A LOT FOR A LITTLE

Martin Colloms offers a high-performance, LS3/5A-sized, design.

FROM TIME TO TIME, *HFN/RR* HAS PUBLISHED DESIGNS for DIY loudspeakers, ranging from single-driver horn-loaded boxes such as Rex Baldock's 1963 'Paraline', through two-way high performance conventional designs like Malcolm Jones' 'Tabor' in 1977, to complex multiway models such as the 1976 'State-of-the-Art'. These articles have always been popular since a loudspeaker can usually be successfully constructed by a reader with little woodworking experience using a 'flatpack' cabinet, it will work first time, and it will generally offer a cost saving over a commercial equivalent. If the constructor is fair-to-good at carpentry, a still greater cost can be gained with a home-made cabinet.

I was therefore commissioned to design a suitable model for the magazine, the HFN DC1, and decided to opt for a miniature loudspeaker, built in a virtually off-the-shelf BBC LS3/5a enclosure. The advantage of using a commercially manufactured cabinet is that they are consistent in quality and will assure the constructor of a professional veneered finish. The 'DC' in the title refers to the crossover concept, seen recently in models from Epos and Mordaunt-Short, whereby a suitably chosen bass/mid drive-unit is connected directly to the amplifier, dispensing with the conventional series low-pass filter section of the crossover network. The treble unit necessary to fill in the last octave or so is integrated with the woofer with a minimal high-pass network.

My examination of the Epos and Mordaunt-Short MS100/300 designs made it clear that some compromise is evident with this technique, relating to the overall tonal balance. In a conventionally designed 2-way loudspeaker, the crossover has additional equalisation to flatten the main driver's typically rising response with frequency. As a consequence, the component values featured by a commercial crossover generally bear little or no resemblance to textbook values, which do not take this vital equalisation into account. With a few exceptions, this tendency for a rising output with frequency for a good bass/mid unit will, if unequalised, lead to a hard, forward tonal balance, dominant in the upper midrange.

However, the direct-coupled driver often exhibits superior clarity and better transient response than a fully equalised and crossed-over equivalent. In comparative tests, it can be found that the conventional mode seems to mask and blur fine detail to some degree, as well as to reduce transparency. Percussive bass can also sound softer and 'slower', even when allowing for the subjective effect of the difference in frequency response.

I recently suggested a way of adding tonal shaping to such a 'direct-coupled' loudspeaker, which is being considered by Epos and is actually available as an optional extra for the Mordaunt-Short MS100. This is to use a simple passive HF step network, placed either between pre and power amplifier or in the amplifier's tape monitor loop, to gently shape the overall response characteristic to give a more neutral and accurate tonal balance. Such a passive line-level equalisation network, when constructed with high-quality components, appears to add negligible degradation and is also very inexpensive. Furthermore, unlike the case with a conventional crossover, the component values may be easily adjusted to fine-tune the sound to suit the location, room acoustics, or to cater to some degree for personal taste.

However, even with equalisation it is not possible to obtain a perfectly flat response from such a system unless the drivers and cabinet are both subject to interactive design and development beyond our resources. For the DC1, therefore, a wide range of 110mm bass/mid drive-units were auditioned in order to select one

with the following properties:

1. A wide response, well-extended in the upper range to around 4-5kHz, with a smooth, controlled natural roll-off thereafter.
2. Low levels of coloration and associated delayed resonances, particularly important in view of the intended direct-coupled use.
3. Good LF damping and power handling to take account of the effective bass boost which will occur after system equalisation.
4. A high level of subjective detail and transparency since this is a major design target for the system.
5. Reliable, consistently high quality, manufacture.

The choice finally fell on a 125mm-framed (5in.) unit with a flared polypropylene cone, a damped dust cap, and a short 10mm, two-layer, advanced technology motor (voice) coil wound on a high temperature Kapton former. The roll surround is a PVC-modified rubber of good termination properties. Manufactured by Rogers, this drive-unit is similar to that used by them for their LS1 model, but the version used is specially selected for the DC1 and coded R125/M.

Such a small unit has good structural properties, and potentially will allow the use of a high crossover frequency in the 5kHz region to the tweeter. It can then be argued that the whole of the fundamental audio range, the seven octaves approximately from 50Hz to 6.4kHz, will be handled by a single diaphragm, direct-coupled to the amplifier. This will have major benefits in terms of polar uniformity, and channel matching, and consequently in terms of stereo focus. The ear is less sensitive to response discontinuities above 4kHz, and a gentle crossover to the treble unit around 5kHz is easy to engineer, the latter then only really filling out the harmonic structure of the music. As Mordaunt-Short have pointed out, this amounts to a range of perhaps an octave and a half.

To keep the HF unit crossover simple, essentially all that is required is just one good quality series capacitor in its feed. The tweeter therefore needs to be carefully selected:

1. It must be of sufficient sensitivity to match the top end response of the unequalised bass/mid driver.
2. A well-damped fundamental resonance to aid the use of a simple crossover.
3. A subjectively transparent character. Many HF units have a commendably smooth sound and frequency response, but we want one that will allow the listener to hear through the driver plane, to be able to identify treble detail in the depth dimension.
4. Not too high a price.

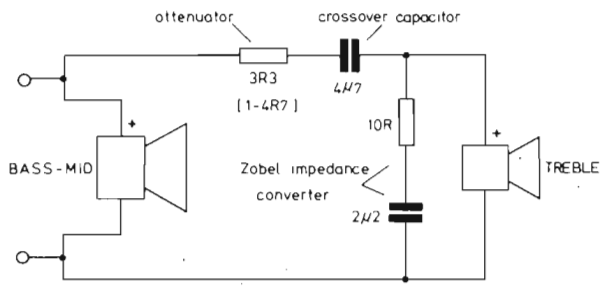
After exhaustive trials of the various drivers available off the shelf, a well-established, moderately-priced unit was chosen, namely the little Audax TW6x9A cone/dome unit. This has a plastic diaphragm with a radiating diameter of 19mm, and is damped with ferrofluid in the magnet gap. In the DC1, this tweeter sounds surprisingly unobtrusive, yet maintains a pleasing level of transparency.

As the bass/mid unit is suited to sealed-box loading, the LS3/5a cabinet is used more or less as supplied, the only change being to the front panel mounting, which needs to be different for the Audax tweeter. (The LS3/5a uses a KEF T27 unit.) Similarly, the bass unit mounting needs to be slightly different – the original's KEF B110 is rear-mounted, but the DC1's Rogers R125/M is surface-mounted and slightly recessed.

Construction

1: Crossover. The bass/mid driver is connected directly to the rear panel terminals. The tweeter crossover is shown in fig.1 and is essentially first-order (6dB/octave) with a single 4.7μF series capacitor. A Zobel network is connected across the tweeter terminals to match impedances in the upper range, while a small series 3.3ohm resistor sets the correct sensitivity alignment to integrate with the woofer. Tests showed that this could be in the range 1-4.7ohms. There are so few components that they may be soldered directly to the tweeter terminals and then glued or taped down. Alternatively, the components could be wired on a small piece of perforated board, securely screwed to the inside rear panel to avoid rattles. The HF section should have its own set of wires connecting it to the input terminals, and it is most important that the two drive-units are in phase.

FIG.1

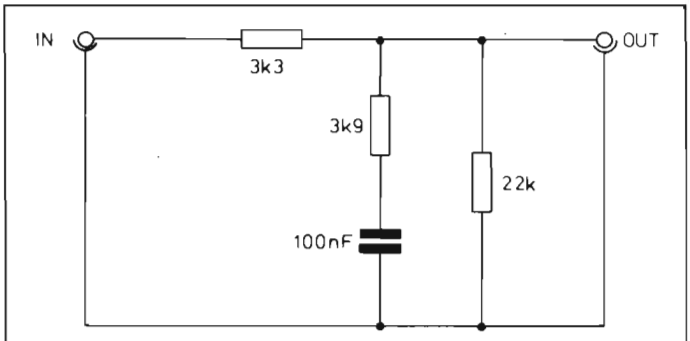


CROSSOVER: 3·3Ω 5W
10Ω 5W
4·7μF plastic film
2·2μF " "

2: Enclosure. Those buying the complete kit are supplied with the expensive but very high quality enclosure used by Rogers for the LS3/5a. If you intend to do your own woodworking, drawings are supplied; the front baffle is of 12mm Medite but the carcase should ideally be of 12mm birch ply. MDF or chipboard could be substituted with some compromise in performance. It is most important to include the screwed and glued internal corner battens, which must be in hardwood, preferably beech. The interior is lined with 25mm polyurethane foam, while side panels (one layer) and top and bottom (two layers) are loaded with bituminous car body panel damping pads.

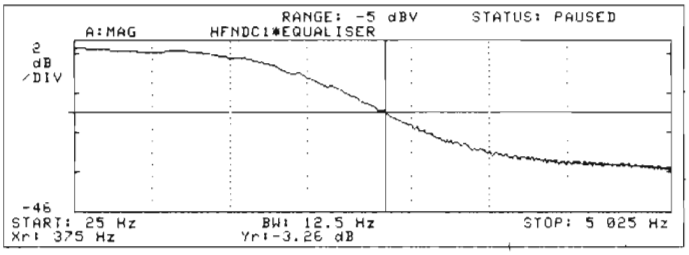
The build quality of the cabinet is important if the system's low coloration and high transparency are not to be degraded.

3: Equaliser. Fig.2 shows the passive equalisation network which can be built on perforated board and housed in a small box or tin with permanently-connected flying leads to minimise losses.



PASSIVE EQUALISER or step network
[1dB loss - see graph]

FIG.2



Component choice is uncritical, though perfectionists could use polypropylene dielectric capacitors and metal film resistors. Fig.3 shows the resulting response shaping, with a depressed 6dB shelf above 1kHz compared with the 100Hz level, hinging about 375Hz.

Use

The DC1 is designed to be used on 45-60cm high stands (like those for the Linn Kan) in close proximity to a flat rear wall. Alternatively, its light weight makes it suitable for direct wall-mounting using a suitable bracket/shelf. Bookshelf mounting is also possible, though vibration and acoustic coupling with larger shelf areas will result in increased coloration as well as a loss of depth and focus.

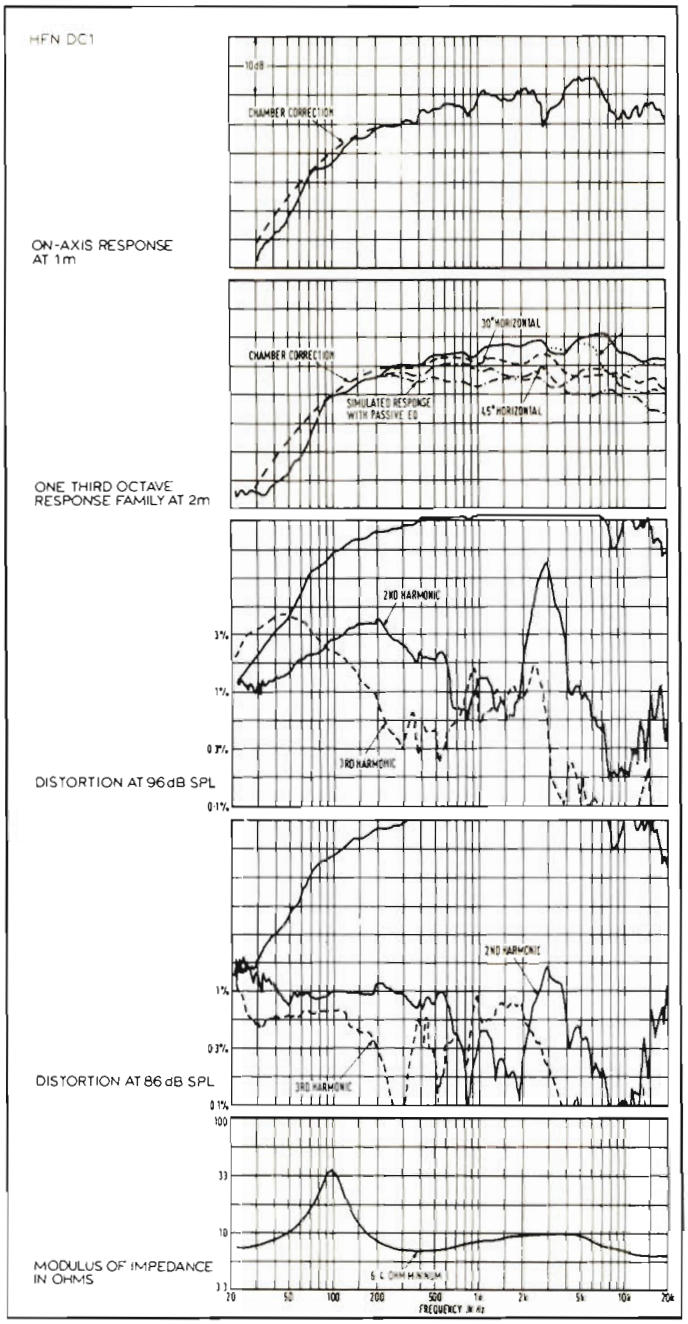
It is worth experimenting to determine the optimum location and, indeed, the best wall to back them with. A pair of DC1s are visually quite unobtrusive and this could be important for some users. With a free space location, a 60° equilateral triangle, with the listener and the two speakers at the apexes, is generally suggested, but with wall-mounting, the speaker spacing may be increased by 10-20%, providing that this does not bring them too close – <1m, say – to furniture, panel surfaces or room corners.

Lab report

The anechoic response curves were taken without the passive equalisation so some account needs to be taken of this, as well as the likely augmentation of the bass output when the DC1s are used against a rear wall.

On-axis at 1m, the response is smooth up to 2.5kHz, above which it becomes lumpy, returning to normal above 7kHz where the treble unit becomes well-established.

Examining the averaged forward response at a 2m measuring distance, the result is fairly tidy. 15° above the listening axis, a dip develops around 9kHz, so the DC1s should be placed around ear



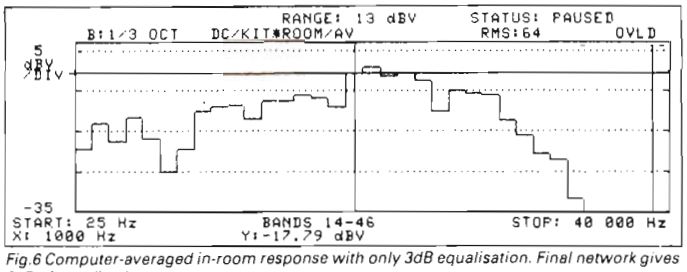


Fig.6 Computer-averaged in-room response with only 3dB equalisation. Final network gives 6dB of equalisation

level. In the lateral plane, the 30° off-axis response is quite favourable and confirms the listening test results, namely that the speakers should not be toed in towards the listener. Rather, they should beam straight ahead, or even toe out slightly. At 45° off-axis, no untoward effects can be seen bar a gradual HF rolloff. (The dash/dot line shows the expected response with the equalisation network and with the LF chamber correction.)

Levels of 2nd and 3rd harmonic distortion were measured at our standard 96dB and 86dB spls. (The 96dB test is rather cruel for a small system, particularly as the 400Hz frequency was levelled at the test sound pressure level.) At low frequencies at 96dB the results were reasonable, but a narrow 10% spike developed at 3kHz, the causes for which have not yet been found. Otherwise, levels of both harmonics were around the 1% mark.

At the more realistic 86dB level, the picture was fairly normal, and typical for a speaker of this size and type.

The smooth impedance curve is notably uniform owing to the simple crossover and shows that the DC1 should be easy to drive. The 100Hz system resonance is well-damped, and the impedance modulus never falls below 6.5ohms.

In-room and equalised, the DC1's sensitivity is approximately 85dB/W. Measured with an earlier 3dB shelving equaliser, the computer-averaged in-room response shows a smooth characteristic, with a lightweight tonal balance, a little forward in the presence (1-4kHz) band. The gentle HF rolloff is naturally correct for this kind of room-averaged response. LF extends to around 50Hz with no trace of boom or overhang. Indeed, if so required, a pair of DC1s would be natural candidates for use with a good subwoofer, and *HFN/RR* intends to publish a suitable design by Trevor Attewell later in the year.

Sound quality

The following comments represent my own views as well as those of my colleagues and of some of *HFN/RR*'s editorial team.

The individual drive-unit outputs showed fine integration, blending unobtrusively, and the DC1s showed a strikingly good level of transparency and detail, with 'fast', immediate transient reproduction. Stereo images were well-focused, and after an initial subjective adjustment to the tonal balance, a good representation of image depth as well as the recorded acoustic was portrayed.

The DC1 appeared a little 'dry' in the bass, but with an articulate character and a modest low frequency extension. The midrange worked well, but some upper region 'thinning' and 'hardness' were apparent, this due to some degree to the inherent residual coloration in the upper range of the bass/mid driver. One or two highly equalised rock recordings – Yazoo or Phil Collins, for example – could catch the speaker out on occasion, the result sounding thin.

In the treble, the sound was articulate but essentially free from 'fizz', grain or sibilance, all of which are still surprisingly common loudspeaker faults. Its presentation of treble depth almost matched that of the mid register, again an unusual attribute.

Overall, even when equalised, the DC1 sounded a little lightweight but the listening panel felt it had musical qualities which greatly outweighed its noted compromises.

It would be unfair for me to make close comparisons with commercial systems, but the HFN DC1 could be said to represent a sort of hybrid of the LS3/5a and the Linn Kan, but with an immediate and obvious musical directness and immediacy resulting from the lack of a bass/mid unit crossover. However, it remains unbalanced tonally, and this must be taken into consideration when passing overall judgment on its sound quality.

[I listened to the DC1 over a weekend, mounted on Cliff Stone Foundation stands against a rear wall and driven by my admittedly unrepresentative high-end system with the appropriate HF shelving filter between pre and power amplifier. I was very impressed with the ease with which this tiny box delivered transparent, deep stereo imagery. Bass, it has to be admitted, is lightweight and not particularly extended, but compares well with the rather lumpy low frequency definition of my Rogers LS3/5as. The rather treble-forward balance takes a little getting used to, but doesn't get in the way of the music, only reminding one of its presence when something with a good deal of surface noise or tape hiss is being played. The other major plus point of the DC1 is the clear, unresonant upper treble, presumably due to the fact that the tweeter is only being used in the upper half of its potential range. A nice one, Martin – **Ed.**]

Availability

Complete kits for the DC1 are being made available through the well-established *HFN/RR* Accessories Club. Initially, we felt that the DC1 should only be made available with the specified cabinet, in order to ensure that all purchasers will be guaranteed the intended level of performance. This cabinet is quite expensive, and the kit for a pair of DC1s will cost £129.99 inc. p&p. If the purchaser is willing to build his own cabinets, however, the kit for a pair of DC1s will cost £49.99 inc. p&p. We do recommend, however, that unless you are good at woodworking, you purchase the kit with the cabinets.

Happy listening.

HFN/RR DC1 LOUDSPEAKER – ORDER FORM
To: HFN/RR Accessories Club, PO Box 200, Bedford MK40 1YH
Please send me . . . complete DC1 kit(s) £129.99 inc. P&P and VAT
. . . DC1 drive-unit kit(s) @ £49.99 inc. P&P and VAT
(Block caps please):
☐ I enclose PO/Cheque/MO*
sh to pay by Access/Visa/Diners Club/American Expr
card number is ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐
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ignature
ase allow 28 days for deliver
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