
IDR
(Increased Digital Resolution)

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Chapter 1 - Looking for a Quick start?

There is a small section on using IDR inside the WaveSystem manual. Please refer to it for complete detail on when to use IDR (within the L1, for example) and how to use the small IDR plug-in.

The following section is intended as a technical overview of Waves IDR, as well as general information about wordlength reduction concepts, dithering, noise-shaping, quantization noise, and more.

Chapter 2 - Waves IDR basics

IDR is Waves' proprietary noise-shaped dithering system co-developed by Waves with Michael Gerzon, a world authority in psychoacoustics. The IDR component in Waves processors can be used to maximize the digital resolution of the resulting audio. IDR's design is a result of Mr. Gerzon's long-term research dating back to 1982 with many of the other leading experts in digital resolution enhancement technologies.

In the industry, IDR and such systems are interchangeably referred to as wordlength reduction systems, bit-depth reduction systems, dithering systems, and "proprietary processes". They are sometimes incorrectly referred to as downsampling, which relates only to sample rate. The end result (or goal) is the same, no matter the name: to capture more detail from a long wordlength (24bits or more) into a shorter wordlength output (such as 16bits).

IDR controls

The Waves IDR system is implemented using the following three elements:

1. Quantize (output wordlength)
2. Dither type
3. Noise shaping curve

All controls are not always available in every plug-in processor.

For instance, only the L1-Ultramaximizer (shown as "+L1" in most application menus) and the L2 hardware mastering limiter offer complete control of all three elements listed above. The small IDR plug-in is internally set to type 1 Normal dither and curve, and the only user control is the Quantize, to select the wordlength.

Some plug-in processors have internal dithering, such as the Renaissance Equalizer and Compressor, which are dual-precision (48bit fixed on DSP, 64bit float on host), which is dithered using a simple flat dither for output to the system (dithered to 24bit/DSP, 32bit/host). No controls are available for this dither.

Other processors have internal noise-shaping (such as Q10, which has each band noise-shaped to provide 120dB signal-to-noise) which also has no user-available controls.

Chapter 3 - About Dither and Noise shaping

Dithering and Noise shaping are two independent, but complementary, techniques to improve the perceived quality of sound after it has been re-quantized.

As will be explained here in some detail, each technique is responsible for the improvement of a different subjective quality of the noise imposed by re-quantization. Therefore, each can be used separately to improve that specific quality.

Dithering is done in order to change the character of the quantization noise to more closely resemble analog hiss, rather than digital quantization noise. The main effect of dithering is to reduce (or, in case of type1, virtually eliminate) all correlation between the quantization noise and the original signal, thus reducing (eliminating) non-linear distortion typical of digital quantization noise. The dithering process 'exchanges' these distortions for a steadier analog-hiss quality signal.

Noise shaping is done in order to optimize the distribution of overall noise energy across the spectrum. This optimization is according to the ear's sensitivity. This means a decrease in noise (whether distortion or hiss) in the ear's sensitive areas (1 to 6kHz), is 'exchanged' for an increase of noise in less sensitive areas (above 15kHz, toward Nyquist).

Hopefully this has helped you see that in both techniques, the issue is about 'exchanging' the character and frequency content of noise (hiss & distortion) according to subjective criteria.

How do these processes help 'capture' 3 more bits of detail? The easiest analogy is to point to dithering in graphics, which is exactly the same process, and exactly the same type of psycho-perceptual model. The brain is capable of perceiving detail that is lower than a noise floor (in this case, dither). However, quantization noise is highly correlated to the signal; in other words, it is related to and governed by the signal. Dithering makes this noise become uncorrelated (as dither is a random signal), therefore allowing the brain to perceive the detail. The noise-shaping then helps to shift the energy of the noise to a less sensitive area of hearing.

Dither

1. No dither <off>. Within all applications (programs that Waves is compatible with and "plug into"), this setting means that the internal data is not dithered at all. In the case of the L2 hardware, it means that the internal 48bit data will be truncated to a 24bit output.The L2's IDR is more advanced, so technical information in the following paragraphs do not apply; refer to the L2 Manual for precise information.
2. IDR type1 dither. This dither is a wide-band dither. type1 adds a certain amount of noise causing a 5dB increase in background noise compared to no dither. It completely eliminates all low-level distortion and signal-dependent modulation effects. The result is a very transparent and clean low-level sound with a high resolution, most resembling the steady low-level hiss of an excellent quality analog system, and in lieu of digital quantization noise. This is the "purist" technology. It is designed for no nonlinear

distortion or modulation noise at low levels, and combines optimal dither noise with psychoacoustic noise shaping. type1 is also optimized to cause minimal side effects when used with stereo signals. type1 is the recommended choice for use when processing high quality mastering applications. By combining level maximization (peak controlling) and IDR processing, 16bit audio created from 20 or 24bit masters this way can have an apparent resolution of 19 bits, more than an 18dB improvement! When signals might be subjected to more than one stage of processing and quantization back to 16bits, the design of resolution-enhancement must satisfy additional requirements than a technology designed just for one-stage use. If applied several times in succession, a digital resolution enhancement technology optimized for one-stage CD mastering can produce unwanted side-effects. Waves type1 technology, however, is the first optimized for use at every processing stage, allowing for the effects of cascading and subsequent signal processing, if needed.

3. IDR type2 dither. This dither is a narrow-band dither, adds virtually no audible noise, and so is nearly 5dB quieter than type1, but with some low-level distortion. However, this distortion is generally much lower than with no dither at all. type2 is of a unique kind designed to minimize the amount of noise added, thereby giving a lower noise level than the IDR type1 process, but at the expense of some low level distortion. type2 does have some advantages for high quality mastering as well, and it is purely your choice whether the ultimate in low distortion of type1 is preferred, or the additional reduction in noise of type2.

Noise shaping

Another way to decrease the perceived level of noise is to "shape" the frequency content of the noise so it matches the ear's sensitivity curves. In basic terms, noise shaping shifts the noise to the frequency ranges where we hear it the least. The three options of Noise shaping provided in the +L1 and the L2 push more of the noise energy to higher frequencies above 15kHz and toward Nyquist, where our ears are least sensitive, and reducing the noise energy at lower frequencies. (Remember not all plug-in processors offer control of the noise-shaping curve). The three Noise shaping options progressively differ in the amount of this "shifting action".

1. Off. No noise shaping, resulting in more audible noise, (and distortion if dither is not used). The result has equal noise (distortion) levels at all frequencies, which is not optimal from a psychoacoustic point of view.
2. M (Moderate).
3. N (Normal). In addition to being very suitable for creation of Production Masters, using Normal with type1 dithering was also designed to be excellent for masters that would be processed again for any reason, including consecutive re-dithering, with an accumulation characteristic that is optimized to be minimal.
4. U (Ultra). This gives the greatest perceived hiss/distortion reduction. Ultra is a very high-quality setting, suitable only for use at the very last stage of mastering high-resolution audio (16bit and longer wordlengths) targeted for high-quality digital media. It is best to use Ultra in the last stage of audio preparation (Production Master). Due to the HF gain, it is theoretically possible that the relatively high amount of high frequency energy could cause undesirable side effects if the signal is going to be processed or digitally edited again. However, with many thousands of IDR-processed masters, no such situations have been reported or observed. Since it is theoretically possible, we wish to inform you of it.

You can hear the effect of Noise shaping by itself by monitoring the +L1 plug-in output and setting Dither type to Off, then selecting one of the Noise shaping options. Of course, the effect of Noise shaping is even greater when used with type1 or type2 dithering, since Noise shaping reduces the audibility of the added dither noise.

You may try the full effect of IDR technology by listening to the same material, with both IDR types and different kinds of noise shaping. The most obvious places to examine are notes or reverb during the end of the sound, or "tail". It is during this time that quantization error is most audible, although it is present on all low-level signals (such as elements that are soft in a mix, etc.)

If you don't feel you fully understand the tradeoffs between IDR and Noise shaping settings, the option that will generally work well for CD-mastering is type1 with Normal noise shaping. For minimum noise with 16bit and greater sources, type2 Ultra; for maximum resolution, type1 Ultra.

The noise reduction figures are even better for doubled sampling rates (such as those in the L2 hardware processor's IDR section). If audibility of noise were the only factor, the choice would almost always be to use Ultra noise shaping, but in some situations, heavy noise shaping of the Ultra kind can theoretically have some disadvantages, and the alternate settings, such as Normal or Moderate may be better.

One additional point that is not concerning a technical disadvantage of Ultra, but an aesthetic one, is that the Ultra setting can preserve and actually reveal the true quality of a master. Therefore, if the original master is not of great quality, you may prefer to use Moderate or Normal to better emulate other "less-revealing" wordlength reduction technologies, such as those that "smooth out" poor-quality masters.

For 16bit applications, Ultra shaping should be avoided in the following situations:

(a) Subsequent digital editing, when the signal is subjected to later editing. At the edit points, an extreme noise shaping might cause low-level, yet audible "clicks" in rare cases when played on very inexpensive CD players. An example application in which you would avoid use of Ultra shaping would be on CD's with production music or sound effects libraries that would certainly be subject to further digital editing.
(b) Poor Error Correction, i.e. when a signal is destined for a carrier medium with poor error correction, such as CDs pressed in pressing plants with poor quality control (who wants that anyway?). When errors that are not properly corrected occur, the Ultra setting, like all forms of heavy noise shaping and other resolution enhancement technologies, tends to cause audible background crackles, especially on very cheap CD players. While these effects generally don't occur on the majority of mid- or hi-fi CD players, they can be noticeable on very cheap products. The amount of such crackles on poor pressings is greatly reduced by the Normal noise shaping. Of course it can be argued that listeners with very cheap players, or users who don't care about poor quality pressings, may not be interested in high-quality reproduction at all!
(c) Subsequent production equalization before duplication (not by the user!), when heavy treble boost

equalization is subsequently employed. (Again, we're referring to EQ by a pre-mastering person before duplication, and not referring to a user who boosts the treble on their system. For the user to do so is fine, and is up to them.) This can cause the strongly boosted higher frequencies used by Ultra noise shaping to become so high in level that they might feed excessive noise energy into loudspeakers. Therefore Ultra shaping is best avoided in situations where subsequent equalization may be used in pre-mastering, such as in a compilation. However, if the mastering is done correctly the first time, large treble boosts would be quite unnecessary, and is somewhat moot in this context. Much less HF gain is used with the Normal and Moderate noise shapers (all of which could be observed on a real-time analyzer, such as Waves PAZ Psychoacoustic Analyzer).

Chapter 4 - Recommended IDR settings

Of course these settings are for when you have access to the full IDR control set, at present just the +L1-Ultramaximizer, or the L2 hardware.

Remember: The small IDR plug-in is internally set to type1 Normal.

Any combination of dither and noise shaping can be used, but the following settings are particularly recommended for different applications.

- General Purpose high-quality use, including material liable to be edited, EQ'd, and re-dithered: type1 Normal
- Lowest Noise: type2 - Ultra
- Low Noise/Highest quality (final production masters): type1 - Ultra
- Low noise while allowing editing/EQ: type2 - Normal
- High Quality, with lowest risks of spurious noises on edits or cheap CD players: type1 - Moderate
- Low noise, with lowest risk of spurious noises on edits or cheap CD players: type2 - Moderate