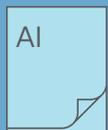
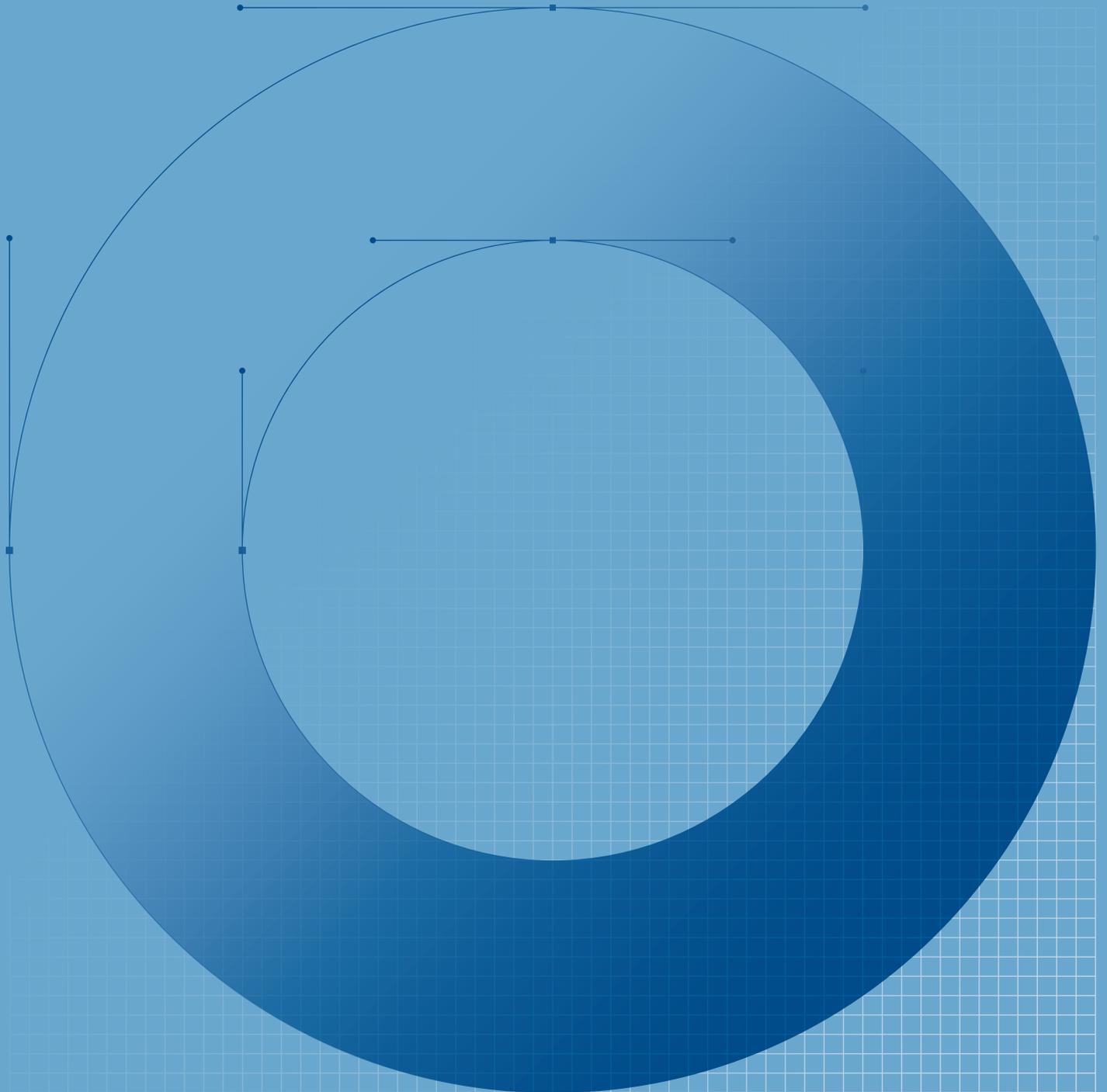


Digital Graphics Primer

Vector Graphics, Raster Graphics, and Their Associated Image File Types

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Introduction

The alphabet soup of file type acronyms and initialisms (JPEG, TIFF, EPS, PDF, etc.) play an important role in the digital arts lexicon but can be confusing to those unfamiliar with their meaning. Even more obscure is the way in which they are created, using vector and raster based applications. For those unfamiliar with the terms vector and raster graphics and the variety of graphic image file types, this primer is meant to shed light on these files and how best to apply them. Following industry standards, it serves as a reference with definitions, best practice guidelines, and sample images.

Files found within the workplace tend to be saved in one of these types and are used interchangeably, sometimes incorrectly. There may be a certain amount of crossover when using different image file types, but they have been purposely created to meet specific graphic needs, and their usage spans the full range of digital arts. Depending on the project at hand, selecting the correct file type is important due to the wide variety of mediums in which they may be applied. Print design, web design, photography, videography, and document creation are just some of the ways in which they may be utilized.

With some exceptions, it is important to note that these files are used as elements in larger design projects—photos, logos, and other graphics applied to creative projects. Not covered are the applications and files that these graphics are used in conjunction with. For example, projects created with Adobe® InDesign®, QuarkXPress®, and Microsoft® Word.

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Vector and Raster Graphics

To begin with, it is important to understand the difference between vector and raster graphics. Depending on the purpose and nature of digital artwork files, graphic image formats break down into one of these two categories. It may be difficult to distinguish between the two by simply viewing an image, but vector and raster images are fundamentally different, created and rendered using entirely different methods. Below are the definitions of these two file formats, how they are created, and how they benefit certain design projects.

Vector Graphics

Vector graphics are visual objects rendered by a computer using geometry and mathematics. Though this may seem rather complex and abstract, applications with graphical user interfaces allow for the creation of these objects with the aid of drawing tools. Control points, lines, curves, and shapes can be drawn and manipulated in a user-friendly, interactive manner.

The information stored within a vector graphics file consists of data representing control points, their relationship to one other on an X and Y axis, the lines that connect them, and the shapes they create. Also contained within the file are applied graphic styles, like line thickness, color fills, patterns, etc.

One benefit of using vector based graphics is manageable file sizes. Because vector data information is similar in structure to that of a database, file sizes tend to be much smaller than their raster equivalent, and adding complexity to a vector graphic generally does not drastically increase the file size.

Another feature that makes vector based graphics popular is scalability. Because of the way vector graphics are rendered they can be sized to meet the requirements of a given project without loss in quality. This allows for a vector graphic to be pixel independent, unlike raster graphics which are pixel dependent. For example, a logo that measures three inches in width will be of the same quality and file size when enlarged to three feet in width.

In print design, vector graphics represent the industry standard for elements like logos, certain forms of illustration, and various graphic elements due to their scalability, editability, and lack of image degradation. Vector graphics are a necessity when using spot colors (like those found in the Pantone Matching System®), as they can be color separated and printed in their assigned colors without separating into the cyan, magenta, yellow, and black colors of 4-color process printing.

For similar reasons vector graphics are also popular in web design. Traditionally, web design has been resolution dependent, relying on a pixel-per-inch standard. Technology has advanced beyond this pixel dependency and use of vector graphics has become more commonplace. The ability to scale design elements without loss of quality is as important now in the creation of certain web graphics as it is in print design.

Raster Graphics

A raster graphic is rendered by assigning color data to pixels arranged in a grid matrix. The size of a raster graphic is measured by the amount of pixels in the matrix's width and height. In addition, raster graphics are measured by pixel density, or the amount of pixels within a one inch square, known as pixels per inch or PPI. These two values, width by height and pixels per inch, are relative measurements. For example, a graphic that measures 6 inches wide by 3 inches tall at 300 pixels per inch is identical to a graphic that is 25 inches wide by 12.5 inches tall at 72 pixels per inch.

The amount of data assigned to each pixel is known as bit depth. The simplest raster graphic contains a bit depth of one, allowing for two possible values, black or white. Bit depth can be increased beyond 32 with the standard being eight. A graphic with a bit depth of eight allows for a range of colors that measures in the millions, more than can be perceived by the human eye.

The color of a pixel as perceived by a viewer is determined by a mix of colors created by different color modes. The most commonly used color mode is RGB, a mix of red, green, and blue. Another common color mode is CMYK, a mix of cyan, magenta, yellow, and black. Other color modes include, bitmap, grayscale, indexed color, Lab color, amongst others. Depending on the type of graphic, its usage, and how it was created, a pixel can contain a variety of other information as well. Examples include pixel transparency, pixel masking, and additional color channels.

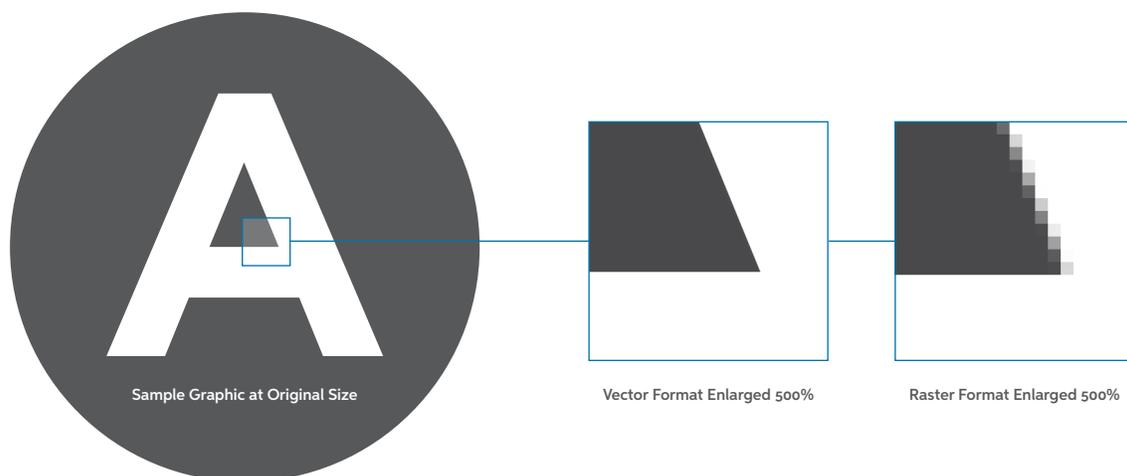
Raster graphics are pixel dependent, meaning they cannot be scaled up in size without a noticeable loss of quality. This dependency is unlike that of vector graphics which, as previously mentioned, can be freely scaled up without degradation. A raster graphic can be reduced in size, but once scaled down it cannot be brought back to its original dimensions.

Also, unlike vector graphics, the dimensions, bit depth, and color mode of a raster graphic directly impacts its file size. Pixels and the information related to them is information that needs to be stored within a file. The more pixels in a graphic, the larger the file size. And, if a graphic is saved in CMYK mode as opposed to RGB, the additional color information will increase a file size. For instance, an illustration rendered as a vector image may have a file size of 3 MB, whereas the same illustration rendered as a raster graphic can be 30 MB in size. Though these numbers represent an arbitrary example, the disparity in size will always be noticeable.

The most common types of raster graphics are digital photographs and illustrations, though any graphic can be rendered in raster format. The same does not hold true for vector graphics. For example a photograph cannot be rendered in vector format, though photorealistic images can be created using vector applications. In general, raster graphics span the full range of digital arts media. Raster graphics are also better suited to 4-color process printing and presentation on digital displays. Though creating raster graphics that print in spot colors is possible, it is not without limitations.

Example Image

These images demonstrate the difference in how vector and raster graphics are rendered. The image on the left is a representation of a graphics' appearance at actual size. Zooming into the sample area, we see that a vector graphic retains the smooth lines inherent to its format, whereas, the raster graphic begins to reveal the pixels used to render the same shape.



Graphic Image File Types

Vector and raster graphics can be generated in a variety of applications, being saved in wide range of file types. Though by no means absolute, the following list represents industry standard file types, and as such, the most commonly distributed amongst users of digital graphics. When selecting a file type it is best to choose from ones covered in this document.

Native File Types

Native files are those generated and saved in the file format of the application used to create them. For instance, a logo design that has been rendered in Adobe Illustrator is saved as an Illustrator or AI file. The file will not be as versatile as other file types when wide distribution is required, but is the best format for continued development, revisions, and application within other Illustrator projects.

Adobe® Illustrator® (AI)

Created by Adobe, Illustrator is the industry standard application for working with vector based artwork. Illustrator files are recognizable by the .ai file extension. Originally designed as a way to create graphics for use in desktop publishing applications, it has developed into a sophisticated tool with a wide-ranging feature set. Illustrator is the preferred application for many creatives of all disciplines. Examples of its many uses include illustration, logo design, branding materials, print collateral, web design, and environmental design.

Adobe® Photoshop® Document (PSD)

Created by Adobe, Photoshop is the industry standard application for working with raster based artwork. Photoshop files are recognizable by the .psd file extension. Originally designed as a way to edit photographs and create or edit graphics for use in desktop publishing, like Illustrator, it too has grown in sophistication with a highly versatile set of features. Photoshop is the preferred application for many creatives of all disciplines. Examples of its many uses include photography, photo editing and manipulation, illustration, print collateral, web design, environmental design, and animation.

Other Vector and Raster Applications Titles

Illustrator and Photoshop are by far the most widely used vector and raster applications in the graphic arts industry. Their long standing history and universal usage by designers, photographers, illustrators, and printers have made them industry standards. This is not to say that they are the only options available. The reason other titles are not mentioned in this document is that they have yet to gain widespread usage, though a quick Internet search will turn up highly rated alternatives.

Open File Types

Open file types have been created for their versatility, and ease of distribution and implementation. As an example, a JPEG graphic can be generated by a wide range of applications. As an open standard file type, the same JPEG file can then be distributed while remaining readable by many other applications.

It's important to note that each file type has been developed for a specific purpose. Though there is some crossover in usage, best practices dictate the use of the proper file type for a given need. Each file type listed below includes examples on how best to use them for a given project.

Bitmap (BMP)

Bitmap graphics were co-developed by Microsoft and IBM for use in the Windows and OS/2 operating systems. Known as bitmap files, they are raster based graphics recognizable by the .bmp file extension. Bitmaps can be saved at different bit depths with each pixel represented by 1, 4, 8, 16, 24, and 32 bits of color data. When a graphic is saved at a lower bit depth it will be rendered with fewer colors. For example, a photograph saved with a bit depth of 8 only allows for 256 colors. To maintain image integrity, a lower bit depth graphic uses dithering patterns to compensate for color loss. This will cause graphics to become grainy in appearance. A graphic saved with a bit depth of 1 only allows for each pixel to be rendered in either black or white. With the advancement of technology leading to more versatile file types, bitmap images have become less popular amongst graphic artists.

Encapsulated Postscript (EPS)

The Encapsulated Postscript file type was developed by Adobe as a way to including all necessary PostScript® printing data within a single graphics file. Known as EPS files, they are recognizable by the .eps file extension. Because EPS files are a self contained file type they are extremely versatile. EPS files can contain both vector and raster graphics. EPS files are often used as a way to distribute graphics created in Adobe Illustrator to those who would like to utilize the artwork but do not have the means in which to work with them natively. They are also readable and convertible by many publishing and graphics applications and are easily transferable from one operating system to another. This versatility has made the EPS file type popular with designers, printers and most others in the graphics industry.

Graphics Interchange Format (GIF)

The Graphics Interchange Format was introduced by CompuServe in 1987. Known as GIF files, they are raster based graphics recognizable by the .gif file extension. The GIF acronym is pronounced with both a hard and soft "G", sounding like GIF or JIF, based on personal preference. GIFs are a bitmap based graphic with a maximum bit depth of 8, allowing for up to 256 colors. Using compression, GIF files were developed as a way to bring color graphics to the Internet that would download quickly over limited bandwidth. GIFs can also be saved with a transparent background, though limited in quality. The use of GIFs gained popularity due to their animation like abilities. They allowed for multiple graphics stored in the same file to be displayed in succession according to a predetermined frame rate. Because of the limited color palette, GIFs are best used for simple graphics with solid color fills and are not appropriate for photos or complex illustrative images. With better graphic format options available, including PNG, JPEG, and SVG, GIFs have fallen out of favor amongst designers and are rarely used.

Joint Photographic Experts Group (JPEG)

Named after its creator, the Joint Photographic Expert Group, and known as JPEG files, they are raster based graphics recognizable by the .jpg (or .jpeg) file extension. The JPEG format was designed as a way to reduce photographic image file sizes through compression. The type of compression that JPEGs employ is known as lossy compression. Lossy compression analyzes the pixel color data of a graphic and eliminates data using a method that will cause the least amount of visual degradation. The amount of compression can be determined by the user, with more compression equaling a smaller file size, though the more compression the greater the loss in quality. Repeated compression, even at the same level, will also cause images to degrade. Visual artifacts seen in highly compressed JPEGs is known as pixelization.

The JPEG file type is one of the most widely supported files and is extremely popular. JPEGs are used by photographers, print and web designers, office asset managers, to name a few. Because JPEG files only support RGB color mode, they are best used for saving and transferring graphics, in web design, and dedicated printing of photographic images. If a graphic is intended for 4-color printing it needs to be saved in a file format that supports CMYK color mode, most commonly the TIFF file type. Sometimes graphics that are better served as vector based files are converted and used as JPEGs which can lead to improper usage causing implementation issues, incorrect color conversion, and poor reproduction.

Portable Document Format (PDF)

Developed by Adobe, the Portable Document Format was designed as a universal way to digitally distribute documents that are typically distributed via print. Known as PDF files, they are recognizable by the .pdf file extension. All elements of a file needed for proper viewing by other applications and use with other devices, including layout, fonts, vector and raster graphics, photographs, etc., are embedded into the PDF making them self contained and independent. PDF files can be created and viewed by a wide range of applications, including Adobe's free Reader® application. Common uses of PDFs include distribution of documents, forms, design proofs, and print-ready design files. PDF files can also be created with interactive features including embedded videos, websites links, document page links, and direct form data entry.

Portable Network Graphics (PNG)

The Portable Network Graphics file type was developed as an alternative to GIF in the creation of web graphics, providing support for 24-bit graphics, enhanced transparency, and lossless compression. PNG files are raster based graphics recognizable by the .png file extension. With greater bit depth support, images can be generated without any apparent degradation to image quality, like the artifacting found in GIF images. The added support for better transparency allows graphics to be created with varying levels of opacity as opposed to the transparent/non-transparent nature of GIF files. This eliminates the jagged edges that GIF images can generate. These enhancements have made the PNG file type a standard in the creation of web graphics (with JPEG graphics being the standard for web-based photographic images). PNG graphics do not support CMYK color mode and are not suitable for use in print design where 4-color process images are required.

Scalable Vector Graphics (SVG)

SVG files are XML-based vector graphics recognizable by the .svg file extension. Developed by the World Wide Web Consortium (W3C), SVG graphics were created to bring the advantages of vector graphics to web design. With most web-based graphics generated as raster files, SVG graphics offer the same qualities of vector graphics found in print design. Graphics saved as SVGs generate smaller file sizes and offer the advantage of scalability. In the modern landscape of web design this is a welcome feature as platform access to web based content continues to diversify. In its current state SVG graphic implementation is still somewhat limited, though all modern browsers offer some level of SVG support. SVGs are a good alternative to some graphics typically saved in the PNG format.

Tagged Image File Format (TIFF)

The Tagged Image File Format was created by Aldus (the copyright now being owned by Adobe) in 1986 as a way to alleviate the multiple proprietary file types being developed by image scanning hardware manufacturers. TIFF files are raster based graphics recognizable by the .tif (or .tiff) file extension. Since its inception, TIFF has become a standard file type for graphics used in the print design and publishing industry. TIFF is used to save photographs, illustrations, and various graphics in the highest quality possible. TIFF is extremely versatile in that it offers support for CMYK, RGB, Lab, Indexed Color, Grayscale, and Bitmap color modes. TIFF also offers support for saving files with maximum bit-depths, multiple layers, and the use of LZW lossless compression. TIFF graphics generate file sizes larger than other image types like JPEG, but are considered to be of the highest quality and are therefore the format of choice among professionals.

File Type Selection and Craftsmanship

With such a wide range of file type options available it can be difficult to decide which type is suitable for certain needs. As a general rule it is best to maintain and archive graphics in their native format. For example, artwork created in Photoshop or Illustrator should be saved in their respective formats even if the final implementation will be of a different file type. If a client or vendor requests a copy, ask which format is preferred and save a copy of the original to meet their needs. Any graphic saved in any format is only as good as the original.

Experienced professionals know how to craft files properly. When using a supplied graphic, and the file type or quality is of a subpar standard, it may be beneficial to track down the creator of the original and obtain a high quality copy direct from the source. Use of low quality graphics will be obvious, a sign of poor craftsmanship, and degrade the quality of any creative arts project.

Sample Images

The images below represent raster file types with unique features that can have an effect on appearance and quality. They include bitmap, GIF, JPEG, and PNG formats. EPS, PDF, SVG, and TIFF file types are not included due to their high-quality nature. Unless created using poor craftsmanship, there would be no discernible difference in appearance. (Note: when comparing samples, viewing this document at 100% will render the best results.)



Adobe Photoshop Original



JPEG with High Compression



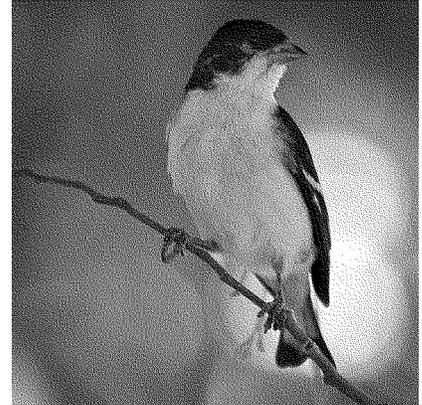
GIF saved for web



PNG Original



PNG with Transparency



Bitmap with a Bit Depth of 1

Graphics Reference Chart

This chart serves as a guide to the file types discussed in this document. It can be used to cross reference file types, their format, implementation, and examples of projects they best serve.

FILE TYPE	FILE EXTENSION	FILE FORMAT	USAGE
Adobe® Illustrator®	.ai	Vector	Vector graphics creation, saving in native format, Illustration, logo design, branding materials, print collateral, web design
Adobe® Photoshop® Document	.psd	Raster	Raster graphics creation, saving in native format, photo editing, illustration, print collateral, web design, animation
Bitmap*	.bmp	Raster	Low quality black and white, grayscale, and color web graphics
Encapsulated Postscript	.eps	Vector / Raster	File distribution, maintaining editability, cross application implementation, use with larger scale design projects
Graphics Interchange Format*	.gif	Raster	Web graphics, short looping web animations
Joint Photographic Experts Group	.jpg / .jpeg	Raster	File distribution, file size compression, photography, web photos and graphics
Portable Document Format	.pdf	Vector / Raster	Office document distribution, interactive forms, design proofing, print-ready file distribution
Portable Network Graphics	.png	Raster	Web graphics requiring varying levels of opacity
Scalable Vector Graphics	.svg	Vector	Web graphics including: logos, icons, simple illustrations, and design elements
Tagged Image File Format	.tif / .tiff	Raster	File distribution, saving and distribution of high quality photography and illustration, use with larger scale design projects

* This file type may still meet specific needs though better options are available.

