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Resonances in Analogue Playback

Of Audio Signals and Resonances

Analogue playback begins with the vibration of the tracking of the stylus in the record groove, which is a direct, mechanical contact. These vibrations are transformed into electrical energy in the cartridge and transmitted through the tonearm wiring in the form of an analogue signal.

This process distinguishes an analogue source from a digital source. Reading a CD with a laser or playing a computer file occurs without this type of physical contact, and therefore the playback is not initiated by strictly mechanical means. The music is transmitted as a digital signal with embedded, coded information. The D/A converter finally transforms the digital signal into an analogue signal, but in this case without the analogue mechanical tracking as the origin of the signal.

The natural question is, what exactly happens when tracking a record? On the one hand you have the original signal created by these vibrations that is eventually heard as music. On the other hand, these same vibrations that create the signal also create unwanted resonances that produce distortion.

The process is easier to visualize when comparing a turntable (including tonearm) with a musical instrument. The basic concept of a guitar, for example, is a resonant body; the resonances that result from plucking a string are an integral part of the music. A guitar manufacturer uses special woods and shapes to generate and enhance specific resonances.

Basically, a turntable is also a potential resonant body; the stylus in the groove also generates vibrations, which are accompanied by inevitable resonances. The difference between a musical instrument and a turntable is that in the turntable these resonances are unwanted, have a marked influence on the sound, and prevent neutral musical playback by imposing unwanted distortions and colorations.

Consequently, every manufacturer of turntables, tonearms and cartridges is faced with the challenge of allowing the wanted vibration of tracking the record’s groove to pass as unhindered as possible while at the same time preventing the unwanted influences of the concomitant resonances.

Materials

A very important aspect of analogue playback and preventing resonances is the choice of construction materials in the turntable and tonearm.

Different materials have very different sonic qualities according to their density and microstructure and they consequently react differently to resonances. Basically the harder or denser the material is, the faster it transmits sound.

Wood, for example, is a soft material with a fibrous structure. It provides a magnificent resonant body when hollow, but that of course is unwanted here. Due to its softness, solid wood is a "slow" transmitter and absorbs resonances, but it also mellows the vibrations that carry the musical signal. Different types of wood can have very diverse densities and cellular structures, and therefore different woods can have very different effects on the sound. Built into a turntable or tonearm, wood always imposes sonic colorations because the nature of its irregular structure absorbs some resonances and supports others.

Plastic has musical qualities similar to wood. It's also a soft material that absorbs resonances and mellows the musical signal. The microstructure of plastic is irregular, so the absorption is also irregular. It has an influence on the sound because the resonances are nonlinear, meaning they are not evenly absorbed over the whole frequency range. Plastic "swallows" vibrations and resonances and transforms them into heat.

Metals are a big group of very diverse materials. Typically, metals have a very organised and regular microstructure and are ideally suited to transmit vibrations and resonances. Some metals, like stainless steel for example, are very dense and therefore very fast in transmitting sound. Metals rarely absorb resonances, but they can amplify resonances and "sing along." The high density and fast transmission can result in resonances bouncing back and forth. Every metal has a different characteristic microstructure that results in marked internal resonances and gives a characteristic sound. The most commonly used metal for turntables is aluminium, and with good reason. Aluminium is less dense and heavy than most other metals and has well-balanced acoustical qualities with no internal resonances within the spectrum of human hearing and a certain capability to absorb resonances.

Connected Materials

Another important aspect is the connection between separate parts and different materials. Naturally, a turntable or tonearm is built from a multitude of separate parts that are connected one way or the other. One obvious idea is the combination of different materials with different characteristics, for example the combination of a dense, fast transmitting material like stainless steel or bronze with a soft, absorbing material like plastic. In this case, the stainless steel would transmit the resonances into the plastic where it would be absorbed. A combination like this can be ideal to supress resonances, but the resonances would be transformed into heat by the plastic and would therefore not be available to transform the vibration of the tracking into electrical energy. The result is a loss of dynamics.

The manner in which different parts are connected is also important. When two parts are connected loosely, resonances also break and get absorbed. Micro vibrations get transformed into heat. A tight connection between two parts enables the (wanted) transmission of vibrations.

What Happens to these Vibrations and the Resonances?

A cartridge needs to be isolated from external disturbances to provide smooth tracking that results in good sound and high resolution. Only the cantilever and stylus should move when tracking the information in the groove and transmitting the vibrational energy; the rest of the cartridge should be stable. The vibration is transformed into electrical energy in the coil and the cartridge's rubber damper absorbs resonances and prevents oscillation. This process should take place without interference, but that's difficult to achieve.

In the case of a properly aligned tonearm and cartridge, the most significant interferences are the resonances that accompany the tracking of the groove. A tonearm is naturally less solid than a turntable, so resonances built up and oscillate here much easier. Consequently, tonearms work "backwards" and can influence the cartridge through the headshell. Often the cartridge loses stability and the tracking process is disturbed with audible sonic colorations when this occurs.

One potential way to prevent this is to absorb or "break up" the resonances. As described above, this can be achieved by using soft and absorbing materials, for example a plastic tonearm tube, or by having (relatively) loose connections between headshell and tonearm tube (such as what can be found in removable headshells). The disadvantage of this method is that the resonances can't escape the headshell and the residual energy in the arm tube is transformed into heat. No material can absorb completely, so there would always be "left over" resonant energy that works backward and negatively affects the cartridge.

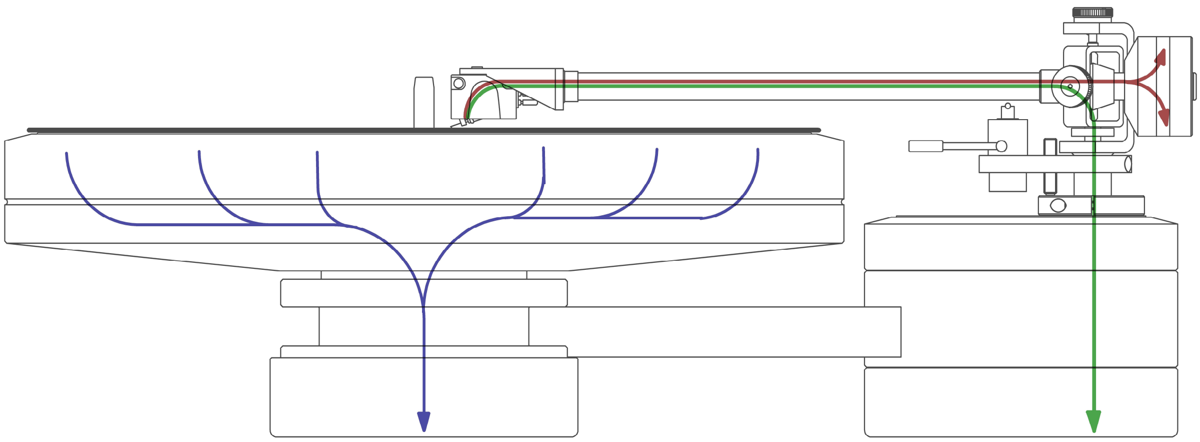
The other option is to channel and discharge the resonances. If this done fast and unhindered, then this is the easiest way to prevent oscillating resonances in the tonearm that work backwards and disturb the tracking process. The resonances are transmitted in the direction of the tonearm bearing and with a suitable bearing construction, they can discharge into the turntable plinth. Once the resonances have left the comparatively fragile tonearm, it's easier to discharge them without sonic consequence and the backward influence on the cartridge is eliminated.

Tonearm bearings should be friction free and stabilize the tonearm to prevent oscillation of the tonearm tube. Most common are play-free, preadjusted ball bearings or unipivot bearings that are stabilized by the tonearm's own weight. In any case, the resonances need to be channelled through small points of contact. With a unipivot tonearm, there is only one point of contact. The tonearm that rests on this single bearing contact needs to be heavy enough to prevent the resonant peaks from "lifting" the arm off the bearing, which occur when micro resonances build up in the bearing. Consequently, a unipivot tonearm usually requires higher mass than a tonearm constructed with preadjusted ball bearings, which affects the basic resonance of the tonearm/cartridge combination.

How are These Issues Solved in Brinkmann's Turntables and Tonearms?

The first important question is the choice of construction material. Our turntables and tonearms are mainly constructed of anodized aluminium. We have only sparsely combined different materials for a very specific purpose. In our design concepts, it makes more sense to channel and discharge interfering resonances than to break up or absorb them. Raw aluminium is a comparatively soft metal that can absorb resonances and spread and transmit them evenly through the organized microstructure. The anodized surface is very dense, almost as hard as diamond, and is perfect to transmit sound very fast and at the same time protect the surface. This combination provides a fast transmission of resonances on the surface and a certain amount of absorption inside the aluminium, unique qualities found in no other material.

Since the bulk of the resonances run through the tonearm, the headshell and tonearm tube of our arms are tightly connected to prevent oscillation and discharge the resonances. Both parts are made from anodized aluminium, and the tonearm tube has an especially hard-anodized surface that is much harder than normal anodizing. Resonances can run over that hard surface at high speed, while the inside of the tube is soft and absorbs some of the resonances. With these measures, there is a certain amount of absorption but without the resonances working backwards to influence the cartridge.



The rest of the resonances that result from tracking the record groove pass into the platter and through the bearing into the plinth. It's important that the platter material neither dampens the wanted vibrations of signal tracking nor “sings along” with the unwanted resonances. A dampening effect of the platter would be audible in the music as a lack of dynamics. A platter that sings along with the resonances would influence the tracking and add unwanted coloration to the music. All Brinkmann turntables have a crystal glass platter mat. Glass has an amorphous but dense microstructure and spreads the resonances evenly through the whole mat instead of absorbing them only at the area where the tracking takes place, before they get transmitted into the platter. Our platters consist of a special aluminium alloy that prevents resonances from swinging back and forth inside the platter, channelling them instead through the bearing and into the plinth where they are discharged.

The plinth is the part of the turntable where both resonance paths – the one through the tonearm and the one through the platter - meet. It's important to discharge the resonances of both paths separately to prevent them from affecting each other. The energy through the tonearm is stronger, faster and more critical for the tracking process, so the major focus is to discharge this energy. The resonances are discharged through a steel spike in the Balance and an aluminium foot in the Bardo and Oasis tables. This provides a fast channel and easy discharge. The resonances through the platter are already smoothed and slowed by the heavy platter and plinth mass. They get discharged through two steel-copper spikes in the Balance and two feet with plastic inserts in the Bardo and Oasis. The copper inserts in the steel spikes allow a soft discharge of the already-smoothed energy. The feet of the Bardo and Oasis have inserts of resonance-optimized plastic designed to absorb resonances evenly over the full frequency range. In both cases these measures prevent the resonances that run through the platter from interfering with the resonances that run through the tonearm. Both resonance paths discharge their energy separately, resulting in clean, high-resolution playback from Brinkmann's turntable designs.

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