

Conventional driver behaviour - Piston or oscillation?

In loudspeaker design the word "Pistonic" is generally used to describe the behaviour of the cone or dome surface. A lot of marketing hype focuses on the surface of the cone in an attempt to distract us from the real problem....In conventional drivers the entire cone / surround / voice coil former and spider behaves like a mass on a spring and more often than not is simply oscillating out of control.

Whilst the marketing guys draw our attention to the surface of the cone, the entire assembly is far from pistonic.

The basic problem with conventional drivers is they are a mass (cone/ dome) on a spring (surround / spider) and they are bound by physics to behave as such. They do not function as pistons i.e. like the alloy pistons in an engine with a fixed rod with a finite mechanical range of forward and backwards motion.

Let's examine our audio pistons

Imagine looking side on at a clear plastic tube, sealed at both ends and containing a Ping-Pong ball, this ball has a coil of copper wire wound round its circumference. The ball rests in the middle of the tube. There is an elastic band with one end fixed to the ping pong ball and the other end is fixed to the end of the tube.

In the middle of the tube there is a ring of magnets around the outside of the tube. Let's assume the magnets are powerful and generate a perfectly symmetrical magnetic field around the ping pong ball and the elastic (spider and surround) is also 100% linear in its operation.

We pass a short "on / off" burst of electric current through the wire, an impulse (to simulate a drum strike) not a constant current, and hey presto the ball shoots forward inside the tube!

But after the ball runs out of forward momentum, the ball then shoots back (pulled by the elastic) and **overshoots** its starting point... It then oscillates back and forth until all the kinetic energy / potential energy is slowly, compared to the initial transient acceleration dissipated. The important bit is "compared to the initial transient / acceleration". I.e. The decay time is much greater than the rise time, by an order of magnitude in many drivers.

It's not how fast a driver starts that counts, it's how fast it stops...

Music signals are all about transients and timing...Not sine waves and signal generators. Real sounds, musical or snapping twig etc, are formed by an initial transient of increased air pressure and then decay back to ambient air pressure. The ear / brains ability to "decode" this compression or rarefaction of the air and decay back to ambient pressure is the only way we hear any sounds.

That's worth a second thought; all the subtle texture, harmonics and decay that add so much to the emotional content in our music are just fleeting spikes in air pressure, followed by a reduction back to ambient air pressure. Simple, elegant, beautiful, yet oh so hard to reproduce.

So let's play some music through our ping pong ball speaker...

First up one single drum strike. Bang, the ball shoots forward causing a compression wave of the air in front as it is propelled forward by the electrical impulse and simultaneously it is being pulled back the elastic band (the spider, surround and suspension) which is now storing this kinetic energy as potential energy. So when the ball reaches the end of its forward motion it is now pulled backwards by the elastic band, and will overshoot its original starting point being carried past the start position by its own momentum. This behaviour is exactly as the laws of physics dictate, a mass on the end of a spring, it will oscillate back and forward until it dissipates all the energy in the elastic band.

So instead of the one clean drum strike you get one clean strike followed by a slowly diminishing number of ghost echoes. Time domain distortion of the worst type.

This is the inherent mechanical failing with all pistonic drivers. Some display gross errors (heavy coned bass drivers) some marginal and some almost undetectable at low SPL's playing simple acoustic music.

But at life like SPL's and with more complex music the majority of pistonic drivers fall apart, displaying gross ghost echoes or time domain distortion.

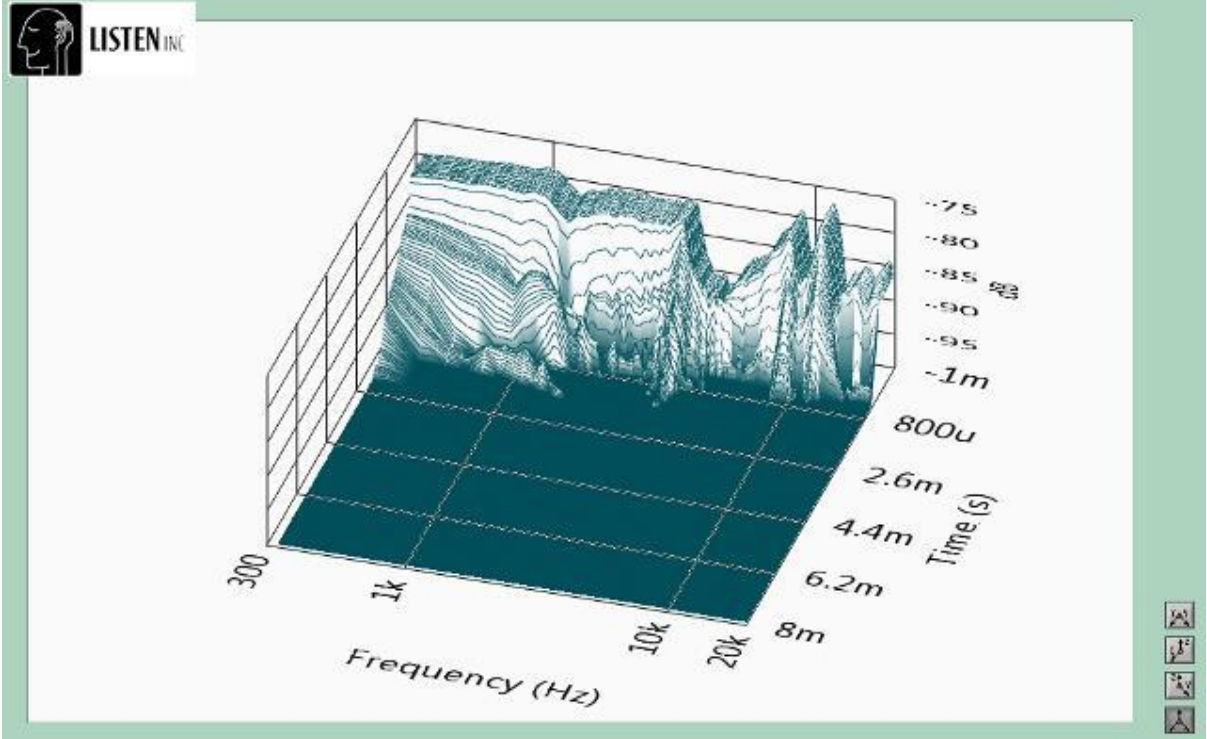
Now start to factor in real music i.e. before the driver has stopped oscillating from the first strike, bang here comes another and another and now a double bass and look out here comes the piano...! You get the picture; it's the compounding of errors one on top of the other which really does the damage. The wider the bandwidth the driver is covering the worse the problem gets. When a bass / mid driver is trying to simultaneously reproduce a 70Hz piano note, a 700Hz vocal note and a 1,700Hz violin note it must be able to start and stop cleanly from its marks i.e. the zero energy point where the spring (surround / suspension) is not exerting any push or pull force on the driver.

Playing music demands that the cone not only starts in the shortest possible time, playing music demands that the cone also **stops** in the shortest possible time.

The actual start and stop (rise and decay) times must by definition be shorter than the minimum time domain errors detectable by the human ear. There is ongoing research and much debate on this subject but the figure of 25 μ S (25 one millionth's of a second) is generally accepted as detectable by most people.

Now when you look at the measured decay times of pistonic drivers you see the scale of the problem. A good dome tweeter takes nearly 6 milliseconds (6 one thousands of a second), a good midrange takes 19 milliseconds and a big bass driver takes around 280 milliseconds (over a quarter of a second!) to settle from a 100 dB impulse signal.

CSD plot of CIA's Silk surround 4.5 inch wide band (200Hz to 20KHz) BMR driver.



So in summary, it's not how fast a driver starts that counts its how fast it stops!

