Theoretical Frequency Response of Records by Format

A disc record exhibits a variable frequency response. Since its tangential velocity varies, it has the largest range of response at the outer edge of the recording and it decreases towards the center. Knowing the theoretical frequency response of the media that you are restoring can be of value when setting up a Low Pass filter to eliminate extraneous noise at the end of a restoration process. However, bandwidth should never be reduced prior to performing the EZ Impulse Filter process (used to reduce transient noise like clicks, pops, static and so forth).

The size of a phono stylus must be small enough so as to contain no more than one-half of a cycle of a signal within the width as it passes by. In other words, the stylus dimension must be at least one half the wavelength of the signal of interest. Using general intuition, you can imagine that if the stylus only needed to be the width of one cycle of the highest frequency signal of interest, then the positive and negative portions of that signal would cancel out as it passed through that portion of the groove. Elliptical styli produce a higher frequency response compared to their conical counterparts because a smaller dimension is occupied tangential to the groove with that smaller dimension in actual contact with the groove wall.

The following equations pertain:

$W = V / F \times 2$

wherein -

W = Smallest dimension of the styli (in inches)

V = Tangential Velocity of the record at the point of interest (in inches per second)

F = Maximum reproducible frequency (in Hz or cycles per second)

Considering a constant angular velocity rotating disc (like a Vinyl LP record), the following formula describes its tangential velocity:

V = Pi x D x RPM / 60

wherein

D = Usable Diameter of the Record at various locations (in inches)

RPM = Constant Angular Velocity of the Record in Revolutions per Minute

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Combining & simplifying the above equations and solving for Frequency (F in Hz)

F = (Pi x D x RPM) / (W x 120)

wherein

D = Usable Diameter of the Record at various locations (in inches)

RPM = Revolutions Per Minute of the Record in Question

W = Smallest dimension of the styli (in inches)

Pi ~ 3.1416

Now, let’s calculate the maximum theoretical frequency response of some common records played with some common styli types (found in the Diamond Cut User’s Manual) using the above equation for each:

1. 33 1/3rd RPM, 12 Inch Record

This type of record measures 11.5 inches on its outer most edge and 6 inches on its inner most edge (by inspection).

Using an elliptical 0.7 x 0.3 mil phono stylus, the frequency response will be as follows:

Theoretical Starting Frequency Response: 33.33 KHz

Theoretical Ending Frequency Response: 17.5 KHz

Response Variance: 15.83 KHz

Average Response: 25.42 KHz

2. 45 RPM, 7 Inch Record

This type of record is 6.5 inches on its outer most edge and 4.5 inches on its inner most edge (by inspection).

Using an elliptical 0.7 x 0.3 mil phono stylus, the frequency response will be as follows:

Theoretical Starting Frequency Response: 25.5 KHz

Theoretical Ending Frequency Response: 17.6 KHz

Response Variance: 7.9 KHz

Average Response: 21.55 KHz

Note 1: Interestingly, the 45 RPM Record seems to be the most optimal design if the requirement for audio reproduction is limited to 20 KHz.

3. 78 RPM, 10 Inch Record

This type of record is 9.5 inches on its outer most edge and 4.5 inches on its inner most edge (by inspection).

Using an elliptical 2.7 x 1.2 mil phono stylus, the frequency response will be as follows:

Theoretical Starting Frequency Response: 16.25 KHz

Theoretical Ending Frequency Response: 7.7 KHz

Response Variance: 8.55 KHz

Average Response: 11.97 KHz

4. 78 RPM, 12 Inch Record

This type of record measures 11.5 inches on its outer most edge and 4.5 inches on its inner most edge (by inspection).

Using an elliptical 2.7 x 1.2 mil phono stylus, the frequency response will be as follows:

Theoretical Starting Frequency Response: 19.57 KHz

Theoretical Ending Frequency Response: 7.7 KHz

Response Variance: 11.87 KHz

Average Response: 13.64 KHz

Note: Interestingly, the 45 RPM Record seems to be the most optimal design if the requirement for audio reproduction is limited to 20 KHz.

5. 33 RPM, 16 Inch Acetate Transcription Record

This type of record has 15.5 inches on its outer most edge and 8.5 inches on its inner most edge (by inspection).

Using an elliptical 2.7 x 1.2 mil phono stylus, the frequency response will be as follows:

Theoretical Starting Frequency Response: 11.27 KHz

Theoretical Ending Frequency Response: 6.18 KHz

Response Variance: 5.09 KHz

Average Response: 8.73 KHz

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6. 160 RPM, Edison Blue Amberol Cylinder Record (circa 1912)

This type of record is 2.125 inches in diameter (by inspection).

RPM = 160 (from the Diamond Cut user's manual)

The Diamond Cut User's manual calls for the use of a 3.7 to 4.2 mil spherical stylus for this type of recording. So, using a spherical 3.7 mil phono stylus (the best case), the frequency response will be as follows:

Theoretical Starting Frequency Response: 2.407 KHz

Theoretical Ending Frequency Response: 2.407 KHz

Response Variance: 0 KHz

Average Response: 2.407 KHz

Note 2: The 2.125 inch cylinder format is inferior in terms of frequency response compared to its rival, the flat Disc record. However, its frequency response is uniform for the duration of play due to its constant tangential velocity.

Note 3: Signals will often be found on record recordings beyond the theoretical limit. These signals are usually distortion and/or noise. The EZ Impulse Filter uses the wider bandwidth required by these noise signals to discriminate between noise and signal, so never reduce the bandwidth of a file prior to reducing Impulse Noise. Bandwidth reduction can be performed after that process has been completed.