Photo CD: disc bytes man

A review of a powerful imaging technology

by Brian P. Lawler

Highlights of Photo CD technology:

1. **Photo CD technology provides access to digitized photo files at a fraction of the cost of scanning services on other types of scanners.**
2. **Films of any type can be scanned to disc – color, black and white, positive or negative.**
3. **Discs have an extraordinary life span, and the data is transferrable to other media.**
4. **Quality of the Pro Photo CD scan is comparable to a drum scan.**
5. **Up to 72 MB of data is stored for each image.**
6. **Discs are universally acceptable on Macintosh, Windows, and other computer platforms – as well as on television players.**
7. **Photo CD discs have a large capacity, making them appropriate for image archiving.**
8. **Kodak's system uses "visually lossless" compression technology which yields a compact image with no visible loss when restored to full size.**

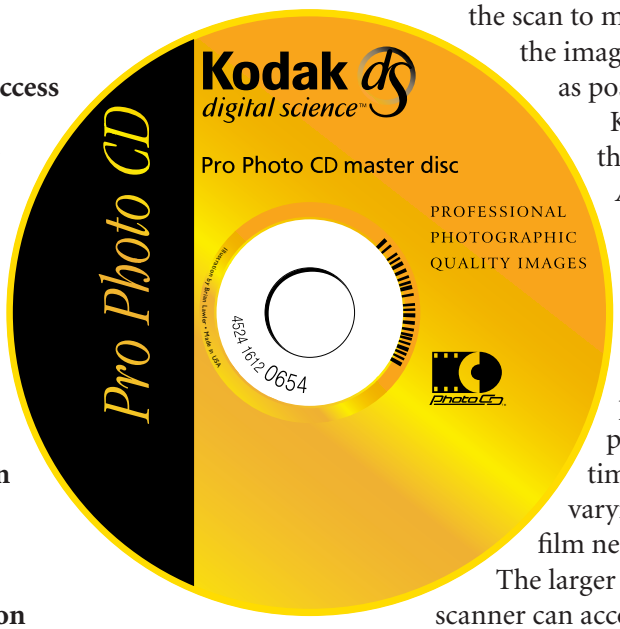


Photo CD: an alternative to owning a scanner

Photo CD brings scanned images to the masses. For as little as $3.00 per image a quality scan of original film is put onto a CD disc and can be used for computerized artwork, multimedia presentations, Internet publishing – or reproduction on the printed page.

The two systems for making Photo CDs allow either 35mm film in one case, or films up to 4x5 inches in size to be scanned and put on disc. The discs have a capacity of about 100 35mm images or 25 larger format images.

All films supported, most sizes too!

Any film can be scanned to Photo CD. The system allows images to be scanned in a "verbatim" mode to capture the image exactly as it looks, or in a mode called *Scene Balance Algorithm* which can "look" at the image, and adjust the quality of the scan to make the image as good as possible.

Kodak developed the *Scene Balance Algorithm* for its high-volume consumer snapshot printers, which make a good print over 95 percent of the time from a wildly varying quality of film negatives.

The larger Pro Photo CD scanner can accommodate film up to 4x5 in size, and has apertures to hold 35mm, 6x6, 6x7, and others, while the smaller unit can scan 35mm exclusively. The larger system also has a higher resolution, yielding a file four times the resolution of the 35mm system.

Photo CD will be around longer than we are

The life span of Photo CD discs is expected to be at least 100 years. Tests by Kodak engineers simulating high-UV exposure, heat, and exposure to airborne pollutants have shown that the discs are impervious to almost all potential degrading forces.

The disc melts at 250° C, but otherwise is not affected by magnetic fields, light, and most solvents. The polycarbonate casing is sealed – even on the edges – to prevent any substance from getting to the data layer, and the reflective surface is made of pure gold which will not degrade under any circumstances.

The irony of longevity in a high-tech world

This archival value is lost, of course, as new technologies make existing CD-ROM drives obsolete. The discs will last but the drives that read them won't! Our hedge against such obsolescence is the fact that Photo CD images are digital and can be copied to the next archival medium without any damage or quality degradation.

Scan quality of Photo CD

The Photo CD workstations are built around CCD-based scanners engineered by Kodak to extract tonal information from film to the degree of quality necessary for excellent archival storage and reproduction of images.

The dynamic range of the 35mm scanner is adequate to record the scene range in any negative, and almost any transparency that is to be scanned.

The new Professional 4050 scanner has a dynamic range equal to that of a drum scanner, making scans from that device comparable at every level to those made on conventional scanners.

The two scanners use Kodak-made CCDs (charge-coupled devices) which are trilinear arrays that scan moving film to capture the image in red, green and blue. The data from the RGB scan is captured, and then converted to a format called *Photo YCC color space.*

YCC color space consists of a black and white channel (luminance) and two "chroma" color channels which can be plugged back in to the black and white to "reconstitute" the image in color.

Who's on Base*64?

The information on Photo CDs is stored in what are called *Image Pacs.* The Image Pacs are computer files that contain subparts and sub-subparts of the image.

The 35mm scanning system creates an Image Pac of between 3 and 6 MB of data inside of which is a single image that after reconstitution is 18 MB in size. There are also four smaller options for the same image that yield files as small as 72K in size.

The Professional 4050 scanner has twice the resolution in its linear CCDs and it can optionally produce an *Image Pac Extension* (IPE) that contains one additional resolution of the each image at 72MB.

In order for an image to have 72MB of data, it must fit the proportions of a 35mm film (3:2). Other proportions yield smaller files; 6x6 yields a 45MB file, for example, which is "padded" with empty pixels on the edges to fit the 3:2 proportions of a 35mm frame.

The size descriptions given to the files are all are named after multiples of a file called *Base.* Base is the file size needed to display on a television screen. Whether an image is larger or smaller than Base determines its resolution in factors of 4. The larger three are:

- **Base**
- **Base*4**
- **Base*16**

The smaller two are:

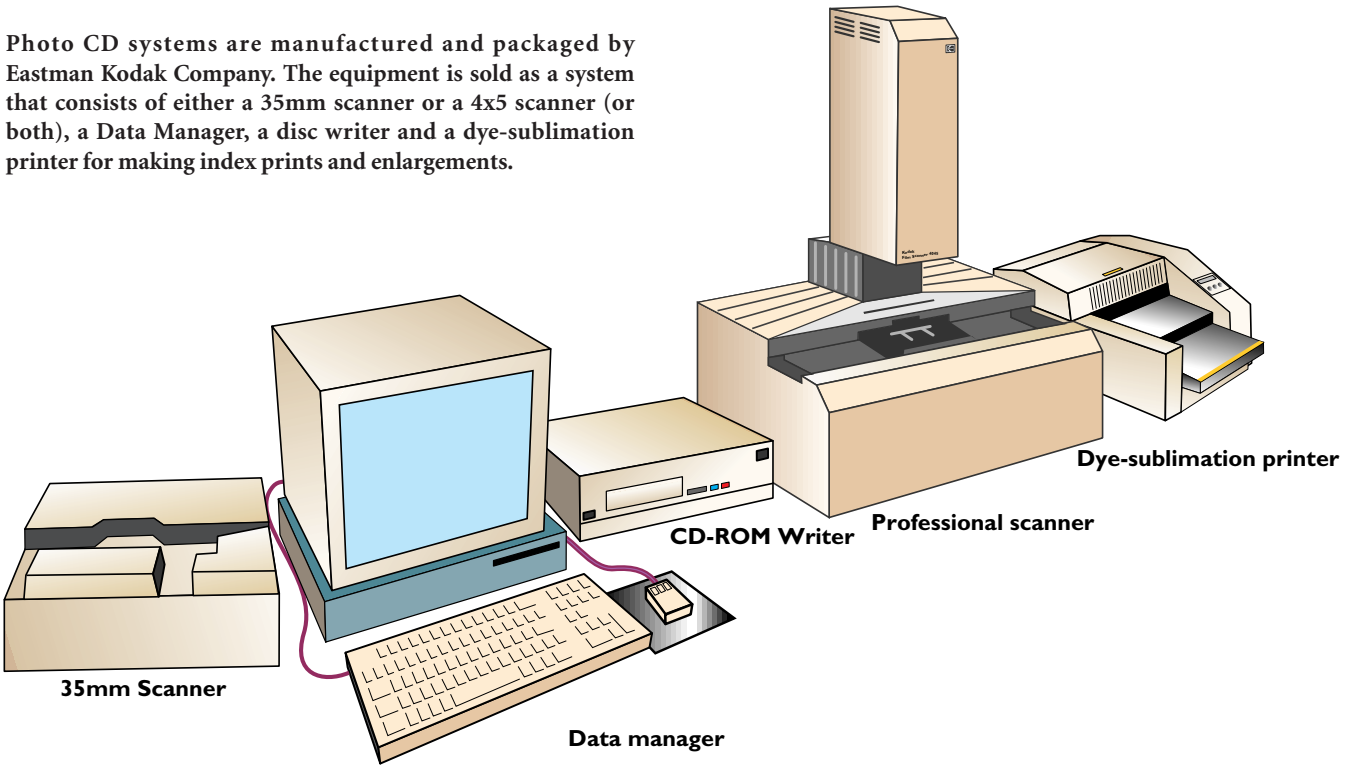
- **Base/4**
- **Base/16**

The Professional Photo CD scanner creates a sixth resolution called **Base*64.** For exact file sizes and resolutions, see Figure 2 (opposite).

Cross-platform becomes a reality

Photo CD Image Pacs can be opened on Macintosh and Windows computers, and most Unix systems.

Photo CD systems are manufactured and packaged by Eastman Kodak Company. The equipment is sold as a system that consists of either a 35mm scanner or a 4x5 scanner (or both), a Data Manager, a disc writer and a dye-sublimation printer for making index prints and enlargements.



Virtually every graphics program supports Photo CD in some way.

Photo CD images can also be shown on television players from Kodak, Philips, 3DO, Sony, Apple and some others. From these players come images at Base resolution only, and that image is shown as a still frame on the television.

Sound can be included in one type of Photo CD, that being the Photo CD *Portfolio II,* a disc designed for the delivery of "multimedia" presentations. The extent of the "multimedia" in the case of Portfolio is sound and still pictures, combined with branching, and the ability of the viewer to choose a topic to be viewed. Photo CD television players can also be programmed to show images in a programmed order and with the images rotated, zoomed, or flipped for proper viewing.

Visually lossless compression

The mathematical and logical operations that are performed on Photo CD images yield a compact and versatile file on the disc. To get there, the files are subjected to some destructive treatment, yet in the process, no *significant* information is lost.

Kodak calls this "visually lossless" which means that there is some loss of image data, but that the losses are restricted to elements in the detail and tone that are not seen by the human eye.

The key to this compression magic is the storage of a file called "residuals." The residuals represents the components of the image that record sharpness and detail. Even when the compression is discarding data, it never throws away the sharpness. On reconstitution, the residuals are put back in place to restore the image's sharpness.

And it works! Comparing Photo CD compression to other compression techniques shows a visibly superior image.

Capacity and practicality of Photo CD as an image archive or library platform

Photo CD discs store relatively large numbers of images – 100 35mm originals, or about 25 images from films up to 4x5 inches in size.

Many photos agencies are turning to Photo CD as a medium for the storage of libraries of photographs. Individuals and organizations with a significant number of images to store, reproduce, distribute and archive will profit from the use of Photo CD.

Image databases like Extensis *Portfolio,* Canto *Cumulus* and others can be used to index and store information about Photo CD discs, giving image librarians the ability to find images by key-word search and extended logical (called *Boolean*) techniques.

One could, for example, search for images by the following search criteria:

[Find me] *ships vertical color not Caribbean*

…which would locate and display all images that met those criteria (if any meet the search criteria). The quality of the search is determined by the thoroughness of the library's creator, and whether the images were cataloged at input with an adequate amount of indexing information.

Photo CD Image Pac file sizes

Image	Resolution in pixels	RGB size	CMYK size
Base/16	128 x 192	72KB	96 KB
Base/4	256 x 384	288 KB	384 KB
Base	512 x 768	1.1 MB	1.5 MB
Base*4	1024 x 1536	4.5 MB	6 MB
Base*16	2048 x 3072	18 MB	24 MB
Base*64	4096 x 6144	72 MB	96 MB

Photo CD images are stored in a file with a series of resolutions, each a multiple of the master image called Base. Three-color RGB images are smaller than CMYK, which have four components. Each Image Pac image is either four times larger or four times smaller than the next size image. See the chart on page 5 for reproduction sizes.

Reproduction math for scanning and working with Photo CD images

Scanner resolution calculations are commonly described as *oversample rates* or scan resolutions, and are typically measured in dots-per-inch (dpi).

Common wisdom dictates that one needs two pixels per halftone dot (measured linearly) to get a reasonable image. Experimentation with this has shown that we can scan a great deal less information and still get excellent reproductions from the resulting halftones.

The formula for determining the rate for scan sampling is:

Q × lpi × %

= scan rate in pixels per inch

The first value – **Q** – is used to apply a percentage of oversampling, which will yield *slightly* more information than necessary in the scan; this oversampling is essential for electronic halftones. Recommended values for Q range from a low of 1.25 to a high of 2.0.

lpi is the chosen halftone frequency in *lines* per inch. The printing process determines this value. The third number is the amount of enlargement or reduction expressed as a decimal number (50% = .5 and 135% = 1.35). The result of this is often a quizzical number like 587.3125; just round up!

But – Photo CD does not allow us to set the resolution, so we need to turn this equation around

With Photo CD, the resolution of the image, in pixels, is fixed. You can choose to use the image or not, according to the available resolution, but how large can it be when it is reproduced?

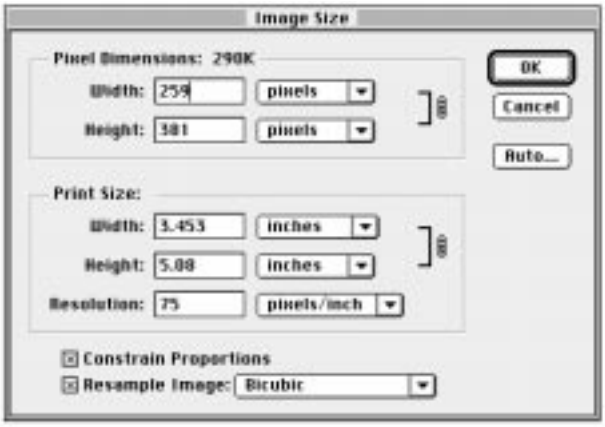
We use the same components for calculating scan resolutions as before, but we *divide* the number of pixels by the "scan rate" to get the maximum dimension for a given image.

$$\frac{\text{number of pixels in one dimension}}{(Q \times \text{lpi})} = \text{inches}$$

Note that the Q × lpi calculation must be done *before* dividing. Here's an example of a Photo CD image at Base*4 (the measurement is for the long dimension of the image).

$$\frac{1536}{(1.25 \times 150)} = 8.17 \text{ in.}$$

The product of 1.25 × 150 lpi is 187.5; Round this up to 188 for efficiency. The 8.17 inch dimension tells us that the image can be reproduced to that size or smaller. If the image is significantly smaller, it would be wise to use a lower resolution Photo CD image.



Photoshop 4.0's Image Size dialog box. The three elements at the bottom: Width, Height, and Resolution are mathematically tied to one another only when the Resample box is unchecked. When checked, the mathematical relationship between resolution and size is broken and the program can subsample (discard) or interpolate (create new) information in the image.

Always do the math on your images (and calculate both dimensions!), because the calculation tells you much about the reproduction capacity of the photo. An alternative is to let Photoshop do the math for you. Using Image>Image Size, you can test the variations to see how large the image can be, as shown in the illustrations on this page.

When you know the size of a photo window in a page, but do not know how many pixels will be required to fit the window, use this third formula:

$$Q \times \text{lpi x inches} = \text{pixels}$$

With the product of this formula, you can choose the correct Image Pac component from a Photo CD to fill the window in the page.

■ This is one of a series of essays I have published on graphic arts subjects. Other topics include Dot Gain, Black and White scanning, Color Trapping, Separation Set-up in Photoshop, Scanning resolution, calibrating your computer system, and more.

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Halftones from Photo CD images

Since Photo CD images are of fixed resolution, changing the resolution at the time of the scan is impossible. Thus, working with the fixed resolution image requires acceptance of the output halftone size according to a chosen oversampling rate, called "Q" in the formulas on these pages.

Most people use an oversampling ratio of 2.0, but tests show that halftones reproduce well at lower oversampling rates – as low as 1.25 over the chosen halftone frequency. With Photo CD this translates into increased enlargement potential. Dimensions are in inches (centimeters).

1.25:1 Q value

Halftone Frequency	Max. Dimensions (Master)	Max. Dimensions (Pro)*
175 (68.8)	14.04 x 9.36 (35.7 x 23.8)	28.09 x 18.72 (71.3 x 47.54)
150 (59.0)	16.38 x 10.92 (41.6 x 27.7)	32.76 x 21.84 (83.2 x 55.47)
133 (52.3)	18.48 x 12.32 (46.9 x 31.3)	36.96 x 24.64 (93.8 x 62.6)
100 (39.3)	24.58 x 16.38 (62.4 x 41.6)	49.10 x 32.76 (124.7 x 83.2)
85 (33.5)	28.91 x 19.28 (73.4 x 48.9)	57.82 x 38.56 (146.8 x 97.9)
65 (25.6)	37.81 x 25.21 (96.0 x 64.0)	75.62 x 50.42 (192.0 x 128.0)
50 (19.68)	49.15 x 32.77 (124.8 x 83.2)	98.30 x 65.54 (249.6 x 166.4)

1.5:1 Q value

Halftone Frequency	Max. Dimensions (Master)	Max. Dimensions (Pro)*
175 (68.8)	11.70 x 7.80 (29.7 x 19.81)	23.40 x 15.60 (59.4 x 39.6)
150 (59.0)	13.65 x 9.10 (34.6 x 23.1)	27.30 x 18.20 (69.3 x 46.2)
133 (52.3)	15.40 x 10.27 (39.1 x 26.0)	30.80 x 20.54 (78.2 x 52.2)
100 (39.3)	20.48 x 13.65 (52.0 x 34.6)	40.96 x 27.30 (104.0 x 69.3)
85 (33.5)	24.09 x 16.06 (61.1 x 40.7)	48.18 x 32.12 (122.3 x 81.6)
65 (25.6)	31.51 x 21.01 (80.0 x 53.4)	63.02 x 42.02 (160.0 x 106.7)
50 (19.7)	40.96 x 27.31 (104.0 x 69.4)	81.92 x 54.62 (208.0 x 138.7)

2.0:1 Q value

Halftone Frequency	Max. Dimensions (Master)	Max. Dimensions (Pro)*
175 (68.8)	8.78 x 5.85 (22.3 x 14.85)	17.56 x 11.70 (44.6 x 29.7)
150 (59.0)	10.24 x 6.83 (26.0 x 17.3)	20.48 x 13.66 (52.0 x 34.69)
133 (52.3)	11.55 x 7.70 (29.33 x 19.5)	23.10 x 15.40 (58.7 x 39.1)
100 (39.3)	15.36 x 10.24 (39.0 x 26.0)	30.72 x 20.48 (78.0 x 52.0)
85 (33.5)	18.07 x 12.05 (48.9 x 30.6)	36.14 x 24.10 (91.8 x 61.2)
65 (25.6)	23.63 x 15.75 (60.0 x 40.0)	47.26 x 31.50 (120.0 x 80.0)
50 (19.7)	30.72 x 20.48 (78.0 x 52.0)	61.44 x 40.96 (156.0 x 104.0)

***This assumes a film size that yields a 3:2 ratio horizontal to vertical. 35mm films yield this ratio (36:24). Other film formats will yield a different horizontal enlargement value in each case.**