

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

12

AD-A162 440

DP - Format of the Drawing Files

Dario Giuse

CMU-RI-TR-85-16

DTIC
ELECTE
DEC 18 1985
S D

Carnegie-Mellon University

The Robotics Institute

Technical Report

DISTRIBUTION STATEMENT A

Approved for public release
Distribution Unlimited

DP - Format of the Drawing Files

Dario Giuse

CMU-RI-TR-85-16

**The Robotics Institute
Carnegie-Mellon University
Pittsburgh, Pennsylvania 15213**

September 1985

Copyright © 1985 Carnegie-Mellon University

This research was supported by the Robotics Institute, Carnegie-Mellon University.

DISTRIBUTION STATEMENT A
Approved for public release
Distribution Unlimited

DTIC
SELECTED
DEC 18 1985
S D

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CMU-RI-TR-85-16	2. GOVT ACCESSION NO. AD-A162440	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DP - Format of the Drawing Files	5. TYPE OF REPORT & PERIOD COVERED Interim	
	6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s) Dario Giuse	8. CONTRACT OR GRANT NUMBER(s)	
9. PERFORMING ORGANIZATION NAME AND ADDRESS Carnegie-Mellon University The Robotics Institute Pittsburgh, PA. 15213	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE September 1985	13. NUMBER OF PAGES 23
	15. SECURITY CLASS. (of this report) UNCLASSIFIED	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE	
	16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited	
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report) Approved for public release; distribution unlimited		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) DP is a highly interactive graphics editor that runs on a personal workstation and can produce general-purpose illustrations as well as circuit drawings. The main purpose of this document, which is a complete specification of the format and semantics of DP drawing files, is to encourage the development of application programs that can read and generate drawings in the DP format and thus exchange information in graphics form.		

DD FORM 1473
1 JAN 73

EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-016-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Table of Contents

1. Introduction	1
2. Main Objectives of the File Definition	2
2.1 Portability	2
2.2 One-pass Scanning	3
2.3 Files as Independent Entities	3
3. Graphic Elements in DP Drawings	5
3.1 Primitive Graphic Elements	5
3.2 Symbols	5
4. Description of the Format	6
4.1 Coordinate System	6
4.2 Bounding Boxes	6
4.3 General Format	6
4.4 Structure of a DP File	7
5. Tree Structure	8
5.1 Format	8
5.2 Example	8
6. Font Information	9
7. Layers Information	10
8. Marks Information	11
9. Grids Information	12
10. Symbol Definitions	13
10.1 Beginning of Symbol Definition	13
10.2 End of Symbol Definition	13
11. Top-level Items	14
11.1 Straight Lines	14
11.2 ASCII Strings	14
11.3 Arcs and Circles	15
11.4 Ellipses	15
11.5 Splines	15
11.6 Polygons	16
11.7 Pins	16
11.8 Instance of a Symbol	16
12. BNF Description of the Format	18
13. Example of a Drawing File	19
14. Compatibility with Previous Versions	22

Accession For	
NTIS CRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	



Abstract

DP is a highly interactive graphics editor that runs on a personal workstation and can produce general-purpose illustrations as well as circuit drawings. The main purpose of this document, which is a complete specification of the format and semantics of DP drawing files, is to encourage the development of application programs that can read and generate drawings in the DP format and thus exchange information in graphics form.

1. Introduction

DP is an interactive graphics editor that can produce arbitrarily complex drawings and runs on a scientific personal computer, Perq System Corporation's PERQ workstation (see Giuse's DP - Command Set [3] for a general description of the program). DP deals with graphics objects such as lines, strings of text, circles, etc., as opposed to being purely bitmap-oriented. All the information entered by the user is preserved in the drawing; this makes it possible, for instance, for a program to analyze a drawing and to extract from it graphical and semantical information.

As an example of information extraction, DP drawing files can be fed into a set of post-processors that extract circuit information from drawings (see Giuse for a description of two such post-processors [9] [7]). Application programs are free to assign their own semantic interpretation to any drawing; DP only deals with the syntactic rules that determine the appearance of graphic items in a drawing.

DP drawings are stored on secondary memory as files, where each file corresponds to one drawing. This document describes the format of drawing files as generated by DP version 6.10; please contact the author if you are running a different version of the program.

The main objectives in the design of the DP file format and the technical reasons behind some of the decisions are described in section 2. Portability, completeness, and the ability to input drawing files in one pass were the primary considerations that influenced the design.

The primitive graphics elements used in DP drawing files and the symbol mechanism, which allows drawings to contain hierarchical structures that can be nested arbitrarily, are described in section 3.

The remaining sections of the document describe the coordinate system, the general structure of drawing files, and the detailed syntax and semantics of each DP graphics item as represented in drawing files.

Section 12 contains the formal description of the syntax of DP files. This description uses an extended BNF grammar.

Finally, presented in section 13 is an example of a simple drawing and the complete listing of the corresponding DP drawing file, illustrating some of the more important points of the format.

2. Main Objectives of the File Definition

The design of the format of DP files evolved from a few objectives that were considered essential. These objectives were often dictated by observations and experience with previous drawing programs (SUDS [8], Draw [4], Markup [5], and SII [6]). Most of these programs ran on the Alto, an early bit-mapped personal workstation developed by the XEROX Palo Alto Research Center.

The main objectives can be summarized as follows:

- **Portability:** drawing files should be portable to different machines and to different operating systems. It should be easy to read or generate drawings using different programming languages; the representation of a drawing should be independent of the particular program that generated it.
- **Completeness:** drawing files should be completely self-contained and should not depend on any external library. A single file should correspond to a single drawing; the file should not have any external dependency.
- **Simplicity:** drawing files should be simple to interpret and should have a direct correspondence to the graphics operations they describe. It should be possible for a program to read a drawing file in just one pass, without the need for elaborate multiple-pass operations that may be time-consuming and difficult to implement.
- **Separation of concerns:** drawing files should be a purely graphical description, without any embedded semantic knowledge about what the drawing represents. The interpretation of a drawing should be left to the user and to appropriate application programs; this achieves complete separation between the "meaning" of a drawing and its graphical appearance, thus increasing the overall flexibility of the system.

2.1 Portability

The main mechanism to achieve portability of drawing files is the choice of using exclusively ASCII characters in the format. The requirement that DP files be text files was considered very important and was central to the development of a large number of application programs that can read and generate DP files. It was clear that this choice would cause files to be somewhat larger than binary files, and that the time required to parse a file would also be longer. On the other hand, a number of reasons that justified the choice of text files exist; those reasons are briefly presented here.

A purely ASCII-based file format makes it easy to transfer and store files to different machines. Format changes between successive versions are easier than in the case of binary files. ASCII files are completely machine independent, while binary files may embed assumptions about machine word size or number representations that may be difficult to eradicate.

ASCII files are typically easier for a program to read, no matter what language the program is implemented in. Several programs have been written that generate simple drawings;¹ DP files can be created using

¹For instance, the program that generates the image of chips on a board described in Giuse [9].

standard I/O statements available in most programming languages, without any knowledge of the internal representation of graphics objects.

Finally, as a side-effect, DP files may be edited using standard text editors. While this is not a recommended procedure, it has proven useful in a few cases where a simple text substitution in a very large file could for instance change the name of a symbol. Moreover, this procedure can be used to salvage drawings that were damaged due to file system errors.

The fact that DP files are pure text files was one of the main reasons that made it possible to interface DP to Mint, the Spice document preparation system, in less than two days. The task would undoubtedly have been much harder if binary files had been used.

As a side remark, a comparison with SUIDS [8] drawings files (which are binary files) showed that DP files are actually 45% smaller than SUIDS files, in spite of the fact that they are entirely ASCII-based. This is because the representation used by SUIDS is extremely bulky; a careful choice of representation would of course result in a binary file being shorter than the corresponding text file.

2.2 One-pass Scanning

It was considered essential for the file format to support one-pass scanning: it should be possible to read a drawing in just one pass through the file, and no information should be used before being defined. For an example of another format that supports single-pass reading, see the description of the CIF format in [2].

The main device to achieve one-pass scanning is the ordering of symbol definitions. Symbol definitions are always output before any of the correspondent symbol calls; moreover, symbol definitions cannot contain other symbol definitions. Each definition appears at the top level in the file, and all the symbols that are used inside other symbols are always output first.

This convention requires more work to generate a file, but it makes reading the file much faster. Since a file may be read several times but is only written once, it was decided to favor reading at the expense of longer writing times. In the case of DP, for instance, the measured overhead for generating files in this order is less than 15 percent of the total time to write a file; this is certainly an acceptable overhead, given the significant savings in reading time.

2.3 Files as Independent Entities

Some drawing systems (see, for instance, [8]) allow drawings that are composed of multiple files, or drawings that contain embedded references to external libraries. The rationale is to reduce the size of drawing files by sharing common definitions among many drawings. Drawings that contain references to external files, however, present two important problems:

- Transferring a drawing to a different machine may be difficult, since all the imported files (including possibly files that are imported indirectly) should also be transferred.
- Modifications to a file may have totally unpredictable effects on drawings that import it. This is especially dangerous in the case of library files, i.e., files that contain collections of commonly used symbols and definitions.

It was thus decided that DP drawings should be totally self-contained entities: no reference to external files is allowed. This makes it extremely easy to transfer a drawing to a different machine.

Totally self-contained drawings must contain the definitions for all the symbols they use; this results in somewhat larger files, since commonly used definitions may have to be duplicated in several files. It was felt, however, that this would not constitute an important problem and that the advantages far outweighed the possible drawbacks.

It may seem that self-contained drawings make the problem of change propagation worse, since the only way to change a commonly used definition is to change all the drawings that use it. It should be noted, however, that external references do not address the problem of change propagation in a multi-machine environment anyway, and this is by far the most severe aspect of the problem. It is probably safer to let the user worry about change propagation explicitly: for instance, a program² has been written that changes the definition of one or more symbols in a set of DP files. This approach allows selective propagation of changes to some of the files, as opposed to the common-library approach which affects all the drawings that use a library symbol.

²The program is named NewSymbol.

3. Graphic Elements in DP Drawings

Only a limited set of basic elements can appear in drawing files: such elements are used to create more complex drawings. All the basic elements represent a geometric concept (a line, a circle, and so on); each drawing is thought of as a collection of geometric elements.

DP does not use bitmaps as representations for objects: it is impossible, for instance, to describe a curve by tracing it on the screen with the cursor. Smooth curves are defined geometrically, in terms of control points. Extensive use of geometric representations makes DP drawings independent of the particular characteristics of the device the drawing was created on.

3.1 Primitive Graphic Elements

The primitive elements used by DP are

- **lines:** finite-length straight line segments,
- **circles and arcs:** full circles or arcs of circles,
- **ellipses:** full ellipses or arcs of ellipses,
- **splines:** 3rd order B-splines, i.e., parametric curves that interpolate a set of points,
- **polygons:** filled polygons identified by a set of vertices and a filling pattern,
- **text strings:** sequences of printing ASCII characters in a given font, and
- **pins:** used inside symbol definitions to provide connection points. Each pin has a pin number associated with it.

3.2 Symbols

Primitive elements may be composed through the Symbol mechanism. When a set of objects is made into a symbol, the latter becomes equivalent to a primitive element. All the operations that apply to primitive elements apply to symbols as well; in particular, symbols may be nested inside other symbols.

The following two mechanisms are provided:

- **definition of a symbol:** definition of a group of elements that determine the shape of the symbol. A definition in itself does not add any element to a drawing: it simply defines how to draw a group of elements if required. A definition can be considered as a template that describes how to draw a picture.
- **instance of a symbol:** creation of a copy of a symbol in a drawing; each instance defines the global offset and the transformation parameters. Creating an instance is equivalent to adding to the drawing the whole set of elements that form the symbol; if transformations are used, the elements may appear rotated or scaled.

4. Description of the Format

Please note that in the rest of the document the phrases "the Reader" and "the DP Reader" will be used to indicate the portion of code in DP that reads drawing files and converts them into graphic items.

4.1 Coordinate System

DP files use a Cartesian coordinate system: abscissas increase to the right, and ordinates increase to the top. All coordinates are expressed as pairs of integers in base 10, in the range -32767 through 32767; the origin is at the point (0, 0). For consistency, numbers other than coordinates are also expressed as decimal integers.³

Angles are always measured in minutes of arc, starting from 0 for the positive X direction and growing counter-clockwise. For instance, an angle of 90 degrees (corresponding to the north) is expressed as $90 \times 60 = 5400$ minutes; south is expressed as $270 \times 60 = 16200$ minutes. The valid range for an angle is [0..21600], with the first and last values representing the same angle. Angles outside the range are always normalized by adding or subtracting 21600.

4.2 Bounding Boxes

The bounding box of an object is defined as the smallest rectangle that completely encloses the object. The edges of the rectangle are parallel to the cartesian axes.

The bounding box of an instance is always computed after the necessary transformations have been applied; for this reason, the dimensions of the box may not coincide with the size of the symbol definition.

4.3 General Format

In general, a text line in a DP file describes one graphic element; some lines are used differently, for instance as comments or as non-graphical information. Lines are terminated by the normal end-of-line convention, and different fields of a line are separated by one blank.

The first character in a line determines what kind of object the line represents. The first character of a line may be one of the following:

- **Capital letter:** the line describes a basic element or a symbol definition.
- **Semicolon:** the line is a comment.
- **@:** the line contains special non-graphical information.

The interpretation of individual fields depends on the particular kind of item and is explained in the following sections.

In order to identify DP files as such, a special convention is used: the first line of the file must be a comment of the form

³With the exception of transformation parameters for symbol instances, which are floating-point numbers.

; DP ver. 8.9

The DP Reader requires this line at the beginning, and will abort the Read operation if the first characters do not match exactly the string "; DP ver.". This line has the double function of rejecting non-DP files and informing DP of what version of the program created the file;⁴ all the characters after the first ten are considered part of the version number.

Except for this special convention, comment lines may appear anywhere in the file.

4.4 Structure of a DP File

The following order is used in all DP files. Since the DP Reader depends on this particular order in a few places, files that do not follow this order are considered illegal.

- **Version number:** the special comment line mentioned above.
- **Time stamp:** an optional comment line with the date and time of creation of the file.
- **Tree structure:** an optional set of comments that describe the tree of symbol definitions and specify dependencies on other symbols. This information is only used by the "i" (Read Symbol From File) command.
- **Font information:** definition of all the fonts used in the drawing. This section is absent if no strings are used.
- **Layer information:** definition of all the layers that constitute the drawing.
- **Marks information:** list of all the special position markers in the drawing. This section is absent if no mark is used.
- **Grids information:** list of mouse and display grids used when creating the drawing.
- **Symbol definitions:** list of all the symbol definitions used within other symbols and at the top level. The definitions are ordered so that lower-level definitions precede higher-level definitions: a symbol is always defined before it is used. This section is absent if the drawing is "flat", i.e., it contains no symbols.
- **Top-level items:** all the objects (primitive graphics elements and symbol instances) that appear at the top level in the drawing, i.e., are not nested inside symbols.

⁴Some details of the format are different in previous versions, and the DP Reader must deal with the differences.

5. Tree Structure

The purpose of this section is to describe dependencies among symbols. This information is used only when a single symbol is read from a file by the Reader. Application programs are free to ignore this section altogether; all the lines in the section are preceded by a semicolon and as such they may be considered as comments.

The special command that reads one symbol from a DP file uses this information to avoid multiple passes over the file. When a symbol is read, all the nested symbols must be read as well; this procedure is potentially recursive, since it is impossible to know what symbols are needed before reaching the top-level definition. The Tree Structure provides the Reader with this information: in particular, each symbol is listed with the transitive closure of all the symbols it uses. This information is precomputed when the file is first created, so that each symbol contains the names of all the symbols it uses either directly or indirectly.

During the "Input One Symbol" command, the DP Reader simply scans the file and enters the symbols that were listed in the Tree Structure as used by the required symbol. Everything else is discarded; the Reader stops after the required symbol has been read.

5.1 Format

For each symbol definition two comment lines are used in the Tree Structure section:

- `;SYMBOL: SymbolName`
- `;CALLS: list of all the nested symbols, separated by blanks`

All the symbols have an entry in the Tree Structure entry. Leaves of the tree, i.e., symbols that are entirely composed of primitive elements, have an empty `;CALLS:` field.

5.2 Example

Imagine a drawing that contains symbol TOP, which imports the two other symbols SYMBOL1 and SYMBOL2; imagine also that both SYMBOL1 and SYMBOL2 import symbol LEAF. The Tree Structure section of the drawing would then look like this:

```
;SYMBOL: TOP
;CALLS: SYMBOL1 SYMBOL2 LEAF
;SYMBOL: SYMBOL1
;CALLS: LEAF
;SYMBOL: LEAF
;CALLS:
;SYMBOL: SYMBOL2
;CALLS: LEAF
```

6. Font Information

This section of the file describes the fonts used by the strings in the drawing. The main purpose of the section is to define local font numbers, i.e., numbers that uniquely identify a particular font. This is the only place in a file where font name, size, etc., are explicitly mentioned; all further references are through the unique local font number.

Local font numbers are only meaningful within one file: the same font entry may well have a different local font number in a different file. Whenever the file is read, the DP Reader automatically converts the local font number into a global font specification.

A font entry specifies two distinct pieces of information: the abstract font specification (e.g. TimesRoman 12 boldface) and the name of a Perq font used to display that font on the Perq screen. Giuse [3] and Sproull [1] give more details on font specifications. Two lines are used for each font entry: the first line contains the abstract font specification, the second line identifies the Perq font file.

The format of the first line (abstract font definition) is the following:

@font *FontNumber Face Size Rotation Family*

- FontNumber:** a small positive integer that uniquely identifies this font. This number will be used in all the strings that use this font, and is meaningless outside the file. Local font numbers are unique, but they are not guaranteed to be contiguous or monotonically increasing.
- Face:** one or two lower-case characters that identify the font face (see Giuse [3] for more details). The characters {r b i} are currently used to indicate Roman, Boldface, and Italics. Characters may be combined when this is meaningful (for instance, bi stands for boldface italics).
- Size:** a positive integer that specifies the size of the font (in points). Big numbers indicate large fonts; see Sproull [1] for more details.
- Rotation:** the font rotation, in minutes of an arc (see section 4.1); normally 0.
- Family:** the name of the font family (e.g., "Bodoni" or "NewHelvetica"). Case distinctions in the family name are ignored, i.e., "Gacha" and "GACHA" are equivalent.

The format of the second line (Perq font) is the following:

@perqfont *FontNumber FileName*

- FontNumber:** must match one of the local font numbers that appear in a @font statement. Note that in files generated by DP this line follows immediately the corresponding @font line, and the FontNumber is thus redundant.
- FileName:** the file name of a valid Perq font. The font must be present on the Perq disk when this line is read; if this is not the case, the Reader prompts the user for an alternative file name. Note that including absolute path names in this file name is likely to impair the portability of the DP file and should be avoided.

7. Layers Information

This section defines the layers used in the drawing and specifies the value of the parameters for each layer (see Giuse [3] for more details on layers). Note that if a layer name is already in use before the file is read, old and new layer are merged and old and new items appear on one layer. In other words, layer names are global to all DDP files; it is impossible to define two different layers with the same name.

In the case of symbol instances, layers act as filters. Imagine for example that a symbol on layer A contains items that are on layer B: if both layers A and B are visible, the items will be displayed. If layer A is made invisible, though, the items will not be displayed even if their own layer (B) is still visible. Since the symbol at the upper level is invisible, none of the objects inside it are visible: layer A is "filtering" all the items contained in symbols that appear on it.

Each line in the Layers Information section defines one layer. The format of each line is the following:

0layer *LayerNumber Name Options*

- LayerNumber:** a small positive integer that uniquely identifies this layer. This number will be used by all the following items, and is meaningless outside the file. Local layer numbers are unique but are not guaranteed to be contiguous or monotonically increasing.
- Name:** the ASCII name of the layer, converted to all upper case. No blanks are allowed in the name.
- Options:** a sequence of characters encoding the options setting for the layer; all characters are upper case. If an option is ON, the corresponding character is present. The current set of characters is: **R** (the layer is Readable), **W** (the layer is Writable), and **O** (the layer will be output when the drawing is written to a file). For example, **RO** means that the layer can be displayed and output but cannot be altered.

8. Marks Information

Marks provide a convenient mechanism to position a drawing around meaningful reference points. Each mark has a number associated with it; this number is currently unused (see Giuse [3] for more details on marks).

The format of a mark entry is the following:

@pageMark *x y number*

x, y: position of the mark, in absolute coordinates.
number: a unique integer associated with the mark (currently unused).

9. Grids Information

This section contains information about the mouse and display grid settings that were in use when the drawing was created. This information is not needed for the correct interpretation of the drawing, and is only provided as a convenience to the user. It is often the case that a drawing is edited using a non-standard grid, causing potential alignment problems if a different grid is used during subsequent editing.

When the Reader encounters the Grids Information section, it sets the current mouse and display grids to match the ones specified in the drawing.

The format of the grid entry is the following:

@grids *mouse-grid display-grid*

mouse-grid: value of the mouse grid, as a positive integer. This indicates the distance between the two nearest points at which the mouse can be located.

display-grid: value of the display grid, as a positive integer. This indicates the distance between points of the grid that DP uses to facilitate item alignment.

Note that only one grid entry is present in a DP file, even though many mouse grids can be used during a DP editing session. Only the current mouse grid is saved in the file.

10. Symbol Definitions

Symbol definitions are collections of items enclosed by a begin-end pair and identified by a unique name. Symbol definitions describe how to draw symbol instances and can be thought of as templates; similar pictures can be generated from the same template (symbol definition) by scaling, rotating, or mirroring the basic definition.

Coordinates within definitions are relative, i.e., they need a translation before they can be displayed; the translation is specified at the time the symbol is instantiated. Coordinates within a symbol definition are stored so that the *center of the symbol* is the point (0, 0): the "center of the symbol" is defined as the center of the bounding box of the symbol. In other words, all the items appearing in symbol definitions are centered around the point (0, 0).

10.1 Beginning of Symbol Definition

This line starts the definition of a new symbol. The format of the line is the following:

D *width height name*

width, height: width and height of the bounding box of the symbol in its non-transformed definition, i.e., when the rotation is 0 and the scaling is 1.0, 1.0.
name: the unique name of the symbol, in upper-case characters. This name is the only way this symbol can be referred to in the future.

After this line the primitive elements that constitute the body of the symbol definition are listed, each one in its normal format (see section 11). Every basic element can appear here, including instances of other symbols; symbols may be nested at any level. The end of the symbol is marked by the End of Symbol Definition.

10.2 End of Symbol Definition

The format of this line is the following:

F

This line marks the end of a symbol definition. The symbol being defined is closed and entered in the list of definitions. This line will typically be followed by either the beginning of a new definition, or by the first top-level item in the drawing.

11. Top-level Items

By default, all items that are not part of a symbol definition are considered to be at the top level of the drawing. All top-level items use absolute coordinates, unlike items that are part of a symbol definition.

Several fields are common to various item types; their meaning is described only once and will not be repeated for individual items. The common fields are:

- Thickness:** a positive integer that indicates the thickness of lines, circles, ellipses, and splines. By convention, the thinnest item has thickness 1; in the current implementation, the thickest item has thickness 7. Numbers greater than 7 are currently interpreted as 7.
- Color:** a positive integer that specifies the color of an item. By convention, color 1 indicates a black item. Colors other than 1 are preserved and used for devices that support colors;⁵ in the current implementation all items except Polygons are displayed in black on the Perq, regardless of the color specified in the file. *The meaning of the color information is likely to change in future versions.*
- Layer:** a local layer number, i.e., a reference to an @layer statement. This indicates what layer the item belongs to. In the case of a symbol instance, this is the layer of the instance, and may act as a filter for nested items.
- Line-Style:** a small integer that determines the line style to be used for lines, circles, ellipses, and splines. The default line style is *solid* and is indicated by line-style 0. Line-style 1 indicates *dotted*, which is a pattern of equally spaced short dashes. Line style 2 indicates *dashed*, which is a pattern of equally spaced long dashes. Line style 3 indicates *dot-and-dash*, which is a repeating pattern of short and long dashes. Line styles greater than 3 are currently undefined.

The following sections contain the description of all the different types of items and the format of the corresponding entries in a DP file. Remember that all numbers are integers, unless otherwise specified.

11.1 Straight Lines

L *x1 y1 x2 y2 thickness color layer line-style*

- x1,y1:** coordinates of the first endpoint of the line.
x2,y2: coordinates of the second endpoint of the line.

11.2 ASCII Strings

S *x1 y1 x2 y2 font color layer string*

- x1,y1:** coordinates of the lower-left corner of the bounding box of the string.
x2,y2: coordinates of the upper-right corner of the bounding box of the string.
font: the local font number for this string. This number must match one of those defined in the section on fonts (section 6).
string: the actual text string, truncated to 80 characters and terminated by the end of the line.

⁵Currently the HP 7221A Plotter is the only device that supports colors.

The size of a string is computed under the assumption that the specified font is used to display the string; using a different font would result in a different size. The reference point is, at any rate, the lower-left corner of the string: the upper-right point can always be computed from the lower-left corner. If a different font must be used for a different device, the string should be positioned in such a way that its lower-left corner ends up at the point $(x1, y1)$.

11.3 Arcs and Circles

A *x y radius angle1 angle2 thickness color layer line-style*

x,y: coordinates of the center of the circle.
radius: radius of the circle.
angle1: first angle of the arc, i.e., first angle encountered on the arc when scanning it counterclockwise; the starting point is on the positive X axis, at $(radius, 0)$ from the center. The angle follows the usual convention explained in section 4.1.
angle2: second angle of the arc. If angle2 is equal to angle1 the arc is a full circle.

Note that a full circle is normally indicated by $angle1 = 0$, and $angle2 = 21600$.

11.4 Ellipses

E *x y radius1 radius2 angle1 angle2 thickness color layer line-style*

x,y: coordinates of the center of the ellipse.
radius1: horizontal radius of the ellipse, i.e., half the horizontal diameter.
radius2: vertical radius of the ellipse.
angle1: first angle of the arc of ellipse, i.e., first angle encountered on the arc when scanning it counterclockwise; the starting point is on the positive X axis, at $(radius1, 0)$ from the center. The angle follows the usual convention explained in section 4.1.
angle2: second angle of the arc; same conventions as before. If angle2 is equal to angle1 the arc is a full ellipse.

A full ellipse is normally indicated by $angle1 = 0$, and $angle2 = 21600$. Note that this representation does not allow an ellipse whose major and minor axes are not parallel to the cartesian axes, but such an ellipse can be represented by nesting it into a symbol and then rotating the symbol.

11.5 Splines

B *x y n k thickness color layer line-style x1 y1 x2 y2 ... xn yn*

x,y: global offset of the spline.
n: number of control points in the spline.
k: degree of the spline; always equal to 3 for 3rd order B-splines, which is the default in DP. Other types of splines are not completely supported for the time being and are not documented here.
x1,y1: coordinates of the first control point, relative to (x,y) .
x2,y2: coordinates of the second control point, relative to (x,y) .
 ...
xn,yn: coordinates of the last control point.

11.6 Polygons

By convention, an n -sided polygon is represented by n vertices; the first and last vertices are considered connected.

Y *x y thickness color layer x1 y1 x2 y2 ... xn yn*

x,y: global offset of the polygon.
color: this parameter is used to select a pattern that fills the polygon. Polygon patterns are predefined and are intended to emulate different shades of gray. Only colors in the range 1 through 17 are supported; color 1 corresponds to solid black, color 17 is solid white. Numbers in between represent intermediate shades of gray, color 8 being an intermediate "solid" gray.
x1,y1: coordinates of the first vertex of the polygon, relative to (x,y).
x2,y2: coordinates of the second vertex, relative to (x,y).
 ...
xn,yn: coordinates of the last vertex of the polygon, relative to (x,y).

Note that the *thickness* parameter is ignored.

11.7 Pins

P *x1 y1 number position color layer*

x1,y1: abscissa and ordinate of the pin.
number: an integer corresponding to the pin number.
position: an integer in the range 0 through 3 that specifies the quadrant the pin number should be displayed in.⁶ Position 0 corresponds to the first (upper-right) quadrant, position 1 corresponds to the upper-left quadrant, and so on.

Pin numbers are ignored by many programs that process DP drawings. A pin contained in a symbol acts as a gravity point in DP, independent of its pin number.

11.8 Instance of a Symbol

This line creates an instance of a symbol. Instantiating a symbol is equivalent to calling a procedure that has been defined and stored away. The instance specifies the global offset and transformations for the symbol; the transformations are applied first, and the offset is applied later. If nested symbols are contained in the definition, each offset/transformation is applied in order, from the innermost to the outermost levels.

Transformations are additive: if a symbol has rotation $R1$ and calls another symbol with rotation $R2$, the final result is the same as if the nested symbol were directly called with rotation $(R1+R2)$. The order of application of transformations is generally irrelevant, with one exception: when a symbol is non-uniformly scaled in the horizontal direction, this scaling should be applied before the rotation. This ensures that the shape of the symbol does not change for different rotations.

⁶Even if this is not an angle, it is used as such when the pin appears inside a transformed symbol.

The format of a symbol instance is the following:

C *x y angle scale-x scale-y layer name*

x,y: abscissa and ordinate of the center of the symbol, i.e., global offset.
angle: rotation of the instance (see 4.1 for angles conventions).
scale-x, scale-y: (these are two real numbers): scaling factors for the instance in the X and Y directions. A scaling factor of 1.0 means the same scale as the definition; a negative factor implies a mirroring operation. Note that because of the order of application of symbol transformations, these factors indicate the scaling of the symbol *before* the rotation is applied, i.e., they indicate the scaling factors relative to the symbol's own X and Y axes.
name: reference to a symbol definition. This string must match exactly the name in a symbol definition, and thus it must be in all upper-case characters. The symbol must be already defined; forward references are not allowed.

12. BNF Description of the Format

This is the description of the format of DP drawing files in an extended BNF syntax. The following additional notations have been used:

{ <item> }⁺ <item> may appear from 1 to infinite times.
 { <item> }^{*} <item> may appear any number of times, including 0.

<char>, not defined here, is essentially the whole ASCII printing set minus EOL. (End-Of-Line).

```

<DP file>            ::= ";" DP ver." <string> {<line>}*

<comment>           ::= ";" {<char>}* EOL

<string>            ::= {<char>}* EOL

<number>            ::= " " <integer> | "-" <integer>

<integer>            ::= {<digit>}+

<real>              ::= <number> "." <integer> | <number>

<digit>             ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

<point>             ::= <number> <number>

<parameters>        ::= <number> <number> <number> <number>

<line>               ::= <symbol definition> | <ENV line> | <DP line>

<ENV line>          ::= "@font" <number> {<char>}+ <number> <number> <string> |
"@perqFont" <number> <string> | "@layer" <number> {<char>}+ <string> |
"@pageMark" <number> <number> <number> EOL |
"@grids" <number> <number> EOL

<DP line>           ::= "L" <point> <point> <parameters> EOL |
"A" <point> <number> <number> <number> <parameters> EOL |
"E" <point> <number> <number> <number> <number> <parameters> EOL |
"B" <point> <number> <number> <parameters> {<point>}+ EOL |
"Y" <point> <number> <number> <number> {<point>}+ EOL |
"S" <point> <point> <number> <number> <number> <string> |
"P" <point> <number> <number> <number> <number> EOL |
"C" <point> <number> <real> <real> <number> <string> |
<comment>

<symbol definition> ::= "D" <number> <number> <string>
                      {<DP line>}+
                      "F" EOL
  
```

13. Example of a Drawing File

The present section contains an example of an actual drawing file. The drawing in the example is shown in fig. 13-1.

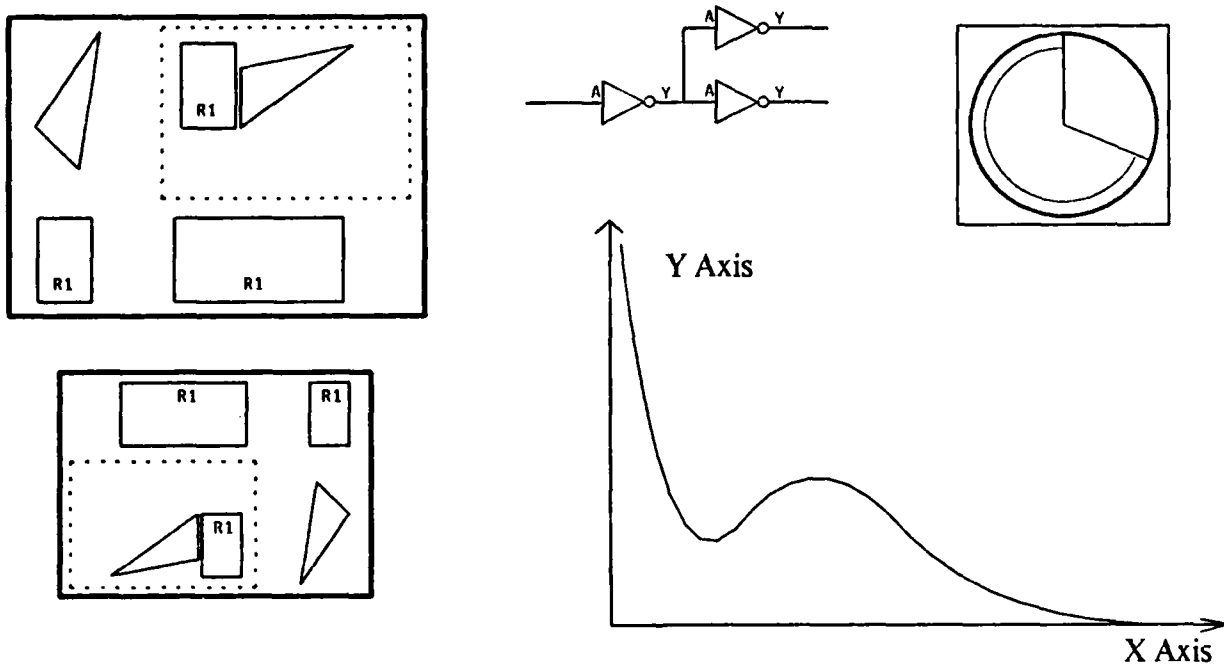


Figure 13-1: The drawing in our example

The complete text of the DP file is also shown. Several points are worth discussing:

- Most of the drawing is on the STANDARD layer, except for the axes system in the graph at the right which is on the FRAME layer instead. This layer includes the two axes and the two strings "Y Axis" and "X Axis"; the layer is currently non-writable, as indicated by the absence of the W parameter from the last field of the line "@layer 2 FRAME RO".
- Two instances of the symbol named PICTURE are used; the two instances appear in the left half of the drawing. The instance at the bottom is scaled down (the scaling parameters are equal to 0.75 and 0.75) and rotated 180 degrees counterclockwise (as indicated by a rotation angle of 10800 minutes).
- The symbol PICTURE is composed of two instances of the symbol RECT, one instance of the symbol TRIANGLE, one instance of the symbol COMPOSITE, four straight dotted lines (having line-style 1), and four straight lines that describe the box around the picture. The four lines have thickness 3 and line-style 0, i.e., they are solid.
- The symbol RECT consists of four straight solid lines (having thickness 1) and of the string "R1". This string is drawn in font Gacha 7 Roman, as indicated by the font number (1) which points to the definition line "@font 1 r 7 0 Gacha".

- The graph at the bottom-right is drawn as a single 3rd-order B-spline, described by the line

B 2 -168 5 3 1 1 1 0 311 1 204 0 108 112 24 6 0 218

The spline is defined by the 5 control points (311,1) (204,0) (108,112) (24,6) (0,218) and is drawn in thickness 1.

```
; DP ver. 6.10
; 09-Jul-85 12:54:17
;SYMBOL: 7404
;CALLS:
;SYMBOL: PICTURE
;CALLS: COMPOSITE RECT TRIANGLE
;SYMBOL: COMPOSITE
;CALLS: RECT TRIANGLE
;SYMBOL: TRIANGLE
;CALLS:
;SYMBOL: RECT
;CALLS:
@font 1 r 7 0 Gacha
@perqFont 1 gacha7.kst
@font 4 r 12 0 TimesRoman
@perqFont 4 gacha7.kst
@layer 1 STANDARD RWO
@layer 2 FRAME RO
@pageMark 41 -121 1
@pageMark -18 7 3
@pageMark 41 -121 2
@grids 1 6
D 30 48 RECT
S -7 -18 5 -9 1 1 1 R1
L 15 -24 15 24 1 1 1 0
L 15 -24 -15 -24 1 1 1 0
L -15 -24 -15 24 1 1 1 0
L 15 24 -15 24 1 1 1 0
F
D 36 78 TRIANGLE
L 18 39 6 -39 1 1 1 0
L 6 -39 -18 -15 1 1 1 0
L -18 -15 18 39 1 1 1 0
F
D 96 80 COMPOSITE
C 8 0 18900 1 1 1 TRIANGLE
C -33 -8 0 1 1 1 RECT
F
D 231 179 PICTURE
C 24 -57 0 3.13844 1 1 RECT
L 108 75 -30 75 1 1 1 1
L -30 -22 -30 75 1 1 1 1
L 108 -22 -30 -22 1 1 1 1
L 108 -22 108 75 1 1 1 1
L 116 81 -115 81 3 1 1 0
```

L-115-89-115 81 3 1 1 0
 L 116-89-115-89 3 1 1 0
 L 116-89 116 81 3 1 1 0
 C-84-57 0 1 1 1 RECT
 C-82 34 0 1 1 1 TRIANGLE
 C 29 50 0 1 1 1 COMPOSITE
 F
 D 45 24 7404
 S-22 2-16 11 1 1 1 A
 P-15 0 1 1 1 1
 S 17 1 23 10 1 1 1 Y
 A 11 0 3 9900 9150 1 1 1 0
 L-15-12 8 0 1 1 1 0
 L-15 12-15-12 1 1 1 0
 L-15 12 8 0 1 1 1 0
 P 14 0 2 4 1 1
 F
 C-223 99 0 1 1 1 PICTURE
 A 248 118 44 5400 20056 1 1 1 0
 L 189 174 189 61 1 1 1 0
 L 295 98 248 118 1 1 1 0
 L 248 170 248 118 1 1 1 0
 L 306 174 306 61 1 1 1 0
 L 306 174 189 174 1 1 1 0
 L 306 61 189 61 1 1 1 0
 A 248 118 52 0 21600 3 1 1 0
 C 7 131 0 1 1 1 7404
 L 55 131 21 131 1 1 1 0
 C 70 131 0 1 1 1 7404
 L 84 131 117 131 1 1 1 0
 L-9 131 -51 131 1 1 1 0
 L 37 173 37 131 1 1 1 0
 C 70 173 0 1 1 1 7404
 L 55 173 37 173 1 1 1 0
 L 84 173 117 173 1 1 1 0
 B 2-168 5 3 1 1 1 0 311 1 204 0 108 112 24 6 0 218
 C-223-89 10800 0.75 0.75 1 PICTURE
 L-4 64-4-167 1 1 2 0
 L 338-167-4-167 1 1 2 0
 L 3 57-4 64 1 1 2 0
 L-12 57-4 64 1 1 2 0
 S 26 31 62 40 4 1 2 Y Axis
 L 323-171 338-167 1 1 2 0
 L 323-164 338-167 1 1 2 0
 S 280-189 316-180 4 1 2 X Axis

14. Compatibility with Previous Versions

The present document describes the format of DP files for internal purposes only; no guarantee is implied as to the stability of the format itself. Although the format has remained substantially unchanged for long periods of time, changes and extensions to DP have required various adaptations and additions to the format.

In particular, it should be noted that changes and extensions may make new formats unreadable by older versions of DP. It is typically impossible to read files whose version number is higher (newer) than the version of DP one is using. The DP Reader, on the other hand, is written in such a way as to be compatible with older versions; all versions of DP can read files whose version number is less than or equal to the particular version being used.

This is believed to apply to all existing versions of the program, including local modifications that you may be using. If this is not the case, please contact the author reporting the version number of the instance of DP you are using, the version number and creation date of the drawing file, and information about how you obtained your version of the program.

References

- [1] Robert F. Sproull.
Font Representations and Formats.
Technical Report, XEROX Palo Alto Research Center, October, 1980.
- [2] R.W. Hon, C.H. Sequin.
A Guide to LSI Implementation.
Technical Report, XEROX Palo Alto Research Center, January, 1980.
- [3] Dario Giuse.
DP - Command Set.
Technical Report CMU-RI-TR-82-11, Carnegie-Mellon University, October, 1982.
- [4] Patrick C. Baudelaire.
Draw Manual.
Technical Report, XEROX Palo Alto Research Center, 1978.
- [5] William M. Newman.
Markup User's Manual.
Technical Report, XEROX Corporation, Palo Alto, 1978.
- [6] C.P. Thacker, R.F.Sproull, R.D.Bates.
SIL, ANALYZE, GOBBLE, BUILD - Reference Manual.
Technical Report, XEROX Corporation, Palo Alto, Ca., 1979.
- [7] Dario Giuse.
SL: a hierarchical wire-lister for DP drawings.
Technical Report, Carnegie-Mellon University, March, 1982.
- [8] Joseph M. Newcomer.
SUDS - User's Manual
Carnegie Mellon University, 1980.
- [9] Dario Giuse.
DP : post-processing a circuit drawing
Carnegie-Mellon University, 1981.

END

FILMED

2-86

DTIC