K2 TECHNOLOGY

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Restore the original sound feeling based on the concept of "Undo"

What is K2

K2 is an information processing technology that enhances sound quality of digital sound sources, co-developed in 1987 by JVC (currently JVCKENWOOD) and Victor Studio of Victor Music Industries (currently Victor Entertainment). It features a number of proprietary technologies, including technology to analyze waveform data that tends to vary from moment to moment within the time domain. Most notable is the fact that the technology was developed through rounds of testing and auditioning by Victor Studio engineers, who are experts in music and sound creation. Based on the vast amount of original master sound sources owned by Victor Studio, "K2 Technology" is a group of technologies that aim at faithful reproduction of the original source as far as possible by passing through the sound quality check carried out by the studio engineers who are thoroughly versed in audio and musical quality.

Fundamental Principles of K2

K2 does not tamper with sound quality to make it sound flamboyant, or exaggerate it. The aim of the development concept is to produce the same quality as the original music source, and the principle is to faithfully restore the sound that existed in its original form. The two keyphrases that were emphasized during development were "the original sound without any changes" and "restoring sound to its original state." This principle remains unchanged for K2 even today. Responding to changes in the environment and the way to enjoy music, "K2" will continue to evolve.

# Development background of "K2 technology"

Origin of K2

The name K2 was taken from the initials of the two engineers who developed the system (Kuwaoka from Victor Company of Japan, and Kanai from Victor Studio).

Development History of K2

The development of K2 was started in response to calls from recording engineers in Victor Studio. They objected to the common idea that there was absolutely no change in sound quality no matter how many times the original data was copied when the music media is transferred from analog records across to digital CDs. Because digitalizing sound is encoded in combinations of zeros and ones. Although no changes occur in theory, the studio engineers claimed that there was a clear difference between the sound quality of the original master and the copied sub-master. So the engineers at JVCKENWOOD set about to clarify the reason for this. Subsequently, it was discovered that although the digital data was exactly the same, electrical distortion (jitter, rippling), etc. occurred when the data was being recorded and saved, which had an adverse effect when converting music played back in digital into analog, thereby proving that changes did occur in sound quality. An attempt by the two engineers to improve the changes in sound quality that occurred at this time led to the original version of K2, which was named the "K2 Interface." Efforts in creating high-quality sound of digital sources with K2, which started from a signal transmission system at a music content production studio, will continue to evolve and expand from being featured in playback equipment to the remastering of songs, cutting records, and more.

Main technologies of K2

K2 Technologies on audio equipment

K2 Technologies for audio content production
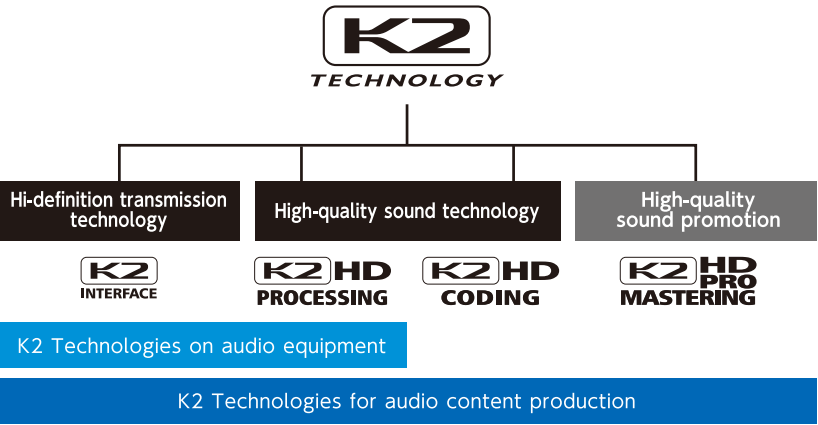
Example of K2 Technology Implementation
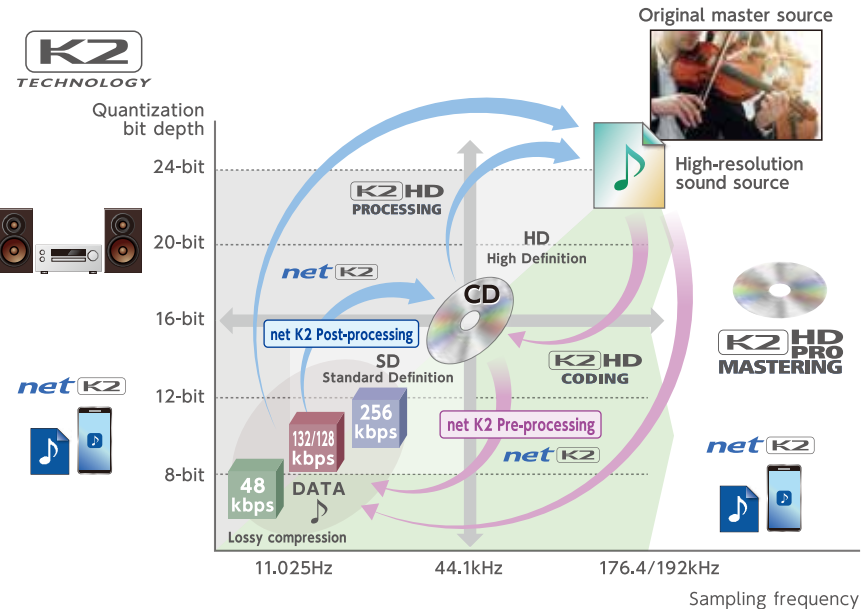
Timeline

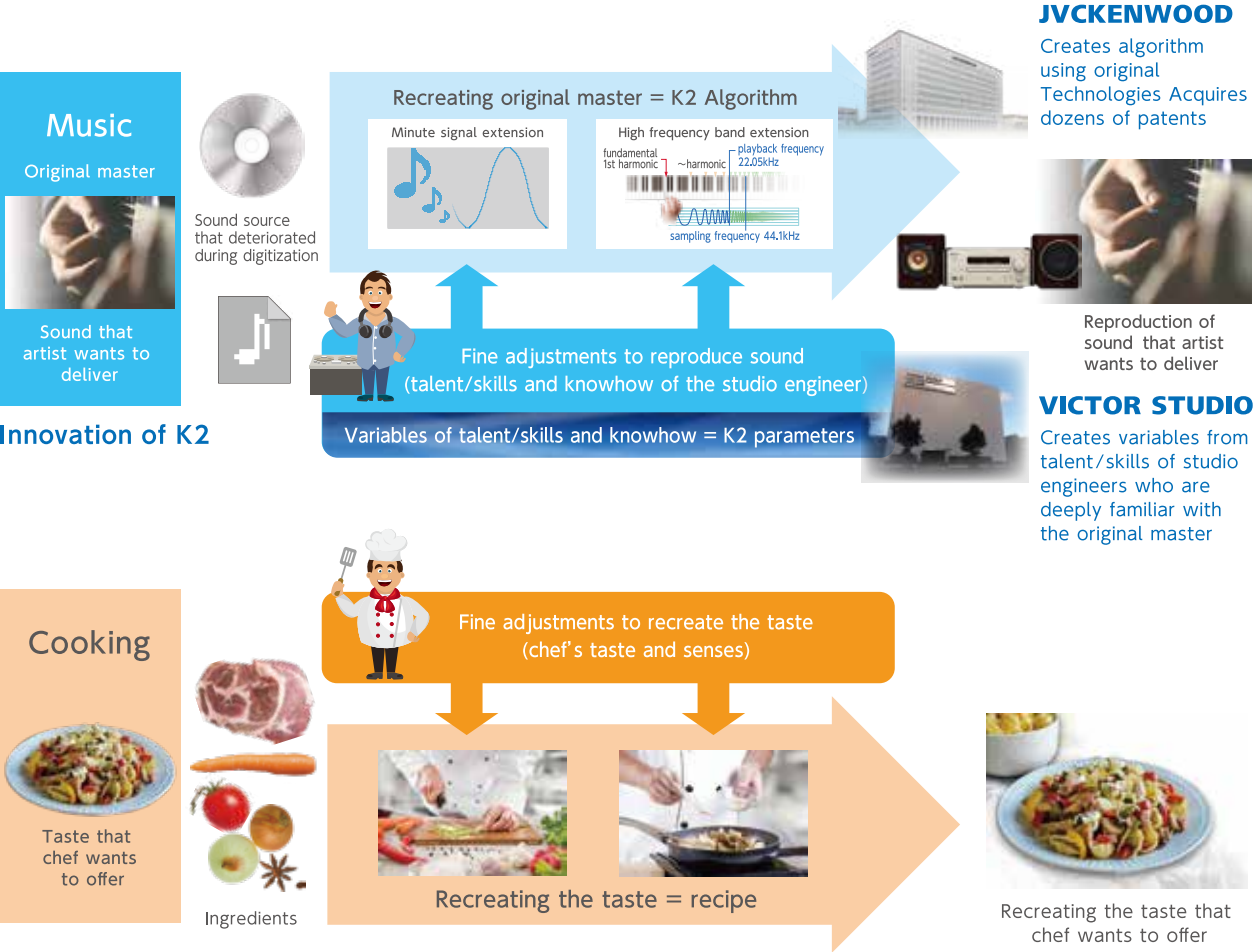| Year	
1987	K2 INTERFACE developed
1993	20bit K2 super coding developed / 20bit K2 AD convertor developed
1994	20bit K2 processing developed / 20bit K2 DA convertor developed / K2 laser cutting developed
1995	20bit K2 Pro / super coding method developed
1996	xrcd developed
1997	EXTENDED K2 processing developed
1998	DIGITAL K2 developed / xrcd2 developed
1999	EXTENDED K2 processing Ver.2.0 developed
2000	CC Convertor developed
2001	DVD K2 developed
2002	ENC K2 developed / CCCD K2 / xrcd24 developed
2003	K2 process engine developed
2004	K2 high-definition coding developed
2005	net K2 high-quality sound music distribution technology developed
2006	net K2 mobile phone music application developed
2007	K2HD Mastering developed
	Licensing for net K2 and K2HD Mastering started
2008	K2HD MASTERING+CRYSTAL developed
2010	K2HD MASTERING+SERIES developed
2012	net K2 iPhone application developed
	K2HD PROCESSOR developed
2016	K2HD PRO MASTERING developed
2017	Optimized for Bluetooth® wireless technology

net K2

net K2 Technology Applied For Compressed Audio (MP3, WMA, AAC, ATRAC3, etc) and Music Distribution.
At the beginning of development, net K2 was separated from information processing in the compression system, but the current K2HD technology includes this processing function, so it is collectively called K2HD processing.

K2 Features

1. Technological innovation comes from uniting the technology of hardware and sensibility of software

K2 was co-developed by audio equipment engineers who make hardware, and studio engineers who create the software for sound production. A round of back and forth during the development stage took place where a studio engineer would evaluate a prototype designed by the hardware engineer on a trial basis, and the hardware engineer reflects the sound direction and improvements pointed out by the software engineer in a specific design, and the studio engineer would once again evaluate the sound quality.

By way of analogy, this is like cooking, where the best, freshest ingredients would be wasted if the end result wasn't tasty, but it's also true that taste isn't all that matters because the quality of ingredients is also important. So a perfect dish can only be created by having an experienced chef who is capable of carefully selecting the right ingredients, and improve the taste by having the dish evaluated in an objective manner. Sound quality goes through an identical process. If you don't actually hear a difference in sound quality, it is worthless no matter how ideal the theory, specs, circuitry or parts may be. It's also important to remember what's being evaluated is not just sound, but music. Professionals from all fields come together to continue developing K2 as it keeps evolving. At JVCKENWOOD Group, we have the ideal one-of-a-kind development environment, where software and hardware experts who are familiar with sound quality and how to transmit music collaborate.

Music

Original master

Sound source that deteriorated during digitization

Sound that artist wants to deliver

Innovation of K2

Recreating original master = K2 Algorithm

Minute signal extension

High frequency band extension
fundamental 1st harmonic ~harmonic playback frequency 22.05kHz
sampling frequency 44.1kHz

Fine adjustments to reproduce sound (talent/skills and knowhow of the studio engineer)

Variables of talent/skills and knowhow = K2 parameters

JVCKENWOOD
Creates algorithm using original Technologies Acquires dozens of patents

Reproduction of sound that artist wants to deliver

VICTOR STUDIO
Creates variables from talent/skills of studio engineers who are deeply familiar with the original master

Cooking

Taste that chef wants to offer

Ingredients

Fine adjustments to recreate the taste (chef's taste and senses)

Recreating the taste = recipe

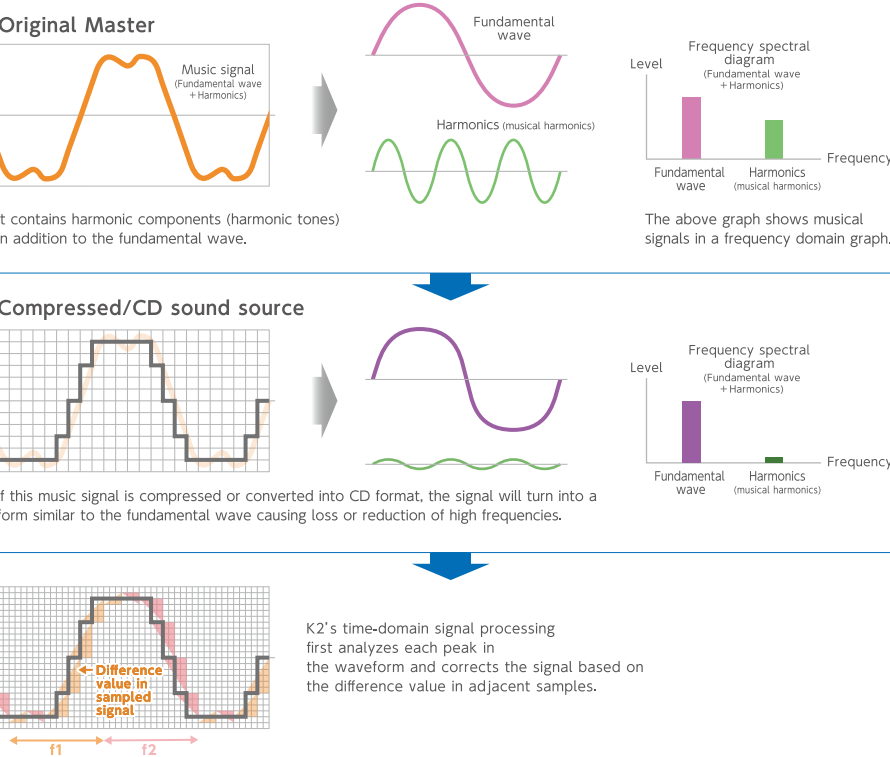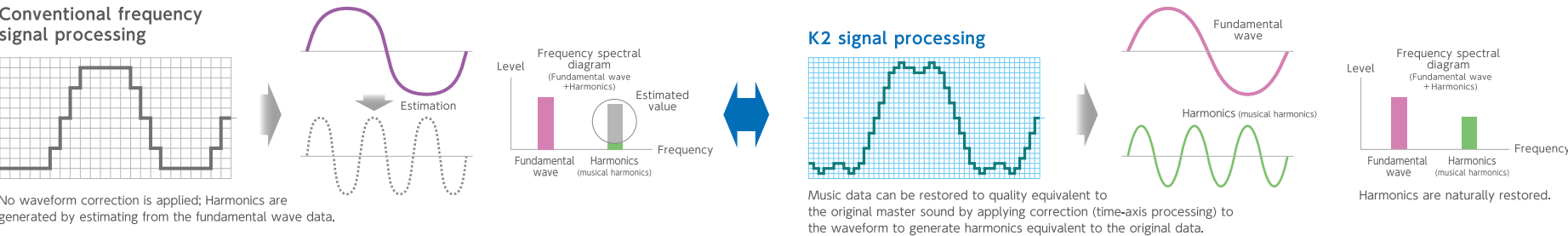Recreating the taste that chef wants to offer

2. Signal processing at time domain

Instead of using the frequency domain, which is applied in similar technologies that restore data lost during digitization using frequency data, K2HD Processing uses the time domain to perform signal processing. This method restores lost data by analyzing each peak in the time-varying waveform; it is a unique method that no other audio manufacturer has used in the past.

The sounds of many instruments are based on harmonics, much of which are lost during digitization. K2 Technology creats the artist's musical expressions and subtle timbre of different musical instruments by analyzing waveform signals based on the time axis.

It is a technology that is only possible with K2, as it processes based on the time axis not the frequency domain.

Conventional frequency signal processing

Level
Frequency spectral diagram
(Fundamental wave +Harmonics)
Estimation
Estimated value
Fundamental wave
Harmonics (musical harmonics)
Frequency

No waveform correction is applied; Harmonics are generated by estimating from the fundamental wave data.

Original Master

Music signal (Fundamental wave + Harmonics)

Fundamental wave

Harmonics (musical harmonics)

Level
Frequency spectral diagram
(Fundamental wave + Harmonics)
Fundamental wave
Harmonics (musical harmonics)
Frequency

It contains harmonic components (harmonic tones) in addition to the fundamental wave.

The above graph shows musical signals in a frequency domain graph.

Compressed/CD sound source

Fundamental wave

Harmonics (musical harmonics)

Level
Frequency spectral diagram
(Fundamental wave + Harmonics)
Fundamental wave
Harmonics (musical harmonics)
Frequency

If this music signal is compressed or converted into CD format, the signal will turn into a form similar to the fundamental wave causing loss or reduction of high frequencies.

Difference value in sampled signal

f1 f2

K2's time-domain signal processing first analyzes each peak in the waveform and corrects the signal based on the difference value in adjacent samples.

K2 signal processing

Fundamental wave

Harmonics (musical harmonics)

Level
Frequency spectral diagram
(Fundamental wave + Harmonics)
Fundamental wave
Harmonics (musical harmonics)
Frequency

Music data can be restored to quality equivalent to the original master sound by applying correction (time-axis processing) to the waveform to generate harmonics equivalent to the original data.

Harmonics are naturally restored.

K2 in sound equipment

K2 Technology is divided into two main groups of "High-definition transmission technology"and "High-quality sound technology".

■ **High-definition transmission technology**

K2 INTERFACE ▶ Used to make equipment and products more precise

■ **High-quality sound technology**

K2 HD PROCESSING ▶ Up-converting low-grade format sound sources to high-grade format

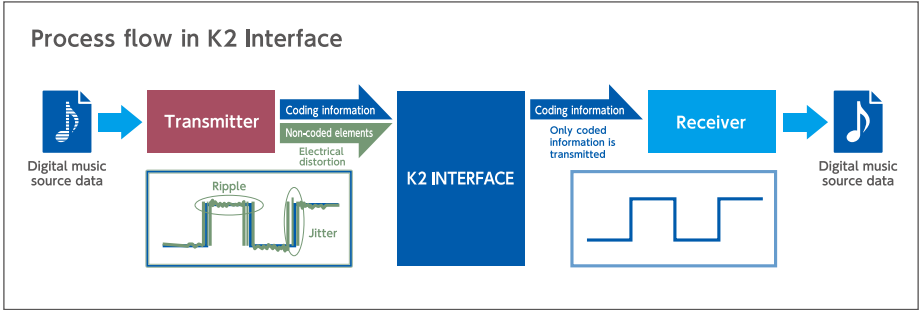**K2 HD CODING** ▶ Down-converting high-grade format sound sources to low-grade format

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K2 Interface

K2 INTERFACE **High-definition transmission technology K2 Interface**

K2 Interface is a high-definition sound technology in the transmission system of digital data based on the concept of K2, which is "reproducing or restoring to the original state without any changes". It is applied to minimize deterioration of sound quality caused by copying a music source or the use type of digital equipment. Various factors (such as jitters and ripples from recording or reading data) that may exert change in sound quality are eliminated or digital data itself is regenerated, even when the digital data of the source and destination are the same.

This technology was developed as the first generation K2 Interface.

Process flow in K2 Interface

Digital music source data — Transmitter — Coding information / Non-coded elements — Electrical distortion — Ripple — Jitter — K2 INTERFACE — Coding information / Only coded information is transmitted — Receiver — Digital music source data

Professional spec K2HD Processor for mastering equipped with K2 Interface (Victor Studio)

Correctly restores the music data as it knows the original source

K2 HD PROCESSING High-quality sound technology K2HD Processing

K2HD Processing is a high-quality sound technology made possible by processing digital data that is derived from one of the fundamental principles of K2, "to restore or return to the original state". Degraded sound sources, which are created by compressing the sound source or converting to a limited format or specs, can be restored to a quality equivalent to the original master. Up to 192 kHz high-frequency range extension (for CD sources: Expands playback frequency from 22.05 kHz to 96 kHz) and bit extension or minute signal extension (for CD sources: bit depth is expanded from 16-bit to 24-bit) are applied to create timbre equivalent to the original and the power needed for sound expression.
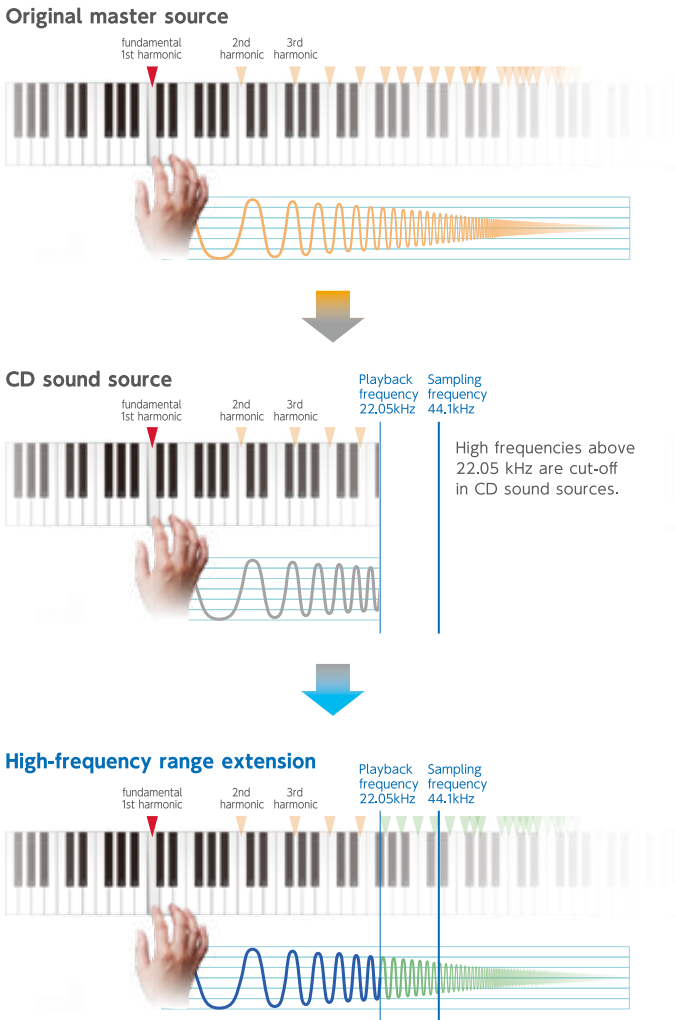
■ High-frequency range extension

Harmonics is a key element in timbre. The sound of both musical instruments and voices are composed of multiple frequencies, and the lowest-frequency sound is called the "root". Frequencies that are integral multiples of the root are mixed to create timbre. (Musical instruments produce different timbre even when playing the same frequency because of differences in harmonics.) With CDs, analog sound is converted into digital sound using a sampling frequency[1] of 44.1 kHz; thus its playback frequency[2] will be up to 22.05 kHz and overtones (harmonics) in higher frequencies are eliminated.
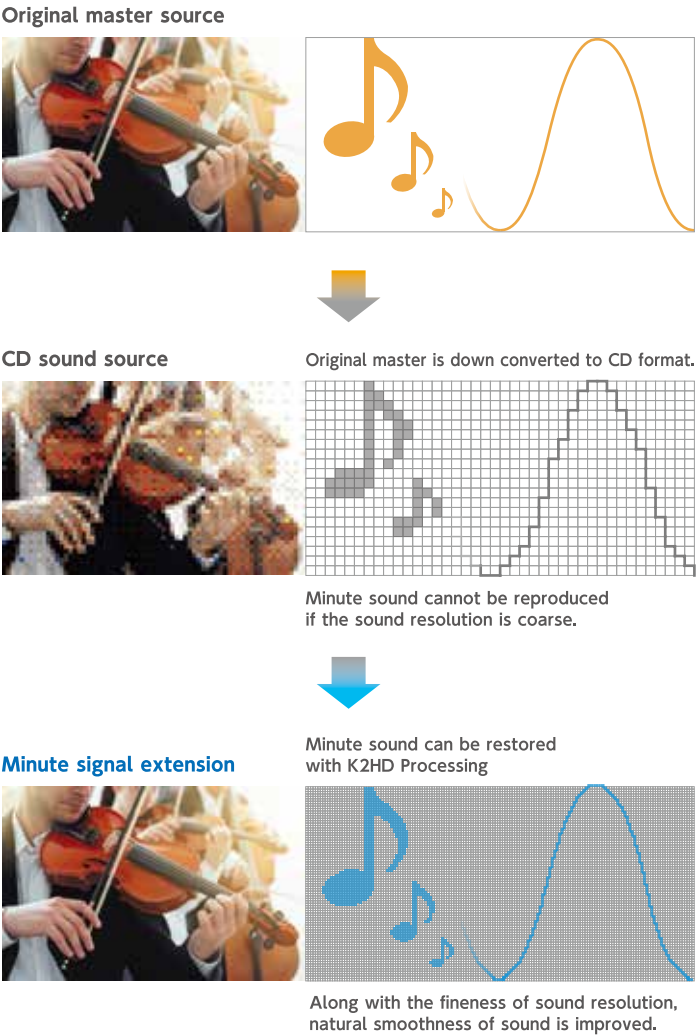
The original algorithm (waveform correction process) featured in the high-frequency range extension in K2HD Processing that utilizes the expertise of Victor Studio, restores cut-off harmonics in the high-frequency range from the remaining sound to reproduce music expression equivalent to the original master.

[1] : Sampling frequency : The number of samples per second in sound that is acquired when an analog signal is converted into a digital signal (AD conversion).
[2] : Playback frequency : Sound frequency that can actually be played back. The value of the playback frequency is half the sampling frequency.
In order to playback the humanly audible frequency range of 20kHz, CDs sample analog sound at 44.1 kHz.

Restoring harmonics of high frequency range

Original master source
fundamental
1st harmonic
2nd harmonic
3rd harmonic

CD sound source
fundamental
1st harmonic
2nd harmonic
3rd harmonic
Playback frequency 22.05kHz
Sampling frequency 44.1kHz
High frequencies above 22.05 kHz are cut-off in CD sound sources.

High-frequency range extension
fundamental
1st harmonic
2nd harmonic
3rd harmonic
Playback frequency 22.05kHz
Sampling frequency 44.1kHz

Minute signal extension

Original master source

CD sound source
Original master is down converted to CD format.
Minute sound cannot be reproduced if the sound resolution is coarse.

Minute signal extension
Minute sound can be restored with K2HD Processing
Along with the fineness of sound resolution, natural smoothness of sound is improved.

■ Minute signal extension (Bit extension)

When converting an analog signal to a digital signal, the number of steps to reproduce the loudness from silence to maximum volume affects the expressiveness of music such as its smoothness and subtlety. CDs express from silence to a maximum volume in 65,536-step resolution because it is 16-bit (2 to the power of 16). However, 16,777,216-step resolution can be achieved with 24-bit extension, allowing reproduction of minute signals not heard on CDs for music with a large volume differences like classical music, to reproduce realistic sound full of ambience such as breath and fine details of strings. With K2HD Processing, Victor Studio's expertise is added as a variable to this bit extension to achieve more natural, smooth sound.

K2HD Processing is not a simple up sampling / bit extension (conversion) for high frequency bands or minute signals of degraded / deteriorated digital sound sources; rather, it is capable of restoring the sound quality equivalent to a master sound source by applying Victor Studio engineers' sound creation expertise into the extension process. When K2HD Processing is implemented, it is possible to achieve sound faithful to deliver "the sound the artist intended" even for compressed digital sound sources.

K2HD CODING

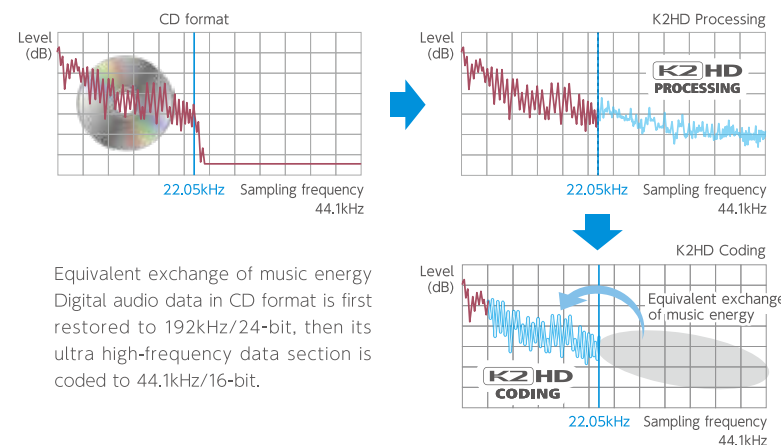### K2HD PRO MASTERING

K2 HD CODING

High-quality sound technology
(coding technology)
K2HD Coding

In digital sound production, when storing master music sources having their vast amount of information into a limited confined format, K2HD Coding is used to maintain musical expressions contained in the original music source. It is capable of storing upper-format digital music sources of up to 192 kHz/24-bit as lower-format 44.1kHz/16-bit music sources.

Thanks to the equivalent exchange of music energy, the high frequency range of 20 kHz and higher in playback frequency (which is normally eliminated in CD format), is modified to 20 kHz or less allowing it to be used within CD format frequencies. This enables conventional CDs to be played back including musical expressions with resolution of up to 192 kHz/24-bit specifications.

Also, if CD format is the only sound source available, reproduction of CD content with expressive power close to the original master can be achieved by expanding the frequency with K2HD Processing and re-coding the data back to CD format.

K2HD Coding Expressing the world of 192kHz/24-bit in CD format

CD format

Level (dB)

22.05kHz Sampling frequency 44.1kHz

K2HD Processing

Level (dB)

K2 HD PROCESSING

22.05kHz Sampling frequency 44.1kHz

K2HD Coding

Equivalent exchange of music energy Digital audio data in CD format is first restored to 192kHz/24-bit, then its ultra high-frequency data section is coded to 44.1kHz/16-bit.

Level (dB)

Equivalent exchange of music energy

K2 HD CODING

22.05kHz Sampling frequency 44.1kHz

K2 HD PRO MASTERING

High-quality
sound promotion
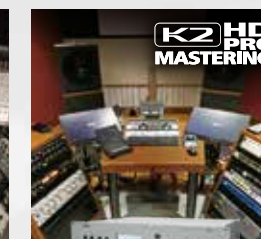### K2HD PRO MASTERING

recording   mixing   K2HD PRO MASTERING

K2 HD PRO MASTERING

Diversifying media, multiplexing formats, and no packaging. The importance of mastering is endless not only in sound or music but for the production of various types of entertainment content.

K2HD Mastering, which was developed in 2007, is a high-dimensional mastering system that fuses sound and music production based on the expertise and creativity of Victor Studio mastering engineers with K2HD Technology. The attractiveness of the music originally contained in the master sound source, drawn out through technology and the senses of the mastering engineer, is stored in each medium as 24-bit high-resolution music information up to 100 kHz using K2 High Definition coding technology. With CD mastering, 192 KHz/24-bit data is stored in 44 KHz/16-bit CD masters to achieve high-sound quality for CDs like never before. This high-dimensional mastering technology has been made possible by combining Victor Studio's FLAIR Mastering Works with unique expertise on creating high-specifications sound, and highly skilled mastering engineers who are capable of making accurate judgments on sound issues and precisely match them with the music.
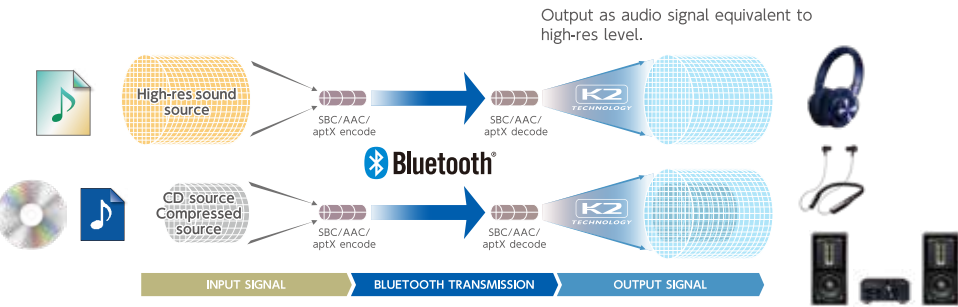
To date, more than 1,000 K2HD PRO Mastering CDs have been released and well received both in Japan and overseas, mainly in Asia.

Achieving high-quality sound equivalent to the original high-resolution sound, even used wirelessly.

Sound source restoration with K2

Waveform correction parameters for each codec are optimized; when paired with Bluetooth®, waveform correction is performed by using the parameters that support the selected codec. The output audio signal will be equivalent to high-res level (192 kHz/ 24-bit format).
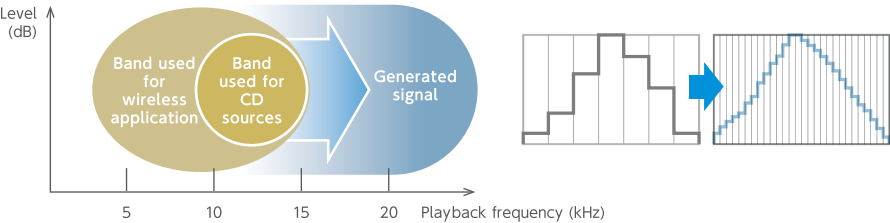
K2 Technology has been optimized to match Bluetooth® wireless technology

K2 Technology can help solve the issue of sound deterioration due to the increasing number of wireless audio equipment.

Audio data is sent wirelessly by compressing data using one of the codecs (e.g. SBC, AAC, Qualcomm® aptX™ audio, etc.) with Bluetooth® wireless technology.

Compared to wired technology, there is a drawback in terms of sound quality with Bluetooth® due to degradation caused by compression. In order to regenerate the lost music data during wireless transmission, K2 Technology can process the signal using optimum parameters that match each codec to achieve sound quality close to that of wired transmission. K2 Technology can make sound sources of widely available Bluetooth®-compatible equipment, such as smartphones, equivalent to high-res level.

Broad and smooth sound can be played back with waveform correction processing optimum for the Bluetooth® wireless technology

In order to regenerate lost audio data caused by the compression process in Bluetooth® wireless technology, high-precision waveform correction is performed by extending the processing range until lower frequency band than the one used conventional CD sound sources. The signal is then output as a high-res equivalent (192 kHz/24-bit format) music signal. As a result, broad and smooth sound close to the original master can be achieved.

Major Patents of the K2 : In Japan

Patent number	Name of the invention
3659489	Digital sound processor and computer program recording media
3888239	Digital sound processing method and processor, as well as computer program
4224807	Sound signal processor and sound signal processing computer program
4123486	Digital sound processing method and digital sound processor, as well as computer program
5023794	Digital sound processor and digital sound processing program
5023812	Digital sound processor and digital sound processing program
4985570	Digital acoustic sound signal processing method and processor
6256293	Digital sound processor, digital sound processing method, and digital sound processing program

Registered Trademarks : In Japan

Registered trademark number	Registered logo	Technology name
5528899	K2 TECHNOLOGY	K2 TECHNOLOGY
5580641	K2 HD CODING	K2HD CODING
5580642	K2 HD PROCESSING	K2HD PROCESSING
5910096	K2 HD PRO MASTERING	K2HD PRO MASTERING

JVCKENWOOD products equipped with "K2 technology"