ECS614U/ECS749P: Sound Recording and Production

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Mixing: Gain/Pan/EQ

Gain Effects

- Gain based audio effects change the level of the signal.
- Gain based effects include:
  - Fader gain - change amplitude of a track.
  - Panning - applying different gains to different output channels.
  - Equalization - change the gain of parts of the frequency spectrum.

Fader Gain

Fader Gain

- Gain is used to set the relative amplitude of each instrument in the mix.
- It is the simplest control but is the most important.
- It is important to learn how to judge the relative levels in a mix (examples within lecture resources).
- The units of gain is decibels.
- *Crazy Scientist Video*.

Decibels

Decibels

- Decibels express the ratio between two quantities.
- The unit of decibels is dB.
- Decibels use the logarithmic function, and are defined with respect to power, P:

$$\mathbf{dB} = 10 \log_{10} \left(\frac{P_1}{P_2} \right) \tag{1}$$

Why Decibels?

Easy to manage a huge range of values:

dB	100	80	60	40	20	0
P Ratio	10^{10}	10^{8}	10^{6}	10^{4}	10^{2}	1

dB	0	-20	-40	-60	-80	-100
P Ratio	1	10^{-2}	10^{-4}	10^{-6}	10^{-8}	10^{-10}

Why Decibels?

It makes the maths easier:

- It is easier to add decibel values that to multiple by their equivalent ratios.
- This is particularly true for large changes, e.g. 100 dB!

Decibel Values

What is the dB change if we double or halve the power?

- Double:

$$\textbf{dB} = 10 \log_{10}\left(\frac{2}{1}\right) = +3.0 \ \ \mathrm{dB} \tag{2}$$

- Halve:

$$\textbf{dB} = 10 \log_{10}\left(\frac{1}{2}\right) = -3.0 \ \ \mathrm{dB} \tag{3}$$

Decibel Values

- What if we multiply the power by 8?

$$8 = 2 \times 2 \times 2 \rightarrow \textbf{dB} = 3 + 3 + 3 = 9 \text{ dB} \tag{4}$$

- What if we divide the power by 8?

$$\frac{1}{8} = \frac{1}{2} \times \frac{1}{2} \times \frac{1}{2} \rightarrow \textbf{dB} = -3 - 3 - 3 = -9 \text{ dB} \tag{5}$$

Decibels in Pressure

- The power is proportional to the square of the pressure.

$$\mathbf{dB} = 10\log_{10}\left(\frac{p_2}{p_1}\right)^2. \tag{6}$$

- Using a property of the log function, this gives,

$$\mathbf{dB} = 20\log_{10}\left(\frac{p_2}{p_1}\right). \tag{7}$$

Decibels in Voltage

- The power is also proportional to the square of the voltage.

$$\mathbf{dB} = 10\log_{10}\left(\frac{V_2}{V_1}\right)^2. \tag{8}$$

- Using a property of the log function, this gives,

$$\mathbf{dB} = 20\log_{10}\left(\frac{V_2}{V_1}\right). \tag{9}$$

Decibels in Pressure (or Voltage)

Double pressure:	$\rightarrow$	+6 dB.
Halve pressure:	$\rightarrow$	-6 dB.
Mpy pressure by 8:	$\rightarrow$	+18 dB.
Divide pressure by 8:	$\rightarrow$	-18 dB.

Sound Pressure Level

- The sound pressure level (SPL) is proportional to the square of the power.

$$\mathbf{dB_p} = \mathbf{10log_{10}} \left(\frac{\mathbf{p}}{\mathbf{p_{ref}}} \right)^{\mathbf{2}}. \tag{10}$$

- Using a property of the log function, this gives,

$$\mathbf{dB_p} = \mathbf{20log_{10}} \left(\frac{\mathbf{p}}{\mathbf{p_{ref}}} \right). \tag{11}$$

- The reference SPL for human hearing is 20 μPa (rms).

Decibels in a Digital System

- In our digital system (e.g. Logic) the amplitude of a signal in decibels is expressed relative to the maximum allowable value, known as **Full-Scale**.
- The digital signal is equivalent to a voltage signal, so amplitude is given by,

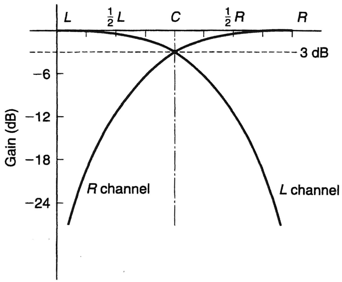
$$\mathbf{dB_{FS}} = \mathbf{20}\log_{\mathbf{10}}\left(\frac{\mathbf{V}}{\mathbf{V_{FS}}}\right). \tag{12}$$

- We don't want any signals to go above the full-scale value, so $\mathbf{dB_{FS}}$ should always be negative.

Panning

Panning

- Panning controls apply an un-even gain in the left and right channels.
- Panning is used to:
  - Add interest to a mix.
  - Give an impression of the source location within the stereo field.
  - Reduce masking between two signals.
- The attribution of gain depends on the panning law that is used. This is defined by the gain on L and R channels when the signal is centered.



Panning

- You can only pan a channel within the actual width of the loudspeakers.
- Panning is used to trick the brain as to the direction of the source.
- Why does panning sound different on headphones?

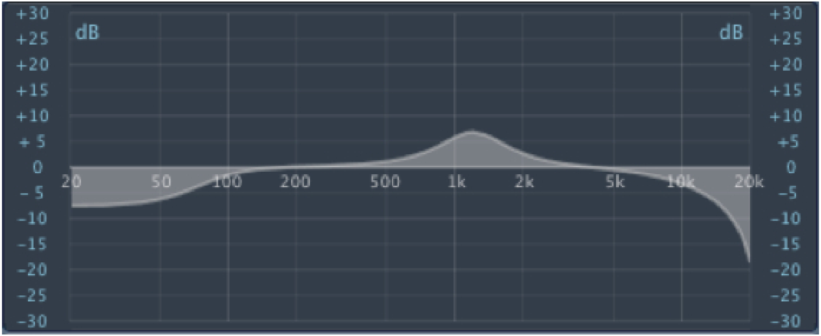
Equalization

Equalization

- An equalizer is a filter that changes the gain in a certain part of the frequency spectrum.
- There are three main reasons for using an equalizer:
    - To change the frequency spectrum of a sound, e.g. to emphasis or attenuate certain parts of the sound.
    - To separate the spectrum of two sources which are masking one another.
    - To remove unwanted artefacts from the signal.

Equalization

- The affect of the equalizer must be examined as a function of gain and frequency.



Equalizer controls

- A typical equalizer contains a number of separate filter bands. Each band will be of a certain type.
  - **Peak** - increase the gain around a certain frequency.
  - **Notch** - decrease the gain around a certain frequency.
  - **High shelf** - increase or decrease the gain at high frequencies.
  - **Low shelf** - increase or decrease the gain at low frequencies.
  - **High pass** - cut the gain below a certain frequency.
  - **Low pass** - cut the gain above a certain frequency.

Equalizer controls

- Each filter type has three parameters.
  - **Frequency** - the frequency about which the filter is centred.
  - **Gain** - the amount of gain applied (not HP or LP).
    - Boost for positive gain.
    - Cut for negative gain.
  - **Q-factor** - the rate at which the change in gain is applied.
    - High Q-factor for sharp change.
    - Low Q-factor for smooth change.

The affect of EQ on phase

- Whenever we make changes to the frequency spectrum of a signal we not only change the magnitude (what you are seeing on the EQ interface) but we also change the phase.
- Care must be taken to avoid unexpected phase summation or cancellation when using EQ.
- Phase changes are more severe for large, sharp magnitude changes (i.e. high gain and Q-factor).