# Pan Rules

When we want to place a signal in the stereo panorama, we usually do this by adjusting the relative amplitudes for the left and right channel - that is: if we want to move the apparent signal source to the left, we increase the volume of the left channels signal and at the same time attenuate the signal for the right channel. This might seem self evident and not even worth to mention, however, there are other means of achieving a similar localization effect - namely, by delaying one channel with respect to the other (which makes use of a psychoacoustic phenomenon known as precedence effect). We will concentrate here on the former approach. Let's represent our pan-position with the variable $p$, a leftmost pan-setting by the setting $p = -1$, a center setting by $p = 0$ and a rightmost setting by $p = +1$. The most simple rule for calculating a gain factor for both channels would simply be a **linear pan-rule**: as $p$ goes from $-1$ to $+1$, fade in the right channel linearly from 0 to 1 and fade out the left channel linearly from 1 to 0. To wrap that into a neat formula, we introduce the variable $p' = (p+1)/2$ which goes through 0...1 as $p$ goes through $-1$...1. Then, our gain factors for left and right channel (which we will denote as $g_L, g_R$) are calculated as:

$$g_L = 1 - p' \qquad \text{and} \qquad g_R = p' \qquad \text{with} \qquad p' = \frac{p+1}{2} \tag{1}$$

we note that the sum of $g_L$ and $g_R$ is always unity in this setting: $g_L + g_R = 1$ and a center setting would lead to: $g_L = g_R = 0.5$. If we want to have unity gain for both signals in center position, we could multiply the whole signal with 2 before or after the panning. As is turns out, this panning rule often makes stereo-signals panned to the center weaker than when panned to the extremes. We would rather have a rule which ensures a constant apparent loudness for all settings. The solution is to not require $g_L$ and $g_R$ to sum up to unity but instead require that the sum of the squares sums up to unity: $g_L^2 + g_R^2 = 1$. Because a signals power is proportional to the signal squared, this is called a **constant power pan-rule**. To satisfy this requirement we have to choose the fade-in to resemble the first quarter period of a sine function and the fade out to resemble the first quarter period of a cosine function. This is achieved by the rule:

$$g_L = \cos(p') \qquad \text{and} \qquad g_R = \sin(p') \qquad \text{with} \qquad p' = \frac{\pi(p+1)}{4} \tag{2}$$

Note that in these equations, the argument for the sine and cosine function must be expressed in radiant and not in degrees - to make them work with degrees, we would have to replace $\pi$ with 180° in the calculation of $p'$. Figure 1 shows the gain factors for left and right channel for the linear and the constant power pan rule. The same rules may occur in various other settings such as in crossfading between two

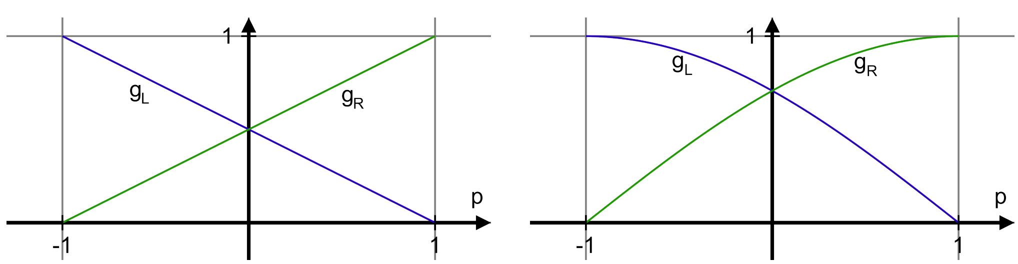


Figure 1: Linear and constant power pan rules

signals or for dry/wet controls on effects.