HDCD® Decoder FAQ

Q: Using your Test CD to verify the design of my CD Player (DAC), I'm not getting the specified amplitude levels for tracks 3-6. Why?
A: What is probably happening is that the implementation of analog Gain Scaling is incorrect. Problems with tracks 7 and 8 in addition to tracks 3-6 could indicate faulty measurement setup or a defective HDCD IC. If tracks 3-6, 7, and 8 all have incorrect levels then it is almost always a Gain Scaling issue. Verify that the use of SCAL, GAIN and HDCD functions are implemented correctly. The gain change between Peak Extended and non-Peak Extended recordings MUST be performed in the analog domain if SCAL is true. The HDCD signal is active whenever HDCD encoded material is detected. Using this pin to activate a front panel indication when HDCD material is present is the intended and recommended usage. HDCD function is not related to the analog gain scale function. The GAIN function is active when HDCD material is detected AND Peak Extend is present.

Q: Why must the HDCD Decoder have either Digital or Analog Gain Scaling implemented?
A: One of the very powerful features of the HDCD process is called Peak Extend. Simply put, Peak Extend increases the effective dynamic range of the HDCD encoded material during playback. It allows for an "extra" 6dB of peak signal amplitude above the standard 0dB full scale normally available. The top 3dB (-3dBfs to 0dBfs) of Peak Extended HDCD recordings contain 9dB of compressed signal level that is uncompressed when decoded. In order to produce this increased dynamic range and because the peak digital signal level prior to decoding is 0dBfs (which cannot increase beyond 0dBfs in the digital domain by definition), the average signal level of decoded Peak Extended recordings must be decreased by 6dB. Since human perception of "loudness" is determined by average levels and not peak levels, decoded Peak Extended recordings will thus sound 6dB quieter than non-Peak Extended recordings, unless the difference in average levels is compensated for after the decoding has been performed. Digital (or Analog) Gain Scaling is used to make the average levels of both types of recordings (non-Peak Extended and Peak Extended) similar by automatically setting the peak level of decoded Peak Extended recordings 6dB higher than non-Peak Extended recordings. If Gain Scaling was not performed, whenever playback changed between non-Peak Extended and Peak Extended recordings the listener would have to manually adjust the playback level to maintain the same subjective loudness. For more detailed information regarding Gain Scaling and Peak Extend, please see the HDCD Process Decoder Gain Scaling Application Note.

Q: What is the difference between digital and analog gain scaling?
A: The HDCD Decoder is able to perform gain scaling in either the digital or analog domains. Both implementations accomplish the same thing. A complete discussion is available in the HDCD Process Decoder Gain Scaling Application note.

Q: How does the HDCD Decoder expand the dynamic range during decoded playback?
A: All CDs sound better on HDCD-equipped CD players because the HDCD Process Decoder also functions as a state-of-the-art digital filter. An HDCD encoded CD when played on an HDCD decoding CD player delivers unparalleled sound quality because; 1) the recording was made using the Model 1 (or Model 2) HDCD Digital Processor which yields the benefits of extremely

accurate A/D conversion, Peak Extend (PE), Low Level Extension (LLE), and high frequency dither addition, 2) The HDCD decoder uses an interpolation filter complementary to the anti-alias filters used in the A/D filter switching process, 3) the HDCD decoder decodes Peak Extend (PE) and Low Level Expansion (LLE). The combination of these three items (PE, LLE, and dither) results in a signal with an effective dynamic range of almost 20 bits.

Q: Will my HDCD encoded CD sound better on my non-HDCD equipped CD Player?
An HDCD encoded CD when played on a standard CD player will sound better because; 1) the HDCD encoded CD was made using subtractive dither and filter switching A/D conversion processes, which yields a higher resolution signal when compared to standard CD's, 2) Peak Extend (PE) soft limiting increases resolution by allowing the (recorded) average signal level to be raised by up to 6dB, 3) Low Level Extension (LLE) improves resolution of low-level signals, 4) High frequency dither addition improves resolution by one bit by lowering the noise floor.

Q: What does the HDCD code look like?
A: The HDCD code is very similar to the packet type of data sent in the Ethernet network protocol. During the final quantization, the encoder inserts it into the least significant bit (LSB) of the 16 bit audio word. Specifically, these code packets are only a little more than one millisecond in duration and are inserted at several 10's of millisecond intervals. The packet of HDCD code is a pseudo random noise encoded bit stream that is only inserted when the encoder deems it necessary to inform the decoder that a change in the encoding algorithm has occurred. This pseudo random code is used for the HDCD command function less than five percent of the time (typically only 1-2 percent). The use of the 16th bit for the HDCD command code is inaudible because the code is inserted for only a very small portion of time and because it is used as dither for the remaining 15 bits when it is inserted. Pacific Microsonics experimentally confirmed this by inserting the HDCD code at several times the normal insertion rate.

Q: Why is the HDCD code needed for less than 5% of the time?
A: Because the HDCD code are instructions and not data, the HDCD decoder only needs to know the change to the previous instruction.

Q: What happens when the HDCD Decoder misses a packet of HDCD code?
A: The HDCD Decoder requires that level change instructions received from the command code be identical between channels. If one channel has an error, then the decoder mistracks for a short period of time (several tens of milliseconds) until the next command code packet arrives. This mistracking is much less audible than a level change in one channel causing a shift in balance and lateral image movement. If either of the code detect timers times out, then the decoder declares the command code not present, cancels all existing commands and restores the decode system to its default state.

Q: How does the HDCD Decoder detect a valid command code packet?
A: During the encode process by the Model 1 HDCD Processor, as one of the last steps during the formation of the command code packet, a synchronizing pattern is prepended to the data and a checksum is calculated and appended. Upon decode by the HDCD Decoder, the LSB of the audio is processed via a pattern matching circuit. If a specific synchronizing pattern is detected and it has valid format and matching checksums, only then is a command code packet registered as valid for that channel.

Q: What happens if the HDCD Decoder detects valid command code using non-HDCD encoded recordings?

A: There is an extremely small probability that the decoder will detect a false command code. The combination of the synchronizing pattern with the bit equivalence for all valid commands and checksum addition to the command code packet requires a match that approximates 39 sequential bits. Pacific Microsonics has mathematically calculated that a false detect would occur approximately once every 150 million years for a dual channel audio signal in which both channels must match within a one second interval with identical gains commands for both channels. Please see the answer above to “What happens when the HDCD Decoder misses a packet of HDCD code?” question.

Q: In simple terms, how does the HDCD Decoder operate with the HDCD code data?

A: The HDCD Decoder examines the LSB of the audio data for each channel and determines if there is the HDCD hidden code present. If so, it resets the code detect timers for each channel and decodes the commands. An HDCD code detect signal is made valid, thus identifying the audio as having been encoded with the HDCD process. Following code extraction, those parameters that affect dynamic range are restored. This includes the expansion of the instantaneous soft limiting peak levels (PE) performed by the encoder if that option was enabled and expansion of the low level gain compression(LLE) based on average signal levels. These exactly complementary gain command instructions are timed to the audio signal so that gain changes are transparent. After the dynamic range of the audio signal has been restored, the HDCD Decoder then performs gain scaling and filter selection. The final step in the decode process involves interpolating the audio signal to twice the sampling frequency using a filter complementary to the encoders anti-alias filter. This audio signal is available as an output to the decode process, or within the HDCD Decoder, this audio signal can be interpolated to four or eight times the sampling frequency to drive common A-D converters.