

# Driver Behaviour: Piston or Oscillation?

Introduction.

The word "Pistonic" is generally used to describe cone surface behaviour or cone break-up behaviour. I believe this has distracted us from the real problem i.e. the whole cone / former / coil / spider and surround are all Oscillating out of control.... like any mass on a spring should...while their beautiful titanium, ceramic, alloy, diamond, paper or latest fad "unobtainum" cones, domes, ribbons and panels surfaces remain "pistonic"!

## **It's not how fast a driver starts that counts, it's how fast it stops!**

I first published this theory in a far more comprehensive article on my Overkill Audio website back in 2005 when I was manufacturing high end speaker systems based around the Manger driver, a unique "Bending Wave" driver with a flexible polymer diaphragm. Back then I had an obvious commercial interest in promoting the benefits of the Manger driver over conventional (i.e. non Bending Wave) drivers.

Now I am in the Fire safety business I have no commercial audio related bias at all and I am happy to share my experiences and the few audio "secrets" that I discovered over the 7 years it took to develop the Ovation, Encore, Angel and Finale loudspeakers. Below 300Hz or 400Hz the Manger needs to be crossed over to "pistonic" drivers. In this thread I would like to take a close look at the fundamental operation of "pistonic" drivers, specifically in the 20Hz to 1 KHz range. Most of my time was spent concentrating on the 20Hz to 500Hz band as I always crossed over to the Manger at 300Hz to 400Hz but 90% of what I discovered below 500Hz applies equally all the way up to 20KHz.

The Problem.

The problem with so called "pistonic" drivers is this, they are never pistonic!

They can not function like a piston i.e. like the alloy pistons in an engine.

All cone, dome, ribbon, panels, stats, co-ax, and compression drivers are all "Oscillation" drivers i.e. mass on the end of a spring. Not 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 containing a ping-pong ball, this ball has a coil of copper wire wound round its circumference. The ping pong 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. (Big assumptions but pistonic theory needs all the help it can get!)

All this model lacks is the paper cone around the ping pong ball, but that brings in aerodynamics which I'll touch on in a separate post. We pass a short 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 out of control 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! Music signals are all about transients, amplitude and ....Timing! All "real" (I.e. not signal generators and sine waves) sounds, musical or snapping twig etc, are formed by an initial transient of air pressure and then decay back to ambient pressure. That's the only way we can hear any sound at all, binary on /off, compression or rarefaction of the air, everything

else is just decay of air pressure back to ambient. That's worth a second thought, all the subtle texture, harmonics and audible decay from a piano, cello, harp, drum or any sound at all, is just a very short spike in air pressure, followed by a reduction in air pressure back to ambient. Simple, elegant, beautiful, and 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 of the air in front of it (yes it does have to move through the air and yes aerodynamics do come into play!) it is propelled forward by the electrical impulse and simultaneously it is being retarded by 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 (carried past the start position by its own momentum) it behaves 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 99% of all 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 do 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. However full range or large bandwidth drivers do have the benefit of little or no crossover to mess things up.

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  $\mu$ 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 really good dome tweeter takes nearly 25 milliseconds (25 one thousands of a second), a top class (ATC dome midrange) takes 190 milliseconds and a big bass driver takes around 480 milliseconds (nearly half of 1 second!) to settle from a 100 dB impulse signal.

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

All the best

Derek.