The PHOTOPLOT STORE

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In order to answer some of your questions about what our laser photoplotting and laser writer systems can do, we've listed a few frequently asked questions and their answers below. We sincerely hope that the information provided here will help you make a more informed decision regarding your purchase of precision photoplots and photomasks If you have any questions that you would like to add here, please let us know.

What exactly is plotter ready data?

For Laser Photoplotting, plotter ready data is in any of the plotter recognizable formats such as Gerber (274-X, F9000/MDA) or Barco DPF. Typically, this data has been designed in the native data format used by the designer's CAD software programs, such as AutoCAD, IntelliCAD, Fletcher Automation's OPAL, Mentor, Cadence, Intergraph, LASI, and DW2000, Macromedia, etc. From the native CAD files, data in intermediate formats, such as DXF, GDSII, EPS, CIF, and EDIF, are generated. These are typically used to convey the data from the designer's CAD programs to the point of conversion to Gerber. The final conversion can be done by using any number of appropriate data translation programs, such as LinkCAD, ASM500, Sonnet, or a Gerber editor that has DXF import capabilities.

In addition, plotter ready data is usually panelized and positioned so that it can be fed directly to the plotter, without having to be further manipulated.

The Photoplot Store can accept nearly all these data formats and convert them to plotter ready format. However, this requires extra steps, chargeable time and the increased possibility of introducing errors, and the data cannot flow through our normal expedited process. Therefore, in order to save our customer's time and money, we highly recommend that they install and use any of the very inexpensive conversion programs described on our Design Optimization Page.

As always, the closer the design is to being optimized for fracture, the less likely it is for us to have to charge extra for data preparation and conversion.

What plotters do we use and what are their specifications?

Follow these links for detailed specifications: Cymbolic Sciences (to 16,000 dpi), Gerber 9725 (to 5,000 dpi), Barco SilverWriter (to 50,800 dpi) and the Barco GigaSetter (to 5080 dpi).

How accurate are our plotters?

The Fire 9000 Series of photoplotters can maintain resolutions up to 1/16-mil and across image sizes up to 34.5x30.5" with accuracy up to 0.25-mil one sigma radial measurement.

The Gerber 9725 plotter has an overall accuracy of ± 0.5 mil, an adjacent centerline accuracy of ± 0.2 mil, and a pin-to-pin variation tolerance of ± 0.5 mil over 20" x 28".

The Barco Large Area Photoplotters have an overall machine/film accuracy of 0.00004"/0.006", a repeatability of 0.00004"/0.003", with software adjustable resolutions between 1/8 and 1/50.8 mil.

What films do we use, and what are their specifications?

Here is a list of links for the various brands of photoplotting films that are used by the Photoplot Store's suppliers:

Kodak Graphic Arts Films (Accumax ARD7 is the primary film that we use for our highest resolution photoplots)
DuPont ImageMaster™ Phototool System

How accurate are our films?

We take great care to maintain an adequately controlled environment during all stages of film processing, and we typically package our films so that the environment has as little effect as possible during transit. Although we use the highest quality and dimensionally stable films available, the film itself is subject to destabilizing factors such as variations in temperature and relative humidity that are beyond our control once they leave our shops. After you receive our films and inspect them, we recommend that you allow them to stabilize for several hours in your working environment before putting them into production. Click here to download an Excel spreadsheet from Kodak which will provide a guideline for what to expect for each degree change in temperature or percent change in relative humidity.

What are these plotter formats 274D, 274X, F9000/Autoplot, Barco DPF, IPC-D-350?

All these data formats are designed to interface between the languages used create electronic design data and the laser photoplotters used to create the master images on film or glass.

RS-274D - A subset of RS-274X. See below.

Click this link for a PDF version of the RS-274X specification.

F9000/Autoplot - Contact Cymbolic Sciences to purchase a copy of the specification.

Click this link for a PDF version of the Barco DPF specification.

IPC-D-350 - Available from the Institute for Interconnecting and Packaging Electronic Circuits.

What are the smallest lines and circles/pads that we can plot, and how closely can we maintain their widths?

As a general rule, laser photoplotters require at least 8 to 10 pixels to form a line, whether on or off axis. The minimum size of the smallest circles/pads is somewhat larger than linear features. For all practical purposes, tolerances on the distances between parallel edges of small geometric patterns can be maintained to within about four to eight times the resolution of the plotter or better, plus a measured amount of edge roughness that is inherent in the system, allowing for both (1) processing variables and (2) rounding errors (including "stairstepping" for round pads and other off-axis edges).

Please note that the minimum corner radius will be about 4.0 µm on any type of feature, clear or opaque.

Without consideration of the type of process or emulsion used, one can use the following table as a rough guide:

Resolution	smallest recommended line/space width	smallest recommended circle/pad diameter	Maximum* projected tolerance, +/-
1/5 mil	1.6 mil (40 µm)	2.4 mil (60 µm)	.00080" (20 µm)
1/10 mil	1.0 mil (25 µm)	1.5 mil (38 µm)	.00050" (13 µm)
1/16 mil	0.8 mil (20 µm)	1.2 mil (28 µm)	.00032" (8 µm)
1/20 mil	0.6 mil (15 µm)	0.9 mil (23 µm)	.00030" (8 µm)
1/25.4 mil	0.5 mil (12 µm)	0.8 mil (19 µm)	.00028" (7 µm)
1/32 mil	0.4 mil (10 µm)	0.5 mil (13 µm)	.00025" (6.4 µm)
1/40.64 mil	0.3 mil (6 µm)	0.4 mil (10 µm)	.00020" (5 µm)
1/50.8 mil	0.2 mil (5 µm)	0.3 mil (8 µm)	.00010" (3 µm)

*** Maximum refers to the absolute worst case scenarios involving curved features and edges that are slightly off-axis. For edges that are parallel to either the X or Y axis, we can eliminate the "stairstepping" part of the tolerance calculations, which is based upon the plotter resolution. The remaining variances are due in large part to processing variables. We typically hold the feature sizes within approximately +/- 0.0001" (+/- 2.0 µm) at all resolutions above 1/5th mil. We recently ran some test coupons to determine the actual line/gap width tolerances that we could hold at 1/8th mil resolution. Picture 1 and Picture 2 together show the results. Generally, the measurements were within about 2 microns (less than 0.0001") of nominal.**

For horizontal and vertical features, the edge roughness on the 1/25.4-th mil plots was measured at 3 µm, and for the 1/40.64-th mil plots, it was measured at 2 µm. ***A recent independent analysis, using a 1000X measuring system, showed that the tolerances achieved at 1/40.64-th resolution were within +/-0.5 µm of nominal.***

Exactly what is meant by resolution?

The resolution of a photoplotter is generally considered to be the smallest distance between the centers of any two adjacent pixels. This is essentially the GRID that is used to place the center of each laser spot. The higher the resolution, the smoother the edges, especially on edges that are off axis.

What are the pixel/spot sizes of our plotters?

On most modern laser photoplotters, the smallest pixel size is equal to the resolution. This can sometimes be adjusted to take advantage of the fact a larger spot size can produce a straighter edge with more rounded "stairstepping". On the Barco Silverwriter with Eagle Optics, the laser spot size is actually about 5 μm in diameter.

What do we mean by Tone/Polarity and Orientation/Parity?

Please click here for a graphical description of these terms.

What are the minimum and maximum aperture sizes for Gerber plot data?

The minimum aperture size that can be read by most plotters is equal to the resolution. The maximum aperture size is generally about 1.0". This also includes aperture macros and custom apertures. (This limit does not apply to subfigures, as described elsewhere on this page.)

What increments should I design the Gerber apertures for the most accurate plotting?

All apertures on modern laser photoplotters are electronic, and no physical equipment is involved. Apertures may be defined with any size or standard shape that is desired. However, when an aperture is read into the Raster Image Processor, the data is rounded to the nearest multiple of the plotter resolution and then to the nearest raster point. This process amounts to a double interpolation, so it is best to create apertures that are even multiples of the resolution.

Actually, the best way to generate the most accurate plots is to use only polygon data, avoiding apertures as much as possible. This eliminates the need for the plotter to interpolate the apertures. Examples of this type of design can be seen if you request a free sample of any of the standard size photoplots listed on our home page.

Do I have to design my data on a grid that exactly fits the resolution of the plotters?

Laser photoplotters can generally accept data that has up to six (6) decimal places, in units of either inches or mm. Since mm units are 25.4 times smaller than inches, the use of mm units can theoretically make the plot 25.4 times as accurate than designs done in inches. However, since the system accuracy does not necessarily depend upon the type of units it

receives in the plot data, the main advantage of using mm is to reduce the effects of rounding.

What formats can we use for aperture tables?

With few exceptions, aperture tables of nearly any format can be input into our Gerber editors. However, these same aperture tables cannot be read directly by our laser plotter front ends. In order to expedite the plotting process and keep your costs to an absolute minimum, we recommend that your Gerber files and aperture lists be combined into either 274-X, F9000/Autoplot, or DPF formats, as specified for each type of plotter on our data upload pages.

Examples of software packages that we recommend to combine your aperture tables and plot instructions into ready to run Gerber plot data can be found on our Design Optimization page.

What are polyfill/POEX/POIN apertures?

These types of modern Gerber data entities are actually not apertures at all. They simply give the plotter the instructions to either fill the area bounded by the closed outline of vector draws, or to make a void within it. In 274-X, the parameters that switch this on or off are the G36 and G37 codes. In F9000/Autoplot files, POEX tells the plotter to fill the area and POIN tells it to make a void. In DPF files, the Contour command generates a filled area, and the Reverse Contour generates a void.

What is a subfigure, and how can its use make my plot data more efficient?

A subfigure in Gerber plot data is very similar to an AutoCAD BLOCK. Since subfigures and blocks may contain arrayed information, they can be used in 274-X, F9000, and DPF files to keep the plot files much smaller than they would if the hierarchy were flattened or exploded.

In 274-X data, the total number of subfigures is limited in practice to 512 placements. (A 5 x 6 step & repeat array generates 30 placements. A step & repeat 5 x 6 array of two layer paint & scratch data generates 60 placements.) For F9000/Autoplot data the limit is about 50,000 placements. There is no such limit for DPF files. 274-X and F9000/Autoplot both allow for only two levels of hierarchy - the top level and one level of subfigures/blocks, whereas DPF accommodates nested blocks. Repeated blocks may be used in all three formats.

What information is contained in the 'mass parameters' and headers of Gerber 274X, F9000, and DPF files.

All three formats include information about the units of the plot data. All three may also include comment information.

274-X and F9000/Autoplot file headers may have additional image, directive, layer specific, aperture, and miscellaneous parameters.

F9000/Autoplot files may include a setting for plotter resolution.

Can we use DXF/DWG data?

The Photoplot Store has the capability to read and process AutoCAD DWG/DXF data through AutoCAD 2004. However, the manipulation of this data in order to create ready to run plot data will be charged to our customers at our standard shop rate (please see the prices page). We highly recommend the use of one of the excellent CAD programs listed on our Design Optimization page in order to both minimize the cost of our services and to expedite our deliveries.

Can we use GDSII data?

The Photoplot Store has the capability convert GDSII data (and several other data formats) to Gerber 274-X. However, the manipulation of this data in order to create ready to run plot data will be charged to our customers at our standard shop rate (please see the prices page). We highly recommend the use of one of the excellent CAD programs or the data format conversion utility listed on our Design Optimization page in order to both minimize the cost of our services and to expedite our deliveries. Click here for a review of the GDSII data format.

Can we use other data formats such as EPS, PDF, GIF, TIFF, JPG, BMP, PNG, AI, CDR?

The Photoplot Store now has the capability to convert your EPS v3.0 (Encapsulated PostScript) data directly to GDS and Gerber formats! EPS is a data format that is typically used to drive laser printers, and can also be used for offset printing. EPS files may contain either vector or raster data. Vector data may be processed quite readily, while raster data can only be processed after performing a raster to vector conversion. Please click here to see our recommended EPS Design Rules. Each of these must be converted to either GDS or Gerber format in order to be useful in our case.

FYI, an Encapsulated PostScript (EPS) language tutorial may be seen by clicking this link.

The Photoplot Store can easily convert PDF files to EPS format and process them as described above. PDF files may be created directly from nearly any program or application (even office suite programs) by means of a *free program* called PDFCreator (free download here). This program can convert any printable feature including all types of text and polygon shapes to PDF format. We've even created plot files with beautifully smooth text from MSWord documents! The PDF file will accurately reproduce your design and the resulting photoplot will look just as fine! Choose the highest resolution in terms of DPI (dots per inch) in order to get the smoothest edges and greatest accuracy.

For users of Adobe Illustrator, simply save your data in EPS format.

The Photoplot Store now has the capability to convert various other data

formats to Gerber plot data and to Photomask data, *so long as the data is in vector format*. Using Adobe Illustrator, we can import data in popular formats such as Adobe Illustrator AI, Adobe Acrobat PDF, Corel Draw CDR, Freehand, and more. Once these are imported, we convert them to EPS data files for a final conversion to Gerber for plotting or to GDS for maskmaking.

Processing of raster/bitmap data (BMP, JPEG, GIF, TIFF, PNG, WMF, etc.) still requires an imprecise, difficult, and costly raster to vector conversion prior to plotting.

In order to create accurate designs that lend themselves to the least complicated conversion to Gerber for photoplotting, we highly recommend that our customers install and use the FREE CAD SOFTWARE that we provide through this link. In particular, CADopia6 is one of the best bargains available in the CAD world today!

What's the difference between a Gerber plotter and a mask writer?

Gerber plotters and mask writers are very similar in several respects, but very different in others. One of the main differences is that mask writers typically image directly onto glass, while Gerber plotters typically image onto polyester-based film.

Most Gerber plotters use a rotating drum as a platform to support the film during exposure, whereas all mask writers must have a flat bed to support the glass or quartz substrate. Some flat bed plotters can be used to expose silver halide emulsion on glass, such as with the Gerber 9725 plotters or the Mivatec LS 3000 machines.

Mask writers are typically set up to expose IC grade photoresist, but some can also expose silver halide emulsion.

What mask writers do we use?

We have several types of mask writers available to generate precision large area photomasks, among which are systems from Heidelberg Instruments, Micronic Laser Systems, and Texas Instruments.

We also utilize E-Beam and Optical Pattern Generation systems to generate our most precise Photomasks.

The typical minimum image sizes for the various direct write to glass processes are as follows:

Process	Image size
Laser Pattern Generation	0.12 & 0.23 mil (3 & 6 μm)
Optical Pattern Generation	0.2 mil (5 μm)
E-Beam	0.02 mil (0.5 μm)

What wavelengths of light are various photomask substrates good for?

Please click this link to see a graphical description of the spectral transmission curves of the various photomask substrates. (Courtesy of Rayotek, Inc.)

What do we charge for shipping and handling?

We do not charge handling fees. As much as possible, we charge exactly what the shippers (FedEx, UPS, etc.) charge us. FedEx does offer us a volume price discount that we pass on to our customers. UPS charges us list price.

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