Pico Executive HD *featuring our new CopperMatrix™ wire from Marigo Labs*

Small Size Belies Brute Force

My Design Concept, by Roy Johnson, designer, Green Mountain Audio, Inc.

THE PICO EXECUTIVE WAS DESIGNED to deliver the clearest possible sound for the most intimate spaces. It would have fully-defined bass from the smallest possible package. Because its small size would allow it to be used on the floor or a table top, it would also need to play very, very quietly with full resolution, for the office, bedroom, dining room or living room. And, given enough power, I wanted this design to play loud, at true-life levels on any music and any soundtrack, even in large rooms. A pair should be able to shake the house, I thought.

In the design phase I relied upon the mathematics I developed several years ago and which led to the Continuum 3's design. It is scalable and every formula can be applied to create any size of speaker. This math begins with the molecular motion required at the listener's position and works backward to the face of the speaker. It then determines the number and proper size of the drivers, tone range each must handle, and their location in space.

The result is always the proper amount of acoustic power delivered everywhere in a room, at all frequencies. Most speakers are designed the other way around -- put into an enclosure and then measured by computers -- which misleads consumers. Since our hearing process is so complicated, no computer can measure how we perceive the sonic modifications made by a room's floor, ceiling, and walls!

The path

During the summer of 2004, I began designing the new Pico Executive by first using my mathematical formulas. The initial result showed that one small woofer could be used, but with two requirements: It needed to be kept close to the floor and could go no higher than the low-voice range. The size of the woofer is magnified by the presence of the floor, because in the intended tone range, its reflection from the floor is indistinguishable as such. One hears a large woofer. This small woofer might be asked to stroke very hard -- another reason it could not be allowed to handle any voices. The long strokes required for heavy bass will always distort the shorter wavelengths of the voice range.

The next result was that a small woofer would require the most efficient bass port, to extend its output as low and as loud as possible. An efficient bass port is large in diameter and has aerodynamically-curved openings for the intake and exhaust. It also must receive its pressure from the most optimum location inside the cabinet, for the best control by the woofer. That port also has to pressurize the room's air in a uniform manner, regardless of where the speaker is placed -- thus there is also an optimum position for the port on the outside of the enclosure.

The mathematics showed how great demands would then be placed on the midrange driver, as it would have to go very low to blend with this woofer -- and also go higher than most any midrange driver ever had -- if it was to meld imperceptibly with the tweeter. That tweeter could be of conventional size, as long as it was one that did not depend upon nearby reflections for 'proper' tone balance, including the reflections off its own front plate. It was also important that it go naturally low, so I could blend it with the midrange driver in the clearest manner.

Of course, the enclosures behind these three drivers had to be as rigid as possible, with no ringing or other resonance. They also had to be as quiet inside as could be achieved at all frequencies -- except at the lowest bass notes, which are necessary to drive the port. The mathematics also indicated the size of the woofer's enclosure -- the width and height -- and also the shape around the midrange driver, where most reflections occur.

Creating Total Performance Bass

Creating the Pico Executive's high performance started with the woofer. After much testing, I decided the correct one to use was the much-praised 6” woofer from our two-way speakers.

First, it has remarkably low distortion, from the bass to the very high voice range, no matter how hard it strokes. It requires only a very small enclosure, with its bass extended by a very large aerodynamic port.

If a conventional small woofer is placed high in the air, such as in a tall cabinet or up on a speaker stand, it will be quite a bit louder in the voice range compared to the bass. This is simply because the cone is more efficient at moving the air in the voice range, literally 'grabbing' more air per stroke compared to the bass, which is known as 'increased radiation resistance.' When a midrange driver is then balanced against that small woofer's voice-range loudness, and a tweeter balanced against that midrange, then no low bass is left. It is there, but far less audible because everything else is so much louder. Our two-way’s 6” woofer is more uniform than

others in its output from the bass all the way into the high-voice range because of the ratio between its moving mass and the softness of its suspension, the depth of that cone, and the damping its foam surround provides. When this woofer is restricted to only the low-voice and bass range, and also kept near the floor or a surface such as a tabletop, it must still be surrounded by the proper size and shape of cabinet face for a uniform tone balance. The balance achieved between all those nearby surfaces increased the woofer's 'radiation resistance' across its entire operating range, making it perform as a large woofer.

Next was where to put the woofer on the cabinet. Could it be hidden underneath the enclosure, for reasons of styling? Yes, but then its performance would change when placed on carpet instead of a wood or tile floor. It would also then be much farther from the ear, so the location of the midrange driver would have be moved that much farther back on top of the woofer's cabinet. That would imbalance the entire speaker towards the rear. That is not good. Could it be on top? No, because the part of the voice-range it did handle would be distorted by the midrange driver's marble enclosure above it.

So the woofer had to be placed on the front -- a position which had no sonic compromises. There were choices for where to place the port. If on the front, the woofer enclosure would have to be 6" taller, making the cabinet-face too large for an even tone balance across the bass range. Also, it would either be placed directly above or below the woofer. If below, (on the front face), the woofer would be too high in the air for the floor to completely reinforce its sound. If above, (again, on the front face), the midrange driver would again have to be moved too far back for good geometric balance.

The port could be placed on one side, but this is a long port, and that would require a wider cabinet, making the front face too large for proper tone balance. It would also compromise the styling I had in mind for each side panel, besides making the speaker too wide 'to fit everywhere.'

The port could go on the rear of the cabinet, but the bass will change as the speaker is placed closer to the wall behind. On the inside, the intake of the port would also be too close to the woofer itself, developing unwanted resonances. The port could not be placed on the bottom, again because of carpet-versus-hard-floors considerations. Any speaker stand would block it.

Therefore, I decided to place the port on top, directly under the midrange and tweeter, the same as in the Continuum 3. Because the enclosure was so small, it turned out that even 1/2" difference in location made a large difference in how well

the port picked up the internal pressure from the woofer. The final location allows it to respond to the pressure changes inside the cabinet from the point where all parts of the cabinet pressurize it equally, for the best control by the woofer. The top-mount location is also the best position for the port to pressurize the room. Its output is unaffected by the closeness of the wall behind. It cannot talk to the woofer's cone on the outside or the inside. Finally, its long tube lies right behind the woofer, where it diffuses the woofer's upper tones into the ultra-low density fiberglass for even more sound absorption in such a small space. Of course, the cabinet supporting the woofer has to be as rigid as possible for the best bass. Nothing should move but that woofer's cone, according to Newton's Laws.

For the Pico Executive, the entire woofer cabinet could have been made of our Q-Stone™, but I did not think anyone would enjoy moving a 90lb. speaker, let alone place it on a side table in an office. Based upon the work in our subwoofers and with the Continuum 3, a compact and very stiff enclosure was developed with a Q-Stone™ face and multiple layers of wood that interlock and overlap at the corners.

The voice range

After testing many midrange drivers, the one selected is also the one I use in the other Pico models. To my knowledge, no other 5.25" midrange driver has a cone as light -- yet rigid and non-resonant. A remarkable driver, it is made with a unique blend of wood fibers, acrylic polymers that lock them together, and graphite that damps the remaining micro-vibrations between the fibers.

This cone goes very high and far into the treble without a hint of breakup distortion. It also goes very low, because its unique suspension gives it the stroke and very-low resonant frequency required. All is controlled by a massive magnet and a high-power voice coil, which is vented with an aluminum phase plug that also broadens the dispersion throughout the upper operating range. The mathematics also showed that only a certain faceplate size around the midrange driver would provide an even tone balance through its entire range.

If the face were smaller, then the low-voice range -- so critical to blending with the small woofer -- would not be loud enough. This is because the surface area of the face has to be just large enough to hold near that low voice-range air pressure while the cone finishes its stroke. Too large, and middle-range reflections occur along with some from the tweeter. The final shape is a modified ellipse because its narrow profile allows uncompromised expansion of sound into the room -- to all listening angles, at all frequencies, and without reflections. Molded in

our cast marble and while quite small internally, it manages to contain a 28" acoustic labyrinth, terminated by a 'resistive vent.' Derived from the Continuum 3, the labyrinth and vent immediately absorb all interior sounds for the greatest clarity.

The treble

The tweeter is a very special design. A patented arrangement of six miniature, neodymium magnets provides a very focused magnetic field and one that is self-shielding. Openings are machined between those magnets which create many small pathways for sound pressures behind the dome to progress into the large acoustic chamber on the rear, where they are absorbed without reflection. With the dome's very flexible suspension and lead-in wires, this large chamber and those efficient pathways permit a very low resonance frequency for the tweeter, which keeps it from interfering with our simple crossover circuit's action.

On the center pole of the magnet structure, behind the dome, a copper cap provides a path for eddy currents to flow. Created by the music, eddy currents are electrical currents that normallyswirl around, quite chaotically, in the magnet and smear high-frequency clarity. Another band of copper is visible around the dome on the outside -- for there are currents there too, which no one had yet addressed. The dome of the tweeter is a fabric weave and after its polymer-treated molding process, is extremely light, very stiff, and non-resonant. The cast marble enclosure for the tweeter was molded to be just larger than the tweeter itself so that a select grade of pure wool felt, placed on the tweeter's face, absorbs the sounds normally reflected from that surface and also diffracted off the edges of the enclosure. Inside the marble, another layer of felt compressively damps the tweeter's zinc-alloy rear chamber and minimizes all chassis resonances. The final result is that highs are crystal clear.

Our Balanced-Phase™ circuit design

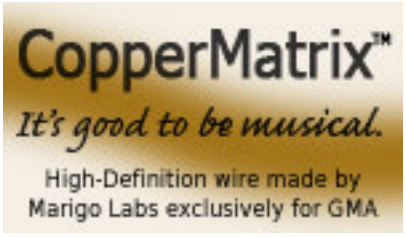
To realize the full potential of these three remarkable drivers took my Balanced-Phase™ 'first-order' crossover technology to its limits. One can crossover a midrange driver only so low before a) the resistance between the woofer and the amplifier increases so much that the bass becomes under-damped, or less-controlled; and b) before the midrange driver finally cries 'enough!' and distorts on bass-heavy music.

A crossover point to the tweeter can be set only so high before the midrange cone lets you know it is not keeping up with the music and sound effects in that low-treble range. Because the Balanced-Phase™ circuit design process allows very small increments in the crossover frequencies to be plainly heard, it did not take too long while working on the final prototype to make the decision for each crossover point -- 350Hz to the woofer and 3,150Hz to the tweeter. The crossover circuit blends the three drivers together seamlessly and makes them truly move as one unit, coherent in time. This circuit also lets any amplifier deliver its power with the least distortion.

Our exclusive CopperMatrix™ wire from Marigo Labs

In the Pico Executive HD, we are fortunate to be the first and the exclusive user of a new style of Litz wire developed by the physicist responsible for Marigo Labs products. Each positive and negative wire going to each

driver from the crossover circuit is a conductor of 500+ ultra-fine strands of ultra-pure, oxygen-free copper. Each strand is individually coated with a proprietary damping and insulating polymer just millionths of an inch thick. These strands are then wound in multiple layers of differing tensions in a proprietary geometric pattern, with the effect of reduced magnetic-field interaction between layers and proper mechanical damping in both the transverse and axial directions. (Pure metals love to ring sideways and along their lengths -- these wires do not and can not.) The exterior of the entire 18-gauge conductor is protected by multiple threads of a cellulose-derived fiber wound in different directions to provide mechanical damping more so than any known plastic insulation and with far less dielectric effect than Teflon. The finished wire is doubly-cryogenically treated, tested, and marked for signal directionality.



As you might imagine, this wire takes an extreme amount of patience to terminate and strain relieve, because each of its 500+ copper strands is only about 25 microns in diameter (0.001"). Each wire must first be stripped of its organic-thread insulation and then prepared for soldering by applying a unique organic-salt flux, then immersed in a bath of liquid solder. For any connection it makes, whether to the crossover parts or to the drivers, it must first be aligned in its direction. Its solder-covered end is either wrapped tightly with the other wire from say, the capacitor in the crossover, or it is heated and bent around the terminal on the driver. Either way, it is then heated again, crushed into the other wire or terminal, and finally soldered again. This produces maximum contact to all the strands and the minimum solder between each strand. Each connection is then de-oxidized and finally strain relieved with heat shrink so that it lasts for life.

When we first obtained this wire, it made such a shocking difference over the excellent-sounding wires we were already using, that one could hear that in another room. It was livelier on dynamics, but in a subtle way, because each peak was clearly defined and yet naturally rounded, with an edge and coarseness to it removed, ones we had never noticed. The decays of any sound, very small or very large, were far more defined than before, with much less 'noise' between each note, yet it was obvious no details were being lost. The timbres of each instrument and voice were more accurate and produced new textures. The power in the music or its subtle grace were much more evident. The improvement this wire made, in what we can most simply call clarity, was so great that it allowed us to further refine the values and choices of any by-pass capacitors used in the crossover circuits, very small ones placed in parallel with any larger capacitors to (usually) make them more transparent to the signals. The result was even better blending between the drivers and increased dynamic contrasts btween any two signals, small or large. The total increase in definition is quite stunning, hence the High-Definition identifier.

The result

I imagined the Pico Executive -- and now, the Pico Executive HD -- would see most use while placed directly on the floor. Since it is so small, it may also be placed on a side table or bureau. Like our other models, you may adjust the midrange and tweeter from front-to-rear to assure the most perfect sound for both seated and standing listeners anywhere in the room. My reliance upon physics and mathematical formulas produced a speaker ready to entertain you in the most intimate settings while waiting to shake your bones upon command. You deserve to hear it all -- whatever you choose to hear and whenever you choose to hear it.