Blending Modes of Photoshop & Co.

Blending modes permit to knit together the tonal values of two layers or colors, and they allow numerous effects. Behind these operations are often simple mathematical formulas. Below you'll find a complete list of all blending modes of Photoshop CS2 and Paint Shop Pro X. Furthermore, I included **Opacity** (in theory a blending mode, too) and the supplementary functions from the Apply Image and Calculations dialogs in Paint Shop Pro and Photoshop. The latter are also blending modes (in some cases identical to some from the layer's palette), acting merely on two images instead of layers (or channels).

All formulas apply for RGB images. In Lab color space Photoshop applies in some cases slightly different formulas.

Opacity

$$C = d*A + (1-d)*B$$ ⇳

Instead of **Opacity** some programs use the term **Transparence**. The terms behave like positive and negative: 100% opacity corresponds to 0% transparence. This blending mode is a relatively simple one, known from everyday life (so to speak). If the layers are swapped, the result will differ, of course, unless opacity is at 50%: In this case you will get the **average** of two pixels' tonal values, i.e. their sum, divided by two. In Paint Shop Pro's Calculations dialog there actually is such an average mode. In the Layer Style / Blending Options dialogs in Photoshop, Photo-Paint and Paint Shop Pro much more subtle opacity settings can be achieved. There, the blending of fore- and background can be set dependent of the tonal values.

In the formula **A** represents the pixel's tonal value that lies in the upper layer (or the foreground), **d** stands for this layer's opacity. **B** stands for the pixel's tonal value that lies in the lower layer (or the background) and **C** is the tonal value of the blended pixel. This formula also applies for a mask's influence on a masked layer, in this case **d** represents the mask's brightness at a given position.

Darken

$$B \le A: \quad C = B$$
$$B > A: \quad C = A$$ ⇕

This mode compares fore- and background pixel-wise (and possibly color-channel-wise) and takes the respective darker pixel into the output image. Photoshop, Paint Shop Pro, PhotoLine and GIMP all compare the different color channels separately, quasi without looking left nor right. The respective smaller tonal value is kept for the result. Therefore, «mixed pixels» are quite common, i.e. pixels that for example have in the red channel the background's tonal value assigned, but in the green and blue channels the tonal values of the foreground. In contrast, Photo-Paint compares all three color values at the same time and takes the pixel that has the lowest value in at least one color channel, entirely - all of its three color channels are transfered to the resulting image. In a "tie" the foreground is favored. There is a third method to handle this mode: Picture Publisher and also PhotoImpact draw not on the three separate RGB values, but on their collective luminance value. As in Photo-Paint, depending on the result the programs take either the foreground or the background pixel. But the decision is now a little bit more balanced because pixels that are especially dark in one color channel cannot longer assert themselves as easily.

Lighten

$$B \le A: \quad C = A$$
$$B > A: \quad C = B$$ ⇕

The opposite of the previous mode: the respective lighter tonal values are taken. Painter knows two brightening modes: In addition to **Lighten** which works according to the Photoshop method there is **Luminance dependent** which gives the same results as Picture Publisher and PhotoImpact.

Multiply

$$C = A*B$$ ⇕

Multiplies the standardized (based on the domain 0...1) tonal values of the fore- and background's pixels. The effect can be compared to two slides put on top of each other and projected together. The light, forced to pass through each of the slides, is weakened twice.

Screen

$$C = 1-(1-A)*(1-B)$$
$$\text{oder } (1-C) = (1-A)*(1-B)$$ ⇕

The opposite of the previous mode. Fore- and background are »negatively multiplied« and lighten each other (as if two slides are projected with different projectors onto the same screen). The correlation with the **Multiply** mode becomes clear if the formula is written as in the second row in the formula box to the right. I.e. if you blend the negatives of the two images with **Multiply**, you will get the negative of the result you would get with **Screen**.

Color Dodge

$$C = B/(1-A)$$ ⇳

In this mode the brightness of the foreground becomes like a mask that "protects the background from exposure". The brighter the foreground is, the more the background gets lightened. A foreground that is truly black does not affect the background at all. A totally white foreground asserts itself against all background values except pure black.

Color Burn

Photoshop's Layer Blending Modes:

Normal
Dissolve

Darken
Multiply
Color Burn
Linear Burn

Lighten
Screen
Color Dodge
Linear Dodge

Overlay
Soft Light
Hard Light
Vivid Light
Linear Light
Pin Light
Hard Mix

Difference
Exclusion

Hue
Saturation
Color
Luminosity

For more modes of CS5 please see the **german** version of this page.

Glossary

Figures in the formulas mean:

oder – Alternative notation (German for **or**)

⇕ – Symmetrical behavior (same result when layers are swapped)

⇳ – Asymmetrical behavior (different result when layers are swapped)

A – Foreground layer

B – Background layer

C – Composite layer

B1, **B2** – Image 1, Image 2 (in Calculations dialog)

H, **S**, **L** – Components of the HSL color system

Y – Luminance

S – A special variant of saturation that is used by Photoshop. It is calculated from the maximum and the minimum of a pixel's three RGB values, according to the following formula:

$S = \max(R,G,B) - \min(R,G,B)$

All tonal values have to be entered within standardized range 0.0 ... 1.0. E.g. the standardized value for tonal value 102 is 102/255 = 0.4.

Other Blending Modes:

Dissolve

This mode doesn't »blend« at all and therefore doesn't really fit in, just like the »Normal« mode. It makes pixels from the foreground layer transparent, randomly - the lower the foreground's opacity, the more pixels will be affected. A layer that is completely opaque will not be changed at all, a layer with little opacity will get very »holey«, so that the background shines through. To put it another

foreground image is.

Linear Dodge

(also: Add)

$$C = A + B$$

Adds the tonal values of fore- and background. This blending mode only exists since Photoshop 7. However, it is also available under the name **Add** in the Calculations dialog. There you have additional scaling and shifting options at your disposal. Without scaling (division of the result by a number between 1 and 2) many tonal values will be added to pure white (they get clipped). Paint Shop Pro offers the Add mode exclusively in the Calculations dialog.

Linear Burn

(also: Subtract)

$$C = A + B - 1$$

This variant of subtraction is also known as subtractive color blending. The tonal values of fore- and background that sum up to less than 255 (i.e. 1.0) become pure black. If the foreground image A is converted prior to the operation, the result is the mathematical subtraction (see below).

Overlay

$$B \le 0{,}5: \quad C = 2 * A * B$$
$$B > 0{,}5: \quad C = 1 - 2 * (1 - A) * (1 - B)$$

This mode is a combination of the modes **Multiply** and **Screen**, dependent on the background's tonal value. If the background is darker than 50% gray, the tonal values get multiplied, otherwise they get »screened« (and afterwards they are doubled in both cases). This becomes more explicit by rewriting the second formula into this one: 1 – C = 2(1 – A)(1 – B). The foreground - or the applied paint - decides in which direction and how strongly the background's mid-tones will be moved. A 50% gray foreground has no influence on the background. Painting with this gray value is like the brush has no color at all. Dark foreground colors shift the mid-tones to darker directions, light ones to light directions. Thereby the background's shadows get compressed, the highlights get spread - or the other way round. One can also say that the background, always shining through, is modulated by the foreground. If the layers are swapped this mode bears other results, at least in those areas where the tonal values of fore- and background lie in different regions (below and above 50%).

Hard Light

$$A \le 0{,}5: \quad C = 2 * A * B$$
$$A > 0{,}5: \quad C = 1 - 2 * (1 - A) * (1 - B)$$

This mode corresponds exactly to **Overlay** with the layers swapped. If the color application or the upper layer is lighter than 50% gray, the background gets lightened, otherwise darkened.

Soft Light

$$A \le 0{,}5: \quad C = (2 * A - 1) * (B - B^2) + B$$
$$A > 0{,}5: \quad C = (2 * A - 1) * (\sqrt{B} - B) + B$$

The foreground modulates the tonal values of the background in a way resembling a Gamma change between 2.0 and 0.5. This results in very soft compositions even in the highlight and shadow regions. In contrast, the partly quite similar blending mode **Overlay** translates the extreme highlights and shadows into very harsh contrasts.

Vivid Light

$$A \le 0{,}5: \quad C = 1 - (1 - B)/(2 * A)$$
$$A > 0{,}5: \quad C = B/(2 * (1 - A))$$

This blending mode, available since Photoshop 7, increases contrast very strongly, especially in highlights and shadows. You can imagine its effect as a combination of **Color Burn** (in the shadows) and **Color Dodge** (in the highlights). The two partial formulas for A < 0,5 and A > 0,5 are identical to the respective formulas of these blending modes (apart from the doublings in the denominators).

Linear Light

$$C = B + 2 * A - 1$$

This mode, also available since Photoshop 7, increases contrast slightly less than the previous one. It resembles **Linear Burn**, but with twice the impact on the foreground's tonal values.

Pin Light

$$B < 2 * A - 1: \quad C = 2 * A - 1$$
$$2 * A - 1 < B < 2 * A: \quad C = B$$
$$B > 2 * A: \quad C = 2 * A$$

In this mode (only available since Photoshop 7, too) the blended image is created according to one of three recipes: Alone from the background image (C = B), from the foreground image which brightness has been doubled (C = 2A), or from the latter, but decreased in brightness by 1, i.e. 256 tonal values (C = 2A - 1). Which recipe is chosen depends on the proportionality of both fore- and background's tonal values. Visually, the result is a combination of the **Darken** and **Lighten** modes. Mid-tone regions remain almost uninfluenced.

Hard Mix

$$A < 1 - B: \quad C = 0$$
$$A > 1 - B: \quad C = 1$$

This blending mode's (available since Photoshop CS) resulting image contains only the six primary colors, black and white. According to the fore- and background pixels' tonal values' proportionality the blended tonal values are set per channel to 0 or 1 (i.e. 255).

Behind

This mode is available in Photoshop and Paint Shop Pro as a brush option. You can paint with a brush like this on (also partly) transparent regions of a layer without painting over pixels that are already there. It doesn't work on background layers as these don't support transparency.

Older German articles about blending modes:

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(PDF-Files)

PP 12/99 S.48 (Deckkraft, Transparenz, Addieren, Hinzufügen, Abblenden)

PP 2/00 S.36 (Subtrahieren, Differenz, Multiplizieren, Füllmuster, Struktur, Filter)

PP 3/00 S.86 Negativ Multiplizieren, Ineinanderkopieren, Schicht, Hartes Licht

PP 5/00 S.90 Weiches Licht, Beleuchtung, Farbig Abwedeln

PP 7/00 S.114 Farbig Nachbelichten, Ausschluss, Division, Abdunkeln

PP 9/00 S.86 Aufhellen, logische Operationen AND, OR, XOR

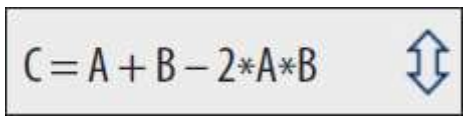
PP 10/00 S.132 Farbton, Sättigung, Farbton & Sättigung (bzw. Farbe und Kolorieren), Luminanz (Helligkeit)

PP 11/00 S.120 Pseudofarbe Farbmodi Rot bis Schwarz Sprenkeln, Dahinter auftragen

PP 1/01 S.74 Bild- und Kanalberechnungen

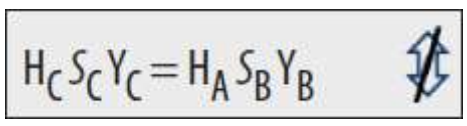
values (as always per color channel). This mode is particularly suited to compare two image versions to each other. If they are identical the difference is zero, otherwise the result shows the variance of the tonal values in each pixel. A white foreground inverts the background whereas a white background inverts the foreground.

Exclusion



Bright image regions cause inversion to the respective other layer, very dark regions change nothing at all. In this way this mode resembles the previous one. In contrast to the previous one, however, medium gray values greatly decrease contrast of the respective other image, in extreme cases up to zero. This mode is symmetric, too, i.e. it works independently from which image is the upper one.

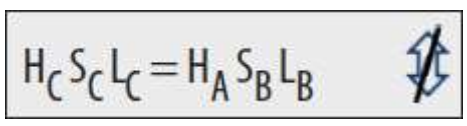
Hue / Hue (Legacy)



Blends the output image from hue H of the foreground and Photoshop saturation *S* and luminance Y from the background. Grays from the foreground remain gray in the resulting image.

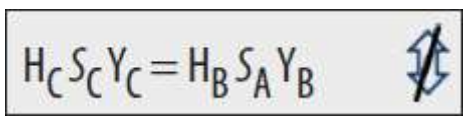
All four blending modes marked "Legacy" in Paint Shop Pro correspond to the equally named modes in Photoshop.

Hue *(only Paint Shop Pro)*



Blends the composite image from hue H of the foreground as well as saturation S and brightness L from the background. H, S and L are parts of the HSL color system. Grays from the foreground image will be treated like reds.

Saturation / Saturation (Legacy)

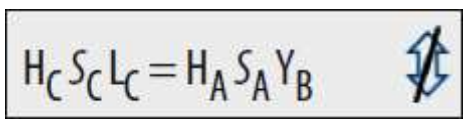


Blends Photoshop saturation *S* of the foreground with hue H and luminance Y of the background. Grays from the foreground de-saturate the background.

Saturation *(only Paint Shop Pro)*

Blends saturation S from the foreground with hue H and brightness L from the background. Grays from the foreground render saturated background colors gray by 50%. Grays in the background equally de-saturate the foreground.

Color / Color (Legacy)

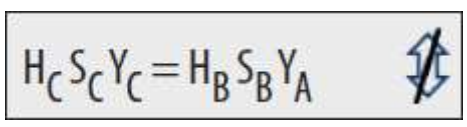


Blends the composite image from hue H and Photoshop saturation *S* of the foreground and luminance Y of the background.

Color *(only Paint Shop Pro)*

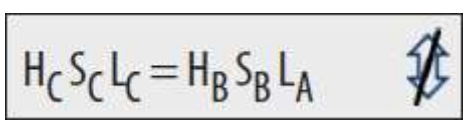
Blends hue H and saturation S from the foreground with brightness L from the background.

Luminosity / Luminance (Legacy)



Blends luminance Y from the foreground with hue H and Photoshop saturation *S* from the background.

Luminance *(only Paint Shop Pro)*



Blends brightness L from the foreground with hue H and saturation S from the background.

The **Luminance** mode corresponds to the **Color** mode with layers swapped.

Add

Addition of tonal values in the Apply Image and Calculations dialogs. When scaled or with a division factor of 2 the result is equal to the **Average** mode (in Paint Shop Pro's Arithmetic dialog) or the **Normal** mode with opacity set to 50%.

Subtract

Common mathematical subtraction. In Photoshop and Paint Shop Pro this mode is only available in the Applay Image and the Calculations dialogs (as a blending mode only in GIMP and PhotoImpact). Photoshop, in the Apply Image dialog, subtracts the **Source** from the **Target**. In the Calculations dialog it subtracts **Source 1** from **Source 2**.

If **B2** (or **Source** or **Source 1)** is inverted prior to the application (in Photoshop this is possible directly from within the Calculations dialog), the result will be equal to a **Linear Burn**.

AND, OR, XOR

The logical operations AND (AND function or logical multiplication), OR (OR function) and XOR (eXclusive OR) combine the color values bitwise. Modes providing these operations can be found in Paint Shop Pro's Calculations dialog. The result depends only on wether a bit in a certain position of the dual 8 bit representation of the pixel's tonal value is one or zero. Therefore, a

