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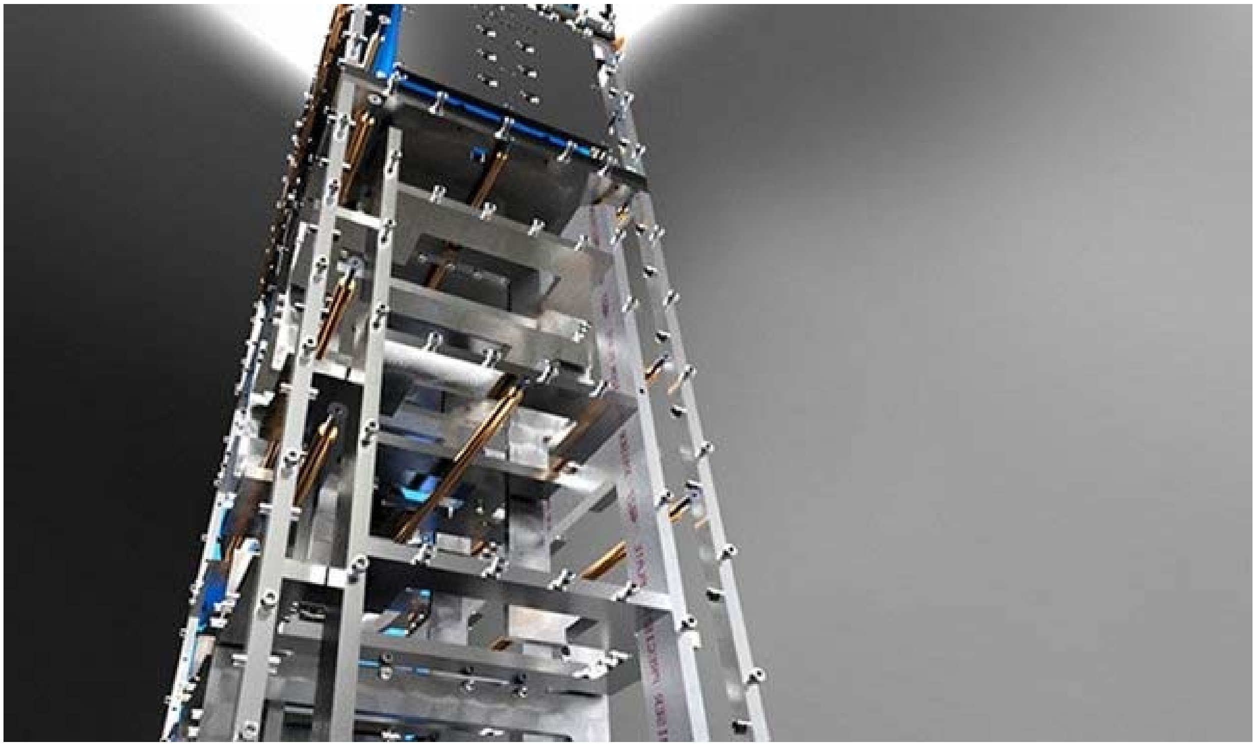
The Technology Behind the Q7

Equipment report

By Robert Harley | Feb 28th, 2013



Although the Q7's woofers, midrange driver, and tweeter look identical to those of the Q5 (except that the woofers are bigger and there are more of them) the Q7's drivers are actually quite a bit more sophisticated. The tweeter is a third-generation beryllium design (the Q5's tweeter was a first generation) with several key improvements. This new tweeter features a fully under-hung motor structure with a more powerful neodymium magnet to increase sensitivity (to a whopping 95dB). The term "under-hung" describes a short voice-coil mounted in a long gap. This design results in more linear operation because the voice coil remains within the gap's magnetic field regardless of the voice-coil's position or excursion.

The 6" midrange is an all-new design with a massive 55mm voice coil driving the Magico Nano-Tec cone. This cone is woven from a carbon-nanotube material originally designed for helicopter blades where light weight and stiffness are absolute requirements. The under-hung motor uses a massive magnet (5" in diameter) made from N48H-grade neodymium (the higher the number in the grade the stronger—and more expensive—the magnet). The magnetic field strength in the gap is a stunning 1.7 Tesla, a value seen only in field-coil drivers (in which the magnetic field is created by an electro-magnet rather than a fixed magnet). The voice coil is a vented titanium design and is mated to a new composite spider material that allows +/-6mm of excursion. The driver, which was designed specifically for the Q7, can reportedly produce 120dB SPL at 1m distortion-free within its passband. Incidentally, while visiting the Magico factory (see sidebar) I visually compared the Q5's midrange driver with this new Q7 midrange unit. Although the look the same when mounted in an enclosure the Q7's midrange was considerably more massive and elaborate. I was able to lift the Q5's midrange driver from a metal table, but not the Q7's midrange, which felt like 100 pounds because of the magnet's strength.

Looking next at the 10" mid/bass unit that's mounted at the top of the enclosure, the driver is again all-new for the Q7. Its design is very similar to that of the midrange, with a massive motor structure and top-grade neodymium magnets for high magnetic field strength in the gap. The voice coil is a whopping 127mm, half the cone diameter. (An engineering textbook in my library shows a photo of a 15" subwoofer driver with a "large" 3" voice coil.) Again, the cone is Magico's Nano-Tec material. Magico claims that this 10" mid/bass driver has the lowest inductance of any driver extant (0.085mH at 10kHz).

The dual 12" woofers are again all-new for the Q7. They use the same 127mm voice coil and underhung motor as the 10" mid/bass. These drivers have an excursion of +/-15mm and can reportedly produce 120dB SPL at 1m at 50Hz.

The drivers were designed using a state-of-the-art finite element analysis software package that allowed Magico Chief Technical Officer Yair Tammam to model the driver behavior in the thermal, magnetic, mechanical, and electrical domains simultaneously. Previously, Tammam told me, he had to model each of these domains separately in different software.

The drivers are designed for maximum magnetic field strength in the gap, low moving mass, and minimal inductance. In addition, Magico has also gone to extreme lengths to minimize eddy currents in the drivers. Eddy currents impede the motion of the voice coil by creating magnetic forces that oppose the voice coil's motion. Eddy currents are so effective in slowing down moving objects that train brakes are based on the phenomenon. One way of reducing eddy currents is by fully saturating the iron in the motor. If the iron is saturated, magnetic flux cannot be induced in the iron, and thus no opposing magnetic force is generated. Magico found just one facility in the world that could saturate the iron in the driver motors to their specification, and it happened to be in England. The drivers start life in Israel, are shipped to England, back to Israel, and then to the US. Magico's Web site shows a pair of plots comparing the saturation of its 10" woofer with a "high-end" woofer.

I once witnessed a dramatic demonstration of eddy currents in which a steel ball-bearing was dropped through a steel tube not much bigger than the ball-bearing itself. The ball-bearing fell through the tube just as quickly as if it were falling through free air. But when the same size bearing, this one magnetized, was dropped through the tube, it took about ten times longer to traverse the tube than the unmagnetized ball-bearing. Looking into the tube from above with a flashlight, I could see the ballbearing floating slowly downward. Why? The ball-bearing's magnetism (and its movement through the tube) induced eddy currents in the tube, with those eddy currents creating their own magnetic field in opposition to the ball-bearing's magnetic field, slowing the ball-bearing's motion. The same thing happens in a loudspeaker motor; the induced eddy currents create a magnetic field that opposes the voice-coil motion. Reducing eddy currents has obvious benefits for a driver's transient performance. This is particularly true when you consider that the faster the voice coil moves, the stronger the eddy currents and the greater the opposition to the voice coil's motion.

Think of the voice coil sitting in a magnetic field with no current flowing through the voice coil. When alternating current from the power amplifier—the audio signal—flows through the coil, a magnetic field is temporarily created around that coil that varies in strength and polarity as an analog of the music. This varyingmagnetic field interacts with the driver's fixed magnetic field, pushing and pulling the voice coil back and forth, and with it, the cone. It's easy to see how the more powerful the fixed magnetic field, the lighter the voice coil and cone, and the lower the eddy currents, the faster and more easily the cone will respond to the musical signal. This not only results in superior transient behavior (the cone starts and stops more quickly) and better control over the cone motion by the amplifier, but also increases efficiency. It's like a lightweight sports car outfitted with a huge-displacement engine that can instantly deliver high torque to the wheels when you depress the accelerator.

Turning to the enclosure, the Q7 is constructed like no other loudspeaker extant. The enclosure is built entirely from machined aluminum pieces—101 of them to be exact—held together with 635 bolts. Most of these pieces form an intricate internal matrix that creates a rigid, inert structure that reduces enclosure vibration to an absolute minimum. The idea is to create a heavy, dense, resonance-free platform that is neither put in motion by energy from the drivers nor stores and then releases energy. The Q7's enclosure is perhaps the most heroic design ever attempted. Note that the Q7's enclosure features three-axis bracing compared with the Q5's two axis bracing. That is, the Q7 has front-to-rear internal bracing in addition to the side-to-side and top-to-bottom reinforcement used in the Q5.

The curved baffle you see on the loudspeaker's front is only part of the baffle structure. Behind the 85-pound curved baffle is a thick 70-pound slab of aluminum to which the two 12" woofers and 10" mid-bass driver are mounted. You can see this structure when looking closely at the enclosure from the side. The flat slab is bolted to the matrix structure and forms the front structural member. The midrange driver floats in its own sub-structure rather than being attached to either baffle. Only the tweeter is mounted to the curved outer baffle. This arrangement keeps resonance to a minimum and prevents energy imparted by one driver from being transmitted to the other drivers.

The four-way crossover is a 24dB Linkwitz-Reily design incorporating Magico's "elliptical" techniques that control specific resonances. The crossover parts are over-the-top; the 10-gauge inductors are bigger than the power transformers in some power amplifiers. The inductors aren't wound with wire but instead are made from flat copper-film. The custom capacitors reportedly have half the parasitic inductance of the previous state of the art.