OKIPAGE 8c

Color Guide

Brilliant Color from Oki

Thank you for choosing the OKIPAGE 8c Color Page Printer.

The OKIPAGE 8c offers brilliant color printing at a fast 8 pages per minute on plain paper and 6 pages per minute on transparencies - the OKIPAGE 8c is the perfect workgroup printer for a wide range of business applications.

The following pages provide the reader with a broad overview of the issues related to color printing, in order that the best use of color be made in the applications chosen. The technical issues are described in an easy-to-understand manner, to assist anyone involved in the preparation of color documents.

Please also familiarize yourself with the Operator documentation provided – this describes specific operational details of the OKIPAGE 8c setup and configuration for specific options.

We are sure that you will find the OKIPAGE 8c an excellent part of your departmental printing solution. If you have any comments regarding this document, please let us know through our Web site, www.okidata.com.

Contents

The use of color

Recent advances have brought color to the desktop in a way that could not have been imagined a decade ago. Using color in print can increase memory retention by up to 65% and readership by as much as 40%, not to mention the added impact that it provides. As color becomes more and more accessible, it is essential to understand the importance of color and how best to use it.

People use color for different reasons. It has become a very important tool and is widely used in marketing to grab attention and communicate ideas. When used effectively, color can alter the viewer's perception.

Color can be used in text documents as well as for graphics. It can be used to emphasize headings or particular words which would otherwise be lost in the vast array of black and white. Color adds impetus to a company logo and can be as important as the design itself. The use of color also makes a document easier to comprehend and can convey information at a glance. An example is using red to highlight negative figures in a spreadsheet.

The use of color should be considered an integral part of any presentation or document, not an afterthought added at the end.

The following examples list some widely used colors and their significance.

RED This is a very powerful and passionate color. The power and passion that it portrays has made it a favorite for many exotic sports cars.

GREEN Unlike red, green is a very calming and 'natural' color. It signifies trees, grass and plant life in general. It is soothing and perhaps associated with a stroll in a field. It is also the color of envy.

BLUE A cool and refreshing color. It is the color of summer skies and a clear blue sea which produces a calming effect. Dark blues are associated with wealth and dignity and also have names that suggest these virtues – Royal blue, Navy blue, etc.

BLACK This is really an absence of color and the contrast that it provides with other colors has made it one of the most widely used. Black is usually associated with night and darkness

WHITE The color of pure snow and in itself suggests purity. It is used in hospitals to portray an air of cleanliness and sterility. Like black, white can be paired with most colors and is therefore very popular.

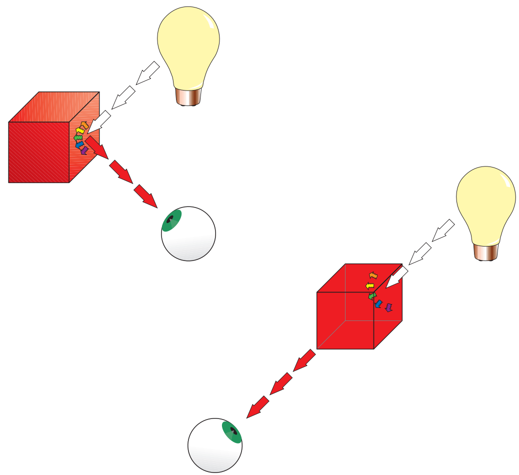
In short, colors can be used effectively to send their own message, regardless of the message that they are supporting. The colors used within a message are seen and automatically decoded before the message itself has been read. This underlines the **importance** and **effectiveness** of using color.

Color perception

Color does not exist by itself but is dependent on the presence of:

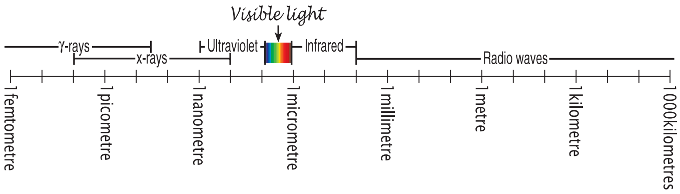
- a light source
- an object
- an observer

Our perception of color involves light from a source being reflected off, or transmitted through, an object and entering the eye.



The electromagnetic spectrum

Light interacts with an object and what we see is the final result of that interaction. An object can reflect, transmit or emit light. A reflective object absorbs some sections of the visible spectrum and reflects the rest. What we see is the reflected portion. An object removing wavelengths at the ultra violet end for example, will appear red in hue. A transmissive object allows light to pass through it and may absorb a section. The color of the object in this case, will depend upon the wavelengths of light that are allowed to pass through. An emissive object emits light and the appearance of the light will depend on the wavelengths emitted. In short, the composition of the light and its interaction with the object will define the color we see.

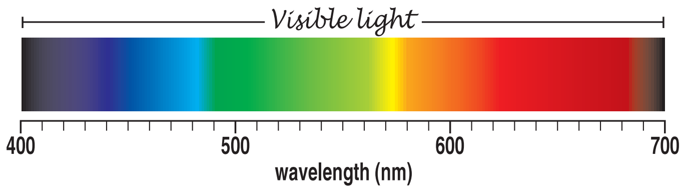


1 micrometer	=	1×10-6 meter	(0·001 mm)
1 nanometer	=	1×10^{-9} meter	(0·000001 mm)
1 picometer	=	1×10^{-12} meter	(0·000000001 mm)
1 femtometer	=	1×10^{-15} meter	(0·000000000001 mm)

All colors we can see fall into what is the visible part of the **electromagnetic (EM) spectrum**. The visible portion of the EM spectrum is minute and although we are ‘blind’ to the rest, the part we can see has a significant effect on our perception of everything around us.

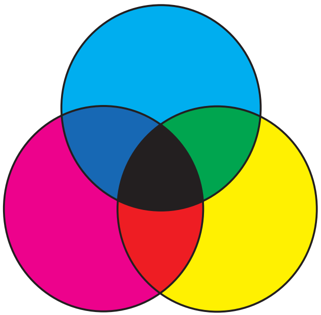
If light containing all visible wavelengths (in balanced quantities) is detected, then white light is seen. If there is an absence of all wavelengths, then black is perceived. The infinite combination of different wavelengths give rise to what we perceive as color. So color is light.

When our eyes receive information containing a strong content of a particular wavelength, we interpret that as a color. A strong content around 700 nm (0.0007 mm wavelength) is interpreted as red; at the other end of the scale, 400 nm is interpreted as violet.

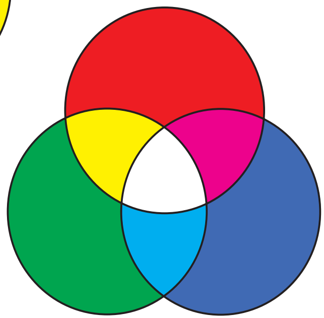


Primary and secondary colors

In theory, all colors can be made up from a very small group of color elements. There are three **primary colors**, and all other colors can, in theory, be obtained by mixing the primary colors in varying proportions. Mixing two primary colors in equal proportions produces what is known as a **secondary color**.



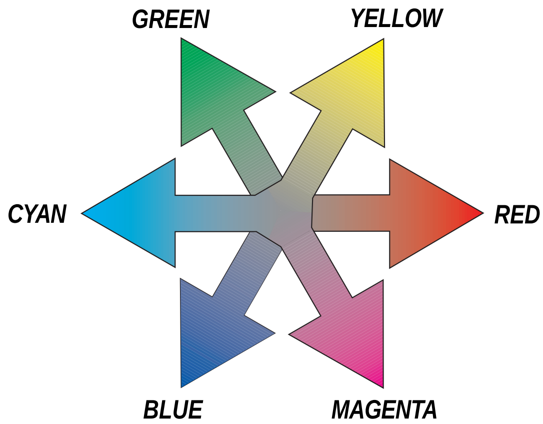
PROCESS



DISPLAY

Additive and subtractive primaries

Primary colors can be split into two categories which are termed **additive** and **subtractive**. It is important to note the difference between mixing additive primaries and subtractive primaries. For example, mixing red and green inks will produce a muddy brown, while red and green light mixes to give yellow. How do the two models differ?

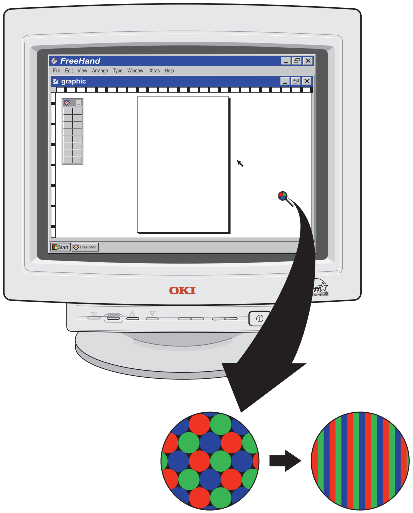


Additive primaries

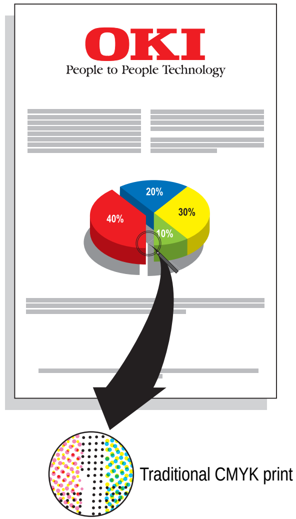
Video technology (such as computer monitors and television screens) uses the additive model. The additive primaries are Red, Green and Blue (RGB). Starting from black (lack of color) and adding red, green and blue (in equal quantities) will generate shades of grey, with white being generated with full, balanced intensities of all three. Mixing the three colors in different quantities will generate intermediate colors.

Subtractive primaries

Cyan, Magenta and Yellow (CMY) are known as the subtractive primaries and are commonly used in printing processes. In this case, we start with a white background (usually paper) and add translucent inks of cyan, magenta and yellow to subtract certain wavelengths of light. For example, cyan ink on a page appears to be this color because the ink removes components of red light and reflects green and blue, which we perceive as cyan.



standard dot display Trinitron™ display



In theory, a combination of the three subtractive primaries will produce black. In practice however, pigments used in inks are not perfect and usually give rise to a dark green/brown. For this reason, in many color output devices, a separate black ink is used to produce greys and black (in shadows and black text for example). This is the CMYK (**C**yan, **M**agenta, **Y**ellow, and Blac**K**) model and is the method most widely used in the color printing and printer industry. The printer uses separate cartridges of cyan, magenta, yellow and black toner to generate high definition color images for the workgroup or networked environment.

Neutral Colors

Although the term color is applied, neutral colors do not have properties of hue or saturation. They are described in terms of lightness only. The neutral colors are black and white and all shades of grey in between. A balanced mix of cyan, magenta and yellow yields a neutral color or black (in theory). The same effect can be achieved with the additive primaries by having an equal mix of red, green and blue light.

Color Complements

Complements are pairs of colors that combine to produce a neutral color. Balanced quantities of all three primaries produce a neutral. Mixing two primaries produces a secondary color. Mixing this secondary color with the remaining primary color produces a neutral color. For example:

CYAN + MAGENTA + YELLOW = NEUTRAL

— **red (magenta + yellow) + cyan = NEUTRAL**

— **green (yellow + cyan) + magenta = NEUTRAL**

— **blue (cyan + magenta) + yellow = NEUTRAL**

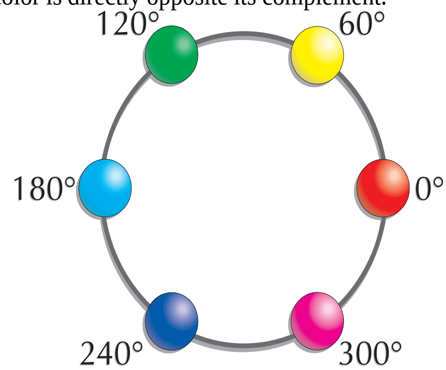
This relationship can be applied to all colors and is shown in more detail in the following section.

Color wheel

The relationship between colors can be best shown on what is known as a color wheel. The hue value of a particular color is expressed in degrees. Red for example is at 0° and green and blue are located at 120° and 240° respectively. The subtractive primaries, yellow, cyan and magenta are located at mid points between these.

The color wheel shows the following relationships:

- the additive primaries are displaced by 120° from each other.
- the subtractive primaries are displaced by 120° from each other.
- each color is a secondary color of the two colors either side of it. e.g. mixing equal quantities of yellow and magenta will produce red.
- a color is directly opposite its complement.



We can continue to mix neighboring colors on the color wheel to produce further, intermediate colors. The number of colors on the color wheel now doubles to twelve (as shown below). Repeating the procedure a number of times produces a color wheel with subtle changes of hue from neighbor to neighbor.

Color Wheel
showing RGB (circles), CMY (squares) and their first set of intermediate colors.

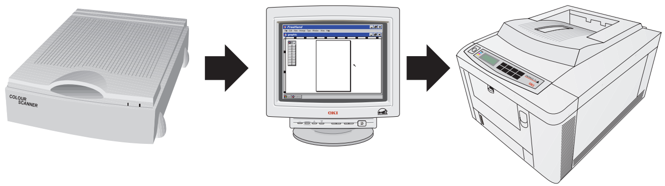
The problems with using color

As already explained, a computer monitor (where an image is first viewed) and a printer (which produces the final document) use different methods to generate colors. They are based around a different set of primaries (RGB for monitors, CMYK for printers). Monitors do not generate a full range of perfect colors and neither do printers. There is a limit on how many colors a monitor or printer can generate. This is known as a device's **color gamut**. Some colors can be reproduced by both devices, while others can be displayed on a monitor, but cannot be printed, or vice versa. This in practice may lead to a color print not resembling the original on-screen image. So what has happened?

Images (graphics and text) can be captured through scans or digital photography, or input directly into the PC via applications programs. However the original image is obtained, it will be displayed and manipulated in RGB color space (on-screen) and finally converted to CMYK for print. Each of these processes requires data conversion/manipulation. An image seen on a computer monitor relies on the monitor's ability to reproduce the image and represent colors within it. Adjustments such as brightness, color and contrast also tailor the image to the preference of the viewer rather than a display of true color. The data sent to the printer may not be adjusted to allow for imperfections in the inks used.

Color management systems

Color Management Systems (CMS), such as those found in the printer driver, allow for any mismatches that may occur between the RGB and CMYK conversion process. Color matching systems go a long way to ensuring a better match between the input data and printed result, but cannot always allow for monitor adjustment or a variation in paper stock. Paper can sometimes appear blue or cream in hue, which will have an effect on the light reflected from the page and therefore change the appearance of some colors. The texture of the paper used will affect the way that light is scattered, and may also result in patches of light or dense color. Therefore, it is best to find and adopt a paper that provides you with the best results. This, of course, may be a process of trial and error, but some recommendations are given in the on-line User's Guide.



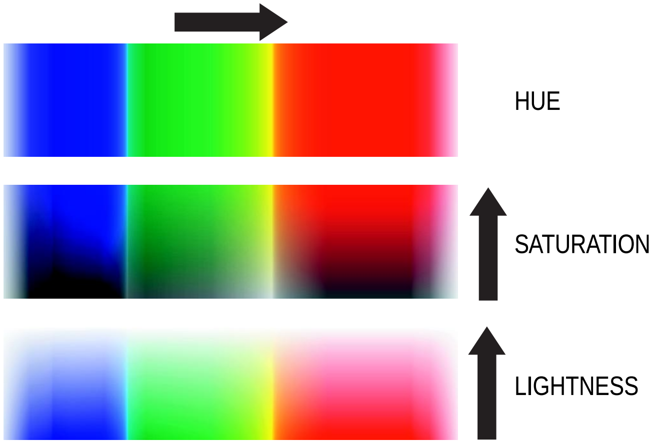
Although color has its obvious benefits, it has also created a whole new set of problems.

- It is important not to go overboard and add dashes of color without thought, as this will undoubtedly have a negative effect on the whole purpose of using color.
- Using colors which are considered garish will also affect the way in which your document or presentation is perceived.
- The proximity of colors is also an important factor and it is best to consider the result when certain colors are paired.

To minimize any problems, it is important to use color with pre-planning and a great deal of care. If specific colors are of paramount importance (such as those in a company logo) then it is best to print these colors beforehand and note the composition that gives the closest match to the required color. Then use the component amounts, regardless of what is displayed on the monitor.

Specifying color

There are many different ways to specify color and there are many different models to cater for this. The color wheel, as already shown, is a two-dimensional view of the HSL model which is based on Hue, Saturation and Lightness as components for specifying color. The third dimension is lightness, which describes the tendency towards black or white.



Commonly used models are:

- HSL
- CMY(K)
- CIE, CIELab, CIELuv
- HSB
- RGB
- YCC

Each of the models have their benefits and disadvantages and are useful in particular situations. Most applications will have support for the RGB model, which (along with CMYK) is perhaps the simplest to use. This model is used to specify colors by varying the proportions and levels of the red, green and blue components.

The amount of red, green and blue present in a color is usually expressed as a number from 0 to 255. Less commonly, it may also be expressed as number between 0 and 65535 or as a percentage. Converting between the systems is straight forward. An example is given below.

Example: To achieve a color that is described as 100% red, 50% Green and 40% blue…

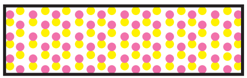
255 Color scale:	100/100	×	255	=	255 red
	50/100	×	255	=	128 green
	40/100	×	255	=	102 blue
65535 Color scale:	100/100	×	65535	=	65535 red
	50/100	×	65535	=	32768 green
	40/100	×	65535	=	26214 blue

The printout from this set of numbers should produce a color close to the original. However, due to the variation in printer inks, it may be necessary to make minor adjustments until the right combination is found. Once a color match is obtained, the RGB components should be entered, regardless of the colors displayed on-screen. To maintain color consistency, use OKI original consumables specifically manufactured for the printer.

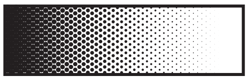
Printing color

No matter how colors are specified, the printer is only able to use a combination of three colors, plus black, to generate an image on paper. To achieve this, the printer uses processes known as halftoning and dithering. Each addressable picture element (pixel) on a monitor screen or printed output contributes to what we see in the final image. The pixels are placed in close proximity so the eye is unable to resolve individual dots. Colors of adjacent pixels appear to merge and produce a new color. Using dot patterns of a given set of colors to generate new colors is known as dithering. Shades of grey can be generated by using a similar technique of black dot placement. This technique is known as halftoning and gives rise to what we perceive as a continuous tone image. Examples of dither and halftone are shown below:

dither pattern



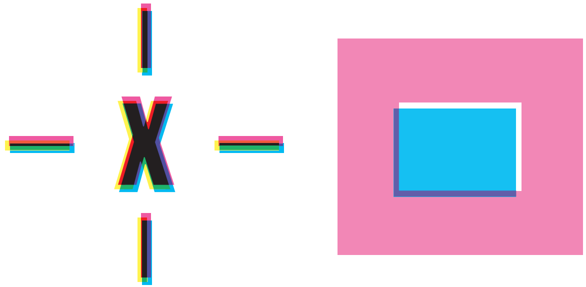
halftone pattern



The entire printing area is split into sections known as cells (much like a grid). The patterns within the cell are then altered to obtain the required amount of grayscale. An area of an image containing 50% grey will contain cells that have half of the dots within the cell printed with black and the other half left empty.

Color registration

The CMYK printing process, as already stated, uses overlapping inks of cyan, magenta and yellow. To produce the best possible output, the colors must print in specific positions so that overlaps and dithering are accurate. If the colors are not aligned, the resulting print will have color shifts (colors produced where incorrect colors overlap to produce an undesired color) or appear blurred. Using black to print grey and text eliminates the problem in these instances, but not when color is constructed from two or more of the process primaries. The print below shows how registration problems can cause undesired effects.



If your printer displays problems (as described above), refer to “Setting the Color Registration” in your on-line User’s Guide.

Color adjustments

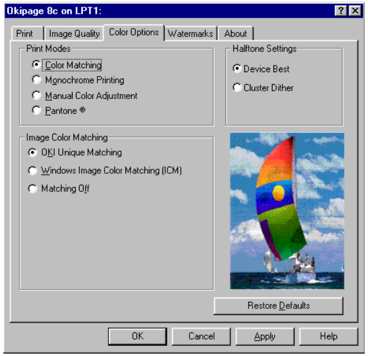
Certain images (such as bitmaps) sometimes print with a strong hint of a particular color. Images that appear fine when viewed on a monitor may not necessarily print that way due to the reasons previously described. The color that appears to dominate the picture will vary depending on factors such as the scanner (or other input device) having a bias towards a particular color, or the monitor's ability to represent certain colors on-screen. To compensate for this, the printer has a color adjustment system that can reduce the amount of any of the process colors put on the page in relation to the others. If you run Windows on your computer, the printer drivers supplied with your printer provide these adjustments. These are outlined in this manual and explained in more detail in the driver's on-line help. (Click the Help button in any driver dialogue box.). For other operating systems or drivers, the printer's Operator Panel menus provide similar adjustments, detailed in the User's Guide.

This is useful if, for example, you find that all of your graphics have a tendency to contain too much blue. To compensate for this, you could reduce the amount of cyan or magenta as it is these two colors that combine to produce blue. Bear in mind that other colors containing cyan or magenta will also be affected. An alternative would be to increase the amount of yellow. This has the advantage of increasing color saturation while balancing the image.

Another method of decreasing strong colors is to increase the lightness setting in the printer driver. To compensate for this, the saturation setting must be stepped down accordingly. As a rule, the saturation should be set down an equal number of steps to the level that the lightness has been stepped up.

The printer driver

There are various features designed to allow you to achieve the best results with your printer. The Color Options tab (within the printer driver) provides a list of color matching techniques and adjustments which can be applied to your graphics and text to provide the optimum balance of color in your document. The options and adjustments that can be made are described below. Clicking on the properties button after a print request has been made and then selecting the color options tab will display the following:



The color matching option is set by default, as is the "Device Best" halftone setting and "OKI Unique Matching". These settings will produce the best results from your printer (in most situations). It is sometimes necessary to use other settings to allow a certain effect to be achieved.

Print Modes

Color Matching

This option, when selected, allows the printer driver to adjust output data to specify how colors in the document will match those printed.

This is the default setting.

Monochrome Printing

All print data is sent as monochrome (black and white) with colors being output as greyscale. Only the black toner cartridge is used in this instance.

Manual Color Adjustment

This leaves details such as settings for halftone, color, lightness and saturation to the user. This allows maximum flexibility but requires thought and pre-planning before use.

Pantone Color Adjustment

Optimizes the printer for use with Pantone calibrated palette files imported into your application. For information on how to import and use Pantone Palette Files, click the How to Pantone icon in your OKIPAGE 8c folder.

Halftone Settings

Device Best

This selects optimum dithering for most print jobs.

Cluster Dither

The driver selects fixed size halftone cells which are useful when printing charts, graphs or other business graphics.

Image Color Matching

OKI Unique Matching

This color matching technique uses OKI color matching technology to match colors in the document to those printed. This matching technique is optimized for the printer and replaces the one normally performed by Windows.

Windows Image Color Matching (ICM)

This allows Windows to handle the color matching operation, but may not provide satisfactory results as it is not specific to your printer. A further drop down list allows you to select the color rendering intent.

Matching Off

No color matching is performed. This means that printed colors will not necessarily match those specified within the document.

Color Settings

Vivid Color

Colors are printed as brightly and vividly as possible, i.e. colors are more saturated and vibrant.

Screen Match

Colors are printed so that they resemble those on-screen. This may not work in practice because brightness, chroma and contrast settings on each individual monitor cannot be allowed for.

Unadjusted Color

No color matching is performed and data is sent directly to the printer. Printed colors may not match those specified within the document.

Monochrome

All color data is converted to greyscale and sent to the printer as black and white with halftone.

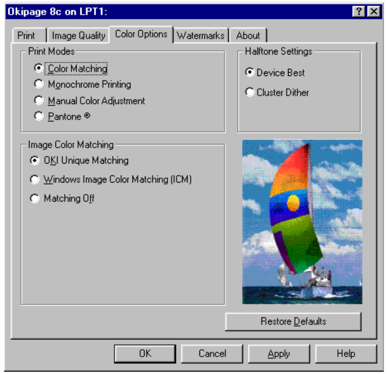
Manual Adjustment

Lightness

This allows the image brightness to be adjusted so that colors within it tend to appear closer to black (negative adjustment or darker) or white (positive adjustment or lighter).

Saturation

This adjusts all colors within the image so that they appear dull (negative adjustment) or vivid (positive adjustment).



Glossary

Brightness

Along with hue and saturation, brightness is one of the three dimensions of color. It is the property that describes the intensity of light reflected or transmitted by an object or source, independent of hue or saturation.

Cluster-dot screening

This is a halftoning method that uses multiple pixels that vary from small to larger dots as the color gets darker. It is characterized by a polka-dot look.

Color gamut

The range of colors that a device can produce is known as its color gamut. Devices are unable to produce all colors that occur in nature so their color gamut is a subset of this.

Color Management System (CMS)

A system used to communicate color fidelity across devices such as input, display and output to ensure that the best color rendition possible is given at all times.

Color mapping

This is the translation of color representation from one device (or system) to another.

Color models

A color model is a system that allows colors to be arranged or identified. There are various models in existence, with some more suitable to specific applications than others.

RGB

Computer monitors, for example, use red, green and blue phosphors to display images and colors are specified using the RGB model.

CMY(K)

Cyan, magenta, yellow and black are the inks used in the four color print process. There is a model used to describe this. Due to the imperfections in printing inks, black ink is used, rather than mixing the other three inks to product black. Black is identified as ‘K’ to avoid confusion with other colors such as blue.

HSL

Colors are defined by hue, saturation and lightness.

HSB

Colors are defined by hue, saturation and brightness. The dimensions are similar to the HSL model, but the HSB model is related to the RGB system.

YCC

This system was developed by Kodak for encoding color images for display on video monitors. RGB values are converted to a luminance component (Y) and chromatic components (C1) and (C2).

CIE

In 1931, the Commission Internationale de l'Eclairage (CIE) devised a color system based on the human visual system and is an accepted standard. This system is not linear and difficult to interpret. There have been modifications to the system that have given rise to CIELab and CIELuv.

Color separations

Each of the process colors are printed separately. Therefore, they must be specified individually, as the color is needed. Image data is therefore split into the primary colors (plus spot colors) before printing.

Color space

This is a method of describing color. Some systems are device-dependent such as RGB and CMYK. The CIE system is a device independent color space. Note that all color models are not color spaces in their own right.

Colorants

These are the colors used by a device to reproduce color. A printing press uses the CMYK colorants.

Density

In this context, density is the ability of the object to absorb light, not the relation to the mass and volume of the object. The more light absorbed, the higher the object density.

Dithering

A technique where pixels of different colors are placed in close proximity to give the illusion of another color as perceived by human vision.

Dot gain

During the printing process, inks may spread, causing dots on a page to print larger than intended. This results in darker tones and colors. The problem can be compensated for by careful adjustment.

Error diffusion

This is usually associated with halftoning but can also be used with dither. The error between a pixel and its intended value is propagated to adjacent pixels to produce a balanced overall effect. Results may sometimes appear grainy.

Grayscale

Differing shades of grey ranging from black to white. Eight bits of data will produce 256 (2^8) shades of grey.

Halftoning

A printed image is composed of dots (or pixels). The spacing of these pixels can give the illusion of shades or tone. Increasing the spacing of dots lightens the shade so that it tends towards white (color of the page).

Highlight

This is the lightest part of an image. In the extreme, this would be white.

Hue

Hue identifies the color and is the property that differentiates blue from red, red from yellow, etc.

Indexed color

Color pixels are represented by 8-bits. This gives the possibility of 256 (2^8) colors which are contained in a lookup table.

Lightness

This describes the intensity of a color and determines whether a color is closer to black or white.

Moiré pattern

This is an undesirable pattern that occurs due to pixel (or) dot placement. The eye is able to pick up repetitive patterns that exist within an image. These can be eliminated during print by careful selection of screen angles.

Pixel

This is the smallest addressable dot or PICture ELement. This has been abbreviated as PIXEL rather than PICEL.

Primary color

All colors can be produced by mixing a limited set of colors. There are two different sets of primary colors associated with the video and printing industries: additive and subtractive primaries

Additive primaries

Red, Green and Blue (RGB) are the additive primaries and the basis for forming other colors in displays such as computer monitors or television.

Subtractive primaries

Cyan, Magenta and Yellow (CMY) are the subtractive primaries and are the basis for inks used in color printing. Color is produced because inks are designed to absorb certain wavelengths of light and transmit others.

Registration

This describes the alignment of the various colors when printing. As each of the process primaries are specified by their own plate and printed individually, it is important that the ink is placed in precise locations or colors will not align to produce the desired result.

Saturation

This property indicates whether the color will be perceived as dull or vivid. For example, a vibrant red is more saturated than brick red.

Secondary color

Mixing two primary colors in equal amounts will produce a secondary color.

Spot color

These are additional colors used in printing that are not a part of the process ink set and specified individually. These colors are required when the end result is of paramount importance (such as within a corporate logo) Spot color can substantially increase printing costs. A separate plate is also required.

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