setlength{\mt}{\fpeval{(\paperheight/1mm - \ylength)/2}mm}
85 \setlength{\mb}{\fpeval{(\paperheight/1mm - \ylength)/2}mm}
86 \newgeometry{left=\ml,right=\mr,top=\mt,bottom=\mb}

```

Here starts the drawing of the graph paper by the picture environment.

```
87 \begin{picture}(\xlength,\ylength)
```

If the horizontal axis is linear, vertical lines are drawn by simple `\multiput` commands. Otherwise, if the scale is logarithmic, the vertical lines are drawn by the `\vlines` command defined above.

```

88 \ifnum#2=0\relax
89 % vertical lines on linear abscissa. Main lines every 10 mm.
90 % Second level lines every 5 mm, Third level lines every 1 mm,
91 % according to the \minimumdistance value
92 \multiput(0,0)(10,0){\inteval{\xlinsq + 1}}{%
93   \linethickness{\lwa}\squarecap\line(0,1){\ylength}}
94 \ifnum\fpeval{\minimumdistance <= 5}=1
95 \multiput(5,0)(10,0){\xlinsq}{%
96   \linethickness{\lwb}\line(0,1){\ylength}}\fi
97 \ifnum\fpeval{\minimumdistance <= 1}=1
98 \multiput(0,0)(1,0){\xlength}{%
99   \linethickness{\lwc}\line(0,1){\ylength}}\fi
100 \else
101 % vertical lines on log abscissa
102 \edef\decxx{\fpeval{\decx + 1}}%
103 \edef\xstep{\fpeval{\xlength / \decx}}
104 % main lines: one for each decade (10) plus one at the end
105 \vlines{\decxx}{1}{\lwa}{\ticklength}{\xstep}{\ylength}
106 % second-level lines: one every unit (1), for each decade
107 \WhileDoOne{2}{9}{\vlines{\decx}{\J}{\lwb}{%
108   \minorticklength}{\xstep}{\ylength}}
109 % third-level lines: for each decade (10) and for each unit (1):
110 % 20, 10, 5, 2 are progressively tested and adopted if the distance
111 % between two subsequent nearest lines is less to \minimumdistance
112 \WhileDoTwo{1}{9}{%
113   \edef\xmindivfloat{%
114     \fpeval{(\K+1)*(1-10-(\minimumdistance/\xstep))}}}
115   % xmindiv corresponds to 1/20 of unit
116   \def\xmindiv{20}
117   % xmindivfloat corresponds to the distance of two
118   % subdivision with respect to the unit
119   \ifnum\fpeval{\xmindivfloat <= 0.5}=1 \def\xmindiv{10}\fi
120   \ifnum\fpeval{\xmindivfloat <= 0.2}=1 \def\xmindiv{4}\fi
121   \ifnum\fpeval{\xmindivfloat <= 0.1}=1 \def\xmindiv{2}\fi
122   \ifnum\fpeval{\xmindivfloat <= 0.05}=1 \def\xmindiv{1}\fi
123   \ifnum\fpeval{\xmindiv == 20}=1\relax
124   \else\WhileDoOne[\xmindiv]{\xmindiv}{19}{%
125     \vlines{\decx}{(\K+\J/20)}{\lwc}{0}{\xstep}{\ylength}}\fi}
126 \fi

```

If the vertical axis is linear, horizontal lines are drawn by simple `\multiput` commands. Otherwise, if the scale is logarithmic, the horizontal lines are drawn by the `\hlines` command defined above.

```

127 \ifnum#3=0\relax
128 % horizontal lines on linear ordinates. Main lines every 10 mm.
129 % Second level lines every 5 mm, Third level lines every 1 mm,

```

```

130 % according to the \minimumdistance value
131 \multiput(0,0)(0,10){\inteval{\ylinsq + 1}}{%
132   \linethickness{\lwa}\squarecap\line(1,0){\xlength}}
133 \ifnum\fpeval{\minimumdistance <= 5}=1
134 \multiput(0,5)(0,10){\ylinsq}{%
135   \linethickness{\lwb}\line(1,0){\xlength}}\fi
136 \ifnum\fpeval{\minimumdistance <= 1}=1
137 \multiput(0,0)(0,1){\ylength}{%
138   \linethickness{\lwc}\line(1,0){\xlength}}\fi
139 \else
140 % horizontal lines on log ordinates
141 \edef\decyy{\fpeval{\decy + 1}}%
142 \edef\ystep{\fpeval{\ylength / \decy}}
143 % main lines: one for each decade (10) plus one at the end
144 \hlines{\decyy}{1}{\lwa}{\ticklength}{\ystep}{\xlength}
145 % second-level lines: one every unit (1), for each decade
146 \WhileDoOne{2}{9}{\hlines{\decy}{\J}{\lwb}{%
147   \minorticklength}{\ystep}{\xlength}}
148 % third-level lines: for each decade (10) and for each unit (1):
149 % 20, 10, 5, 2 are progressively tested and adopted if the distance
150 % between two subsequent nearest lines is less to \minimumdistance
151 \WhileDoTwo{1}{9}{\edef\ymindivfloat{%
152   \fpeval{(\K+1)*(1-10^-(\minimumdistance/\ystep))}}
153 % ymindiv corresponds to 1/20 of unit
154 \def\ymindiv{20}
155 % ymindivfloat corresponds to the distance of two subdivisions
156 % with respect to the unit
157 \ifnum\fpeval{\ymindivfloat <= 0.5}=1 \def\ymindiv{10}\fi
158 \ifnum\fpeval{\ymindivfloat <= 0.2}=1 \def\ymindiv{4}\fi
159 \ifnum\fpeval{\ymindivfloat <= 0.1}=1 \def\ymindiv{2}\fi
160 \ifnum\fpeval{\ymindivfloat <= 0.05}=1 \def\ymindiv{1}\fi
161 \ifnum\fpeval{\ymindiv == 20}=1\relax
162 \else\WhileDoOne[\ymindiv]{\ymindiv}{19}{%
163   \hlines{\decy}{(\K+\J/20)}{\lwc}{0}{\ystep}{\xlength}}\fi
164 \fi

```

Custom code provided by the user. After executing the code to compose the rectangular graph paper and the user custom code, the latter is reset if the `\GP@customcodereset` is true.

```

165 \GP@custom
166 \end{picture}
167 \ifGP@customcodereset\def\GP@custom{}\fi}

```

4.3 Circular graph papers

The `Graphpaper` class provides commands to draw three different circular graph papers: linear polar chart, log polar chart, Smith chart.

4.3.1 Service macros for Smith charts

Here follows a list of service macros used by circular graph papers.

Definition of the counter `\I`, used both in polar paper and Smith chart.

```

168 \newcount\I

```

`Rbox` composes a tick and a label in a rotated box. It is used to compose the ticks and labels along the external circle of circular graph papers. It accepts three arguments:

The first one is optional and represents the angle of rotation (default 0); the second one is optional too, it is inserted by round parentheses, and it represents the position of the box which can be given in cartesian (x, y) or polar coordinates $(\theta : \rho)$ (default 0:0); the third one is mandatory and contains the label.

```

169 \NewDocumentCommand\Rbox{0{0} D(){0:0} m}{%
170   \fptest{#1>=0}{\edef\RotLab{\fpeval{#1-90}}}{\edef\RotLab{\fpeval{#1+90}}}%
171   \put{#2}{\color{black}\segment(0,0)(#1:1)\put{#1:1}{%
172     \rotatebox{\RotLab}{\makebox(0,0)[c]{%
173       \fptest{#1>=0}{\Pbox[b]}{\Pbox[t]}{\scriptstyle#3}[0]}}}%
174   }%
175   }\ignorespaces}

```

`\Xcircle` macro (used only for Smith charts) assumes that the scale factor `\Scala` (s) has already been defined and it takes only one mandatory parameter (x). It draws a circle with center $(sx/(x + 1), 0)$ and radius $s/(x + 1)$. (x represents the real part (resistance) of the normalised impedance.)

```

176 \NewDocumentCommand\Xcircle{m}{%
177 \edef\Czero{0,0}\edef\Rzero{\Scala}%
178 \edef\Rdue{\fpeval{1/(#1+1)*\Scala}}%
179 \edef\Cdue{\fpeval{\Rzero-\Rdue},0}%
180 \Circlewithcenter\Cdue radius\Rdue\ignorespaces}

```

`\Ycircle` macro (used only for Smith charts) assumes that the scale factor `\Scala` (s) has already been defined. It assumes that the circle diameter is `100\unitlengths` long and it takes only one mandatory parameter (y). It draws an arc of a circle with center $(s, s/y)$, starting point at $(s, 0)$ (and therefore radius s/y) and with an angle calculated in order to have the end point on the external circle. (y represents the imaginary part (reactance) of the normalised impedance.)

```

181 \NewDocumentCommand\Ycircle{m s}{%
182 \edef\Czero{0,0}\edef\Rzero{\Scala}% external circle center and radius
183 \edef\Rdue{\fpeval{\Scala/abs(#1)}}% Small circle radius
184 \edef\Cdue{\Rzero,\fpeval{\Scala/#1}}% Small circle center
185 \edef\Cuno{\Rzero,0}% First intersection point
186 \ModAndAngleOfVect\Cdue to\Mod and\Alfa % Small circle center polar coordinates
187 \IntersectionOfLines(\Czero)(\Cdue)and(\Cuno)(\fpeval{\Alfa+90}:1)to\Inter
188 \SymmetricalPointOf\Cuno respect\Inter to\Idue
189 \ModAndAngleOfVect\Idue to\Mdue and\Adue
190 \SubVect\Cdue from\Idue to\IIDue
191 \ModAndAngleOfVect\IIDue to\Mod and\Alfa
192 \fptest{#1>0}{\edef\Alfa{\fpeval{270-\Alfa}}\Arc(\Cdue)(\Idue){\Alfa}}%
193 {\edef\Alfa{\fpeval{270+\Alfa}}\Arc(\Cdue)(\Cuno){\Alfa}}%
194 \IfBooleanT{#2}{\Rbox[\Adue](\Idue){\color{black}#1}}\relax
195 \ignorespaces}

```

The following two macros are used to compose the resistance axis below the Smith chart.

`CalcRxx` macro (used only for Smith charts) assumes that the scale factor `Scala` (s) has already been defined. First, it calculates the reflection coefficient $\Gamma = s \frac{x-1}{x+1}$ from resistance x . A tick and a label are inserted for this value of x .

```

196 \newcommand\CalcRxx[1]{%
197 \edef\Rxx{\fpeval{\Scala*(#1 - 1)/(#1 + 1)}}%
198 \segment(\Rxx,\LowResZero)(\Rxx,\LowResUno)\relax
199 \Pbox(\Rxx,\LowResUno)[t]{\color{black}\scriptsize#1$}[0]\ignorespaces}

```

`GradResist` macro (used only for Smith charts) draws the graduated axis for resistance and executes the `CalcRxx` for several values of resistance in order to compose the

ticks and the labels.

```

200 \newcommand\GradResist [1]{%
201   \color{black}
202 \edef\LowResZero{-#1}\edef\LowResUno{\fpeval{\LowResZero-1}}%
203 \I=0\edef\Auxx{0}\relax
204 \fpdowhile{\I<=10}{\CalcRxx{\Auxx}}%
205 \advance\I by1\edef\Auxx{\fpeval{\Auxx+0.1}}\ignorespaces}
206 \CalcRxx{1.5}\I=2\edef\Auxx{2}\relax
207 \fpdowhile{\I<=9}{\CalcRxx{\Auxx}}%
208 \advance\I by1\edef\Auxx{\fpeval{\Auxx+1}}\ignorespaces}
209 \CalcRxx{15}\CalcRxx{30}%
210 \edef\Rxx{\Scala}%
211 {\segment(-\Rxx,\LowResZero)(\Rxx,\LowResZero)%
212 \segment(\Rxx,\LowResZero)(\Rxx,\LowResUno)%
213 \Pbox(\Rxx,\LowResUno)[t]{\infty}[0]}}

```

GradPolar macro (used only for polar charts) draws the graduated axis for log polar charts.

```

214 \newcommand{\GradPolar}[1]{%
215   \color{black}
216   \edef\yline{\fpeval{-1.2 * \Scala}}
217   \linethickness{\lwa}
218   \segment(-\Scala,\yline)(\Scala,\yline)
219   \edef\ytickstart{\yline}
220   \edef\ytickstop{\fpeval{\yline-2}}
221   \edef\yytickstop{\fpeval{\yline-1}}
222   \segment(\Scala,\ytickstart)(\Scala,\ytickstop)
223   \segment(-\Scala,\ytickstart)(-\Scala,\ytickstop)
224   \fptest{#1=0}{%
225     \segment(0,\ytickstart)(0,\ytickstop)
226     \edef\plstep{\fpeval{\Scala/10}}
227     \linethickness{\lwb}
228     \multiput(\plstep,\yline)(\plstep,0){9}{\line(0,-1){1}}
229     \multiput(-\plstep,\yline)(-\plstep,0){9}{\line(0,-1){1}}%
230   }%
231   \I=0
232   \fpwhiledo{\I<#1}{%
233     \linethickness{\lwa}
234     \edef\xtick{\fpeval{\I*\Scala/#1}}
235     \segment(\xtick,\ytickstart)(\xtick,\ytickstop)
236     \segment(-\xtick,\ytickstart)(-\xtick,\ytickstop)
237     \J=2
238     \fpwhiledo{\J<=9}{%
239       \linethickness{\lwb}
240       \edef\xtick{\fpeval{\Scala/#1 * (\I + ln(\J)/ln(10))}}
241       \segment(\xtick,\ytickstart)(\xtick,\yytickstop)
242       \segment(-\xtick,\ytickstart)(-\xtick,\yytickstop)
243       \advance\J by1\relax}
244     \advance\I by1\relax}}
245 }

```

4.3.2 Polar graph papers

The polar graph papers are composed by the command `\PolarChart`. The syntax is

<code>\PolarChart [<i>diameter</i>] {<i>decades</i>}</code>

where $\langle diameter \rangle$ is the dimension (plus some extra space for labels and margins) of the polar chart. Its default value corresponds to the `\paperheight` (the minimum dimension of the paper). The mandatory parameter $\langle decades \rangle$ must be an integer number. Its value corresponds to the number of decades of the radial coordinate for the log polar graph paper. If its value is zero, the chart is linear. The maximum number of allowed decades is set by the macro `\NDecMax`: its default value is 2.

Declaration of the command and its arguments.

```
246 \NewDocumentCommand\PolarChart{0{\paperheight} m}{%
```

Typographical settings and definition of the main features of the graphpaper. `\xlength` and `\ylength` represent the lengths of the rectangle dimensions in which the polar graph is plot. The origin of the coordinate system is in the center of the page.

```
247 \newpage
248 \parindent=0pt
249 \pagestyle{empty}%
250 \ifcsname pmargin\endcsname\relax\else\newlength\pmargin\fi
251 \setlength{\pmargin}{20pt}
252 \newgeometry{left=\pmargin,right=\pmargin,top=\pmargin,bottom=\pmargin}
253 \def\factor{140}
254 \unitlength=\fpeval{#1/\factor}pt
255 \def\xlength{\fpeval{(\textwidth-0.01pt)/\unitlength}}
256 \def\ylength{\fpeval{(\textheight-0.01pt)/\unitlength}}
257 \begin{picture}(\xlength,\ylength)%
258   (\fpeval{-\xlength/2},\fpeval{-\ylength/2})%
259 \color{gridcolor}%
260 \edef\Scala{50}% The scale factor
```

Circle stroking. In linear scale 10 radial units are present, therefore, 10 circles are drawn with tick lines, medium lines circles every 0.5 unit and thin lines circles every 0.1 unit.

```
261 \fptest{#2=0}{% start circle linear radius sequence.
262 \I=1
263 \fpdowhile{\I<100}{\edef\R{\fpeval{0.01*\Scala*\I}}%
264 {\fptest{\fpeval{\I-10(round(\I/10,0))}=0}{\linethickness{\lwa}%
265 }%
266 {\fptest{\fpeval{\I-5(round(\I/5,0))}=0}{\linethickness{\lwb}}%
267 {\linethickness{\lwc}}%
268 }\Circlewithcenter0,0radius\R
269 }\advance\I by1\relax}%
270 }% end circle linear radius sequence
271 {%
272 \edef\LnDieci{\fpeval{\ln(10)}}%
273   \edef\ScalaDecade{\fpeval{\Scala/#2}}%
274 \fptest{#2<3}{%
275   \newcount\Dec \Dec=1\relax
276 \fpdowhile{\Dec<=#2}{%
277   \linethickness{\lwa}%
278   \edef\R{\fpeval{\Dec*\ScalaDecade}}%
279   \Circlewithcenter0,0radius\R% Thick circles
280 % First band from 1 to 4 (excluded)
281 \edef\LPLA{1}%
282 \fpdowhile{\LPLA<4}{
283 \edef\Logaritmo{\fpeval{\Dec-1+(\ln(\LPLA))/\LnDieci}}%
284 \edef\R{\fpeval{\ScalaDecade*\Logaritmo}}%
285 \fptest{\R>0}{\fptest{\LPLA=round(\LPLA,0)}%
```

```

286 {\linethickness{\lwb}}{\linethickness{\lwc}}%
287 \Circlewithcenter0,0radius\R}{}%
288 \edef\LPLA{\fpeval{\LPLA+0.2}}}%
289 % Second band from 4 to 10 included
290 \edef\LPLA{4}%
291 \fpdowhile{\LPLA=<10}{%
292 \edef\Logaritmo{\fpeval{\Dec-1+(ln(\LPLA))/\LnDieci}}}%
293 \edef\R{\fpeval{\ScalaDecade*\Logaritmo}}}%
294 \fptest{\R>0}{\fptest{\LPLA=round(\LPLA,0)}%
295 {\linethickness{\lwb}}{\linethickness{\lwc}}%
296 \Circlewithcenter0,0radius\R}{}%
297 \edef\LPLA{\fpeval{\LPLA+0.5}}}%
298 \advance\Dec by1\relax}%
299 }{%
300 \ClassWarning{GraphPaper}{Logarithmic polar graph paper:\MessageBreak
301 too many decades: \number#2\space\MessageBreak
302 Reduce their number}%
303 }}% End logarithmic circle radius sequence
304 \ignorespaces
305 %

```

Radial lines. \I represents the angle in degrees and it runs from 0 to 359. Tick lines every 10° ; medium lines every 5° for units 2, 7, 8, 9, 10; thin lines every 2° for units 3, 4, 5, 6; thin lines every 1° for units 7, 8, 9, 10.

```

306 \I=0\edef\R{\Scala}%
307 \fpdowhile{\I<360}{\edef\A{\fpeval{\I}}%
308 \fptest{\fpeval{\I-10(round(\I/10,0))}=0}%
309 {\linethickness{\lwa}\segment(0,0)(\A:\R)
310 \Rbox[\A](\A:\R){\color{black}\A}}% multiple of 10
311 {\fptest{\fpeval{\I-5(round(\I/5,0))}=0}%
312 {\linethickness{\lwb}}%
313 \segment(\A:5)(\A:10)
314 \segment(\A:30)(\A:\R)}% multiple of 5
315 {\linethickness{\lwc}}%
316 \fptest{\fpeval{\I-2(round(\I/2,0))}=0}%
317 {\segment(\A:10)(\A:\R)}% multiple of 2
318 {\segment(\A:30)(\A:\R)}% multiple of 1
319 }%
320 }%
321 \advance\I by 1\relax
322 }\ignorespaces

```

Graduated axis.

```

323 \GradPolar{#2}

```

Custom code provided by the user. After executing the code to compose the rectangular graph paper and the user custom code, the latter is reset if the `\GP@customcodereset` is true.

```

324 \GP@custom
325 \end{picture}
326 \ifGP@customcodereset\def\GP@custom{}\fi}

```

4.3.3 Smith chart graph paper

The Smith chart graph paper is composed by the command `\SmithChart`:

<code>\SmithChart [<di>iameter</di>]</code>

where $\langle diameter \rangle$ is the dimension (plus some extra space for labels and margins) of the Smith chart. Its default value corresponds to the `\paperheight` (the minimum dimension of the paper).

```

327 \NewDocumentCommand\SmithChart{0{\paperheight}}{%
328   \newpage
329   \parindent=0pt
330   \pagestyle{empty}%
331   \ifcsname pmargin\endcsname\relax\else\newlength\pmargin\fi
332   \setlength{\pmargin}{20pt}
333   \newgeometry{left=\pmargin,right=\pmargin,top=\pmargin,bottom=\pmargin}
334   \def\factor{140}
335   \unitlength=\fpeval{#1/\factor}pt\relax
336   \def\xlength{\fpeval{(\textwidth-0.01pt)/\unitlength}}
337   \def\ylength{\fpeval{(\textheight-0.01pt)/\unitlength}}
338   \begin{picture}(\xlength,\ylength)%
339     (\fpeval{-\xlength/2},\fpeval{-\ylength/2})%
340   \color{gridcolor}%
341   \edef\Scala{50}% scale factor based on the main circle but valid
342     % for everything inside the graph paper.
343   {\color{black}\Pbox(0,0){}[4]}% Black dot in the origin
344   % images of the vertical cartesian lines
345   \I=0\relax
346   \fpdowhile{\I<6}{\edef\Aux{\fpeval{\I/20}}{%
347     \fptest{\I=0}{\color{black}}{\color{gridcolor}}\thicklines\Xcircle{\Aux}}%
348   \advance\I by1\edef\Aux{\fpeval{\I/20}}\Xcircle{\Aux}%
349   \advance\I by1\ignorespaces}%fino a 0.4
350   \fpdowhile{\I<16}{\edef\Aux{\fpeval{\I/20}}\relax
351     {\thicklines\Xcircle{\Aux}}\advance\I by2\edef\Aux{\fpeval{\I/20}}\relax
352     \Xcircle{\Aux}\advance\I by2\ignorespaces}% fino a 1
353   \fpdowhile{\I<36}{\edef\Aux{\fpeval{\I/20}}\relax
354     {\thicklines\Xcircle{\Aux}}\advance\I by4\edef\Aux{\fpeval{\I/20}}\relax
355     \Xcircle{\Aux}\advance\I by4\ignorespaces}% fino a 2
356   \fpdowhile{\I<96}{\edef\Aux{\fpeval{\I/20}}\relax
357     {\thicklines\Xcircle{\Aux}}\advance\I by8\edef\Aux{\fpeval{\I/20}}\relax
358     \Xcircle{\Aux}\advance\I by8\ignorespaces}%fino a 5
359   \fpdowhile{\I<296}{\edef\Aux{\fpeval{\I/20}}\relax
360     {\thicklines\Xcircle{\Aux}}\advance\I by16\edef\Aux{\fpeval{\I/20}}\relax
361     \Xcircle{\Aux}\advance\I by16\ignorespaces}% up to 15
362   % Images of the horizontal cartesian semi-lines
363   \Ycircle{1}%
364   {\thicklines\segment(-\Rzero,0)(\Rzero,0)}% diameter
365   \Rbox[180](-\Rzero,0){0}\Rbox[0](\Rzero,0){\infty}
366   \Ycircle{0.05}\Ycircle{-0.05}\I=2% \I=2 is to avoid a division by 0
367   \fpdowhile{\I<18}{\edef\Aux{\fpeval{\I/20}}\relax
368     {\thicklines\Ycircle{\Aux}*\Ycircle{-\Aux}*\}%
369   \advance\I by1\edef\Aux{\fpeval{\I/20}}\relax
370   \Ycircle{\Aux}\Ycircle{-\Aux}\advance\I by 1\ignorespaces}% restarts from 1
371   \fpdowhile{\I<40}{\edef\Aux{\fpeval{\I/20}}\relax
372     {\thicklines\Ycircle{\Aux}*\Ycircle{-\Aux}*\}%
373   \advance\I by 2\edef\Aux{\fpeval{\I/20}}\relax
374   \Ycircle{\Aux}\Ycircle{-\Aux}\advance\I by 2\ignorespaces}% restarts from 2
375   \fpdowhile{\I<80}{\edef\Aux{\fpeval{\I/20}}\relax
376     {\thicklines\Ycircle{\Aux}*\Ycircle{-\Aux}*\}%
377   \advance\I by 4\edef\Aux{\fpeval{\I/20}}\relax
378   \Ycircle{\Aux}\Ycircle{-\Aux}\advance\I by 4\ignorespaces}% restarts from 4

```

```

379 \fpdowhile{\I=<140}{\edef\Aux{\fpeval{\I/20}}\relax
380 {\thicklines\Ycircle{\Aux}*\Ycircle{-\Aux}*}%
381 \advance\I by 10\edef\Aux{\fpeval{\I/20}}\relax
382 \Ycircle{\Aux}\Ycircle{-\Aux}\advance\I by 10\ignorespaces}% stops at 7.5
383 {\thicklines\Ycircle{8}*\Ycircle{-8}*}%
384 % non linear graduation for the abscissas
385 \GradResist{62}%
386 % Polar graduation in normalised wave length percentages
387 \edef\Rout{\fpeval{1.09*\Rzero}}%
388 \edef\RoutCifre{\fpeval{\Rout+2}}%
389 \edef\RoutTak{\fpeval{\Rout+1}}%
390 {\color{black}%
391 \Circlewithcenter 0,0radius\Rout
392 \I=0\fpdowhile{\I<10}%
393 {\edef\LAng{\fpeval{180-\I*36}}\edef\Cifre{\fpeval{\I*5}}%
394 \put(\LAng:\RoutCifre){%
395 \rotatebox{\fpeval{\LAng-90}}{\makebox(0,0)[b]{\scriptsize\Cifre}}}%
396 \advance\I by 1\ignorespaces}
397 \I=0\fpdowhile{\I<50}{%
398 \edef\LAng{\fpeval{180-\I*7.2}}\segment(\LAng:\Rout)(\LAng:\RoutTak)%
399 \advance\I by 1\ignorespaces}
400 %
401 % Outside circle encloses everything except the abscissa graduation.
402 % Everything lays inside a square
403 \Circlewithcenter0,0radius{\fpeval{\Scala+9}}}%
404 % Now the user supplied code is executed
405 \GP@custom
406 \end{picture}
407 \ifGP@customcodereset\def\GP@custom{\fi}%

```

4.4 User interface

Here follows the user commands to draw the graph papers, as described in section 3:

```

408 \NewDocumentCommand{\bilinear}{-}{\carta{0}{0}}
409 \NewDocumentCommand{\semilogx}{m}{\carta{#1}{0}}
410 \NewDocumentCommand{\semilogy}{m}{\carta{0}{#1}}
411 \NewDocumentCommand{\loglog}{0{0}mm}{\carta[#1]{#2}{#3}}
412 \NewDocumentCommand{\polar}{-}{\PolarChart{0}}
413 \NewDocumentCommand{\logpolar}{m}{\PolarChart{#1}}
414 \NewDocumentCommand{\smith}{-}{\SmithChart}

```

The user commands to customise the appearance of the graph papers is defined.

Their syntax was previously described in section 3:

```

415 \NewDocumentCommand{\setgridcolor}{m}{\colorlet{gridcolor}{#1}}
416 \NewDocumentCommand{\setmajorlinethickness}{m}{\setlength{\lwa}{#1}}
417 \NewDocumentCommand{\setmediumlinethickness}{m}{\setlength{\lwb}{#1}}
418 \NewDocumentCommand{\setminorlinethickness}{m}{\setlength{\lwc}{#1}}
419 \NewDocumentCommand{\setminimumdistance}{m}{\setlength{\mindistanceunit}{#1}}
420 \NewDocumentCommand{\setxside}{m}{%
421 \ifnum\fpeval{#1 > \paperwidth}=1 \ClassError{graphpaper}{X side too wide!} \fi
422 \setlength{\xsideunit}{#1}}
423 \NewDocumentCommand{\setyside}{m}{%
424 \ifnum\fpeval{#1 > \paperheight}=1 \ClassError{graphpaper}{Y side too wide!} \fi
425 \setlength{\ysideunit}{#1}}
426 \def\GP@custom{}
427 \newif\ifGP@customcodereset \GP@customcoderesettrue

```

```
428 \NewDocumentCommand{\customcode}{0{1} m}{%
429 \ifnum#1=\z@ \GP@customcoderesetfalse \fi%
430 \def\GP@custom{#2}}
```

4.5 Class code end

```
431 %
432 \endinput
```