BRIKWORM™

Bits and bels and Dynamic Range

In the analogue world, the change from one thing to another has an infinite number of gradations. As a pendulum swings from one fixed point to another, it passes through an infinite number of analogue positions inbetween. The same thing applies to audio signals: there are an infinite number of volumes, notes, and so on.

These infinite possibilities aren't actually needed, as it is not possible for the human ear to tell the difference between them. In the digital world the infinite possibilities are converted into 'nearest' integer (whole number) values and so something is lost, just a very small amount.

Bits

Audio signals are converted into binary numbers which are expressed in 'bits'. The number of 'bits' used has an effect on the audio quality. This is similar to how photography is affected by the number of pixels: a low number of pixels creates a jagged image whereas a large number of pixels creates a smoother, more lifelike image.

Each 'bit' has two states, one or zero. Each time a number is expressed using an extra 'bit' the number of possible combinations of ones and zeros is doubled. For example, a two 'bit' number has four possible combinations (0-0; 0-1; 1-0; 1-1); a three 'bit' number has eight possible combinations.

Compact Disc (CD) uses 16 'bits' which results in 65,536 possible combinations – high resolution. It is interesting to note that this represents a higher number of possible combinations than there were molecules in the grooves of vinyl records!

Bels

The decibel is used to express the change in magnitude of a signal and is written in shorthand 'db' after a number. This system was devised long before digitisation and is a global standard. In audio terms, db relates to volume (the change in magnitude of audio signal).

A few useful examples are: a change in magnitude of 6db represents a doubling of an audio signal; a 12db change is four times; 18 db is eight times; 20db is 10 times; 40db is 100 times; 60db is 1,000 times.

This is interesting, because you will have noticed that the 6db change has the same effect on magnitude as a change by a factor of one 'bit' has on audio resolution: a doubling. Thus it can be said that each 'bit' gives rise to 6db of change.

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Dynamic Range
A CD has 16 'bits' of resolution.
Each 'bit' gives 6db of possible change
Therefore, 16 bits x 6db gives 96db of possible change.
This is often referred to as the 'dynamic range'. eg 'dynamic range of 96db'.

BrikWorm™ uses 24-bit converters, which have a resolution of 16,777,216 possible combinations and the potential for 144db (24 x 6db) of dynamic range, but don't get too excited, the human ear has 140db of dynamic range; from zero to the threshold of pain and no manufacturer has yet managed to make a converter which has even that much dynamic range. The reality is that the BrikWorm™ converters give about 18 usable 'bits', which is approximately 256,144 possible combinations and approximately 108db of dynamic range (106db to be precise). This means that there is about four times more dynamic range than a CD.

Some interesting figures with BrikWorms

Noise floor
The BrikWorm™ outputs (A-H at the stage end) have a maximum level of +16dbu. If you measure the output noise without any signal (digital black) then the noise floor will be at approximately -110dbu so there is a potential dynamic range of around 126dbu (lots).

Preamp noise
If you turn up the standard BrikWorm™ preamp gain to maximum (setting 4 is +45db or about 200 times) on a given channel and measure the output noise at A-H (at the stage end) you will find it is at around -80db. In other words, there is a 96db difference between the level of the maximum preamp noise and the maximum output level. This is interesting because if you were to try to record this noise onto CD you would find it difficult (96db is the dynamic range of a CD).

Setting 2 (+22db of gain) is recommended for a normal dynamic vocal microphone; the output noise at this gain setting will be around -100db which means that there will be around 116db of dynamic range available.

Gain steps
There are five steps of gain in the standard BrikWorm™ preamp. Taking the lowest setting (0) as the starting point, the subsequent steps are +12db, +22db, +35db and +45db. Notice that this is approximately 12db per step which is like two bits of conversion.

There are two main reasons for having these step sizes:
- firstly, with 18 bits of conversion the output quality will always be at least that of a CD and,
- secondly, having too many gain steps is counter-intuitive: after having set a 'coarse' level using the BrikWorm™, the fine control is manged by the mixing desk as you'd expect.