Equalization of (old) records

Summary

Vinyl (or older materials) records have been printed for one century now with almost the same basic process but according to different standards along all these years. There is a number of sources on the web describing what the specific labels printed and the corresponding techniques they applied, a quick search can reveal how large this number is. The differences all lie in how the sound engineers coped with the limitations of the cutting process: generally speaking the lathe attenuated the content of bass frequencies and enhanced high frequencies following different equalization curves. RIAA (Recording Industries Association of America) established what became the worldwide standard for records cutting in the middle 50's and all the labels aligned to it. Phono preamplifiers must cope with those different standard to properly reproduce old records and restore a correct tonal balances during playback.

Record and playback curves

During the playback, the original content of the record must be restored applying a reverse equalization that boosts low frequencies and attenuates highs.

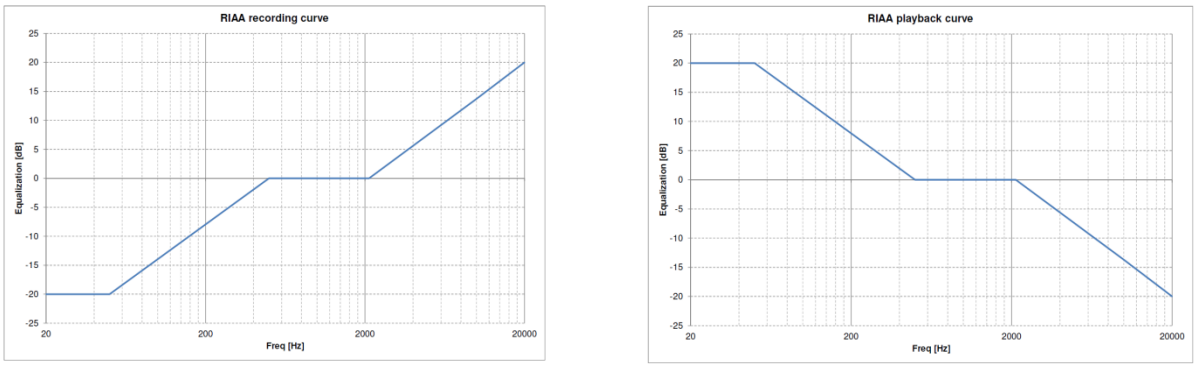

Fig. 1 RIAA recording equalization (left) and corresponding playback (right) curves. The latter must be embedded in the phono preamplifier for a correct reproduction of records. Other curves are similar.

Modern phono preamplifiers can equalize a record with an accuracy of 0.1dB or even better but almost all of them come with only the current RIAA standard. Unfortunately, if a record is played through a wrong equalization accuracy will be lost. Playback errors may get very large at the extremes of the audio band and are usually limited to 1db or so in the 100Hz-10kHz band, the following examples is the (theoretical) result of the RIAA equalization of an AES record: below 100Hz error increases in deep bass area while in the most fundamental 100Hz-10kHz band it stays within ± 1dB.

AES and RIAA are pretty similar standards and errors are limited (see fig. 2). Things can get much more preoccupying if an old shellac (a 78rpm) is played with the available RIAA equalization. An FFRR 78rpm record played back through the RIAA curve will have a gross tonal unbalance (see fig. 3).

Equalization curves in practice

Equalization curves are based on a few parameters

- The bass turnover frequency indicates the point where the bass gets attenuated in recording and boosted in playback. This is the most important parameter. It is usually expressed as its corner frequency or the corresponding time constant.
- The treble cut is the frequency at which the highs are boosted in recording and attenuated in playback. It can be expressed as the corner frequency, the associated time constant or the resulting attenuation at 10kHz (with reference to the flat midrange band).
- The bass shelf is the maximum amplification of bass frequencies allowed during playback, it can be expressed in terms of the frequency at which the deep bass attenuation starts or the maximum level in dB of deep bass with reference to the flat midrange area. It may also identified by a literal code.

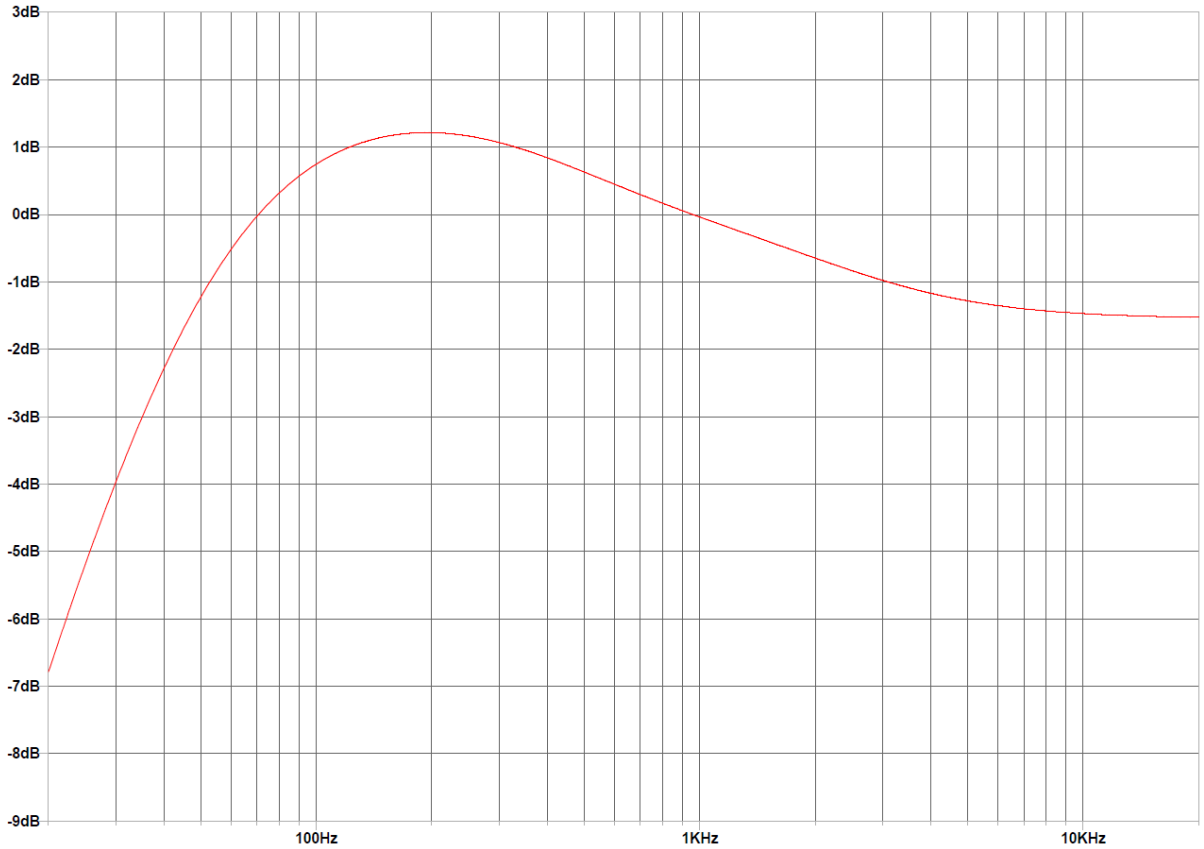

Fig. 2 Equalization error resulting after processing a record printed per the AES standard and played through a RIAA equalization.

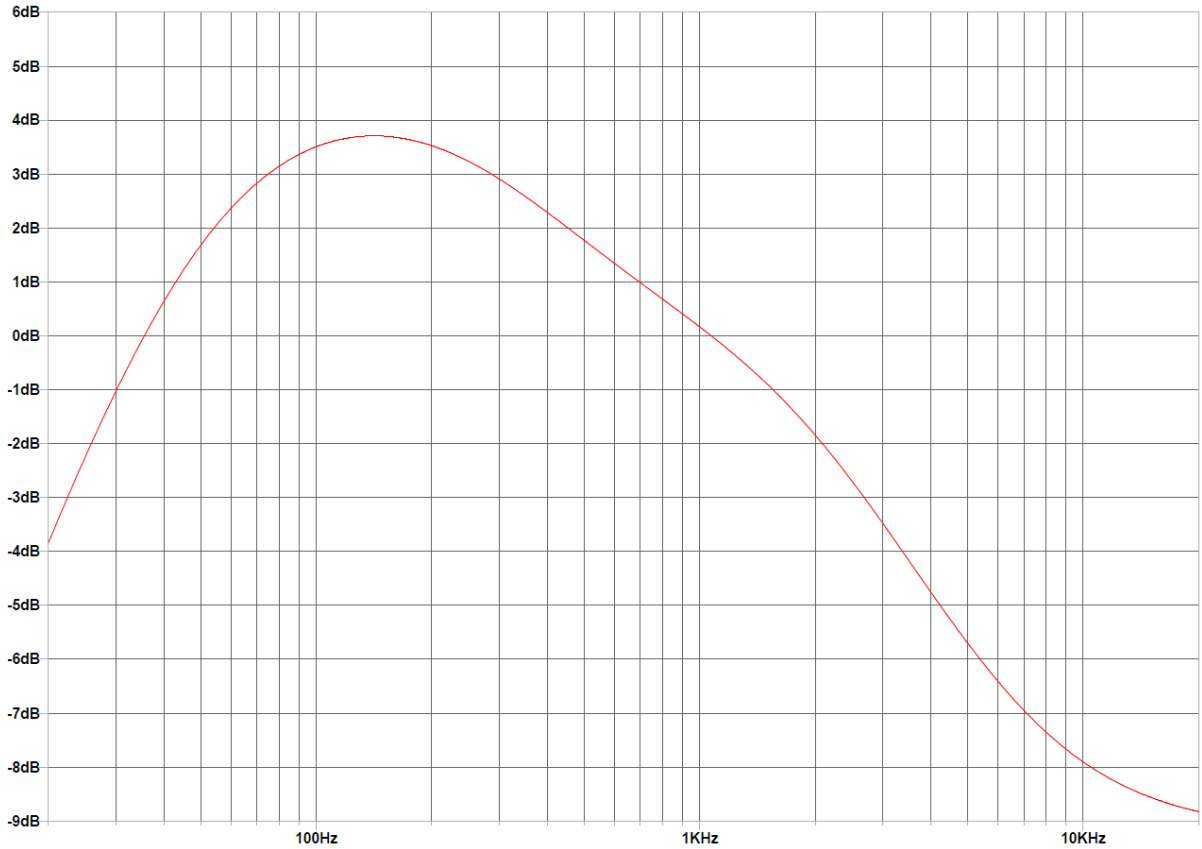

Fig. 3 Equalization error of a FFRR 78rpm record processed through a RIAA equalizer.

In reality, playback curves cannot reproduce sharp corners so practical RIAA and all the older playback curves are rounded at the nominal frequencies of 50.05Hz (bass shelf), 500.5Hz (bass turnover) and 2122Hz (treble cut), see figure 4 for a comparison of theoretical and practical curves and for an indication of curve parameters.

Let's see how the single parameters affects the playback equalization curve and the effect they have on the tonal balance.

Bass turnover

The bass turnover frequency sets the fundamental tonal balance of the playback. It can vary from 200Hz of some ancient Columbia records up to 1kHz, the most recent pre-RIAA records were cut in the 350Hz-800Hz range. A lower turnover frequency corresponds to a lower bass boost and, as a matter of facts, the most ancient records were cut at lower frequencies so errors in reproduction can get very large when the standard RIAA equalization is applied instead of the original and appropriate curve.

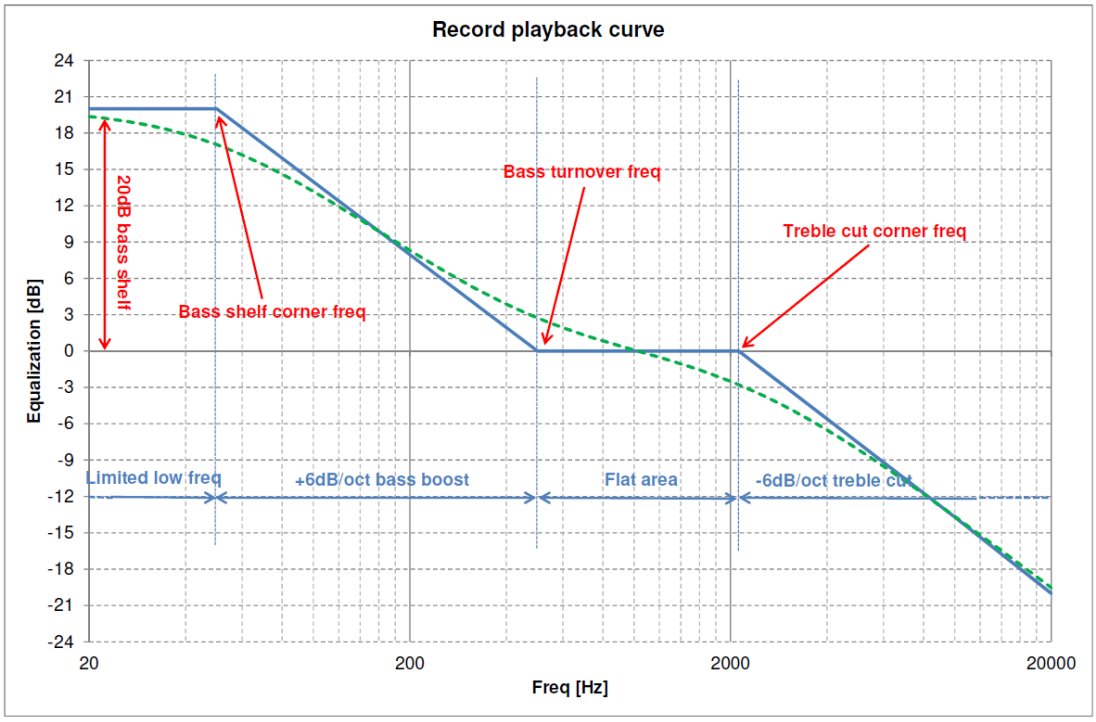

Fig. 4 Equalization areas and parameters for theoretical RIAA (blue) and practical (green) curves and main parameters.

Bass shelf

As discographic industry evolved, a bass shelf was introduced along with an increase of the turnover. Bass shelf is beneficial in preventing rumble due to warped media or due to turntable bearing and motor and limits the max amplification of deep bass safeguarding woofers.

Treble cut

Treble cut effect in playback can start from 1592Hz for the Columbia 78 up to 6366Hz for the Decca FFRR (same age). RIAA set the standard at 2122Hz limiting the midband flat area.

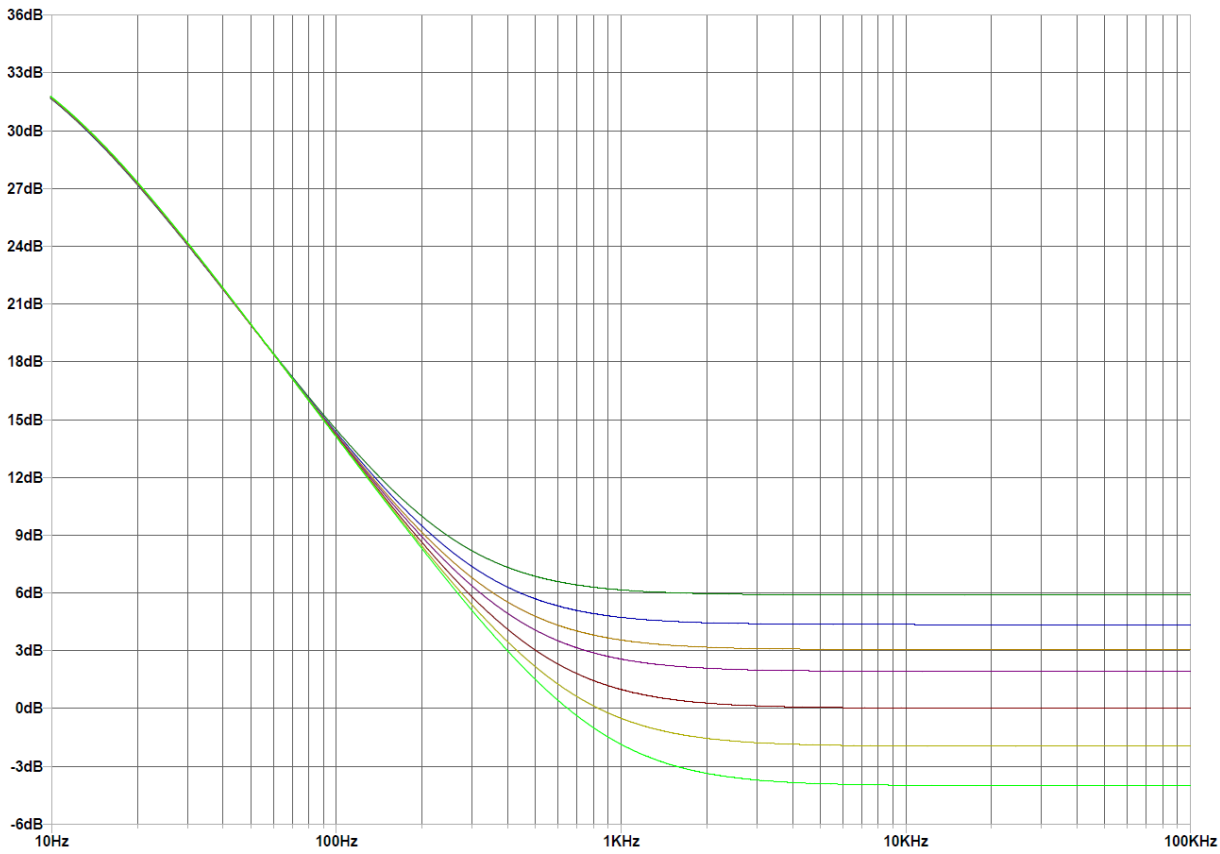

Fig. 5 Effect of bass turnover frequency on playback equalization curve. RIAA is in red and has a +3dB point at 500.5Hz. Other curves are from 250Hz to 800Hz.

Subsonic filter and anti-scratch filter

Equalization of old records may, finally, require an adjustment to the playback curves to cope with excessive subsonic frequency noise or surface noise at higher frequency. The former is addressed with a 12dB/oct or steeper high pass filters at 50Hz or lower frequencies, the latter with milder 6dB/oct low pass filters from 6kHz and upward. In the late 70's a more effective approach to bass rumble was proposed: signal is split in low frequencies (below 150Hz or so) and converted to mono and hence summed back to the remaining stereo high frequency. The stereo-to-mono conversion nulls the rumble as it appears with opposite phases in the Right and Left channel. A typical correction is as in the following figure 8.

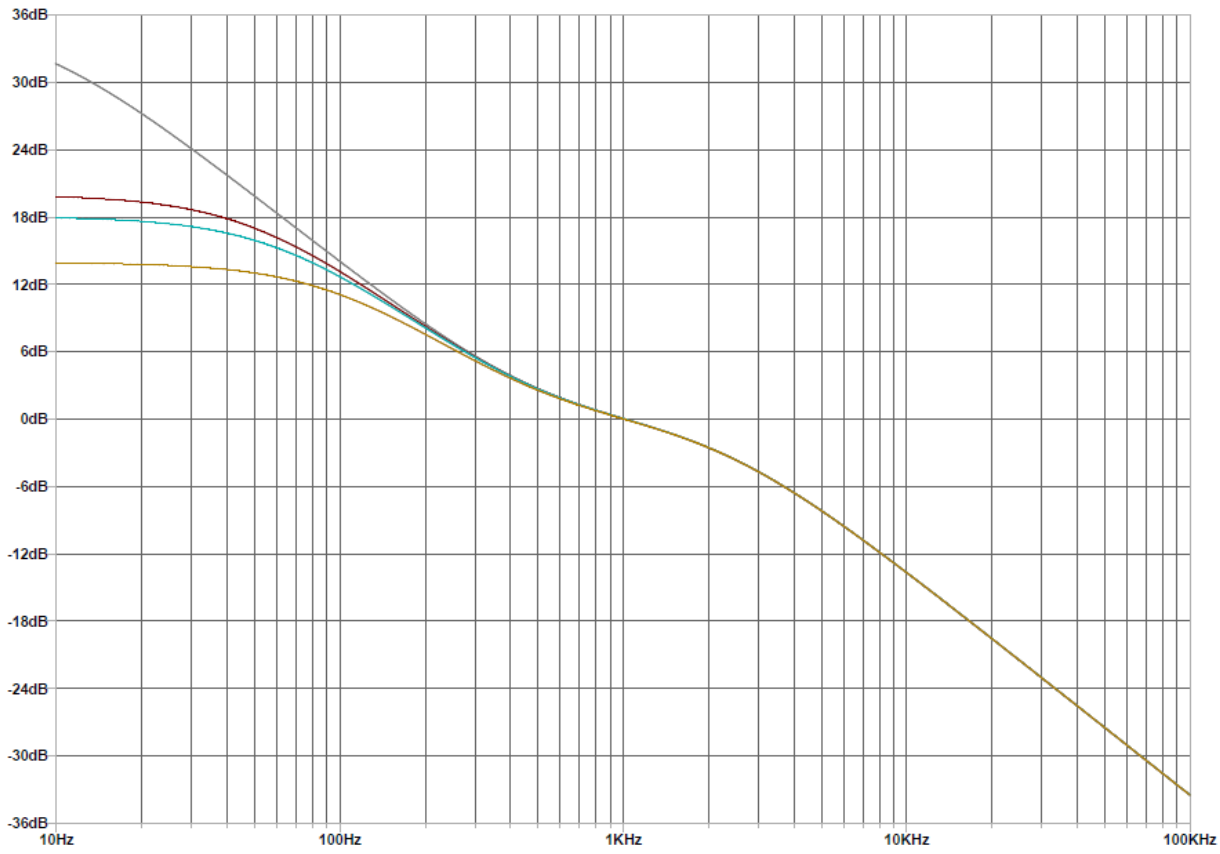

Fig. 6 Effect of different bass shelves on the standard RIAA curve (in red). Bass shelf can be found at +14dB, +18dB, +20dB (RIAA) or omitted (curve raises with a +6dB/oct slope to infinity) in older records.

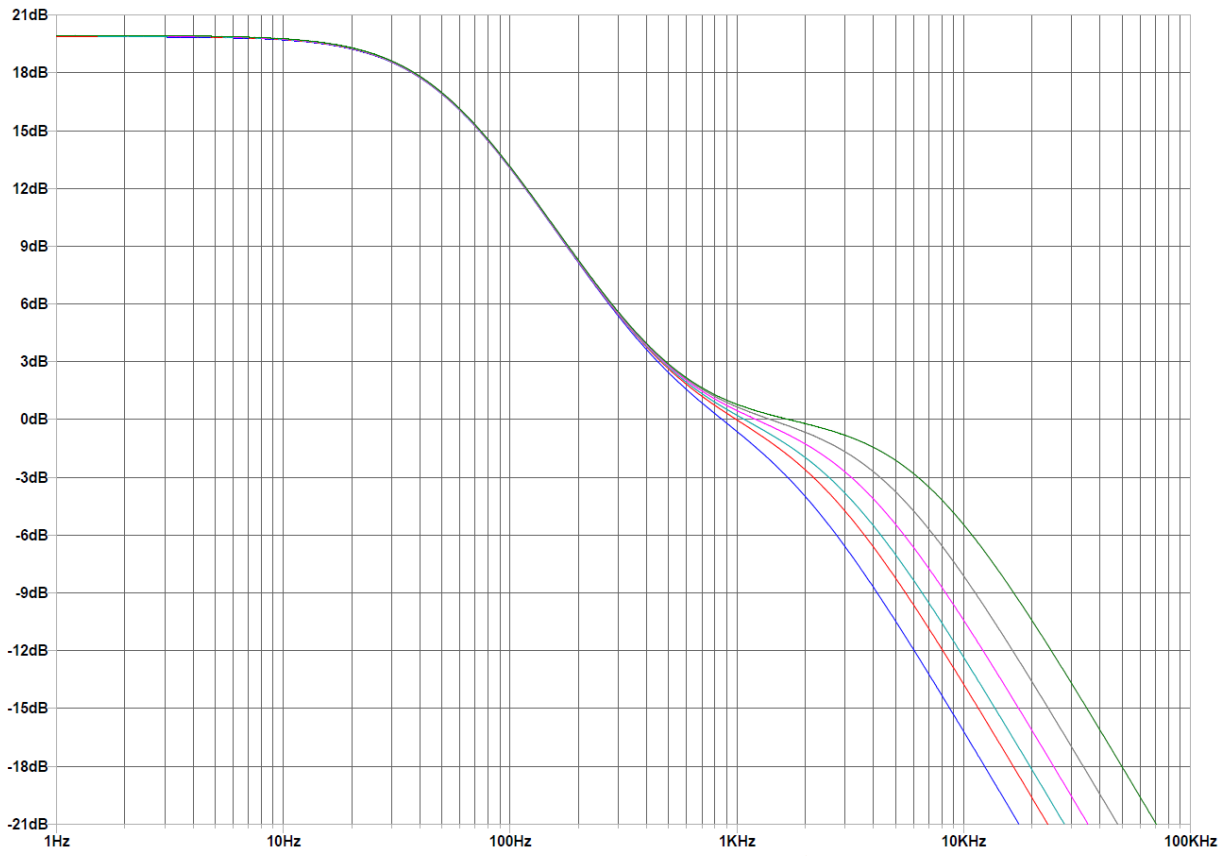

Fig. 7 Treble cut from 1592Hz to 6366Hz superimposed to the standard RIAA curve (in red).

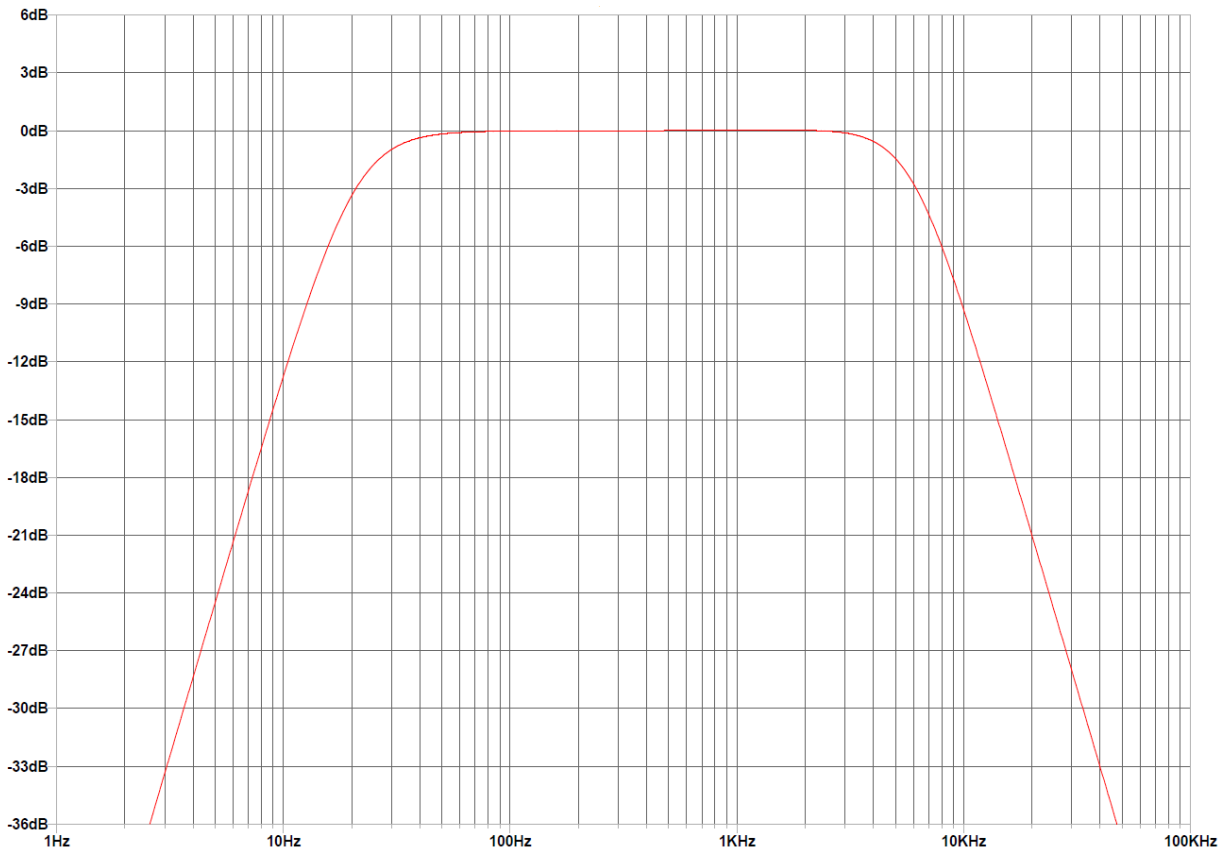

Fig. 8 Rumble filter (slope 12dB/oct and cutoff 20Hz) and scratch filter (slope 6dB/oct and cutoff 7kHz) to reduce noise in older worn records.

Reference material

http://wiki.audacityteam.org/wiki/78rpm_playback_curves, and at the referenced sources, contains a very chomprensive list of equalization curves for old records. For the sake of clarity the following tables correlates the different parameters for equalization.

Bass shelves table

Bass shelf [dB]	Corner frequency [Hz]	Time constant [us]	Standard nomenclature [letter]
INF	Not applicable	Not applicable	N
20	50	3183	R
18	62.5	2546	B
14	100	1592	C

Note: bass shelves at 16dB (A) and 12dB (X) were defined but seldom used in the past

Bass turnovers table

Bass turnover frequency [Hz]	Time constant [us]
200	796
250	637
300	531
350	455
400	398
500	318
630	253
800	199
1000	159

Treble cuts table

Attenuation at 10kHz [dB]	Treble cut frequency [Hz]	Time constant [us]	
-16.0	1592	100	
-13.7	2122	75	
-12.3	2500	64	
-10.5	3183	50	
-8.0	4340	37	
-5.4	5900	27	Shown as -6
-5.3	6366	25	Shown as -5.5

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