

THE FREQUENCY DOMAIN ANALYSIS OF MP3 DECODERS

by

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The Frequency Domain Analysis of MP3 Decoders

Thesis directed by Associate Professor Catalin Grigoras

ABSTRACT

This research study aims to further the study of the MP3 format by adding another layer to the analysis process. Previous studies have demonstrated the padding of MP3 files (Zero Level Samples) to show generations of compression. This study offers an examination that explicitly demonstrates what happens in the frequency domain, specifically with the cutoff frequency.

The research test files involved 90 MP3 files recorded using three MP3 recording devices within the same acoustic environment. Various transcoding applications converted the MP3 audio streams to WAV Pulse Code Modulation (PCM) files. The audio files were then analyzed using the Long Term Average Sorted Spectrum (LTASS) to display variations in cutoff frequencies between transcoding tools.

The form and content of this abstract are approved. I recommend its publication.

Approved: Catalin Grigoras

DEDICATION

This thesis is dedicated to my wife Krystal Savage, and my daughter Briella Savage. I wouldn't be where I am today without you.

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TABLE OF CONTENTS

CHAPTER

I.	INTRODUCTION	1
II.	MATERIALS.....	6
III.	METHODOLOGY	9
IV.	RESULTS	13
V.	CONCLUSIONS	65
	REFERENCES	68
	APPENDIX.....	69
	TASCAM DR-07 64KBPS.....	69
	TASCAM DR-07 128KBPS.....	73
	TASCAM DR-07 192KBPS.....	77
	MARANTZ PMD620 64 KBPS.....	81
	MARANTZ PMD620 128 KBPS.....	85
	MARANTZ PMD620 192 KBPS.....	89
	SONY PX820 128 KBPS	93
	SONY PX820 192 KBPS	97

CHAPTER I

INTRODUCTION

Brief MP3 Overview

MP3 is an acronym that stands for MPEG Audio Layer III, a lossy compression standard created by Karlheinz Brandenburg, a Moving Picture Experts Group member. The purpose of the MP3 codec was to reduce the file size of lossless audio files while keeping as much quality intact as possible. The reduced file size allowed enthusiasts to save space on their storage devices, thus enabling them to store more data and or transfer files more easily online.

In addition, the codec reduces file size by removing information in the frequency domain (of the audio) that the human ear does not detect using psychoacoustic techniques such as frequency masking.

The MP3 algorithm had a significant impact in the early 1990s. Then, hard drive capacity was not as big as we have today and your typical song could range anywhere from two to four minutes in length. Pair that with 56-128kbps internet download speeds, and you were in for a lengthy wait. To put this into perspective, consider the following table as it demonstrates the difference in file size between a WAV and MP3 file after the bit rates are adjusted.

Table 1: Raw Audio Example

Format	Duration	Sample Rate	Bit Depth	Channels	File Size
WAV	3 Min	44100 kHz	16 bit	2	31.752 MB

Table 2: Compressed Audio Example

Format	Duration	Sample Rate	Bit Rate	Channels	File Size
MP3	3 Min	44100 kHz	320 kbps	2	7.2 MB

77.3% reduction in file size in comparison to the Wav file

Table 3: Compressed Audio Example

Format	Duration	Sample Rate	Bit Rate	Channels	File Size
MP3	3 Min	44100 kHz	128 kbps	2	2.88 MB

90.9% reduction in file size size in comparison to the Wav file

The file size of an MP3 can be controlled by adjusting the bitrate, number of channels and sample rate. Bit Depth and Sample Rate determine the original recording's quality. The higher the bit depth, the higher the signal to noise ratio and dynamic range. A higher Sample Rate equates to a more accurate recording.

When a Wav file is encoded to MP3, the sample rate and bit depth transfer over as well, but it's not exact. If the bit depth were reduced from 16 bit to 6 bit, there would be a highly noticeable degradation in audio quality. To keep as much of the audio quality intact, you adjust the bit rate (bits per second) instead of bit depth (bits per sample).

Brief MP3 Decoder Overview

MP3 decoders are used to convert MP3s so they can be played back via software/Hardware MP3 players. The decoder can also convert the MP3 to a different format such as: AIFF, WAV or other formats. Information lost in the MP3 encoding process cannot be recovered when converted to the previous format. Some handheld recorders come with proprietary software for editing, encoding and decoding audio files, others will provide a list of recommended software.

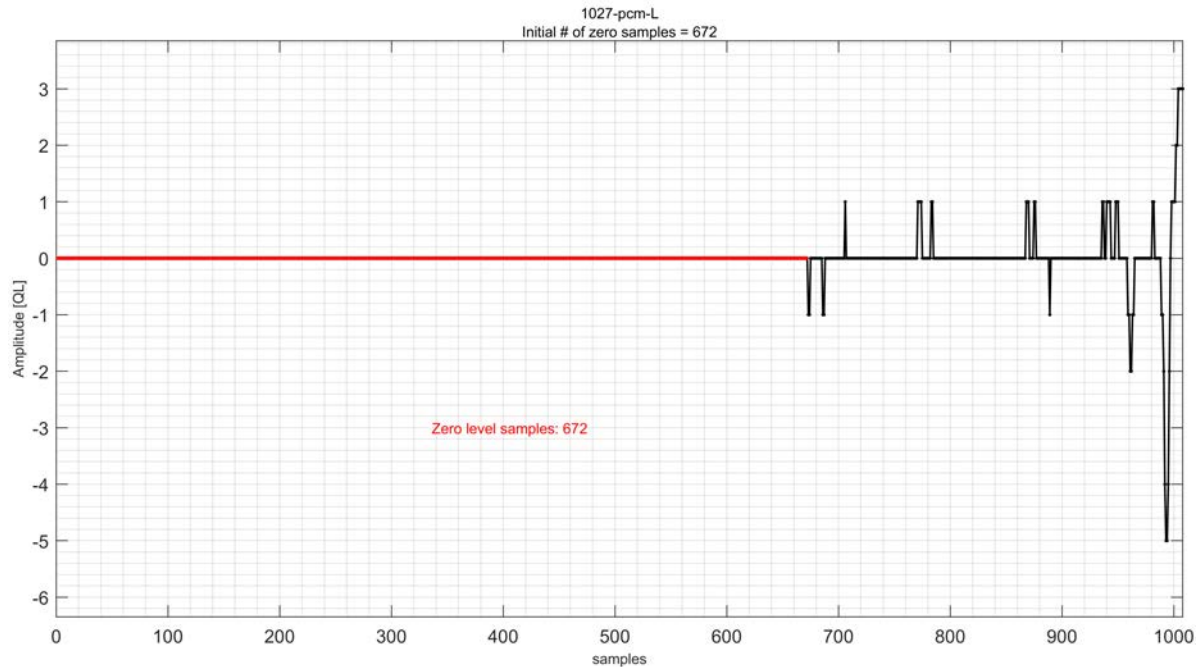
Previous Research

Literature Review

We understand from previous studies that MP3s (lossy format) have silence and or padding added to the files, known as Zero Level Samples (ZLS), which can indicate the generation of compression that exists within an MP3 file.

The methodology behind ZLS discussed in ‘Analysis of Zero-Level Sample Padding of Various Mp3 Codecs (Berman, Josh. 2013)’ requires MP3 files to be taken from its source (recording device) and transcoded by a decoder to a WAV file. The Wav file is then analyzed using The Long Term Average Sorted Spectrum (LTASS), noting the number of zeros.

Here is an example of MP3 padding



Left channel of Marantz Recording, decoded with Adobe Audition 3.0.1

The original hypothesis was that each generation of compression would introduce more padding (zeros) added to the compressed audio files. Both Berman and Yancy concluded that the results from their research did not display an increase in zeros per generation of compression across all applications used. It's for this reason that the analysis 'Zero Level Samples' could not be used on its own for authenticating an MP3 file.

Berman states "The MP3 standard states certain things that make an MP3 file readable by any decoder, however each decoder may decode the information differently". This is one gap in the study of MP3s that should be explored.

Purpose of the Study

The study aims to expand on previous research of MP3s and decoders by determining if there are any noticeable differences in the frequency domain of the audio file. Specifically, the cutoff frequency when transcoding the audio file from MP3 to WAV PCM using different transcoding tools. Hopefully, this study can be used as an aide alongside The Zero Level Samples Method to further audio authentication purposes.

CHAPTER II

MATERIALS

The MP3 Recording Devices Used

The following are recorders used in this study.

Table 4: Recording Devices

Recording Device	Kbps	Channels
Marantz PMD620	64/128/192	2 (Stereo)
Sony IC Recorder (ICD PX820)	128/192	2 (Stereo)
TASCAM DR-07	64/128/192	2 (Stereo)

The Transcoding Applications Used

The following applications in the table below were used to transcode the MP3s recorded with the recorders in the Table 4.

Table 5: Transcoding Applications

Application	Version/Build	MP3 Codec
Adobe Audition	3.0.1	Adobe
Adobe Audition 2021	Build 14.4.0.38	Adobe
dBpoweramp	16.6 [64-bit]	LAME 3.100
FFmpeg	v.git-2020-08-31-4a11a6f	LAME 3.100
iZotope RX9 Advanced	V9.1.0.1175 [64-bit]	LAME 3.99r
NCH Switch Plus	v.9.47	LAME 3.99r
Reaper	v.6.25	LAME 3.99.5/3.99r
SUPER	v.2000/Build 77	LAME 3.99.5

Each transcoding application has a MP3 decoding codec, this is needed to transcode the recorded MP3s into WAV files for LTASS analysis. All but two of the transcoding tools use the LAME (LAME Ain't an MP3 Encoder). LAME is an open source codec (free to the public) that allows MP3 encoding and decoding. Adobe uses its own proprietary codec for Adobe 2021 and 3.0.1.

Throughout this study, transcoders with the exception of Adobe Audition 3.0.1 and Adobe Audition 2021 may be referenced by shorthand or partial names. Table 5 shows Reaper v.6.25 as having two versions of lame, 3.99.5 and 3.99r. which were discovered during HEX analysis.

CHAPTER III

METHODOLOGY

The steps and procedures used to conduct this study revolve around recording 30 seconds (or more) of audio in the same acoustic environment using multiple handheld MP3 recorders with their factory stock microphones. The selection of audio recorders, recording environment and transcoding tools represented those found in a real-world environment.

The next step was to create forensic copies of all recorded audio files. This way, the original recordings remain persevered. Subsequently, the process involved creating several transcoded audio files with different transcoding applications.

Lastly, all transcoded audio files and original MP3s recorded by the MP3 recorders were analyzed and then documented, emphasizing the results in the frequency domain, the cut-off frequencies (COF).

In addition, the study does not provide the original MP3 cut-off frequency signature for each recording device as an extraction process does not exist at the time of this study.

Table 6: Transcoding Specifications:

Rate	Bit Depth	Mono/Stereo
44100kHz	16 Bit	Stereo

Audio File Analysis Process

The analysis of all audio files used the Long-Term Average Sorted Spectrum (LTASS). LTASS is the sorted version of Long Term Average Spectrum (LTAS) which displays an averaged representation of an audio recording. The reason why I'm analyzing the data using LTASS is for accuracy and to eliminate biasness and or false perception.

Recorders Used and Recording Settings

These recorders were chosen for this study because of their accessibility, ease of use and their features: Onboard stock microphones, battery powered and the ability to record at different settings.

MARANTZ – PMD620

- 64 kbps
- 128 kbps
- 192 kbps

SONY ICD PX820

- 128 kbps
- 192 kbps

TASCAM DR-07

- 64 kbps
- 128 kbps
- 192 kbps

The Sony ICD PX820's 64kbps recordings were omitted because they were mono and not stereo as needed for this research.

Looking at Fig 2 there are two concatenated spectrograms of recording DR000227. Fig 2.1 displays the same files, but zoomed in. The recording specifications for this file are as follows

Recorder: TASCAM DR-07 **Recording Spec:** 128 kbps **Transcoders used:** SUPER and Reaper v6.25.

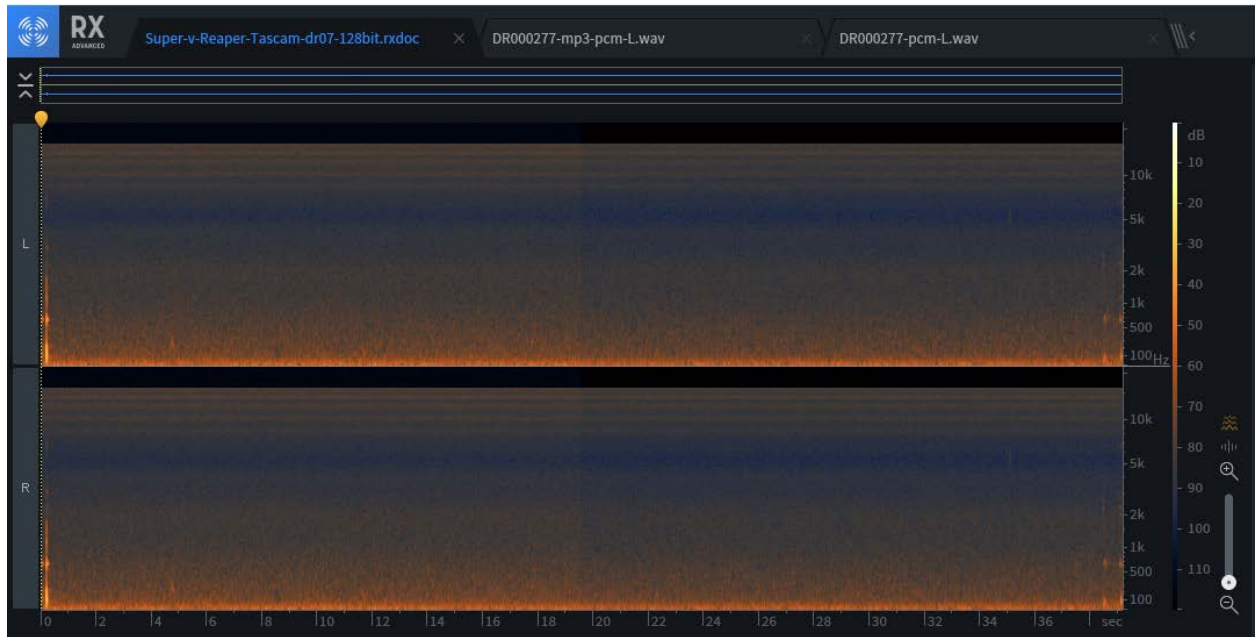


Figure 2: Concatenated Spectrogram view of SUPER (Left) and Reaper v6.25 (Right)

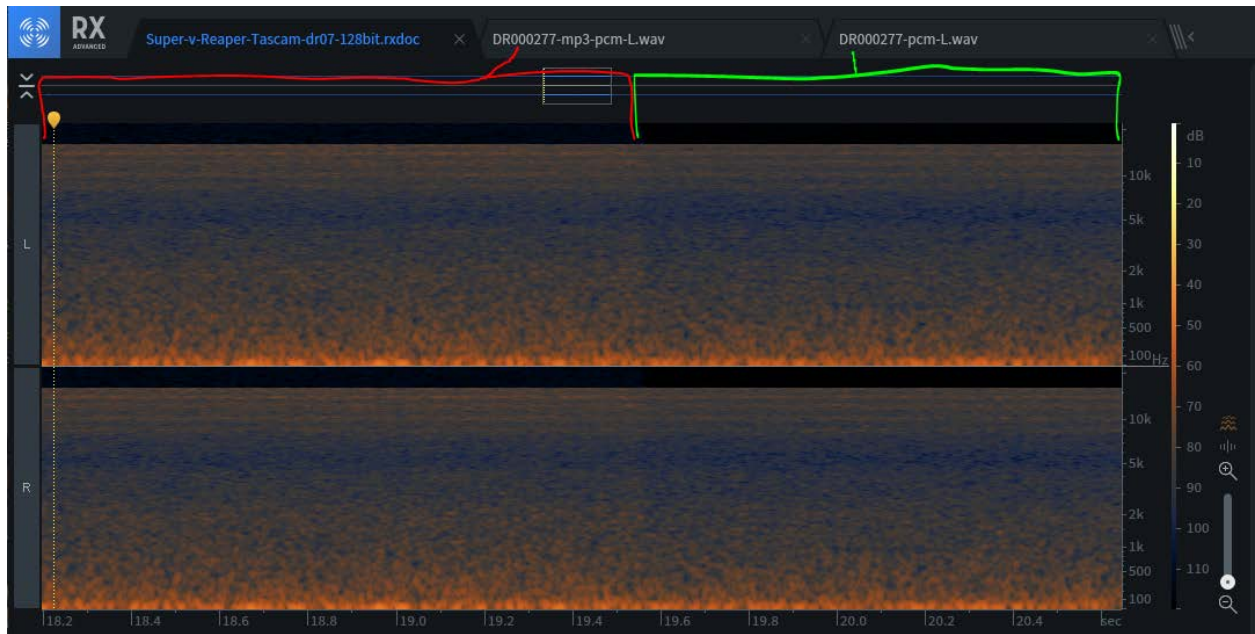


Figure 2.1: Concatenated Spectrogram view of SUPER (Left) and Reaper v6.25 (Right) Zoomed

The standard for authenticating MP3 files provides a procedure to follow and gives labs the freedom to use tools of their choice. However, different tools will equate to different results.

CHAPTER IV

RESULTS

The charts below summarize the test results by a test recording device, bit rate setting, and transcoding software tool based upon quantitative data from LTASS analysis.

MARANTZ PMD620 64kbps Recordings

Table 7: Test File 1027.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1027.MP3	Adobe Audition 3.0.1	9.8594	7898-7998	7895	10.275	7898-7998	7891
	Adobe Audition 2021	6.9754	7798-7898	7888	6.507	7798-7898	7888
	dBpoweramp 16.6 [64-bit]	9.8491	7898-7998	7895	10.275	7898-7998	7891
	FFmpeg	9.9137	7898-7998	7895	10.2493	7898-7998	7891
	iZotope RX9 Advanced	7.9445	7898-7998	7893	8.9306	7898-7998	7895
	NCH Switch Plus v.9.47	9.7711	7898-7998	7891	10.4103	7898-7998	7894
	Reaper v.6.25	9.8483	7898-7998	7894	10.3964	7898-7998	7894
	SUPER v.2000 Build 77	11.3096	7898-7998	7895	11.8421	7898-7998	7896

Table 8: Test File 1028.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1028.MP3	Adobe Audition 3.0.1	9.4861	7898-7998	7891	10.1281	7898-7998	7892
	Adobe Audition 2021	6.4829	7798-7898	7890	6.5529	98-198	7887
	dBpoweramp 16.6 [64-bit]	9.4901	7898-7998	7891	10.1281	7898-7998	7892
	FFmpeg	9.535	7898-7998	7891	10.1379	7898-7998	7899
	iZotope RX9 Advanced	9.3753	7898-7998	7894	8.183	7798-7898	7893
	NCH Switch Plus v.9.47	9.3956	7898-7998	7895	10.1686	7898-7998	7895
	Reaper v.6.25	9.6659	7898-7998	7892	10.2253	7898-7998	7896
	SUPER v.2000 Build 77	11.321	7898-7998	7892	11.3315	7898-7998	7893

Table 9: Test File 1029.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1029.MP3	Adobe Audition 3.0.1	9.0336	7898-7998	7896	9.6582	7898-7998	7893
	Adobe Audition 2021	6.8584	7798-7898	7889	7.0698	7798-7898	7888
	dBpoweramp 16.6 [64-bit]	9.0357	7898-7998	7896	9.6805	7898-7998	7893
	FFmpeg	8.982	7898-7998	7895	9.6913	7898-7998	7893
	iZotope RX9 Advanced	8.3076	7898-7998	7896	8.4608	7898-7998	7896
	NCH Switch Plus v.9.47	9.5693	7898-7998	7895	9.3138	7898-7998	7894
	Reaper v.6.25	9.0693	7898-7998	7894	9.6254	7898-7998	7894
	SUPER v.2000 Build 77	10.5688	7898-7998	7893	10.9411	7898-7998	7895

Table 10: Test File 1030.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1030.MP3	Adobe Audition 3.0.1	9.1542	7898-7998	7893	9.5277	7898-7998	7895
	Adobe Audition 2021	7.6794	7798-7898	7892	7.04	7798-7898	7888
	dBpoweramp 16.6 [64-bit]	9.151	7898-7998	7893	9.5277	7898-7998	7895
	FFmpeg	9.1476	7898-7998	7893	9.5003	7898-7998	7895
	iZotope RX9 Advanced	8.052	7798-7898	7891	8.0197	7798-7898	7901
	NCH Switch Plus v.9.47	8.8963	7898-7998	7892	8.976	7898-7998	7896
	Reaper v.6.25	8.9529	7898-7998	7896	9.1002	7898-7998	7894
	SUPER v.2000 Build 77	10.1864	7898-7998	7893	10.6259	7898-7998	7897

Table 11: Test File 1031.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1031.MP3	Adobe Audition 3.0.1	9.4122	7898-7998	7898	9.655	7898-7998	7891
	Adobe Audition 2021	7.1843	7798-7898	7893	6.8923	7798-7898	7897
	dBpoweramp 16.6 [64-bit]	9.3946	7898-7998	7898	9.633	7898-7998	7891
	FFmpeg	9.4135	7898-7998	7898	9.6709	7898-7998	7895
	iZotope RX9 Advanced	7.6858	7898-7898	7901	8.105	7898-7998	7895
	NCH Switch Plus v.9.47	9.5834	7898-7998	7895	9.3177	7898-7998	7892
	Reaper v.6.25	9.549	7898-7998	7893	9.5857	7898-7998	7894
	SUPER v.2000 Build 77	10.6253	7898-7998	7896	11.128	7898-7998	7895

Table 12: Test File 1032.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1032.MP3	Adobe Audition 3.0.1	10.0767	7898-7998	7893	10.0604	7898-7998	7893
	Adobe Audition 2021	7.2204	7798-7898	7891	7.1888	7798-7898	7890
	dBpoweramp 16.6 [64-bit]	10.0466	7898-7998	7893	10.0604	7898-7998	7893
	FFmpeg	10.0471	7898-7998	7893	10.0221	7898-7998	7893
	iZotope RX9 Advanced	8.5041	7898-7998	7894	8.0493	7898-7998	7894
	NCH Switch Plus v.9.47	9.8896	7898-7998	7891	9.5771	7898-7998	7895
	Reaper v.6.25	10.0788	7898-7998	7893	9.7886	7898-7998	7894
	SUPER v.2000 Build 77	11.4124	7898-7998	7892	10.7489	7898-7998	7894

Table 13: Test File 1033.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1033.MP3	Adobe Audition 3.0.1	10.043	7898-7998	7894	9.9728	7898-7998	7894
	Adobe Audition 2021	6.7541	7798-7898	7889	6.8536	7798-7898	7889
	dBpoweramp 16.6 [64-bit]	10.043	7898-7998	7894	9.9728	7898-7998	7894
	FFmpeg	10.0271	7898-7998	7894	9.9321	7898-7998	7894
	iZotope RX9 Advanced	8.6043	7898-7998	7890	8.9	7898-7998	7892
	NCH Switch Plus v.9.47	10.0338	7898-7998	7896	9.9409	7898-7998	7893
	Reaper v.6.25	9.7454	7898-7998	7891	10.2462	7898-7998	7899
	SUPER v.2000 Build 77	11.6412	7898-7998	7896	11.701	7898-7998	7895

Table 14: Test File 1034.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1034.MP3	Adobe Audition 3.0.1	9.7963	7898-7998	7891	10.5411	7898-7998	7893
	Adobe Audition 2021	6.6034	7798-7898	7898	6.5998	7898-7998	7888
	dBpoweramp 16.6 [64-bit]	9.7963	7898-7998	7891	10.5425	7898-7998	7893
	FFmpeg	9.7683	7898-7998	7891	10.5569	7898-7998	7893
	iZotope RX9 Advanced	8.5992	7898-7998	7892	8.306	7898-7998	7892
	NCH Switch Plus v.9.47	9.2542	7898-7998	7891	10.689	7898-7998	7891
	Reaper v.6.25	9.6051	7898-7998	7893	10.3047	7898-7998	7893
	SUPER v.2000 Build 77	10.8842	7898-7998	7897	11.3999	7898-7998	7892

Table 15: Test File 1035.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1035.MP3	Adobe Audition 3.0.1	9.6562	7898-7998	7899	9.1405	7898-7998	7893
	Adobe Audition 2021	7.0101	7798-7898	7886	7.1311	7798-7898	7890
	dBpoweramp 16.6 [64-bit]	9.6562	7898-7998	7899	9.1664	7898-7998	7893
	FFmpeg	9.674	7898-7998	7899	9.0977	7898-7998	7893
	iZotope RX9 Advanced	9.018	7898-7998	7892	8.8452	7898-7998	7897
	NCH Switch Plus v.9.47	9.2649	7898-7998	7894	9.4001	7898-7998	7892
	Reaper v.6.25	9.4615	7898-7998	7895	9.4889	7898-7998	7892
	SUPER v.2000 Build 77	10.99	7898-7998	7894	11.6466	7898-7998	7893

Table 16: Test File 1036.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1036.MP3	Adobe Audition 3.0.1	9.1165	7898-7998	7897	9.784	7898-7998	7894
	Adobe Audition 2021	7.0143	7798-7898	7890	7.8362	7798-7898	7895
	dBpoweramp 16.6 [64-bit]	9.1165	7898-7998	7897	9.784	7898-7998	7894
	FFmpeg	9.1298	7898-7998	7897	9.784	7898-7998	7894
	iZotope RX9 Advanced	8.1004	7898-7998	7896	8.6966	7898-7998	7892
	NCH Switch Plus v.9.47	8.9705	7898-7998	7894	9.7114	7898-7998	7892
	Reaper v.6.25	9.0582	7898-7998	7898	10.0465	7898-7998	7894
	SUPER v.2000 Build 77	10.4692	7898-7998	7893	11.5552	7898-7998	7893

The analysis of file 1027. MP3 display 3 transcoders sharing the same left and right cut off frequencies. Adobe Audition 3.0.1, dBpoweramp and FFmpeg use LAME 3.100 an Adobe uses its proprietary codec and share the following COFs Left = 7895/Right = 7981.

After analyzing file 1028.MP3 two of the previous three transcoders share COFs. Adobe Audition 3.01 and dBpoweramp COFs are $L = 7891/Right = 7892$.

Adobe Audition 2021 shows the same COF for its left and right (7888) channel when dealing with file 1027.MP3, but the left and right channel differ on file 1028.MP3. COF $L = 7890/R = 7887$.

File 1029.MP3 Adobe Audition 3.0.1 and dBpoweramp share the same COFs for the left and right channel (7896/7893). Izotope RX9 has the same COF for the left and right channel (7896/7896) and Reaper displays (7894/7894).

File 1030.MP3 Adobe Audition 3.0.1, dBpoweramp and FFmpeg share the same COFs (7893/7895). Izotope RX9 and Reaper no longer have the same COF in their respective left and right channels

Marantz PMD620 128kbps

Table 17: Test File 1001.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1001. MP3	Adobe Audition 3.0.1	9.4303	19598-19698	19605	6.0157	98-198	19601
	Adobe Audition 2021	5.8712	98-198	19607	3.7822	98-198	19601
	dBpoweramp 16.6 [64-bit]	9.4658	19598-19698	19605	6.0158	98-198	19601
	FFmpeg	9.4303	19598-19698	19605	5.988	98-198	19601
	iZotope RX9 Advanced	8.2608	19598-19698	19606	5.3585	98-198	19612
	NCH Switch Plus v.9.47	9.0627	19598-19698	19605	6.1007	19598-19698	19611
	Reaper v.6.25	9.2119	19598-19698	19613	6.132	19598-19698	19601
	SUPER v.2000 Build 77	10.9297	19598-19698	19605	7.6113	19598-19698	19603

Table 18: Test File 1002.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1002. MP3	Adobe Audition 3.0.1	8.1606	19598-19698	19605	8.7739	19598-19698	19607
	Adobe Audition 2021	4.9041	98-198	19590	4.8934	98-198	19606
	dBpoweramp 16.6 [64-bit]	8.1525	19598-19698	19605	8.7739	19598-19698	19607
	FFmpeg	8.1332	19598-19698	19605	8.8161	19598-19698	19607
	iZotope RX9 Advanced	6.8887	19598-19698	19601	7.4608	19598-19698	19601
	NCH Switch Plus v.9.47	7.7407	19598-19698	19603	9.0174	19598-19698	19619
	Reaper v.6.25	7.7177	19598-19698	19602	8.8534	19598-19698	19605
	SUPER v.2000 Build 77	9.172	19598-19698	19603	10.4865	19598-19698	19607

Table 19: Test File 1003.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1003. MP3	Adobe Audition 3.0.1	7.225	19598-19698	19605	7.2135	19598-19698	19609
	Adobe Audition 2021	3.9725	98-198	19610	4.3039	98-198	19600
	dBpoweramp 16.6 [64-bit]	7.259	19598-19698	19605	7.2238	19598-19698	19609
	FFmpeg	7.2396	19598-19698	19606	7.2224	19598-19698	19609
	iZotope RX9 Advanced	6.2659	98-198	19600	5.7938	19598-19698	19600
	NCH Switch Plus v.9.47	6.9559	19598-19698	19605	7.0328	19598-19698	19604
	Reaper v.6.25	7.2625	19598-19698	19604	7.2508	19598-19698	19597
	SUPER v.2000 Build 77	9.1006	19598-19698	19603	8.8095	19598-19698	19603

Table 20: Test File 1004.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1004. MP3	Adobe Audition 3.0.1	8.9576	19598-19698	19604	7.8866	19598-19698	19603
	Adobe Audition 2021	5.6984	98-198	19599	4.8518	98-198	19609
	dBpoweramp 16.6 [64-bit]	8.9511	19598-19698	19604	7.8866	19598-19698	19603
	FFmpeg	8.9645	19598-19698	19604	7.8636	19598-19698	19603
	iZotope RX9 Advanced	7.5725	19598-19698	19607	6.4379	19598-19698	19606
	NCH Switch Plus v.9.47	9.2323	19598-19698	19609	6.7738	19598-19698	19604
	Reaper v.6.25	9.1064	19598-19698	19605	7.6882	19598-19698	19601
	SUPER v.2000 Build 77	10.609	19598-19698	19607	9.106	19598-19698	19609

Table 21: Test File 1005.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1005. MP3	Adobe Audition 3.0.1	8.2709	19598-19698	19607	8.1334	19598-19698	19603
	Adobe Audition 2021	4.7123	98-198	19597	4.8736	98-198	19593
	dBpoweramp 16.6 [64-bit]	8.2709	19598-19698	19607	8.1334	19598-19698	19605
	FFmpeg	8.252	19598-19698	19607	8.1337	19598-19698	19605
	iZotope RX9 Advanced	6.4541	19598-19698	19598	6.8489	19598-19698	19609
	NCH Switch Plus v.9.47	8.2225	19598-19698	19602	7.4663	19598-19698	19602
	Reaper v.6.25	7.8373	19598-19698	19609	8.2037	19598-19698	19610
	SUPER v.2000 Build 77	9.0469	19598-19698	19605	9.8429	19598-19698	19603

Table 22: Test File 1006.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1006. MP3	Adobe Audition 3.0.1	7.8282	19598-19698	19608	8.4797	19598-19698	19601
	Adobe Audition 2021	5.0295	98-198	19598	5.1981	98-198	19603
	dBpoweramp 16.6 [64-bit]	7.8282	19598-19698	19608	8.5216	19598-19698	19601
	FFmpeg	7.8127	19598-19698	19608	8.4648	19598-19698	19601
	iZotope RX9 Advanced	7.0692	19598-19698	19603	7.0007	19598-19698	19600
	NCH Switch Plus v.9.47	7.9982	19598-19698	19604	8.5559	19598-19698	19602
	Reaper v.6.25	8.1201	19598-19698	19605	8.3103	19598-19698	19604
	SUPER v.2000 Build 77	10.0187	19598-19698	19611	9.8221	19598-19698	19604

Table 23: Test File 1007.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1007. MP3	Adobe Audition 3.0.1	8.2211	19598-19698	19602	8.3335	19598-19698	19608
	Adobe Audition 2021	4.585	98-198	19603	4.0898	98-198	19604
	dBpoweramp 16.6 [64-bit]	8.2344	19598-19698	19602	8.3335	19598-19698	19604
	FFmpeg	8.2404	19598-19698	19601	8.3419	19598-19698	19604
	iZotope RX9 Advanced	7.0736	19598-19698	19606	5.7797	98-198	19605
	NCH Switch Plus v.9.47	8.4089	19598-19698	19605	7.0516	19598-19698	19602
	Reaper v.6.25	8.4295	19598-19698	19601	8.1218	19598-19698	19610
	SUPER v.2000 Build 77	9.7679	19598-19698	19602	9.0818	19598-19698	19605

Table 24: Test File 1008.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1008. MP3	Adobe Audition 3.0.1	5.6977	19498-19598	19598	5.8014	19598-19698	19601
	Adobe Audition 2021	4.549	98-198	19593	3.8238	98-198	19591
	dBpoweramp 16.6 [64-bit]	5.6977	19498-19598	19599	5.8126	19598-19698	19601
	FFmpeg	5.7048	19498-19598	19598	5.8178	19598-19698	19601
	iZotope RX9 Advanced	5.3629	98-198	19603	5.0327	98-198	19599
	NCH Switch Plus v.9.47	5.7309	19498-19598	19602	5.701	19498-19598	19598
	Reaper v.6.25	5.7494	19598-19698	19601	5.9272	19598-19698	19604
	SUPER v.2000 Build 77	7.3301	19598-19698	19598	6.9364	19598-19698	19598

Table 25: Test File 1009.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1009. MP3	Adobe Audition 3.0.1	5.6091	98-198	19602	5.0819	98-198	19594
	Adobe Audition 2021	3.5947	98-198	19611	3.4815	98-198	19595
	dBpoweramp 16.6 [64-bit]	5.6091	98-198	19599	5.0819	98-198	19594
	FFmpeg	5.5997	98-198	19603	5.0846	98-198	19594
	iZotope RX9 Advanced	5.0498	98-198	19606	4.684	98-198	19599
	NCH Switch Plus v.9.47	5.969	98-198	19602	5.2765	98-198	19592
	Reaper v.6.25	5.6802	98-198	19608	5.1681	98-198	19599
	SUPER v.2000 Build 77	6.2091	19598-19698	19606	5.9524	19498-19598	19596

Table 26: Test File 1010.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1010. MP3	Adobe Audition 3.0.1	4.5692	98-198	19599	5.3353	98-198	19607
	Adobe Audition 2021	3.2269	98-198	19594	3.31	98-198	19608
	dBpoweramp 16.6 [64-bit]	4.5625	98-198	19599	5.3353	98-198	19607
	FFmpeg	4.5592	98-198	19599	5.2816	98-198	19607
	iZotope RX9 Advanced	3.9277	98-198	19600	4.8748	98-198	19602
	NCH Switch Plus v.9.47	4.4419	98-198	19605	5.1029	98-198	19598
	Reaper v.6.25	4.8281	98-198	19601	5.3073	98-198	19609
	SUPER v.2000 Build 77	5.1761	98-198	19605	6.211	98-198	19608

The analysis of the Marantz PMD 620 recorder at 128kbs displays Adobe Audition 3.0.1, dbpoweramp, and FFmpeg share the same left and right cut-off frequencies on the following recordings.

1001.MP3: 19605/19601

1002.MP3: 19605/19607

1004.MP3:19606/19609

1006.MP3:19608/19601

1010.MP3:19599/19607

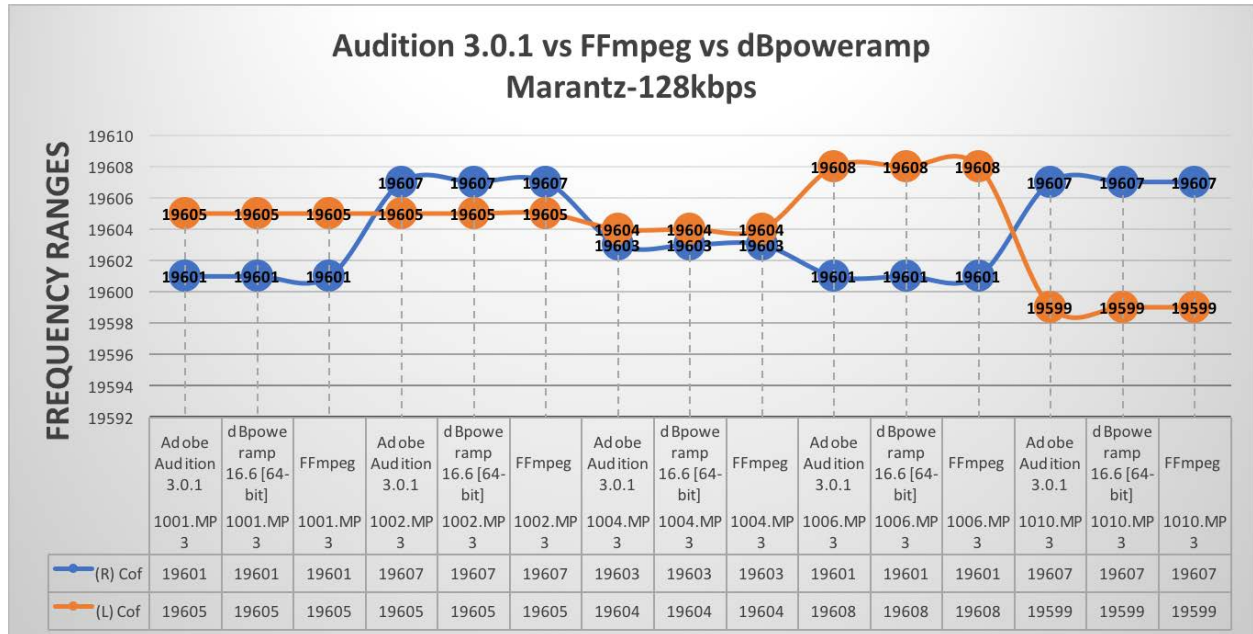


Figure 3: Chart displays relationship between Adobe Audition 3.0.1, FFmpeg and dBpoweramp

In 20% of the recordings, Izotope RX9 displays consistent cut off frequencies between the left and right channels of recordings 1002.MP3 and 1003.MP3. NCH Switch Plus accounts for 10% of the recordings where the left and right channels share the same cutoff frequency. SUPER v.2000 also accounts for 20% of recordings where left and right channels share the same COF. Those recordings are 1003.MP3 and 1008.MP3.

Marantz PMD620 192kbps

Table 27: Test File 1013.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1013.MP3	Adobe Audition 3.0.1	24.531	19598-19698	19628	25.1371	19598-19698	19632
	Adobe Audition 2021	20.706	19598-19698	19632	20.9361	19598-19698	19629
	dBpoweramp 16.6 [64-bit]	24.5068	19598-19698	19628	25.1371	19598-19698	19632
	FFmpeg	24.525	19598-19698	19628	25.0873	19598-19698	19632
	iZotope RX9 Advanced	21.8567	19598-19698	19637	22.0816	19598-19698	19637
	NCH Switch Plus v.9.47	24.8115	19598-19698	19626	24.8927	19598-19698	19636
	Reaper v.6.25	24.7783	19598-19698	19630	25.1109	19598-19698	19636
	SUPER v.2000 Build 77	25.6435	19598-19698	19634	26.2252	19598-19698	19638

Table 28: Test File 1014.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1014.MP3	Adobe Audition 3.0.1	24.7705	19598-19698	19634	24.7902	19598-19698	19635
	Adobe Audition 2021	21.0128	19598-19698	19623	20.6535	19598-19698	19630
	dBpoweramp 16.6 [64-bit]	24.7405	19598-19698	19634	24.7902	19598-19698	19635
	FFmpeg	24.7341	19598-19698	19635	24.8342	19598-19698	19635
	iZotope RX9 Advanced	21.6573	19598-19698	19619	22.0508	19598-19698	19625
	NCH Switch Plus v.9.47	24.7992	19598-19698	19631	24.8057	19598-19698	19631
	Reaper v.6.25	24.8849	19598-19698	19635	24.6914	19598-19698	19631
	SUPER v.2000 Build 77	25.8676	19598-19698	19635	25.35	19598-19698	19631

Table 29: Test File 1015.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1015.MP3	Adobe Audition 3.0.1	24.4805	19598-19698	19634	26.0118	19598-19698	19631
	Adobe Audition 2021	20.6644	19598-19698	19614	22.0804	19598-19698	19627
	dBpoweramp 16.6 [64-bit]	24.471	19598-19698	19634	26.0118	19598-19698	19631
	FFmpeg	24.4991	19598-19698	19634	25.9693	19598-19698	19631
	iZotope RX9 Advanced	21.9157	19598-19698	19630	23.052	19598-19698	19634
	NCH Switch Plus v.9.47	24.3929	19598-19698	19636	25.4462	19598-19698	19635
	Reaper v.6.25	24.5494	19598-19698	19634	25.435	19598-19698	19630
	SUPER v.2000 Build 77	25.809	19598-19698	19634	26.6007	19598-19698	19635

Table 30: Test File 1016.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1016.MP3	Adobe Audition 3.0.1	24.8394	19598-19698	19633	25.8431	19598-19698	19638
	Adobe Audition 2021	20.4727	19598-19698	19615	21.954	19598-19698	19633
	dBpoweramp 16.6 [64-bit]	24.8394	19598-19698	19633	25.8431	19598-19698	19638
	FFmpeg	24.7999	19598-19698	19633	25.8187	19598-19698	19638
	iZotope RX9 Advanced	21.7694	19598-19698	19627	23.6508	19598-19698	19635
	NCH Switch Plus v.9.47	24.7029	19598-19698	19637	25.948	19598-19698	19629
	Reaper v.6.25	24.3718	19598-19698	19633	25.9653	19598-19698	19638
	SUPER v.2000 Build 77	25.9077	19598-19698	19634	27.0385	19598-19698	19638

Table 31: Test File 1017.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1017.MP3	Adobe Audition 3.0.1	25.1701	19598-19698	19634	25.658	19598-19698	19635
	Adobe Audition 2021	20.6675	19598-19698	19628	21.618	19598-19698	19631
	dBpoweramp 16.6 [64-bit]	25.1709	19598-19698	19634	25.6513	19598-19698	19635
	FFmpeg	25.1934	19598-19698	19634	25.658	19598-19698	19635
	iZotope RX9 Advanced	22.5243	19598-19698	19622	23.1697	19598-19698	19622
	NCH Switch Plus v.9.47	25.1704	19598-19698	19631	25.2729	19598-19698	19633
	Reaper v.6.25	25.2167	19598-19698	19633	25.7811	19598-19698	19636
	SUPER v.2000 Build 77	26.1118	19598-19698	19629	26.6398	19598-19698	19636

Table 32: Test File 1018.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1018.MP3	Adobe Audition 3.0.1	24.7096	19598-19698	19631	25.8739	19598-19698	19636
	Adobe Audition 2021	20.905	19598-19698	19611	21.606	19598-19698	19633
	dBpoweramp 16.6 [64-bit]	24.6877	19598-19698	19631	25.8767	19598-19698	19636
	FFmpeg	24.7624	19598-19698	19631	25.8598	19598-19698	19636
	iZotope RX9 Advanced	22.0808	19598-19698	19632	23.1957	19598-19698	19631
	NCH Switch Plus v.9.47	24.9893	19598-19698	19632	25.5903	19598-19698	19636
	Reaper v.6.25	24.7605	19598-19698	19632	25.7012	19598-19698	19637
	SUPER v.2000 Build 77	26.1955	19598-19698	19633	26.969	19598-19698	19633

Table 33: Test File 1019.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1019.MP3	Adobe Audition 3.0.1	25.0876	19598-19698	19628	25.2712	19598-19698	19635
	Adobe Audition 2021	21.0637	19598-19698	19631	21.5447	19598-19698	19627
	dBpoweramp 16.6 [64-bit]	25.0876	19598-19698	19631	25.2712	19598-19698	19635
	FFmpeg	25.1554	19598-19698	19631	25.2539	19598-19698	19635
	iZotope RX9 Advanced	22.1509	19598-19698	19635	22.6372	19598-19698	19634
	NCH Switch Plus v.9.47	25.0103	19598-19698	19636	24.9704	19598-19698	19631
	Reaper v.6.25	24.862	19598-19698	19634	24.9584	19598-19698	19636
	SUPER v.2000 Build 77	25.8747	19598-19698	19633	26.1167	19598-19698	19635

Table 34: Test File 1020.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1020.MP3	Adobe Audition 3.0.1	24.2749	19598-19698	19633	26.2772	19598-19698	19636
	Adobe Audition 2021	20.9264	19598-19698	19623	22.3648	19598-19698	19628
	dBpoweramp 16.6 [64-bit]	24.2686	19598-19698	19633	26.3193	19598-19698	19636
	FFmpeg	24.2736	19598-19698	19631	26.3183	19598-19698	19636
	iZotope RX9 Advanced	21.6623	19598-19698	19631	23.3041	19598-19698	19630
	NCH Switch Plus v.9.47	24.3442	19598-19698	19630	26.4802	19598-19698	19635
	Reaper v.6.25	24.4542	19598-19698	19634	26.2933	19598-19698	19636
	SUPER v.2000 Build 77	25.7256	19598-19698	19633	27.675	19598-19698	19632

Table 35: Test File 1021.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1021.MP3	Adobe Audition 3.0.1	24.4531	19598-19698	19623	25.1262	19598-19698	19634
	Adobe Audition 2021	20.4318	19598-19698	19633	21.6361	19598-19698	19630
	dBpoweramp 16.6 [64-bit]	24.4549	19598-19698	19623	25.1262	19598-19698	19634
	FFmpeg	24.4604	19598-19698	19623	25.107	19598-19698	19634
	iZotope RX9 Advanced	21.7011	19598-19698	19627	22.9657	19598-19698	19623
	NCH Switch Plus v.9.47	24.7134	19598-19698	19626	25.3861	19598-19698	19635
	Reaper v.6.25	24.6242	19598-19698	19632	25.5133	19598-19698	19634
	SUPER v.2000 Build 77	25.8658	19598-19698	19630	26.3225	19598-19698	19635

Table 36: Test File 1022.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
1022.MP3	Adobe Audition 3.0.1	25.3402	19598-19698	19631	25.747	19598-19698	19629
	Adobe Audition 2021	20.8208	19598-19698	19627	21.6675	19598-19698	19627
	dBpoweramp 16.6 [64-bit]	25.3402	19598-19698	19631	25.747	19598-19698	19629
	FFmpeg	25.3402	19598-19698	19631	25.7278	19598-19698	19629
	iZotope RX9 Advanced	22.4537	19598-19698	19618	22.7857	19598-19698	19632
	NCH Switch Plus v.9.47	25.3959	19598-19698	19633	25.506	19598-19698	19628
	Reaper v.6.25	25.2435	19598-19698	19627	25.4756	19598-19698	19629
	SUPER v.2000 Build 77	26.1113	19598-19698	19639	26.7733	19598-19698	19634

Adobe Audition 3.0.1, dBpoweramp, and FFmpeg account for 70% of the transcoders sharing the COFs in the left and right channels of the following recordings

1013.MP3

1015.MP3

1016.MP3

1017.MP3

1018.MP3

1021.MP3

1022.MP3

Additionally, Reaper v.6.25 shares left and right channel COF with Adobe Audition 3.0.1, dBpoweramp and FFmpeg on recordings 1016.MP3 and 1020.MP3. Reaper v.6.25 and SUPER v.2000 both share a left turn right cut off frequency on recording 1014.MP3

Shared COF (Reaper v6.25 and SUPER v.2000)

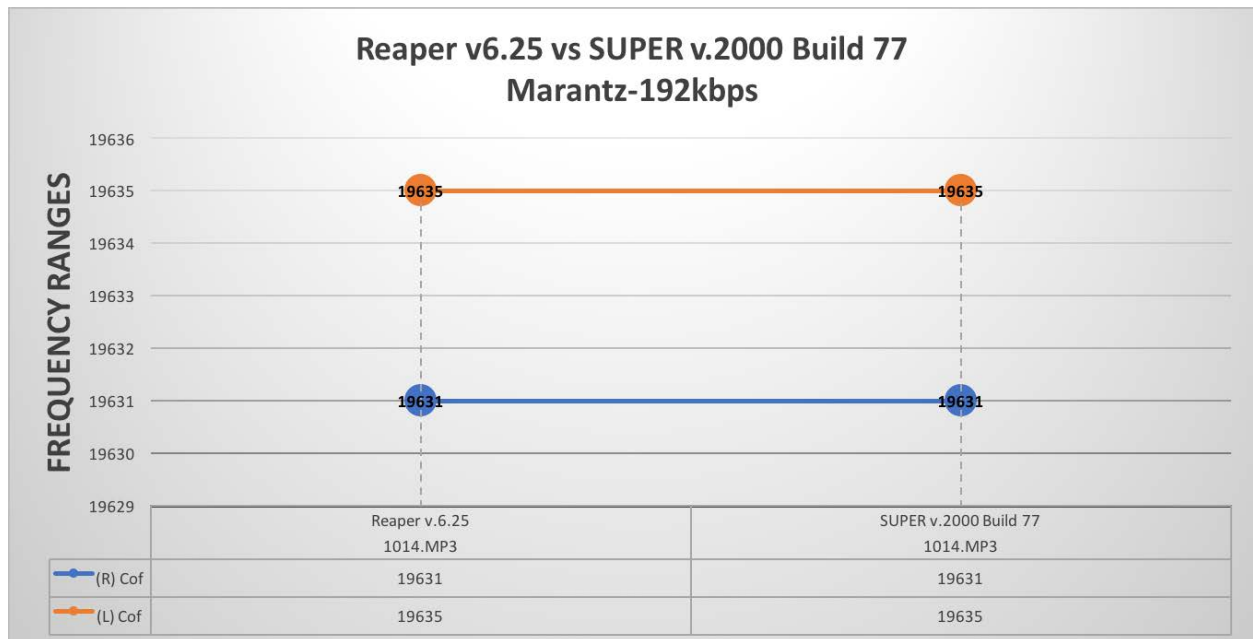


Figure 4: Reaper/SUPER shared Cut Off Frequencies Recording 1014.MP3

TASCAM DR-07 64kbps

Table 37: Test File DR000315.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0315	Adobe Audition 3.0.1	30.3144	15998-16098	16048	30.3338	15998-16098	16048
	Adobe Audition 2021	29.323	15998-16098	16046	29.293	15998-16098	16047
	dBpoweramp 16.6 [64-bit]	30.2502	15998-16098	16047	30.4001	15998-16098	16047
	FFmpeg	30.2468	15998-16098	16047	30.4167	15998-16098	16047
	iZotope RX9 Advanced	29.8714	15998-16098	16045	29.9538	15998-16098	16045
	NCH Switch Plus v.9.47	30.021	15998-16098	16051	29.9577	15998-16098	16051
	Reaper v.6.25	29.7926	15998-16098	16046	29.8661	15998-16098	16045
	SUPER v.2000 Build 77	30.5391	15998-16098	16045	30.3604	15998-16098	16051

Table 38: Test File DR000316.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0316	Adobe Audition 3.0.1	29.9769	15998-16098	16043	30.1074	15998-16098	16052
	Adobe Audition 2021	28.8346	15998-16098	16042	28.7824	15998-16098	16047
	dBpoweramp 16.6 [64-bit]	30.2262	15998-16098	16043	30.3494	15998-16098	16052
	FFmpeg	30.1921	15998-16098	16047	30.3222	15998-16098	16052
	iZotope RX9 Advanced	30.4075	15998-16098	16050	30.4033	15998-16098	16048
	NCH Switch Plus v.9.47	30.2824	15998-16098	16049	29.9709	15998-16098	16051
	Reaper v.6.25	30.3784	15998-16098	16044	30.2593	15998-16098	16049
	SUPER v.2000 Build 77	30.3528	15998-16098	16042	30.6603	15998-16098	16046

Table 39: Test File DR000317.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0317	Adobe Audition 3.0.1	30.4958	15998-16098	16051	30.6642	15998-16098	16051
	Adobe Audition 2021	28.6529	15998-16098	16050	29.2409	15998-16098	16048
	dBpoweramp 16.6 [64-bit]	30.7722	15998-16098	16050	30.6221	15998-16098	16051
	FFmpeg	30.7796	15998-16098	16050	30.651	15998-16098	16051
	iZotope RX9 Advanced	31.1016	15998-16098	16052	30.9936	15998-16098	16051
	NCH Switch Plus v.9.47	30.4982	15998-16098	16044	30.5747	15998-16098	16052
	Reaper v.6.25	31.0113	15998-16098	16049	31.0481	15998-16098	16047
	SUPER v.2000 Build 77	30.5681	15998-16098	16046	30.5756	15998-16098	16078

Table 40: Test File DR000318.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0318	Adobe Audition 3.0.1	30.0836	15998-16098	16047	30.377	15998-16098	16049
	Adobe Audition 2021	29.0332	15998-16098	16044	29.0672	15998-16098	16045
	dBpoweramp 16.6 [64-bit]	30.1042	15998-16098	16048	30.3041	15998-16098	16050
	FFmpeg	30.1277	15998-16098	16048	30.3092	15998-16098	16050
	iZotope RX9 Advanced	29.995	15998-16098	16042	30.1234	15998-16098	16042
	NCH Switch Plus v.9.47	30.2231	15998-16098	16048	30.1469	15998-16098	16048
	Reaper v.6.25	30.2043	15998-16098	16047	30.17	15998-16098	16045
	SUPER v.2000 Build 77	30.8189	15998-16098	16046	30.7476	15998-16098	16050

Table 41: Test File DR000319.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0319	Adobe Audition 3.0.1	30.1996	15998-16098	16049	30.0148	15998-16098	16050
	Adobe Audition 2021	29.3567	15998-16098	16041	28.8729	15998-16098	16052
	dBpoweramp 16.6 [64-bit]	30.2199	15998-16098	16050	30.1487	15998-16098	16050
	FFmpeg	30.1996	15998-16098	16049	30.1687	15998-16098	16050
	iZotope RX9 Advanced	30.3454	15998-16098	16051	30.2857	15998-16098	16049
	NCH Switch Plus v.9.47	30.6028	15998-16098	16048	30.4453	15998-16098	16049
	Reaper v.6.25	30.2308	15998-16098	16049	30.4753	15998-16098	16051
	SUPER v.2000 Build 77	30.8142	15998-16098	16074	30.7893	15998-16098	16052

Table 42: Test File DR000320.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0320	Adobe Audition 3.0.1	29.8195	15998-16098	16051	29.7828	15998-16098	16046
	Adobe Audition 2021	28.6853	15998-16098	16044	28.7584	15998-16098	16048
	dBpoweramp 16.6 [64-bit]	29.9445	15998-16098	16044	30.0642	15998-16098	16045
	FFmpeg	29.9528	15998-16098	16044	30.0784	15998-16098	16045
	iZotope RX9 Advanced	29.4547	15998-16098	16043	29.5611	15998-16098	16045
	NCH Switch Plus v.9.47	29.2657	15998-16098	16051	29.1591	15998-16098	16050
	Reaper v.6.25	29.5675	15998-16098	16043	29.5422	15998-16098	16043
	SUPER v.2000 Build 77	30.3388	15998-16098	16043	30.3944	15998-16098	16050

Table 43: Test File DR000321.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0321	Adobe Audition 3.0.1	30.692	15998-16098	16051	30.6295	15998-16098	16044
	Adobe Audition 2021	29.2006	15998-16098	16048	29.7103	15998-16098	16049
	dBpoweramp 16.6 [64-bit]	30.7726	15998-16098	16043	30.6262	15998-16098	16041
	FFmpeg	30.8263	15998-16098	16042	30.6108	15998-16098	16040
	iZotope RX9 Advanced	30.684	15998-16098	16048	30.7444	15998-16098	16045
	NCH Switch Plus v.9.47	30.7079	15998-16098	16052	30.4811	15998-16098	16048
	Reaper v.6.25	30.7292	15998-16098	16049	30.6942	15998-16098	16045
	SUPER v.2000 Build 77	30.841	15998-16098	16051	30.8724	15998-16098	16044

Table 44: Test File DR000322.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0322	Adobe Audition 3.0.1	30.0689	15998-16098	16045	30.0362	15998-16098	16045
	Adobe Audition 2021	28.9736	15998-16098	16046	28.965	15998-16098	16045
	dBpoweramp 16.6 [64-bit]	30.1445	15998-16098	16045	30.1242	15998-16098	16045
	FFmpeg	30.124	15998-16098	16045	30.0688	15998-16098	16045
	iZotope RX9 Advanced	30.0821	15998-16098	16045	30.124	15998-16098	16045
	NCH Switch Plus v.9.47	29.8319	15998-16098	16046	29.5713	15998-16098	16046
	Reaper v.6.25	30.2147	15998-16098	16045	30.17	15998-16098	16045
	SUPER v.2000 Build 77	29.7852	15998-16098	16048	29.8049	15998-16098	16051

Table 45: Test File DR000323.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR000323	Adobe Audition 3.0.1	30.7397	15998-16098	16051	30.793	15998-16098	16048
	Adobe Audition 2021	29.6898	15998-16098	16051	29.3541	15998-16098	16046
	dBpoweramp 16.6 [64-bit]	30.6568	15998-16098	16051	30.7047	15998-16098	16040
	FFmpeg	30.6603	15998-16098	16051	30.6655	15998-16098	16040
	iZotope RX9 Advanced	30.5486	15998-16098	16048	30.6116	15998-16098	16051
	NCH Switch Plus v.9.47	31.0339	15998-16098	16040	30.9801	15998-16098	16050
	Reaper v.6.25	30.5657	15998-16098	16051	30.397	15998-16098	16051
	SUPER v.2000 Build 77	30.9224	15998-16098	16045	30.9437	15998-16098	16045

Table 46: Test File DR000324.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR000324	Adobe Audition 3.0.1	30.7952	15998-16098	16051	30.6511	15998-16098	16041
	Adobe Audition 2021	29.8445	15998-16098	16041	29.9108	15998-16098	16040
	dBpoweramp 16.6 [64-bit]	30.7562	15998-16098	16052	30.6745	15998-16098	16040
	FFmpeg	30.7741	15998-16098	16052	30.6918	15998-16098	16049
	iZotope RX9 Advanced	30.7873	15998-16098	16052	30.8508	15998-16098	16052
	NCH Switch Plus v.9.47	30.9868	15998-16098	16042	31.2159	15998-16098	16046
	Reaper v.6.25	30.8003	15998-16098	16041	31.0018	15998-16098	16052
	SUPER v.2000 Build 77	31.2464	15998-16098	16043	31.1129	15998-16098	16043

The analysis of file DR000315.MP3 transcodings shows variations of different cut off frequencies in the left and right channels. Some transcoders share cut off frequencies in the left or right but few share the cut off frequencies of the left and right channels. Five of the eight transcoding tools displayed the same left and right cut off frequency for file

DR000322.MP3.Shared COF of Tools

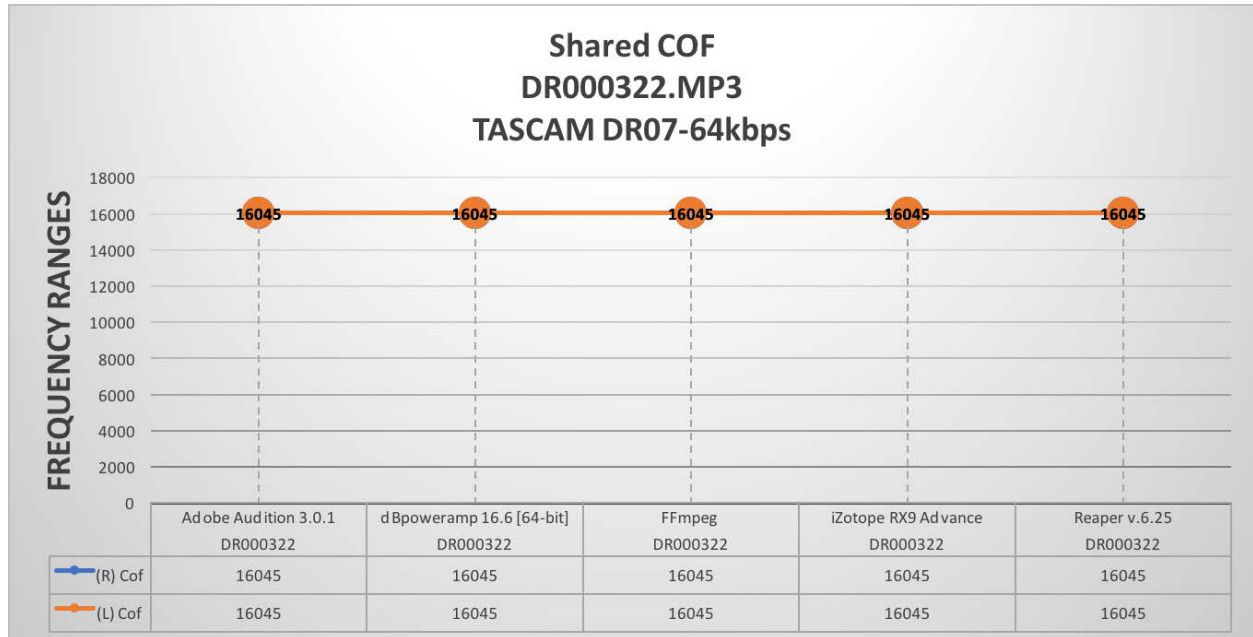


Figure 5: Adobe Audition 3.0.1, dBpoweramp 16.6, FFmpeg, RX9 Advanced, Reaper v6.25 COF(s)

SUPER also shares the cut-off frequencies of 16045/16045 but on DR000323.MP3 instead of DR000322.MP3. Izotope shares another instance of the COF match on recording DR000315.MP3. dBpoweramp and FFmpeg account for over 60% of the matched cut off frequencies in this data set.

The remaining transcoders vary in cutoff frequencies or they share cut off frequencies that are not associated with the same recording file(s).

TASCAM DR-07 128kbps

Table 47: Test File DR000277.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0277	Adobe Audition 3.0.1	29.2507	15998-16098	16040	29.2507	15998-16098	16040
	Adobe Audition 2021	28.5044	15998-16098	16047	28.467	15998-16098	16043
	dBpoweramp 16.6 [64-bit]	29.2976	15998-16098	16040	29.4851	15998-16098	16044
	FFmpeg	29.3608	15998-16098	16040	29.482	15998-16098	16043
	iZotope RX9 Advanced	29.536	15998-16098	16042	29.4331	15998-16098	16041
	NCH Switch Plus v.9.47	29.7524	15998-16098	16044	29.8515	15998-16098	16044
	Reaper v.6.25	29.4838	15998-16098	16048	29.539	15998-16098	16041
	SUPER v.2000 Build 77	28.5956	15998-16098	16041	28.4366	15998-16098	16046

Table 48: Test File DR000278.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0278	Adobe Audition 3.0.1	30.0197	15998-16098	16051	30.0197	15998-16098	16051
	Adobe Audition 2021	28.6117	15998-16098	16049	28.5526	15998-16098	16046
	dBpoweramp 16.6 [64-bit]	30.2404	15998-16098	16045	30.2737	15998-16098	16046
	FFmpeg	30.195	15998-16098	16044	30.2882	15998-16098	16047
	iZotope RX9 Advanced	30.2207	15998-16098	16047	30.3385	15998-16098	16047
	NCH Switch Plus v.9.47	29.6422	15998-16098	16050	29.6492	15998-16098	16043
	Reaper v.6.25	29.9563	15998-16098	16049	30.0738	15998-16098	16047
	SUPER v.2000 Build 77	28.9029	15998-16098	16050	29.1061	15998-16098	16041

Table 49: Test File DR000279.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0279	Adobe Audition 3.0.1	30.4053	15998-16098	16046	30.4053	15998-16098	16046
	Adobe Audition 2021	28.7673	15998-16098	16045	28.801	15998-16098	16051
	dBpoweramp 16.6 [64-bit]	30.2774	15998-16098	16045	30.4044	15998-16098	16044
	FFmpeg	30.3379	15998-16098	16045	30.3505	15998-16098	16044
	iZotope RX9 Advanced	30.5611	15998-16098	16045	30.3089	15998-16098	16040
	NCH Switch Plus v.9.47	30.0529	15998-16098	16050	30.324	15998-16098	16042
	Reaper v.6.25	30.5256	15998-16098	16044	30.3073	15998-16098	16040
	SUPER v.2000 Build 77	29.0852	15998-16098	16041	29.0465	15998-16098	16047

Table 50: Test File DR000280.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0280	Adobe Audition 3.0.1	29.9947	15998-16098	16048	29.9947	15998-16098	16048
	Adobe Audition 2021	28.8782	15998-16098	16042	28.6901	15998-16098	16047
	dBpoweramp 16.6 [64-bit]	30.0816	15998-16098	16048	29.876	15998-16098	16048
	FFmpeg	30.1393	15998-16098	16049	29.8705	15998-16098	16048
	iZotope RX9 Advanced	30.2544	15998-16098	16047	30.3429	15998-16098	16047
	NCH Switch Plus v.9.47	30.2686	15998-16098	16047	30.112	15998-16098	16046
	Reaper v.6.25	30.1927	15998-16098	16047	30.183	15998-16098	16047
	SUPER v.2000 Build 77	28.905	15998-16098	16048	28.6705	15998-16098	16043

Table 51: Test File DR000281.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0281	Adobe Audition 3.0.1	30.7151	15998-16098	16047	30.7151	15998-16098	16047
	Adobe Audition 2021	29.3533	15998-16098	16046	29.7237	15998-16098	16043
	dBpoweramp 16.6 [64-bit]	30.7653	15998-16098	16046	30.8397	15998-16098	16047
	FFmpeg	30.8637	15998-16098	16046	30.9295	15998-16098	16042
	iZotope RX9 Advanced	30.9685	15998-16098	16042	31.2132	15998-16098	16045
	NCH Switch Plus v.9.47	30.8389	15998-16098	16042	30.923	15998-16098	16043
	Reaper v.6.25	30.8376	15998-16098	16045	31.0796	15998-16098	16046
	SUPER v.2000 Build 77	29.6097	15998-16098	16046	29.7855	15998-16098	16046

Table 52: Test File DR000282.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0282	Adobe Audition 3.0.1	30.1901	15998-16098	16050	30.1901	15998-16098	16050
	Adobe Audition 2021	28.5091	15998-16098	16049	28.9993	15998-16098	16049
	dBpoweramp 16.6 [64-bit]	30.1846	15998-16098	16050	29.8486	15998-16098	16052
	FFmpeg	30.2428	15998-16098	16052	29.9042	15998-16098	16052
	iZotope RX9 Advanced	30.5386	15998-16098	16043	30.1529	15998-16098	16046
	NCH Switch Plus v.9.47	30.0972	15998-16098	16046	29.9174	15998-16098	16050
	Reaper v.6.25	30.3716	15998-16098	16046	30.0852	15998-16098	16047
	SUPER v.2000 Build 77	29.1261	15998-16098	16044	29.2885	15998-16098	16044

Table 53: Test File DR000283.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0283	Adobe Audition 3.0.1	30.9318	15998-16098	16051	30.9318	15998-16098	16051
	Adobe Audition 2021	29.5957	15998-16098	16042	29.6803	15998-16098	16052
	dBpoweramp 16.6 [64-bit]	30.9586	15998-16098	16051	30.7954	15998-16098	16051
	FFmpeg	30.9697	15998-16098	16051	30.8089	15998-16098	16051
	iZotope RX9 Advanced	30.7843	15998-16098	16048	31.1557	15998-16098	16047
	NCH Switch Plus v.9.47	30.5877	15998-16098	16051	30.5981	15998-16098	16052
	Reaper v.6.25	30.9777	15998-16098	16045	30.9739	15998-16098	16045
	SUPER v.2000 Build 77	29.499	15998-16098	16047	29.4636	15998-16098	16041

Table 54: Test File DR000284.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0284	Adobe Audition 3.0.1	30.3931	15998-16098	16051	30.3931	15998-16098	16051
	Adobe Audition 2021	29.0937	15998-16098	16045	29.2813	15998-16098	16045
	dBpoweramp 16.6 [64-bit]	30.3301	15998-16098	16044	30.5042	15998-16098	16048
	FFmpeg	30.3296	15998-16098	16042	30.4865	15998-16098	16049
	iZotope RX9 Advanced	30.5164	15998-16098	16039	30.6127	15998-16098	16044
	NCH Switch Plus v.9.47	30.5362	15998-16098	16048	30.6138	15998-16098	16047
	Reaper v.6.25	30.6871	15998-16098	16043	30.5509	15998-16098	16041
	SUPER v.2000 Build 77	29.7149	15998-16098	16044	29.417	15998-16098	16040

Table 55: Test File DR000285.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR000285	Adobe Audition 3.0.1	30.7246	15998-16098	16050	30.7246	15998-16098	16050
	Adobe Audition 2021	29.6061	15998-16098	16051	29.8728	15998-16098	16041
	dBpoweramp 16.6 [64-bit]	30.5876	15998-16098	16046	30.6157	15998-16098	16051
	FFmpeg	30.5897	15998-16098	16046	30.6264	15998-16098	16051
	iZotope RX9 Advanced	31.0265	15998-16098	16051	30.9641	15998-16098	16042
	NCH Switch Plus v.9.47	30.4602	15998-16098	16075	30.6489	15998-16098	16076
	Reaper v.6.25	30.9832	15998-16098	16041	31.0578	15998-16098	16042
	SUPER v.2000 Build 77	29.807	15998-16098	16043	29.8126	15998-16098	16046

Table 56: Test File DR000286.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR000286	Adobe Audition 3.0.1	30.2978	15998-16098	16046	30.3399	15998-16098	16046
	Adobe Audition 2021	29.6171	15998-16098	16045	29.4397	15998-16098	16051
	dBpoweramp 16.6 [64-bit]	30.4116	15998-16098	16046	30.5572	15998-16098	16046
	FFmpeg	30.3817	15998-16098	16046	30.5069	15998-16098	16047
	iZotope RX9 Advanced	30.7088	15998-16098	16045	30.5786	15998-16098	16045
	NCH Switch Plus v.9.47	30.5622	15998-16098	16050	30.5478	15998-16098	16049
	Reaper v.6.25	30.4485	15998-16098	16045	30.6253	15998-16098	16045
	SUPER v.2000 Build 77	29.5436	15998-16098	16048	29.5641	15998-16098	16050

Test files DR000277.MP3 and DR000278.MP3 display no matching COFs amongst transcoders within their data sets. Some transcoding tools share the same left or right COF, but not both (per data set). FFmpeg and dBpoweramp both share the COF 16045/16044 for test file DR000279.MP3. The rest of the transcoding tools vary in their COF results for the same test

files. Analyzing Test File DR000280.MP3 presents two pairs of transcoders sharing COFs which can be seen below.

Shared COFs Test File DR000280.MP3

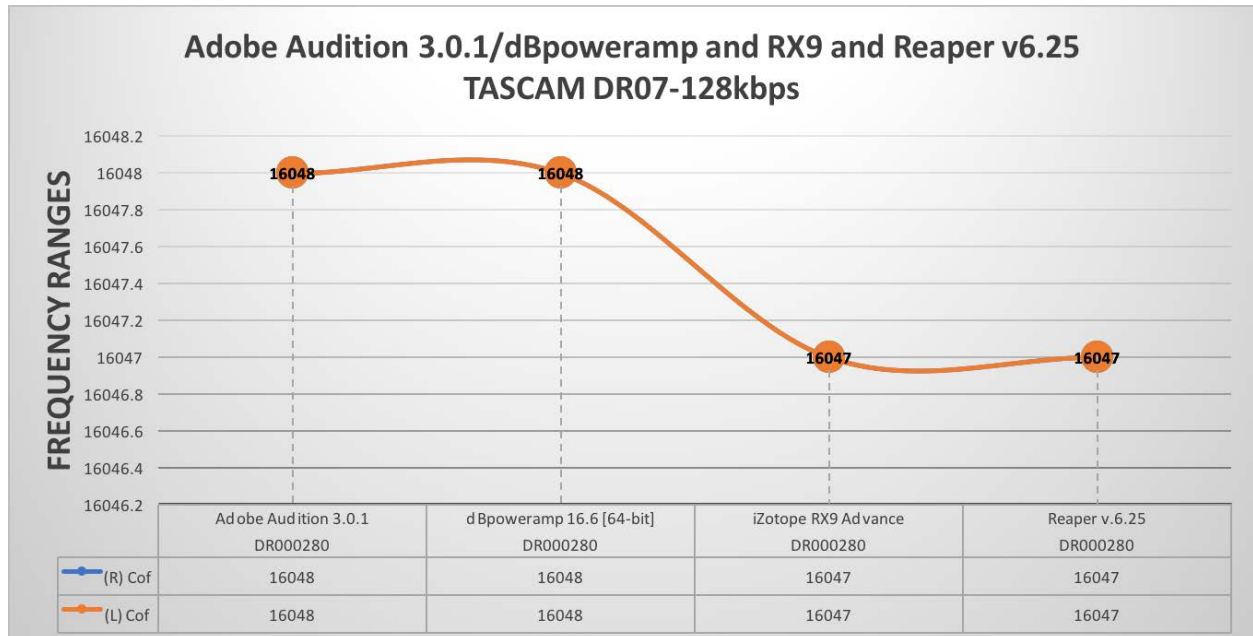


Figure 6: Adobe Audition 3.0.1, dBpoweramp, RX9, Reaper v6.25

Audition 3.01 and dBpoweramp share COFs 16048/16048 and Reaper v6.25 and RX9 share COFs of 16047/16047. These same transcoders share another set of COFs on Test File DR000286.MP3.

Shared COFs Test File DR000286.MP3

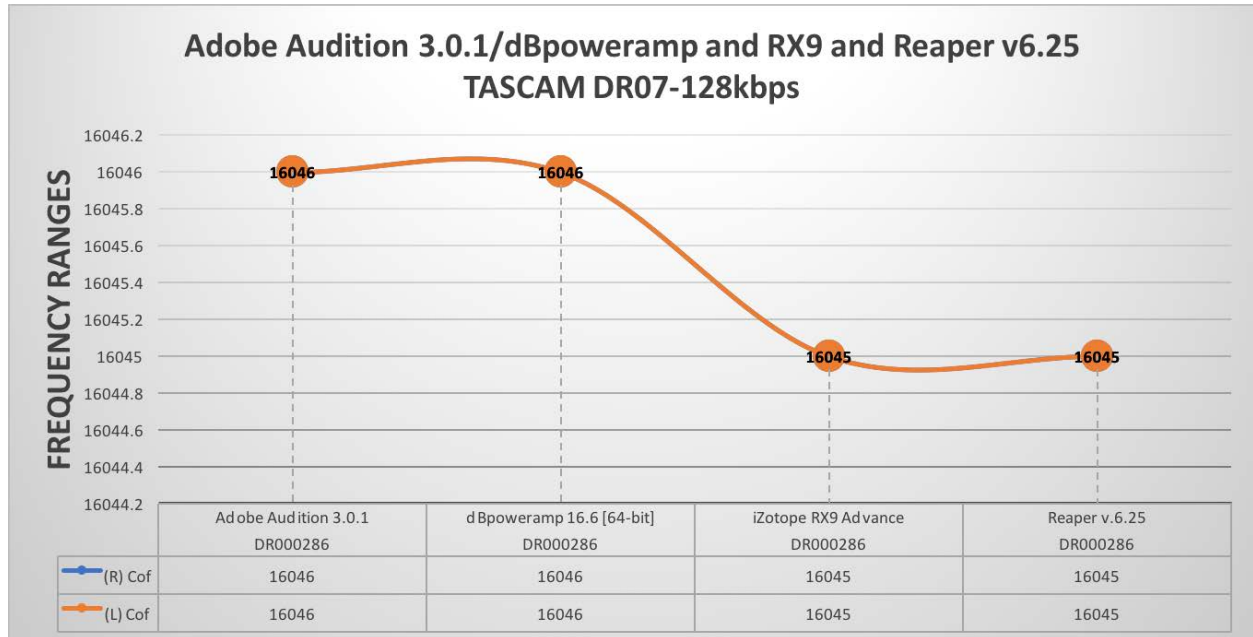


Figure 7: Adobe Audition 3.0.1, dBpoweramp, RX9, Reaper v6.25

Reaper v6.25 and Adobe Audition 2021 both share the same COF 16045/16045 but on separate test files (DR000283.MP3/DR000284.MP3). The pattern of transcoders sharing the same COF on with mismatch test files is consist within the TASCAM DR-07 12kbps data set.

TASCAM DR-07 192kbps

Table 57: Test File DR000288.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0288	Adobe Audition 3.0.1	30.742	15998-16098	16045	30.742	15998-16098	16045
	Adobe Audition 2021	29.6555	15998-16098	16047	29.5876	15998-16098	16047
	dBpoweramp 16.6 [64-bit]	30.5906	15998-16098	16044	30.5322	15998-16098	16042
	FFmpeg	30.625	15998-16098	16044	30.4815	15998-16098	16042
	iZotope RX9 Advanced	30.6294	15998-16098	16043	30.7241	15998-16098	16043
	NCH Switch Plus v.9.47	30.7445	15998-16098	16044	30.5926	15998-16098	16045
	Reaper v.6.25	30.5832	15998-16098	16043	30.7415	15998-16098	16043
	SUPER v.2000 Build 77	30.6594	15998-16098	16046	30.6757	15998-16098	16044

Table 58: Test File DR000289.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0289	Adobe Audition 3.0.1	31.0848	15998-16098	16048	31.0848	15998-16098	16048
	Adobe Audition 2021	29.2899	15998-16098	16049	29.307	15998-16098	16047
	dBpoweramp 16.6 [64-bit]	31.0527	15998-16098	16049	30.9251	15998-16098	16047
	FFmpeg	31.0041	15998-16098	16050	30.7975	15998-16098	16072
	iZotope RX9 Advanced	30.7932	15998-16098	16051	31.0813	15998-16098	16075
	NCH Switch Plus v.9.47	30.9427	15998-16098	16045	30.7385	15998-16098	16071
	Reaper v.6.25	31.0634	15998-16098	16045	31.0876	15998-16098	16039
	SUPER v.2000 Build 77	30.7255	15998-16098	16051	30.5621	15998-16098	16040

Table 59: Test File DR000290.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0290	Adobe Audition 3.0.1	30.482	15998-16098	16050	30.482	15998-16098	16050
	Adobe Audition 2021	28.6533	15998-16098	16039	28.4237	15998-16098	16046
	dBpoweramp 16.6 [64-bit]	30.3718	15998-16098	16043	30.1584	15998-16098	16050
	FFmpeg	30.4222	15998-16098	16042	30.2511	15998-16098	16050
	iZotope RX9 Advanced	30.3691	15998-16098	16040	30.4276	15998-16098	16041
	NCH Switch Plus v.9.47	30.1155	15998-16098	16043	30.1273	15998-16098	16042
	Reaper v.6.25	30.3431	15998-16098	16041	30.4709	15998-16098	16040
	SUPER v.2000 Build 77	30.4883	15998-16098	16047	30.4551	15998-16098	16046

Table 60: Test File DR000291.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR00 0291	Adobe Audition 3.0.1	31.4304	15998-16098	16042	31.4304	15998-16098	16042
	Adobe Audition 2021	29.5994	15998-16098	16048	29.32	15998-16098	16042
	dBpoweramp 16.6 [64-bit]	31.3355	15998-16098	16046	31.2817	15998-16098	16047
	FFmpeg	31.2902	15998-16098	16046	31.3364	15998-16098	16047
	iZotope RX9 Advanced	31.2225	15998-16098	16047	31.2695	15998-16098	16046
	NCH Switch Plus v.9.47	30.7752	15998-16098	16046	30.9524	15998-16098	16052
	Reaper v.6.25	31.1651	15998-16098	16048	31.1532	15998-16098	16047
	SUPER v.2000 Build 77	30.9758	15998-16098	16047	30.9484	15998-16098	16047

Table 61: Test File DR000292.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR000292	Adobe Audition 3.0.1	31.0612	15998-16098	16043	31.0612	15998-16098	16043
	Adobe Audition 2021	29.1544	15998-16098	16039	29.4945	15998-16098	16044
	dBpoweramp 16.6 [64-bit]	30.8623	15998-16098	16042	30.944	15998-16098	16051
	FFmpeg	30.9205	15998-16098	16049	30.9724	15998-16098	16050
	iZotope RX9 Advanced	31.1578	15998-16098	16045	31.1647	15998-16098	16044
	NCH Switch Plus v.9.47	31.0351	15998-16098	16048	31.0371	15998-16098	16047
	Reaper v.6.25	30.9553	15998-16098	16042	31.0024	15998-16098	16045
	SUPER v.2000 Build 77	30.9671	15998-16098	16049	30.9955	15998-16098	16049

Table 62: Test File DR000293.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR000293	Adobe Audition 3.0.1	30.274	15998-16098	16043	30.274	15998-16098	16043
	Adobe Audition 2021	29.0111	15998-16098	16049	29.3266	15998-16098	16048
	dBpoweramp 16.6 [64-bit]	30.2695	15998-16098	16044	30.4115	15998-16098	16043
	FFmpeg	30.275	15998-16098	16044	30.4622	15998-16098	16043
	iZotope RX9 Advanced	30.7017	15998-16098	16045	30.5554	15998-16098	16042
	NCH Switch Plus v.9.47	30.4463	15998-16098	16044	30.2977	15998-16098	16043
	Reaper v.6.25	30.4581	15998-16098	16043	30.5407	15998-16098	16044
	SUPER v.2000 Build 77	30.9383	15998-16098	16041	31.0217	15998-16098	16044

Table 63: Test File DR000294.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR000294	Adobe Audition 3.0.1	30.5348	15998-16098	16048	30.5348	15998-16098	16048
	Adobe Audition 2021	29.0892	15998-16098	16051	28.8834	15998-16098	16046
	dBpoweramp 16.6 [64-bit]	30.4132	15998-16098	16048	30.548	15998-16098	16041
	FFmpeg	30.3945	15998-16098	16049	30.5517	15998-16098	16041
	iZotope RX9 Advanced	30.4987	15998-16098	16046	30.3629	15998-16098	16039
	NCH Switch Plus v.9.47	30.3359	15998-16098	16050	30.276	15998-16098	16046
	Reaper v.6.25	30.338	15998-16098	16048	30.3818	15998-16098	16040
	SUPER v.2000 Build 77	30.6945	15998-16098	16042	30.5775	15998-16098	16041

Table 64: Test File DR000295.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR000295	Adobe Audition 3.0.1	30.4371	15998-16098	16046	30.4371	15998-16098	16046
	Adobe Audition 2021	29.2074	15998-16098	16051	29.0797	15998-16098	16042
	dBpoweramp 16.6 [64-bit]	30.379	15998-16098	16052	30.4662	15998-16098	16046
	FFmpeg	30.3191	15998-16098	16052	30.4715	15998-16098	16046
	iZotope RX9 Advanced	30.4462	15998-16098	16052	30.5528	15998-16098	16046
	NCH Switch Plus v.9.47	30.6467	15998-16098	16047	30.3769	15998-16098	16051
	Reaper v.6.25	30.5105	15998-16098	16051	30.5561	15998-16098	16052
	SUPER v.2000 Build 77	30.5306	15998-16098	16044	30.5711	15998-16098	16045

Table 65: Test File DR000296.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR000296	Adobe Audition 3.0.1	30.4634	15998-16098	16049	30.4634	15998-16098	16049
	Adobe Audition 2021	29.5065	15998-16098	16051	28.9078	15998-16098	16044
	dBpoweramp 16.6 [64-bit]	30.4317	15998-16098	16049	30.4601	15998-16098	16046
	FFmpeg	30.5001	15998-16098	16049	30.548	15998-16098	16046
	iZotope RX9 Advanced	30.5572	15998-16098	16044	30.5789	15998-16098	16046
	NCH Switch Plus v.9.47	30.3985	15998-16098	16049	30.2679	15998-16098	16044
	Reaper v.6.25	30.5647	15998-16098	16045	30.5255	15998-16098	16048
	SUPER v.2000 Build 77	31.2147	15998-16098	16049	31.1994	15998-16098	16048

Table 66: Test File DR000297.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
DR000297	Adobe Audition 3.0.1	30.4948	15998-16098	16040	30.4948	15998-16098	16040
	Adobe Audition 2021	29.2955	15998-16098	16047	29.2136	15998-16098	16044
	dBpoweramp 16.6 [64-bit]	30.3598	15998-16098	16040	30.4887	15998-16098	16040
	FFmpeg	30.4329	15998-16098	16040	30.4786	15998-16098	16048
	iZotope RX9 Advanced	30.3451	15998-16098	16042	30.2859	15998-16098	16048
	NCH Switch Plus v.9.47	30.573	15998-16098	16047	30.471	15998-16098	16043
	Reaper v.6.25	30.3016	15998-16098	16041	30.3292	15998-16098	16042
	SUPER v.2000 Build 77	30.5619	15998-16098	16047	30.5865	15998-16098	16040

Here are some of the results found while analyzing transcoded files from the TASCAM DR-07 at 192 kbps.

The first test file DR000288 displays two sets of transcoders that share cut off frequencies. The transcoders in question are dBpoweramp, FFmpeg, Reaper and RX9 Advnace. The chart below outlines their COFs.

Transcoder COFs (FFmpeg, dBpoweramp, Reaper and RX9)

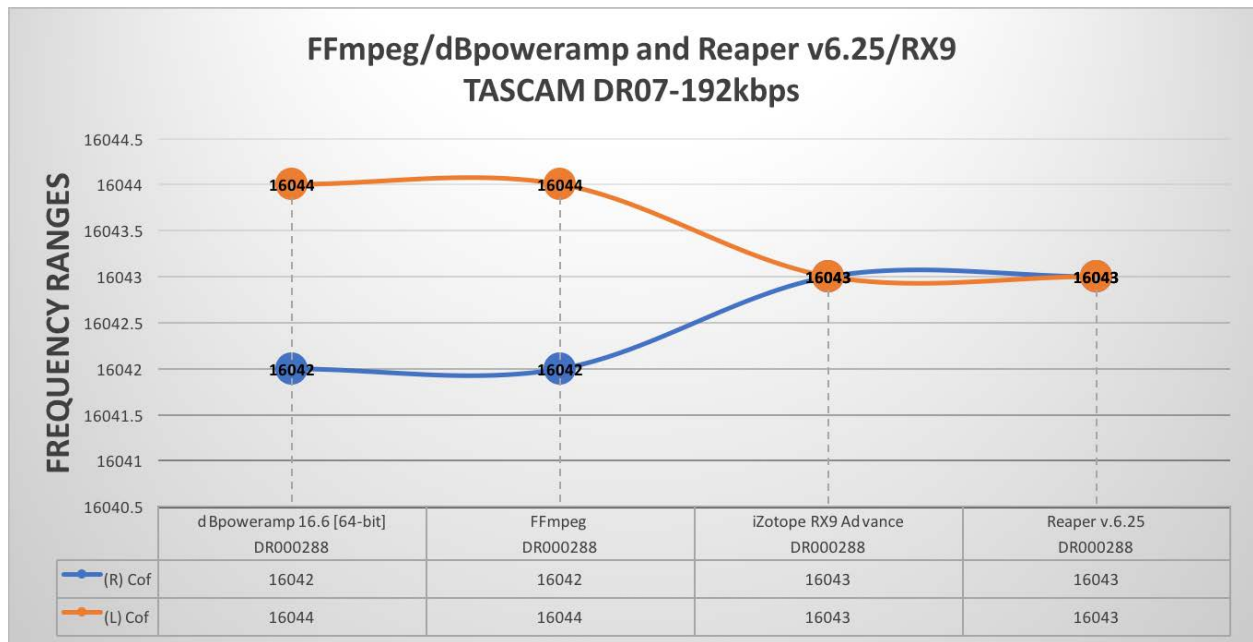


Figure 8: FFmpeg, dBpoweramp, Reaper v6.25 and Izotope RX9 Advanced Share COFs

The transcoders in figure above do not share the same COFs anywhere on any other test files within this data set. The most consistent cutoff frequencies in this data set are between FFmpeg and dBpoweramp which account for 50% of the cutoff frequency matches.

The chart below display COFs for FFmpeg and dBpoweramp

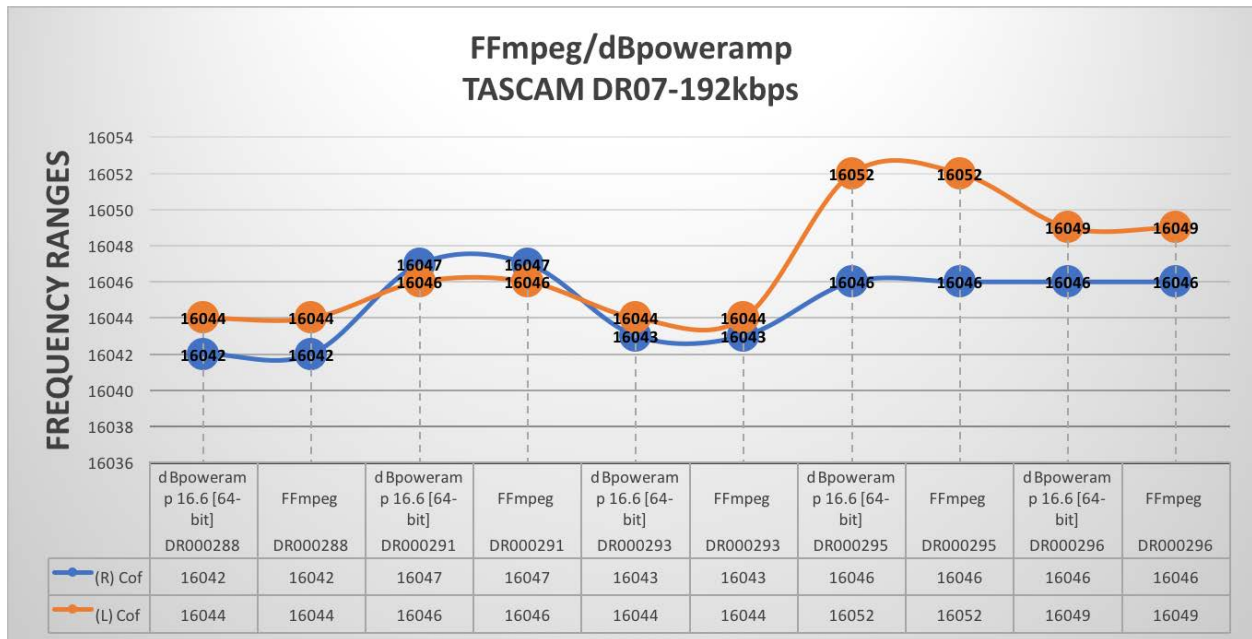


Figure 9: FFmpeg and dBpoweramp Shared COFs

The analysis conducted on the Sony PX820 stereo recordings are 128kbps and 192kbps. The 64 kbps setting did not generate stereo recordings, only mono so for that reason the 64kbps recordings were omitted from the study.

SONY ICD 128kbps

Table 67: Test File 22020621.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020 621	Adobe Audition 3.0.1	18.175	17298-17398	17313	16.9806	17298-17398	17315
	Adobe Audition 2021	17.702	17298-17398	17328	16.4809	17298-17398	17336
	dBpoweramp 16.6 [64-bit]	18.182	17298-17398	17313	16.9616	17298-17398	17315
	FFmpeg	18.2159	17298-17398	17313	16.9524	17298-17398	17315
	iZotope RX9 Advanced	17.9584	17298-17398	17332	16.776	17298-17398	17313
	NCH Switch Plus v.9.47	17.8903	17298-17398	17315	16.9655	17298-17398	17317
	Reaper v.6.25	18.0598	17298-17398	17331	16.6929	17298-17398	17312
	SUPER v.2000 Build 77	17.8102	17298-17398	17314	16.9948	17298-17398	17315

Table 68: Test File 22020622.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020 622	Adobe Audition 3.0.1	18.6873	17298-17398	17313	19.3046	17298-17398	17315
	Adobe Audition 2021	18.6676	17298-17398	17318	19.3697	17298-17398	17310
	dBpoweramp 16.6 [64-bit]	18.6918	17298-17398	17313	19.3112	17298-17398	17315
	FFmpeg	18.696	17298-17398	17313	19.3135	17298-17398	17315
	iZotope RX9 Advanced	18.3451	17298-17398	17307	19.1439	17298-17398	17314
	NCH Switch Plus v.9.47	18.5184	17298-17398	17320	19.1863	17298-17398	17312
	Reaper v.6.25	18.2692	17298-17398	17307	19.3264	17298-17398	17311
	SUPER v.2000 Build 77	18.4803	17298-17398	17310	19.2788	17298-17398	17313

Table 69: Test File 22020623.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020623	Adobe Audition 3.0.1	17.9081	17298-17398	17317	18.4379	17298-17398	17312
	Adobe Audition 2021	17.719	17298-17398	17317	17.9261	17298-17398	17310
	dBpoweramp 16.6 [64-bit]	17.927	17298-17398	17317	18.4409	17298-17398	17312
	FFmpeg	17.9468	17298-17398	17317	18.445	17298-17398	17312
	iZotope RX9 Advanced	18.187	17298-17398	17330	18.3436	17298-17398	17308
	NCH Switch Plus v.9.47	17.9962	17298-17398	17329	18.0754	17298-17398	17309
	Reaper v.6.25	18.2534	17298-17398	17330	18.282	17298-17398	17308
	SUPER v.2000 Build 77	18.0153	17298-17398	17316	18.1194	17298-17398	17320

Table 70: Test File 22020624.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020624	Adobe Audition 3.0.1	19.1712	17298-17398	17308	18.6843	17298-17398	17309
	Adobe Audition 2021	18.9014	17298-17398	17307	18.3416	17298-17398	17310
	dBpoweramp 16.6 [64-bit]	19.1671	17298-17398	17308	18.6817	17298-17398	17309
	FFmpeg	19.1823	17298-17398	17308	18.6784	17298-17398	17309
	iZotope RX9 Advanced	19.2487	17298-17398	17327	18.7067	17298-17398	17320
	NCH Switch Plus v.9.47	19.0959	17298-17398	17308	18.7714	17298-17398	17310
	Reaper v.6.25	19.1883	17298-17398	17327	18.4743	17298-17398	17309
	SUPER v.2000 Build 77	18.8608	17298-17398	17308	18.8062	17298-17398	17339

Table 71: Test File 22020625.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020625	Adobe Audition 3.0.1	18.8021	17298-17398	17327	17.5744	17298-17398	17337
	Adobe Audition 2021	18.8983	17298-17398	17327	17.7822	17298-17398	17311
	dBpoweramp 16.6 [64-bit]	18.004	17298-17398	17327	17.5846	17298-17398	17337
	FFmpeg	18.8364	17298-17398	17327	17.6038	17298-17398	17316
	iZotope RX9 Advanced	18.7854	17298-17398	17311	18.2622	17298-17398	17310
	NCH Switch Plus v.9.47	18.9995	17298-17398	17318	17.9357	17298-17398	17309
	Reaper v.6.25	18.7002	17298-17398	17313	18.1769	17298-17398	17310
	SUPER v.2000 Build 77	18.5951	17298-17398	17319	17.9041	17298-17398	17311

Table 72: Test File 22020626.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020626	Adobe Audition 3.0.1	19.0178	17298-17398	17316	18.3233	17298-17398	17321
	Adobe Audition 2021	19.3242	17298-17398	17319	18.0961	17298-17398	17333
	dBpoweramp 16.6 [64-bit]	19.0428	17298-17398	17316	18.3253	17298-17398	17320
	FFmpeg	19.0208	17298-17398	17316	18.303	17298-17398	17321
	iZotope RX9 Advanced	19.2201	17298-17398	17320	18.8968	17298-17398	17333
	NCH Switch Plus v.9.47	19.5732	17298-17398	17311	18.2506	17298-17398	17321
	Reaper v.6.25	19.0925	17298-17398	17320	18.6488	17298-17398	17315
	SUPER v.2000 Build 77	19.5113	17298-17398	17316	18.3053	17298-17398	17309

Table 73: Test File 22020627.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020627	Adobe Audition 3.0.1	16.7732	17298-17398	17314	17.5231	17298-17398	17336
	Adobe Audition 2021	16.7794	17298-17398	17315	17.3141	17298-17398	17336
	dBpoweramp 16.6 [64-bit]	16.7698	17298-17398	17314	17.523	17298-17398	17336
	FFmpeg	16.7648	17298-17398	17314	17.5331	17298-17398	17336
	iZotope RX9 Advanced	17.0682	17298-17398	17310	17.311	17298-17398	17308
	NCH Switch Plus v.9.47	16.8349	17298-17398	17315	17.3782	17298-17398	17341
	Reaper v.6.25	17.1425	17298-17398	17311	17.2415	17298-17398	17308
	SUPER v.2000 Build 77	16.8947	17298-17398	17318	17.4732	17298-17398	17310

Table 74: Test File 22020628.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020628	Adobe Audition 3.0.1	17.9084	17298-17398	17308	17.8943	17298-17398	17322
	Adobe Audition 2021	18.0163	17298-17398	17307	17.7925	17298-17398	17324
	dBpoweramp 16.6 [64-bit]	17.9062	17298-17398	17308	17.8954	17298-17398	17321
	FFmpeg	17.8973	17298-17398	17308	17.8939	17298-17398	17321
	iZotope RX9 Advanced	18.1189	17298-17398	17311	17.7065	17298-17398	17308
	NCH Switch Plus v.9.47	18.1012	17298-17398	17308	17.6709	17298-17398	17316
	Reaper v.6.25	18.1477	17298-17398	17311	17.9371	17298-17398	17308
	SUPER v.2000 Build 77	17.89	17298-17398	17311	18.0751	17298-17398	17318

Table 75: Test File 22020629.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020629	Adobe Audition 3.0.1	18.4862	17298-17398	17311	18.2585	17298-17398	17313
	Adobe Audition 2021	18.6659	17298-17398	17311	18.1935	17298-17398	17310
	dBpoweramp 16.6 [64-bit]	18.4846	17298-17398	17312	18.2496	17298-17398	17307
	FFmpeg	18.468	17298-17398	17311	18.2578	17298-17398	17307
	iZotope RX9 Advanced	18.7393	17298-17398	17310	18.1668	17298-17398	17313
	NCH Switch Plus v.9.47	18.5403	17298-17398	17310	18.4326	17298-17398	17310
	Reaper v.6.25	18.7963	17298-17398	17308	18.2248	17298-17398	17310
	SUPER v.2000 Build 77	18.4072	17298-17398	17310	18.4805	17298-17398	17306

Table 76: Test File 22020630.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020630	Adobe Audition 3.0.1	18.5691	17298-17398	17316	17.2403	17298-17398	17316
	Adobe Audition 2021	18.2905	17298-17398	17327	17.4345	17298-17398	17331
	dBpoweramp 16.6 [64-bit]	18.5574	17298-17398	17316	17.241	17298-17398	17316
	FFmpeg	18.5329	17298-17398	17316	17.2532	17298-17398	17316
	iZotope RX9 Advanced	18.4287	17298-17398	17320	17.3606	17298-17398	17324
	NCH Switch Plus v.9.47	18.2071	17298-17398	17332	17.1647	17298-17398	17325
	Reaper v.6.25	18.4659	17298-17398	17332	17.5249	17298-17398	17311
	SUPER v.2000 Build 77	18.7649	17298-17398	17316	17.2258	17298-17398	17328

As with all recordings in the studying, there are varying cut off frequencies between the left and the right channel. Some trends that were noticed involve the consistencies between the following transcoders; Adobe Audition 3.0.1, FFmpeg, and dBpoweramp.

The consistencies in the cutoff frequencies can be seen in the chart below.

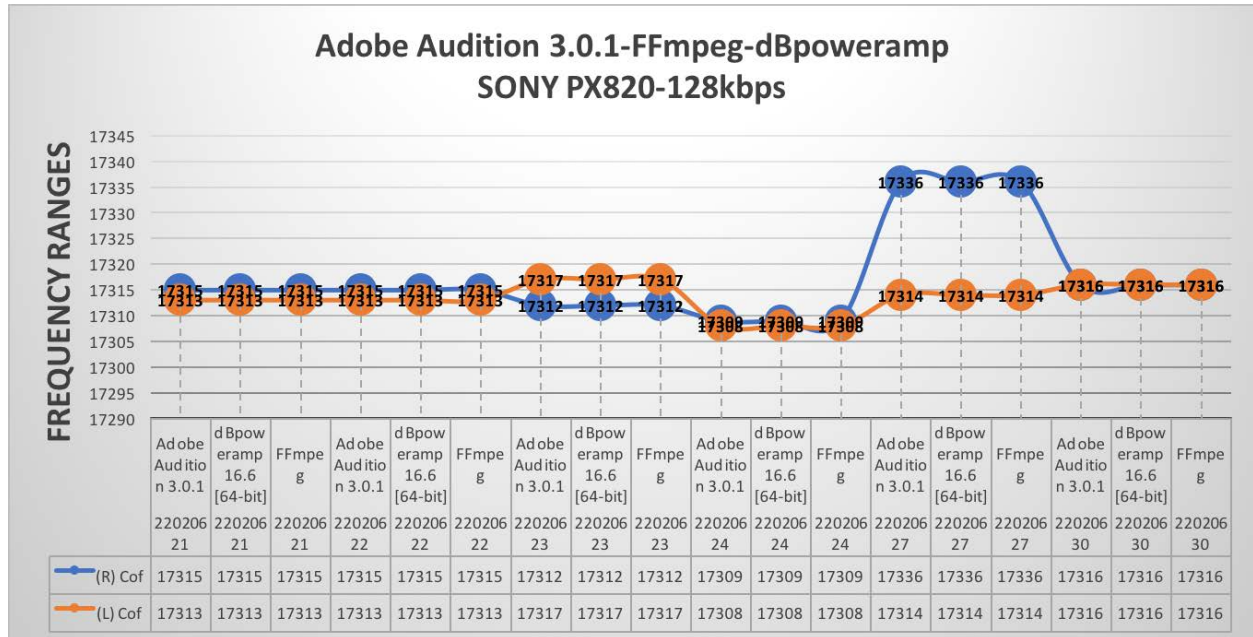


Figure 10: Adobe Audition 3.0.1, dBpoweramp, and FFmpeg COF consistencies

The transcoders displayed in the figure blank contained consistent COFs accounting for 60% of the COF matches within the data set. dBpoweramp and FFmpeg were also very consistent accounting for 70% of the COF matches within the data set. Reaper and Izotope RX9 also had consistencies but not as many as dBpoweramp, FFmpeg and Adobe Audition 3.0.1. You can see the consistencies between Reaper and RX9 in these two charts

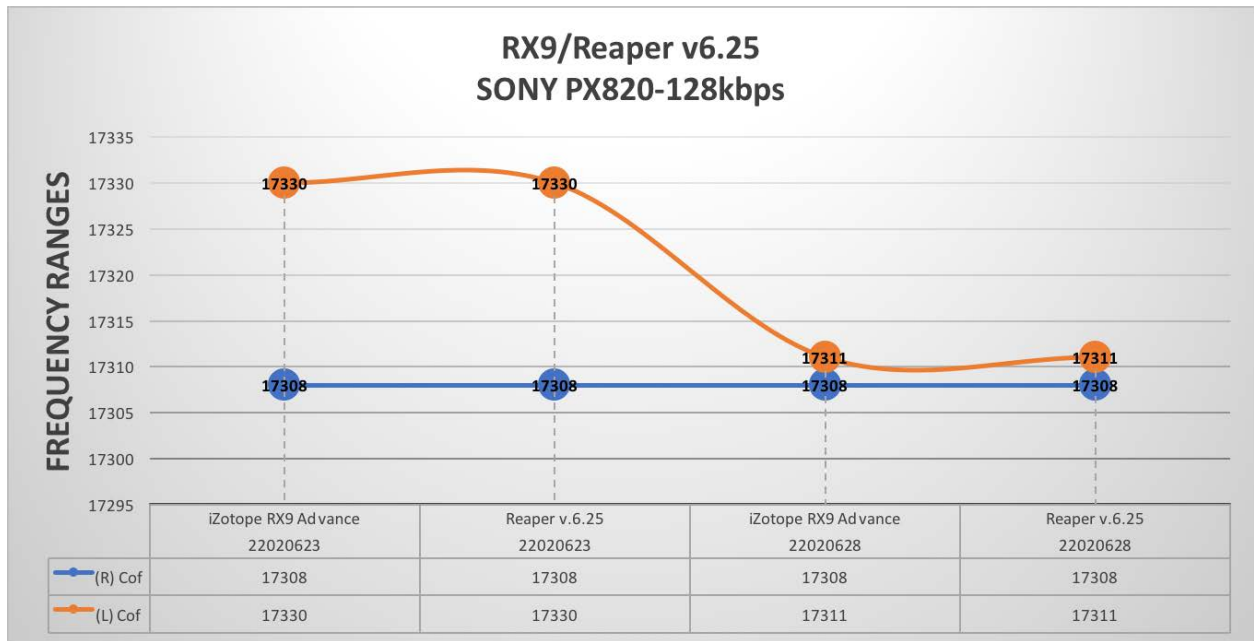


Figure 11: Reaper v6.25 and Izotope RX9 COF Matches

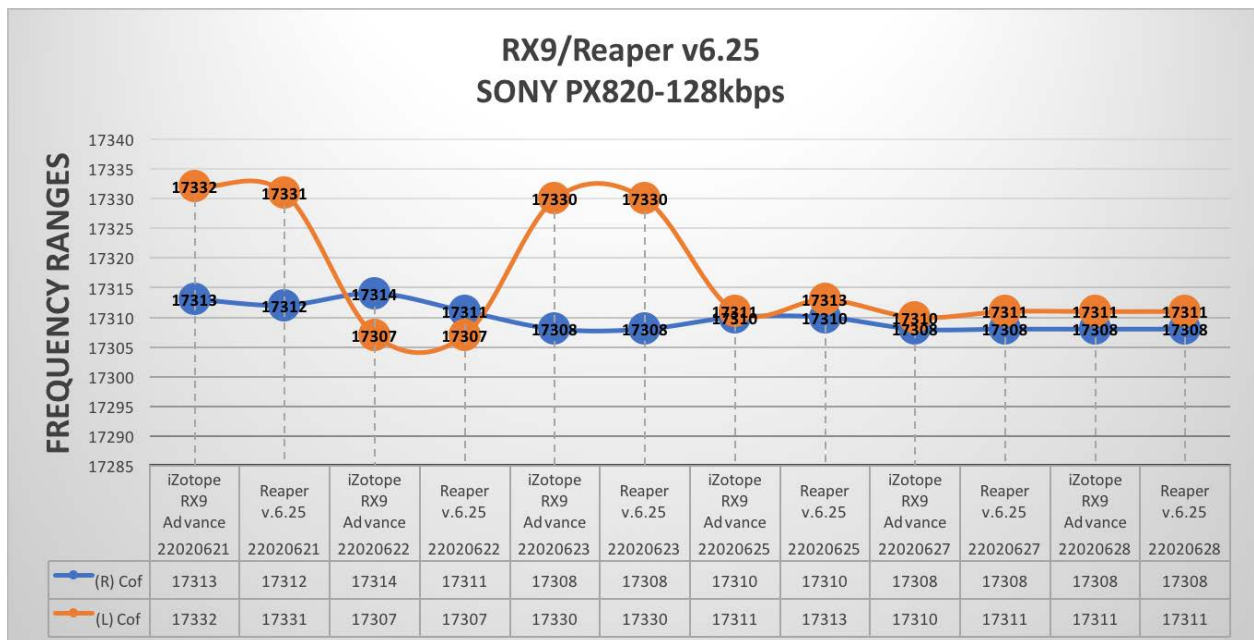


Figure 11.1: Reaper v6.25 and Izotope RX9 COF consistencies

Figure 11 shows the COF matches of cut off frequencies between 2 test recordings 22020623.MP3 and 22020628.MP3. Figure 11.1 shows a bigger picture of overall consistencies across multiple test file recordings.

SONY ICD 192kbps

Table 77: Test File 22020601.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020601	Adobe Audition 3.0.1	18.7874	20098-20198	20102	19.1	20098-20198	20106
	Adobe Audition 2021	18.2682	20098-20198	20110	18.8624	20098-20198	20104
	dBpoweramp 16.6 [64-bit]	18.7971	20098-20198	20102	19.139	20098-20198	20106
	FFmpeg	18.8156	20098-20198	20102	19.1282	20098-20198	20106
	iZotope RX9 Advanced	18.8966	20098-20198	20103	18.9988	20098-20198	20109
	NCH Switch Plus v.9.47	18.6465	20098-20198	20106	19.3301	20098-20198	20108
	Reaper v.6.25	18.6679	20098-20198	20102	19.053	20098-20198	20108
	SUPER v.2000 Build 77	18.9625	20098-20198	20103	19.4243	20098-20198	20108

Table 78: Test File 22020602.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020602	Adobe Audition 3.0.1	18.9187	20098-20198	20106	18.5654	20098-20198	20104
	Adobe Audition 2021	18.7172	20098-20198	20105	17.7271	20098-20198	20103
	dBpoweramp 16.6 [64-bit]	18.9266	20098-20198	20106	18.5912	20098-20198	20104
	FFmpeg	18.9269	20098-20198	20106	18.6133	20098-20198	20104
	iZotope RX9 Advanced	18.7856	20098-20198	20103	18.503	20098-20198	20103
	NCH Switch Plus v.9.47	19.0859	20098-20198	20106	18.344	20098-20198	20106
	Reaper v.6.25	19.026	20098-20198	20108	18.5179	20098-20198	20100
	SUPER v.2000 Build 77	19.6637	20098-20198	20106	18.8217	20098-20198	20100

Table 79: Test File 22020603.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020603	Adobe Audition 3.0.1	18.5484	20098-20198	20111	18.9841	20098-20198	20109
	Adobe Audition 2021	17.6859	20098-20198	20108	18.731	20098-20198	20100
	dBpoweramp 16.6 [64-bit]	18.6058	20098-20198	20111	18.973	20098-20198	20109
	FFmpeg	18.6004	20098-20198	20111	18.9469	20098-20198	20109
	iZotope RX9 Advanced	18.4022	20098-20198	20102	19.2863	20098-20198	20109
	NCH Switch Plus v.9.47	18.4226	20098-20198	20094	19.2567	20098-20198	20108
	Reaper v.6.25	18.4446	20098-20198	20106	19.0595	20098-20198	20109
	SUPER v.2000 Build 77	18.4534	20098-20198	20104	19.5684	20098-20198	20108

Table 80: Test File 22020604.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020604	Adobe Audition 3.0.1	19.2498	20098-20198	20105	18.9809	20098-20198	20104
	Adobe Audition 2021	17.9783	20098-20198	20108	18.8162	20098-20198	20101
	dBpoweramp 16.6 [64-bit]	19.217	20098-20198	20105	18.9677	20098-20198	20102
	FFmpeg	19.2385	20098-20198	20105	18.9416	20098-20198	20104
	iZotope RX9 Advanced	18.51	20098-20198	20105	18.8661	20098-20198	20107
	NCH Switch Plus v.9.47	18.8811	20098-20198	20108	19.5058	20098-20198	20113
	Reaper v.6.25	18.4787	20098-20198	20105	19.2839	20098-20198	20104
	SUPER v.2000 Build 77	19.1591	20098-20198	20107	19.0466	20098-20198	20101

Table 81: Test File 22020605.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020605	Adobe Audition 3.0.1	18.6874	20098-20198	20104	19.567	20098-20198	20099
	Adobe Audition 2021	17.9133	20098-20198	20111	18.9227	20098-20198	20099
	dBpoweramp 16.6 [64-bit]	18.6514	20098-20198	20104	19.6023	20098-20198	20099
	FFmpeg	18.6686	20098-20198	20104	19.6023	20098-20198	20103
	iZotope RX9 Advanced	18.4747	20098-20198	20106	19.3738	20098-20198	20104
	NCH Switch Plus v.9.47	18.3503	20098-20198	20103	19.797	20098-20198	20103
	Reaper v.6.25	18.5021	20098-20198	20106	19.38	20098-20198	20109
	SUPER v.2000 Build 77	18.1622	20098-20198	20104	19.8645	20098-20198	20101

Table 82: Test File 22020606.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020606	Adobe Audition 3.0.1	19.4399	20098-20198	20102	18.7738	20098-20198	20107
	Adobe Audition 2021	18.6495	20098-20198	20106	18.4739	20098-20198	20104
	dBpoweramp 16.6 [64-bit]	19.4531	20098-20198	20102	18.7763	20098-20198	20107
	FFmpeg	19.4104	20098-20198	20102	18.8168	20098-20198	20107
	iZotope RX9 Advanced	19.48	20098-20198	20102	18.8177	20098-20198	20109
	NCH Switch Plus v.9.47	19.1686	20098-20198	20101	18.4277	20098-20198	20109
	Reaper v.6.25	19.8667	20098-20198	20101	18.895	20098-20198	20108
	SUPER v.2000 Build 77	19.529	20098-20198	20102	18.7582	20098-20198	20106

Table 83: Test File 22020607.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020607	Adobe Audition 3.0.1	18.3091	20098-20198	20101	20.3996	20098-20198	20111
	Adobe Audition 2021	18.0201	20098-20198	20103	19.8412	20098-20198	20097
	dBpoweramp 16.6 [64-bit]	18.3114	20098-20198	20101	20.41	20098-20198	20104
	FFmpeg	18.3094	20098-20198	20101	20.4831	20098-20198	20104
	iZotope RX9 Advanced	18.1478	20098-20198	20103	20.3897	20098-20198	20108
	NCH Switch Plus v.9.47	18.484	20098-20198	20105	20.3554	20098-20198	20097
	Reaper v.6.25	18.3548	20098-20198	20103	20.379	20098-20198	20108
	SUPER v.2000 Build 77	18.5956	20098-20198	20103	20.4166	20098-20198	20108

Table 84: Test File 22020608.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020608	Adobe Audition 3.0.1	20.0951	20098-20198	20110	19.4826	20098-20198	20103
	Adobe Audition 2021	19.8919	20098-20198	20109	19.6949	20098-20198	20104
	dBpoweramp 16.6 [64-bit]	20.0717	20098-20198	20110	19.4801	20098-20198	20103
	FFmpeg	20.1019	20098-20198	20110	19.5031	20098-20198	20103
	iZotope RX9 Advanced	19.5672	20098-20198	20109	19.6785	20098-20198	20105
	NCH Switch Plus v.9.47	19.9048	20098-20198	20110	19.5371	20098-20198	20106
	Reaper v.6.25	19.8794	20098-20198	20109	19.8245	20098-20198	20103
	SUPER v.2000 Build 77	20.4406	20098-20198	20111	19.4258	20098-20198	20103

Table 85: Test File 22020609.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020609	Adobe Audition 3.0.1	19.5071	20098-20198	20102	19.1244	20098-20198	20108
	Adobe Audition 2021	19.3843	20098-20198	20104	18.6323	20098-20198	20102
	dBpoweramp 16.6 [64-bit]	19.5149	20098-20198	20102	19.1307	20098-20198	20104
	FFmpeg	19.504	20098-20198	20102	19.1685	20098-20198	20104
	iZotope RX9 Advanced	19.3908	20098-20198	20105	19.6124	20098-20198	20099
	NCH Switch Plus v.9.47	19.1452	20098-20198	20107	19.5348	20098-20198	20100
	Reaper v.6.25	19.4087	20098-20198	20107	19.5918	20098-20198	20109
	SUPER v.2000 Build 77	19.8276	20098-20198	20102	19.7001	20098-20198	20107

Table 86: Test File 22020610.MP3 Results

Test File	Transcoding Tool	(L) Att [dB]	(L) Range [Hz]	(L) Cof	(R) Att [dB]	(R) Range [Hz]	(R) Cof
22020610	Adobe Audition 3.0.1	18.9	20098-20198	20107	19.8781	20098-20198	20124
	Adobe Audition 2021	18.2773	20098-20198	20102	18.446	20098-20198	20103
	dBpoweramp 16.6 [64-bit]	18.8882	20098-20198	20107	19.8542	20098-20198	20106
	FFmpeg	18.923	20098-20198	20107	19.8154	20098-20198	20106
	iZotope RX9 Advanced	18.812	20098-20198	20103	19.5524	20098-20198	20109
	NCH Switch Plus v.9.47	18.9018	20098-20198	20105	19.3691	20098-20198	20121
	Reaper v.6.25	18.9271	20098-20198	20103	19.8721	20098-20198	20108
	SUPER v.2000 Build 77	19.0175	20098-20198	20100	19.4517	20098-20198	20107

The analysis results from this data set are similar to the results in the Sony 128kbps data set with a few exceptions. At 192 kbps dBpoweramp and FFmpeg account for 80% of the Matched cut-off frequencies. You can see the match COFs in the chart below

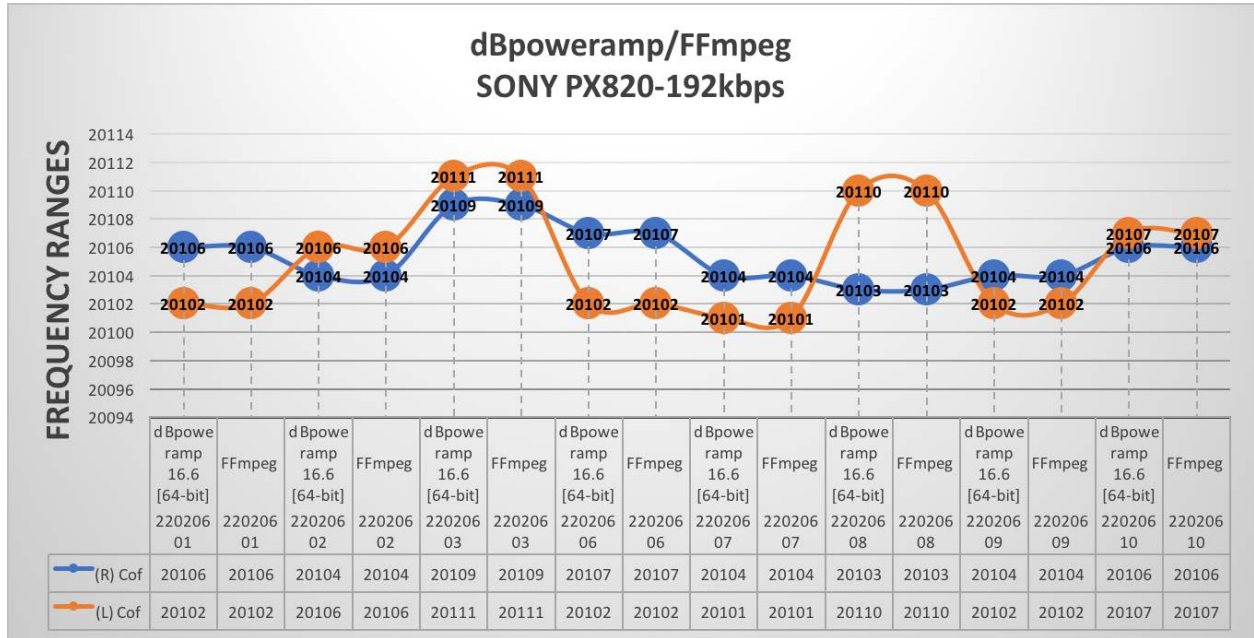


Figure 12: dBpoweramp and FFmpeg shared COF

The overall COF range is higher in this data set as well as you can see in figure 12 when compared to figure 11.1. RX9 and Reaper share two pairs of matched frequencies but at higher cut-off frequencies.

CHAPTER V

CONCLUSIONS

Conducting this research has been eye-opening. My original hypothesis was that different MP3 decoders would have a different cut-off frequency. While it is true that there are different cut-off frequencies, there were some patterns recognized more than others across all tools used within this study.

Adobe Audition 3.0.1, FFmpeg and dBpoweramp were transcoders showing the most consistency in terms of matched COFs between the left and right channel. Very rarely do the other transcoders share COFs with these three, let alone each other. There are some occasions where Reaper shared the same consistent cut off frequencies and there was one instance where five transcoders shared the same cut off frequencies but only for one subset of recordings and wasn't reproduced for the remainder of the study.

Adobe Audition 2021, FFmpeg, Reaper, and SUPER produced intermittent consistencies in the cut-off frequencies. For example, they produced the same cut-off frequencies in one recording but different cut-off frequencies in another. Other trends that were noticed revolved around consistencies in COF on individual channels and matching COFs of left and right channels, but on different test files within the same data set.

Furthermore, all transcoding applications fluctuate in COF within the same cycle of recordings. See graphics below displaying the COFs (Example Adobe Audition 3.0.1).

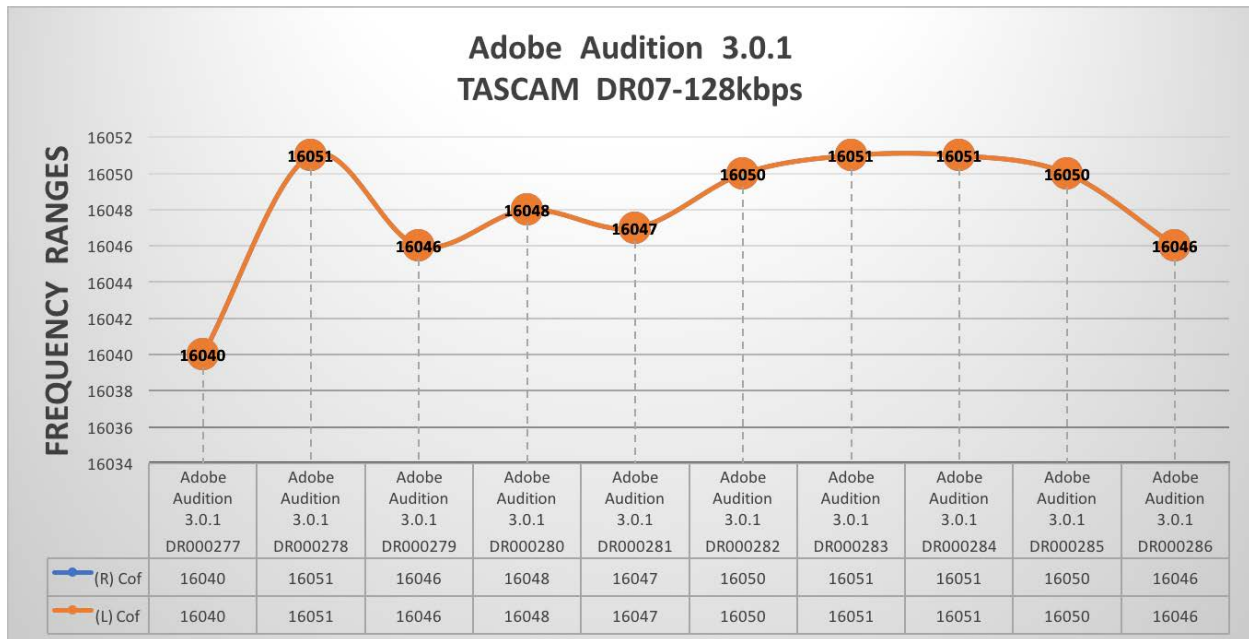


Figure 13: Adobe Audition 3.0.1 Left/Right COFs TASCAM DR07 Recordings (128kbps)

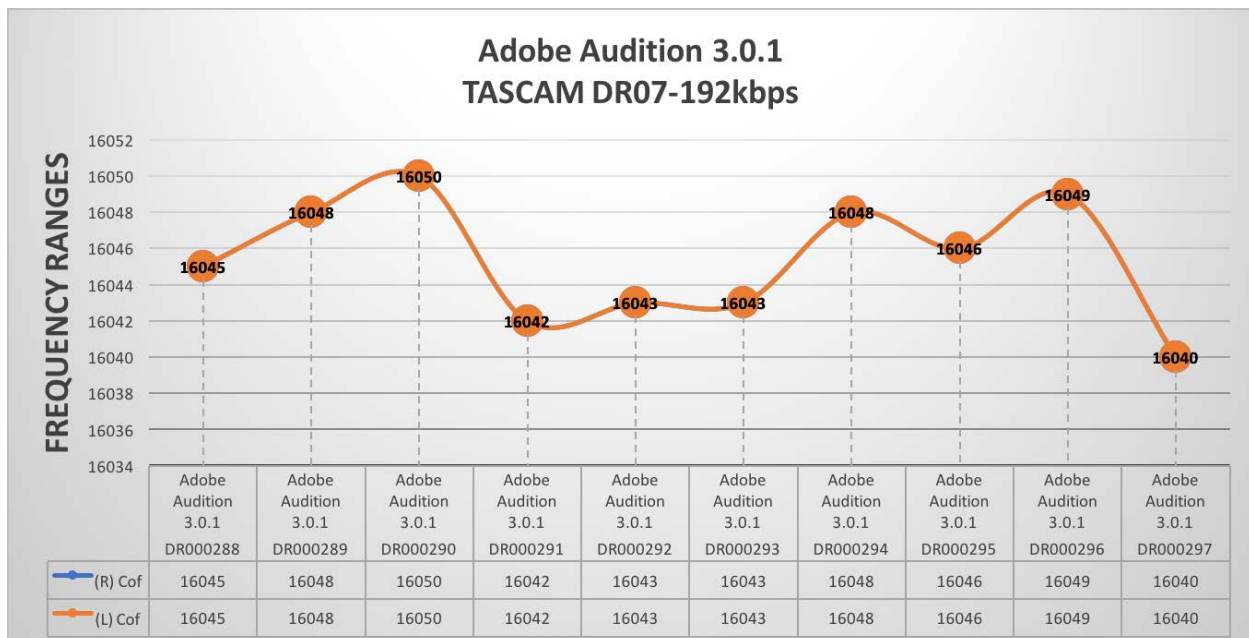


Figure 14: Adobe Audition 3.0.1 Left/Right COFs TASCAM DR07 Recordings (192kbps)

Figure 13 and 14 both display variations in COF across the recordings within the data set however, these are the only instances where the analysis results display the same frequencies within its own left and right channels.

Future Research

There are many ways that this study could be enhanced and or taken further. One way is using a more extensive test data set with multiple recorders of the same make and model. Using the same make and model recorder will allow one to see if there are any variations and anomalies between the model's initial MP3 recordings before transcoding.

Modern Handheld Recorders

Many modern recorders offer features such as; Wi-Fi control and alternative microphone positioning. The ability to position microphone capsules in the same position would allow for more accurate recordings. Wi-Fi control would allow remote recording without disturbing the recording environment or the need to physically touch the recorders between each recording cycle resulting in more accurate recordings.

As we clearly see from this study, the cutoff frequency changes based on the transcoding tool being used. More transcoders would help create a larger data set and further the study. We can combine the results of the COF with the ZLS.

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Grigoras, Catalin, and Jeff M. Smith. "Forensic Analysis of AAC Encoding on Apple iPhone Voice Memos Recordings." Audio Engineering Society, 18 June 2019.

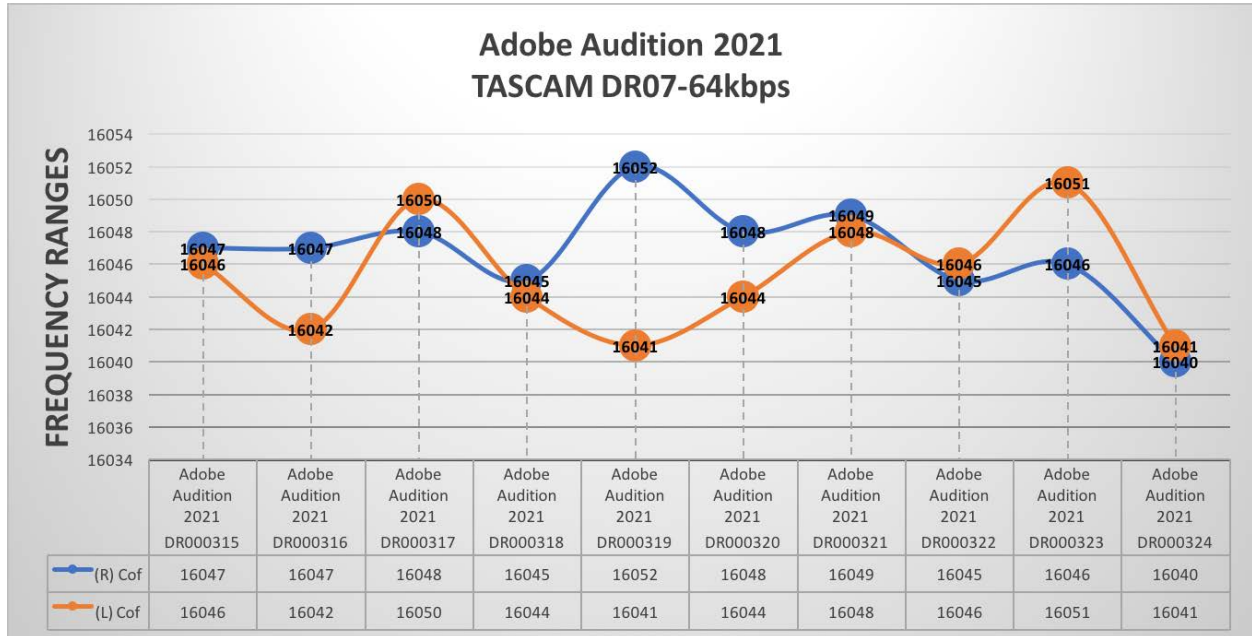
Schroeder, Ernst F., and Johannes Boehm. "Original File Length (OFL) for mp3, mp3PRO and Other Audio Codecs." Audio Engineering Society, 22 Mar. 2003.

Yancey, Jeremy. "ANALYSIS OF ZERO-LEVEL SAMPLE PADDING OF AAC AND WMA ENCODERS" University of Colorado Denver, 2019

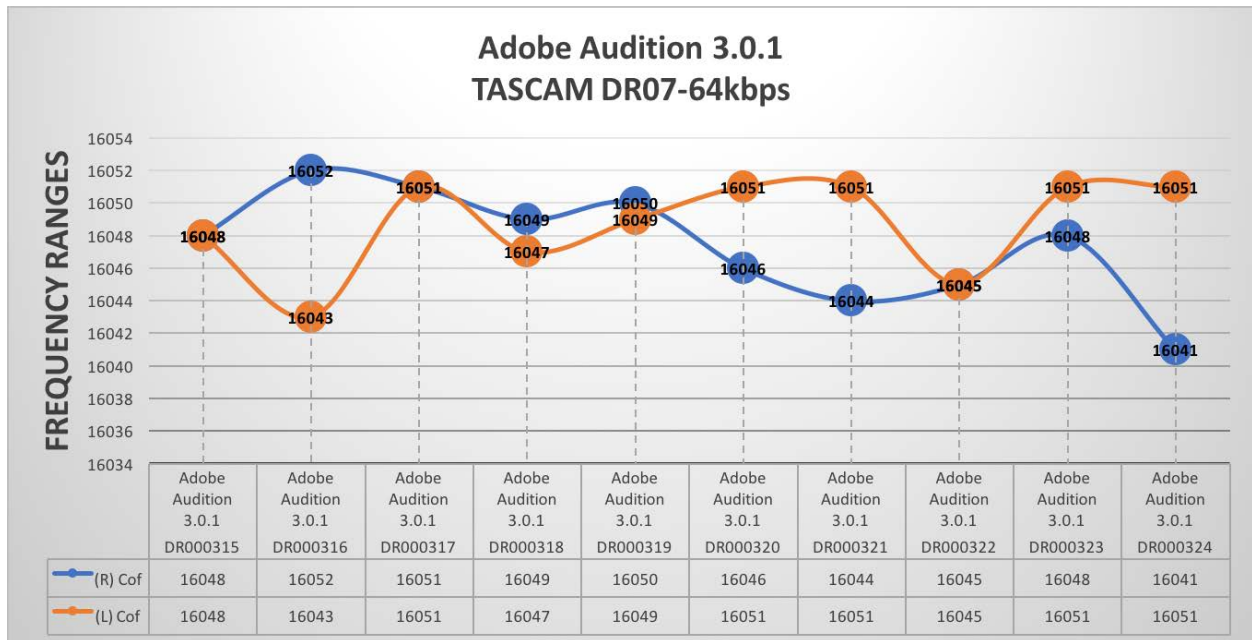
APPENDIX

TASCAM DR-07 64KBPS

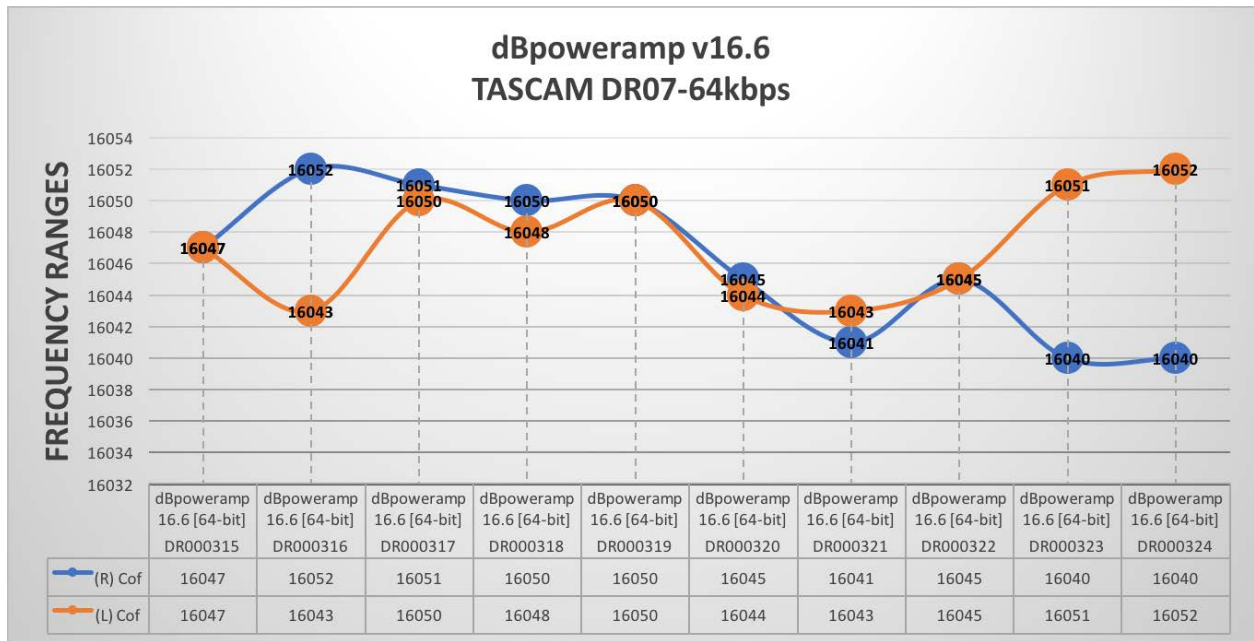
Each graph below displays data by transcoder and its effects on the recorded files COFs



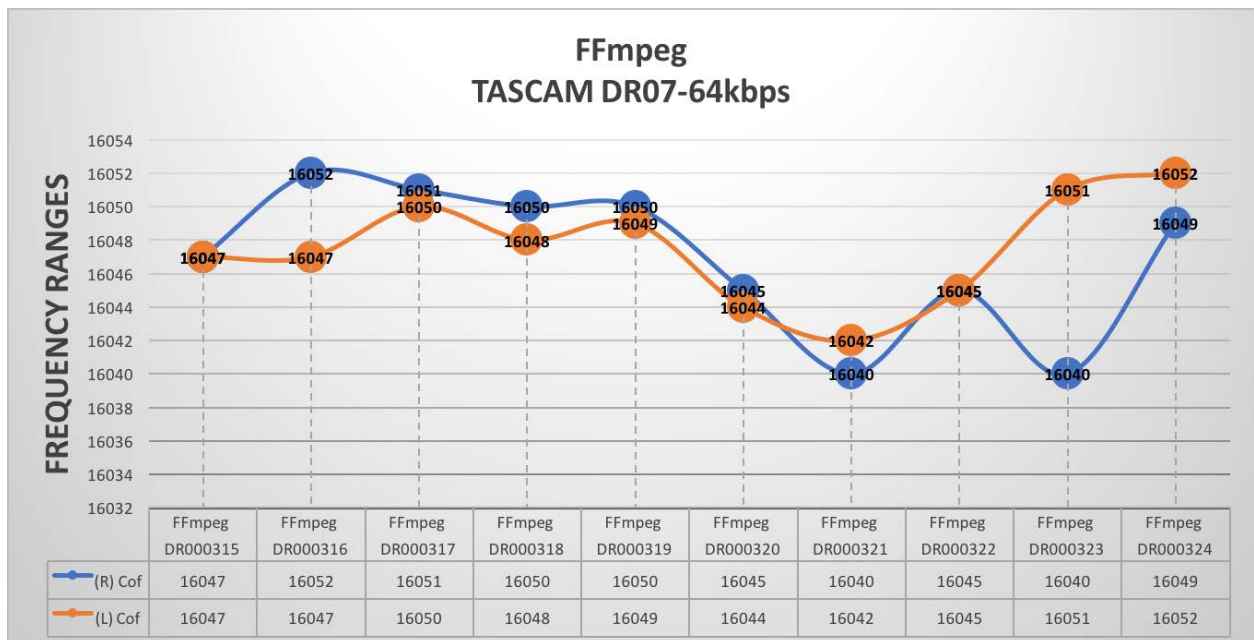
Adobe Audition 2021 effects on Tascam 64kbps Recordings



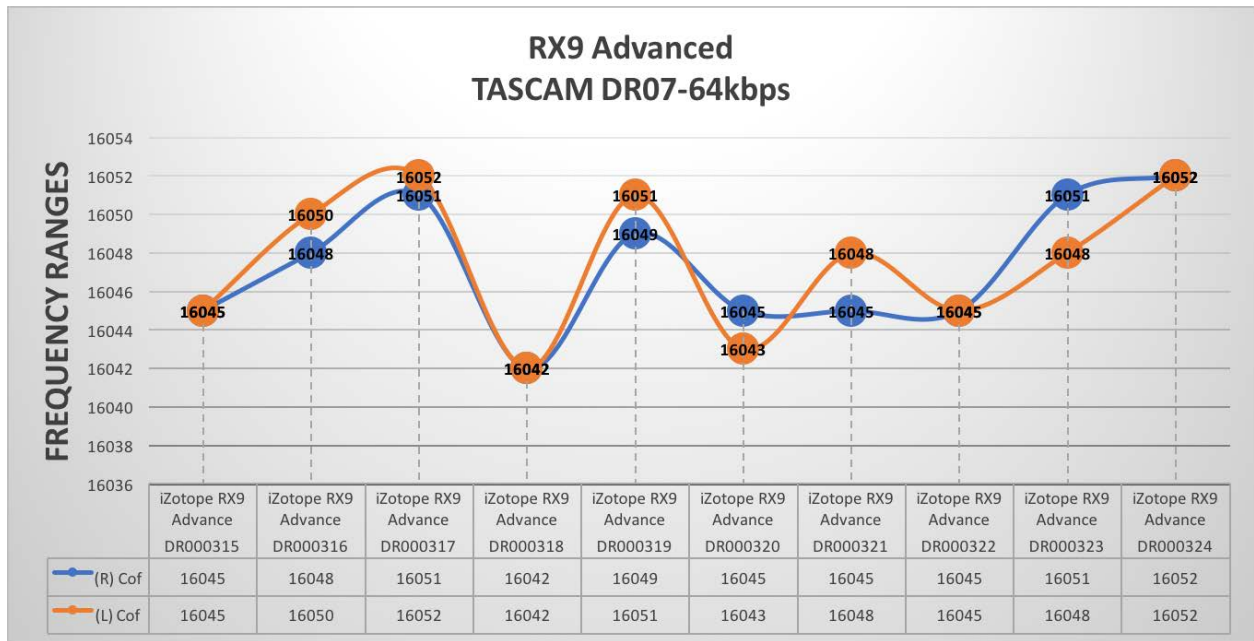
Adobe Audition 3.0.1 effects on Tascam 64kbps Recordings



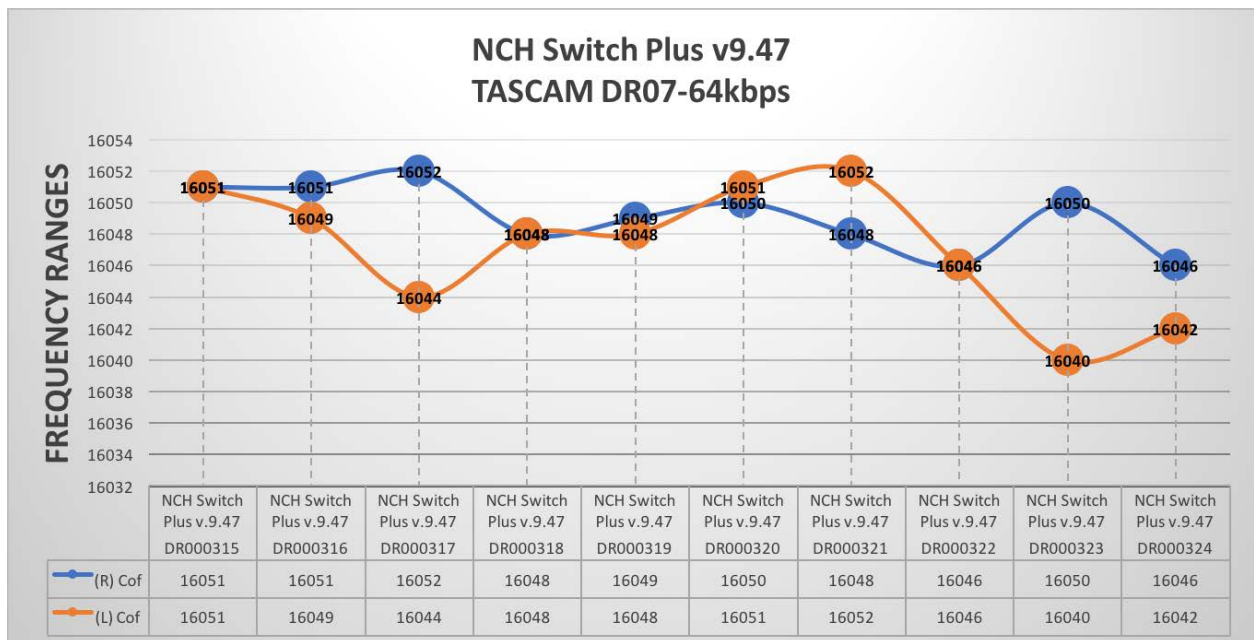
dBpoweramp effects on Tascam 64kbps Recordings



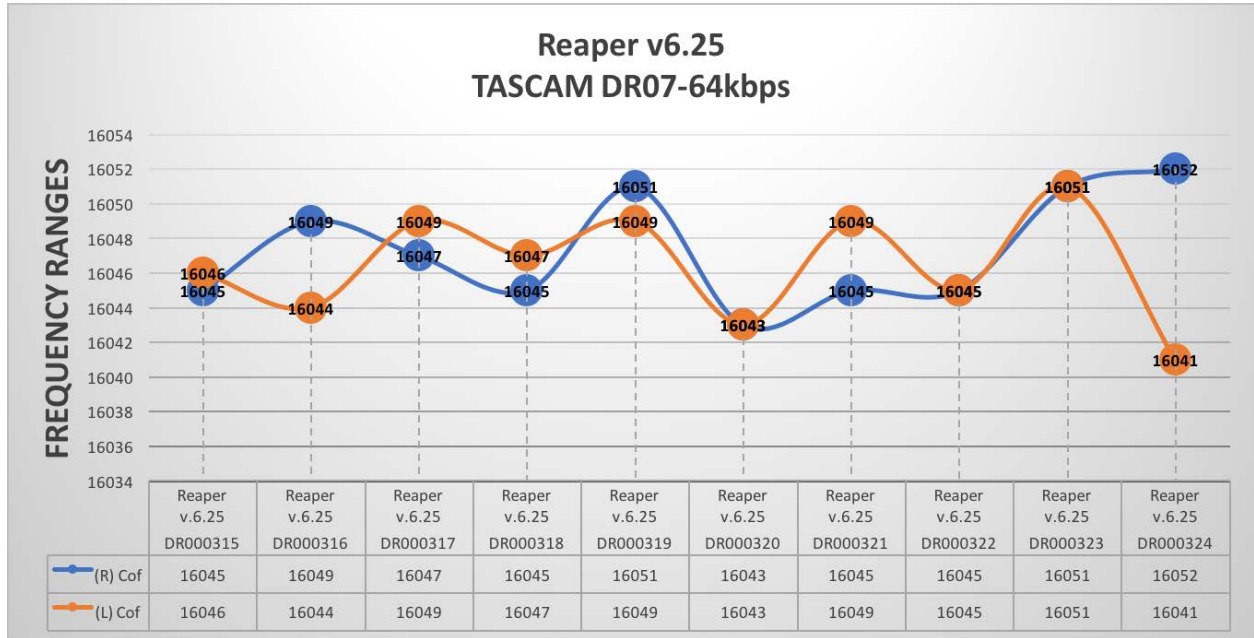
FFmpeg 2021 effects on Tascam 64kbps Recordings



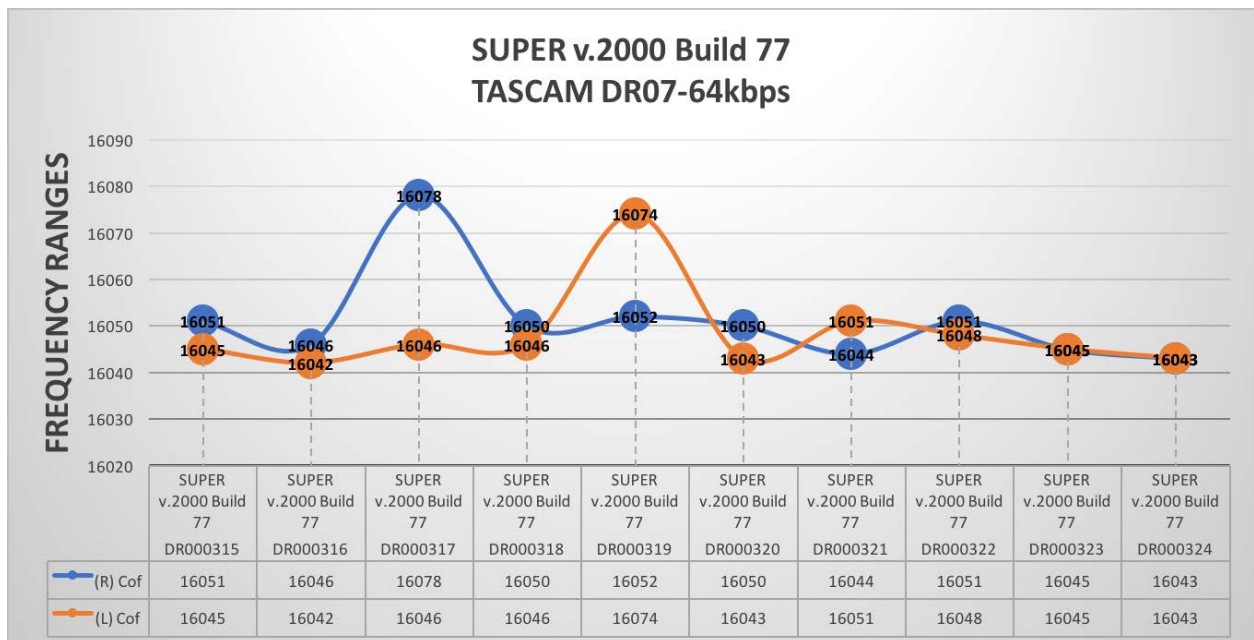
RX9 effects on Tascam 64kbps Recordings



NCH Switch Plus effects on Tascam 64kbps Recordings



Reaper effects on Tascam 64kbps Recordings



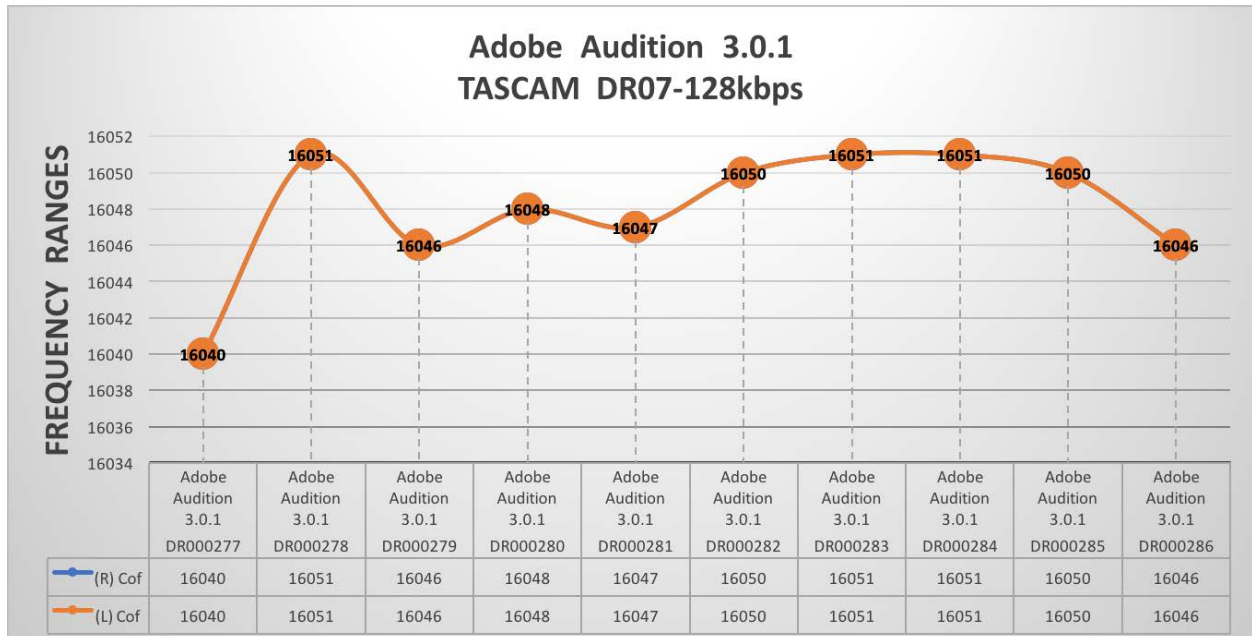
SUPER effects on Tascam 64kbps Recordings

TASCAM DR-07 128KBPS

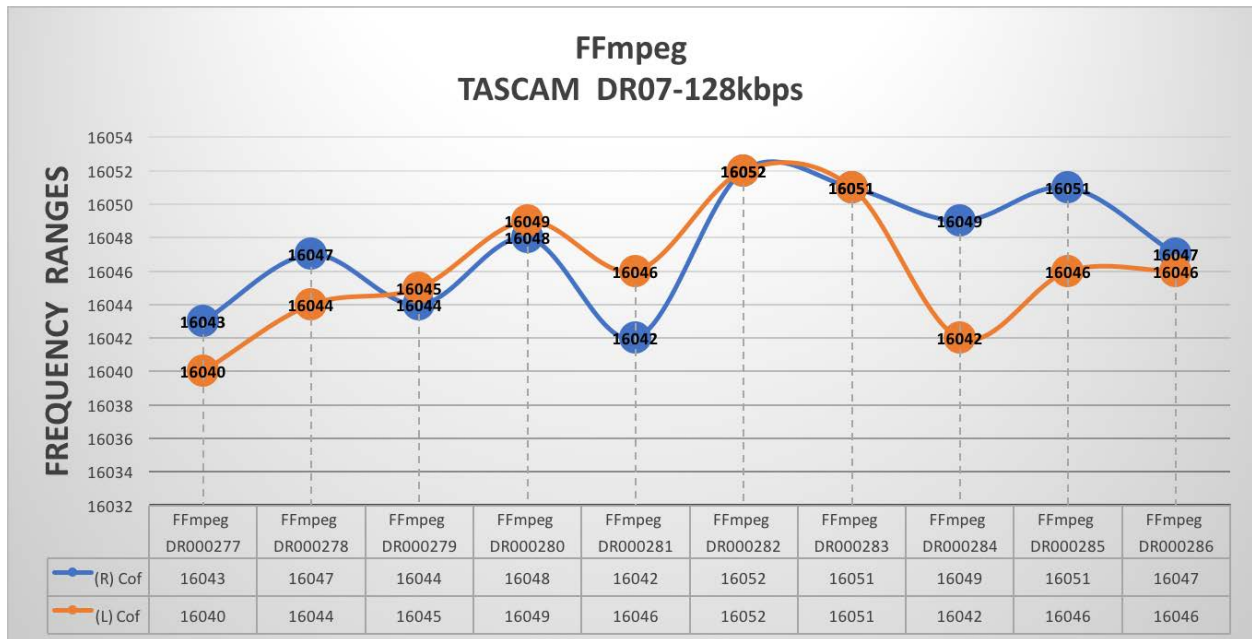
Each graph displays data by Transcoder and its effects on the recorded files COFs



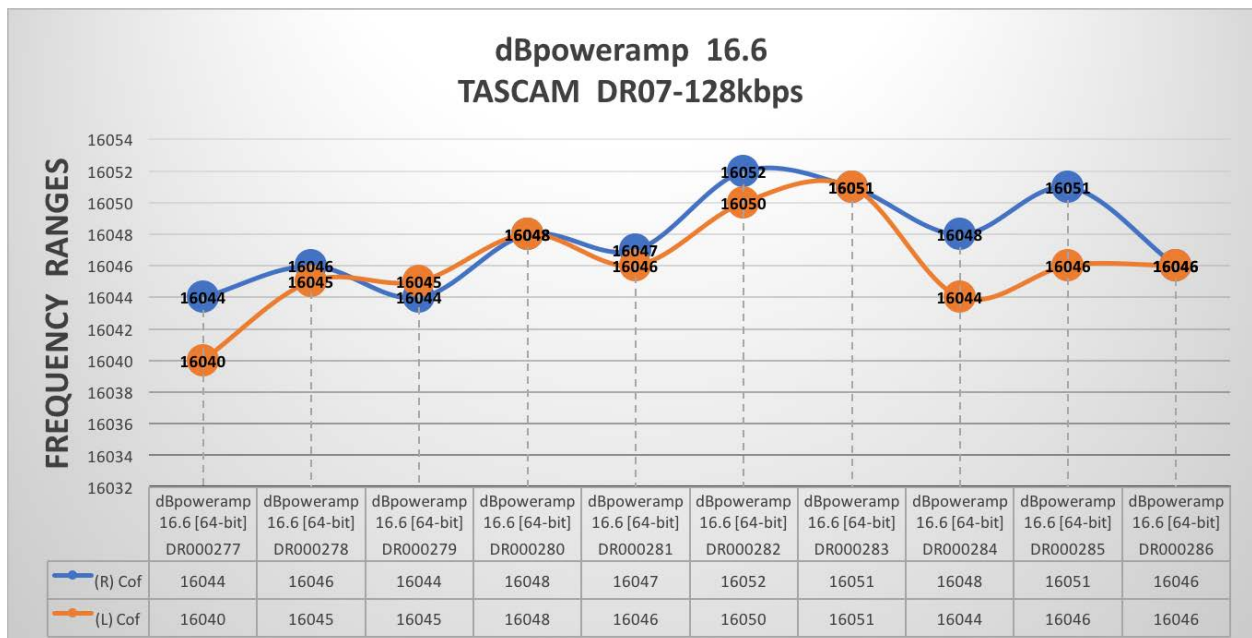
Adobe Audition 2021 effects on Tascam 128kbps Recordings



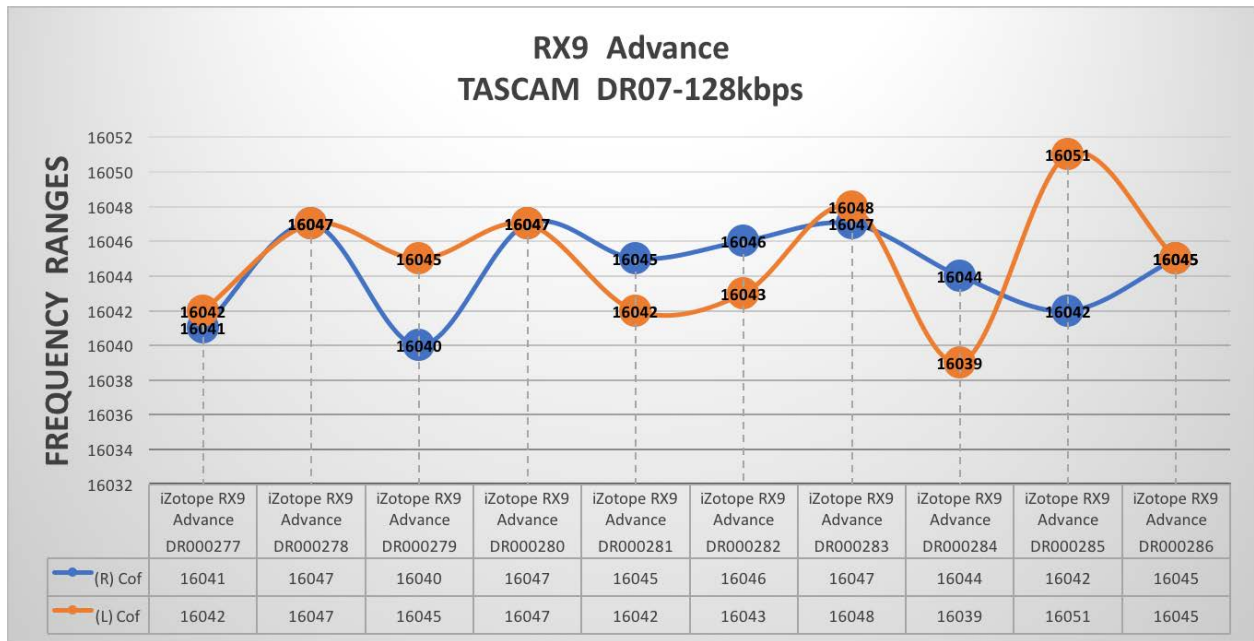
Adobe Audition 3.0.1 effects on Tascam 128kbps Recordings



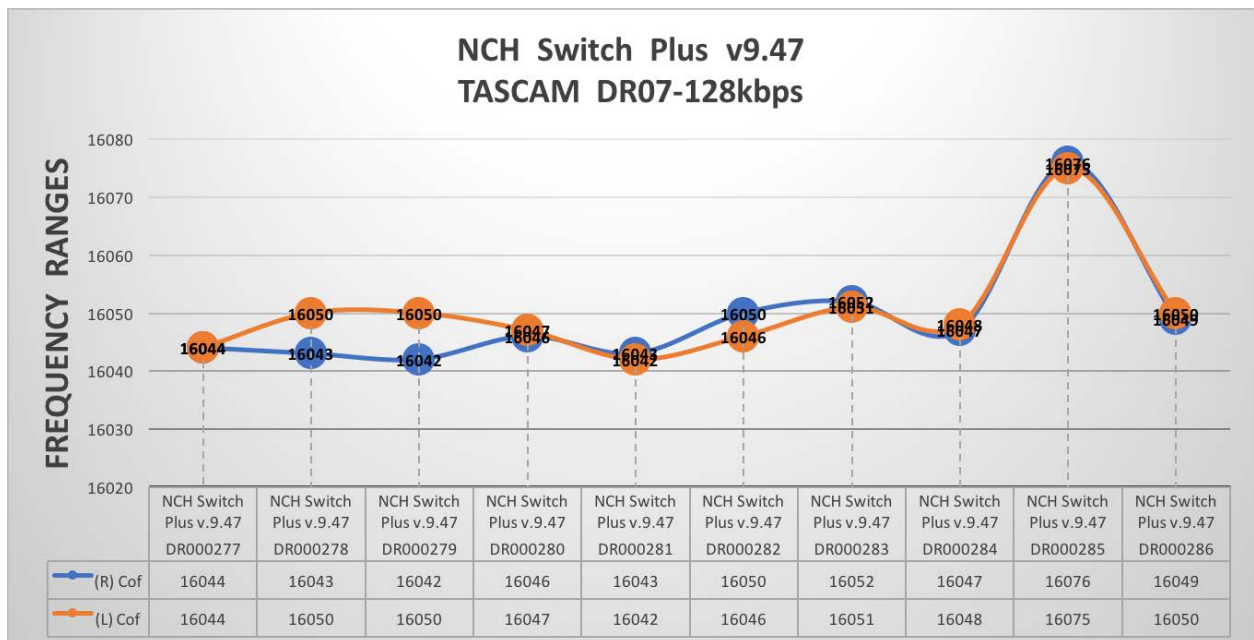
FFmpeg effects on Tascam 128kbps Recordings



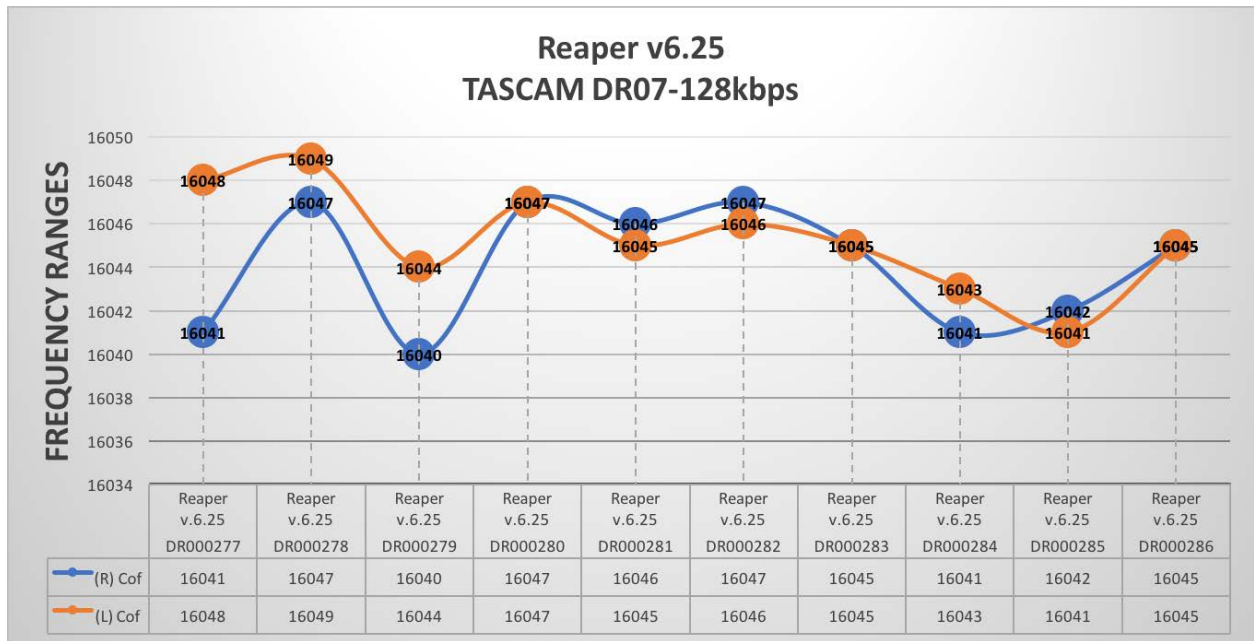
dBpoweramp effects on Tascam 128kbps Recordings



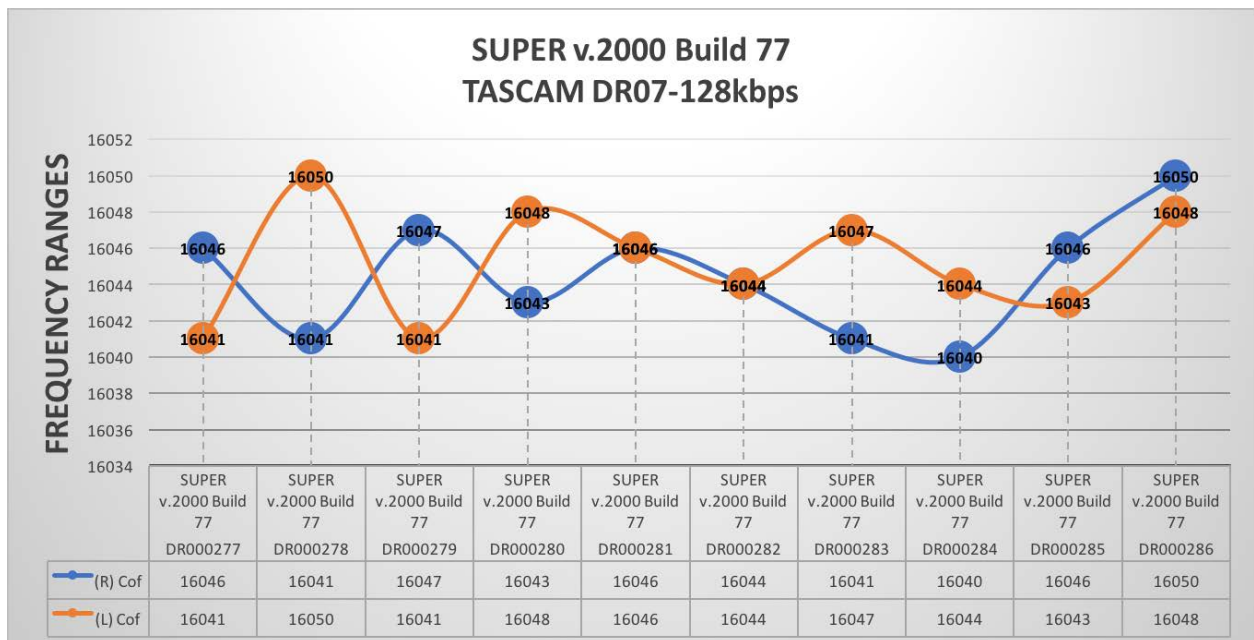
RX9 effects on Tascam 128kbps Recordings



NCH Switch Plus effects on Tascam 128kbps Recordings



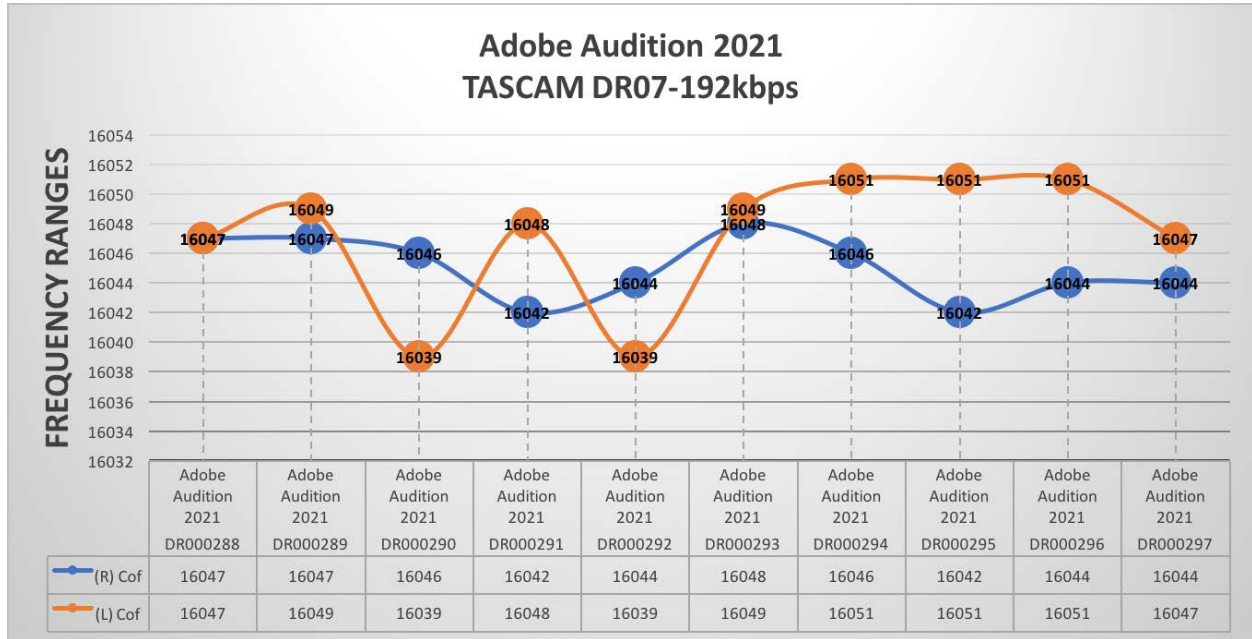
Reaper effects on Tascam 128kbps Recordings



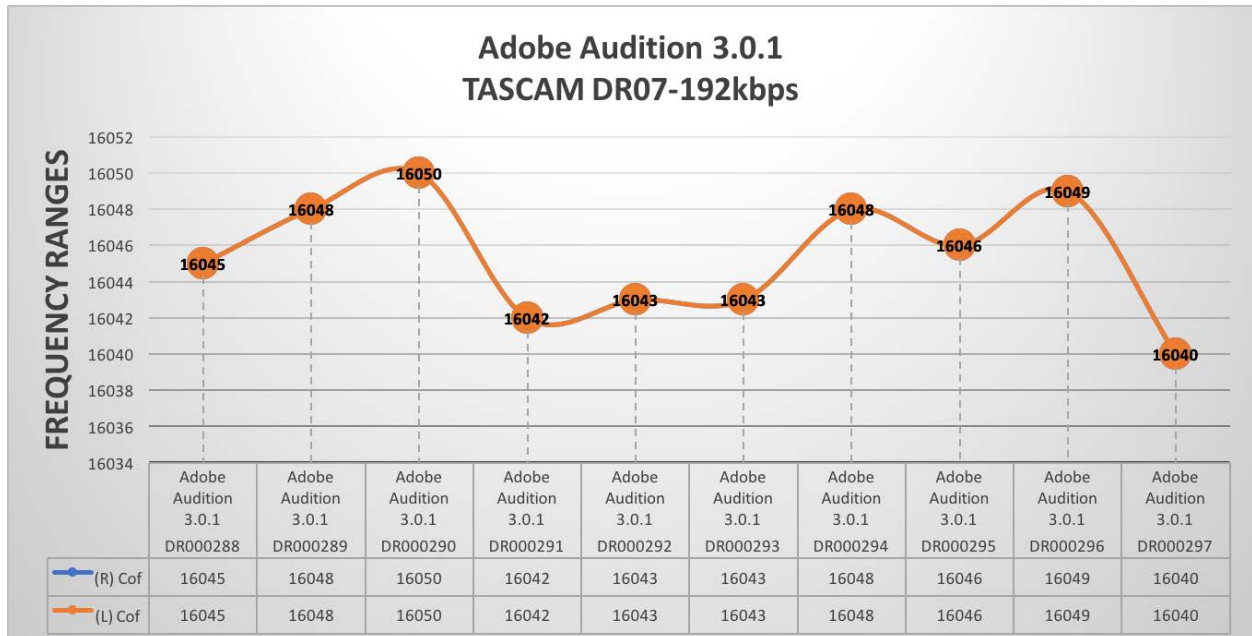
SUPER effects on Tascam 128kbps Recordings

TASCAM DR-07 192KBPS

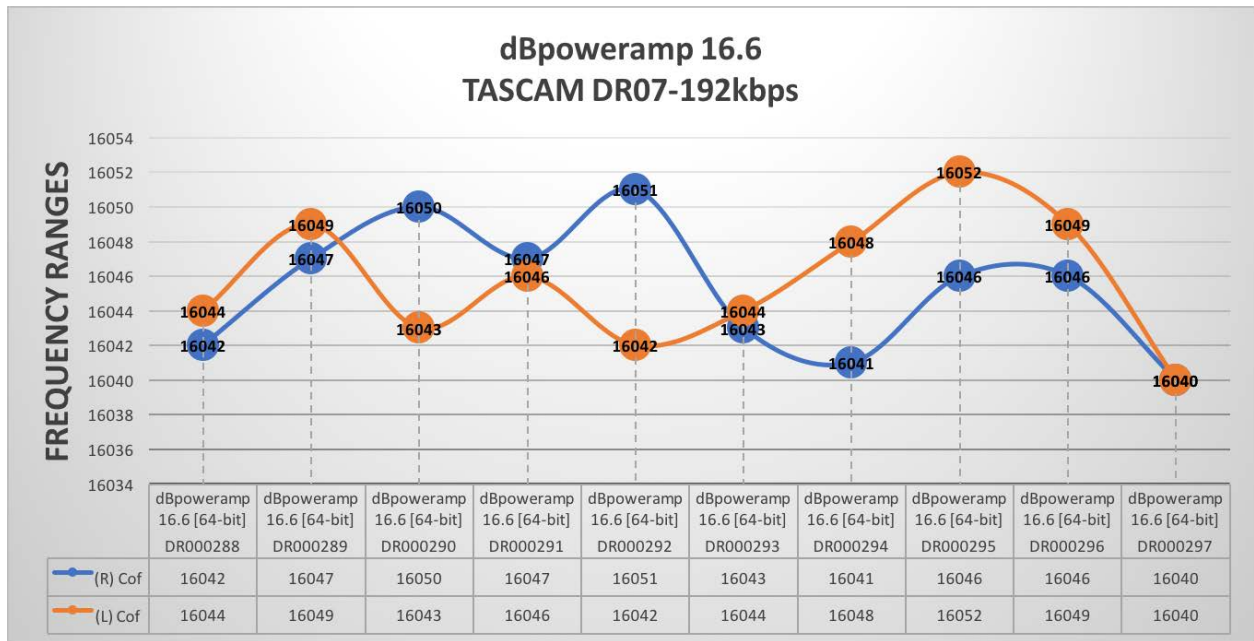
Each graph displays data by Transcoder and its effects on the recorded files COFs



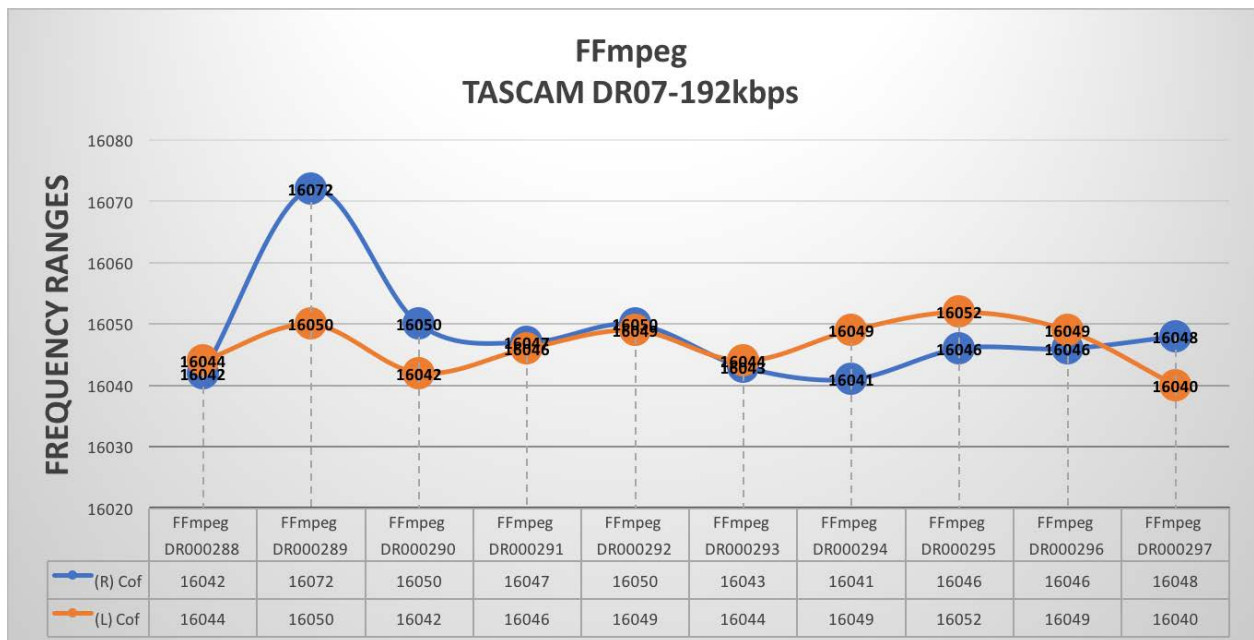
Adobe Audition 2021 effects on Tascam 192kbps Recordings



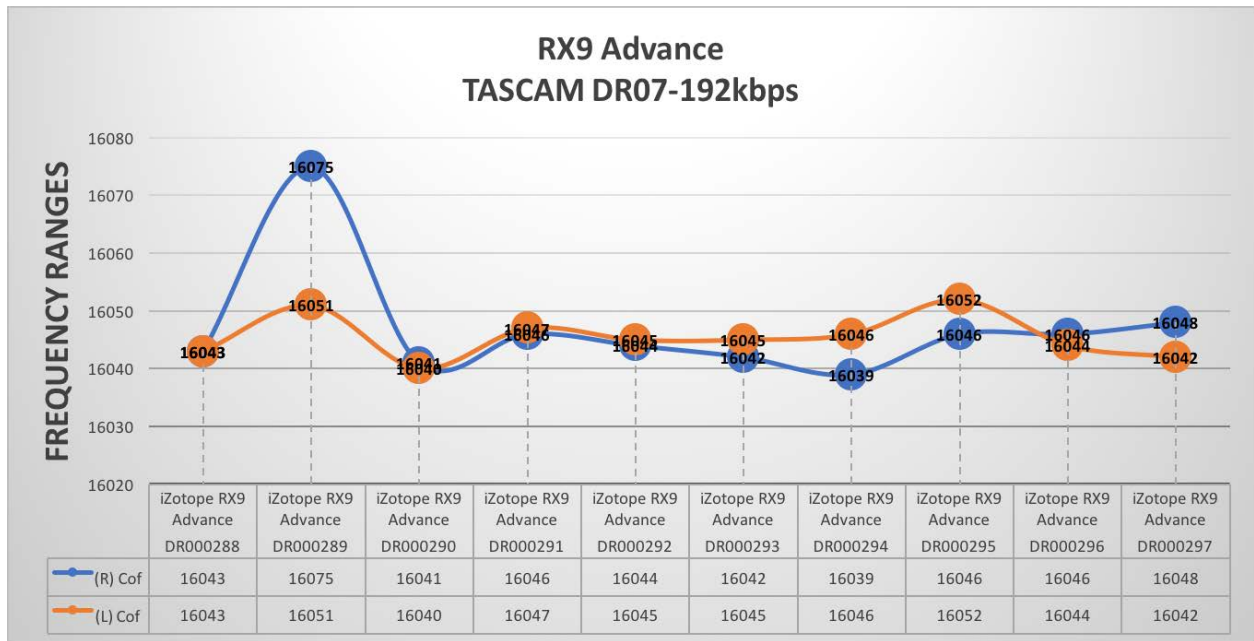
Adobe Audition 3.0.1 effects on Tascam 192kbps Recordings



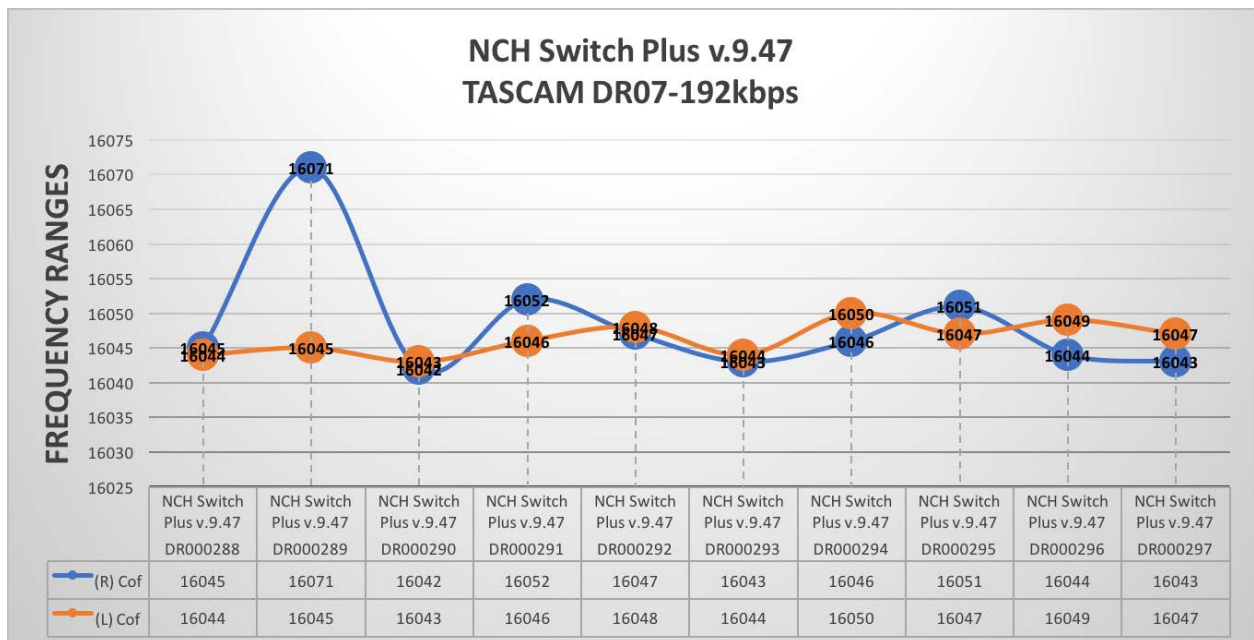
dBpoweramp effects on Tascam 192kbps Recordings



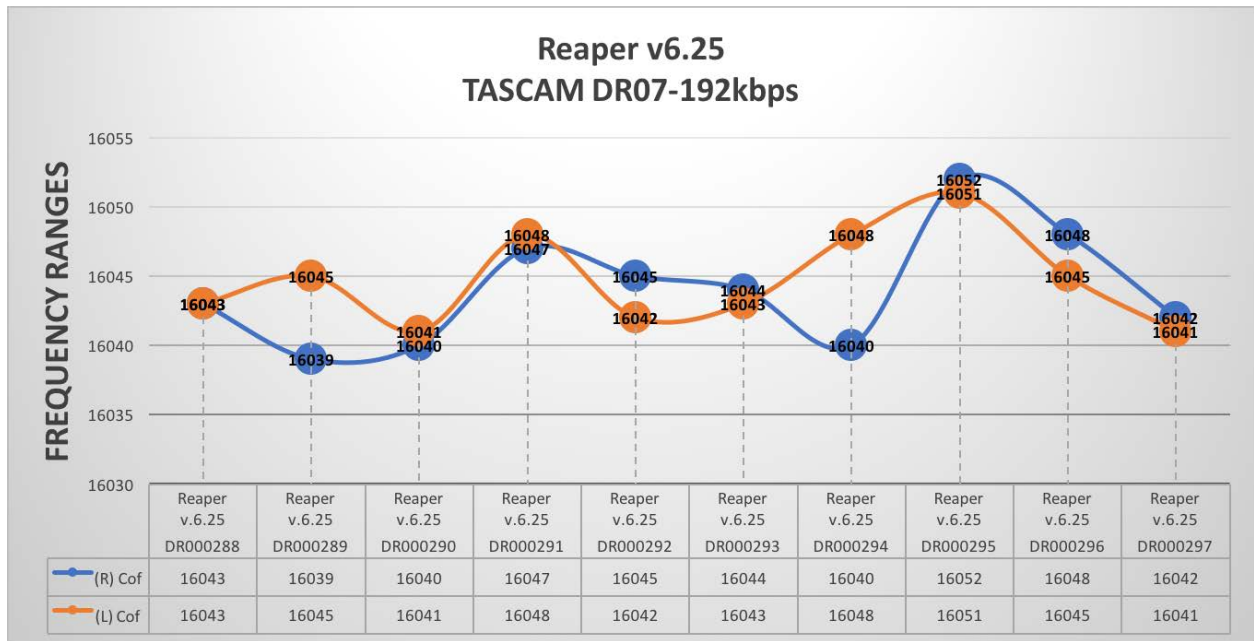
FFmpeg effects on Tascam 192kbps Recordings



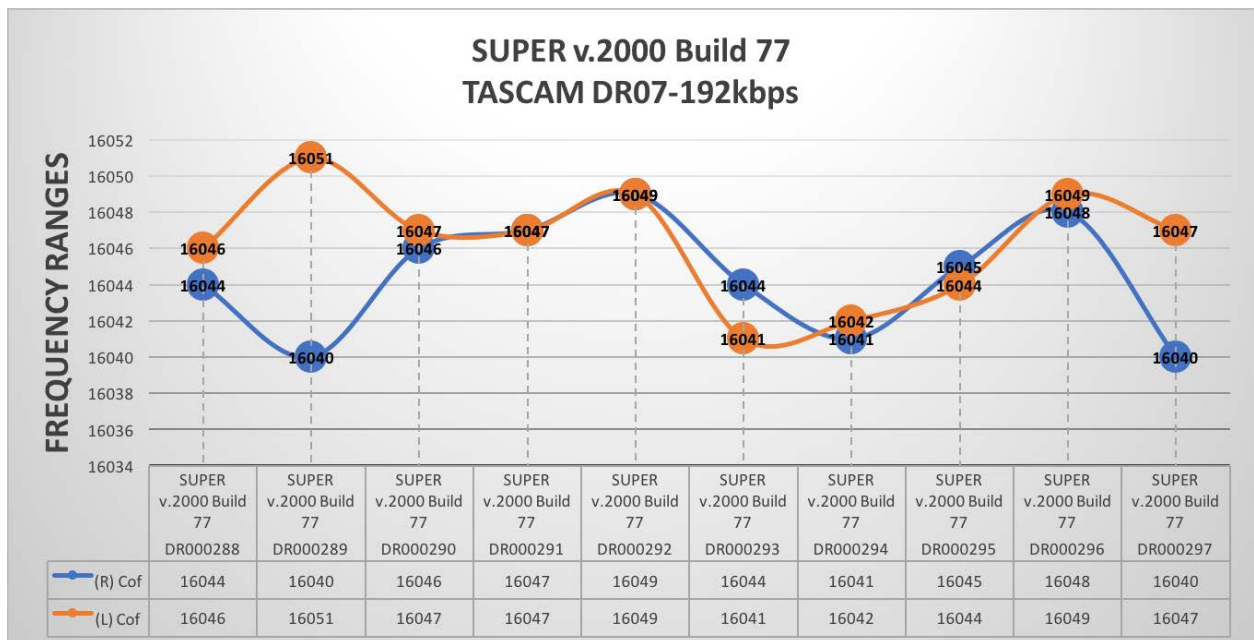
RX9 effects on Tascam 192kbps Recordings



NCH Switch Plus effects on Tascam 192kbps Recordings



Reaper effects on Tascam 192kbps Recordings



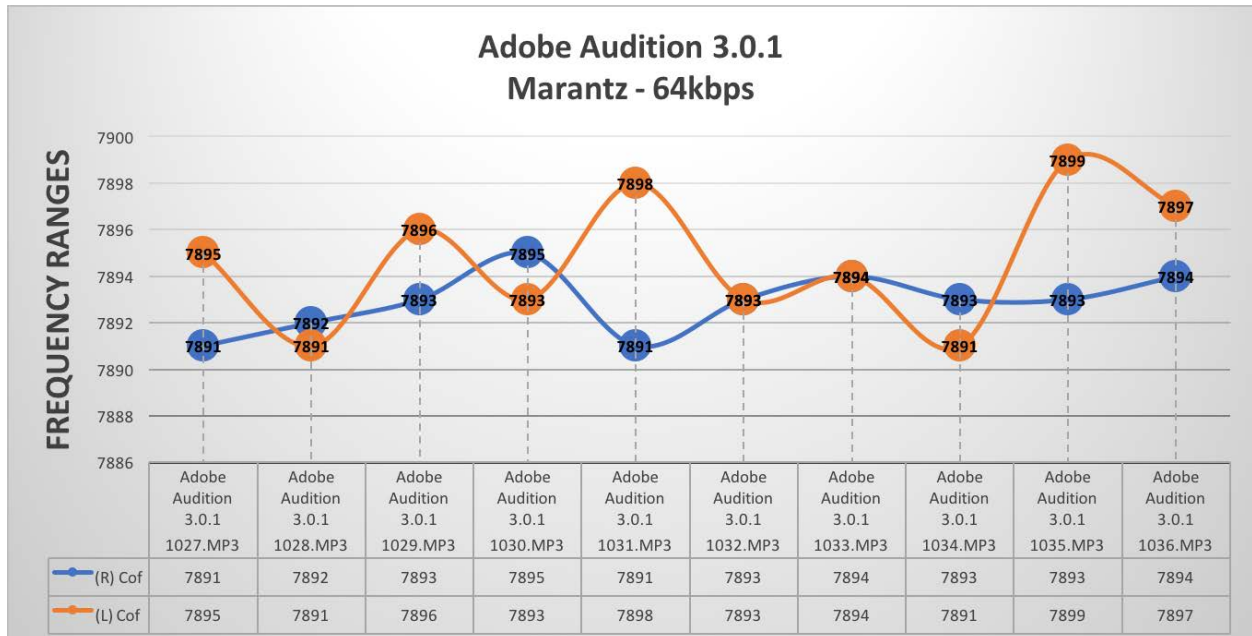
SUPER effects on Tascam 192kbps Recordings

MARANTZ PMD620 64 KBPS

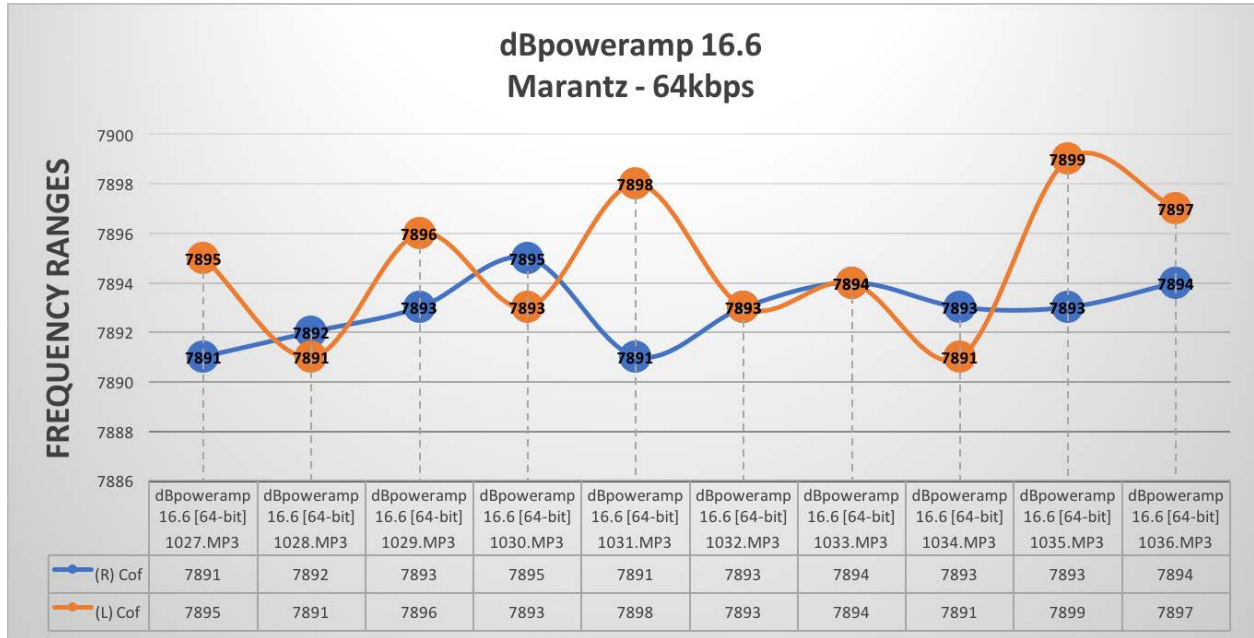
Each graph displays data by Transcoder and its effects on the recorded files COFs



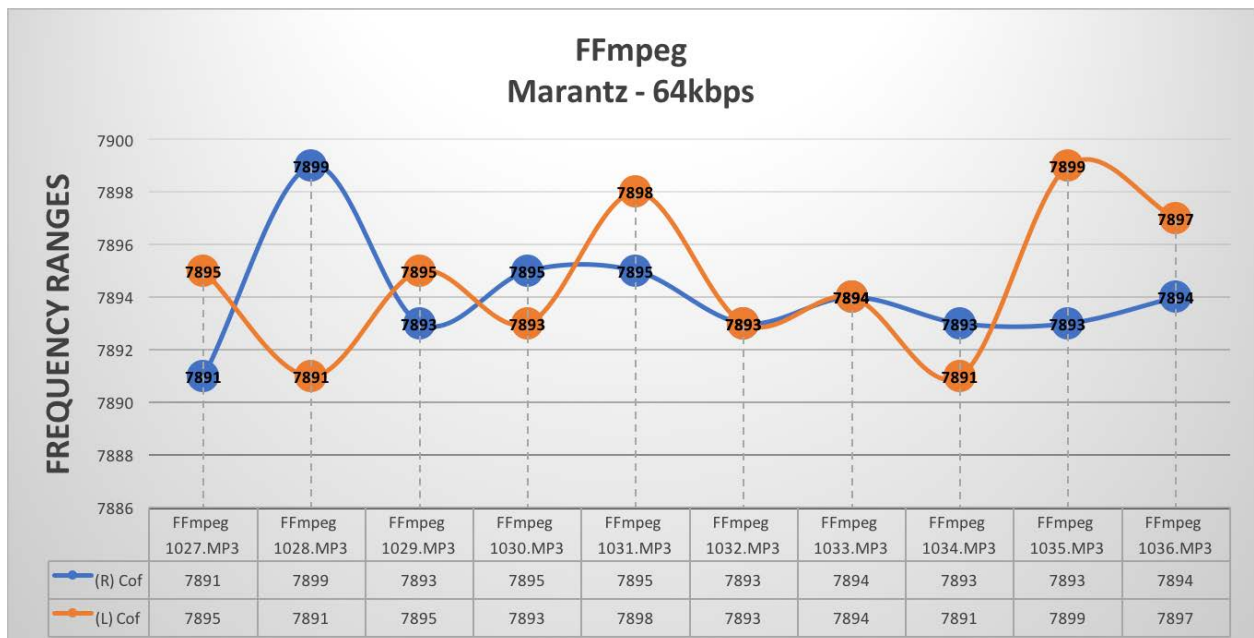
Adobe Audition 2021 effects on Marantz 64kbps Recordings



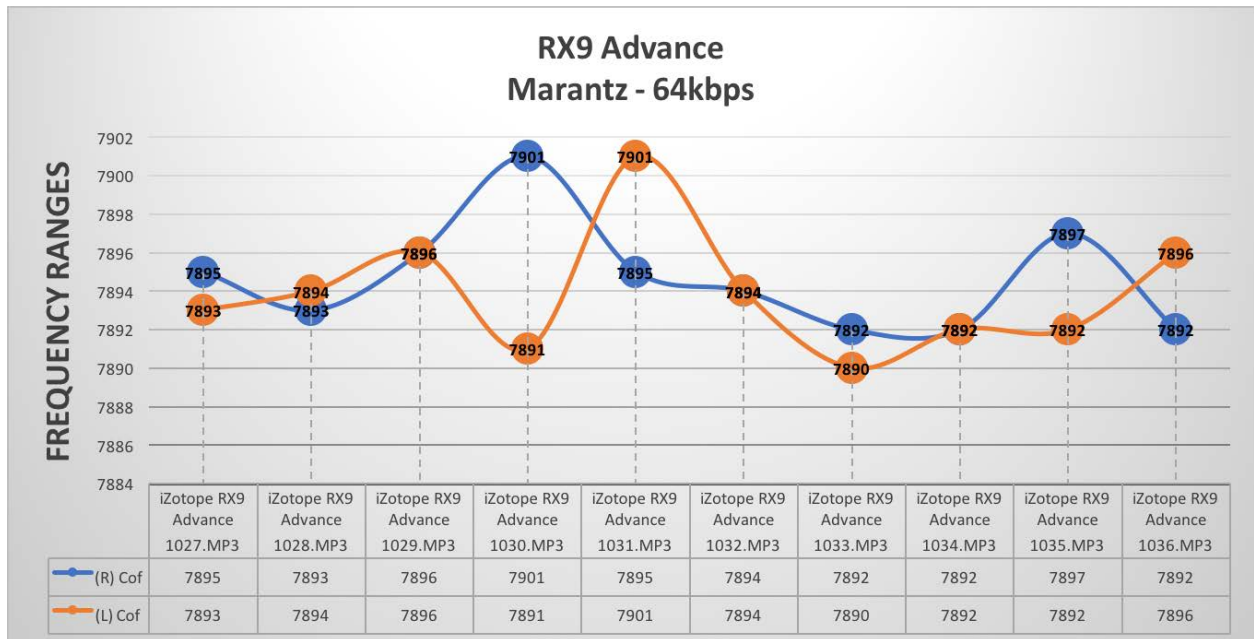
Adobe Audition 3.0.1 effects on Marantz 64kbps Recordings



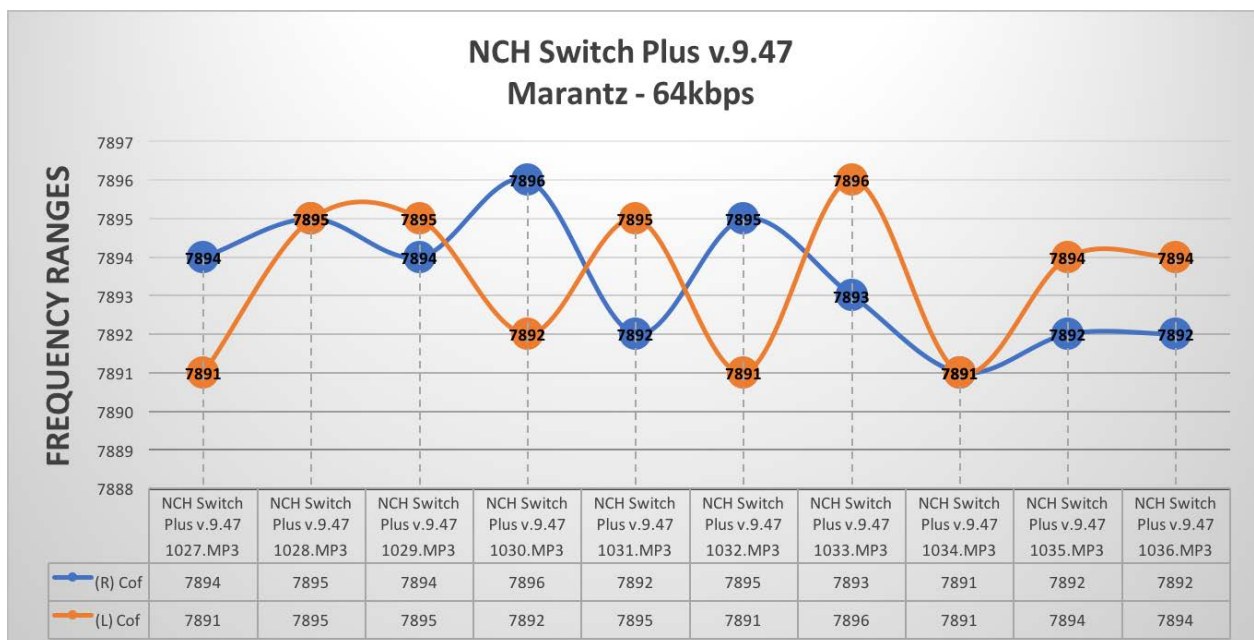
dBpoweramp effects on Marantz 64kbps Recordings



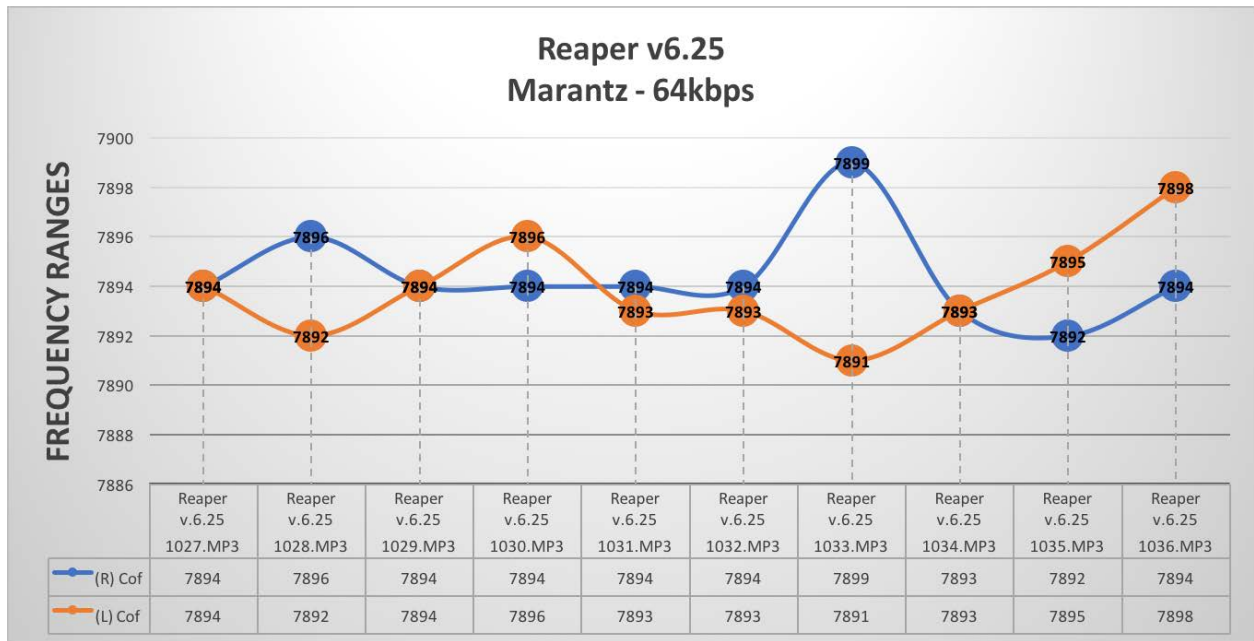
FFmpeg effects on Marantz 64kbps Recordings



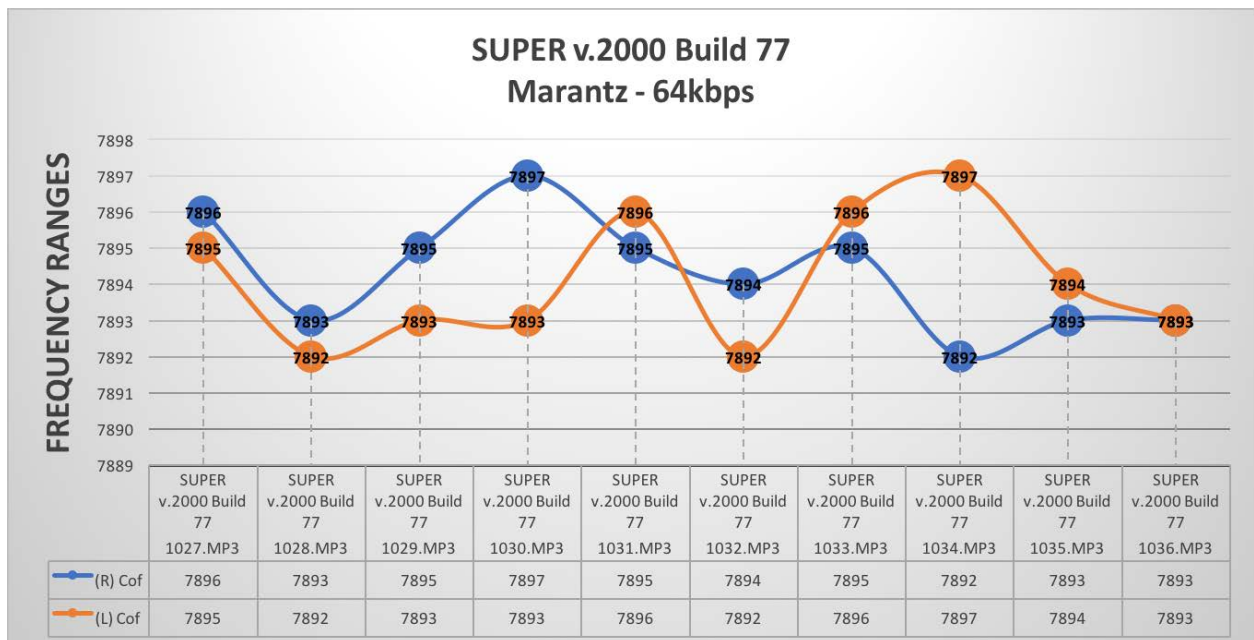
RX9 effects on Marantz 64kbps Recordings



NCH Switch Plus effects on Marantz 64kbps Recordings



Reaper effects on Marantz 64kbps Recordings



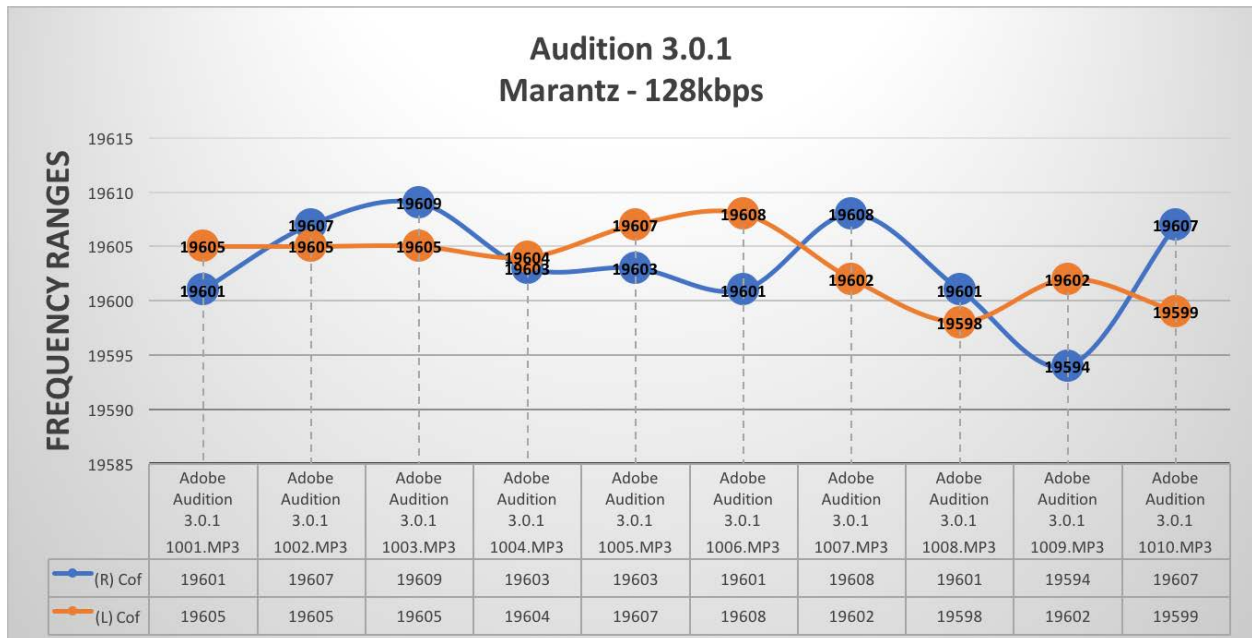
SUPER effects on Marantz 64kbps Recordings

MARANTZ PMD620 128 KBPS

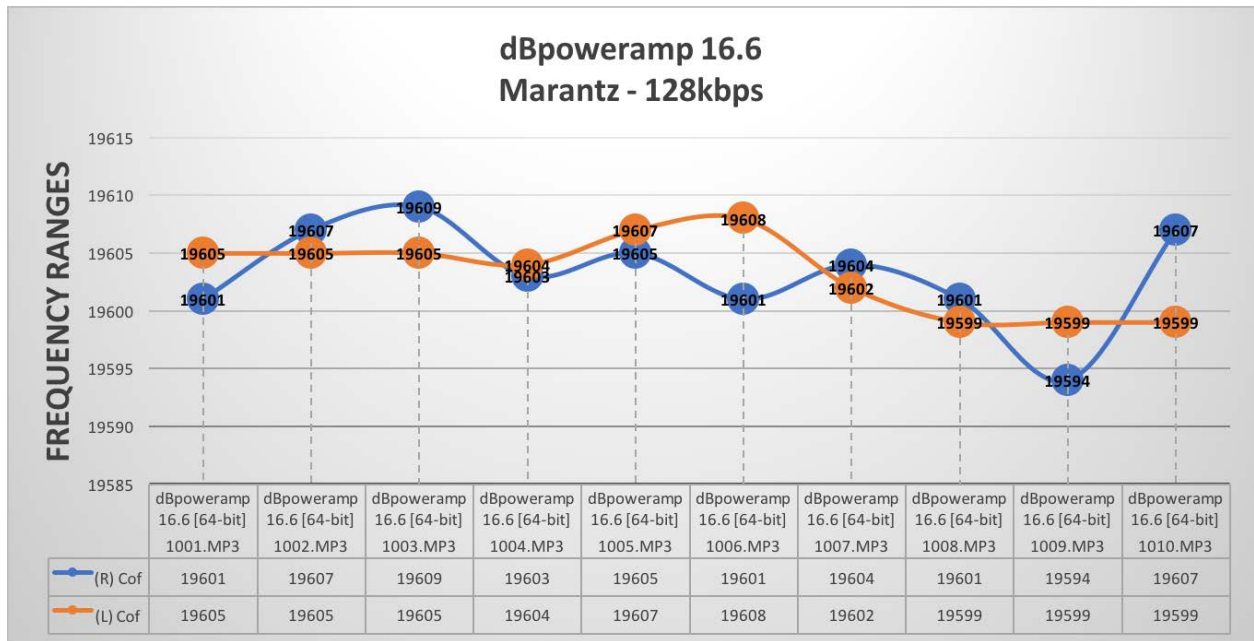
Each graph displays data by Transcoder and its effects on the recorded files COFs



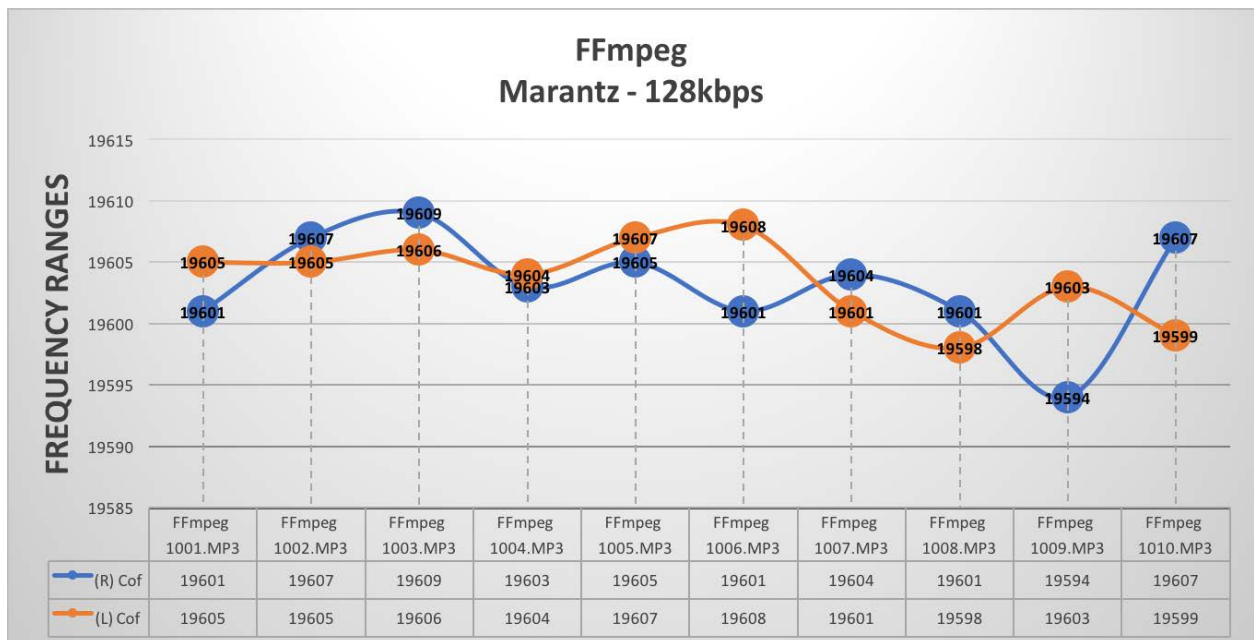
Adobe Audition 2021 effects on Marantz 128kbps Recordings



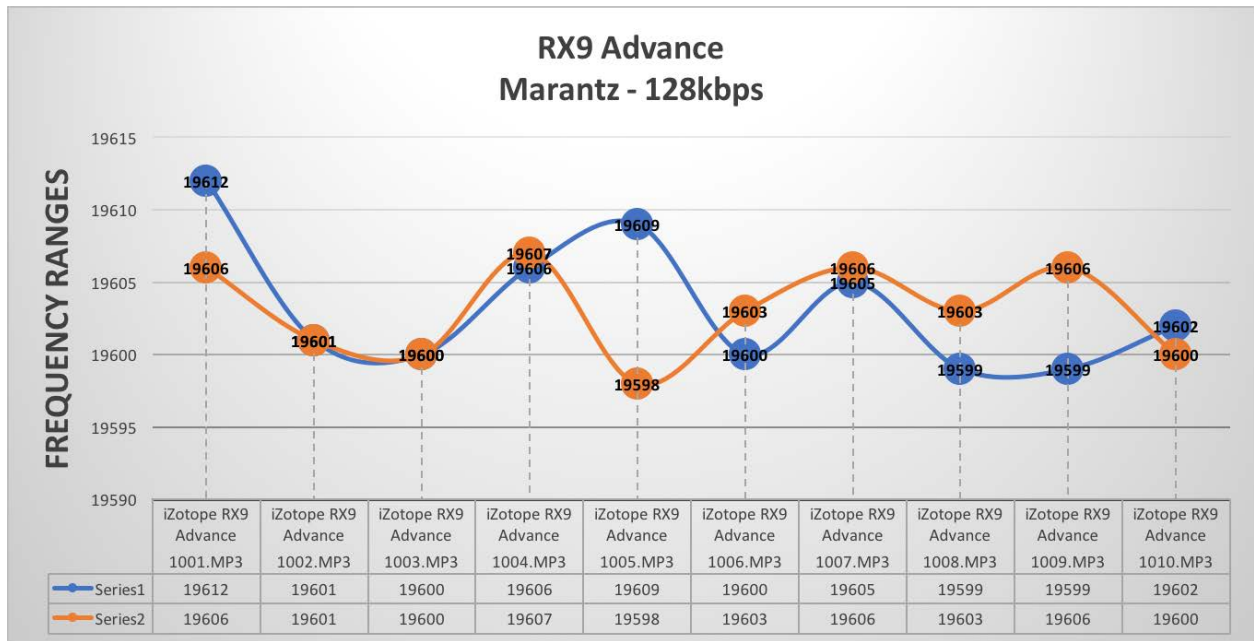
Adobe Audition 3.0.1 effects on Marantz 128kbps Recordings



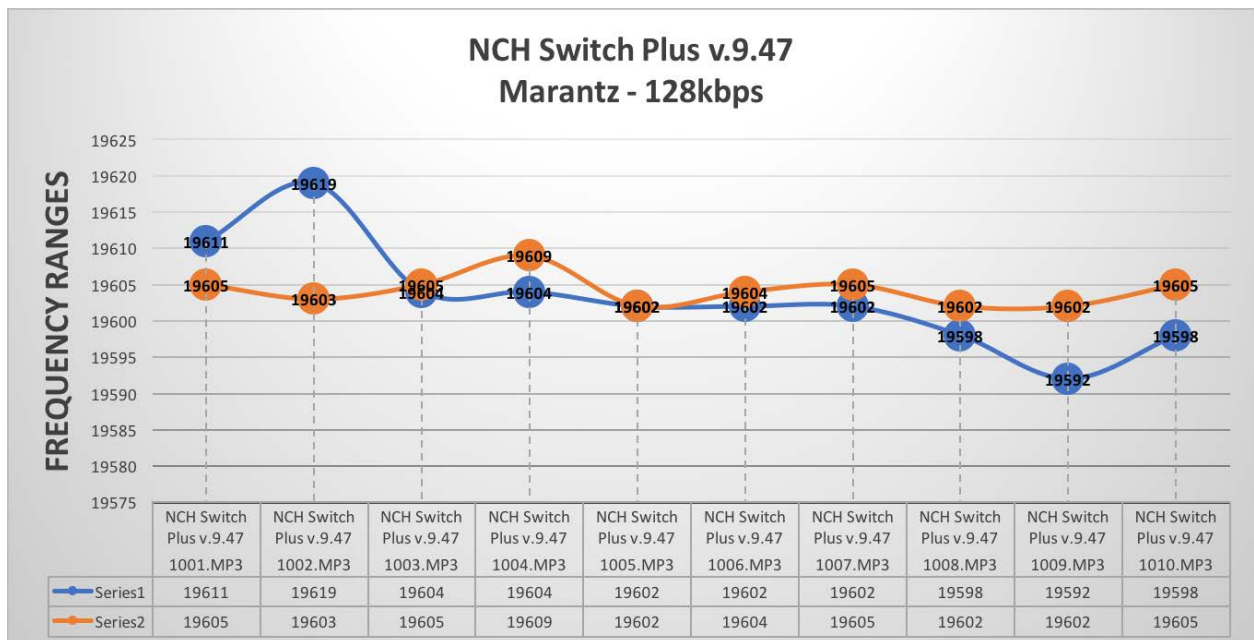
dBpoweramp effects on Marantz 128kbps Recordings



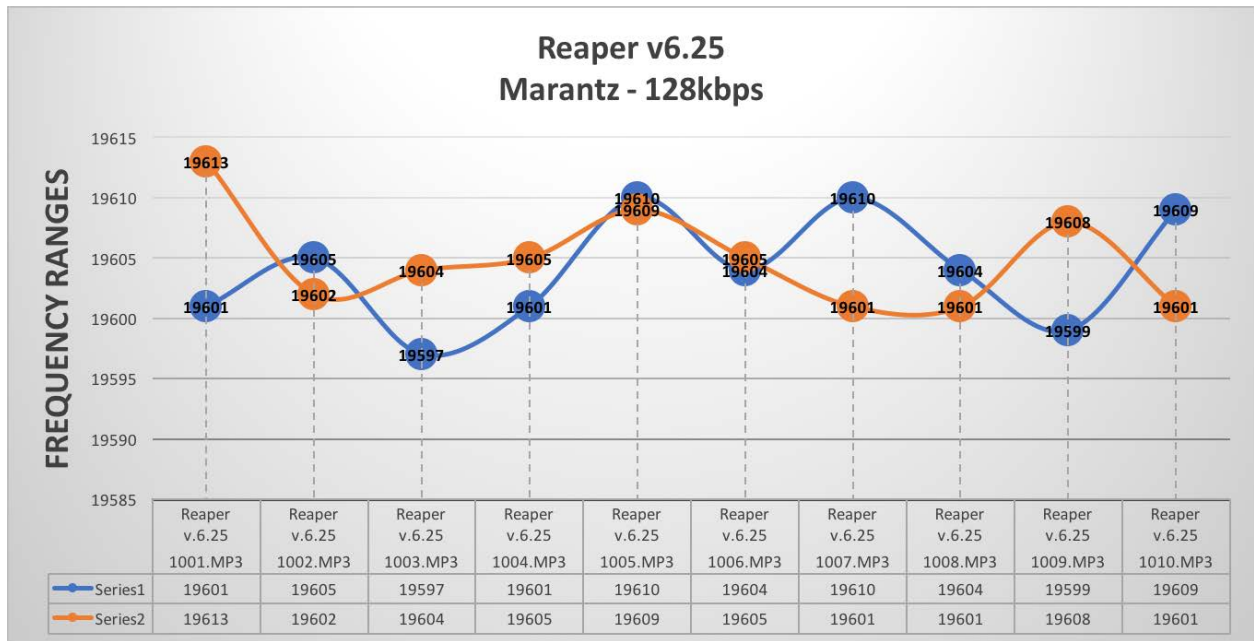
FFmpeg effects on Marantz 128kbps Recordings



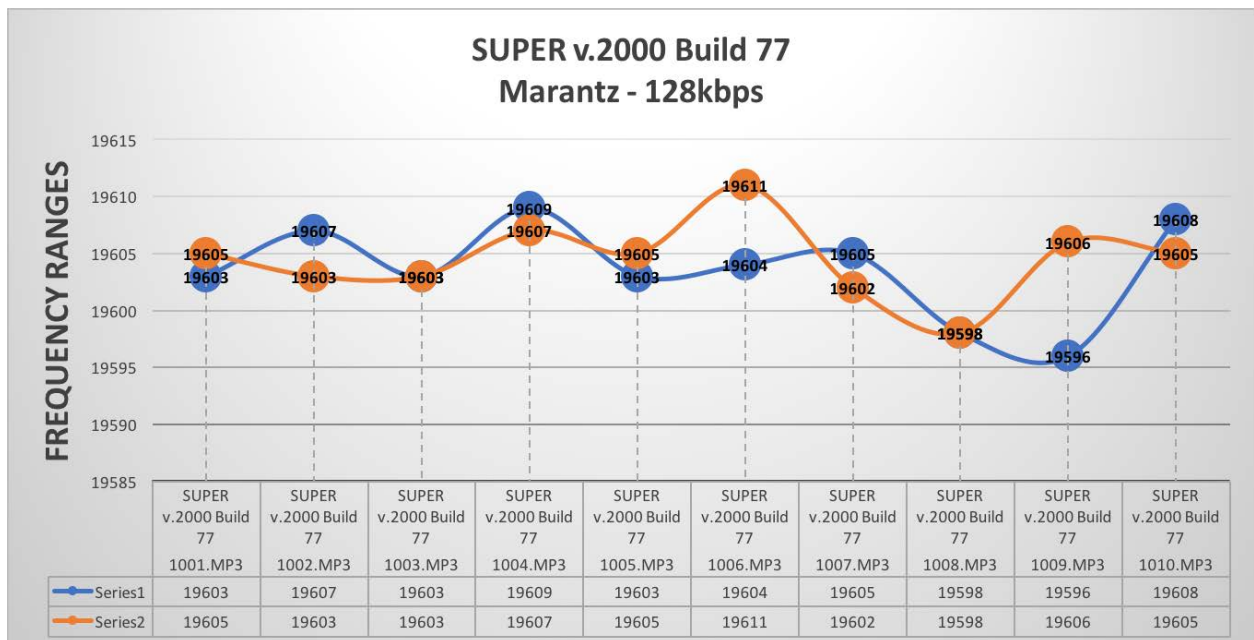
RX9 effects on Marantz 128kbps Recordings



NCH Switch Plus effects on Marantz 128kbps Recordings



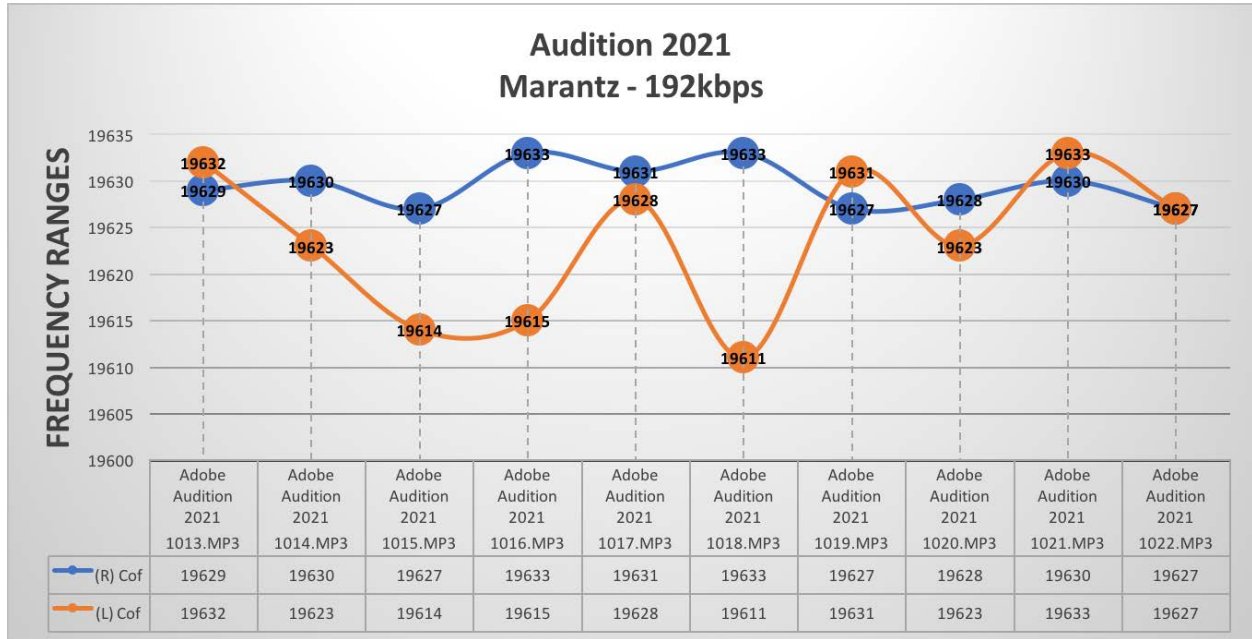
Reaper effects on Marantz 128kbps Recordings



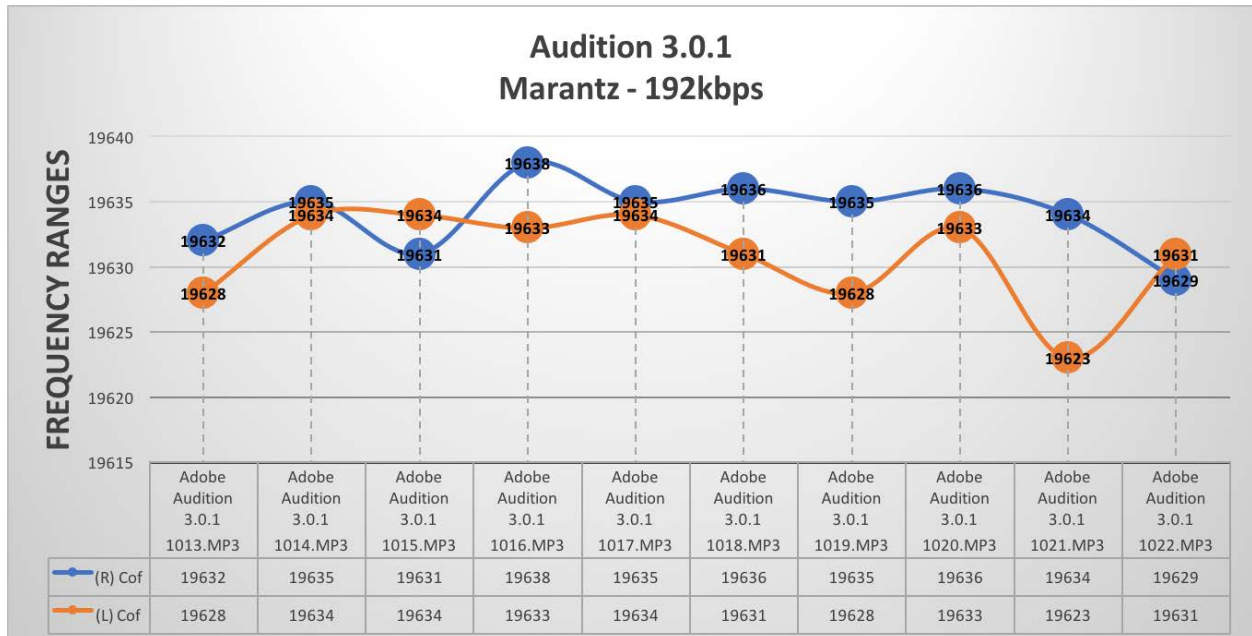
SUPER effects on Marantz 128kbps Recordings

MARANTZ PMD620 192 KBPS

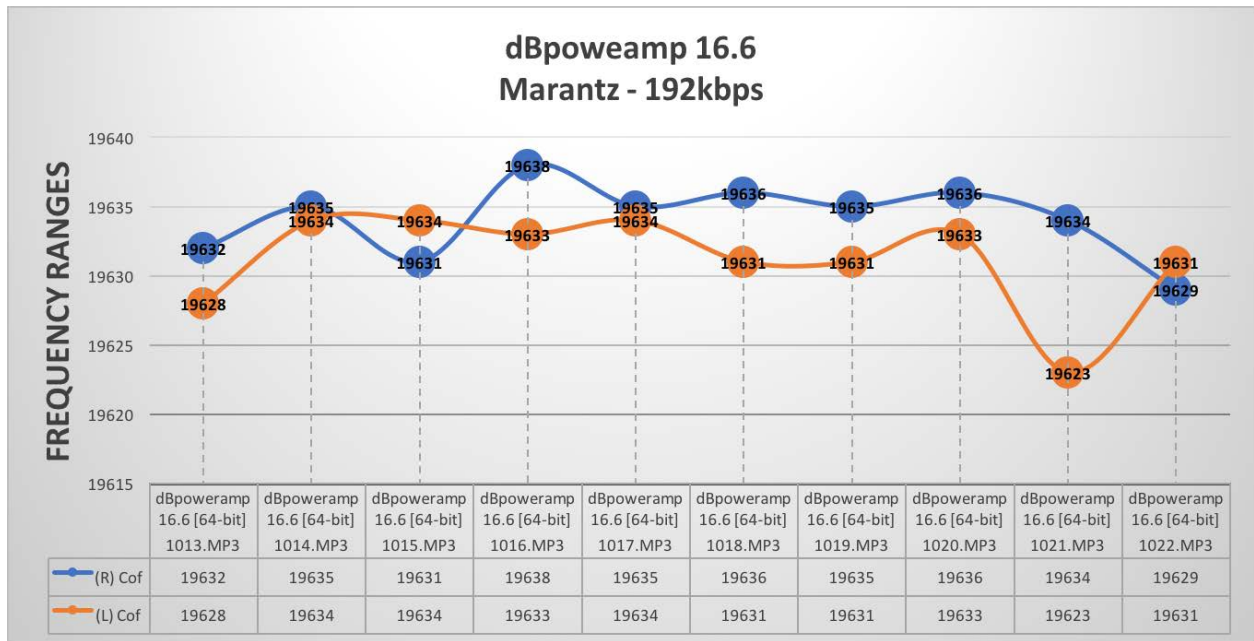
Each graph displays data by Transcoder and its effects on the recorded files COFs



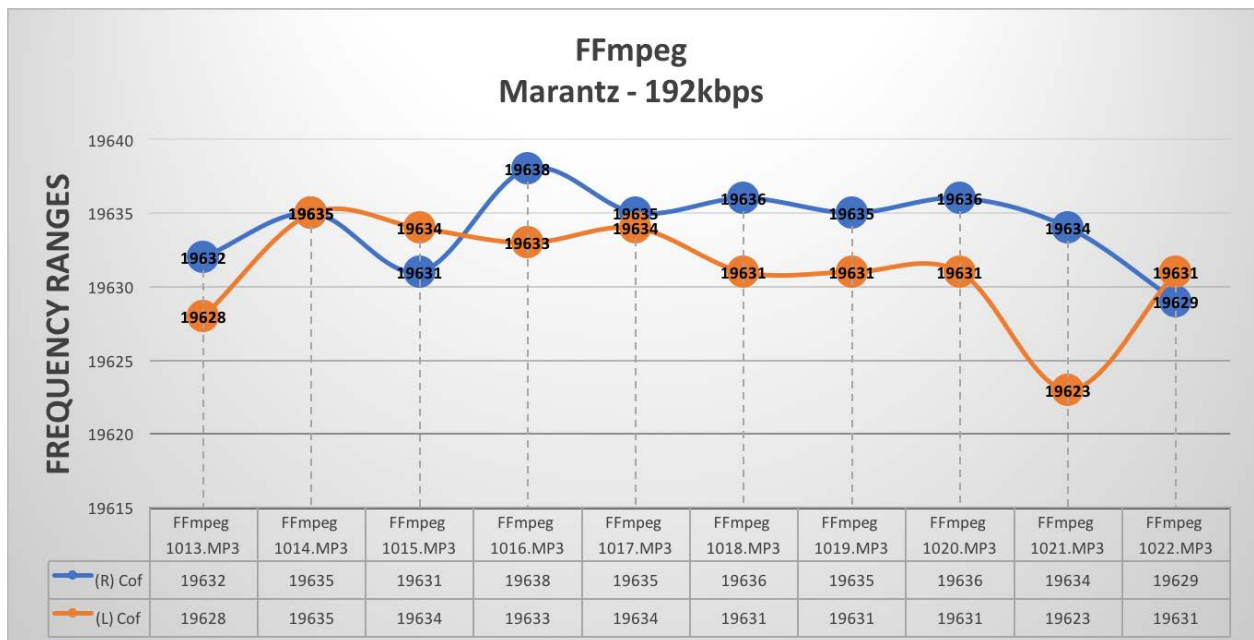
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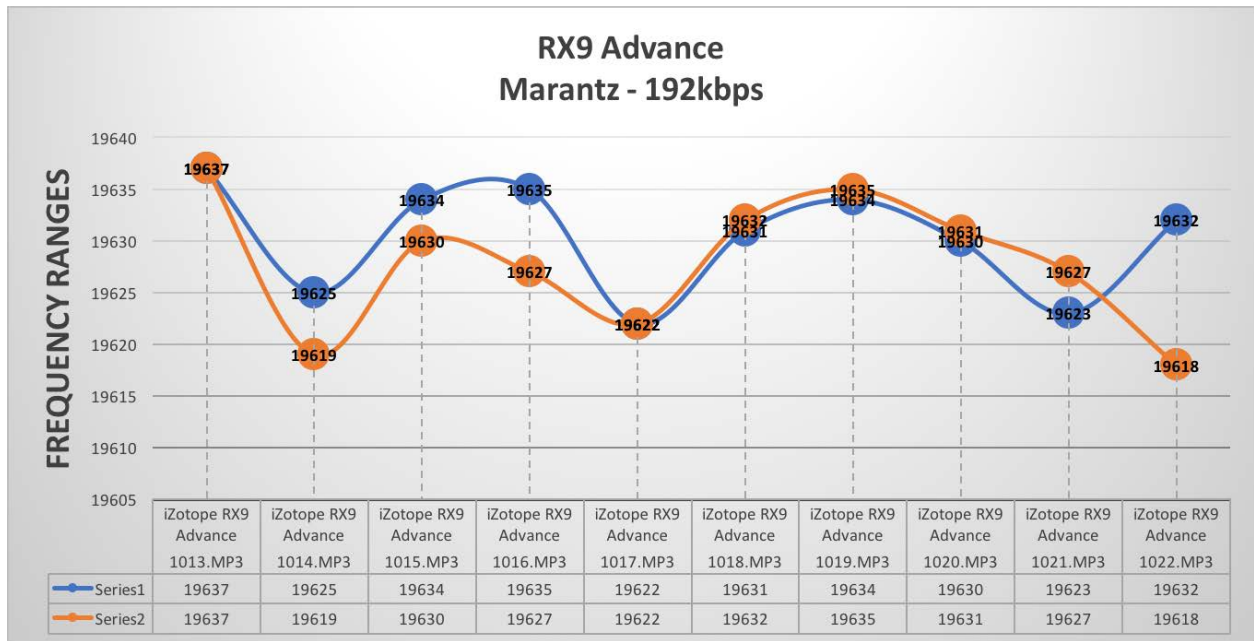
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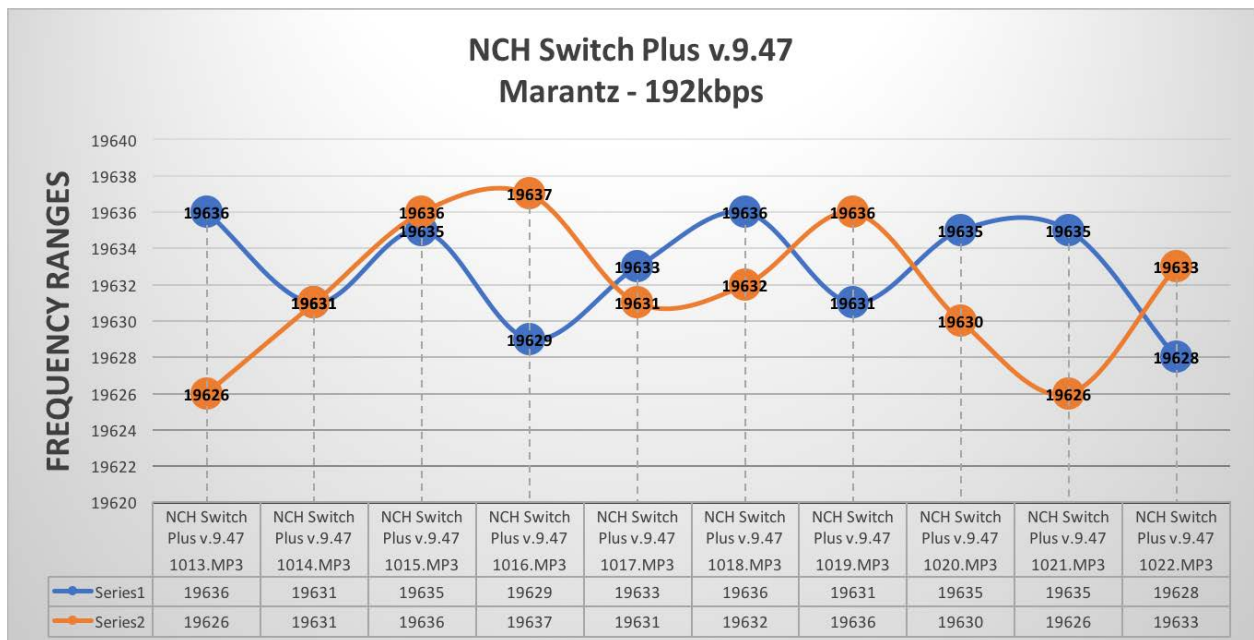
dBpoweramp effects on Marantz 192kbps Recordings



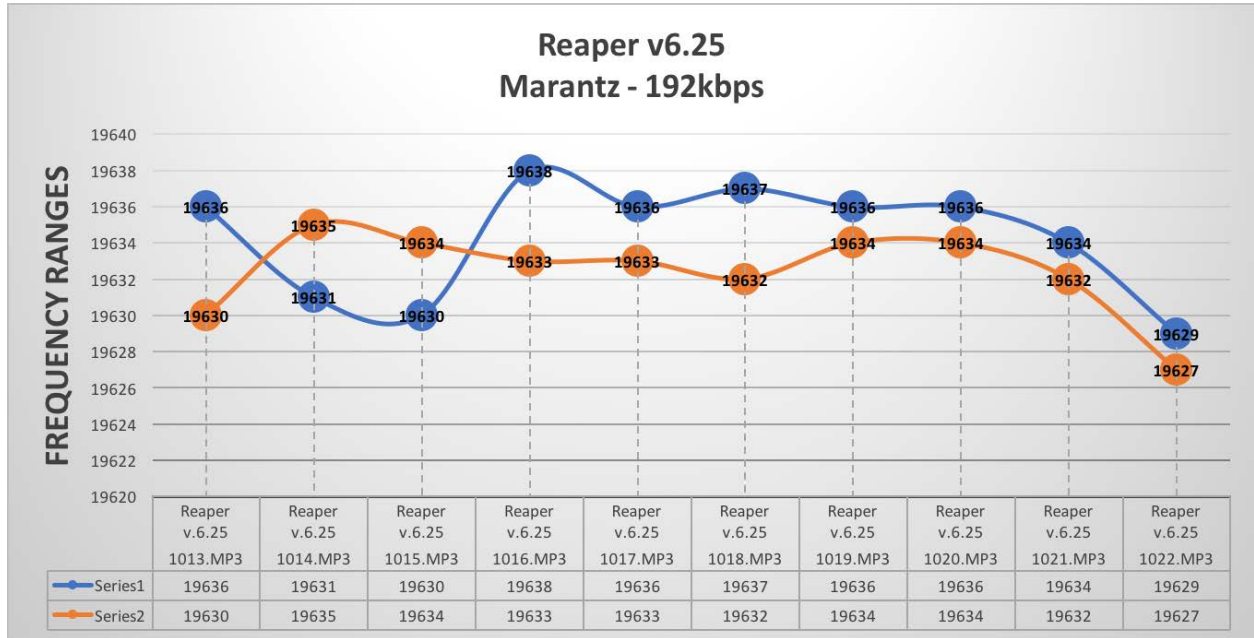
FFmpeg effects on Marantz 192kbps Recordings



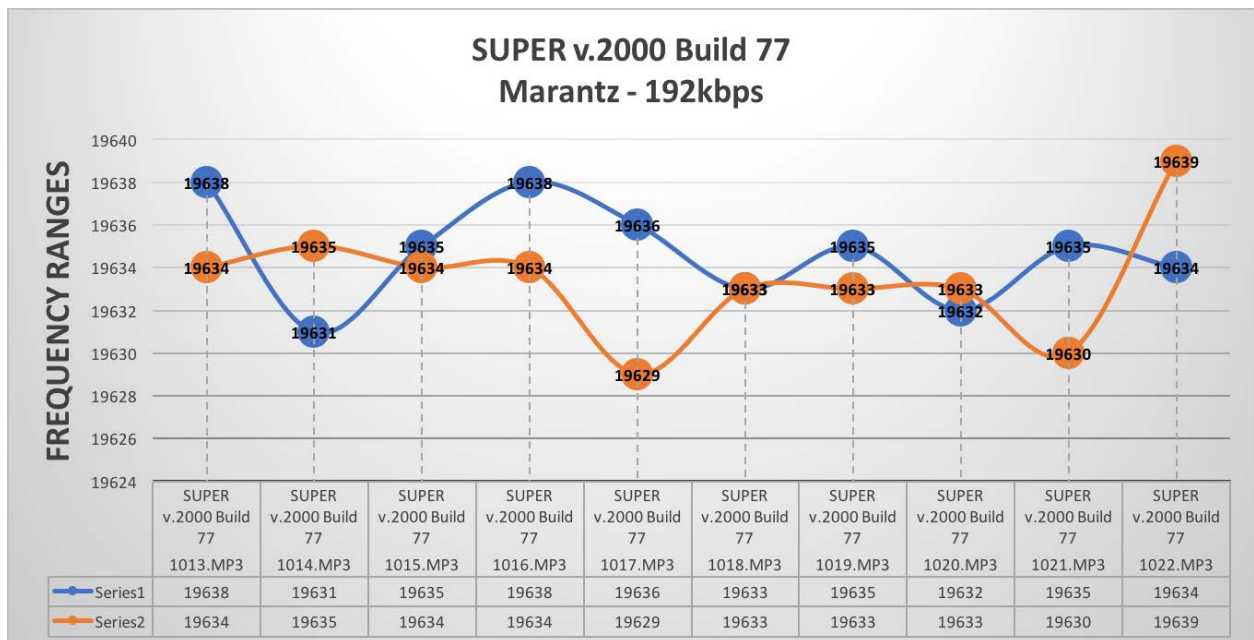
RX9 effects on Marantz 192kbps Recordings



NCH Switch Plus effects on Marantz 192kbps Recordings



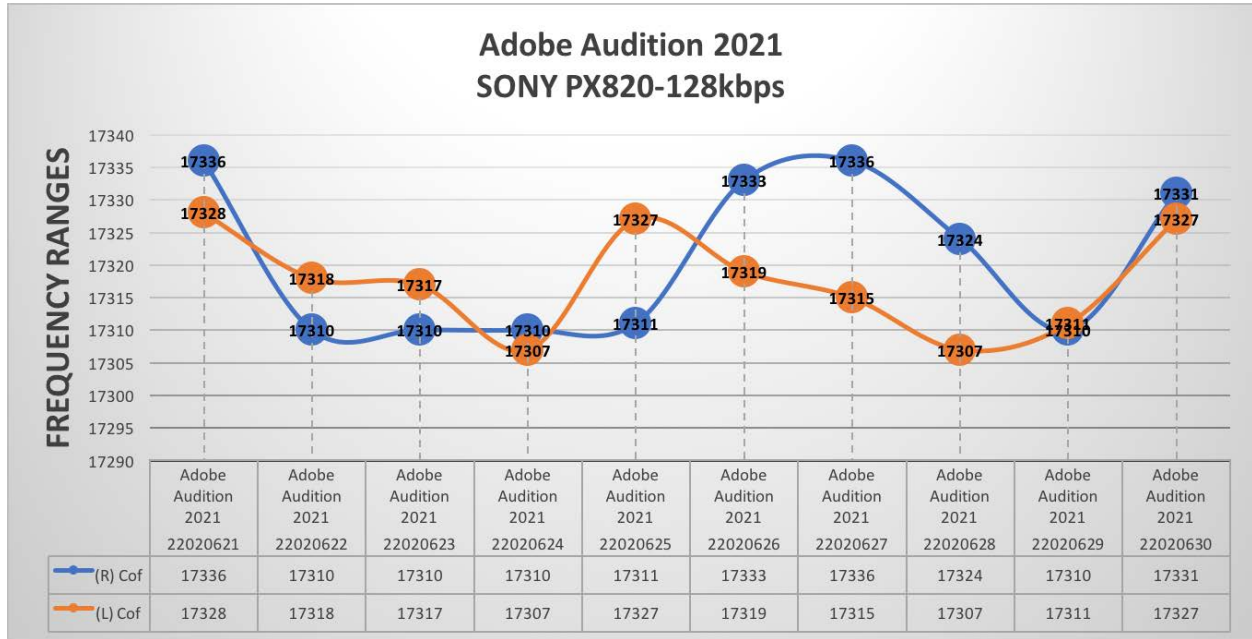
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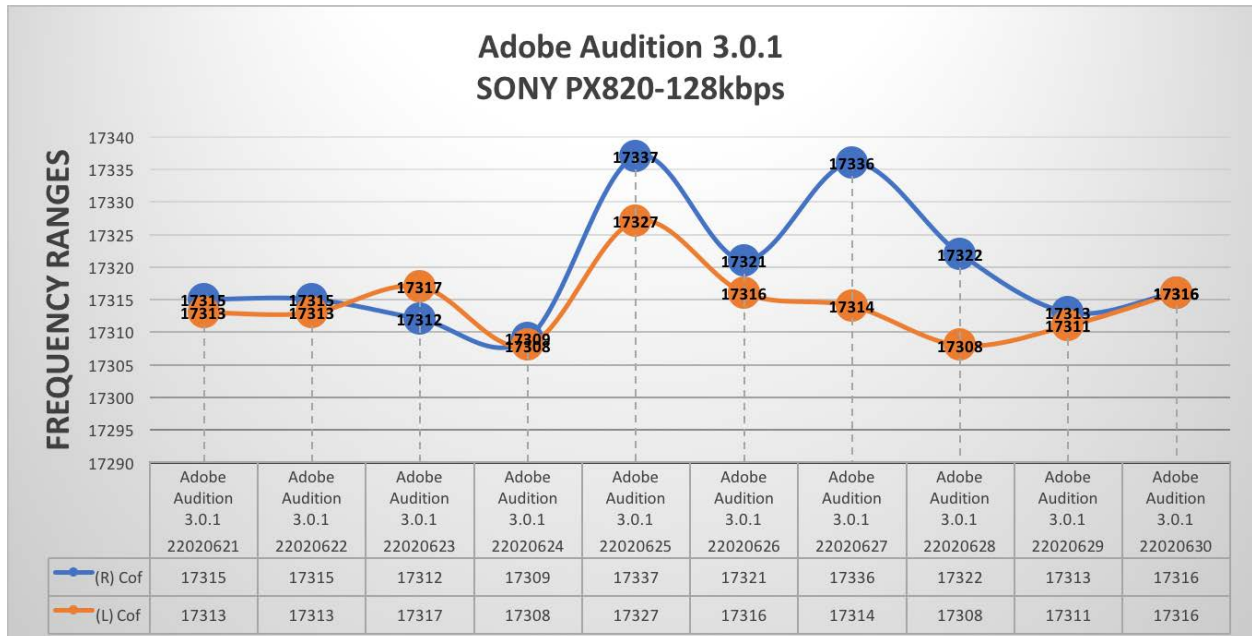
SUPER effects on Marantz 192kbps Recordings

SONY PX820 128 KBPS

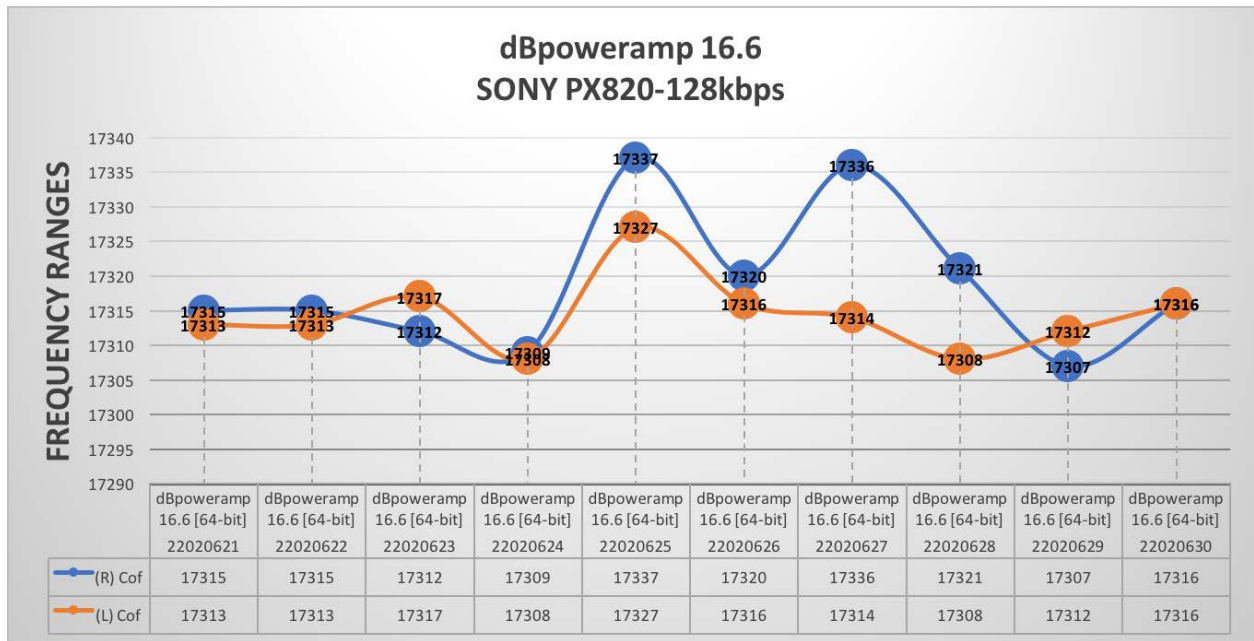
Each graph displays data by Transcoder and its effects on the recorded files COFs



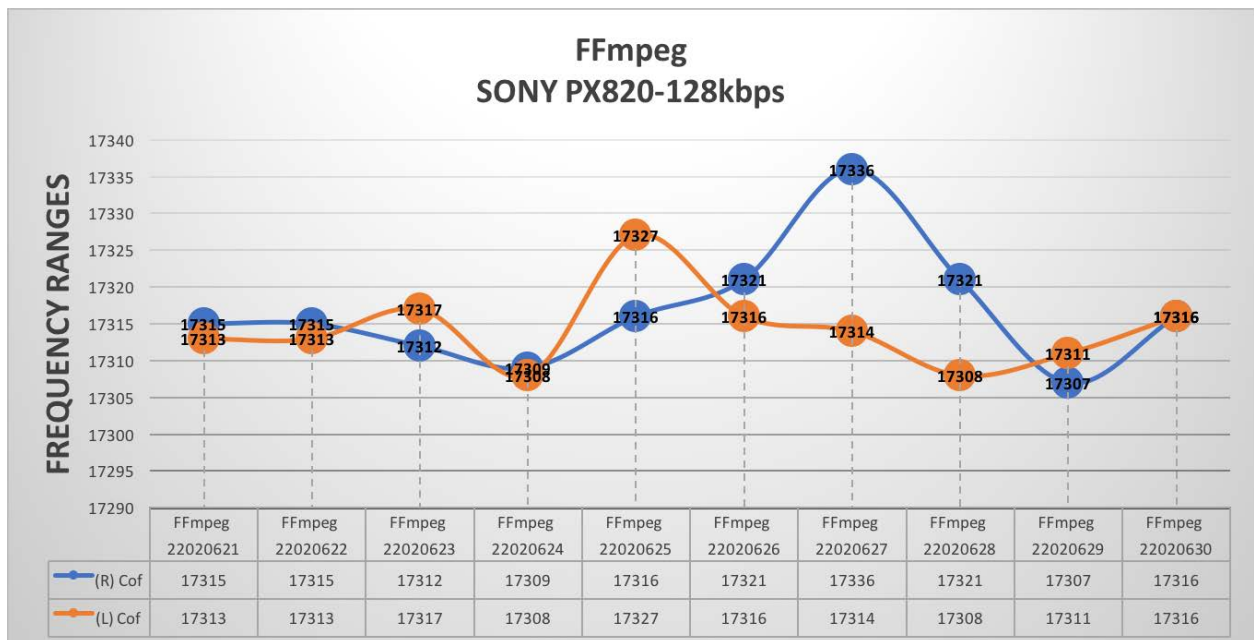
Adobe Audition 2021 effects on Sony 128kbps Recordings



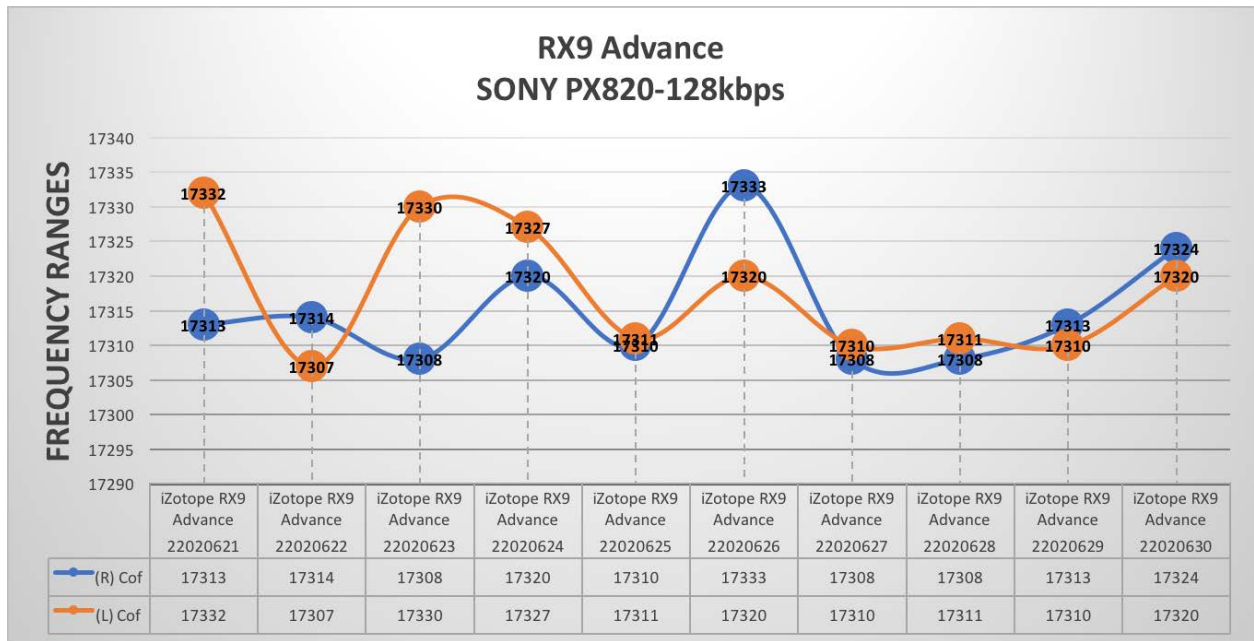
Adobe Audition 3.0.1 effects on Sony 128kbps Recordings



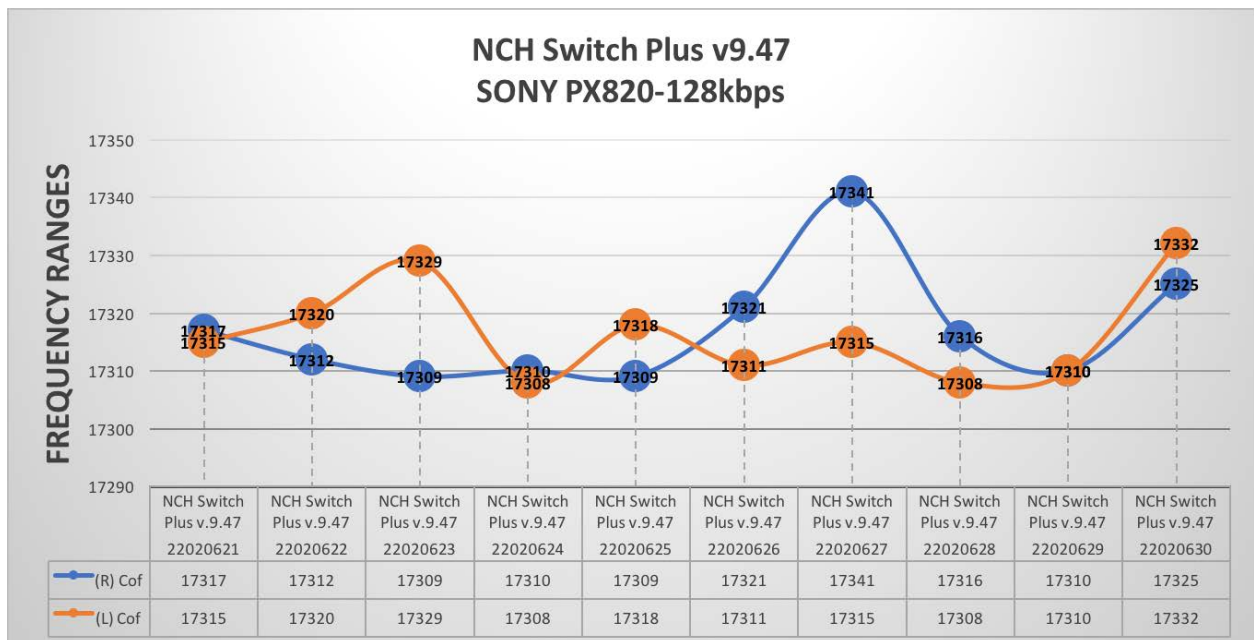
dBpoweramp effects on Sony 128kbps Recordings



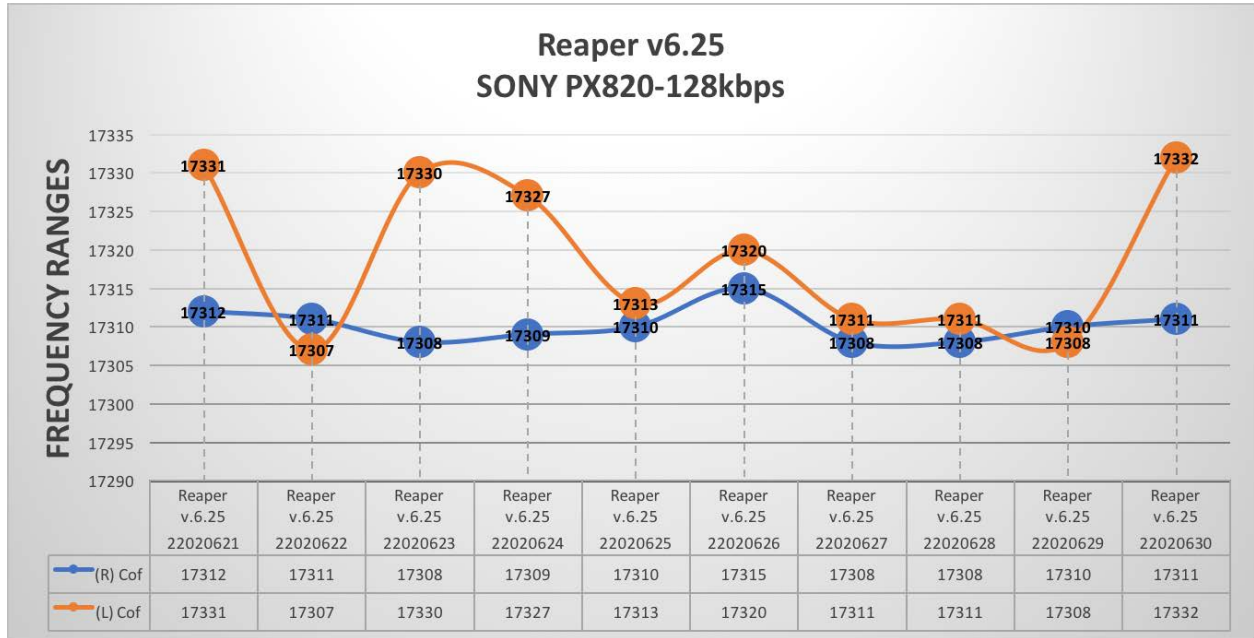
FFmpeg effects on Sony 128kbps Recordings



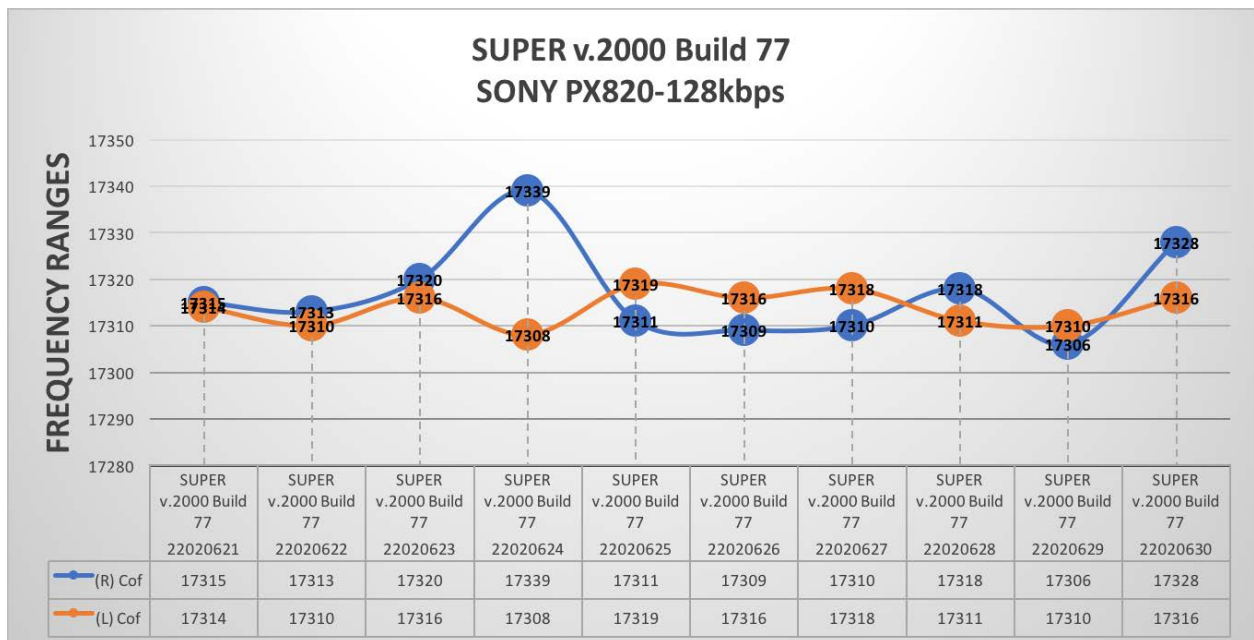
RX9 effects on Sony 128kbps Recordings



NCH Switch Plus effects on Sony 128kbps Recordings



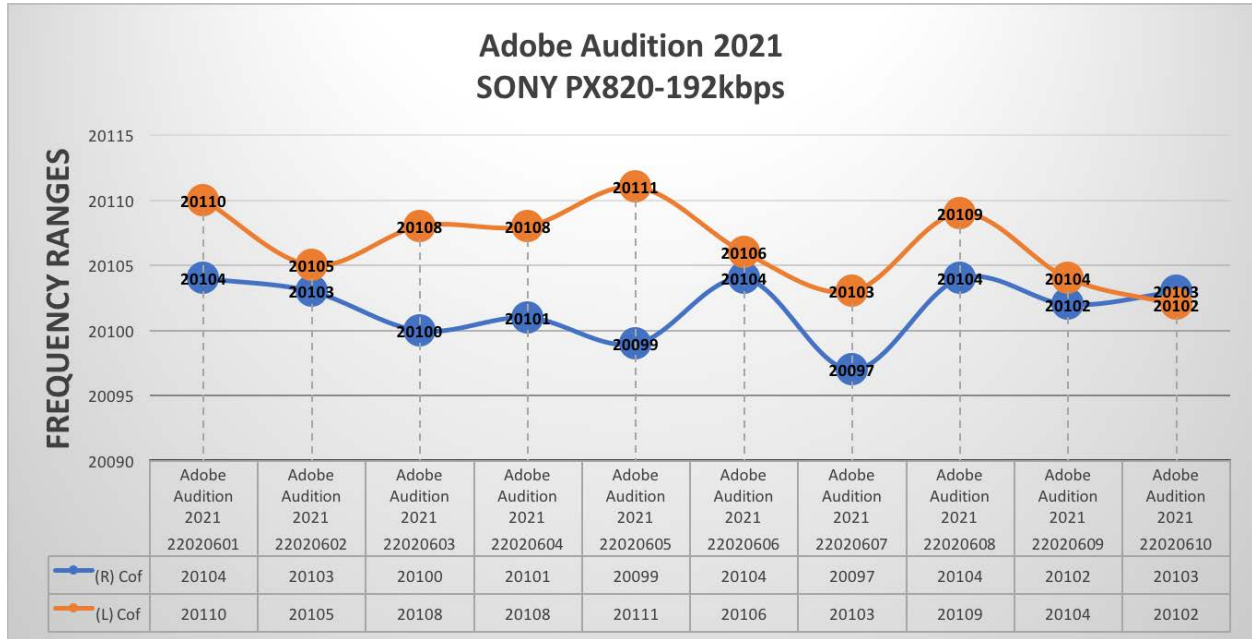
Reaper effects on Sony 128kbps Recordings



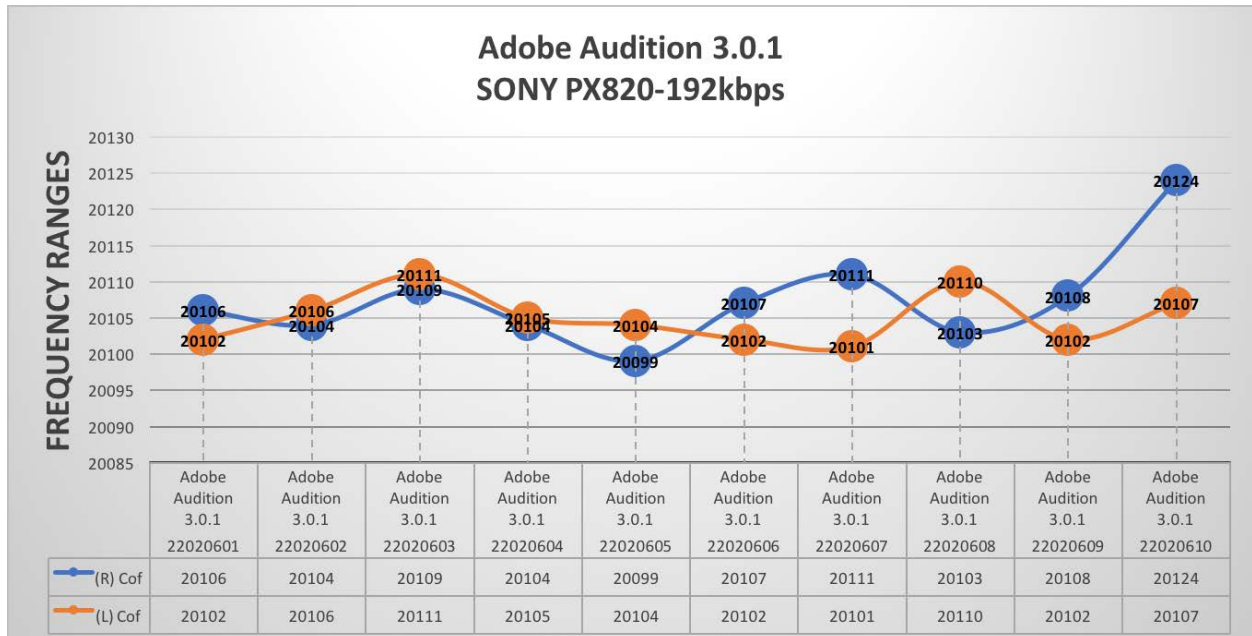
SUPER effects on Sony 128kbps Recordings

SONY PX820 192 KBPS

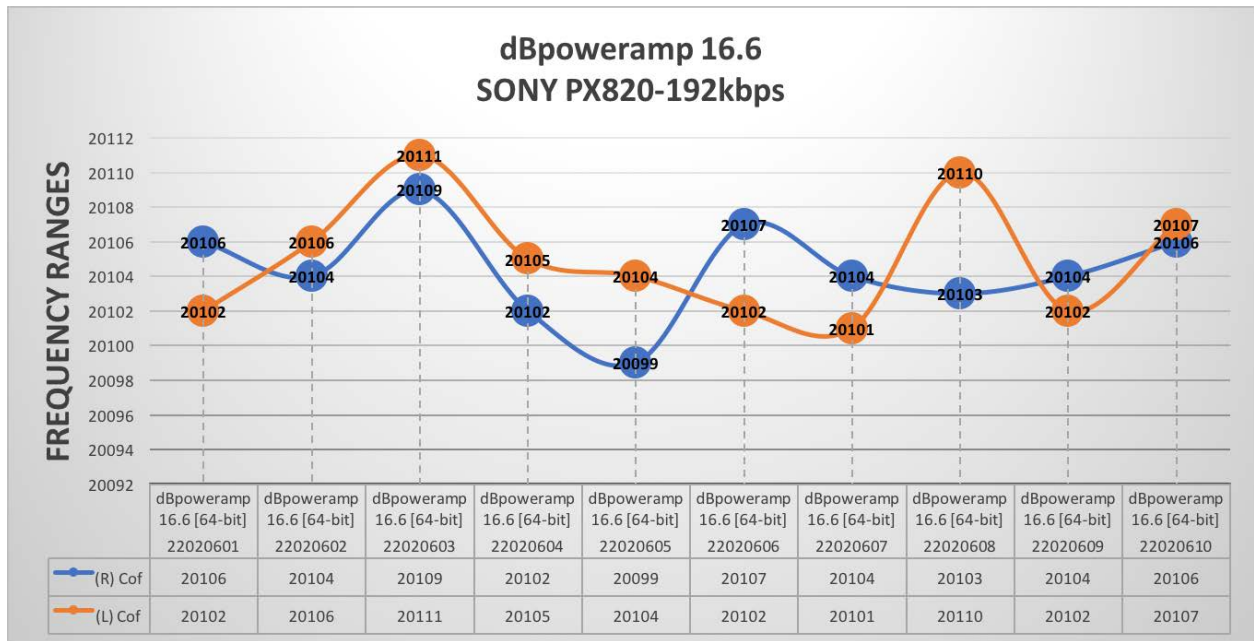
Each graph displays data by Transcoder and its effects on the recorded files COFs



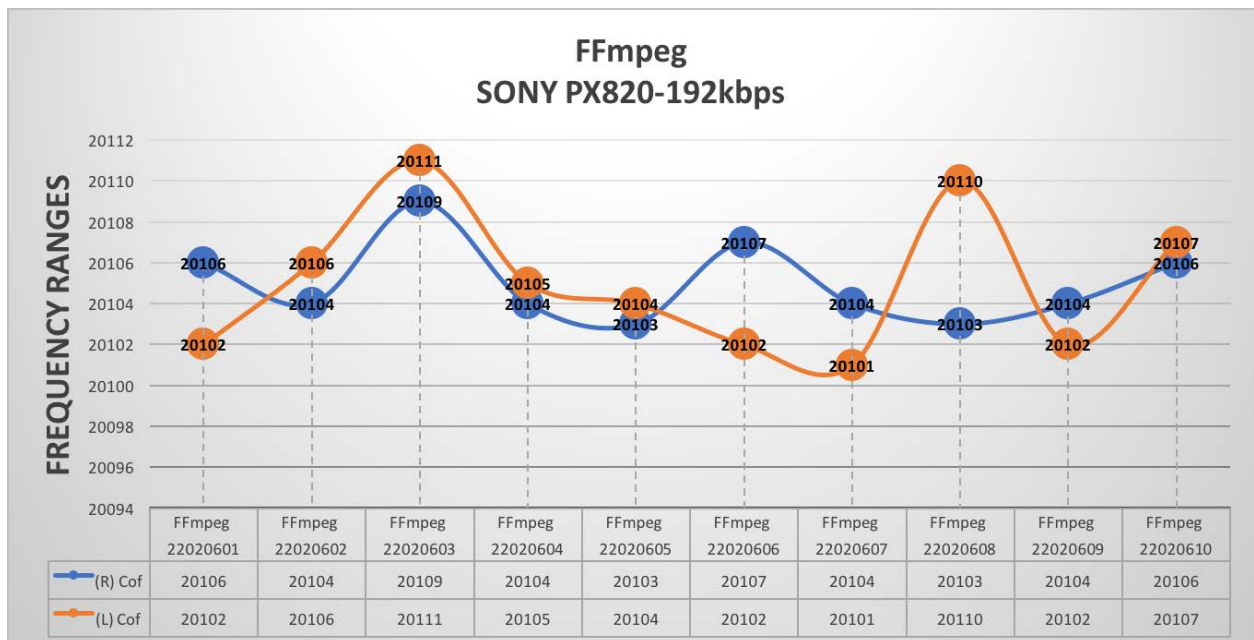
Adobe Audition 2021 effects on Sony 192kbps Recordings



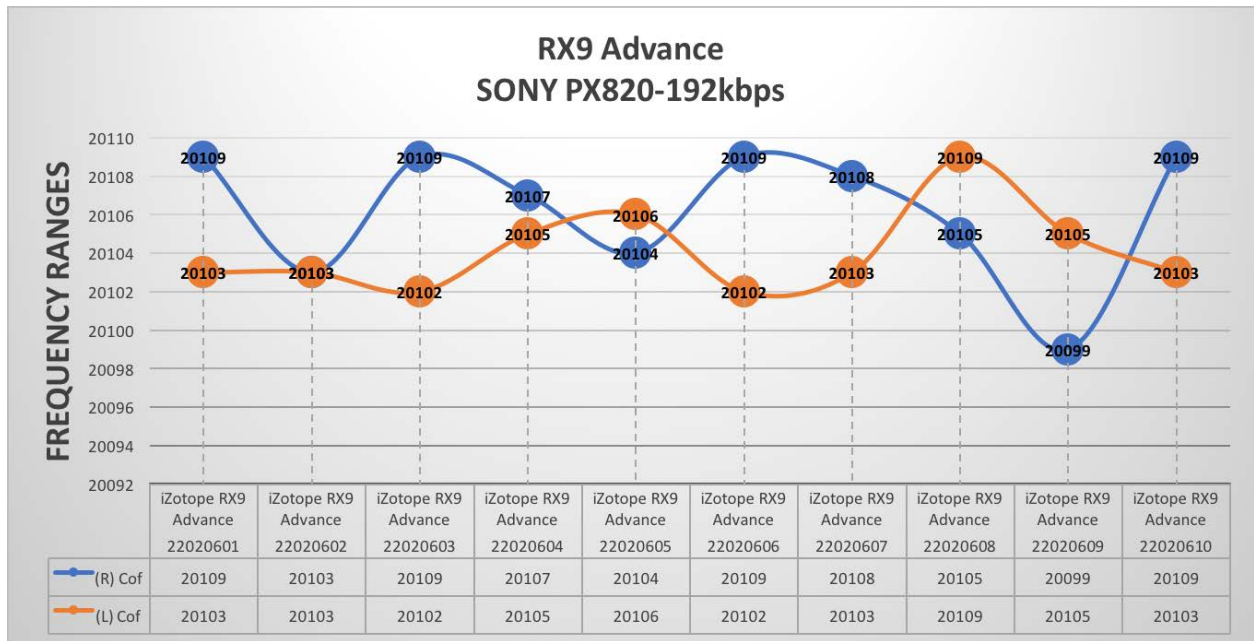
Adobe Audition 3.0.1 effects on Sony 192kbps Recordings



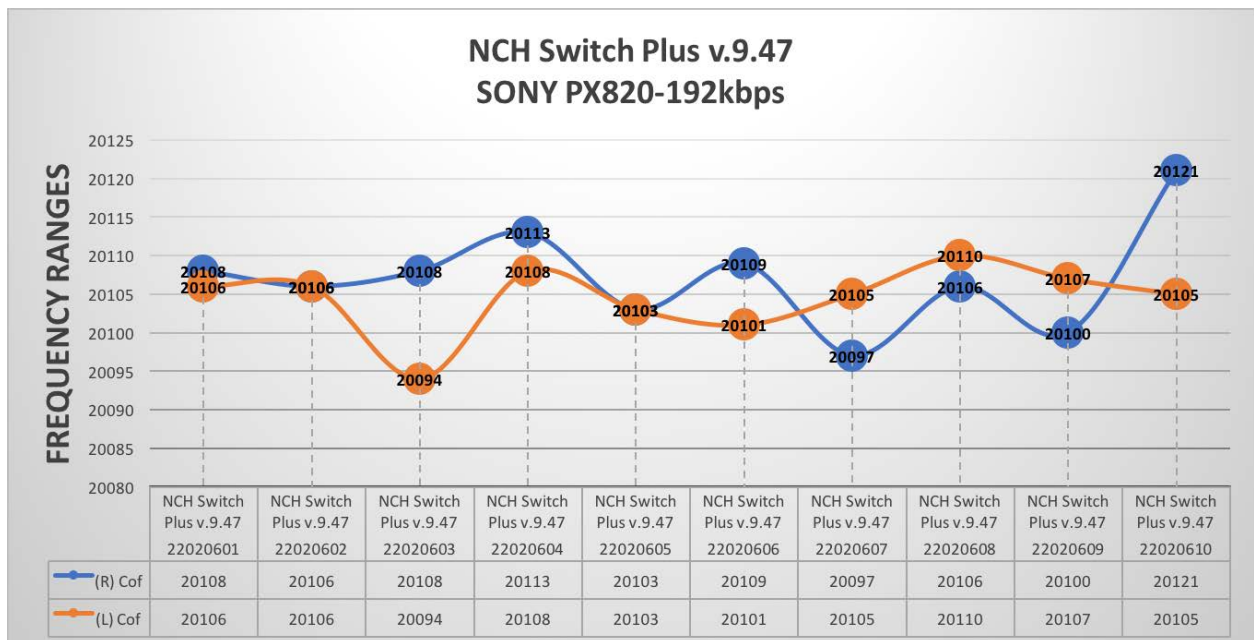
dBpoweramp effects on Sony 192kbps Recordings



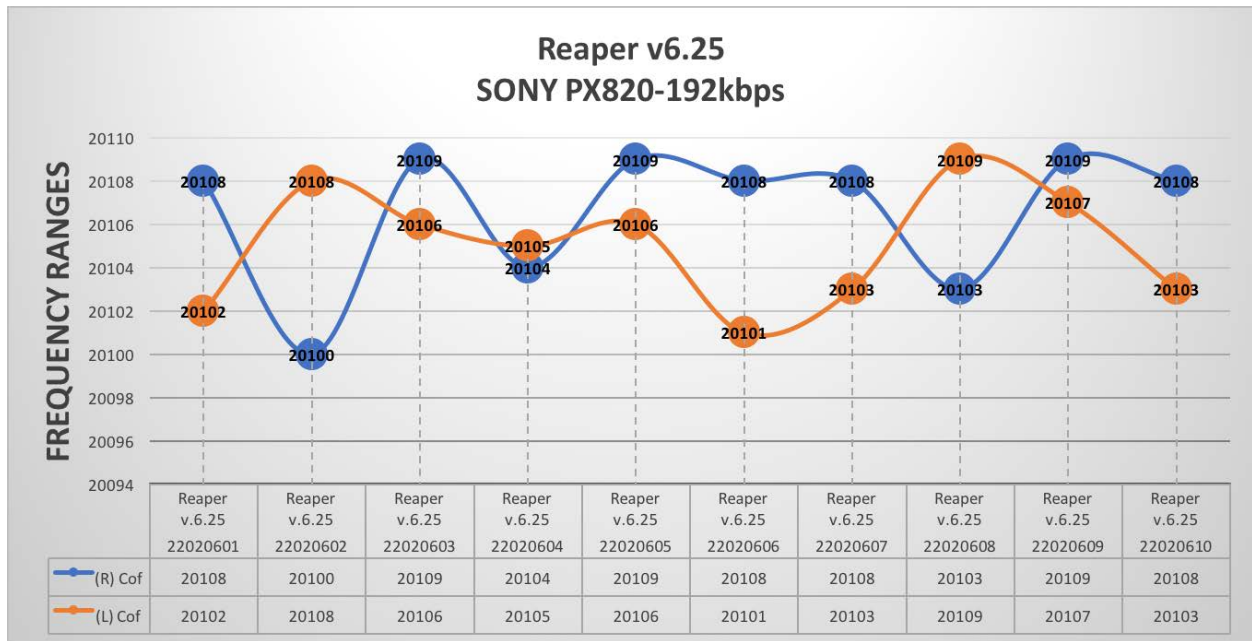
FFmpeg effects on Sony 192kbps Recordings



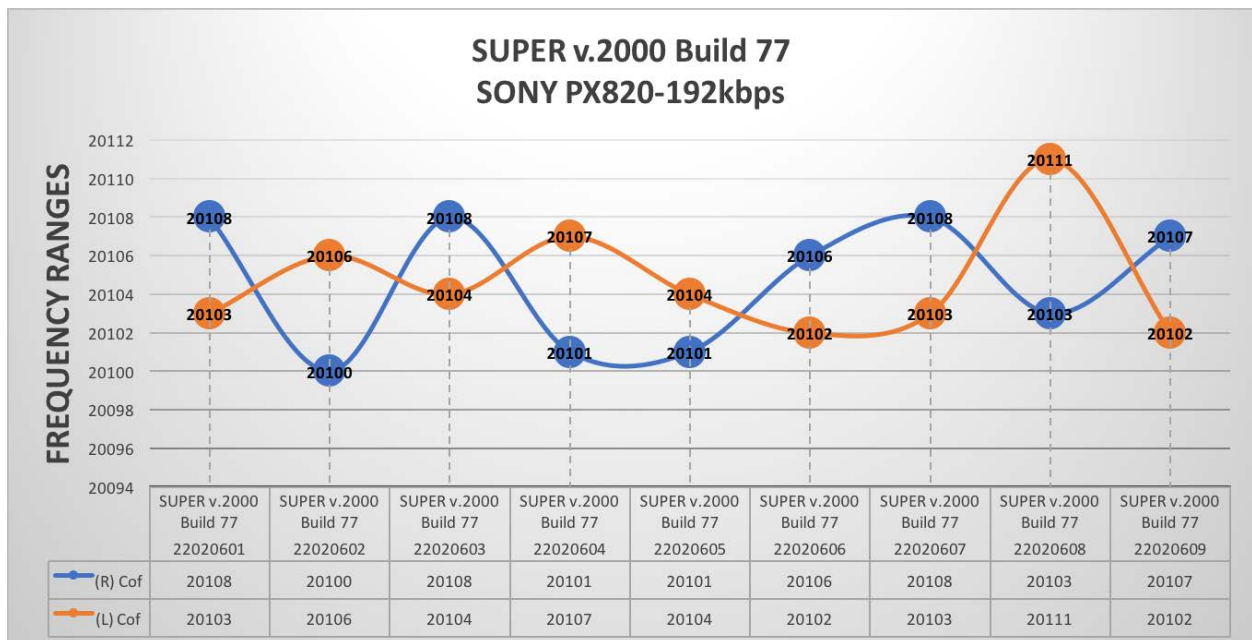
RX9 effects on Sony 192kbps Recordings



NCH Switch Plus effects on Sony 192kbps Recordings



Reaper effects on Sony 192kbps Recordings



SUPER effects on Sony 192kbps Recordings