



The BBC LS3/5a – Revisiting a Classic

MARTIN COLLOMS LOOKS AT THE BACKGROUND TO THE BBC LS3/5A, RE-ASSESSES ITS RELEVANCE TO TODAY'S HI-FI SCENE, AND ALSO CHECKS OUT ITS STIRLING BROADCAST V2 SUCCESSOR

MARTIN COLLOMS

History

The story of the *LS3/5a* begins in what many regard as the golden years of the BBC, in the days when it ran a substantial Engineering Department. The loudspeaker division flourished under the stewardship of such legendary engineers as D.E.L. Shorter, and subsequently Dudley Harwood, to develop broadcast quality monitoring speakers that were good enough to assess programme quality. Existing commercial models, which had largely been designed through trial and error, had proved too inconsistent, and also suffered from excessive coloration.

In the late 1950s and the 1960s, research was undertaken to track down the various problems, and several speaker designs were created, from the large *LS5/1A* two-way, based on a big 15-inch paper cone bass/mid with two paralleled 38mm Celestion *HF1300* hard dome tweeters (in this case from GEC and labelled *BCS1852*) strapped across its face, to the smallest of them all, the miniature *LS3/5a* with its 5inch (110mm) bass/mid and 19mm dome tweeter, both KEF-sourced. Engineers who played a major role in the *3/5* and *3/5a* development included Derek Mathers, Maurice Whatton and Spencer Hughes. (Spencer later went on to found Spendor. His famous 2 cubic foot *BC1* model was privately developed while he was still at the BBC, to which his contract conferred intellectual property rights, which is why the speaker also subsequently appeared as the Rogers built *LS3/6*.)

Writing under the pseudonym F.M. Hughes, I first assessed the miniature BBC *LS3/5a* for *Hi Fi For Pleasure* in 1976, in a 30-speaker group test. That particular sample was made by KJ, later branded Audiomaster, under the direction of Robin Marshall, an ex-BBC engineer who subsequently founded Epos, though a number of other manufacturers also took out licences to make the *3/5a*. For this ambitious assessment, live versus recorded judgments complemented stereo listening and laboratory testing (see contemporary photo by HFP editor Trevor Preece). I subsequently tried versions from KEF, Chartwell, Rogers, and Spendor, and an idiomatic but very successful non-BBC cylindrical rival from

Jim Rogers called the *JR149*. I still have that original Audiomaster *LS3/5a*, frequently used as a long term reference 30 years on, plus a middle period version from Rogers, and thought a 21st century reassessment might be interesting.

Rumour has it that once this unlikely candidate (originally knocked together for a scale model studio experiment) officially entered the BBC development programme, it proved really hard to finalise, partly due to variations in driver response. Furthermore, design precepts which had proved effective with larger speakers turned out not to apply to such a small model. The *3/5a* had to be largely voiced by ear, with extended reference to live sound, since its small dimensions and consequently wide directivity gave unexpected results when compared with the usual expectations based on the axial frequency response.

This is why the frequency response is not flat; the speaker was critically voiced octave-by-octave, so that the whole radiated sound, driver and cabinet effects included, sounded most lifelike. Some years later Laurie Fincham, then Engineering Director at KEF Electronics and an exacting perfectionist, was determined to better the *3/5a*, probably piqued by the BBC's success using KEF drivers. He created a high tech miniature called the *Reference 101* with an almost perfectly flat frequency response. While its technical neutrality was unquestionable, it neither sounded as lifelike, nor did

The test panel for the unsighted live versus recorded test for the *LS3/5a*. The drummer was Barry Fox, the panel was from left to right Stewart Tyler (ProAc), David Weymss (BBC), Derek Scotland (Lentek, Audiolab), Stephen Liebmann (student), Marianne Colloms, Martin Colloms, Julian Vereker (Naim Audio).



“Because these speakers are quite easily damaged by excess power input, do check before buying a secondhand pair. Even better, try and get some sort of guarantee on condition.”

it really better the musical performance of the standard *3/5a*. (Laurie’s efforts should not be dismissed, however, without mentioning that he had previously designed the best selling quality bookcase miniature ever, the Goodmans *Maxim*, not to mention the similarly successful Celestion *Ditton15*.)

The most famous clone must be the Linn *Kan* which borrowed the *3/5a* enclosure and major parts, threw away the crossover and its monitor equalisation, and created one of the fastest and most involving wall mount miniatures ever. Blatantly inaccurate and decidedly coloured, it proved both the strengths and the weaknesses of the BBC design. Linn fans were being kind when they described the BBC model as too polite!

More than 60,000 pairs of the original *LS3/5as* were made, so there should still be plenty around!

Engineering details

The *LS3/5a* is a sealed box with an internal volume of about 5 litres. It does not use reflex loading, due to the additional coloration and distortion this could introduce with a small box. The KEF *SP1003* long throw bass/mid driver has a strong 110mm pressed-steel, Dorma chassis, and an 85mm vacuum-formed Bextrene cone, heavily coated with Plastiflex (a PVA adhesive used in book binding) for damping. The half-roll surround is made of low-loss, long-life butyl rubber. The 25mm voice-coil is wound on a Nomex (nylon based fibre) former which degrades rapidly if overheated (a frequent cause of failure). In-box resonance is around 75Hz, providing a -6dB low frequency point at about 60Hz.

High frequencies are handled by the KEF *T27* tweeter, which has a low profile, layer-damped Mylar dome diaphragm and a low mass 19mm voice-coil. Good examples extend to 40kHz. This unit was adapted by adding a protective perforated brass cover that also trims the upper frequency range.

Both these drivers were manufactured for many years, and used by KEF loudspeakers in large volume production models like the original *Concerto* and *Cresta* introduced in the late 1960s. However, these drivers are now long obsolete, so new *LS3/5as* or replacement drive units are no longer available, and great care must be taken to avoid over-driving existing examples – 1960s voice-coils don’t have the thermal power handling of today’s equivalents.

High frequency reflections from the flush-fitting wood frame grille are addressed by a set of thick, acoustically absorbent wool-felt strips arranged as a square around the tweeter. Details such as this, plus the care taken in the installation of the bass/mid driver, and the specific

material, build and damping of the enclosure, still sets this speaker apart in terms of low panel resonance and an absence of spurious reflections. The enclosure itself is built from 12mm birch plywood, lined with bitumen pads to control panel resonances, while the use of solid beech as corner fillets is also a critical element in the overall sound.

With low coloration a specific engineering target, the final requirement was an electrical network that would shape and balance the system sound energy, provide an accurate blend for the two drivers, and a very natural overall sound quality suitable for programme monitoring. The very complex 13-element crossover includes a treble network inductor that also operates as a level-matching auto-transformer. Components include high quality screened air-gap inductors and film capacitors, and equalisation is applied in both high and low frequency sections. The level-adjusting transformer taps allow the precise matching of mid to treble, and the whole thing is hard-wired, fed from a single terminal pair.

Hardly any component in either enclosure or driver may be substituted without the blend suffering audible disturbance. This is because the *3/5a* sets such a high standard for tonal balance that errors which would pass unnoticed in an ordinary speaker are readily exposed.

Secondhand purchase

Because these speakers are quite easily damaged by excess power input, do check before buying a secondhand pair. Even better, try and get some sort of guarantee on condition. A useful check involves putting the speakers close together on a carpet, face-to-face, about an inch apart. Feed a fairly loud mono signal to both, and invert (reverse) the input wires to one speaker so the pair is connected out of phase. Then carefully adjust their relative position to achieve maximum cancellation at all frequencies. It won’t be perfect, but a good degree of cancellation indicates good pair match for all drivers and crossovers, and the likelihood that all is intact. You could – very carefully – prise up the Velcro attached grille to check that the drivers are old original types: there are many stories about non-standard paper cone bass units and fabric dome tweeters being fitted as substitutes.

To achieve an accurate balance, BBC engineers found it essential to match the level of bass/mid and treble closely. This meant any speaker could be paired with any other, and a reference standard for overall tonal balance could be maintained. Not only were the drivers selected and matched, the exact driver sensitivity match for a given loudspeaker was achieved via the tapped transformer in the crossover network. Some examples



have reportedly been mislabelled or misattributed when put up for sale, to increase their value.

The '11 ohm' version

Variations in the bass driver behaviour became unacceptable around the mid-1980s, so a new driver was designed alongside a simplified matching crossover. This resulted in a slightly lower average impedance, giving rise to the term '11 ohm' for this revised version, which appeared from 1988.

All the 11 ohm crossover networks were manufactured by KEF. They used open-core ferrite rod inductors, and the tapped transformer was replaced by a tapped resistor ladder, which may also have affected sound quality. Greater driver manufacturing consistency meant that the crossover could be slightly simplified while maintaining the intrinsic timbre of the loudspeaker. This was partly due to the use of a nitrile-modified polymer surround, offering better damping and termination for cone resonances. In some respects the 11 ohm model sounded more accurate: more 'hi-fi', with a little less mid coloration, reduced 'nasality' and a drier bass.

This was considered an advantage for its primary purpose of programme monitoring, but for some listeners there were also some losses: in an audio system capable of expressing dynamics and rhythm, the 11 ohm version was found to be a retrograde step. The higher Q butyl rubber surround used on the original seemed to endow the bass with superior punch and 'boogie factor', while the new implementation of the target alignment seemed to take away some dynamic punch and far-field image transparency. While I have always respected the monitor accuracy of the 11 ohm versions, I still consistently prefer the '15 ohm' original, warts and all.

Sound Quality (15 ohm original)

Historic reports on the *LS3/5a* were based on the use of then contemporary equipment and program material. Thirty years on we can clean up the speaker terminals, select a good speaker cable, and fire them up on the end of a familiar modern system. Revisiting this design (and taking care not to drive the speakers too hard, which is tempting since they're so smooth and well balanced), one is struck by an essential 'rightness' that's still instantly capable of showing up errors in modern rivals. While there are some mild underlying errors – restricted bass, 'plump' upper bass, an old fashioned 'plastic cone' nasality in the upper mid, and a treble which sounds a tad bright on modern mixes – the original *3/5a* nevertheless hits the musical target, time after time.

A string quartet comes out sounding correctly

balanced: the cello is not boxy, the violin sounds light and airy, while the bass viol is both robust and articulate. Solo piano reproduction is streets ahead of most modern speakers, leaving them sounding boxy and generally coloured by comparison, and lacking the innate differentiated 'singing' character of the live instrument.

Singing voices sound open, lively and articulate, with accurate sibilants and exceptional intelligibility. With modern amplification, the underlying transparency and resolution of this classic design is brought out. Image depth is satisfying, focus and lateral precision are exceptional, and the soundstage is well detached from the speaker, which is always a good sign. Small scale jazz is a revelation, the ensemble playing sounding well judged, nicely timed and musically satisfying, albeit with some dynamic compression – common enough with low sensitivity speakers such as these.

It was no surprise to confirm that larger orchestral works had to be played at sensible volume levels, or that playing heavy rock or cathedral organ was largely pointless. Entertainment value does in part come from loudness – the whole body experience if you like – and you have to accept that the *LS3/5a* was never designed to provide this.

However, this speaker remains a supremely accurate and musically truthful small-scale monitor, whose particular virtues and achievements are still an example to the industry, and which I continue to use as a long term reference. An example of its ruthless analysis concerned a huge and highly praised three-way from a top manufacturer which had come in for review. Even though it clearly had seeds of greatness, I just could not get on with this particular design, which proved confusing. The easy way out was to locate a single *3/5a* on a high stand, put it next to one of these problematic speakers, set up mono speech and conduct an A/B test at carefully matched volume. I could immediately hear the problem in the review speaker, which sounded withdrawn, muffled, lower-mid dominant, and quite lacking in articulation. The rest was easy.

Lab report

Pair matching was very good, as specified by the BBC. Sensitivity was a low 81.5/82dB/W for the pair, though their high impedance means that actual efficiency is about 2dB higher than that. The minimum impedance is 8 ohms, while the 'music spectrum related average' is on the button at 15 ohms, and very kind to amplifiers, connectors and cables. The sealed box system resonance was measured at 95Hz, somewhat higher than the 78Hz noted for a sample in 1976.



“This highly neutral and musically involving BBC classic still deserves recommendation, albeit with understandable reservations concerning acknowledged limitations of modest low frequency extension, maximum loudness, and the dynamic expression of low efficiency designs.”

Working on the BBC rule for an average room – that the maximum in-room, perception-related sound level is 5dB less than the single-channel on-axis 1m maximum (in this case 98dB/50W) – we obtained a pleasantly loud 95dB maximum level. This does, however, compare unfavourably with in-room maxima of 100dB for modern small speakers, and up to 110dB for larger three-way designs. The safe 15ohm 3/5a power rating is 50W programme (unclipped), with a suggested minimum of 25W.

On axis the 3/5a measured as it did originally. It achieved a close-toleranced +/-2.5dB from 80Hz to 8kHz, without curve smoothing and despite the diffraction/power response equalisation incorporated to realise the ‘monitor sound’. On this early production sample, there’s no sign of the +2dB peak at 1.5kHz seen in later examples, which disproves the folklore that this peak is caused by the baffle cut-out for the recessed bass unit.

The treble extends to 32kHz, -6dB, while the bass nominally reaches -6dB at 67Hz. Under room-boundary loading this extends to 54Hz, with some lingering subjective lower level output down to 35Hz, thanks to the relatively slow roll-off of the sealed-box alignment.

Spatial averaging shows a mild 2dB trough at about 500Hz, a mild peak at 1.2kHz, no energy loss around the 4.5kHz crossover frequency, and smooth extension to 10kHz before the usual ‘house curve’ roll-off towards 20kHz. The speaker achieved a very creditable 58Hz to 10kHz, +/-3dB, 1/3-octave weighted, on 24cm high stands. for the overall spatial average under room conditions.

Enclosure coloration was low, thanks in part to the small surface area. Measured vertically above axis, the response closely matched the reference result. For 15 degrees below axis the output showed a narrow dip at 3.2kHz, not very audible, but better avoided for best focus. Laterally off-axis, even at 30 degrees, the response held to +/-3dB limits with little midrange loss and evidently good diffraction. By 45 degrees the response limits had widened, but were still fine at +/- 4dB 80Hz to 18kHz, with a mild 3dB trough seen at 2kHz. All

these results indicate very good directivity behaviour.

Tested for energy decay on axis, the frequency/coloration-related weighted ETC (energy time decay) waterfall analysis looked pretty clean, with minor artefacts at about 11kHz and 16.5kHz. On the impulse-weighted waterfall analysis for energy decay, showing transient speed, the result is actually very good, and in fact comparable with the best of today’s offerings. I believe this second result correlated well with the speaker’s notably precise subjective transient definition, as well as its generally good transparency.

I measured harmonic distortion at a moderate but useable 90dB sound level and found that the significant third harmonic bettered 0.7% below 80Hz, averaging 0.2% over the rest of the frequency range, still a good result by today’s standards. Notwithstanding their age, my Audiomaster pair measured as well as ever, and remain accurate, well designed and notably well balanced loudspeakers.

Conclusions

This LS3/5a reassessment proved quite an education. In my opinion the perception and engineering standards set by the BBC some forty years ago remain largely unchallenged, and enough of that knowledge was incorporated in the design of this miniature for that message to be sustained down the years. Happily the KEF component parts were of sufficient quality to remain in good order for this re-evaluation.

Secondhand prices vary widely, from around £300 to £700 per pair, depending on condition, type and manufacturer. This highly neutral and musically involving BBC classic still deserves recommendation, albeit with understandable reservations concerning acknowledged limitations of modest low frequency extension, maximum loudness, and the dynamic expression of low efficiency designs.

Used in a modern audio chain, with good spiked stands, cleaned terminals and the usual semi-free-space placement, the LS3/5a still achieves its recognised high standards for low coloration, smooth frequency response and tonal accuracy. Image depth borders on ‘very good’, focus is excellent, while micro-dynamic and low level resolution is also quite competitive. Vocals are distinct and articulate, while piano reproduction has a natural quality, free from the usual ‘small box’ plumminess and excess ‘woodiness’ in the lower midrange. The sound is clear and vibrant with sufficient detail resolution to ensure it need not be played loud to be informative. The legendary reputation of this best selling BBC monitor is well founded.

EDITOR'S NOTE:

There are numerous websites devoted to the LS3/5a. The most useful is that run by Paul Whatton (son of Maurice), to be found at: <http://www.ls35a.com>



The Stirling Broadcast

BBC LS3/5a V2

STIRLING'S LS3/5a V2 IS NEXT OF KIN TO THE LS3/5a AND THE MAIN INHERITOR OF ITS LEGACY. MARTIN COLLOMS EVALUATES IT IN THE CONTEXT OF THE ORIGINAL LS3/5a

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After Stirling Broadcast had constructed a number of late period, second series (11 ohm) *LS3/5a* speakers, the supply of original KEF drive units finally ran out. The company therefore took the decision to try and create an equivalent model. Their aim was to match the BBC specification as closely as possible, both technically and subjectively. Derek Hughes, some time design chief of Spondor and son of the late Spencer, was engaged to produce the new model. The result is distinguished by the suffix *V2*, and is now approved by the BBC as offering comparable monitoring accuracy to the previous 11 ohm model.

The new speaker, which retails for £898 per pair, is exquisitely finished, with almost jewel-like build quality. The original model came with a screw-on front panel, and the vast majority had a sealed, glued-in back panel. A few very early models had screw-on backs and Stirling decided to do the same with the new *V2*. The original rather coarse Tygan grille material has been replaced by a more acoustically transparent stretched cloth made from a softer, machine-knitted polyester.

Other changes include the replacement of the KEF *T27* 20mm hard polyester dome tweeter by a ScanSpeak 19mm doped fabric dome, sunk in a very short 'horn' or phase corrector. The original driver had quite a high fundamental resonance while the new type is more sophisticated with complex rear loading to improve the lower treble behaviour. The tweeter faceplate retains the traditional perforated brass protector plate. The bass-mid unit is still back mounted – in fact deliberately spaced a little further back than the depth of the front panel – to match the acoustic and delay behaviour of the original driver. The latter used a doped Bextrene cone, which gave rise to some awkward variability; the *V2* has a similar-looking formed polypropylene co-polymer cone, which has a damping coating and a synthetic rubber roll surround. The foundation of the bass-mid unit is now a die-cast magnesium alloy chassis, replacing the original pressed steel frame.

Modern components are used in a crossover network which has been completely revised to provide the correct equalisation for the new drivers. High quality air- and



iron-cored inductors partner selected polypropylene film capacitors. The network allows for three different settings of relative high frequency level, in steps of 0.5dB, and each crossover is matched to the specific driver pairs.

As before, the enclosure is built of top quality birch plywood damped by bituminous pads and lined with high absorption acoustic foam. However, the panel resonances are subjectively slightly higher pitched than those of the original – perhaps modern glues are stronger? The *V2* is bi-wired, with cable connection via heavy-duty gold-plated binding posts.





Sound Quality

Supplied as well-run-in loan stock, our samples were found to be up with the best of other recent pretenders to the *3/5a* crown. The welcome trademarks of pin-point stereo focus and very good tonal balance were immediately apparent, together with an accurate top-to-bottom overall balance and notably neutral timbres. The treble is smooth and articulate, the midband even and relatively low in coloration, and there is also plenty of fine detail. The bass is surprisingly articulate and tuneful, with the *3/5a*'s characteristically full, upper bass 'sound' present and correct. That mild lift in the mid-bass is part of the overall character, and without it this speaker would sound unnaturally thin and small.

These are undoubtedly very good little speakers, and clearly deliver monitor standards of accuracy. But I still felt that they didn't quite match the total sound quality produced by my own 30 year old, 15 ohm Marshall-built *LS3/5as*. That said, that the difference isn't huge, and may only be audible on direct comparison. The original *3/5a* sounds more open, more spacious, as well as a little more upbeat, and is also somehow more faithful to the sound of natural instruments.

Paired up side-by-side in mono, solo piano is revealing. At matched volume levels, the original model has more reach into the air and reverberant acoustic of the recording venue, while the piano left hand register sounded less boxy, more even and more vital. Once heard, this difference is unmistakable, and in its way clearly points in the direction of the exceptional midband quality of the Quad *2805*, [Issue 1]. It was this almost crystal-like clarity, with the notable absence of characteristic 'little box' midband coloration, which in my opinion has long distinguished the original *LS3/5a* from all its clones.



You can certainly tell that I am a long-standing fan of this classic design when used within its limits!

Lab report

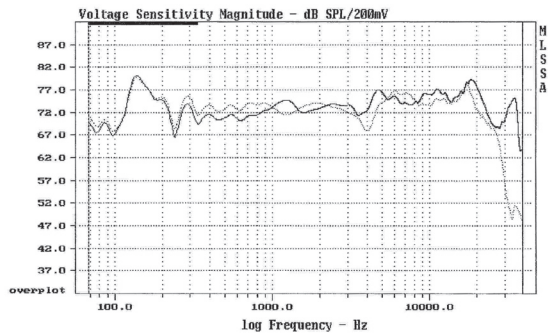
Checking out the Stirling *LS3/5a V2*'s lab performance, pair matching was excellent, confirming the design's inherent smoothness and tight manufacturing tolerances. Sensitivity was specified at 82.5dB/W (compared to my old reference samples' 81.5dB/W), and was spot on target.

The impedance is an easy load of typically 11ohms. The response of the original extends to 38kHz, whereas the new *V2* cuts off sharply at 25kHz, but I do not think that the difference is audible. Both achieved quite tight +/-3dB tolerances from 60Hz to 23kHz, and have a similar trend, but there is nevertheless a mild underlying difference which I think matters. Eyeball-averaging the responses, the Stirling has some energy loss in the 3-5kHz range, and, taking a critical view of the mean treble level, the Stirling is also 2dB 'richer' over the range 270Hz to 900Hz. I consider this significant in the context of the subjective differences we heard, irrespective of technical issues concerning the drive units.

Relative loss of energy in the low treble was confirmed by a multiple axis view of the Stirling's output. It is most uniform on or slightly above the tweeter axis, but is beginning to notch in the crossover region on the bass-mid driver axis. At a fairly mild angle (for a small speaker) of 15 degrees below axis, the notch was 20dB deep at 3.3kHz, and also peaked up by 2.5dB at 2kHz, and the output was attenuated by an average of 5dB from 3.5kHz to 5kHz. The original version showed rather less variation in output with axis, indicating a smoother power response through the crossover region, which is likely to result in a more 'open' sound.

Conclusion

OK, so I still prefer the original to any of its successors, but should I recommend the Stirling? Certainly there is mild disappointment in coming to the conclusion that some of the unique essence of the original has never been fully recaptured. It seems that the particular focus of experience and effort found at the BBC Designs Department can never be fully recreated. But in the real world this Stirling is a beautifully crafted miniature, albeit with modest power handling. In an overall market context it is exceptionally accurate and comes with a large measure of the BBC inheritance, so recommendation is mandatory.



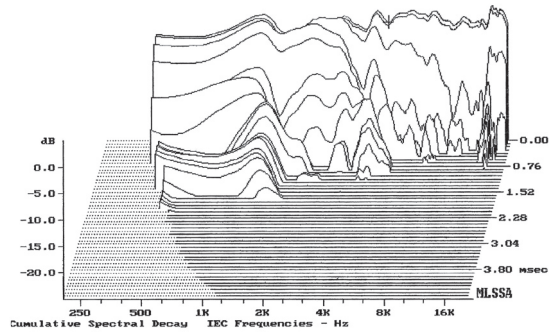
CURSOR: y = 48.5199 x = 38897.3428 (10834)

old v V2 dotted

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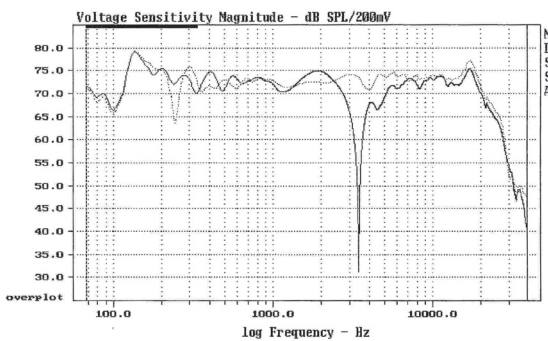
MLSSA: Frequency Domain

Axial response, original versus Stirling, dotted



-2.65 dB, 5140 Hz (100), 0.000 msec (1)

LS3/5a original: Waterfall decay response showing clean transient response of this classic design



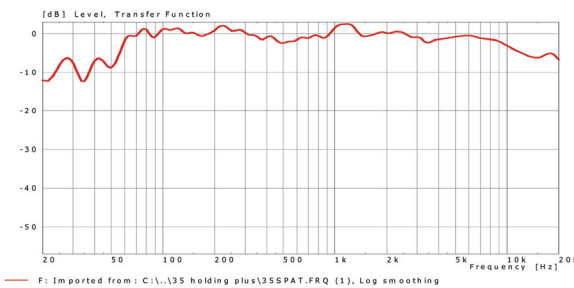
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V2 above dotted and below axis

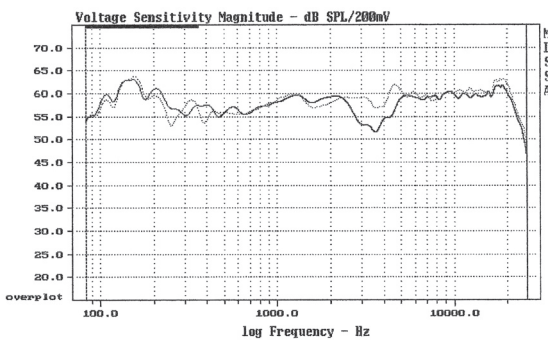
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MLSSA: Frequency Domain

Stirling axial dotted, 15 degrees below axis, bold



Room average spatial response for original LS3/5a showing remarkable integration with the room acoustic indicating a fine power response.



CURSOR: y = 47.9765 x = 25770.6541 (11189)

3/3a-original axial and 15 deg below axis

LS3/5a original: axial dotted, 15 deg below axis, bold, note small variation.

MANUFACTURER'S SPECIFICATIONS

Model: **Stirling V2**

Type 2-way sealed-box

Drivers

Bass/mid	SEAS 110mm die-cast frame, 85mm polypropylene cone
Treble	ScanSpeak 19mm soft dome, acoustically loaded front and back

Dimensions (WxHxD) 18.8 x 30.2 x 16.8cm

Frequency response 75Hz to 20kHz

Impedance 11 ohms

Contact www.stirlingbroadcast.net

Telephone 01963 240151

UK Price £898/pair

see HIFICRITIC's sound quality rating archive at www.hificritic.com

