Photo CD

The introduction by Kodak of Photo CD has generated a lot of interest, particularly among digital photographers and electronic publishers. The promise of Photo CD is that it will provide an easy means of getting images into electronic format. Still, there are many open questions about Photo CD and what it will mean in a professional pre-press environment. To help answer these questions we'll look at the distinguishing features of Photo CD.

Photo CD types

There are five types of Photo CDs:

- **Photo CD Master** – This is the mass-market format. It contains images of 35mm (millimeter) film originals scanned at 2048 by 3072 pixels. The data is readily available in five different resolutions. (See discussion later.)
- **Pro Photo CD Master** – Designed for professional photographers, scans at higher spatial resolution and for format sizes up to 4 by 5 inches.[1]
- **Photo CD Portfolio** – Contains only TV resolution images, for use with mass market slide shows. Holds up to 800 images, or 1 hour of audio, or some combination of images and audio.
- **Photo CD Catalog** – Contains only lower resolution images, can index up to 6000 images. Likely to be used by stock photo houses or photographers, but may also be used more generically as a catalog of inventory. Comes with software for searching the image database.
- **Photo CD Medical** – For specialized imaging requirements (not only medical but also for applications like mapping).

[1]This scanner is expected to be available around the third quarter of 1993.

Within the graphic arts, the two types of Photo CD that are likely to be of the most interest are Photo CD Master and Pro Photo CD Master.

Photo CD Master

Photo CD Master is what your corner photo finishing shop will offer. If you give them a roll of 35mm film, they provide you with: prints and negatives (or slides), and a CD in a carrying case with a cover sheet showing a thumbnail shot of each of the images. With Photo CD Master you can access the images in five spatial resolution settings[2]:

- 16 Base resolution – Full scan resolution
- 4 Base resolution – HDTV (High Definition Television) quality
- Base resolution – TV quality
- Base/4 resolution – Low resolution image manipulation
- Base/16 resolution – Used for the thumbnails on the CD cover sheet

[2]See the Linotype-Hell technical information article entitled Scanned File Size for more information on both spatial and tonal resolution.

Kodak considers the 16 Base resolution to be visually 'loss-less' based on experiments that they have done comparing photographically enlarged photos to ones that were scanned via Photo CD and enlarged electronically. For graphic arts applications, the maximum enlargement is a function of quality of the original image, the data recorded by the scanner, and the subsequent data manipulation. Kodak has reported that based on typical industry criteria, Photo CD images are suitable for GA applications up to a magnification of 700%[3] at a screen ruling of 150 lpi.

[3]For simplicity's sake, you can consider a 35 mm image to be about 1 inch by 1½ inches. That makes a 700% enlargement about 7 x 10½ inches.

Photo CD data acquisition

Name	Array size (in pixels)	Size in K	Size before compression
16 Base	2,048 by 3,072[4]	2K by 3K	18 MB file[5]
4 Base	1,024 by 1,536	1K x 1.5K	4.5 MB file
Base	512 by 768	.5K x .75K	1.12 MB file
Base/4	256 by 384	.25K x .375K	288 KB file
Base/16	128 by 192	.125K x .1875K	72 KB file

[4]The spatial resolution for Photo CD Master is often listed as 2,000 by 3,000 pixels, but is actually 2,048 by 3,072 pixels. This is a 2K by 3K array (2K = 2 x 1024 = 2048, 3K = 3 x 1024 = 3072). The same holds true for Pro Photo CD Master which is often listed as 4,000 by 6,000 pixels, but is actually 4,096 by 6,144 pixels or 4K by 6K. Comparing the file sizes shows the meaning behind the numbers 1/16, 1/4, Base, 4x, 16x (i.e., 16 x 1.12MB = 18MB).

[5]2,048 times 3,072 is equal to 6,291,456 pixels. Each pixel is 24 bit and takes 3 bytes (8 bits) to store. 3 times 6,291,456 is 18,874,368 bytes which is equal to 18 megabytes.

Photo CD scanning

The Kodak Photo CD scanner uses a stationary tri-linear array (three linear arrays with a R,G, or B filter) of 2048 elements. It is designed exclusively for 35mm film. During scanning, the film is moved parallel to the long dimension of the frame. This results in a scanned data file of 2048 by 3072 pixels in R, G, and B per frame of 35mm film. Before this data is quantized for storage, several transformations are made to optimize the encoding of the data for various applications and to achieve data compression.

The primary consumer application for Photo CD is television display. Kodak therefore has chosen to refer to the TV display resolution as the Base image. This resolution is achieved by averaging 16 pixels in the original high resolution 16 Base image to create each single pixel at Base resolution. This averaging is done in a two-step process so that an intermediate resolution HDTV image (4 Base) is also available. In addition, since TV uses luminance/chrominance data, the scanner RGB data is mathematically transformed into a single luminance and two chrominance components before processing. Kodak identifies the particular luminance and chrominance that they use as PhotoYCC™ (or YCC for short).[6]

[6]The Y in YCC represents luminance (brightness), and the two Cs are chrominance (or color) channels. Y, C, and C are coded into eight bits of information each.

Two lower resolution images (Base /4 and Base /16) are also created using the pixel averaging technique. These are used for indexing and reference applications. The key to the Photo CD data compression starts with the use of luminance/chrominance. It is generally agreed that lightness (or luminance) data has a higher frequency contribution than does the color (or chrominance) data. In Photo CD encoding, as in TV, the chrominance data is subsampled on average by a factor of two. This provides an immediate reduction in data. Then, rather than storing the full 16 Base and 4 Base images, Kodak uses an image reconstruction technique using the Base image as a reference. It compares a reconstructed image against a scanned image during initial processing and stores the differences at both the 4 Base and 16 Base image sizes. These differences are stored using Huffmann codes, achieving further compression. The Base, Base/4, and Base/16 images are stored as full YCC images with 8 bits per component.

[7]This is why Kodak can only give an estimate for the amount of images that will fit on Photo CD Master. It could be anywhere from 100 to 130 images. (100 images on a CD that holds approximately 600 MB of data means that the compression is quite significant.)

These techniques result in a total file size for all five resolutions of 4 to 6 MB per image rather than the greater than 18 MB that otherwise would have been required just for the initial data. (See chart.)The amount of compression varies depending on image content. For example, a photograph of a flat gray background would compress magnificently because of the lack of detail.[7]

[8]Prices may vary depending on the number of scans done. 80¢ is a relatively low price, Prices from $3 to $8 have also been quoted by Photo CD suppliers.

Kodak reports that photofinishers will charge around $20 for film processing and the Photo CD. For a 24 exposure roll that is about 80¢ per shot.[8] The actual scan time per shot is around 5 to 10 seconds, but increases to closer to 30 seconds when considering set-up time. This means that about 100 to 300 images can be digitized in an hour.

Pro Photo CD Master

Differences between Photo CD Master and Pro Photo CD Master:

- Pro Photo CD Master uses a scanner that not all Photo CD sites will have.
- The Pro Photo CD Master scanner can handle transmission and reflection originals up to 4 by 5 inches. The spatial resolution is 4096 by 6144 pixels.
- The scanned file size is correspondingly larger, approximately 72 MB. Compression brings this file size down to around 18 MB.

Spatial resolution

Since spatial resolution is one of the key differences between Photo CD Master and Pro Photo CD Master, let's look at the importance of this single factor. Kodak has stated that you can blow up a Photo CD Master image to 700% without a problem when that image is output at a 150 lpi screen ruling. To see just what this means, let's look at the spatial resolution.

The actual size of the image area of a 35mm negative is 24 by 36 mms.[9] Given that the 2,048 by 3,072 pixels from the scan must be enlarged to cover the target area, in practical terms, that means that the spatial resolution of an unenlarged scan is 85.333 pixels per mm or 2167.5 pixels per inch.[10]

This means is that there is an upper limit to the size that you can enlarge these images. And while this is really no different from any other scanned images, depending on enlargement size, the Photo CD Master scanner may not capture enough information. On the other hand, the 16 Base image may contain too much information for small images.[11] (See chart.)

[9] 35 mm refers to the width of the film, the image area in that width is 24 mm, but the image area length is 36.

[10] 2,048 pixels divided by 24 mm is equal to 85.333 pixels per mm. 3,072 pixels divided by 36 mm is the same.

[11] There is no sense in using more data than is actually needed, particularly when you consider the size that these files will be once they are decompressed.

Photo CD Master Enlargement (based on 16 Base Format)

Screen Ruling	Scanning ratio[12] 1:1	2:1	Maximum Enlargement at 1:1	Maximum Enlargement at 2:1
100 lpi	100 ppi	200 ppi	2048% (approx. 20" x 30")	1024% (approx. 10" x 15")
150 lpi	150 ppi	300 ppi	1536% (approx. 15" x 22½")	768% (approx. 7½" x 11¼")
200 lpi	200 ppi	400 ppi	1024% (approx. 10" x 15")	512% (approx. 5" x 7½")
300 lpi	300 ppi	600 ppi	768% (approx. 7½" x 11¼")	384% (approx. 3¾" x 5⅝")

[12] A scanning ratio of 1:1 is generally acknowledged to be the bare minimum needed while 2:1 is considered the maximum. For an estimate on enlargement sizes for 4 Base, divide enlargements by two. Pro Photo CD Master has twice the spatial resolution, but actual enlargement sizes will depend on the size of the original.

Quality and productivity issues

One open question regarding Photo CD is the color quality that it will provide. Some areas to watch are the following:

- Sharpening – No sharpening is done during Photo CD scans. Sharpening must be done with pre-press system software after image acquisition.
- Color computer – No color computer is available to support rapid image enhancement and correction, i.e., YCC to CMYK transforms, highlight, shadow, tone adjustments UCR/GCR (Under Color Removal/Gray Component Replacement), gray balance etc. These must all be applied sequentially in a later step at a workstation.
- Access time – Access time to images on a WORM (Write Once Read Many) CD is not nearly as fast as on other media. Therefore it is likely that images will be copied to higher speed media as a step in the production process. The decompression speed will also be a factor in this.
- Density range – The density range of the Photo CD scanners is around 2.8. Photomultiplier tube scanners like the Linotype-Hell DC3000 can capture a 3.9 density range.
- Base settings – The success or failure of Photo CD images in print will depend in large part on the quality of the software used to prepare the images for printing. Photo CD provides generic digitization of the full image area. Cropping, rotation, highlight, shadow placement, and tone reproduction are all accomplished during or after the image is imported into

the prepress system. Traditionally, these tasks have been accomplished on a repro scanner during pre-scan set-up and processed on the fly.

- Highlight and shadow control – A blown highlight or a plugged shadow in a scan cannot be saved later on in the production process.
- Negative as input – Many Photo CD scans will be made from 35mm negatives.[13] Negatives present certain problems in interpretation for scanners. Kodak has a great deal of experience in photofinishing methods for correcting color balance and exposure in photographic printing from negatives, but only time will tell whether these same algorithms will produce pleasing results for digital images. Kodak also contends that these techniques can be used to correct for poorly exposed chromes.
- Imperfections – For scans that will probably sell for under a dollar, issues like dust specks on the original may be overlooked.

[13] An interesting color matching issue is raised when the original is a color negative. How can you tell if the scan is accurate to the original? Furthermore, how can you judge any enhancements that are done to the image?

If Photo CD users find that they spend a lot of time re-working these generic scans into usable shape, then the advantage of a cheap scan will be lost.

Format

Another key issue is the ability to write images in Photo CD format. Kodak holds the rights to that process and licenses it to developers who want to use it. Kodak is not licensing the ability for other scanners to write in the Photo CD format or allowing non-Kodak scanners to press CDs in that format.

Kodak is offering a third party software developers kit, but until outside software is available, users will have to rely on Kodak-developed software to convert Photo CD images into PostScript™ formats. Kodak's conversion program is called Photo CD Access and turns Photo CD images into a variety of formats including EPS (Encapsulated PostScript), TIFF (Tagged Image File Format), and Pict (a Macintosh® picture file format).[14]

[14] An Adobe Photoshop™ plug-in called Photo CD Acquire will also be available.

Parallels in history

In 1985, when Apple Computer introduced the LaserWriter™, many people predicted that it would be severely hurt the sales of imagesetters. In fact, the opposite occurred. Sales of imagesetters soared. LaserWriters gave users a quality benchmark for comparison, and having this they could see the value of the higher quality output of imagesetters. A similar situation is likely to occur with Photo CD. Photo CD will popularize the use of digital color. It will open new markets for color, change concepts of workflow, and underline the value of high quality scans from scanners like those from Linotype-Hell.

Conclusion

Linotype-Hell has many open questions regarding Photo CD, primarily related to color quality and performance. We are confident that high-end scanners will continue to outperform scanners like those used within Photo CD. What is most exciting to us is the effect that Photo CD will have in promoting the electronic mechanical and electronic pre-press in general. And, we are very excited about the application of Photo CD in conjunction with desktop publishing products as well as in the newspaper industry in conjunction with products like LinoPress.™

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