Gerber RS-274X Format

User's Guide

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Preface

The information in this Guide was published previously as the *Gerber Format Guide*, which documented *RS-274X format*, also called *Gerber Format*, for both vector and raster devices. Acknowledging that vector plotting is rapidly becoming an outdated technology, this Guide describes use of RS-274X only in raster applications and eliminates codes that pertain to vector applications. This does **not** imply that existing files that include codes and parameters not described in this edition of the Guide will not work. The intent of this Guide is to describe and document uses of RS-274X format.

Contents

Introduction

Gerber data is a simple, generic means of transferring printed circuit board information to a wide variety of devices that convert the electronic PCB data to artwork produced by a photoplotter. Virtually every PCB CAD system generates Gerber data because all photoplotters read it. It is a software structure consisting of X,Y coordinates supplemented by commands that define where the PCB image starts, what shape it will take, and where it ends. In addition to the coordinates, Gerber data contains aperture information, which defines the shapes and sizes of lines, holes, and other features.

Gerber Format, which is the format in which Gerber data is expressed, actually is a family of data formats that are subsets of EIA Standard RS-274D. *Extended Gerber Format*, which is also called *RS-274X*, provides enhancements that handle polygon fill codes, positive/negative image compositing, and custom apertures, and other features. RS-274X also encapsulates the aperture list in the header of the Gerber data file and therefore allows files to pass from one system to another without the need to re-input the aperture table. RS-274X produces a variety of Gerber data called *X data*.

RS-274X is a *superset* of the EIA Standard RS-274D format. RS-274X supports some of the parameter data codes (G codes) and aperture codes (D codes) contained in RS-274D, as well as codes referred to as *mass parameters*. Mass parameters are plot parameters that define characteristics that can affect an entire plot, or only specific parts of the plot, called *layers*. Mass parameters extend the capabilities of Gerber Format. Their presence makes the Gerber data *X data.*

Who should use this Guide?

In order to use this Guide, you should have a fundamental understanding of PCB fabrication or PCB design and laser plotting concepts. This Guide is intended for use by:

- PCB designers preparing data for conversion to RS-274X

- PCB fabricators creating or using Gerber data files

- Developers of software applications using RS-274X data

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How to use this Guide

You will find the following sections in this Guide:

Rules and Guidelines explain file content and structure and outlines rules and guidelines for creating a correct RS-274X file. It also contains a sample file.

Reference defines use and constraints on use of every RS-274X parameter and data code currently supported. Parameters and data codes are described separately. Both are presented in alphanumerical order.

You will also find a **Glossary** and **Index** at the end of the Guide.

Related documentation

This Guide assumes you are familiar with Electronic Industries Association EIA Standard RS-274D. You can obtain a copy of this standard from the Electronic Industries Association, Engineering Department, 2001 Eye Street NW, Washington, DC 20006 USA.

Where to go for help

Should you need assistance, contact the Barco Graphics ETS North American Technical Assistance Center by telephone during normal business hours (eastern time) at (888) 727-9972, by fax at (860) 291-7021.

Rules and Guidelines

This section provides background information, describes organization, and presents guidelines for use of RS-274X. For detailed descriptions of use of individual codes and parameters, see *Reference*, page 15.

File structure

An *RS-274X plot file* is a file consisting of RS-274X parameters and standard RS-274D codes which, when correctly interpreted, result in an image that may be displayed or plotted.

Data blocks

The file is composed of a number of *data blocks* containing parameters and codes. Each data block is delimited by an end-of-block character, typically an asterisk (*).

Each data block may contain one or more parameters or codes. For example:

```
X0Y0D02*
X50000Y0DO1*
```

Layers

One or more data blocks may be grouped into a *layer* of information that describes part of a graphic image. In RS-274X context, a layer is a *named **information component of the image*** composed of one or more data blocks. Each layer may have characteristics, such as name, polarity, and interpolation mode, that differ from other layers of information . In addition, an individual layer may be "knocked out "of the surrounding graphic image, and may be repeated and/or rotated individually.

> *Note: A layer must not be confused with a PCB layer. A PCB layer has a physical definition and might be compared to a physical plane. An RS-274X layer is simply a group of data blocks that may be manipulated collectively and separately from other layers.*

Data types

An RS-274X file may contain the following kinds of data appearing in the following general order:

1. RS-274X Parameters

RS-274X parameters are also called *mass parameters* or *extended Gerber format*. The inclusion of these parameters in the file makes the plot file RS-274X, or *X data*, instead of standard RS-274D.

2. Standard RS-274D Codes

Standard RS-274D codes were once called *word address format*. They consist of:

- one-character **function codes** such as G codes, D codes, M codes, etc. Function codes were the *words* of the old terminology. They describe how coordinate data associated with them should be interpreted (such as linear or circular interpolation), how the imaging device should move (light source on or off), and more.

- **coordinate data** define points to which the imaging device must move. The coordinate data represented the *address* of the old terminology. X,Y coordinate data describe linear positions. I, J coordinates define arcs.

RS-274X parameters

RS-274X parameters define characteristics that apply to an entire plot or to a single layer, depending on the parameter's position in the file and whether it generates a new information layer in the file (as, for example, layer-specific parameters do). RS-274X parameters consist of two alpha characters followed by one or more optional modifiers.

RS-274X parameters are delimited by a *parameter delimiter*, typically a percent (%) sign. Because parameters are also contained in a data block, they are also delimited by an end-of-block character. For example,

`%FSLAX23Y23*%`

This parameter is a Format Statement (FS) describing how the coordinate data in the file should be interpreted (in this case, 4.2 format for both X and Y coordinates). It is delimited by an end-of block character (*) as well as by a parameter delimiter (%).

RS-274X parameters may be grouped according to the scope of their function in the file. The groups should appear in the file in the following order:

1. **Directive parameters** control overall file processing.
2. **Image parameters** supply information about an entire image.
3. **Aperture parameters** describe the shape of lines and components throughout the file.
4. **Layer-specific parameters** describe processing of one or more data layers.
5. **Miscellaneous parameters** provide capabilities that do not fall into the above groups.

RS-274X parameters are generally placed at the beginning of the file in the order shown above. Certain parameters, such as the layer-specific parameters, may be embedded within the file.

The next sections describe each parameter type.

Directive parameters

Directive parameters control overall file processing. They include:

AS	Axis Select
FS	Format Statement
MI	Mirror Image
MO	Mode of units
OF	Offset
SF	Scale Factor

As a general rule, directive parameters should be placed at the beginning of the file. For simplicity sake, you should use each directive parameter only once in a file, although it is not illegal to use a directive parameter more than once. Each directive parameter controls processing until another like it is encountered.

When used more than once in a file, subsequent directive parameters may be embedded anywhere in the standard RS-274D code data or grouped with other layer-specific parameters.

Directive parameters do not generate a new layer.

Image parameters

Image parameters supply information about the entire (composite) image. Image parameters include:

IJ	Image Justify
IN	Image Name
IO	Image Offset
IP	Image Polarity
IR	Image Rotation
PF	Plotter Film

Image parameters should be used only once in a file and should be placed at the beginning of the file. If an image parameter occurs more than once in a file, the last one encountered will be the operative parameter.

Aperture parameters

Vector plotters control the width and shape of features by projecting light through a series of openings, or apertures, in a rotating wheel. Each position on the wheel is identified by a unique D code. When the D code appears in the data, the wheel rotates to the referenced position for exposure.

Unlike a vector device, a raster device has no apertures and therefore requires a description of the aperture geometry to create the required lines and other features. The aperture parameters provide the description.

The aperture parameters include:

AD   Aperture Description
AM   Aperture Macro

In general, aperture parameters apply to an entire file. An exception is an embedded AD parameter, which will generate a new layer if it redefines a D code previously used in the image data.

Note: Generating a new layer may result in unanticipated results because it causes certain RS-274D values (such as interpolation mode) to be reset.

The AM parameter describes a special aperture by using the following set of predefined aperture shapes to describe an aperture:

Circle
Line (vector)
Line (center)
Line (lower left)
Outline
Polygon
Moiré
Thermal

See the AM command description, page 19, for more information.

Layer-specific parameters

Layer-specific parameters supply information for the processing of one or more *information* layers (not to be confused with board layers). They may be used more than once in a file. Layer-specific parameters always generate a new layer and should be placed at the beginning of the new layer. If not repeated for a given layer, the previous layer-specific parameters remain in effect.

The layer-specific parameters include:

KO   Knockout
LN   Layer Name
LP   Layer Polarity
SR   Step and Repeat

Note: Generating a new layer may result in unanticipated results because it causes certain RS-274D values (such as interpolation mode) to be reset.

Miscellaneous parameters

There is a single miscellaneous parameter:

IF   Include File

The IF parameter is used to include (nest) external files in a file.

Standard RS-274D Codes and Coordinate Data

Standard RS-274D codes (D codes, G codes, M codes, etc.) specify how the coordinate data should be manipulated. Each code applies to coordinate data located in the same data block as the code (that is, between EOB characters). It also applies to coordinate data following it until another code of the same type is encountered, or until a new layer is generated. This continuing action is referred to as *modal*.

For example, G02 specifies clockwise, single-quadrant circular interpolation and is modal. All coordinate data following it will be considered clockwise arc data until another interpolation code is encountered, or until a new layer is generated. When a new layer is generated, interpolation will be reset to linear (G01).

Like parameters, standard RS-274D codes may be grouped according to function. They generally appear in the file in the following sequence:

1. **N codes** (sequence numbers) are similar to line numbers and may be assigned to data blocks to simplify organization. Sequence numbers may be 0 to 99999. N codes are not necessary.

2. **G codes** (general functions) specify how to interpolate and move to the coordinate locations following the code until changed or until a new layer is generated (modal).

3. **D codes** (plot functions) select and control tools, specify line type, etc.

4. **M codes** (miscellaneous functions) perform a variety of functions such as program stop and origin specification.

Standard RS-274D codes are described in detail starting on page 45.

Coordinate Data

Coordinate data includes:

- **X,Y data** define linear positions along the X and Y axes.

- **I,J data** define arcs.

For example,

X200Y200D02*

This data block directs the plotter to move in a positive direction to coordinate location 0.2,0.2 (assuming leading zeroes are omitted) with the light source off (tool up). Additional X,Y coordinate data positions following this code will also cause motion with the light source off until a different code is encountered.

Absolute versus relative data

Depending on the preceding FS parameter in the file, coordinate data may be defined either relative to the plot origin (that is, as absolute values) or relative to the last coordinate position (that is, as incremental data).

Numerical precision

Coordinate data may be expressed in inches or millimeters to ±6.6 decimal places (that is, up to six integer digits and six fractional digits). Unless preceded by a "-", the direction is assumed to be "+".

Axis assignment

The coordinate axes may be assigned to any physical plotter axes using the AS parameter, but typically the A plotter axis is assigned to X and the B axis to Y.

General File Preparation Guidelines

Follow these guidelines when preparing RS-274X data:

- Use data blocks in a way that organizes the file visually for easy reading.

- Enter all codes and parameters in upper case.

- Use file names that comply with the system file naming conventions. DOS and therefore Windows 3.1 files names are limited to eight characters. UNIX systems are case-sensitive.

- End every data block with an end-of-block character, typically *. For example,

  `X0000Y5000D02*`

- Do not break a line within a block.

- End every file with an end-of-program code (M00 or M02).

RS-274X Parameter Guidelines

- Begin and end RS-274X parameter data with a parameter delimiter, typically %. The parameter delimiter must immediately follow the end-of-block without intervening spaces. For example,

  `%ASAXBY*%`

- Parameters may be entered singly or grouped between delimiters, up to a maximum of 4096 characters between delimiters. A maximum of 80 characters between delimiters is recommended. Always consider readability. For example,

  `%SFA1.0B1.0*ASAXBY*%`

- Line breaks are permitted between parameters to improve readability. For example,

  `%SFA1.0B1.0*`
  `ASAXBY*%`

- Use an explicit decimal point with all numerical values associated with a parameter. If the decimal point is omitted, an integer value is assumed.

- Express numerical values in the units defined by the MO code in the file (inches or millimeters).

- In general, enter RS-274X parameters at the beginning of the file (or at the beginning of the layer for layer-specific parameters). Enter them in the order shown in Table 1.

Note: When RS-274X parameters are embedded in the RS-274D data, all data preceding the parameter will be processed before the data blocks affected by the embedded parameters are interpreted.

Table 1   RS-274X Parameter Order of Entry

Parameter Required	Parameter Optional	Function	Comments	Default
	AS	Axis select		A=X, B=Y
FS		Format statement		
	MI	Mirror image	Single use recommended. When used more than once, enter these parameters at the beginning of a layer. These codes do not generate a new layer.	No mirror
	MO	Mode (inch or millimeter units)		Inch
	OF	Offset		A=0, B=0
	SF	Scale Factor		A=1.0, B=1.0
	IJ	Image Justify	Use only once at the beginning of the file.	No justification
IN		Image Name		
	IO	Image Offset		A=0, B=0
	IP	Image Polarity		Positive
	IR	Image Rotation		0
	PF	Plotter Film		
AD		Aperture Description	May be used singly or may be layer-specific. Enter these parameters at the beginning of the file or layer.	
	AM	Aperture Macro		
	LN	Layer Name		
	LP	Layer Polarity		Positive
	KO	Knockout		Off
	SR	Step and Repeat		A=1, B=1
	RO	Rotate		No rotation

RS-274D Data Guidelines

Follow these guidelines when preparing RS-274D data:

- Enter functions codes and coordinate data following the RS-274X parameters.

- Function codes apply to coordinate data in the same block as well as to subsequent coordinate data. They do not affect coordinate data preceding the block in which they occur.

- Enter function codes in the file in the order shown in Table 2.

Table 2   RS-274D Code Order of Entry

Code	Function	Comments
N	Sequence number	Optional
G	General functions: linear interpolation, circular interpolation, polygon area fill, etc.	Once encountered, remains in effect until countermanded.
D	Aperture or tool assignment; line/flash control	Once encountered, remains in effect until countermanded.
M	Miscellaneous function: program stop or end.	Every file must end with M00 or M02.

Sample Files

The examples on these pages illustrate the use of both mass parameters and standard RS-274D codes.

Example 1

Example 1 illustrates a single layer image.

```
*G04 EXAMPLE 1: 2 BOXES
%FSLAX23Y23*%                          Format statement - leading zeroes omitted,
                                       absolute coordinates, X2.3,  Y2.3.
%MOIN*%                                Set units to inches.
%OFA0B0*%                              No offset
%SFA1.0B1.0*%                          Scale factor is A1, B1
%ADD10C,0.010*%                        Define aperture D-code 10 - 10 mil circle
%LNBOXES*%                             Name layer "BOXES".
G54D10
X0Y0D02*X5000Y0D01*
X5000Y5000D01*X0Y5000D01*X0Y0D01*      RS-274D data
X6000Y0*X11000Y0D01*
```

X11000Y5000D01*X6000Y5000D01*
X6000Y0D01*D02*
M02*   End of data
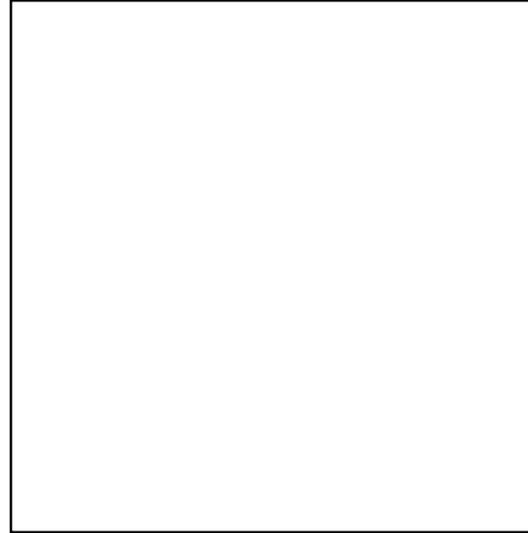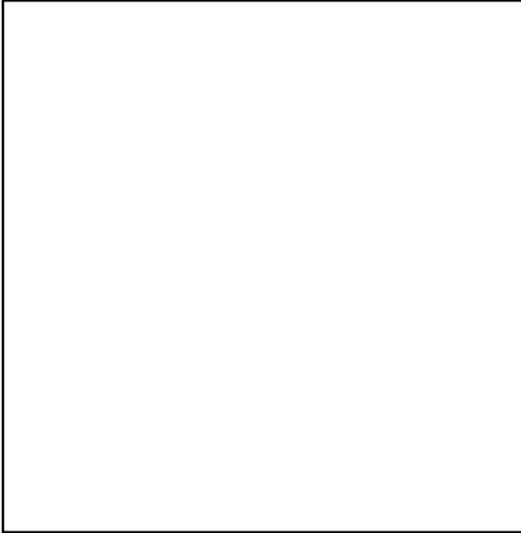
Example 2

Example 2 illustrates RS-274-X data.

%ASAXBY*	Axis Select, A=X, B=Y
FSLAX23Y23*	Format Statement, Leading zeros omitted, absolute data, 2 integer digits and 3 fractional digits
MIA0B0*	Mirror about the specified axis; 0=no, 1=yes
MOIN*	Mode inches
OFA0B0*	Offset 0
SFA1.0B1.0*%	Scale Factor
%IJALBL*	Image justify
INXTEST*	Image name
IOA0B0*	Image offset
IPPOS*	Image Polarity
IR0*%	Image Rotation
G04 Define Apertures*	Comment
%AMTARGET125*	Aperture Macro
6,0,0,0.125,.01,0.01,3,0.003,0.150,0*%	Moiré Description
%AMTHERMAL80*	Aperture Macro
7,0,0,0.080,0.055,0.0125,45*%	Thermal Description
%ADD10C,0.01*	Aperture Description, D10 is a circular aperture with 0.01" diameter
ADD11C,0.06*	Aperture Description, D11 is a circular aperture with 0.06" diameter
ADD12R,0.06X0.06*	Aperture Description, D12 is a rectangular aperture, 0.06" X 0.06"
ADD13R,0.04X0.100*	Aperture Description, D13 is a rectangular aperture, 0.04" X 0.100"
ADD14R,0.100X0.04*	Aperture Description, D14 is a rectangular aperture, 0.100" X 0.04"
ADD15O,0.04X0.100*	Aperture Description, D15 is a obround aperture, 0.04" X 0.100"
ADD16P,0.100X3*	Aperture Description, D16 is a 3 sided polygon 0.100" overall size
ADD17P,0.100X3*	Aperture Description, D17 is a 3 sided polygon 0.100" overall size
ADD18TARGET125*	Aperture Description, D18 is a special aperture called "TARGET"

ADD19THERMAL80*%	Aperture Description, D19 is a special aperture called "THERMAL"
%LNXTEST1*	Layer Name XTEST1
LPD*	Layer Polarity Dark
SRX1Y1I0J0*%	Step and Repeat set to 1 X 1 (Not Required)
G54D10*	Aperture select
G01X0Y250D02*	Linear move with light off
X0Y0D01*	Linear move with light on
X250Y0D01*	Linear move with light on
X1000Y1000D02*	Linear move with light off
X1500D01*	Linear move with light on
X2000Y1500*	Notice since D01 is modal it does not need to be repeated
X2500D02*	Notice since the X & Y commands are modal, Y is not repeated
Y1000D01*	Here, X is not repeated and uses its previous value of 2.500"
D02*	Light off no move
G54D11*	New aperture selected
G55X1000Y1000D03*	G55 prepares for flash It is not necessary. D03 is the flash command.
X2000D03*	Y value does not change
X2500D03*	This method reduces the size of the file
Y1500D03*	Here, X does not change from previous value
X2000D03*	Flash
G54D12*	New aperture select
X1000Y1500D03*	Move to (1.0, 1.5) and flash
G54D13*	New aperture select
X3000Y1500D03*	Move and flash
G54D14*	New aperture select
Y1250D03*	Move and flash
G54D15*	New aperture select
Y1000D03*	Move and flash
G54D10*	New aperture select
G01X3750Y1000D02*	Linear move, light off. Start point of the following arc command
G75*	Sets the mode to 360 degree circular interpolation
G03X3750Y1000I250J0D01*	Move from start point above to end point drawing a complete circle
G54D16*	New aperture select
G55X3400Y1000D03*	Flash
G54D17*	New aperture select
G55X3500Y900D03*	Flash
G54D10*	New aperture select
G36*	Start Polygon fill
G01X500Y2000D02*	
Y3750D01*	
X3750*	
Y2000*	
X500*	
X500Y2000D02*	
G37*	End Polygon fill
G54D18*	New aperture select
G55X0Y3875D03*	Flash
X3875Y3875D03*	Flash
%LNXTEST2*	Layer Name
LPC*%	Layer Polarity clear
G36*	Start Polygon fill
G01X1000Y2500D02*	
Y3000D01*	
G74*	Quadrant arc
G02X1250Y3250I250J0D01*	Clockwise arc move with radius .25"
G01X3000*	Complete 90 degree arc
G75*	360 degree arc mode

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G02X3000Y2500I0J-375D01*	Clockwise arc move with radius .375"
G01X1000*	Linear move light on
X1000Y2500D02*	Linear move light off
G37*	End Polygon fill
%LNXTEST3*	Layer Name
LPD*%	Layer Polarity Dark
G54D10*	New aperture select
X1500Y2875D02*	
X2000D01*	
D02*	
G54D11*	
X1500Y2875D03*	
X2000D03*	
G54D19*	New aperture select
X2875Y2875D03*	
M02*	End of file
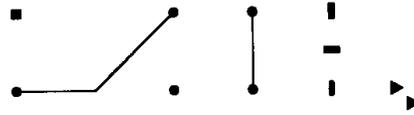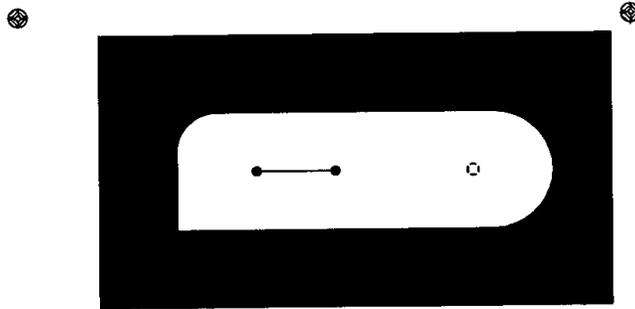
Reference

RS-274X parameters

This section describes every RS-274X parameter supported at time of publication. They are arranged in alphabetical order. Standard RS-274D code descriptions begin on page 45.

Each parameter description illustrates the parameter data block format, explains each parameter modifier, lists restrictions, and gives an example.

The data block format illustration uses the following notation conventions:

%Parameter code<required modifiers>[optional modifiers]*%

where:

Parameter code	is the 2-character code (AD, AM, FS, etc.)
<required modifiers>	must be entered to complete definition
[optional modifiers]	may be required depending on the required modifiers

The AD parameter is used to describe apertures (D codes) used in the RS-274X file. All apertures used in an RS-274X file must be described in terms of shape and size for the file to be interpreted correctly. The AD parameter must precede use of the associated aperture D-code. A definition remains in effect until redefined.

Two kinds of apertures may be used in an RS-274X file: *standard* apertures and *special* apertures.

Standard apertures

The AD parameter identifies standard apertures by D-code number and describes them in terms of shape (circular, rectangular, obround, or polygonal) and size (diameter if round, height and width if rectangular or obround, outside dimension and number of sides if polygonal). Apertures may be solid or open (that is, with a hole) and are always centered.

Special apertures

The AD parameter is also used to assign a D-code to a file containing an aperture description. The aperture description file may be a .mac file created by the AM (Aperture Macro) parameter or a .des file created by an Aperture Editor such as the Gerber GPC Aperture Editor. See the AM parameter description for further information on aperture macros.

AD parameter syntax rules

- Like other mass parameters, begin and end each parameter block with a parameter delimiter (typically %).

- Within the AD parameter block, separate each modifier by an X.

- Dimensions must be positive and will be rounded to the resolution of the output device.

- The various plotters and output devices may permit different D-code ranges, but the range must not exceed 10 to 999.

Data Block Format

%ADD<D-code number><aperture type>,<modifier>[X<modifer>]*%

where:

|	
ADD	the AD parameter and D (for D-code)
<D-code number>	the D-code number being defined (10 - 999)
<aperture type>,<modifier>[X<modifier>]	the aperture descriptions. **<aperture type>** may be one of the following:
	• a standard aperture (C, R, O, P, or T) with modifiers (see below). Modifiers depend on aperture type. Use **X** to separate each modifier. All dimensions are positive and will be rounded to the resolution of the output device.

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- a file name containing the aperture description (.des file)
- an aperture macro name previously defined by the AM parameter (.mac file)

Note: Be sure to use the units (inches or millimeters) specified by the MO parameter for all modifiers.

Standard apertures:

C, **<outside diameter>[X<X-axis hole dimension >[X<Y-axis hole dimension>]]**
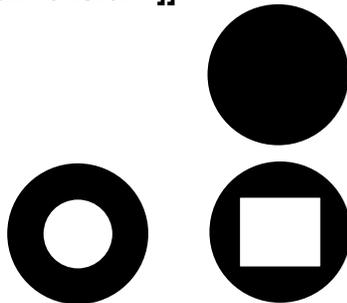
Circle. To define a solid aperture, enter only the diameter. To define a hole, enter one dimension for a round hole, two for a rectangle. The hole must fit within the aperture. For a square hole, X must equal Y. Both aperture and hole will be centered. For example,

%ADD10C,.05X0.025*%

D-code 10 is a .05 circle with a .025 round hole in the center.

R, **<X-axis dimension>X<Y-axis dimension>[X<X-axis hole dimension>X<Y-axis hole dimension>]**

Rectangle or square. May be solid or open. If the X axis dimension equals the Y dimension, the aperture will be square. To define a solid aperture, enter only the X and Y dimensions; omit the hole dimensions. To define a hole, enter one dimension for a round hole, two for a rectangle. The hole must fit within the aperture. Both rectangle and hole will be centered. For example,

%ADD22R,0.020X0.040*%

D-code 22 is a .02 x .04 solid rectangle.

O, **<X-axis dimension>X<Y-axis dimension>[X<X-axis hole dimension>[X<Y-axis hole dimension>]]**
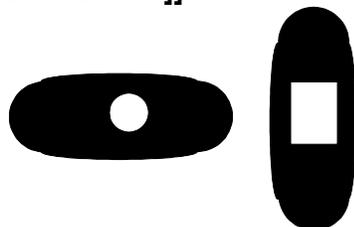
Obround (oval). May be solid or open. If the X dimension is larger than Y, the shape will be horizontal. If the X dimension is smaller than Y, the shape will be vertical. To define a solid aperture, enter only the X and Y dimensions; omit the hole dimensions. To define a hole, enter one hole dimension for a round hole, two for a rectangular or square hole. If open, the hole must fit within the aperture. For example,

%ADD22O,0.020X0.04X0.005X0.010*%

D-code 22 is a vertical obround .02 wide x .04 high with a .05 x .01 rectangular hole.

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P,   **<outside dimension>X<number of sides>[X<degrees of rotation>[X<X-axis hole dimension>X<Y-axis hole dimension>]]**
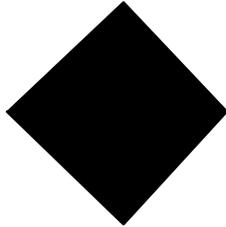
Regular polygon. May be solid or open. To define a solid aperture, enter only the outside dimension and number of sides (3 to 12). The first point is located on the X axis. May be rotated ±360° from the X-axis. If open, the hole must fit within the outside dimension. *Note: If you use the hole dimension modifiers, you must enter a rotation (even if it is 0).* For example,

%ADD17Diamond,.030X4X0.0*%

D-code 17 is a polygon within an outside dimension of .03, 4 sides, with no center hole.

Examples

%ADD10C,.025*%   Define D-code 10: 25 mil round

%ADD22R,.050X.050X.027*%   Define D-code 22: 50 mil square with 27 mil round hole

%ADD57O,.030X.040X.015*%   Define D-code 57: obround 30 x 40 mil with 15 mil round hole

%ADD30P,.016X6*%   Define D-code 30: polygon (hexagon), 16 mil outside dimension with 6 sides

%ADD15CIRC*%   Define D-code 15: a special aperture described by aperture macro CIRC defined previously by an aperture macro

The AM parameter is used to define named apertures (sometimes called *special apertures*) in *aperture macro* format consisting of building blocks called *primitives*. The named aperture macros may be used in AD parameter descriptions just like the standard apertures (that is, circle, rectangle, obround, polygon, and thermal). Every non-standard aperture must be described before the D-code associated with it occurs in the file.

Special apertures offer two advantages over standard apertures:

- They allow multiple shapes called primitives to be combined in a single aperture, which permits creation of unusual or complicated apertures.

- They need not be centered.

- Aperture macro modifiers may be variable. Variable modifiers are supplied by the AD parameter that references the aperture macro.

- An aperture macro variable may be a numerical function of another macro variable (+, -, etc.).

Aperture macro contents

An aperture macro contains the following elements:

- aperture macro name

- one or more of the seven aperture primitives, each identified by a primitive number (see Table 3 below for a description of the primitives)

- primitive modifiers that describe the primitive in terms of exposure, position, dimensions, etc.

- variable primitive modifiers to be supplied by the AD parameter

- optional embedded comment blocks

- numerical operators

AM parameter syntax rules

- Like other mass parameters, begin and end each parameter block with a parameter delimiter (typically %).

- Within the AM parameter block, separate each primitive and modifier group by an end-of-block character (typically *).

- Within each primitive group, separate modifiers by commas.

- Modifiers may be absolute values, such as 0, 1, 2, or 9.05, or they may be variable modifiers to be supplied by the AD parameter when it refers to the aperture macro.

- Identify variable modifiers to be supplied by the AD parameter as *$n* where *n* indicates the order in which the modifier is expected in the AD parameter. $1 would be the first variable modifier expected in the AD parameter, $2 the

second, and so on, numbering sequentially from left to right. If an absolute value is entered instead of a variable, the variables shift right. For example, if an absolute value is entered for the first variable, the next variable becomes $1 even though it is the second modifier of the primitive.

- The interpretation of each modifier differs for each primitive. See Table 3 on the next page for a full explanation of aperture macro primitives and modifiers.

- Do not begin a variable primitive modifier with a minus sign (for example, -$1). To indicate negative, precede the variable with 0 (for example, **0-$1**).

- Start optional comment strings with a leading 0 (for example, ***0 THIS IS A COMMENT*).**

- Position and dimensions are expressed in the units specified by the MO parameter. Decimal points are permitted.

- Use only the following numerical operators with variable modifiers:

Operator	Function
+	add
-	subtract
/	divide
x	multiply
=	equate
n	numerical factor

- Make sure the aperture macro file name matches the aperture macro name and that it has a .mac extension.

Data Block Format

%AM<aperture macro name>*<primitive number>,<modifier$1>,<modifier$2>,[<...>]*[<primitive number>[<modifiers>]]*...*%

---

where:

AM	the AM parameter
<aperture macro name>*	the name to be used in the AD parameter
<primitive number>,<modifier$1>,<modifier$2>,<modifier$3>,...*	the primitive number with modifiers. The primitive number identifies the geometry (outline, polygon, etc.). The modifiers differ with the various primitive numbers. Use either actual values (for example, 0.050 for a width) or a variable placeholder (for example, $1 for exposure on/off).

Table 3 Aperture macro primitives

Primitive number	Description	Variable Modifiers	Description
1	**Circle**	$1	Exposure on/off 0 = OFF (laser off, no exposure) 1 = ON (laser on, image exposed) 2 = reverse current exposure state
		$2	Diameter
		$3	X center position
		$4	Y center position
2 or 20	**Line (vector)**: a line defined by width, and beginning and end points. The line ends are rectangular.	$1	Exposure on/off 0 = OFF (laser off, no exposure) 1 = ON (laser on, image exposed) 2 = reverse current exposure state
		$2	Line width
		$3	X start point
		$4	Y start point
		$5	X end point
		$6	Y end point
		$7	Rotation in degrees (+ = counterclockwise, - = clockwise)
21	**Line (center)**: a centered rectangle defined by width, height, and center point. The end points are rectangular.	$1	Exposure on/off 0 = OFF (laser off, no exposure) 1 = ON (laser on, image exposed) 2 = reverse current exposure state
		$2	Rectangle width
		$3	Rectangle height
		$4	X center point
		$5	Y center point
		$6	Rotation in degrees (+ = counterclockwise, - = clockwise)
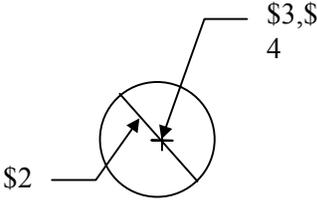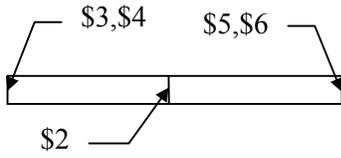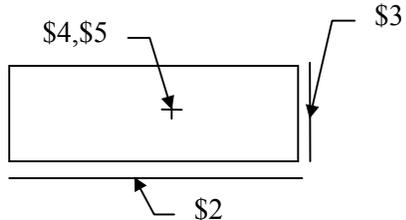
22	**Line (lower left)**: a rectangle defined by width, height, and the lower left point. The end points are rectangular.	$1	Exposure on/off 0 = OFF (laser off, no exposure) 1 = ON (laser on, image exposed) 2 = reverse current exposure state
		$2	Width
		$3	Height
		$4	X lower left point
		$5	Y lower left point
		$6	Rotation in degrees (+ = counterclockwise, - = clockwise)
3	End of file	none	Must be used to end .des files.
4	**Outline**: an open or closed shape defined by a start point, *n* additional points (up to 50), and the X,Y coordinates that define them. For a closed shape, the first and last points must be identical.	$1	Exposure on/off 0 = OFF (laser off, no exposure) 1 = ON (laser on, image exposed) 2 = reverse current exposure state
		$2	*n*, the number of points in the outline
		$3	X start point
		$4	Y start point
		$5	X point #1
		$6	Y point #1
		$7	X point #2
		$8, etc.	Y point #2. Continue as needed.
		$9 or the last number used	Rotation in degrees (+ = counterclockwise, - = clockwise)
5	**Polygon**: a closed, symmetrical, centered shape defined by n vertices (3 to 10 inclusive), a center point, diameter, and rotation.	$1	Exposure on/off 0 = OFF (laser off, no exposure) 1 = ON (laser on, image exposed) 2 = reverse current exposure state
		$2	number of vertices (integer)
		$3	X center point
		$4	Y center point
		$5	Diameter
		$6	Rotation in degrees (+ = counterclockwise, - = clockwise)
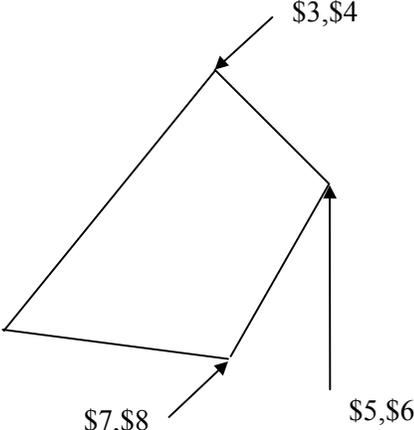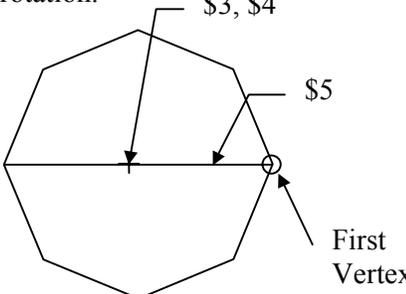
6	**Moiré**: a cross hair centered on *n* concentric circles defined by the center point, outside diameter, line thickness, and gap between circles.	$1	X center point
		$2	Y center point
		$3	Outside diameter
		$4	Circle line thickness
		$5	Gap between circles
		$6	number of circles
		$7	Cross hair thickness
		$8	Cross hair length
		$9	Rotation in degrees (+ = counterclockwise, - = clockwise)
7	**Thermal**: a cross hair centered on a circle defined by outside and inside diameter.	$1	X center point
		$2	Y center point
		$3	Outside diameter
		$4	Inside diameter
		$5	Cross hair thickness
		$6	Rotation in degrees (+ = counterclockwise, - = clockwise)

Example 1

%AMDONUT*1,1,$1,$2,$3*1,0,$4,$2,$3*% Define an aperture macro named DONUT consisting of two concentric circles:

1,1,$1,$2,$3 Circle (1), exposure on (1), diameter ($1), X center ($2), Y center ($3) all to be supplied by AD parameter

1,0,$4,$2,$3 Circle (1), exposure off (0), diameter ($4, different from first circle), X center and Y center ($2 and $3, same as first circle)

The AD parameter using this macro might look like the following:

%ADD32DONUT,0.100X0X0X0.080*%   Define D-code 32 to be aperture macro **DONUT**. The diameter of the first circle will be 0.100. The center of both circles will be at 0,0. The diameter of the second circle will be 0.080.

$1 = 0.100
$2 = 0
$3 = 0
$4 = 0.080

Example 2
%AMDONUT*1,1,$1,$2,$3*$1=$2+0.030*1,0,$1-$4,$2,$3*%

Define an aperture macro named **DONUT** consisting of two concentric circles with diameter of the second circle defined as a function of the diameter and center point of the first:

1,1,$1,$2,$3   Circle (1), exposure on (1), diameter ($1), and center point X,Y ($2, $3) to be defined in the AD parameter

$1=$2+0.030   Define a variable to be used to calculate the diameter of second circle to be a function of the diameter and center point X coordinate of the first.

1,0,$1-$4,$2,$3   Circle (1), exposure off (0), diameter ($1-$4), and center point X,Y ($2, $3, same as the first circle).

The ADD parameter using this aperture macro might look like:

%ADD33DONUT,0.020X0X0X0.014*%   Define D-code 33 to be aperture macro **DONUT**. The diameter of the first circle 0.020. The center of both circles will be 0,0. The diameter of the second circle will be ((0 + 0.030) - 0.014).

Example 3
%AMDONUT*1,1,0.100X0X0*1,0,0.080X0X0*%

Define an aperture macro named **DONUT** consisting of two concentric circles, using primitive modifiers.

%ADD32DONUT*%   The resulting AD command only needs to reference the aperture macro name.

The AS parameter is used to assign any two data axes to the output device A or B axes.

Data Block Format

AS A<X or Y>B<X or Y>*

where:

A and B   are output device axes

X and Y   are data axes

Default

AXBY

Example

%ASAYBX*%   Assign the X axis data to the output device B axis and the Y axis data to the output device A axis.

The FS parameter is used to define the format of the input coordinate data and to define the allowable N, G, D, and M code lengths. It should be the first RS-274X parameter in the file. It is recommended that only one be used in the file. It is usually the first parameter.

The FS parameter allows you to specify the following format characteristics:

- Number of integer and decimal places in coordinate data (coordinate format)
- Zero omission (leading or trailing zeroes omitted)
- Absolute or incremental coordinate notation
- Sequence number (N-code) length
- General function code (G codes) length
- Draft code (D code) length
- Miscellaneous code (M code) length

Note: Decimal point programming is not supported.

Coordinate format

Coordinate format specifies how many integer and how many decimal places to expect in the coordinate data. For example, 2.3 format specifies two integer and three decimal places. A maximum of six integer and six decimal places may be specified (999999.999999). Different formats may be defined for the X and Y axes.

Zero omission

Zero omission compresses data by omitting either leading or trailing zeroes from coordinate values. Any given string of digits may be interpreted very differently depending on the zero omission specification. Coordinate format also affects how zero omission is interpreted.

Leading zero omission eliminates all zeroes that precede non-zero digits but retains following zeroes. For example, with 2.3 coordinate format, *15* would be interpreted as *0.015*.

Note: Use leading zero omission for NO ZEROES OMITTED files.

Trailing zero omission eliminates all zeroes following non-zero digits but retains preceding zeroes. For example, with 2.3 coordinate format, *15* would be interpreted as *15.000*.

Absolute or incremental notation

Coordinate values may be expressed as either absolute distances from a fixed 0,0 point or as relative distances from the preceding coordinate position.

RS-274D code lengths

The FS parameter can be used to specify length limits for the following standard RS-274D codes:

N Sequence number
G General function
D Plot function
M Miscellaneous function

These codes are described starting on page 45.

Data Block Format

%FS<L or T><A or I>[Nn][Gn]<Xn><Yn>[Dn][Mn]

where:

FS	The FS parameter
<L or T>	Use **L** to omit leading zeroes. Use **T** to omit trailing zeroes.
<A or I>	Use **A** for absolute coordinate values. Use **I** for incremental coordinate values.
[Nn], [Gn], [Dn], and [Mn]	Enter the code and an integer length limit, for example, **N2** to specify two-digit sequence codes.
<Xn> and <Yn>	Enter **X** or **Y** and the number of integer and decimal places in the coordinate data for each axis, for example, **X23** for X-axis data with two integer and three decimal places (99.999). 6.6 is maximum. The X and Y axes may have different values.

Example

%FSLAX25Y25*%	Coordinate data will have leading zeros omitted (L) and be expressed as absolute (A) positions with two integer and five decimal places in both axes (X25Y25).

The IF parameter is used to identify an external file to be included in the RS-274X file. The files referenced by the IF parameter will be interpreted exactly as if they were included at the point of reference in the RS-274X file. Included files may also contain IF parameters, up to 10 levels of nesting.

The IF parameter is often used to include an external aperture file containing AD and AM parameters that describe the apertures used in the RS-274X file, sometimes referred to as an "external" aperture list. The IF parameter can also be used to include external data files, which allows you to merge multiple data files. Included files simplify the creation of standard plot sequences such as title blocks and coupons.

Data Block Format

%IF<filename.ext>*%

Examples

%IFCOUPON3.GBR*%   Include file COUPON3.GBR.

%IFCIRCL.mac*%   Include aperture macro file CIRCL.mac.

%IFAPT004.des*%   Include aperture description file APT004.des.

The IJ parameter is used to override the absolute data coordinates for final placement of the image on the output device. The image may be centered or may be placed at an absolute position relative to the lower left of the platen.

> *Note: When centered, the pixel coordinates for the platen reside in the first quadrant (+X and +Y). X and Y are positive numbers, greater than zero and less than the platen size.*

When more than one IJ parameter appear in the data, the final entry encountered is the one used.

Data Block Format

%IJ[A<parameter >B<parameter>][<offset>]*%

where:

IJ	the Image Justify parameter
A	the plotter A axis justification
<parameter>	**L** left or lower justification (default)
	C center justification
B	The plotter B axis justification
<parameter>	**L** left or lower justification (default)
	C center justification
<offset>	the starting position offset relative to 0,0

Default

None

Examples

%IJ*%	Left justify in X and lower justify in Y.
%IJAC*%	Center justify in X, lower justify in Y.
%IJACB.100*%	Center justify in X, offset .1 units in Y.
%IJALB.10*%	Left justify in X, offset .1 units in Y.
%IJB.100*%	Same as previous example.
%IJA1B1*%	Offset image 1 unit in X and Y.

The IN parameter is used to assign a name of up to 77 alphanumeric characters to the entire image of the RS-274X file. Information layers may also be named; see the LN parameter.

Data Block Format

%IN<character string>*%

where:

<character string>   up to 77 alphanumeric characters except the asterisk (*).

Examples

%INSOLDERMASK*%

%INPANEL_1*%

The IO parameter is used to offset an image from the 0,0 point. The offset is expressed as an increment in the units defined by the MO parameter along the output device A and B axis. The AS parameter is used to correlate data axes with output device axes. The offset may be different for each axis and may be entered for a single axis.

Data Block Format

%IOA<±n>B<±n>*%

where:

IO   the Image Offset parameter

A<±n>   the offset along the output device A axis

B<±n>   the offset along the output device B axis

Default

%IOA0B0*%

Examples

%IOA1.0B1.5*%   Offset the image 1.0 units along the A axis and 1.5 units along the B axis from 0,0.

%IOB5.0*%   Offset the image 5.0 units along the B axis from 0,0.

The IP parameter is used to specify the positive or negative polarity of the entire file image. This *image polarity* differs from *layer polarity*, which is specified by the LP parameter and which applies only to one or more data layers of the entire image.

Data Block Format

%IP<POS or NEG>*%

where:

IP   the IP parameter

<POS or NEG>   Use **POS** for positive polarity, **NEG** for negative polarity.

Default

%IPPOS*%

Example

%IPNEG*%   Output the entire image with negative polarity.

The IR parameter is used to rotate the entire image counterclockwise in 90° increments about the 0,0 coordinate. All apertures follow the rotation. If you do not use the IR parameter, 0° rotation is assumed.

Data Block Format

%IR<90 or 180 or 270>

where:

**IR**   the IR parameter

<90 or 180 or 270>   Enter the desired value.

Default

%IR0*%

Example

%IR90*%   Rotate the entire image 90° counterclockwise.

The KO parameter is used to specify that a rectangular region of the image will have the opposite polarity of the image or layer in which it occurs (either clear or dark), making it a "knockout" from the surrounding region.

Knockout

Positive image polarity
Dark layer polarity
Clear knockout

Negative image polarity
Clear layer polarity
Dark knockout
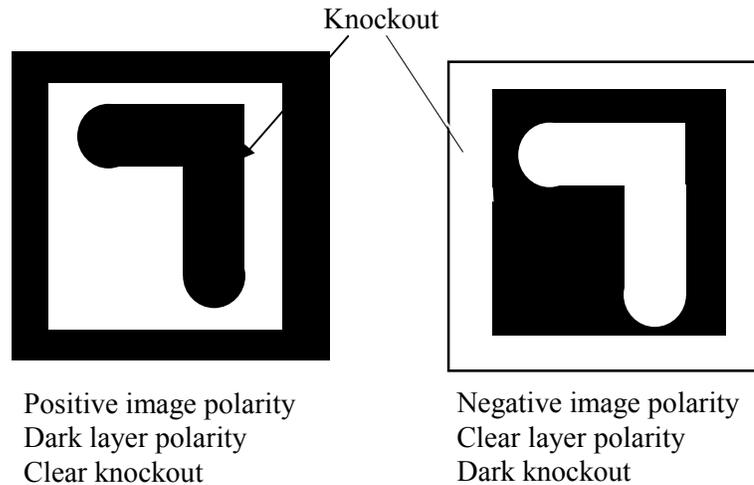
KO is typically used to :

- set the initial background polarity of the final image
- set travel extent along the Y axis
- knock out a region around a component
- disable knockout on the current data layer

A knockout can be defined in one of two ways:

- lower left point and height and width
- border width around a component

When a knockout is defined around a component, the knockout is applied to all data following the KO parameter until the knockout is disabled. To disable a previously defined knockout, enter KO with no modifiers.

Data Block Format

%KO[C or D][X<coordinate>Y<coordinate>I<width>J<height>]or [K<border dimension>]

---

where:

KO   the KO parameter

C or D   Enter **C** for clear or **D** for dark.   To create a knockout defined by the data extents, do not enter modifiers. To disable a previously enabled knockout, enter neither **C** nor **D**.

X<lower left X coordinate>Y<lower left Y coordinate>I<width>J<height>

Use this modifier to define the knockout by a lower left point, width, and height.

K\<border dimension\>   Use this modifier to define the knockout as a border around a component. Express the dimension in units specified by the MO parameter.

Examples

%KODX0I0I20J26*%   Create a dark knockout that extends from 0,0 to 20,26. This in effect sets the Y travel extent.

%KOCK.050*%   Create a clear knockout .050 units around all sides of the data that follows the KO parameter until the knockout is disabled.

%KOD*%   Make the region defined by the extents of the data following the command dark.

%KO*%   Disable a previously enabled knockout.

The LN parameter is used to assign a name of up to 77 alphanumeric characters to the information layer that follows the parameter in the RS-274X file. Entire image files may also be named; see the IN parameter.

Data Block Format

%LN<character string>*%

where:

<character string>   up to 77 alphanumeric characters except the asterisk (*).

Examples

%LNSOLDERMASK*%

%LNINTERNAL_VCC*%

The LP parameter is used to specify the positive or negative polarity of the information layer or layers following it. This *layer polarity* differs from *image polarity*, which is specified by the IP parameter and which applies to the entire image. The layer polarity applies to all data following the LP parameter until another LP parameter is encountered.

Data Block Format

%LP<C or D>*%

where:

LP   the IP parameter

<C or D>   Use **C** for clear polarity, **D** for dark polarity.

Default

%LPD*%

Example

%LPC*%   Make all succeeding data clear.

The MI parameter is used to turn mirror imaging either on or off. When on, all A-and/or B-axis data following the parameter will be mirrored (that is, inverted or multiplied by -1) until another MI command is used. Notice that mirroring A-axis data flips the image about the B axis. Mirroring B-axis data flips the image about the A axis.

Note: MI does not mirror special apertures.

The AS parameter is used to correlate the X and Y axes with the output device A and B axes.

Data Block Format

%MI[A<0 or 1>][B<0 or 1>]*%

where:

MI   the MI parameter

A<0 or 1>   To invert A-axis data (flipping the image about the B-axis), enter A1. To disable, enter A0.

B<0 or 1>   To invert B-axis data (flipping the image about the A-axis), enter B1. To disable, enter B0.

Default

%MIA0B0*%

Example

%MIA0B1*% Disable mirroring of A-axis data. Invert B-axis data, flipping the image about the A-axis.

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The MO parameter specifies that dimension data should be interpreted as inches or millimeters. Integer and decimal place format is specified by the FS parameter. Inches are assumed if units are not specified.

Data Block Format

%MO<IN or MM>*%

where:

MO   the MO parameter

<IN or MM>   Enter **IN** to specify inches. Enter **MM** to specify millimeters.

Default

%MOIN*%

Example

%MOIN*%   Dimension data will be expressed in inches.

The OF parameter is used to offset the final image up to ±99999.99999 units from the imaging device 0,0 point. The data may be offset along the imaging device A or B axis, or both. Values used with the OF parameter are expressed in units specified by the MO parameter, are always absolute, and are used primarily with absolute coordinate data. Incremental coordinate data may be offset simply by moving the imaging device to the desired offset position before starting the plot. The FS parameter specifies whether the data is absolute or incremental.

If an embedded FS parameter changes the format from absolute to incremental, the OF parameter value is saved and reinstated another FS parameter returns the format to absolute.

Data Block Format

%OF[A<±offset value>][B±offset value]

where:

OF   the OF parameter

A±n   Offset along the A axis. Use 5.5 format.

B±n   Offset along the B axis. Use 5.5 format.

Default

%OFA0B0*%

Example

%OFA1.0B1.0*%   Offsets the plot 1 unit from 0,0 along both the A and B axes.

The PF parameter is used to indicate to the operator the film (or other media) to be used to image the data file.

Data Block Format

%PF<name>*%

where:

PF   the PF parameter

<name>   up to 20 alphanumeric characters; asterisk (*) is an illegal character

The SF parameter is used to specify a scale factor of from 0.0001 to 999.99999 for the output device A- and/or B-axis data. The factor may be different for each axis. All data following the parameter will be multiplied by the factor until another SF parameter is encountered. The AS parameter is used to correlate the X and Y data axes with the imaging device A and B axes.

Data Block Format

%SF[A\<factor>][B\<factor>]*%

where:

SF   the SF parameter

A\<factor>   the A-axis data factor

B\<factor>   the B-axis data factor

Default

%A1B1*%

Example

%SFA.5B3*%   Multiply A-axis data by .5, B-axis data by 3.

The SR parameter is used to duplicate the data following the parameter a specific number of times (repeats) at a regular intervals (steps). The number of times the image is repeated and the space between repeats may be specified independently for X and Y data.

When entered without parameters, it is also used to disable a previous SR parameter.
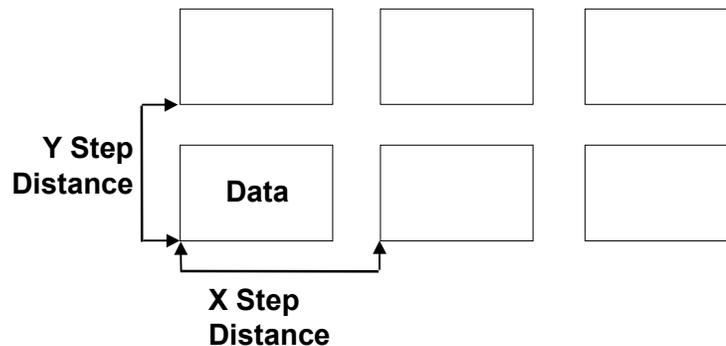
Data Block Format

%SR[X<number of repeats>][Y<number of repeats>][I<X-axis step>][J<Y-axis step>]

where:

SR	the SR parameter
X<number of repeats>	the number of times the data will be repeated along the X-axis
Y<number of repeats>	the number of times the data will be repeated along the Y-axis
I<X-axis step distance>	the distance between the X-axis repeats
J<Y-axis step distance>	the distance between the Y-axis repeats

Default

%SRX1Y1I0J0*%

Examples

%SRX4I5.0J2*% Repeat the image four times along the X axis with 5.0 units from one step to the next. The J modifier will be ignored because no Y repeats were specified.

%SRX2Y3I2.0J3*%   Repeat the image twice along the X axis and three times along the Y
                             axis. X-axis repeats will be spaced 2.0 units apart. Y-axis repeats
                             will be spaced three units apart.

%SR*%   Disable a previous SR parameter.

Standard RS-274D Codes

This section describes standard RS-274D codes (D codes, G codes, and M codes) that are applicable to raster output.

D Codes

D codes (draft codes) select apertures and determine whether the feature described should be imaged as a line or "flashed". Table 4 lists supported D codes.

Table 4 D Codes

Code	Function	Comments
D01 (D1)	Draw line, exposure on	You cannot draw using an aperture defined by an aperture macro (AM parameter). These apertures can only be flashed.
D02 (D2)	Exposure off	
D03 (D3)	Flash aperture	D03 remains in effect until a new layer is encountered.
D10-D999	Select an aperture defined by an AD parameter.	

G Codes

G codes are general function codes. They specify how the coordinate data should be interpolated (linear or circular), turn the Polygon Area Fill feature on and off (see page 49 for more information on Polygon Area Fill), and can also be used to specify absolute or incremental format. Table 5 lists supported G codes.

Table 5 G Codes

Code	Function	Comments
G00	Move	Affected by Polygon Area Fill (see page 49.)
G01	Linear interpolation (1X scale)	See page 47.
G02	Clockwise circular interpolation	See page 47.
G03	Counterclockwise circular interpolation	
G04	Ignore data block	
G10	Linear interpolation (10X scale)	See page 47.
G11	Linear interpolation (0.1X scale)	
G12	Linear interpolation (0.01X scale)	
G36	Turn on Polygon Area Fill	See page 49.
G37	Turn off Polygon Area Fill	See page 49.
G54	Tool prepare	Usually precedes an aperture D-code
G70	Specify inches	See also MO parameter.
G71	Specify millimeters	See also MO parameter.
G74	Disable 360° circular interpolation (single quadrant)	See *Circular Interpolation*, page 47.
G75	Enable 360° circular interpolation (multiquadrant)	See *Circular Interpolation*, page 47.
G90	Specify absolute format	See also FS parameter.
G91	Specify incremental format	See also FS parameter.

Linear Interpolation (G01, G10, G11, G12)

Linear interpolation plots a straight line from the present position to the X,Y coordinate specified by the data block.

Data Block Format

G01 X±m.n Y±m.n Dnn

where:

G01   Specifies linear interpolation

X±m.n Y±m.n Defines the line end point

Dnn   D-code (exposure on or off)

Circular Interpolation (G02, G03, G74, G75)

There are two types of circular interpolation: single quadrant (90°) and multiquadrant (360°). Single quadrant interpolation produces an arc. Multiquadrant interpolation can produce arcs that are larger than 90° and also circles.

Single Quadrant Circular Interpolation (G74)

G02 and G03 specify single quadrant (90°) circular interpolation; G74 disables it. Single quadrant circular interpolation plots an arc within one quadrant (90°). Single quadrant arcs must fit entirely within the quadrant in which they begin. A separate data block is required for each quadrant. A minimum of four data blocks is required to plot a circle.

Data Block Format

Gnn X±m.n Y±m.n Im.n Jm.n Dnn

where:

Gnn   G02 specifies clockwise circular interpolation
                 G03 specifies counterclockwise circular interpolation

X±m.n Y±m.n Defines the arc end point. These variables are in the format defined by the format statement (FS parameter). A sign is optional.

Im.n Jm.n   Defines the incremental distance between the arc start point and the center measured parallel to the X and Y axes respectively. Notice that these numbers are unsigned values. The direction to the center is determined implicitly.

Dnn   D-code (exposure on or off)

	Incremental Data		**Absolute Data**
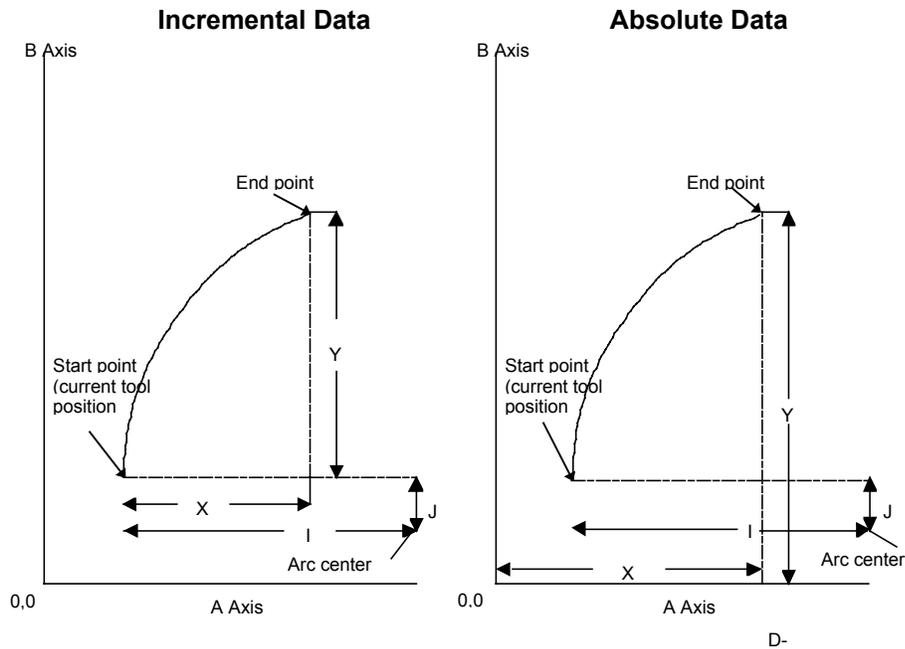
Multiquadrant (360°) Circular Interpolation (G74, G75)

A data block containing only G75 specifies 360° circular interpolation, which plots arcs in more than one quadrant using only one data block. Every block following a G75 code will be interpreted as 360° interpolation until a G74 is encountered. The I and J variables will be considered signed. If no sign is present, the circle will be in a positive direction from the start point.

A G74 code turns 360° multiquadrant circular interpolation off, reverting to single quadrant interpolation. To turn circular interpolation off and revert to linear interpolation, use G01.

Data Block Format

Gnn X±m.n Y±m.n ±Im.n ±Jm.n Dnn

where:

Gnn   G74 turns off 360° circular interpolation
               G75 turns on 360° circular interpolation

X±m.n Y±m.n Defines the arc end point

I±m.n J±m.n Defines the distance between the arc start point and the center measured parallel to the X and Y axes respectively. These variables are always incremental values in the format defined by the format statement (FS parameter). A sign is optional.

Dnn   D-code (exposure on or off)

An example of multiquadrant interpolation is shown on the next page.

%FSLAX43Y43*%
G75*
G01X3000Y-2000D02*
G03X-3000Y-2000I-3000J4000D01
G01*

DESIRED PLOT

Arc center, (0,2)

0,0

End point (-3,-2)   Start point (3,-2)
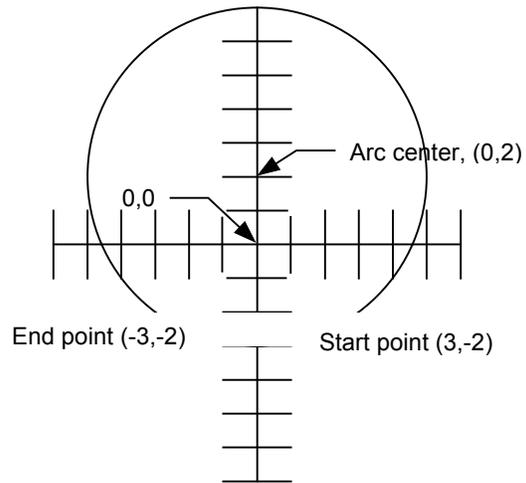
Polygon Area Fill (G36, G37)

G36 and G37 provide a more efficient means of filling closed polygons than stroke fill. When these codes are used, the filled area is defined simply by its closed outline. Stroke fill is an inefficient method of filling a polygon.

G36 turns on polygon area fill. G37 turn it off. There are no variables or apertures. Following a G36 and before G37, all lines drawn with D01 are considered edges of the polygon. D02 closes and fills the polygon.

G36*

X2Y4D02*

X7D01*

Y2D01*

X11Y6D01*

X7Y9D01*

X7D01*

X2D01*Y4D01*G37*

12

10

8

6

4

2

D-000004.WPG

2   4   6   8   10   12

49
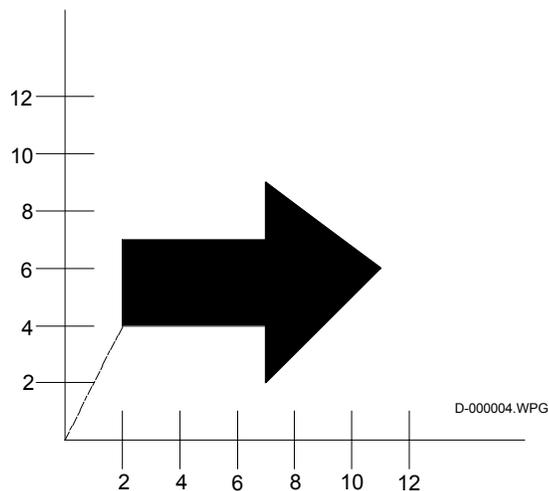
M Codes

M-codes identify the end of a file. Three M codes are commonly used:

M00   Program stop
M01   Optional stop
M02.   End of program

Glossary

ABSOLUTE POSITION: Position expressed as a distance from the 0,0 point in the data.

APERTURE: Previously, an opening in a wheel through which light passed to expose film. Currently a D code assignment and description of geometry that determines the shape of a feature.

APERTURE MACRO: A mass parameter that describes the geometry of a special aperture and assigns it to a D code.

APERTURE PARAMETER: A mass parameter (AD or AM) that assigns an aperture description to a D code.

CIRCULAR INTERPOLATION: Specifies that the data should be interpreted as arcs; may be single-quadrant or multiquadrant.

COMPOSITE IMAGE: The entire image, including all information layers.

COORDINATE DATA: X,Y position data that describes placement of features in the image.

D CODES: Draft (tool) RS-274D codes. They specify tool exposure action (line draw or flash).

DELIMITER: A character that indicates the beginning and end of a mass parameter.

DIRECTIVE PARAMETER: A mass parameter that controls overall file processing.

EXTENDED GERBER FORMAT: Gerber data that includes mass parameters.

FUNCTION CODES: G codes, D codes, M codes that are part of RS-274D.

G CODES: General function RS-274D codes. They specify interpolation, polygon area fill, etc.

GERBER DATA: Data expressed in Gerber Format.

GERBER FORMAT: A subset of RS-274D Word Address Format that is the universal plotter language; may also contain mass parameters, whose presence make it Extended Gerber Format, or RS-274X.

IMAGE PARAMETER: A parameter that supplies information about an entire image.

KNOCKOUT: A rectangular region about an information layer whose polarity is the opposite of the layer polarity.

LAYER: A named information component of Gerber data that may be treated as a unit, for example, rotated or repeated; has no relationship to a physical PCB layer.

LAYER-SPECIFIC PARAMETER: A mass parameter that applies to a single information layer (for example KO, LN, LP, and SR).

LINEAR INTERPOLATION: Specifies that the data should be interpreted as straight lines.

MASS PARAMETERS: Commands or codes that may be embedded in Gerber Data that specify how the data should be processed.

MULTI-QUADRANT INTERPOLATION: Specifies that the data should be interpreted as arcs that can extend into more than one quadrant, up to 360°).

NEGATIVE: An artwork in which the intended conductive pattern is transparent to light and the areas to be free from conductive material are opaque.

NUMERICAL PRECISION: The number of integer and decimal places used to express a number.

POLARITY: Describes whether the circuitry will be imaged as dark on a clear background (positive) or clear on a dark background (negative). Polarity may be applied to an entire image or to a single layer.

POLYGON AREA FILL: A feature that provides a more efficient means of creating solid (filled) polygons than stroke fill.

RELATIVE POSITION: Position expressed as a distance from the last position.

RS-274D: Electronics Industries Association (EIA) standard data format; a superset of Gerber Format.

RS-274X: Extended Gerber Format, that is, Gerber Format with mass parameters.

SINGLE QUADRANT INTERPOLATION: Specifies that the data should be interpreted as an arc that must fit entire within a single quadrant (90°).

STEP AND REPEAT: A method by which successive exposures of a single image are made to produce a multiple image production master.

STROKE FILL: An inefficient means of creating solid (filled) polygons by "painting" the area.

X DATA: Gerber data that includes mass parameters.

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