



DÔME[®]

WHITE PAPER
Development file





CONTENTS

1/ GENERAL DESCRIPTION	[Page 4]
2/ EXISTING ART STATE	[Page 5]
3/ GOALS	[Page 5]
4/ TESTS	[Page 6]
4.1 STUDIES, MEASURES AND TESTS ABOUT THE OPTIMIZATION OF BASS FREQUENCIES REPRODUCTION	[Page 6]
4.1.1 With a loading volume of 0.4 liter	[Page 7]
4.1.2 Loading volume of 0.6 liter	[Page 8]
4.1.3 Loading volume of 0.8 liter	[Page 9]
4.1.4 Research to raise power	[Page 11]
4.2 STUDIES, MEASURES AND TESTS ABOUT THE OPTIMIZATION OF HIGH FREQUENCIES REPRODUCTION	[Page 13]
4.2.1 Test of a full range transducer for the whole system bandwidth.	[Page 13]
4.2.2 Test of integration of a coaxial tweeter in a woofer	[Page 13]
4.3 Creation of an optimized chassis that integrates the two transducers in order to have the smallest possible size while it improves the baffle effects	[Page 17]
4.4 To sharpen the setting, we made some tests in different acoustic configurations	[Page 18]
4.5 Comparative tests with other competitive systems	[Page 19]
5/TECHNICAL DIFFICULTIES	[Page 21]
5.1 Concerning the mechanics: transducer integration	[Page 21]
5.2 Concerning the acoustic study	[Page 22]
5.3 Concerning aesthetics and design	[Page 22]
6/ ADVANCES MADE	[Page 23]
7/ SPECIFIC EQUIPMENTS	[Page 23]

1/ GENERAL DESCRIPTION

Product nature

In the Home Theatre field, the electro-acoustic systems have spread according to three successive waves.

The first one started at the beginning of the 1990s. The first 5.1 systems stemmed from the Hi-fi world. Around 2 traditional stereo loudspeakers, a central channel would be added, as well as 2 rear channels and a subwoofer. The whole was very voluminous, required lots of wires and wasn't necessarily homogeneous. Thus, the settings remained very complicated and restricted to technophiles. It was even common to see systems mixing several types of finishes and several brands.

The second wave integrated the notion of pack, brought little by little by the manufacturers. The key points were more compact systems, same finish and homogeneous sound. That was the first phase of integration, the first products were sold at a retail price of about €1.000. This market destroyed itself in 4 to 5 years time, because the products quickly became low-cost products dedicated to mass marketing. You could find 5.1 packs at €29 (Inc. VAT), thus the quality level of sound restitution was completely dropped in favor of the price war.

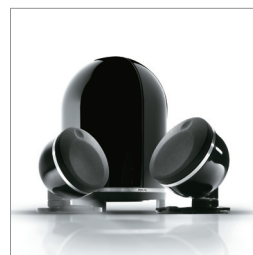
From the ashes of the previous wave, a new type of product was born, driven once again by the electro-acoustic great brands, the high-end compact systems for Home Theatre. These products are generally made of 5 small identical loudspeakers (satellites) and a subwoofer. We can define these systems by the research of a quality sound in the most compact possible volume of 1 to 2 liters internal volume for the satellites. In order to remain competitive, most of these products are made in Asia.

FOCAL developed products during these different successive waves. We still have today, for each Hi-fi line, a Home Theatre complement. But, we have never produced a low-cost or compact system. Our smallest pack is made of satellites which internal volume is of about 3 liters.

In parallel to the Home Theatre market, we are attending a dematerialization of music. A multi-room notion appeared, that's to say, listening to music in several different locations of a house without being concerned about the source that emits. We can now create some listening zones spread in several places in the house, like the kitchen or the bathroom. We can compare this phenomenon to the one of light: from a unique center light that lighted the all room, we now moved on to several spotlights that give a warmer atmosphere. In the acoustic field, we can speak about sound spotlight.

We find many integration products in-ceiling or in-wall. That kind of products is often used when building new houses, but they are harder to integrate in ancient buildings. So there is a market for compact systems that can be integrated. Quality and aesthetics are expected in this promising market, there's not only a price notion contrary to mass marketing demand.

FOCAL's challenge is to be able to offer a system made of micro-loudspeakers with an internal volume inferior to 1 liter but remaining in a quality tonal balance. These loudspeakers could be declined in Home Theatre packs, sold in 2.1 Hi-fi pack or separately.



2 / EXISTING ART STATE

Results of bibliographical research

A lot of famous brands in the Hi-Fi world already have a good position in this high-end market.

We can classify their products in 2 categories:

- The design products: aesthetic research and use of “rich” materials. They are generally of an average acoustic quality and of a small internal volume (from 0.5 to 1 liter).
- More traditional products, with good aesthetic level but a little bit more voluminous (between 1.5 to 2 liters). There are numerous mechanical and electric tricks in order to get the most compact possible product.

3 / GOALS

Problems to solve – Performance to reach

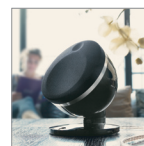
We decided to study a rotating sound spot with an internal volume from 0.5 to 1 liter, which could be fixed on walls, on ceilings or on a table without any visible wire.

We will use a coaxial speaker or a speaker plus a tweeter in 2 separate ways.

FOCAL considers that this small loudspeaker must be a complete loudspeaker, a miniature loudspeaker that can be used with or without an active subwoofer. Thus it must:

- work at high sound level without distortion, with little distortion on a full range electric signal from 20Hz to 20kHz (that's to say without electric crossover that suppresses very low frequencies),
- keep a balanced tonal listening, even at high sound level,
- have a sensitivity superior or equal to 85dB/2.84V/1m (sensitivity close to that of the competitors),
- not have a minimum impedance inferior to 3 Ohms,
- have a bandwidth superior or equal to 120Hz -20kHz (+/-3dB)
(in order to make the bandwidth compatible with the Home Theatre amplifier norm that uses a cut-off frequency at 120Hz),
- be compatible with the power of modern Home Theatre amplifiers that can deliver power up to 130 Watts. Thus it must be mechanically and electrically reliable and mustn't have its acoustic performance damaged. (high power handling)
- be compatible with the designer expectations concerning shape and size (outside size: $\emptyset 4^{15/16}$ " (125mm) and internal volume 0.6 liter), mechanical function, materials, dimensions.

On paper, these goals are hardly reachable because the volume reduction of the loudspeaker shows lots of drawbacks.



4 / TESTS

Studies, measures and tests about the optimization of the bass frequencies reproduction:

4.1 Studies, measures and tests about the optimization of the bass frequencies reproduction:

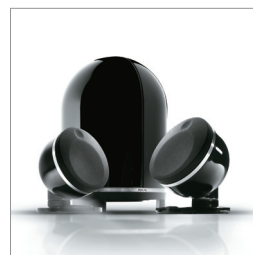
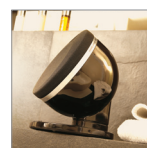
Search for the minimum volume in order to have a bandwidth in the bass compatible with the sensitivity level superior to 85dB/1m.

In order to find a better compromise between all the results, we made a succession of prototypes in order to estimate the performance compared to our goals.

- For each test, we had to make:
- Acoustic and magnetic simulations (parameter adaptation),
- creation of 2 prototype drivers for stereo listening,
- creation of 2 prototype loudspeakers (in accordance to the expected dimensions and volumes),
- measures and creation of a 2-way crossover with a tweeter,
- comparison listening on a full range signal and with a filtered signal at 120Hz with subwoofer.

Below is the list of the main tests we made. Other intermediary tests have been made to optimize the compromises:

- by adding mass to the moving assembly,
- a different filtering,
- spider,
- surround,
- double voice coil driver,
- listening with different electronics,
- listening in different rooms (small damped room, big rooms semi-reverberating, reverberating, etc...

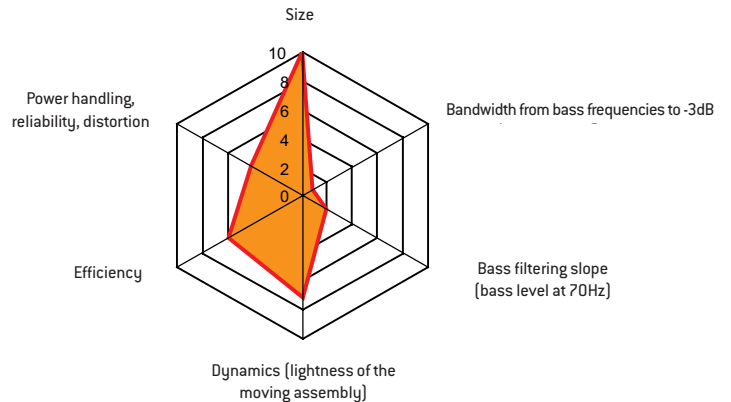


4.1.1 With a loading volume of 0.4 liter

4.1.1.1 Test with a standard FOCAL driver of 3^{1/8}" (80mm) with a moving ground of 3.5g in closed box

Results:

- Efficiency: 84dB
- Frequency at -3dB: 198Hz
- Level at 70Hz: -21dB
- Power handling: 20 Watts

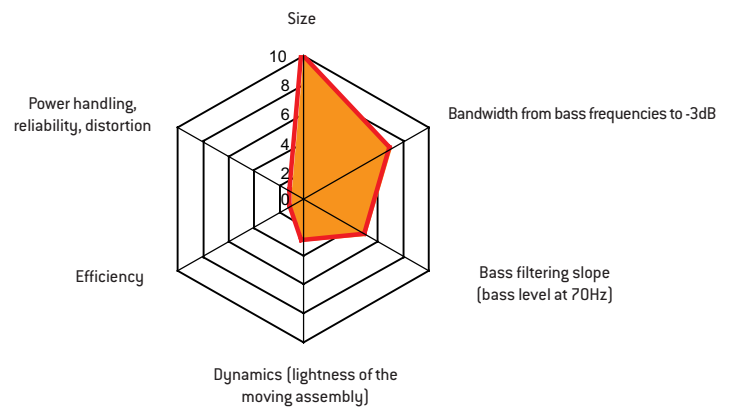


Conclusion: Listening in full range permitted to show a very important weakness to reproduce bass frequencies. Listening with a subwoofer needs a cut-off frequency close to 180Hz that is not possible with the norm of Home Theatre amplifiers that generally cuts bass frequencies at 120Hz.

4.1.1.2 Test with a 3^{1/8}" (80mm) driver with a moving ground of 8.8g in closed box

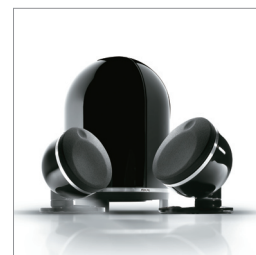
Results :

- Efficiency: 78dB
- Frequency at -3dB: 128Hz
- Level at 70Hz: -15dB
- Power handling: 10 Watts



Conclusion: bass frequencies are present but the cone moves a lot and quickly saturates and it's not possible to reach high sound levels. Low power handling necessarily imposes a high-pass filter to suppress low frequencies.

We didn't find a good compromise in these configurations of 0.4 liter load, compatible with our requirements. And we wanted to slightly increase the loudspeaker size in order to use other load types and other drivers.

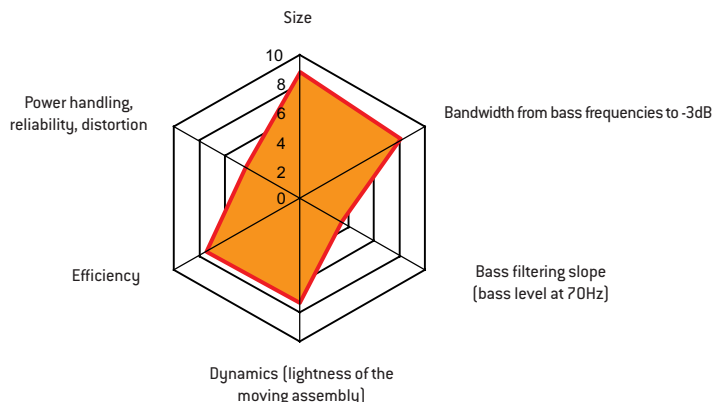


4.1.2 Load volume of 0.6 liter

4.1.2.1 Test with a 3^{1/8"} (80mm) driver with a moving ground of 4g in vented box

Results :

- Efficiency: 85dB
- Frequency at -3dB : 122Hz
- Level at 70Hz : -18dB
- Power handling: 10 Watts

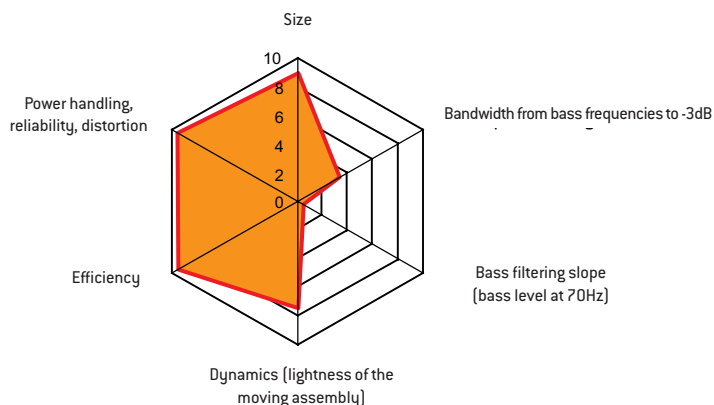


Conclusion: Using a vented box permitted to have extension in the bass frequencies at –3dB while maintaining good efficiency. Below 120Hz, the bass level decreases very quickly. This imposes the use of a subwoofer because bass frequencies under 100Hz are almost absent. A high-pass filter is necessary to have good power handling because below its tuning frequency, the driver works in acoustic short-circuit. It doesn't fit our requirements as we expect it to work also without subwoofer and without a high-pass filter.

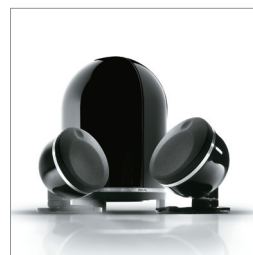
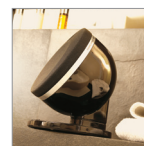
4.1.2.2 Test with a standard Focal 3^{15/16"} (100mm) driver with a moving ground of 6g in vented box

Results :

- Efficiency: 88dB
- Frequency at -3dB : 163Hz
- Level at 70Hz : -24dB
- Power handling: 80 Watts



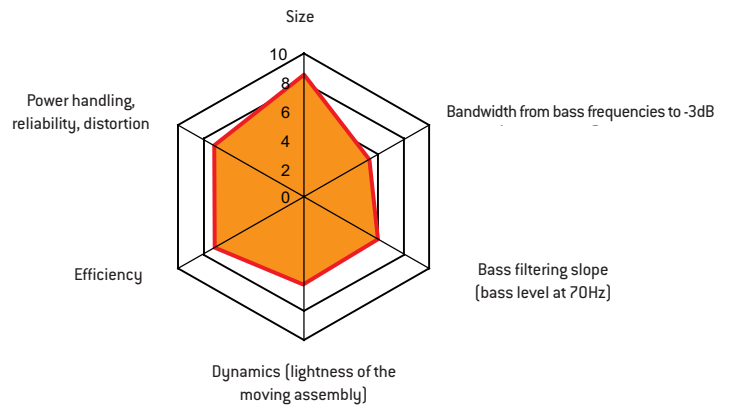
Conclusion: the use of a driver of bigger dimensions increases power handling because the cone movement is weaker. Our standard drivers with that size of cone offer much efficiency, but don't permit to produce bass frequencies.



4.1.2.3 Test with 3^{15/16"} (100mm) drivers with a moving ground of 8.8g in closed box

Results :

- Efficiency: 85dB
- Frequency at -3dB : 137Hz
- Level at 70Hz: -13.5dB
- Power handling: 80Watts



Conclusion: the set of results is quite homogeneous, the closed box permits to reduce the bass filtering slope to hear more bass frequencies when the loudspeaker is in a small room or next to a wall. Nevertheless, we want to have a little bit more bass to offer much comfort. Noise of surround at high level.

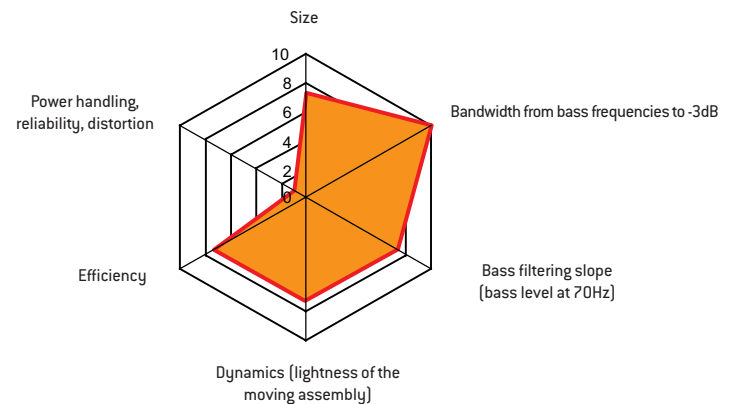
So we wanted to raise a little bit more the sound level.

4.1.3 Loading volume of 0.8 liter

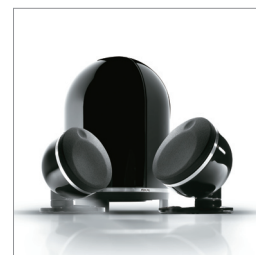
4.1.3.1 Test with a 3^{1/8"} (80mm) driver with a moving ground of 4g in vented box

Results :

- Efficiency: 85dB
- Frequency at -3dB: 102Hz
- Level at 70Hz: -13dB
- Power handling: 10Watts



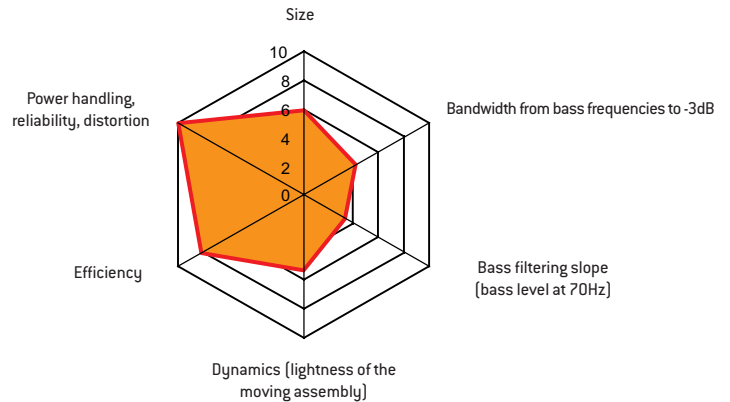
Conclusion: offers the lowest cut-off frequency but doesn't offer power handling any more.



4.1.3.2 Test with 5^{1/8"} (130mm) drivers with a moving ground of 14g in closed box

Results :

- Efficiency: 86dB
- Frequency at -3dB: 143Hz
- Level at 70Hz: -17dB
- Power handling: 150Watts

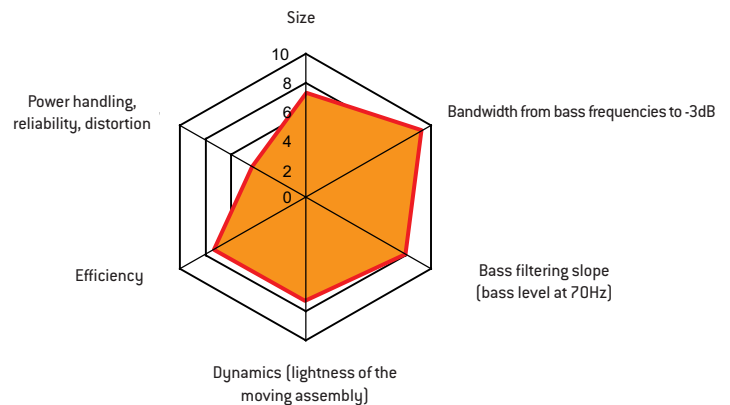


Conclusion: the bigger size of the driver permits to have very high power handling and important dynamics but there's not enough volume to make drivers of 5^{1/8"} (130mm) work.

4.1.3.3 Test with a 3^{15/16"} (100mm) driver with a moving ground of 8.8g in vented box

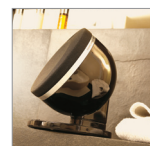
Results:

- Efficiency: 85dB
- Frequency at -3dB : 117Hz
- Level at 70Hz : -12dB
- Power handling: 50Watts (noise of ports)



Conclusion: this configuration offers good performance on the whole set of requirements, with particularly more bass. We noticed that the bass level decreases when the sound level rises. We think it's because of the port saturation (loss in the air/port friction+ turbulences). When we added the grille, it generated much noise. This problem is not easy to solve because the loudspeaker dimensions are too small. (no possibility of rising the port diameter, adding any radius, or changing the design...).

Still at high sound level, we noticed the presence of an offset, the problem is reduced when using a more rigid spider: the speaker resounds higher (78Hz -> 115Hz). We had power handling tests during 6 hours and we noticed that the spider quickly deteriorates because the resonance frequency of the spider went from 115Hz to 86Hz. There's still an offset problem.



For mechanical reliability reasons, as well as performance conservation, we do not wish to use a vented box.

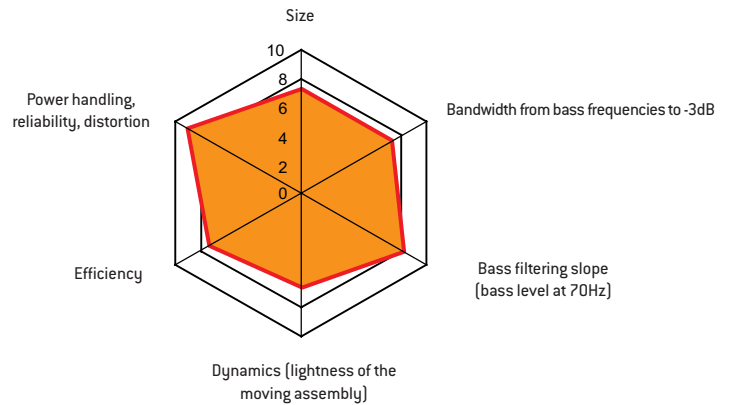


4.1.4 Research to raise power

4.1.4.1 Test with a 3^{15/16}" (100mm) driver with a moving ground of 8.8g in closed box

Results :

- Efficiency: 85dB
- Frequency at -3dB: 130Hz
- Level at 70Hz: -11.5dB
- Power handling: 130Watts



- The sound level rise suppressed all the surround noises that appeared at high level. This was due to a too important air pressure inside the loudspeaker because of the lack of volume.

- The closed box permitted to suppress the offset problems at high level and to prevent the speaker from being carried away. The driver voice coil remains perfectly centered in the air gap whatever the signal level and nature.

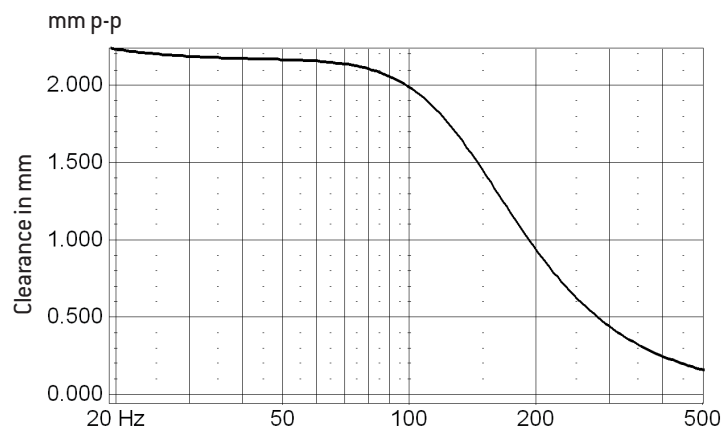
Thanks to the good power handling of the loudspeaker, we wanted to try using a more flexible spider to gain more bass frequencies. We took a spider so that the VAS (Equivalent Acoustic Volume) of the driver is highly superior to the loading volume:

- The driver VAS goes from 0.9 to 1.5 liter.

Now, only the volume of the driver (0.8 liter) constitutes the return force of the driver moving assembly: acoustic surround.

We noticed that we could raise the bass level without damaging the power handling (no Offset, no moving assembly carried away).

The measures with KLIPPEL permitted to show that the level of clearance of the moving assembly remains the same for the frequencies under 100Hz, so the loudspeaker has high power handling. At very high level, the clearance is limited to the driver Xmas (length of the voice coil).



Under 100Hz, the moving assembly clearance doesn't raise when the frequency diminishes. This confers to Focal-Dôme outstanding power handling and it can then be used in "full range" mode, non-filtered in high pass.

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A longer voice coil of 0.15" (4mm) has been tried. It permitted to go further in terms of sound level and distortion but we couldn't keep it because on some very dynamic music tracks, it could touch the magnet bottom, which produces a very unpleasant noise. (Close to a hammer)
We decided to keep the voice coil previously used.

Some more or less magnetic motors have been tested in order to find the best balance between efficiency, bass and power handling.

The most powerful magnet was kept because it provided numerous advantages like permitting, among other things, to compensate the non-linearity of the driver at high-level (drop of BL):

- better tonal balance at high sound level (with slight increase of bass level, because the Qts increases),
- less distortion at high level,
- deeper bass frequencies,
- more linear and progressive bass response (no overload) which is favorable when the loudspeaker is close to a wall.

The only drawback is the high bass frequency between 150Hz and 250Hz is a little over-damped, which is less favorable when the loudspeaker is placed away from a wall and/or if the listening level is low.

Reliability tests were made. The loudspeaker was continuously supplied 24h/24 with a non-filtered music signal. The level was set to the maximum of the driver excursion capacities.
After 330 hours of test, we noticed no change in the speaker parameters and the acoustic result.

Results :

- Efficiency: 85dB
- Frequency at -3dB: 130Hz - 9kHz
- Level at 70Hz: -11.5dB
- Power handling: 130Watts

Globally, this bass/midrange transducer offers a good compromise on all requirements, in spite of less high bass frequencies. In compensation, the bass frequencies at 70Hz increased so the loudspeaker seems more linear. This transducer doesn't permit on its own to reproduce high frequencies (20kHz).



4.2 Study, measures and tests about the optimization of high-frequencies reproduction

4.2.1 Test of a full range transducer for the whole system bandwidth

We made some tests with a full-range speaker up to 20kHz:

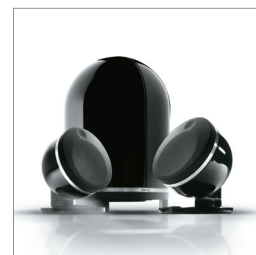
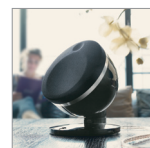
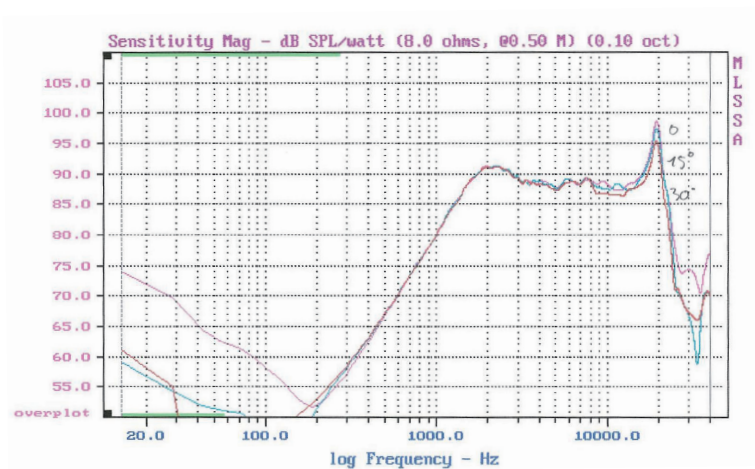
- +/-3dB response curve in the loudspeaker with corrective filter (+/-7dB without corrective filter),
- cutting in the bass frequencies -3dB 160Hz,
- very strong directivity in the treble (very modified tonal balance outside the axis),
- distortion (soft hiss),
- a cone too light to produce bass frequencies.

Conclusion: the obtained results are very average. It seems very difficult to have an outstanding transducer at the same time in the bass (heavy) and in the treble (light). We prefer dropping this solution in favor of the use of a second transducer specialized in the treble.

4.2.2 Test of integration of a coaxial tweeter in a woofer

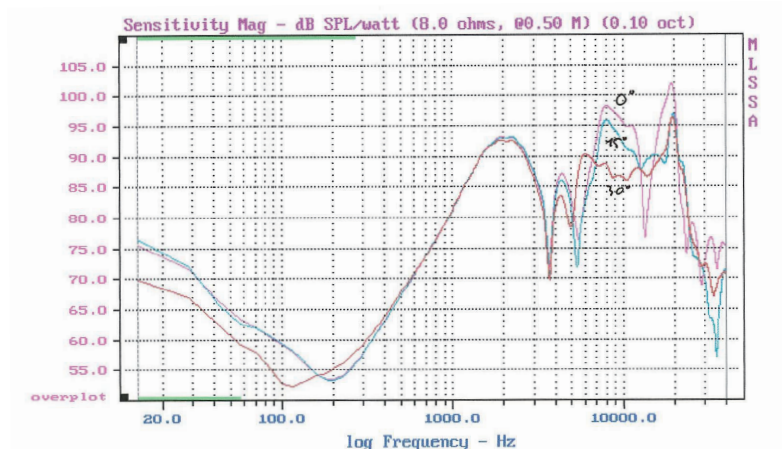
We don't have much space to integrate this treble transducer in this small loudspeaker because the expected dimensions are slightly bigger than the woofer. We wish to have some tests of integration of a concentric treble transducer in the woofer.

For these tests, we used a tweeter that has a linear response curve (on baffle plan). The directivity between 0°, 15° and 30° is almost absent and doesn't show any fault.



4.2.2.1 Test with a concentric tweeter placed on a slim stand

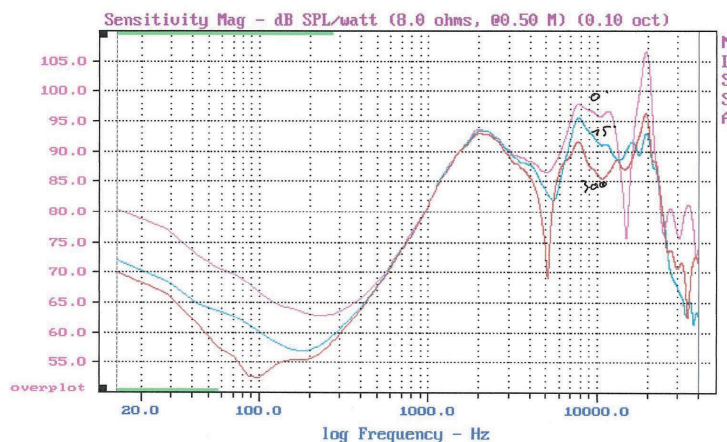
- the response curve is very highly damaged since it gets into +/-13dB.
- the measures out of the axis show very important changes in the response curve of 15dB.



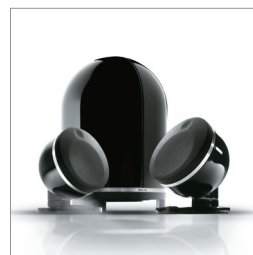
Those results are very bad. The response curve variations are the signs of important variations in the acoustic phase. It's impossible to have a good connection with the bass transducer.

4.2.2.2 Test with a concentric tweeter placed on a large stand

- The response curve has improved but remains highly damaged since it gets into +/-11dB
- The measures outside the axis have improved but show very important changes in the response curve up to 13dB.



These results are again too bad and do not correspond to our requirements. We think that the tweeter baffle is too small because its dimensions are too close to the emitted wave lengths and create some disruptions. We wish to change the tweeter location by loading it by the driver cone.



4.2.2.3 Test with a concentric tweeter placed at the base of the driver cone

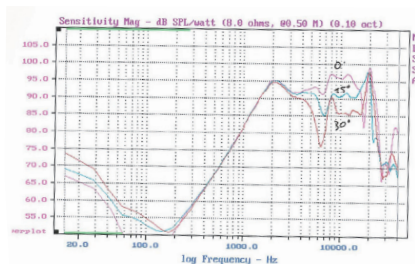
To do this, we had to reduce the outside diameter of the tweeter going from 1^{5/8}"(40.75mm) to 1^{1/4}"(32mm) in order to be placed inside the voice coil of the woofer.

We made a study of feasibility and a prototype to integrate an aluminum/magnesium tweeter in a 32mm diameter while maintaining the performance of the actual tweeter (same magnet, same voice coil, same cone shape but with a smaller diameter cut-out).

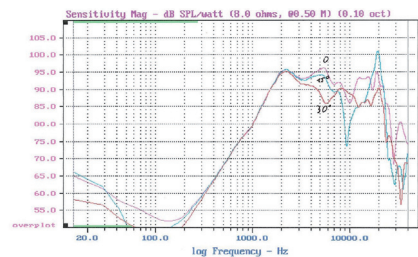
Afterwards, we made some measures with different tweeter positions.

Tweeter placed at the base of the cone, 0.2" (5mm) forward then 0.2" (5mm) backward

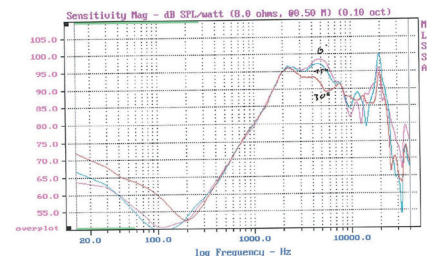
- The response curves are very different and globally they get into +/-5dB
- The response measures outside the axis are also very different from one another. For the 3 positions, the most important loss is of -15dB at 30°



Concentric tweeter 5mm forward



Concentric tweeter placed at the base of the cone



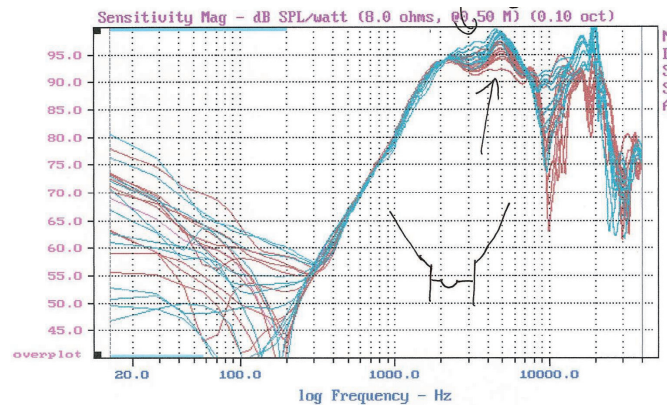
Concentric tweeter 5mm backward

The best results are obtained when the tweeter is not fixed on a support. However, we are very skeptical about the influence on the tweeter response when the woofer cone is reaching important clearance.

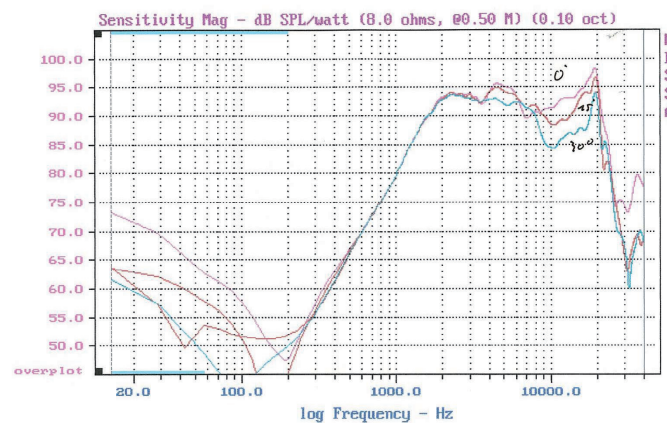


We wanted to measure this influence on +/-0.5" (12mm):

- We measured variations in the tweeter curve on +/- 17dB.
- We added a small conic horn used by a competitor and we obtained variations in the tweeter curve of +/-13 dB, which is slightly better than the previous version.



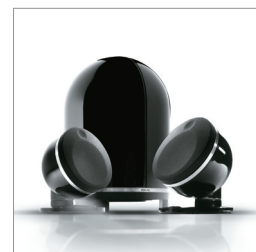
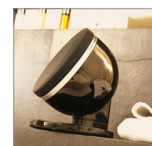
- We increased the size of the horn until getting the variations of the tweeter curve of +/-3dB but the horn dimensions become much too important to be integrated in the speaker and without changing the response curve of the woofer.



Globally, we are very far from the tweeter original linearity (that's to say +/-1dB) on IEC standard baffle. The results are not acceptable because we want to have variations inferior or equal to +/-3dB.

We dropped the use of a coaxial tweeter that is not adapted to a Hi-Fi use.

We had to modify the loudspeaker design to place the tweeter next to the woofer so that it's not subject to load variations and to baffle effects linked to the woofer.



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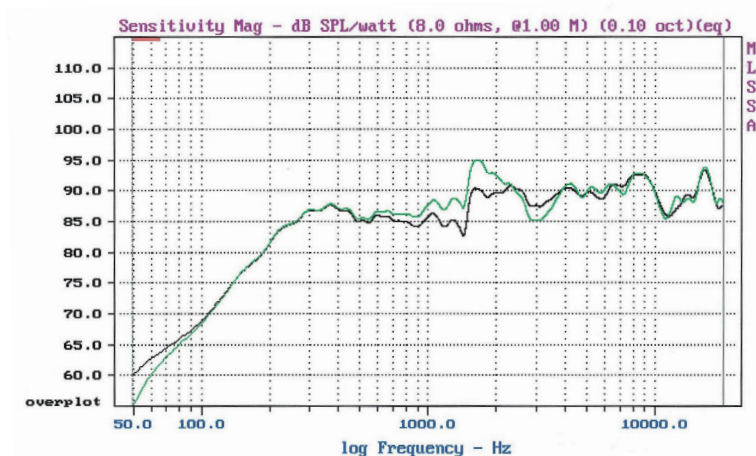
4.3 Creation of an optimized chassis that integrates the two transducers in order to have the smallest possible size while it improves the baffle effects

- Use of a common chassis,
- Transducer overlapping,
- Woofer and treble decentering to reduce the baffle effect.

-> The external diameter goes from 4^{15/16"} [125mm] to 5^{11/16"} [145mm]; in compensation, we reduced the loudspeaker depth in order to keep the useful volume for this system (0.8 liter).

Measures of the response curve with this new configuration:

- The tweeter shows very few accidents and owns small variations of +/- 1.5dB.
- The woofer/midrange transducer was improved. The wave that was situated between 1.5 and 3kHz now goes from +/-5dB to +/-2dB.

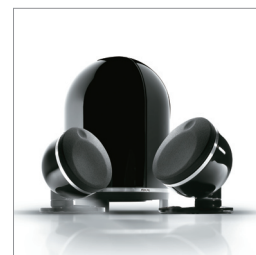


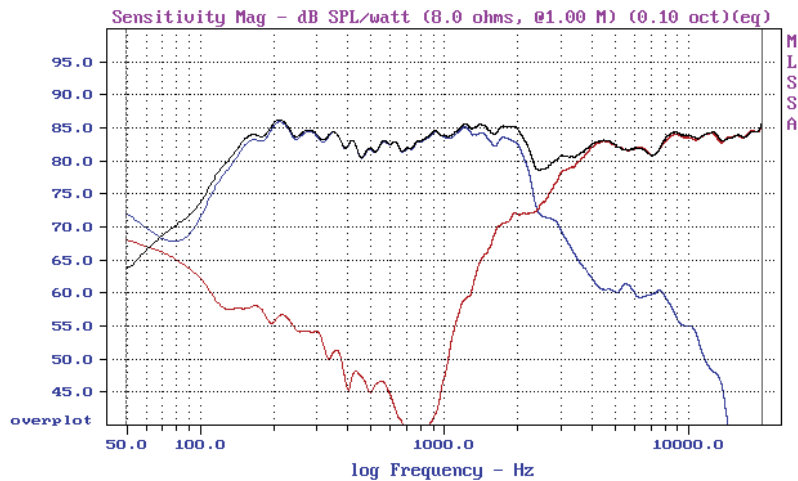
- Green curve, driver centered on the cylinder
- Black curve, driver moved off-center

Result verification

By adding a crossover, we can see there's no phase problem between the different transducers, few waves in the speaker response curve and this, in spite of:

- the loudspeaker cylinder shape (important baffle effect),
- the loudspeaker small size (dimension close to 2kHz wave length),
- the use of non-directive speaker (small diameter of the drivers).





Conclusion: the new combined baffle of the woofer/midrange transducer plus the separate tweeter offer a very interesting result on the loudspeaker linearity, because it gets into +/-2.5dB from 130Hz to +25kHz.

4.4 To sharpen the setting, we made some tests in different acoustic configurations

Page
18

The lifestyle domain is a little bit different from the hi-fi domain because of:

- the listening place (often the room is clear),
- the loudspeaker location (on a shelf or fixed on a wall),
- the associated electronics (small hi-fi or home theatre amplifier).

4.4.1 Small listening room of 39m²: (treated ceiling, carpet, absorbent material curtain)

- with the loudspeaker fixed to a wall in high position -> there's much level in the high bass frequencies 150-200Hz. The tonal balance is correct and the sound image is slightly rough, this is due to wall reflections (important percentage of reflected sound).

- with the loudspeaker on a shelf-> there's much level in the bass and high bass frequencies. The midrange seems to be standing back. It gives a warm sound.

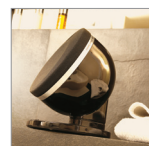
- with a loudspeaker put on a stand in the middle of a room -> there's not enough level in the bass and high bass frequencies. It gives quite a cold sound, the sound image is detailed.

4.4.2 Big listening room of 80m² :

The results are almost identical to the small listening room with globally a little less of high bass and bass frequencies.

4.4.3 In clear rooms :

The treble level is increased (due to wall sound reflections)



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Conclusion: after these tests, we optimized the crossover by deliberately increasing the sound level in the midrange to improve the tonal balance when the loudspeaker is on a shelf or fixed on a wall as in 90% of installations.

We also added some absorbent in the loudspeaker that offers a more linear response, reducing the low midrange of 0.5dB at 200Hz and increasing the level at 100Hz of +0.5dB.

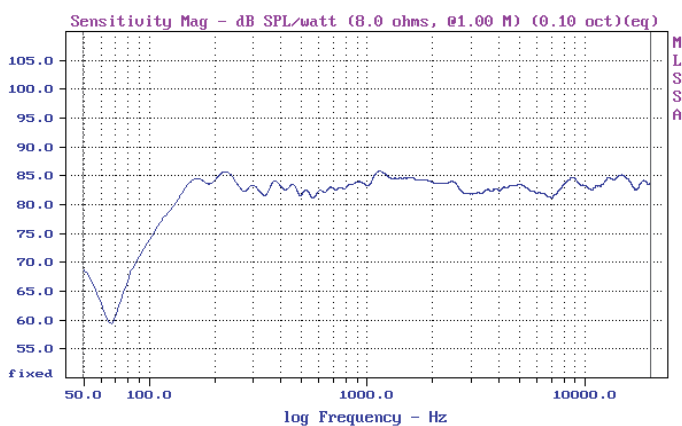
The grille supplement reduces the treble level of 1.5dB. We didn't want to compensate the level loss because the tests in the clear room naturally increase the treble level. Besides, some Home Theatre amplifiers of average quality gave the sensation to have much treble (harmonic supplement and lack of level in the bass frequencies).

The last response curve gets into +/-1.5dB on the whole bandwidth (with grille).

The distortion measures at 1 Watt show that they are inferior to 1% :

- 1 % at 100Hz
- 0,35 % at 1kHz
- 0,3 % at 5kHz

- Efficiency: 85dB
- Frequency at -3dB: 125Hz to 25kHz
- Level at 70Hz: -11dB
- Power handling: 130 Watts in full range



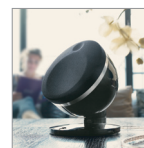
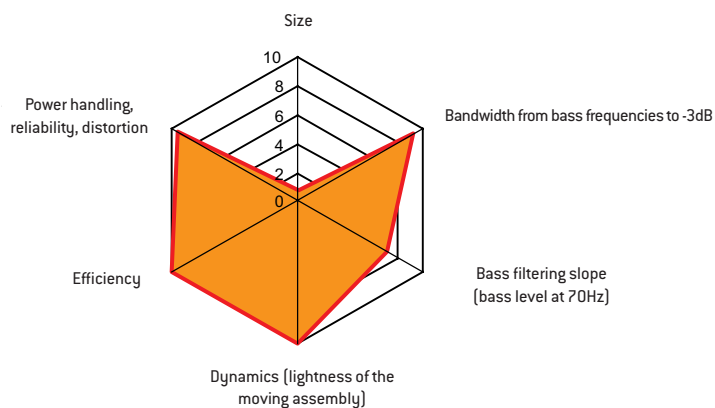
Final response curve of Focal Dôme with grille.

4.5 Comparative tests with other competitive systems

• Competitor A (1.9 liter)

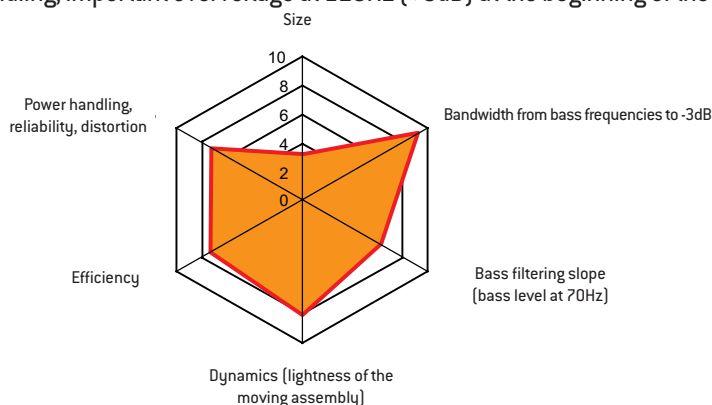
It has more than the double load volume.

The response is slightly linear above all in wall position +6dB at 100Hz



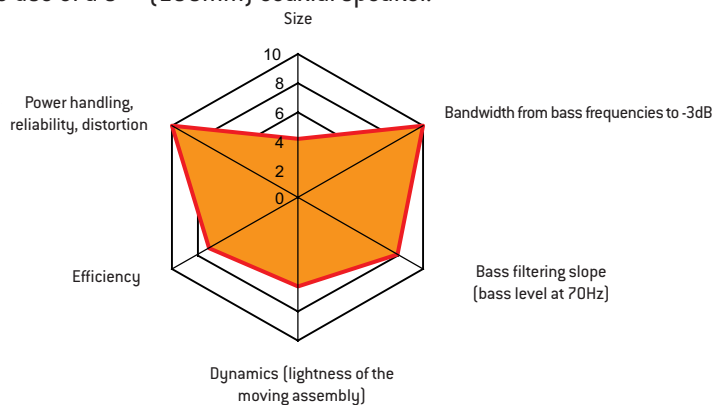
• Competitor B (1.4 liter)

It lacks power handling, important overvoltage at 120Hz (+6dB) at the beginning of the range, load volume 1.4 liter.



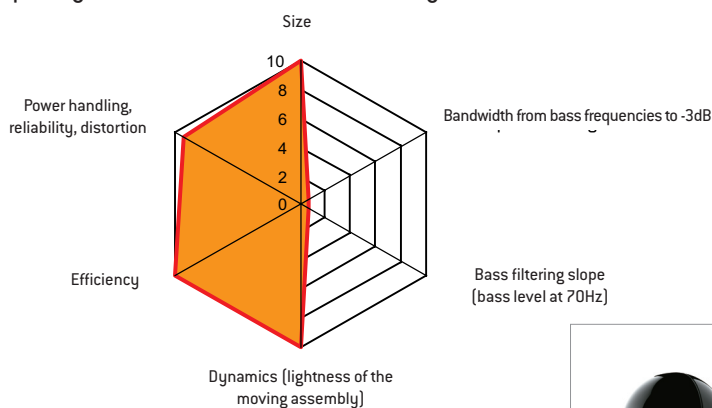
• Competitor C (1.2 liter)

It offers a good compromise on all points but owns a slightly more important volume, besides the treble quality is damaged by the use of a 5^{1/8"} (130mm) coaxial speaker.



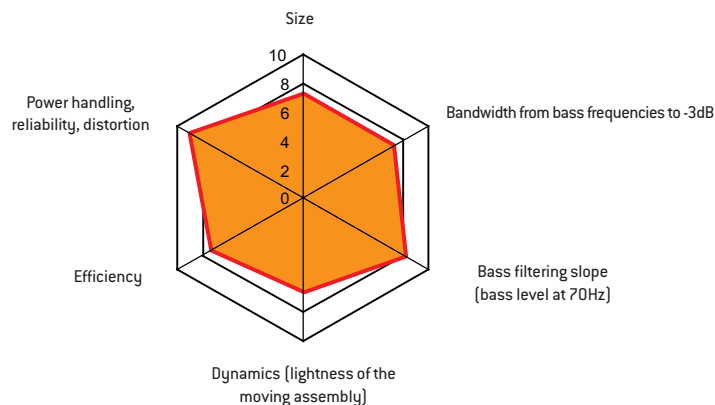
• Competitor D (0.5 liter)

It has a very small load volume but has a too high cut-off frequency (250Hz). The use of a Home Theatre amplifier offers a cut-off frequency in the bass at 250Hz if necessary.



- **New FOCAL compact system (0.8 liter)**

To conclude, this new compact system offers a good compromise on all points (size, level, efficiency, power handling, system linearity, reliability...) and permits to reach a high quality level.



5 / TECHNICAL DIFFICULTIES

Methods and means implemented to solve them

The small size of the loudspeaker constitutes the main difficulty:

5.1 Concerning the mechanics: transducer integration

For the solutions that integrate a vented load, it was impossible to have an inferior port tuning at 90Hz with this volume and the loudspeaker dimensions that doesn't create a noise of air circulation. Indeed, with a port length of $2\frac{3}{8}$ " (6cm) and a surface of 0.6" (1.7cm), the speed of the air contained in the port reaches 20m/s for 1 Watt. In order not to have any turbulence problem, we should have had a length of $19\frac{11}{16}$ " (50cm) and a surface of $1\frac{9}{16}$ " (4cm); we would have had an air speed of only 2.5m/s.

The lack of space makes the integration of the aerodynamic ports difficult.

The woofer transducer compensates the small emitting surface by some important clearance. -> very high mechanical solicitation that creates problems of transducer reliability that had to be solved by the use of an acoustic surround (closed box) a very high quality woven speaker, optimized simulation for high-level listening, ...



The loudspeaker efficiency is not very high in comparison with a big hi-fi loudspeaker. To get the same sound level, we have to increase the amplifier level. That's to say much electrical power to be absorbed by the speaker voice coil. To absorb that extra power, we took a voice coil used on a bigger speaker (7"/180mm) that we improved by using a varnish more resistant to very high temperature and a double voice-coil in parallel. The double voice coil offers, among other things, a bigger varnish surface for the same wire gauge. To clear up this heat, we had to use a magnet with a narrow air gap.

5.2 Concerning the acoustic study:

The baffle effects (the loudspeaker edges are very close to the transducers and modify the transducer response curve). We had to modify the transducer layout and make small compensations on the filtering.

The lack of sound level limits the bass level. We had to use a heavier moving assembly, more powerful magnets.

The small size of the loudspeaker makes it not very directive and the results can vary much according to the different acoustics of the room, the positioning and that's the same for the acoustic measures.

The Home Theatre amplifiers are very different from one another (the satellite outputs can be non-filtered, filtered with a fixed frequency, filtered with adaptable frequency). That's the same for the subwoofer output. The summation of both can sometimes vary of more or less several dB.

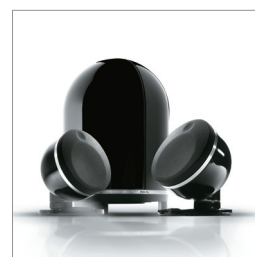
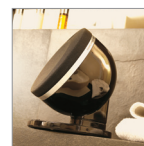
That kind of loudspeaker is difficult to develop and has an important part of subjectivity. We had to make a lot of tests and work out the average of the results to find the best compromise on all the measures.

5.3 Concerning aesthetics and design:

This loudspeaker finish is high-end with a glossy black aspect (piano lacquer type). Our supplier had to develop a process that guarantees a perfect finish. A production line was especially created for that type of parts (cleaning of the parts in several baths + "ecoating" treatment + glossy varnish + control of the parts).

The joint system of the loudspeaker uses a virtual pivot and required many adjustments:

- In the design (elastic connection, isostatic connection, ...)
- In the creation (tight adjustment of the parts taking into account the remains of the removal from the mould, burrs). The supplement of a specific grease was necessary.



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6 / ADVANCES MADE

Original features of the chosen solution in terms of performance

The Focal-Dôme loudspeaker offers with a 0.8 liter volume the same performance as a 1.4 liter loudspeaker:

- the bass frequency is more linear (no overvoltage and level at 70Hz : -11dB),
- extended bandwidth: 125Hz to 25kHz, at 31dB
- identical efficiency: 88dB,
- same (even superior) power handling (130 Watt in full range),
- The last response curve gets into +/-1.5dB on all bandwidth (with grilles),
- The distortion measures at 1 Watt show that they are inferior to 1%:

- 1 % at 100Hz
- 0.35 % at 1kHz
- 0.3 % at 5kHz

This loudspeaker is not very directive. It makes it much sensitive to local treatment and to the loudspeaker positioning. This loudspeaker was optimized for a positioning next to a wall or on a bookshelf.

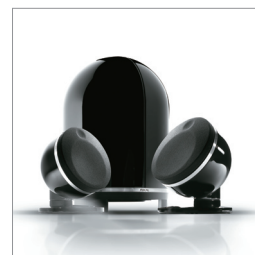
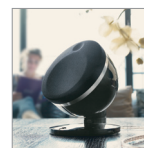
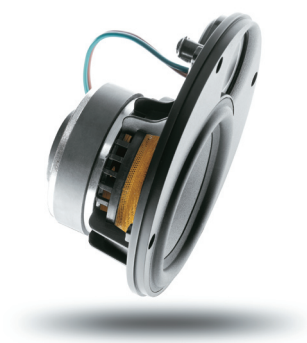
Compared to our competitors, this product offers very high-performance on all the measures with an inferior load volume. In terms of miniaturization, advance is critical. Besides, in terms of design and integration, the requirements are fully met.

Page
23

7 / SPECIFIC EQUIPMENTS

Simulation, measure and control software for this study

- Klippel
- Mlssa
- Lspcad
- Gemini
- Daas



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