# Sound Improvement of Digitally Compressed Audio

## *MP3 (and All "Lossy" Digital Compression) Sound Enhancement and Restoration*

---

***BBE MP (Minimized Polynomial Non-Linear Saturation) Process improves digitally compressed sound, such as MP3, by restoring and enhancing the harmonics lost through compression. BBE MP works by re-generating harmonics from the source material, effectively recovering warmth, details and nuance.***

***BBE MP improves the regular CD sound as well as digitally compressed audio.***

---

### 1. Wide Product Application

MP3 Player, MD Player, CD Player, Headphone Stereo, Mini-Component Stereo, Portable Stereo, Car Stereo, TV, DAB, Satellite Radio , Internet Radio, etc.

### 2. Applicable Technologies

***All Digitally Compressed (Lossy Compression) Audio and CD (PCM)***

MPEG Layer Audio (MP1, MP2, MP3), MPEG4 Audio, CD (PCM), etc.

### 3. Improvements

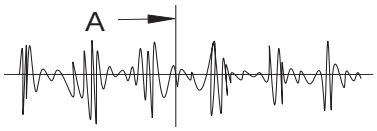
- Restores and enhances harmonics lost through compression.
- Restores harmonics' phase alignment.
- Restores stereo image reduced by compression, and regain full-stereo performance.
- Reveals the delicate and aesthetically delightful details in the music.
- Restores warmth to the spoiled digitally compressed sound.

### 4. Solution

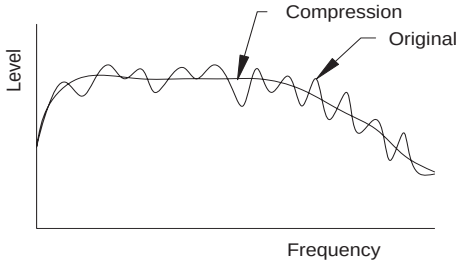
Very Simple Digital Software (1/10 to 1/100 of comparable processes)

# How *BBE* MP Process Works

## Digital Compression



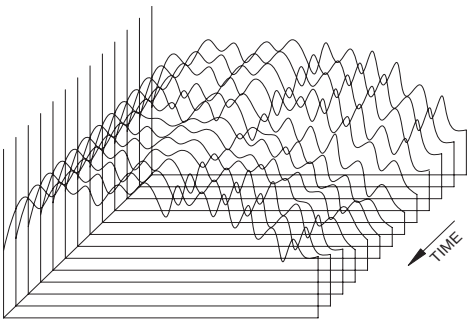

WAVE FORM



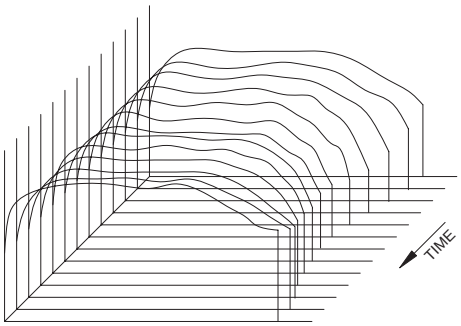

FREQUENCY SPECTRUM A

The core concept of digital compression is removing redundancy from the data. There are many strategies for accomplishing the task, but in any case digital compression is mainly performed within the frequency domain. The above left waveform is sound wave seen on a scope. Sampled at the instant "**A**", the spectrum of the sound is mapped like the above right, indicated as "**Original**". This is essentially the sampling process. The sampled spectrum appears to be very complex. However, it is generally accepted that smoothing this complex curve does not greatly affect the sound, while reducing substantial amount (more than 90%) of data. The result is a smooth curve indicated as "**Compression**". This is the core of digital compression.

The sampling continues in the time domain at about 40KHz, generating the series of spectrum histogram displayed below left.




ORIGINAL AUDIO SPECTRUM




DIGITALLY COMPRESSED AUDIO SPECTRUM

Besides the main frequency domain compression, the digital compression is performed in the time domain as well. After the both frequency and time domain compression processes, the spectrum datum is simplified as illustrated above right. *(Note: The illustration is overly simplified for easier understanding.)* Thus, a huge amount of information is removed and permanently lost. (This is the reason why this type of compression is called "Lossy" Compression.) Moreover, MP3 often uses a lower sampling rate than a CD, which creates a total loss of information above the specific frequency (1/2 of the sampling frequency). Note the sudden information loss over the specific

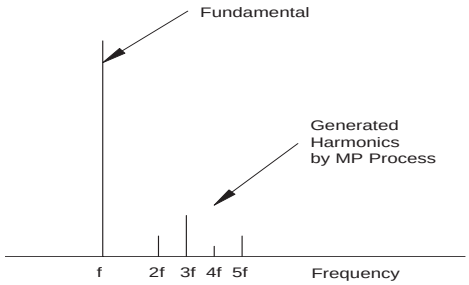
frequency in the illustration below. The specific frequency also varies depending on the contents of frequency spectrum.

The sound reproduced from this data file sounds okay, a piano still sounds like a piano and a trumpet sounds like a trumpet, but the details, nuance, and musicality are lost. The sound becomes rather dull.

BBE process helps to restore and enhance the sound by detecting the reduced harmonics, boosting them and correcting the time alignments. However, if the harmonics are completely lost, they must be regenerated.

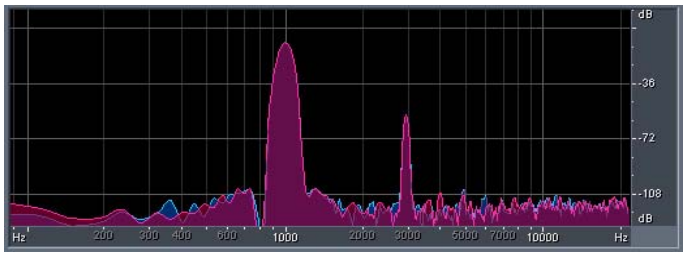
## MP Process

The MP (Minimized Polynomial Non-Linear Saturation) Process mainly generates odd order harmonics indicated as "**Generated Harmonics by MP Process**" from a "**Fundamental**" noted in the illustration below. The odd order harmonics tends to makes the sound brighter, sharper and more distinguished, when they are added to the original sound. The right amount of odd order harmonics provides clear and lively sound.

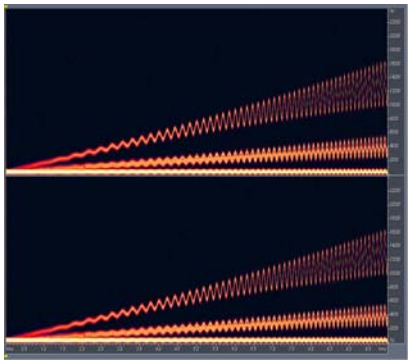


MP Process

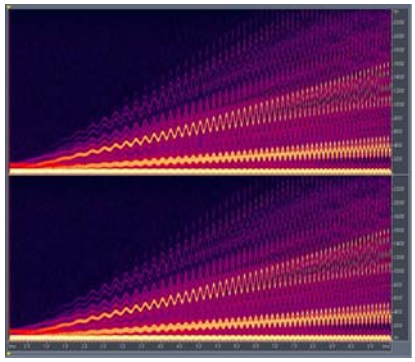
The picture below shows the actual operation of the MP process. The 3KHz (3rd order) and 5KHz (5th order) harmonics are seen, generated from the 1KHz (fundamental).




The following pictures visualize the actual demonstration of the BBE MP process on a test signal. The left picture is a multiple-modulation-sweep test signal (X: Time 0-10 Sec, Y: Frequency 0-24 KHz). The right picture is the result of the BBE MP process applied to the same signal. A series of harmonics are generated covering the wide frequency range.

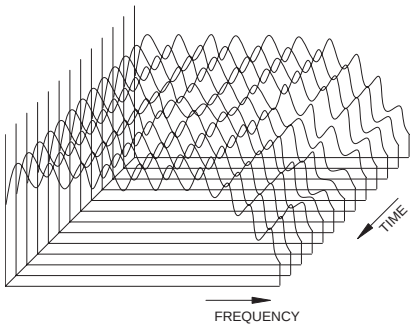


**Test Signal**



**BBE MP Processed**

This MP process covers the entire audio bandwidth, evenly from low to high frequencies, without enhancing or coloring any particular frequency range. The spectrum histogram, after adding the regenerated harmonics, is shown below.

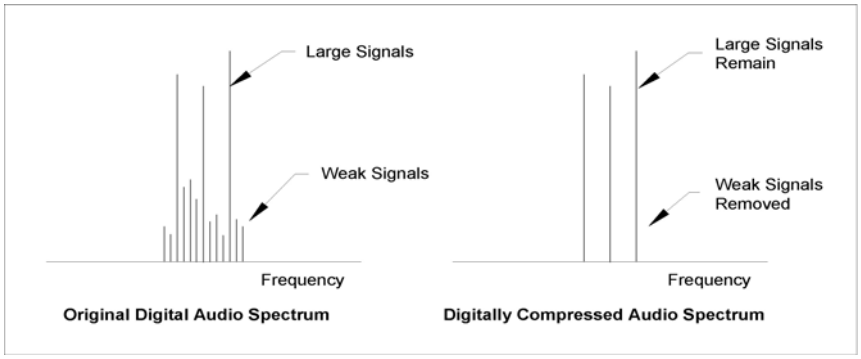



BBE MP PROCESSED AUDIO SPECTRUM

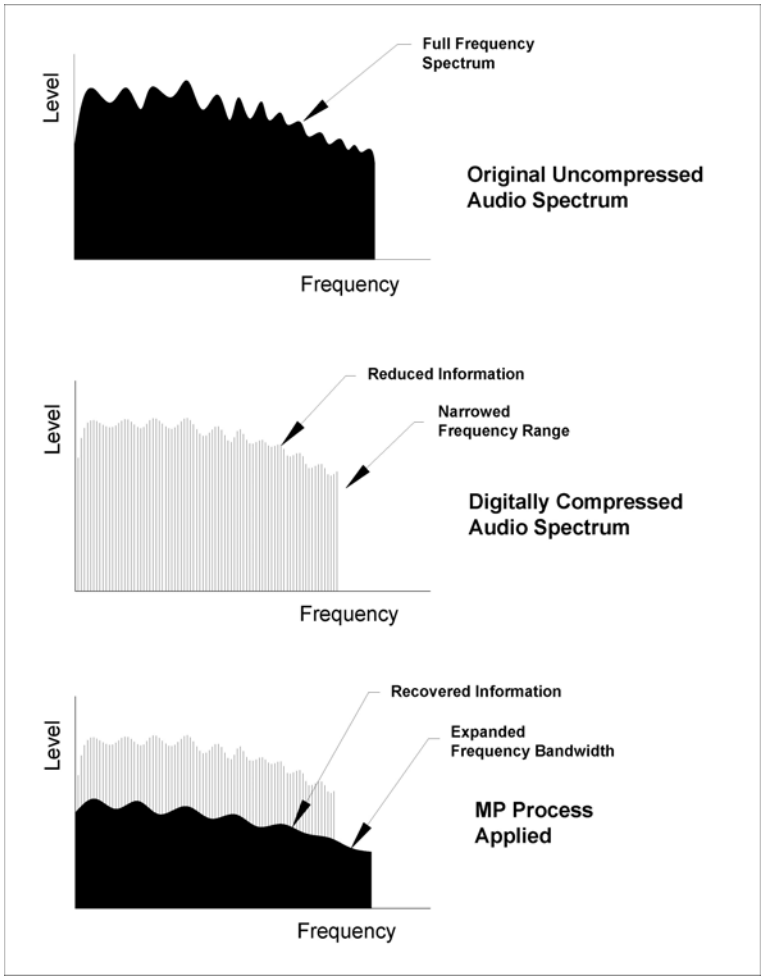
This histogram is not necessarily the same as the original, but it is closer to the original, so the actual sound is significantly recovered.

## Another Digital Compression

Another type of digital compression works by discarding nearby weaker signals while leaving stronger signals untouched. These weaker signals are masked and cannot be heard when situated beside stronger signals. This reduces the file size, theoretically without affecting the sound. The following illustration explains this mechanism. The left picture shows part of the original digital audio spectrum with strong and weak signals randomly mixed. The right picture shows this spectrum simplified after removing weak signals. According to digital compression theory, these two spectrums should sound the same. Unfortunately, this is not true because most of these weak signals are harmonics. Harmonics carry critical information that expresses the details and nuances of an audio signal, so the sound's character is lost without them.

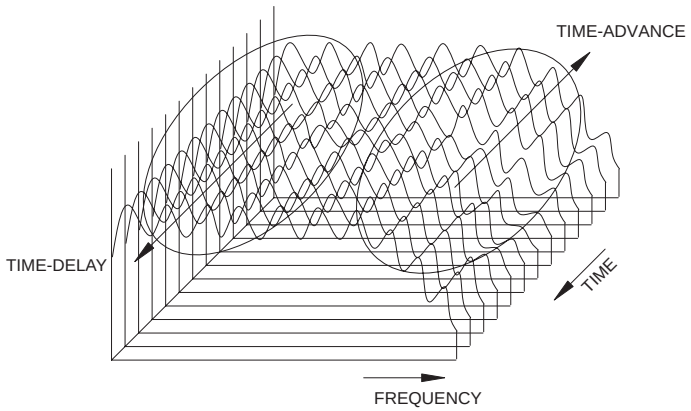



The MP process regenerates the lost harmonics from the remaining signals. The following pictures illustrate the function of MP process. The top picture shows the frequency spectrum before digital compression, which contains full spectrum of information across the entire bandwidth. The center picture shows how digital compression reduces the information and narrows the frequency range. The final picture shows how the MP process recovered that information and expanded its frequency bandwidth. (The frequency bandwidth expands to the one half of sampling frequency.)



## BBE MP Process

The BBE Process, which provides a linear phase advance in proportion to the frequency, is placed before the MP process. The MP process evenly generates higher harmonics from the entire audio bandwidth. Since the BBE-processed sound has a tapered time alignment (the higher the frequency, the more time advance), the generated harmonics are time-advanced in the higher frequencies. This allows the brain to analyze the sound more easily with the least amount of added harmonics. (It is common knowledge in the psycho-acoustic studies that time-advanced harmonics, compared to fundamentals, make the brain's interpretation of sound easier.)



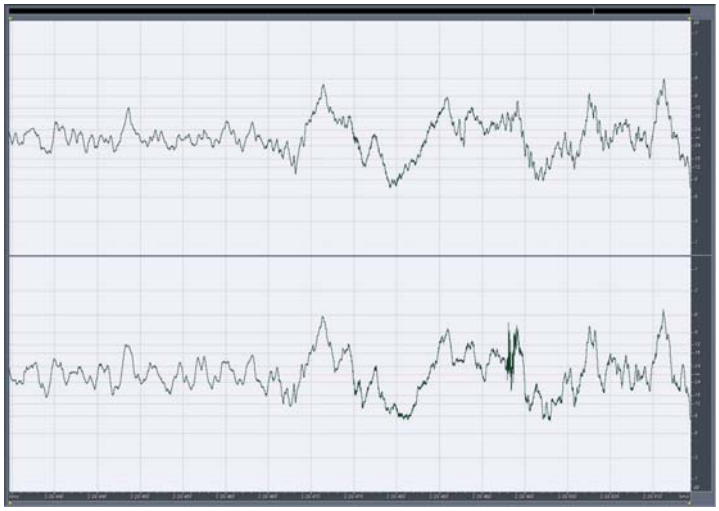

BBE MP PROCESSED AUDIO SPECTRUM

The BBE process progressively enhances the higher frequencies. The harmonics generated by the MP process tends to have more elements in the higher frequencies compared to the lower frequencies. The degree of this contrast is optimized by the BBE process gain.

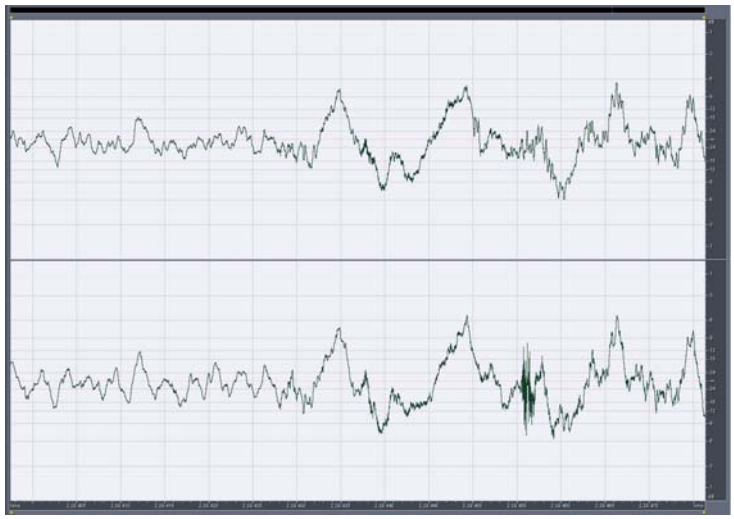
The BBE MP process turns digitally compressed and spoiled sound into a warmer and richer sound with more details, clarity and sharpness.

## Sound Improvement of Regular CD

The waveforms below are details from Emmylou Harris's "I Still Miss Someone." The upper picture shows a WAV file – an exact copy of the original CD. The bottom picture shows the result of the BBE MP process. Quite a few high frequency elements (small vibrations) are seen riding on the large waves. The shape of larger waves is also different from the original. These are due to the harmonics generated by the BBE MP process.



**Emmylou Harris "I Still Miss Someone," Original CD**



**Emmylou Harris "I Still Miss Someone," BBE MP Processed**

**BBE Sound, Inc. June 23, 2006**
**www.bbesound.com**