Virtual Education Lab: What does a comb filter look and sound like?

As previously discussed, a comb filter occurs when a sound and a delayed version of it are combined. In a critical listening room, this can potentially be caused by refelcted specular reflections combining with the direct sound due to wall or ceiling reflections at the mix position or console reflections. The formula for a comb filter is simply 1000/2*Δt where Δt is the delay in time in milliseconds. In Figure 1, we show a comb filter for a sound delayed by 1 ms. When plotted with a linear frequency axis, the nulls resemble the regularly spaced teeth in a comb, hence the name. The first drip occurs at 500 Hz and successive nulls occur every 1000/Δt Hz. This means, for exambple, that the first null due to side wall reflections with longer delays will begin at lower frequency than shorter delayed console reflections. The depth of the nulls and peaks associated with destructive and constructive interference, respectively, depends on the relative strength of the delayed signal compared to the direct sound. When they are theoretically equal, the nulls are essentially infinite, and the peaks are 6 dB. Figure 1 also illustrates that as the reflected sound is attenuated from 0 dB to -24 dB, the level of the nulls and peaks are reduced. Therefore, any type or absorptive attenuation of the reflected sound in a recording control room is beneficial in reducing the interference in the reflection-free zone, RFZ, between the direct sound and the first arrival from the rear wall diffuse reflections.

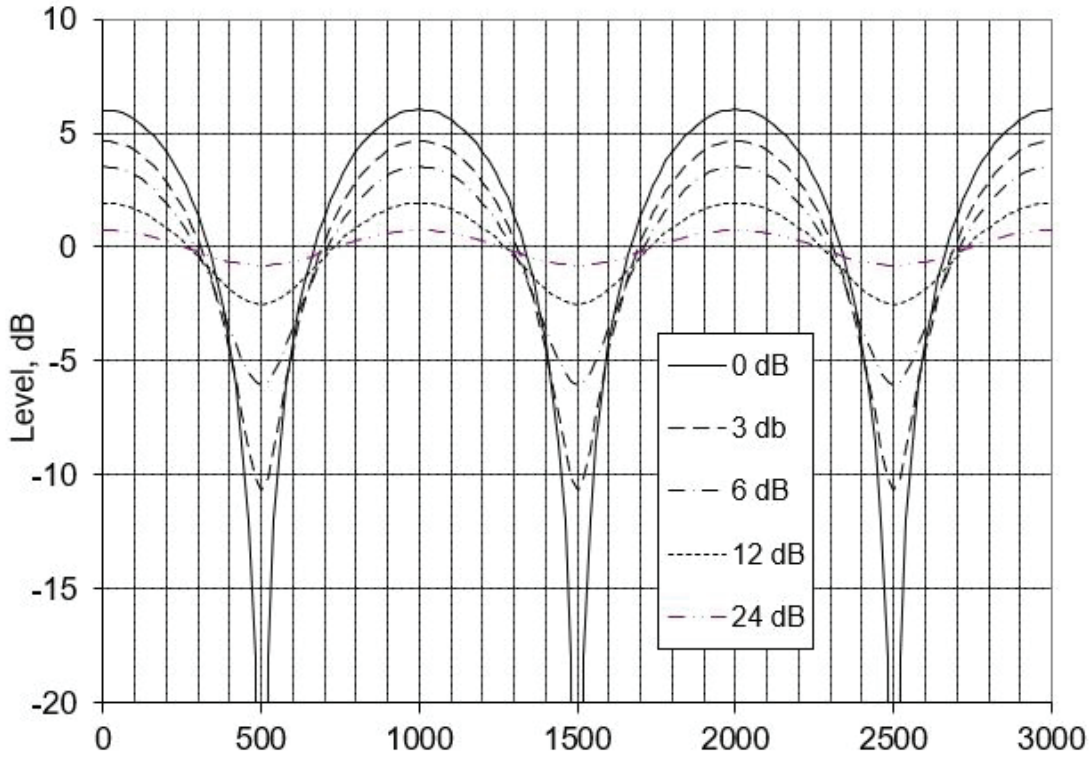

Figure 1. Comb filter resulting from the combination of the direct sound and a 1 ms delayed reflection, with various levels compared to the direct sound, plotted with a linear frequency axis.

The audible effect of comb filtering is easy to experience using a delay line. If a signal is combined with a delayed version, you will experience various effects referred to as chorusing or flanging. If the delay is caused by a reflection wtih a fixed time delay, the effect is referred to as chorusing. If the delay is variable and sub-millisecond, a swishing sound is experienced due to the changing comb filter interference and is called flanging. Shorter delays have wider bandwidth notches and thus remove more energy than longer delays. This is why microsecond and millisecond delays are so audible.

While chorusing and flanging are interesting effects when used with musical instruments, strong isolated delays cause audible acoustical disrortion in a critical listening room. Whether specular reflections are mitigated with absorption or diffusion, the treatment should provide broad bandwidth control.

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