IGx Infrasonic Generator

White Paper

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England

Redefining Low Frequency Audio Sound

Developed in Sheffield, England, the new Wilson Benesch IGx Infrasonic Generator is the latest low frequency sound generator from Wilson Benesch. The IGx Infrasonic Generator builds upon the groundwork laid by the multi-award winning Torus Infrasonic Generator that it replaces. The Torus incorporated a fundamental rethinking on how low frequency sound should be generated. Like the Torus, the IGx features a range of unique technologies including the push-pull motor design, a super lightweight Carbon Fibre – Polyethylene Terephthalate diaphragm (PET) and a rounded geometric enclosure that mimics the very instruments it seeks to reproduce.

The Carbon Fibre – Polyethylene Terephthalate 18” Diaphragm: The Stiffest, Lightest Diaphragm Made Today

In the development of the original Torus a completely new carbon fibre fabric was developed through a collaborative development funded in part by Wilson Benesch and grant funding which the company had won to support new technology development using public money. Wilson Benesch collaborated with two leading companies in the field of fibre weaving and composite design to create a Carbon Fibre – Polyethylene Terephthalate fabric. This material is woven exclusively for Wilson Benesch.

The main key advantage of the Carbon Fibre – PET material is that it allows Wilson Benesch to form the complex geometry that creates the toroidal form of the IGx diaphragm. It is the PET material and the unique orientation of the carbon fibres in the fabric that allow the fibres to form along multiple axes and conform to the mould as the technician forms the shape of the IGx diaphragm in the Wilson Benesch VRTM Suite at our factory in Sheffield.

WB: 1 The Carbon Fibre - PET Material that is made specially for Wilson Benesch is also used in the carbon fibre tops that are used in the company's reference loudspeaker line. Seen here a technician forms the top of the Endeavour 3zero loudspeaker.

The IGx 18" diaphragm is the stiffest, lightest, and most highly damped dynamic drive unit diaphragm ever made. The multi-axis orientation carbon fibre weave enables Wilson Benesch to make this beautiful diaphragm from one single piece of fabric, diametrically opposite to the patchwork approach to carbon fibre diaphragm production seen across the industry now.

The IGx diaphragm weighs 110g but it is able to easily support 125 times its own mass, a testament to the stiffness of the structure.

WB: 2 Carbon Fibre Weaving at The Advanced Manufacturing Research Centre in Sheffield

WB: 3 The Carbon Fibre Spools that feed the weaving machine to create carbon fibre fabric

Why is Stiffness so important in Low Frequency Sound Reproduction?

Sound is a waveform of energy. To understand how sound waves move, the air around us can be considered like a liquid. Low frequency sound is perceived by the ear when it receives sound pressure in the form of long wave forms and the ear perceives high frequency sound when it receives short wave forms.

A dynamic drive unit creates sound by converting electrical energy from the amplifier into kinetic energy moving the diaphragm of the drive unit to push and compress the air in front of the diaphragm of the drive unit to create a wave form. To produce high frequency sound, the diaphragm need only move a small amount of air to produce a small sound wave, but to create low frequency sound, the diaphragm must move large amounts of air to produce a large sound wave. Going back to another analogy, imagine if we stand in a perfectly still lake and try to create a ripple in the water with our hand, to create many small ripples is relatively easy, it can be done in fact with by casting a small pebble into the water, but in order to create large ripples or a wake, one must use not only one hand but in fact probably two in sync and lots of muscle power to form a wake in the water, indeed a large rock when lifted and thrown into the water will create a large wake and not a ripple like the pebble.

The challenges are no different for a dynamic drive unit, when creating low frequency sound such as required by a subwoofer, the drive unit diaphragm must move large amounts of air to create low frequency sound waves. To do this accurately and effectively, the diaphragm must be stiff and it must be driven with lots of power. Going back to our analogy in the lake, imagine having a large wooden board, all of a sudden the power in not just your hands and arms can be used, but in your entire body can be used to create a large wake. If that wooden board was flexible, the task of creating a wake would be much harder or even impossible as energy created by your body is lost as the flexible board bends and deforms in the water. Thus the diaphragm in a subwoofer should be as stiff as possible to convert as much of the energy from the amplifier into kinetic energy and push the air in front of the woofer as efficiently as possible.

Carbon Fibre is one of the stiffest materials known to man. Weight for weight, carbon fibre is ten times stiffer than steel, whilst also being significantly lower in mass than aluminium.

Why is a Low Mass, Lightweight Diaphragm so Important?

If fidelity is accuracy, then within a system that is recreating a recorded piece of music, timing is fidelity. Any delay in the drive unit diaphragm transient response to the signal that it is delivered by the amplifier is a loss of fidelity. If we then consider a higher mass diaphragm and a low mass diaphragm, it is easy to consider why a low mass diaphragm offers advantages in terms of speed and therefore accuracy and fidelity. This is physics at its most basic level, if we take the analogy of a stationary car and imagine that our task is to record the fastest time possible in accelerating down a straight road from 0-60mph as quickly as possible. If that car was full of heavy luggage, the first thing we would instinctually do is remove the luggage and then record the fastest possible acceleration. What we are doing is reducing the mass and therefore inertia of the car that the engine must overcome to accelerate the car.

In a subwoofer design, the challenge is much the same. In this instance the engine is the amplifier and the diaphragm is the car. By producing the lowest mass, lightest 18” dynamic drive unit cone in existence today, Wilson Benesch have created the ideal diaphragm for low frequency sound generations.

Extremely High Stiffness. Extremely Low Mass. Fidelity.

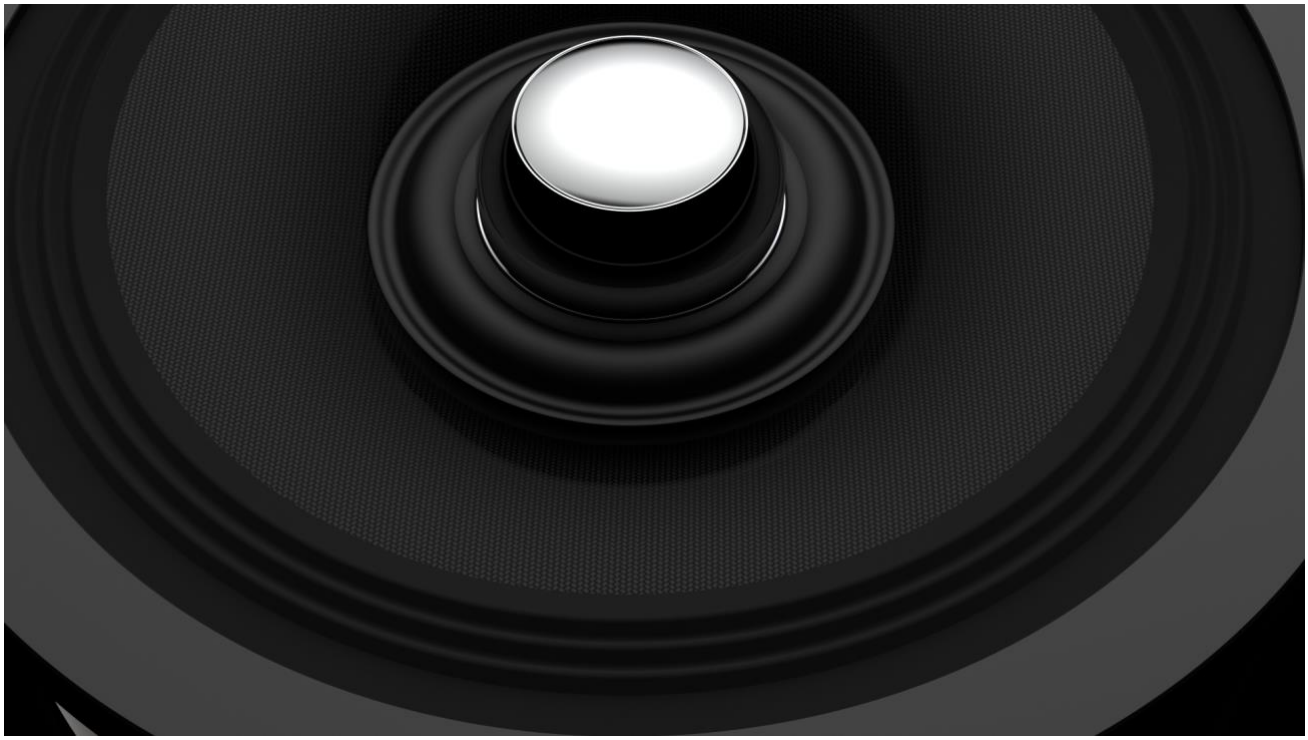
IGx - Infrasonic Generator: Because it is Not a Subwoofer

At the heart of the IGx there is no dynamic drive unit in the conventional sense. A conventional dynamic drive unit places a diaphragm inside a basket with a voice coil that is connected to a stiff spider at the centre of the basket structure that controls the position of the diaphragm with a rubber surround that connects to the basket perimeter. Conversely the IGx does not have a basket at all, during playback the position of the lightweight diaphragm is dictated to and controlled by two coils and two high power magnets that operate in a push-pull formation. The two magnets and coils in turn reside around a huge steel core that is placed in the centre of the IGx in the vertical axis.

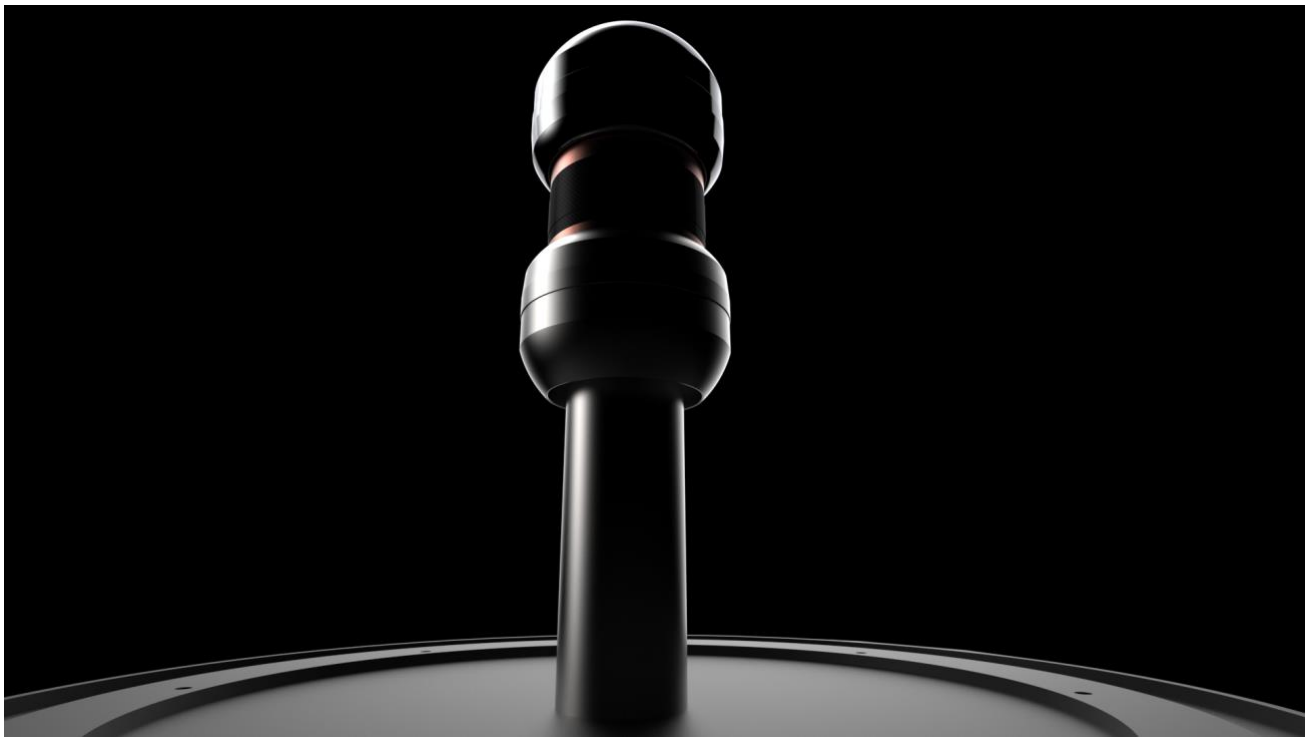
A dual motor push/pull drive consisting of two sets of 82mm diameter voice coils that are deployed in front of and behind the diaphragm around a massive 16kg precision machined central core containing high energy rare-earth magnets. The coils use non-commercially available but incredibly high heat conducting boron nitride, and the core conducts all the heat and structural borne resonant energy directly to the ground bypassing the cabinet.

The result is a push-pull design that has multiple advantages over a conventional woofer design, principally,

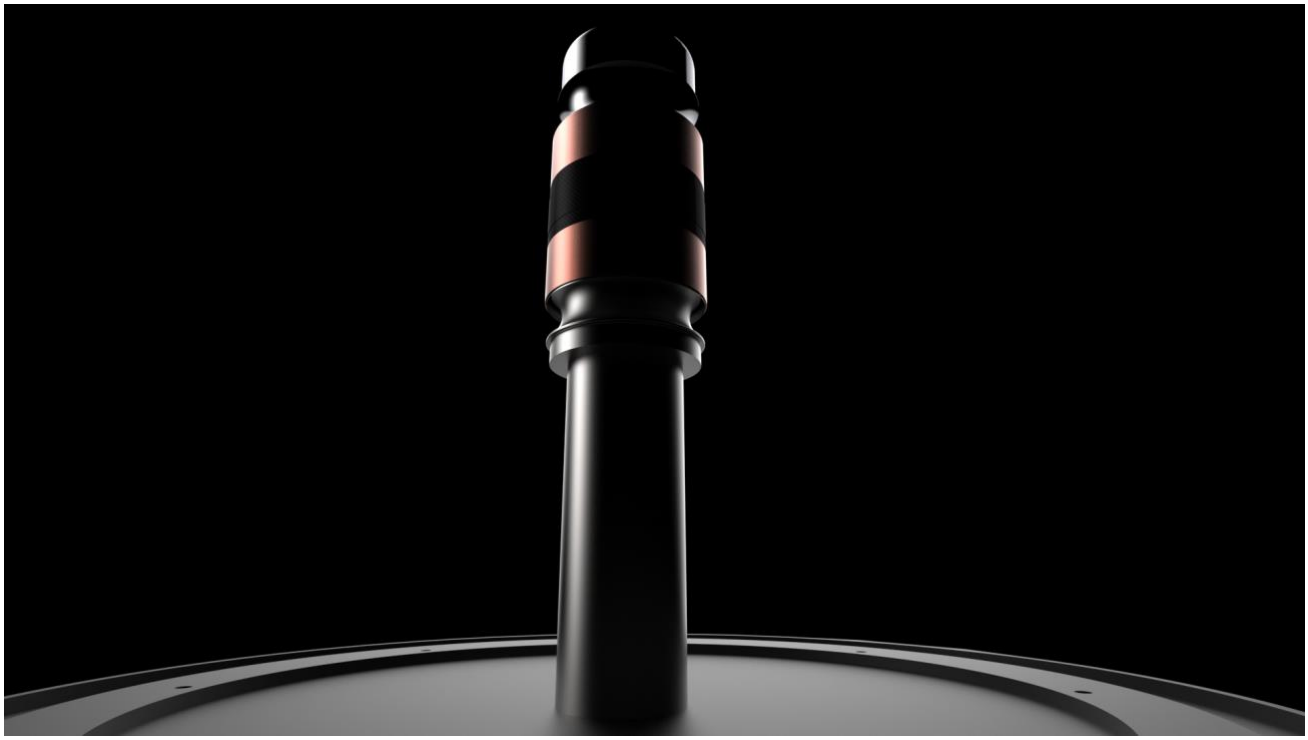
1. It eliminates the requirement for a stiff spider to dictate the position of the diaphragm. A stiff spider retards the movement of the diaphragm. This high hysteresis design induces latency and delay into the diaphragm's movement and thus delays in sound reproduction.
2. Instead the position of the diaphragm is dictated to electro-magnetically by two magnets driving two coils in a push-pull formation. The powerful amplifier delivers instantaneous power which drives the coils and in turn the diaphragm with almost no latency.
3. Efficiency, because the IGx is not having to overcome the spider which induces latency and massive inefficiency in the use of the power of the amplifier to overcome the stiffness of the spider, the energy provided by the amplifier is used efficiently to drive a lightweight carbon fibre diaphragm, as such Wilson Benesch can use relatively low power amplifiers to drive the IGx whilst maintaining industry leading dynamics and step response.
4. Almost of the energy generated in the IGx enclosure is placed directly through a central steel core. The steel core is a giant 16kg structure around which the two coils and two magnets reside. It is the movement of these components that drives the diaphragm which is in turn bonded to the top of the steel core. Unlike a conventional subwoofer design, which has a rubber surround which is bonded to the basket to provide the structural integrity of the subwoofer, the IGx relies upon its steel core. As such the vast proportion of the energy that would normally excite the enclosure of the IGx, is instead absorbed into a huge steel core and in turn travels to the base of the IGx and into the ground. This is a significant advantage that the IGx has over conventional designs which suffer from subwoofer drone which is the overhang of vibrational energy that has excited the enclosure of the subwoofer and pollutes the listening space.
5. The Steel Core is placed in the vertical axis, this ensures that all the moving components of the IGx are moving through the gravitational plane.
6. The steel core is also one huge heat sink, it is able to absorb the large amounts of heat that the two coils create, draining this heat away from the coils and away from the magnets to ensure that the system maintains optimal operational temperatures.



WB: 4 The 18" Carbon Fibre - PET Diaphragm round the huge 16kg Steel Core at the centre of the IGx



WB: 5 The IGx CORE - The Core can be seen here with the top motor and the bottom motor which house one powerful Neodymium Magnet in each. The coils underneath this can just about be seen



WB: 6 Now with the magnet housings removed, the two coils can be observed with a carbon fibre collar at the centre to link them with maximum stiffness to create one functional component

WB: 7 With the coils removed the two large Neodymium Rare Earth Magnets can be observed residing around the central steel Core

The New IGx Surround

The IGx suspension system has been revised with a cambric, triple roll, impregnated fabric that delivers significantly higher precision travel and lower hysteresis adding to the compound benefits of air volume, high mass, greater precision and higher power. The cambric fabric surround ensures superb dynamic performance with even the largest excursions.

WB: 8 The IGx 18" Carbon Fibre - PET diaphragm in production with the cambric fabric surround and top voice coil shown

Efficient Class D Amplification

The modular digital electronics driving the IGx are housed in the base of the IGx. Wilson Benesch selected a 500w Class D amplifier to drive the IGx. Diametrically opposite to all other subwoofer designs which require massive amounts of power to drive the diaphragm due to inefficient designs which require the stiffness of super stiff spiders to be overcome before movement of the diaphragm can be induced, the IGx does not have to overcome this problem.

Class D amplification has developed rapidly in recent years. The quality of such amplification technology now far exceeds what was possible when the Torus was developed. There are many advantages of Class D in subwoofer design which include,

1. Compact Small Form Factor
2. Highly Efficient
3. Low Heat Generation
4. Reliability

The IGx delivers astonishing speed, accuracy and control, enabling it to easily blend with quicker, smaller drivers in the main loudspeakers in a way that no conventional subwoofer can. Bass extension, without compromising musicality.

WB: 9 The IGx electronic control boards and class D amplification being tested during construction

Controls

The IGx control boards that control the amplifier have been developed in partnership with CASS Audio who did much of the development work with the GMT System One Turntable control systems as part of the GMT Consortium.

The IGx controls allow adjustment of phase 9-180-degree adjustment, filter setting 30-90Hz and Gain -30dB to +60dB.

The filter has been completely revised and was designed from scratch to enable the high level of precision. It is built to exacting quality levels using the finest components throughout. The result provides the owner with a very simple system to achieve the bandwidth required of the system which is significantly different improved of the original Torus design.

Inputs & Outputs

Low level RCA and XLR inputs are provided. Along with a High level Neutrik connection input are provided.

The IGx Enclosure: Geometry, Volume & Damping in IGx

Air volume doubled. Despite having almost exactly the same foot print due to the small increase in height allied with the state of the art metal enclosure IGX benefits from double the air volume over its predecessor. The available air allows greater freedom of movement of the dynamic parts enabling lightning fast transient response from the significantly more powerful state of the art class D power amplifier.

IGx air volume has been doubled by comparison to the Torus, this is despite having almost exactly the same foot print. Wilson Benesch has increased the height of the IGx slightly, but the new State-of-the-Art metal enclosure that replaces the MDF enclosure affords the IGx a much larger air volume. The available air allows greater freedom of movement of the dynamic parts enabling lightning fast transient response from the significantly more powerful Class D power amplifier.

It is widely recognised that highly optimised structures exhibit geometrically optimal elements. In pursuit of performance nature has already rejected less than optimal designs and by looking at forms found in nature one can learn many lessons in design. The Wilson Benesch font was designed on pure geometrical forms and it's the ethos that has underpinned every design for three decades.

The shell shown in figure 6 is one of the finest examples of such a structure. The mollusc shell provides protection to the soft flesh of the mollusc residing inside, therefore this structure needs to be strong. The shell has evolved into a curved shape since this geometric form is one of the strongest forms, distributing weight and pressure evenly to the entire structure. The IGx enclosure and indeed the toroidal form of the diaphragm can be seen to use a curved form to add to stiffness across the structure, it is the optimal form and therefore function for a low frequency generator.

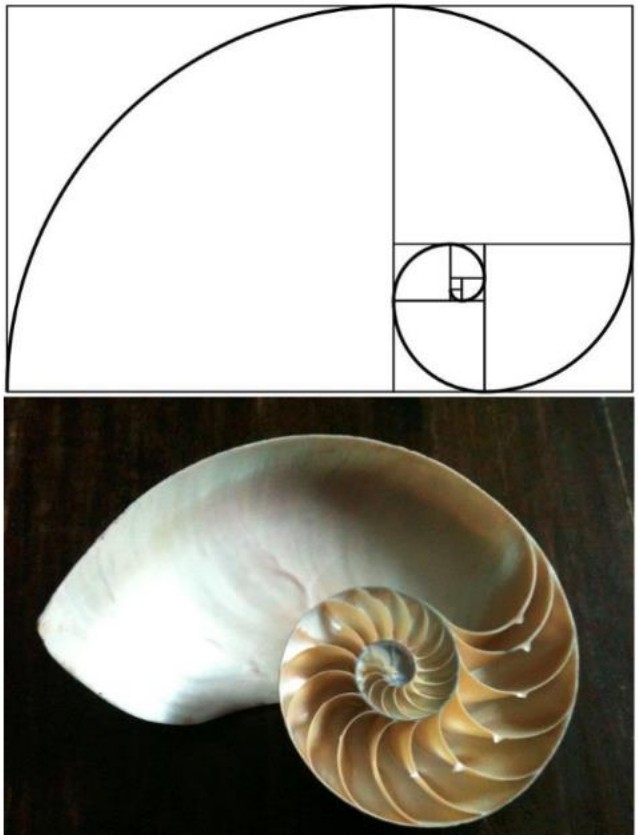
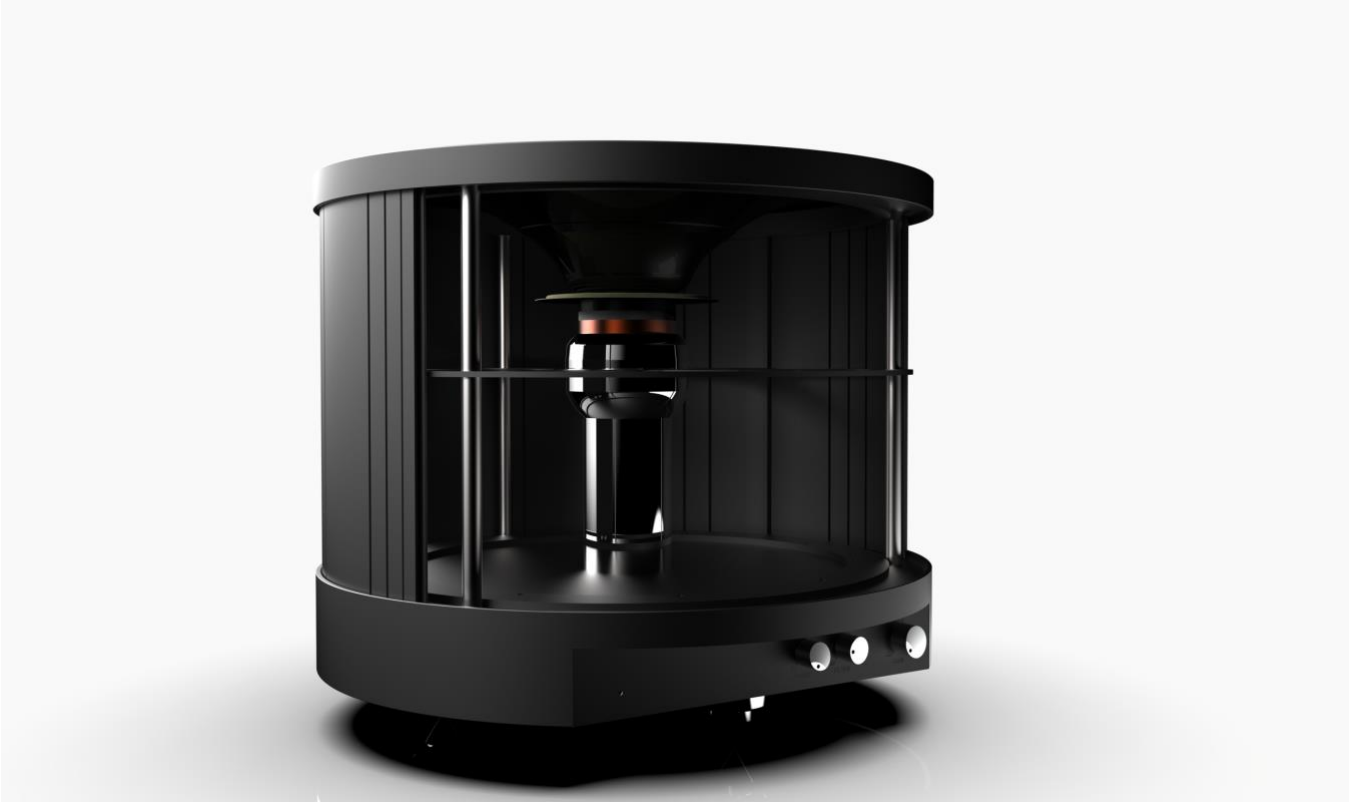


Figure 1: The Fibonacci Spiral generated by mathematics and shell of a Mollusc showing this Golden Ratio in Nature

I addition to exploiting the advantages of a curved form in its enclosure, the IGx also uses a 13mm steel ties across its vertical axis and a large 8mm precision laser cut steel cross brace in the horizontal axis. Wilson Benesch machine a large bottom plate and top ring from aluminium. The bottom plate in particular is a large component that is hewn from a 50kg billet of raw aluminium. This structure adds mass at the lowest point of the IGx and contains the electronics that drive the IGx. To add additional stiffness and damping across the IGx enclosure Wilson Benesch then tie this huge base into the top ring, holding captive and under tonnes pressure the extruded aluminium curved panels that form the IGx enclosure. The use of ties in architecture to provide additional stiffness and damping across a building is common. Wilson Benesch use this principle across its product lines, in the R1 Carbon HIFI Rack, in the Precision Series and in the Fibonacci Series.

WB: 10 The IGx base being machined in the Wilson Benesch CNC Suite at Falcon House



WB:11 The IGx Infrasonic Generator in cross-section showing the base plate and the top ring, plus the three steel ties connecting them in the vertical axis and the 8mm steel cross brace through the middle of the horizontal axis of the IGx

IGx ~ Infrasonic Generator SPECIFICATIONS

DRIVE TECHNOLOGY	18” Carbon Fibre - Polyethylene Terephthalate (PET) Diaphragm Push-Pull Motor Around Steel Core
INTERFACE GAIN	-30dB to +60dB
OUTPUT POWER	100W continuous 500W maximum into 4ohm
FREQUENCY RESPONSE	5Hz to 90Hz Max (-3dB) 5Hz to 30Hz Min (-3dB)
INPUT IMPEDANCE	10k ohms (RCA) 10k ohms per phase (XLR) 180k ohms (Speakon)
DISTORTION (THD) PHASE SHIFT	< 0.03% @1W
PHASE SHIFT	Balanced passive all-pass filter (0deg to 180deg variable)
PHASE SHIFT BYPASS	Panel mounted toggle switch (Direct or Variable phase)
ANALOGUE INPUTS	1 x Left RCA 1 x Left XLR 1 x Right RCA 1 x Right XLR 1 x Left & Right High level Speakon
INPUT SENSITIVITY	100mV (Low level unbalanced RCA) 50mV per phase (Low level balanced XLR) 1 V (High level Speakon)
POWER CONSUMPTION	10W-15W (idle) 650W maximum
INPUT VOLTAGE FUSE RATING	230Vac (50/60Hz) UK // 115Vac (50/60Hz) USA
FUSE RATING	T2A 250V UK // T4A 110V USA
DIMENSIONS	Height 432mm (17.01”) inc. spikes. Diameter 510mm (20”) Weight 54kg (119lbs) // Magnetic Grill 3kg (6.6lbs)