BOOK REVIEWS:
VALVE AMPLIFIERS
ELECTRONICS
CONSTRUCTORS
GUIDE

WE BUILD AND
TEST KEF'S
K90 KIT
LOUDSPEAKER

MOTIONAL FEEDBACK:
CAN IT GIVE US THE
PERFECT
LOUDSPEAKER?

FREE D.I.Y. SUPPLEMENT No. 23
We offer below a selection of our CVC PREMIUM range of audio valves. These CVC BRAND valves are from selected world wide sources, processed in our special facility to provide low noise/hum/microphony PRE-AMP valves and POWER VALVES burnt-in for improved stability and reliability. Use this sheet as your order form. If you require matched pairs, quads or octets etc. Please allow £1.00 extra per valve for this service and mark alongside the valve type number 'M2, M4, M8' etc as required.

### Price list and Order Form for CVC PREMIUM Audio Valves

#### PRE-AMP VALVES

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Total carried forward ...

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### MATCHING CHARGES

- £
- POST & PACKING (UK) £3.00
- TOTAL EXC VAT £
- VAT @ 17.5% (UK/EEC ONLY) £
- TOTAL TO PAY £

Please make cheques payable to: 'CHELMER VALVE COMPANY' or pay by ACCESS/MASTERCARD/VISA. Please give details:

- SIGNATURE: 
- NAME: 
- ADDRESS: 
- POST CODE: 

Please make cheques payable to: 'CHELMER VALVE COMPANY' or pay by ACCESS/MASTERCARD/VISA. Please give details:

- SIGNATURE: 
- NAME: 
- ADDRESS: 
- POST CODE: 

Valve Amplifiers sound better still with CVC Premium Valves!

130 New London Road, Chelmsford, Essex. CM2 ORG. Tel: 01245 355296/265865 Fax: 01245 490064
KIT NEWS
All the latest bits and bobs to help you get the very best out of your home brewed designs.

KEF K90 KIT LOUDSPEAKERS
We put together a pair of KEF's K90 kit loudspeakers, using their Uni-Q drive unit. With KEF's engineering experience behind them, we're expecting great things.

MEET YOUR CAPACITORS
A strange pastime it may be, but Dominic Baker has been listening to different brands of capacitor for loudspeaker crossovers. Here are his findings.

AUDIOCAD PRO - PART 2
A comprehensive loudspeaker modelling package for the IBM PC is put through its paces by Dominic Baker.

ELECTRONICS CONSTRUCTORS GUIDE
Aimed at students and enthusiasts as well as professionals, Paul Cuthbertson, an experienced electronics engineer himself, brings you his words of wisdom in the world of electronics design and construction.

VALVE AMPLIFIERS
Written by Morgan Jones, Valve Amplifiers contains theory, hints on modifications and upgrades and new designs you can build yourself.

LETTERS FEATURE - MOTIONAL FEEDBACK
Three pages devoted to the art of motional feedback. This mechanism promises deep bass with fantastic quality and low distortion. Why isn't everyone using it?

DIY LETTERS
Write in for advice on your DIY project - here's where we provide the help you've been looking for.
F. Langford-Smith
Radio Designers Handbook

Langford-Smith Radio Designers Handbook is recognized as being the most important reference work ever published.

Vintage Audio are pleased to be able to reprint this important work and bring it to you in its original format. The Book contains 1500 pages, in 38 chapters, on every aspect of Valve Amplifier Circuits. Such is the extent of the subjects covered it would be impossible to list them all here. It is best summed up in the author’s preface to the book:

“It has been written as a comprehensive self explanatory reference handbook for the benefit of all who have an interest in the design and application of Audio Amplifiers”.

To order your copy at £59 Please Call or Fax us on (01144) 1734 451737

Vintage Audio
850 Oxford Road, Reading, Berks.
CREDIT CARDS TAKEN
LIBERTY TWO
Free demo disks are now available from Marton Music for version 2 of Liberty Audiosuite's LAUD audio analysis software. The full blown version should be available for purchase in July '96.

Significant enhancements over the current version are claimed including a real time analyser, pink noise generator (with both third and sixth octave analysis), automatic adjustment of input sensitivity along with marker positioning, and manufacturing pass/fail procedures.

The system is designed to be user friendly with built in Easy-Script to simplify operation. The complete system including Echo soundcard, calibrated microphone, pre-amp, manuals and all cables and probes will cost a total of £535 + VAT. Customers running the current version can upgrade for £72. For the free demo disk or any further information contact Tony Seaford on the number below.

Marton Music
5 Masterson Avenue,
Read,
Burnley,
Lancs. BB12 7PL
Tel: 01282 773198

GOODBYE TO WILMSLOW?
After 35 years of supplying loudspeaker kits and components to audiophiles the world over, word is spreading that Wilmslow Audio may soon cease trading. At the moment it's not known if a buyer can be found to take over the business when the current owners emigrate, but it looks as though the name Wilmslow at least will soon vanish from component supplier lists.

SUMMER AT AUDIocom
Welsh component suppliers Audiocom have added several new lines to their latest catalogue. They now stock ultra fast soft-recovery rectifier diodes for use in valve and transistor amplifier power supplies. Also new is a range of DAC chips, including Burr-Brown's PCM69AP, Philips' DAC-7 and Analog Devices' 1862N.

Those with a soft spot for bullion can sate their appetite with a range of uninsulated silver cables, while the slightly less well-to-do can take advantage of a price reduction for five or more of Sanyo's OS-CON electrolytic capacitors.

Audiocom
2 Swallowtree Gardens,
Saundersfoot,
Dyfed SA69 9DE
Tel: 01834 814036

AP UPGRADES
Graham Nalty's AP Electronics is offering a range of upgrades for owners of popular amplifiers. These include the likes of the Audiolab 8000A, Naim Nait, A&R A60, and Pioneer A400.

AP Electronics
15 Derwent Business Centre,
Clarke Street,
Derby DE1 2BU
Tel: 01332 674929

AUDIO-LINKS SALE
Until the end of July, or until stocks are exhausted, you can save money on some of Audio-Links' components like silver wire, Ansar capacitors, Alps potentiometers and Elna switches.

For lists and prices, send a C5 size SAE to:

Audio-Links
7 Fairmont Crescent,
Scunthorpe,
N. Lincs. DN16 1EL
Tel: 01724 870432

BILLINGTON VALVE AMP PARTS
Just to make sure the temperature doesn't drop below sweltering this summer, Billington are announcing stocks of components for budding valve amplifier constructors.

The range of predominantly government surplus oil-filled chokes (prices from about £10 to £35) is complemented by a list of mains transformers. This is made up of C-core oil-filled types as well as more standard shrouded and unshrouded versions.

All bar one of the output transformers available are designed for push-pull use with valves such as the EL34 pentode, with estimated power ratings of between 30 and 100watts.

So you know exactly what's going on inside your valve amp, there's also a range of 'power station' style moving iron meters in state of the art bakelite and brass cases. Quantities are limited, though, so it's first come, first served.

Billington Export Ltd.
Units E1 & E2,
Gillmans Ind. Est.,
Billingshurst,
W. Sussex RH14 9EZ
Tel: 01403 784961

NVA BUDGET DACON
NVA have developed a low cost version of their DACon digital to analogue convertor. The new Junior DACon uses a smaller in-built power supply instead of the 300VA external version of the original, although it can be upgraded to the level of its senior counterpart.

Built, the new version is available at £300 and as a kit for £180. The DACon senior will also now be available in kit form for £320 plus £180 for each PSU.

NVA
6 Watermill Ind. Est.
Aspenden Road,
Buntingford,
Hertfordshire SG9 9JS
Tel: 01763 272707
Hart Audio Kits -
Your Value for Money Route to Better Sound
2 Penyllan Mill, Oswestry, Shropshire, UK. SY 10 9AF
Phone 01691 652894 Fax. 01691 662864

Ordering your HART kit is easy, simply post, telephone or fax your order anytime. Let us know what you require, with your name, address, cheque or credit card number and expiry date. Your daytime phone number is also useful in case we need to get back to you, if you haven't furnished our address on your kit list just ask for FREE lists. Overseas orders are welcome and we can send anywhere in the World. Post on UK orders is £2.75 plus p&p, over £20 - £1.50. Express Courier £10.

QUALITY AUDIO KITS
24hrs SALES LINE 01691 652894
ALL PRICES INCLUDE UK/EU VAT

K1100 PRECISION AUDIO CONTROLS
The K1100 is fully designed in house, and with the latest component values, is a modern day version of the world famous "machine in a box" K1000. This kit is designed to totally surround the element giving the best heat transfer. This elegant design also means that it is small and handy enough for home use. The kit comes complete with all parts ready to assemble inside the fully finished 228 x 134 x 63mm case. Complete with full easy to follow instructions and Step by step construction. The K1100 is designed to be a perfect partner to any loudspeaker system and is ideal for all "Do It Yourself" Hi-Fi enthusiasts. The K1100 is manufactured in the UK from our new Andante Ultra High Quality linear low resistive resists, your subsequentkit purchase.

MANUAL POTENTIOMETERS
- 2 Gang 10K Ohm. £35.87
- 2 Gang 10K, 500K & 1.0M £46.46
- 2 Gang 10K Special Silverline, zero cross talk and zero centre loss £17.40

MINIATURE POTENTIOMETERS
- 2 Gang 5K Ohm Volume Control £26.20
- 2 Gang 10K Ohm Special Balance, zero cross talk and less than 10% loss in centre position £26.99

SOLDERING
- The use of modern component values makes the soldering effort semaine for good results. Everyone will feel the actuality use our own workshop. See Our Lits for the best soldering kit.

1145K KIT - K1450 ACOUSTIC PROJECT
This kit is designed to be super loudspeaker system. The K1450 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

P1100 SILENT GUITAR PROJECT
Kit comes complete with all parts ready to assemble inside the fully finished 228 x 134 x 63mm case. Comes with full easy to follow instructions. The P1100 is designed to be a perfect partner to any guitar system and is ideal for all "Do It Yourself" Hi-Fi enthusiasts. The P1100 is manufactured in the UK from our new Andante Ultra High Quality linear low resistive resists, your subsequentkit purchase.

22100 KIT - K22100 ACOUSTIC PROJECT
This kit is designed to be a super loudspeaker system. The K22100 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

22150 KIT - K22150 PROJECT
This kit is designed to be a super loudspeaker system. The K22150 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

22200 KIT - K22200 PROJECT
This kit is designed to be a super loudspeaker system. The K22200 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

22250 KIT - K22250 PROJECT
This kit is designed to be a super loudspeaker system. The K22250 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

22300 KIT - K22300 PROJECT
This kit is designed to be a super loudspeaker system. The K22300 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

22350 KIT - K22350 PROJECT
This kit is designed to be a super loudspeaker system. The K22350 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

22400 KIT - K22400 PROJECT
This kit is designed to be a super loudspeaker system. The K22400 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

22450 KIT - K22450 PROJECT
This kit is designed to be a super loudspeaker system. The K22450 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

22500 KIT - K22500 PROJECT
This kit is designed to be a super loudspeaker system. The K22500 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

22550 KIT - K22550 PROJECT
This kit is designed to be a super loudspeaker system. The K22550 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

22600 KIT - K22600 PROJECT
This kit is designed to be a super loudspeaker system. The K22600 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.

22650 KIT - K22650 PROJECT
This kit is designed to be a super loudspeaker system. The K22650 is suitable for all moving coil and moving magnet transducers this kit is especially recommended for, and which fits upon the new generation of the world best high quality moving iron transducers.
KEF's K90 KIT LOUDSPEAKERS

Our skilled in-house technician, Nick Lucas, gets his hands on KEF's K90s. Did they survive the experience? Read on!
Wilmslow Audio, the loudspeaker kit people, sent us three of their KEF kits for review, namely the 60s, 80s and 90s. All the kits contain front mouldings, trim rings, sealing gaskets, fixings, instructions and front panel templates.

The crossovers, DN60, DN80 and DN90, are built on good quality printed circuit boards with flying leads attached and are sold separately. KEF do not manufacture flat-pack wood for the cabinets, terminal dishes, internal wadding, damping or ports. Unfortunately, it looks like Wilmslow Audio, KEF’s largest UK distributor for their kits, will have ceased trading by the time you read this, but all these items should be available from local carpenters and the suppliers listed in this month’s DIY Supplement.

The Crossover
Although fairly complex looking and using a large number of components, the crossover for the K90s can be followed fairly easily. Starting in the bass, 4.8mH, 2.25mH and 180μF provide a 3rd order low pass filter. 3.3Ω, 23mH, 200μF and 50μF form a filter that damps resonant peaking in the impedance curve, in this case suppressing the upper of the two peaks characteristic of reflex loaded loudspeakers.

The midrange driver uses a 3rd order high pass filter to roll-off low frequencies and match the bass driver. Rolling off treble is a 4th order filter and impedance compensation is provided by the series combination of 6Ω and 20μF. To match the midrange driver, a 4th order high pass filter is used for the tweeter; the two resistors provide the correct attenuation.

KEF's Uni-Q Drive Unit
This popular three model constructor series has been around for a couple of years now and is centred on KEF's Q200H Uni-Q drive unit. This is an 8" driver which has its tweeter sitting where the dust cap of the bass/midrange cone would usually be. This coherent source arrangement means that all the sound radiated by the driver is coming from the same point, whereas in a normal two way 'speaker for example it would be coming from two different points. This can provide very clear imaging, which KEF have tried to make the most of by using a low diffraction mounting arrangement for the driver.

The plastic front moulding and trim mirror the profile of the cone, helping to reduce diffraction effects. Aesthetically, this also gives a professionally finished look to the loudspeakers.

The KEF Kit Range
The KEF kit 60 is the smallest of the three. It uses the Q200H driver in a front ported cabinet with a volume of 18.5 litres, and has a claimed sensitivity of 90dB and a power rating of 100 watts. The KEF kit 80 is a floorstander that uses the same Q200H along with an 8" acoustic bass radiator (the BD200H ABR) in place of the port. This is basically a drive unit minus the magnet - it's driven only by the air movement of the Q200H - and KEF claim it has the effect of improving and increasing the bass response. Sensitivity-wise, KEF say the kit 80 manages 89dB and can cope with 125 watts.

Largest of the three in a ported enclosure of 35 litres is the KEF kit 90. This uses the Q200H, this time with the B200H bass unit which yields a claimed sensitivity of 89dB and a power rating of 150 watts. All three kits are bi-wireable.

Relaying this information to Dominic I received the response, "Build one". Opting for the top of the range, of course, I chose the KEF kit 90.
Building The KEF K90 Loudspeakers

The instructions provided are short and concise, supplying all the information you will need for correct assembly. They contain a 3D finished drawing, components list, cabinet plans, construction tips, assembly notes and technical specification. Note well, read the instructions thoroughly; you may feel information is missing, but if you look carefully it will appear magically in the text.

The flat-pack for the cabinets, supplied by Wilmslow Audio, was made of high quality 15mm medium density fibreboard (MDF) as recommended by KEF. Before cabinet assembly began I found it easier to drill starter holes for the terminal dishes and front mouldings, checking these for correct orientation. I fixed the crossover PCB to the shelf panel after extending the flying leads, realising they were too short to reach the terminal dish. I also fitted the damping material to the inside surface of each top, side and back panel, covering at least half of the inside surface area.

The wood panels came together perfectly using Evostick Resin 'W' wood glue. First of all I laid one side panel flat and then built on this the front, back, top, bottom and shelf and finally the other side. Cabinet maker's clamps would be the ideal aid, but packing tape wrapped around the cabinets sufficed. I left the cabinets to set for 24 hours. It was then a simple matter to stuff the wadding inside the cabinets and fit the front moulding. Following the instructions carefully and keeping to the colour codes for the crossover I wired up the drive units and screwed the terminal dishes into place.

Finishing Off

The final touch was beautifying the mouldings with their trim rings and Bob's your uncle. I ran a quick DC resistance check, both K90s read 5.5ohms, so I fired them up.

Overall it was a very enjoyable build taking approximately three hours per speaker, but it remains to be seen how the finely tuned ears of our editorial department will react to them...
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| 6CG7 Yugoslavian | 6.75 | ECC81 Mullard UK (CV4024) | 7.50 |
| 6V6GT STC UK | 5.93 | ECC82 Mullard UK (CV4003) | POA |
| 6X4W Raytheon USA | 3.00 | ECC83/EC6830S Tesla | 13.13 |
| 6336A | 66.00 | ECC83 Yugoslavian | 2.93 |
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| 5881/6L6WGC | 4.50 | PL519 Mullard |
| 3.60 | ECC83/12AX7WB 3.75 |
| 6L6WGC | 6.30 | F86 | POA |
| 6L7GT | 2.50 | EL34G | 6.20 |
| 5881/6L6WGC | 4.50 | PL519 Mullard |

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| B7A for 6C33CB | 3.23 |
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| 813 ceramic | 7.50 |
| Octal McMurdo UK | 1.20 |
| Octal PCB, foreign | 1.20 |
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The Cabinet

<table>
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<th>KEFkit 90</th>
<th>Internal Port Diameter</th>
<th>Internal Port Length</th>
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<td>KEFkit 90</td>
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<td>125 mm</td>
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</table>

The cabinet is a fairly straight-forward affair. Up top, a 9 litre sealed enclosure is used for the Uni-Q midrange and treble driver. The cabinet damping and internal wadding are important here, preventing reflections from the rear of the cabinet coming back through the driver which can produce a clattery sound. The bass chamber is a 26 litre box, reflex loaded to give deep and efficient bass.

Firing up the KEFs with the first few tracks of Boys For Pele revealed well detailed, precise imaging, especially with Tori Amos' vocals. Instruments were clearly located in the left to right spread of the soundstage, although a fairly marked lack of stage depth robbed the music of realism.

Thus far I had no tonal qualms about the K9Os, but this started to change with 'Professional Widow' and 'Talula' where vocals showed up some sibilance and harpsichord notes had a sharp edge to them. Muted trumpets on Charles Mingus' Mingus, Mingus . . . album and string instruments on orchestral works also suffered from the same effect.

While Mingus' plucked bass was attractively dynamic, it confirmed an extra richness at the bottom end which was obvious on the saxophones of his album and the drums and Hammond organ of Carlos Santana's Santana CD. The combination of midrange emphasis and full bass meant that the KEF K90 'speakers sounded rather poorly integrated and tended to get confused on busier pieces of music.

The KEF K90s are capable of good dynamics and bass weight, but their rather two-dimensional soundstage and prominent midrange let them down.

KEF KIT K90

At a glance, the KEF kit K90s look well engineered. The response is flat and smooth in true KEF tradition, but there are some trends which I suspect will be detrimental to their sound. Although essentially flat, there is quite a lot of energy concentrated below 1kHz, lifting lower midrange above treble level. This can result in an over-full or thick sound, especially in conjunction with well extended bass. Pulled well away from walls though, the K90s should sound reasonably balanced.

Although the impedance curve averages out at 7.8Ω and doesn't drop below 4Ω at any point, it isn't the smoothest around. The sharp rises and falls indicate the K90s are a reactive load, which can, as it does with KEF's Reference Series, affect amplifier performance quite markedly. Sensitivity was below average too, measuring just 84.5dB, so they'll take some driving. I'd recommend 50 watts minimum for best results. DB

**Frequency Response**

**Impedance**

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<tr>
<td>20k</td>
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</table>

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DIY LOUDSPEAKER UPGRADE

Upgrading Your Loudspeakers the DIY Way

Want to upgrade your loudspeakers without shelling out for a new pair?

Dominic Baker offers some words of advice.

The early stage of the DIY hi-fi bug normally begins with loudspeaker tweaking. Whether it's splitting a crossover for bi-wiring or building an existing speaker into cabinets you designed yourself, loudspeakers seem to have a strong appeal. I suppose it's because from the outside they appear simpler. There are relatively few components compared to an amplifier for example, and the drivers move as you play music, giving you a 'feel' for the way they work.

One area we consistently get asked about is upgrading the components in a loudspeaker's crossover. Commercial constraints normally mean that your £500 loudspeakers will come with cheap, reversible electrolytic capacitors and ferrite core inductors with spindly wire soldered to a circuit board. Just hard wiring the existing components and upgrading the internal wiring to a good quality speaker cable will bring a discernible difference. But while you're there it's tempting to replace the components themselves.

Remember though, especially in more up-market designs, that the components in a crossover will have been carefully chosen and balanced. Putting a higher grade capacitor in may unbalance the sound because its electrical characteristics or sonic signature are different. I'd recommend to anyone wishing to experiment that they hard wire the upgraded crossover using high quality wire and silver solder and then listen to the difference between the standard and the upgraded version. If it's worse, then you still have a route back.

INDUCTORS
Inductors can be replaced fairly easily. Air core inductors are superior to the ferrite cored ones normally supplied. Ferrite cores can saturate if they are not large enough, causing a fall in impedance which may overload your amplifier. Some exhibit hysteresis and the core itself can vibrate causing signal distortion. For large values of inductor, like those in the bass crossover section of a three way design where an air core is impractical due to its size and the amount of wire needed, use a laminated core inductor around 0.5-1" thick. Everywhere else an air core type should be used.

When you replace the inductors in a loudspeaker's crossover, there are two important figures you need to know; inductance and resistance. The inductance will be expressed in milliHenries (typically between 0.1mH and 10mH), and is the part that determines the crossover frequency. The resistance in ohms (typically 0.1Ω to 3Ω), is also very important. If the upgraded inductor has a different resistance (DCR) it will exhibit a different insertion loss and, especially, different resonant Q. unbalancing the crossover. Air core inductors have a higher resistance for a given wire gauge because more turns of wire are needed to achieve a specific inductance. Thicker wire will reduce the resistance.

CAPACITORS
Capacitors are a little more difficult. I've swapped a 4µF Alcap reversible electrolytic for a 4µF Solen polypropylene and watched the crossover point and signal level change considerably on our FFT Spectrum Analyser. Without this kind of test equipment you are shooting in the dark.

I assembled a group of capacitors for listening, spanning 1-12µF, typically used in midrange/treble sections where the differences are most noticeable. When you design a loudspeaker, the effect of the capacitor's electrical and sonic character can be designed in. But to keep things simple here, I decided to use them purely as upgrades to existing designs.

One of the problems with this is that the better capacitors have a lower Equivalent Series Resistance (ESR) and so allow more signal to pass. Putting a lower ESR capacitor in the treble section of a crossover will make the loudspeaker brighter. To keep this effect to a minimum during comparison, the capacitors were used in the midrange and treble sections of a three way design, so both sections should stay aligned.

The loudspeaker was a prototype design using a Focal Audiom 7K midrange driver and Focal T120K tweeter on an open baffle. These are very good quality drivers with a high sensitivity of 97dB and a very detailed, transparent sound. They also share the same core material so tonal variations are minimised. I highlighted the differences between capacitors quite strongly and proved an ideal tool for this test. Using silver soldered gold-plated croc. clips, I was able to swap capacitors over quickly and listen to the results. All are film type.

Especially to achieve a specific inductance. Thicker wire will reduce the resistance.
ALCAP ELECTROLYTIC
It would be easy to label electrolytic capacitors ‘bad’ and film types ‘good’, but that would be to misrepresent their qualities. The Alcaps actually sounded very good - they were soft and musical in a very inoffensive manner. I’ve heard cheap non-audio grade polyesters and polypros sound gritty and harsh, so the Alcaps certainly show them a thing or two.

Ultimately they don’t have the fine detail or transient attack of the others in this test, but alongside the Solens are top for value. If you’re finding the treble in your speakers a bit relentless, and they’re using a film capacitor, it could well be worth changing to an Alcap to temper the sharpness and produce a more listenable balance.

ANSAR SUPERSOUND
The ‘Supersound’ capacitors are made by Ansar and can be bought from various suppliers who put their own name on them. These came from RATA, but Cricklewood Electronics, Audiokits and a few others all have their own versions.

Their sound is, in essence, very similar to the Solens. A forward balance coupled to a clean and detailed delivery makes for an impressively dynamic sound with fast attack on transients. They weren’t quite as hard as the Solens can be and were better damped in the treble, giving slightly better focus.

KIMBERCAP
The Kimbercaps were hardest to place in this group. Some aspects of their sound were very good indeed: a pleasant richness compared to the dryer and more analytical Supersounds for example. But with it there is a slightly duller tonal quality. This makes them a good match for sharp sounding metal dome tweeters, which can have a brighter tone than is strictly accurate. Here they will soften the sharpness without compromising detail.

Kimber mark the inner and outer foils of their capacitors, so make sure you get them the right way around. Although there was only a slight difference, they did sound a little more open when used the way Kimber recommend.

HOVLAND MUSICAP
Most expensive in this test, the Hovlands are also the biggest. A good sign. A reliable rule of thumb to follow is the bigger the can size for a given value, the better they seem to sound. Where the Kimbercaps were only a small jump up from the Solen and Supersound capacitors, the Hovland Musicaps took a clear step forwards.

Like the Solens they can sound a little forward, probably a result of their very low ESR. But the extra ambience combined with a very clean treble delivery that seemed far less prone to ringing or sibilance than the other types does make them really quite special. You don’t half pay for it though.

SOLEN
Although the cheapest film capacitor I auditioned, the Solen polypropylenes have a very good sound indeed. With a slightly more forward balance than the Supersound capacitors, they could become a little hard in some applications, but they are certainly detailed and very clean sounding.

If you are worried about the hardness but like their price tag, a good idea is to parallel them with an Alcap to get the value you want. This seems to work very well, the softness of the Alcap balancing the forward nature of the Solen without seeming to lose any detail in the process.

PRICE COMPARISON TABLE (£)

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<th>Cap</th>
<th>1μF</th>
<th>2μF</th>
<th>4μF</th>
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</table>

Prices are for the closest value available in the range to those shown (e.g. there is no 2μF RATA Supersound, only a 2.2μF). The Alcap 100V range costs roughly twice the price of the 50V types.
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<table>
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<th>Value (uF)</th>
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**Speaker Caps**

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Vintage Audio
850 Oxford Road, Reading, Berks.
Dominic Baker continues his look at AudioCad Pro, an advanced loudspeaker modelling package for IBM PC compatibles suitable for professionals and enthusiasts.

In the last supplement I gave a general overview of AudioCad Pro and its features. It is an extremely comprehensive package, offering a wide range of features to the budding designer. Now, Part 2 will show you AudioCad Pro in action, giving examples of some of the simulations it can perform and how you can use them to help you with your designs.

If you are using AudioCad Pro in conjunction with a computer based measurement package, such as IMP or MLSSA, it will use the measured data you input to perform the simulations. Here, AudioCad is at its most powerful, using real figures to generate the results. If you do not have access to measuring equipment, AudioCad will simulate the loudspeaker from basic Thiele-Small parameters. However, this is no different from any other simulation package, so we'll concentrate here on its use with a measurement system.

Using the Import command, the frequency response, phase and impedance data can be fed into the package. It is best to give the files the same name, with a different suffix for each measurement, eg. HM210Z0.AMP, HM210Z0.IMP, HM210Z0.PHA etc so that they can all be imported at the same time. Once the data is loaded use Calculate Parameters to check whether the Thiele-Small parameters are plausible.

Next, you can use AudioCad to calculate Le, the voice coil inductance, for use later on in the crossover design. Click the mouse on the point in the impedance curve where you intend to place the crossover point. Also from the impedance curve, Calculate Q will instruct AudioCad to calculate fs (resonant frequency), Qms, Qes and Qts (mechanical, electrical and total Q factors for the driver).

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start to see the power of AudioCad. All of the data you will use later to optimise and simulate a design is generated from real measurements on the actual driver you will be using. There will often be notable differences between the manufacturer's supplied data and what you actually measure yourself. Loudspeaker parameters can vary from batch to batch, and there is a tolerance range within each batch too. So the supplied data is often a best case situation, not a real one.

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The compensation will give a very flat impedance curve though, allowing you to view the driver as an 8Ω resistor rather than a reactive device which makes crossover calculations easier. This is basically how AudioCad Pro's crossover designer works; the impedance is first equalised to make calculation simpler and more accurate.

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Once all of the decisions have been made, you can begin the optimisation process. AudioCad Pro will optimise the impedance for an individual driver or a complete system, and likewise with the amplitude response. It is fast and easy to use, but does require some knowledge of crossover electronics and how they work so that you fully understand the process and can make sensible decisions. Netcalc is an ideal package for gaining this experience without having to build numerous designs. It is affordable and very user friendly, enabling even novice constructors to get a firm grasp on crossover design within a few days.

AudioCad Pro really is one of the most complete packages I've come across. From one disc it does what you would normally need two or three less comprehensive packages to achieve, making it fine value in my opinion too. For professionals and enthusiasts alike, it's a very valuable design tool indeed.

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If you have access to measurement equipment, it is possible to optimise the impedance of a complete loudspeaker. First measure the impedance and electrical phase (Fig.1) of the loudspeaker so that the data can be entered into AudioCad. To start with, approximate values are inserted into the RCL network (Fig.2) which compensates for impedance rise. A target value, say 8Ω, is then specified and the first portion of the impedance curve to be equalised is marked with a box using the mouse (Fig.3). AudioCad will now re-scale the initial approximate values in the RCL network to flatten the impedance curve in the area selected (Fig.4). Now the impedance rise in the bass has been flattened, you can select the midrange rise and optimise this in exactly the same way; select starting values for a second RCL network, set target impedance, then optimise. Fig.5 and Fig.6 show a two-section RCL network and the equalised response. There is still a slight lift above 10kHz, which you can adjust for using the same process.
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ELECTRONICS CONSTRUCTORS GUIDE
by Paul Cuthbertson

Haider Bahrani gets organised with Paul Cuthbertson’s Electronics Constructors Guide.

The Electronics Constructors Guide is a book for the amateur and professional alike. The first three chapters dedicate themselves to the organisation and documentation of the design and construction process. Whether it’s a home DIY project or a manufacturer’s prototype, the principles are the same.

The emphasis here is on the preparation necessary before diving into the construction phase of any electronics project, turning the whole escapade into one that is planned as strategically as a Napoleonic battle. Documentation is also encouraged throughout both (or either) the design and construction processes, with more than one or two tips given on how to go about it.

Some will consider this a guide on how to suck eggs. In essence this is true, but many of these procedures are all too often neglected by the pros, and not encouraged in amateur fields. In fact, I would recommend this book for the first three chapters alone. The author is clearly speaking (or writing) with the mind of an engineer rather than a technician, encouraging methodical and modular construction patterns with a balance between effective and efficient design. The book appears to be pouring scorn over anyone who considers diving for the soldering iron and strip board as the first step on any project.

The following two chapters give a run through the necessary, or in certain cases not so necessary, tools with some design ideas thrown in for good measure. I say some, but Paul Cuthbertson has really spilled his thoughts out onto a banquet serving dish here. For someone who needs to learn a lot of basics quickly, or who has forgotten for that matter, there’s a lot of detail covered in these pages. Anyone scared of a bit of maths should fear not, because what little maths there is, is presented clearly and thoughtfully.

Chapter six is where things really do start to get interesting, particularly for someone taking their first step into the electronics mine field. This chapter delves into the world of components. By these I mean resistors, capacitors, transistors, etc. Steering well away from the ideal world, the book tries to give an insight into how both passive and active components work, again without blinding the reader with mathematics.

The follow up chapter is a thorough going over of some design examples. The first and the simplest of these is an LED driving circuit. Despite its simplicity, it is perhaps one of the best introductions to electronic circuitry I’ve read. The author really cuts down to the bone on this one, explaining all the nitty gritties. The examples increase in complexity, culminating in a power supply design, the description of which I’m sure most will feel quite comfortable following.

The warning lights are bright red in chapter eight. Problems in electronic circuitry, more often than not, are associated with the power supply, earthing or noise injection into the circuit. Earth loops are a typical pain in the electronics constructor’s neck, as are noisy supply lines and spaghetti wiring. Reading this chapter won’t make all these problems go away, but it will at least give you some idea as to what they are when they rear their ugly heads.

Chapter nine changes the tack of the book, aiming now more at the prospective manufacturer than the hobbyist. Build quality and ease of assembly should both be concerns for the amateur constructor, but the coverage in this chapter goes far beyond. This and the next three sections focus on product construction and prototyping on a serious level. Just skimming over these chapters gives a very good insight into how product development should be done. There’s even a chapter (No. 13) called ‘Going Into Production,’ which is the finale and goes as far as financing.

The Electronics Constructors Guide, despite its more professional inclinations, is one book I would definitely recommend to the hobbyist. It should also be a must for all students. Essential reading.

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Valve Amplifiers

by Morgan Jones

A comprehensive introduction, reviewed by Andy Grove

Valve Amplifiers by Morgan Jones is a comprehensive introduction to valve audio electronics. The opening chapter covers the essential electrical and electronic principles, beginning with the electron and rapidly progressing to the concept of charge and thence to current, voltage and so on. There is also an introduction to equivalent circuits, Thevenin's theorem and Kirchhoff's laws and even feedback and the operational amplifier. Surprisingly this chapter also introduces the transistor and uses it to demonstrate transconductance and amplification.

Simple valve stages and their mechanics are explained in Chapter Two, with load lines and theoretical analyses; here we meet the triode, the pentode, the cathode follower and most of the other valve building blocks. Some of the more exotic stages, such as the mu-follower and White cathode follower, will be new to those used to the Mullard 5-20. The valve's characteristics as a real world device are clearly shown: for example the distortion caused by nonlinearity can be seen in the example load lines.

Chapter Three is all about passive components, real life components, the capacitors, resistors, inductors, and of course transformers, which make up most of an amp's guts. Component choice is important for sound quality and here is a rational explanation of some of the physical problems inherent in today's bits. Capacitor losses and microphony together with the problems inherent in practical inductors are explained.

Power supplies are covered in Chapter Four, starting with rectification and progressing to choke input filters and on to solid state and valve regulators. There are good tips on the use of IC regulators and some example circuits for HT and LT supplies using them. The importance of good PSU design for sound quality is always emphasised.

Next, the power amplifier and the problems to be overcome are introduced. The different classes and modes of operation from the Class A single-ended stage through to the various push-pull topologies are discussed. The logical procedures for choosing the output valves and transformer, driver stage and so on are covered both separately and in the form of classic amp circuits such as the 5-20 and Quad II. Possible pitfalls like amplifier stability are looked at from a practical, rule of thumb viewpoint, and the author also makes some interesting observations on commonly used building blocks and suggests improvements.

Pre-amplifiers are covered in the following chapter, which takes the reader from the line stage and on into the depths of RIAA equalisation. Signal switching and volume controls are dealt with in some detail, with a listing for a program which works out the resistor values for stepped attenuators. Noise and hum are considered as is the effect of stray capacitances on the EQ network - again a BASIC listing is given to aid calculation.

The final chapter gives very useful advice on constructing amplifiers, the tools necessary, chassis layout and so on. There is also some safety advice on avoiding nasty accidents while experimenting.

This is the first edition of the book, so it would be prudent to double check the information contained against other references such as the Radio Designer's Handbook.

Overall this book is an excellent introduction to valve amp design. It gives an insight into how they work and educates the reader. The writing style is practical and easy to follow.

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Motional Feedback

Noel Keywood takes a look at a technique that promises to bring us the perfect loudspeaker. So why hasn't it done so?

A READER'S SYSTEM
by J.F. Wright

In this letter I hope to provide useful information for anyone interested enough in Motional Feedback to repeat my experiments. Since stability seems to be a big problem, I will start my explanation here.

When negative feedback is used to control a system, it must be truly negative at all frequencies. If one reactive element is introduced into the feedback loop, it produces a 90degree (maximum) phase shift at some frequency. This adds to the 180degree phase inversion of negative feedback to produce a 270degree phase shift.

The loudspeaker in this system is a reactive element; the induced e.m.f. in the feedback coil is proportional to the rate of change of flux i.e. cone velocity. The system is therefore a differentiator, so introducing a coupling capacitor - another differentiator - into the feedback loop produces another 90 degree phase shift at some frequency. If the loop gain exceeds unity then we have a ringing or continuous oscillation at that frequency, a potential problem experimenters need to be aware of.

An approach to achieving a usable system is to reduce the amount of feedback used until stability is achieved. Using just enough feedback to control the Q of the driver to fit a particular alignment still gives a worthwhile reduction in distortion. However, I was going for total control.

In my system there was a region of high frequency instability, probably caused by mutual inductance between the two loudspeaker coils (like leakage inductance in an output transformer). This is why I band limited the gain of the error amplifier to 480Hz. I didn't explore this further.

The circuit diagram is given in Fig. I. The feedback signal is proportional to

The feedback signal is proportional to

MOTIONAL FEEDBACK CIRCUIT
from Mr J.F. Wright (Fig 1)

I first heard Motional Feedback back in the early 1970s, at a Philips launch seminar held in Eindhoven, Holland, their home town. I was overwhelmed by the quality of bass it produced. Yet I never heard Motional Feedback working again.

Why did the idea die? A few years ago, I decided to lash up a system to see for myself. Lacking any information, a basic system operating on the principle of negative feedback was up and running in one Saturday morning and delivered great bass for a few minutes - then it went bang. This was a good enough omen: Motional Feedback conceals a whole slew of difficulties for the unwary and most of them, if not comprehensively tackled, tend to end up in one result - self destruction.

The problems were too great for me to tackle in the limited time I had available. However, reading about this in our June 1994 issue, Mr J.F. Wright - an electrical engineer - decided otherwise. He built a system, identified its core characteristics and problems and made it work. Hi-Fi World readers have tenacity.

Here, in reasonably understandable terms, are the wonders and difficulties behind Motional Feedback. My thanks to Tannoy and Andy Grove for their contributions. As Mr J.F. Wright has shown, with a bit of determination, Motional Feedback can be made to work. Good luck! N.K.
the cone velocity. The only reactive element in the feedback loop is the loudspeaker itself, to ensure stability.

The TDA1514 circuit is a Maplin kit with two alterations: a) shorting out the input capacitor b) increasing the value of the bootstrap capacitor to 470μF. These mods. have no effect on stability, serving only to increase the drive voltage to the output stage. It was fed by a 16V-0-16V power transformer and bridge rectifier.

The op-amp RC4227 is also available from Maplin. The circuit was built on Veroboard and separately powered at +/-15V. Decoupling capacitors of 22μF were included close to the I.C.s.

![Diagram](image)

**EQUALISATION AMPLIFIER (Fig3)**

The differential amplifier will not be needed if a loudspeaker with isolated coils is used (Ed note: see Audax twin isolated coil drivers at end of article). I used it to reject any voltage drop across the power amp's ground return. The gain of each stage was fixed at about 30, giving 60dB open loop gain, which I felt was a good compromise. Power amp distortion increases with higher gain, and op-amp bias current generates offset errors with higher resistances, which is temperature dependent (although the OP27 has a bias cancellation input circuit and is better than most in this respect). Using the offset adjustment pins on an op-amp degrades temperature stability.

I had problems with 3V of offset voltage, for the following reasons I believe. As the power amp. warms up, the output voltage, caused by offsets, changes. This is coupled via the loudspeaker to the feedback circuit, which increases the output voltage, causing it to heat up, further increasing the output voltage (i.e. the condition is regenerative). This produced a region of instability at a fraction of a Hz. The voltage increases until it saturates.

This is a strange difficulty; there must be a phase inversion somewhere in the chip. The modification shown in Fig.1 reduces the feedback (and increases signal gain) at very low frequencies, the turnover frequency being about 1Hz, in order to minimise this problem.

The phase margin is reduced but this is limited (damped), and it is a very low frequency. This means all direct-coupled power amp I.C.s are not a good choice, because the feedback works down to very low frequencies, which introduces other problems. Unless offsets are independent of temperature, there's little point in providing adjustment to remove them. If you do provide an adjustment, disconnect the feedback temporarily or you'll be adjusting forever!

A properly (custom) designed amplifier should enable higher levels of both gain and feedback (i.e. loop gain), giving greater control. Gain errors caused by a network in the feedback loop can be cancelled exactly by including an identical network in the signal path.

The drive unit I used was the Earbender EBB-50 from B.K. Electronics.

The system's frequency response is shown in Fig. 2. The dip in the curve at about 250Hz confused me at first - I thought reflections were to blame, but it corresponds to the minimum impedance of the drive unit. The phase shift is zero at about 250Hz (i.e. it's a resistive load) and the feedback voltage is very low. Exactly why this is so I don't know; is velocity also a minimum? Is the output sounded distorted. This turned out to be 20W into 4ohms, so there is no point in providing more than, say, 25W for each drive unit.

This brings us to what to look for in a drive unit. Very low Q and low Fs don't seem that important. A smooth midrange from Hi Tech diaphragm materials aren't important, if the driver is to reproduce bass frequencies only. Large excursion and high minimum impedance frequency are.

I strongly recommend a high pass filter to eliminate unwanted low frequency noise. I used one to cut off below 20Hz, since without it even turning up a volume control produced large excursions.

With regard to sound quality, I think the results are remarkable. It is well extended and clean sounding i.e. no boominess. As it stands the system is small, simple, cheap and effective; with refinement, the design should be capable of excellent results. The loudness is of course limited.

I hope you have found this informative and that it will inspire others.

J.F. Wright
Chorlton,
Manchester.

**REFERENCES**


**Tannoy reply**

Mr Wright's observations on motional feedback very much concur with our own. The Tannoy method is similar in that two voice coils are used, but we were able to use very fine wire for the sense coil, to avoid reducing the efficiency of the driver. We also used a power amplifier with a very high output impedance (current drive), to eliminate voice coil heating effects, known as compression, from the system. The Q is then set by the amount of velocity feedback applied. Differentiating the feedback signal gives us acceleration feedback, so by means of a second feedback loop, it is possible to place the
LF roll-off of the system anywhere you want.

In terms of stability, I agree that having the same BL profiles for the two coils provides a safe solution under overload conditions, but not the ultimate linearity. That's the solution we adopted on the 625 ALF. In terms of the amplifier, you need quite a wide bandwidth, say 5kHz or more for a subwoofer. The system is then made stable by a filter in the feedback loop. 2nd order at 250Hz worked fine in our case. We also found it was wise to use a d.c. servo on the power amplifier to avoid drift.

To get the best from such a system, it is our belief that the loudspeaker should operate under current drive, to give further improvements in linearity. The information here is from a lecture on the subject I recently presented at Essex University, as part of a short course in Audio Systems Engineering. It represents a distillation of much of the work I have done in the field.

Dr Paul Mills
Chief Engineer,
Tannoy Ltd.

THEORY & PRACTICE
by Noel Keywood and Andy Grove.

With Motional Feedback we are attempting to force the loudspeaker cone to follow the input signal to the system. This can, potentially, eliminate a wide range of loudspeaker evils, making it a very attractive prospect. The considerable distortions of cone/box loudspeakers can be suppressed, box resonance effects can be suppressed, box size and Thiele-Small parameters can be lessened in impact and importance and time-domain effects, like overhang, can be eliminated.

In effect we are forcing the speaker cone to follow the signal applied, giving perfect bass reproduction (M.F. can be full range, but this adds extra complication). But when you force a system to act beyond its "natural" parameters, it becomes highly stressed. This is another reason why M.F. tends to self-destruct. It demands use of a strong drive unit, driven by power amplifiers incapable of destroying it, all guarded by protection circuits. The low frequency limit is best kept sane (20Hz-30Hz) to curb excessive cone excursion.

The easiest way of deriving a feedback signal is to wind a sensing coil on the drive coil former, which will produce an output from movement in the magnetic field.

Audax make two drive units with twin drive coils that are closely spaced. They are electrically isolated from each other too.

Output from a feedback coil can swing from +90degrees to -90degrees around resonance, so whilst the system remains stable, the amount of feedback that can be applied is limited by this behaviour. For this reason it is common to employ an all-direct coupled power amplifier, plus d.c. servo feedback to set its low frequency limit and maintain d.c. stability.

Sound pressure level is related to cone acceleration, so a flat response loudspeaker is a "constant acceleration" device. However, feedback taken directly from a sensing coil is velocity related, producing a constant velocity characteristic where bass rolls off at -6dB/octave. To restore conditions, feedback related to acceleration must be applied (alone or simultaneously), which in practical terms means feedback must be reduced at -6dB/octave with decreasing frequency. However, this too will introduce a 90degree phase shift, again limiting feedback and influencing stability. To maintain the stability margin, velocity feedback and pre-equalisation can be used, a scheme Mr Wright adopts.

Finally, Dr Paul Mills, Chief Engineer at Tannoy, suggests that a current drive (transconductance) amplifier possessing high output impedance is preferable to a conventional voltage drive amplifier with low output impedance, when Motional Feedback can be used to suppress low frequency resonance. Either will work, however, so this discussion is a little outside the brief of our look at the unique problems raised by applying Motional Feedback.

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<th>AUDAX DUAL VOICE COIL DRIVE UNITS</th>
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A block diagram of Tannoy's prototype motional feedback system.
D.I.Y. Letters

LOUDSPEAKER GAMBLE

Thank you, Noel and Dominic for the valuable advice you offered at the Scottish Hi-Fi Show last year. I have been very unsatisfied with budget offerings on the market and, as a result, I have built a pair of speakers based on KLS-1.

The open baffled midrange/closed box bass 3-way speaker is a very appealing design approach. To suit, I chose the Scanspeak D2010B tweeter, kept the MW 114-S with labyrinth and RCF L10P10-1 bass unit for a smaller enclosure.

Unfortunately, the gamble I was banking on, that is stumbling on a suitable crossover through months of relentless tweaking, hasn't quite paid off.

The bass unit does not seem half as sensitive as the specifications led me to believe, I've had to attenuate the midrange to match the bass (Tannoy 607mk II as reference). There also is an uncomfortable difference in bass weight from track to track, due to an almost non-existent upper bass. Playing around with positioning does not do much but changing to the sealed midrange enclosure helps. This may be partly due to the porous dustcap of the bass unit which is recommended for use only in sealed enclosures, by the supplier. Crossovers are also not as smooth as they could be. Could you recommend changes to solve these problems?

James Kebuchi
Loughborough, Leicestershire.

Even though you have supplied a lot of details about your design, we can still only offer guidance rather than definitive advice. As a starting point I'd use the crossover we designed for the MW114-S, so at least one part of your loudspeaker is producing a known result. This should give you a flat response from 200Hz to 6kHz or so. Try listening just to this driver on its own; it should give an even and balanced sound.

For the bass end it looks as though you've set the crossover point too high. Try increasing the inductor to 9mH and reduce the capacitor to 70µF; this should set the crossover closer to the desired 200Hz.

Your box alignment of 30litres or so looks about right, giving a predicted lift of around 2dB at 100Hz and rolling off at -3dB at 50Hz. This should give quite strong bass, so I suspect that you are being fooled by the effects of the crossover.

The information I have given you can only be used as a rough guideline. You really do need to get hold of some measuring equipment, like Liberty's IMP for example. DB

NOISY 300B?

I am interested in your 300B amplifier design, but I have a few questions about the performance data. You say the hum level is -72dB and I find this rather high. Are the heaters of the 300Bs fed with AC? If so why can't they have stabilised 5 volt heaters as this can easily be done with modern ICs.

You mention a rather limited treble response of 18kHz. I see no obvious reason why this cannot be changed to at least 25kHz as you state yourself that very expensive output transformers are used in this design.

Do you know about the Dutch Vanderveen toroid output transformers? I have heard they are amazing everyone with their incredible band response from 1Hz to over 100kHz at very low distortion and no phase shift. The prices are very reasonable. It seems the whole concept is very special, maybe you could make an article over these.

De Schamphelaere JM.
Ghent, Belgium.

Stabilising A.C. heater volts will not affect hum. If you are suggesting we use D.C., it can be done, but then...
heater life is shortened, due to migration from the positive end of the filament. It's not an issue with low cost valves, but it can be for anyone who wants to use, say, original 300Bs, which may cost £200-£300 each.

Alternatives are to use D.C. and switch polarity regularly, or use high frequency A.C. (i.e. above 20kHz), but both are complex. Since 300B heaters consume 1.2A, 5A total is required for four valves, which limits options. We use hum bucking and this results in adequately low hum; it isn't an issue.

No audio output transformer usefully works from 1Hz to 100kHz. It may pass a signal at these extremes, but it will not pass power (>5W) or have a flat response. That such a claim is made strikes me as frivolous.

The bandwidth of our 300B circuit gives a good measured performance without using any feedback, and using a minimum of components. It is an elegant and effective circuit. Making something ever more complex adds to expense and can subtract from sound quality.

The toroidal vs laminated transformer chestnut (donut!) again? Because the toroidal transformer is like a long winding with it's ends joined it should be possible to achieve a very low leakage inductance. As toroids are available in better materials such as M5 and M4, better low frequency performance should also be possible.

But, because of the shape nowhere to put the wire! So there is the problem. You only get a teensy bit of iron in your toroidal transformer unless you make it super big, then the physical size affects HF performance. This is a Cutch 22, just like that suffered by a laminated transformer.

Also, with a toroid the weeny core cross section won't stand for any DC offset current caused by valve imbalances. Probably the best solution is a C core transformer with its dimensions specified to suit a particular application. Also, an air gap would control permeability and then we might end up with something better. It would also be expensive. AG

MEASURING IMPEDANCE

I have made a loudspeaker and wish to do an impedance curve for it. I have an audio frequency generator and a multimeter. Could you please tell me what I need and give me the circuit to carry this out.

Stephen Dudley
London.

It may be possible to measure impedance with the equipment you have, but it will depend on the specifications of your meter. You will need to be able to measure AC current and RMS voltage level accurately.

First you will need to connect your audio generator to a power amplifier, preferably something with quite high feedback and good current delivery so that it is not affected by the load. I'd make measurements at the following points: 10Hz, 20Hz, 50Hz, 100Hz, 200Hz, 500Hz, 1kHz, 2kHz, 5kHz, 10kHz, 20kHz and plot the results on log graph paper drawing a smooth line.

at 3V, you can connect your multimeter in series between the +ve loudspeaker cable and the +ve terminal on the loudspeaker. With the meter set to read AC current, expect to see around 200-500mA. Divide voltage by current to find the impedance at that particular frequency and mark the point on your graph. Repeat this procedure for every point above.

If your meter is accurate, you should get a very reasonable result. The other option would be to invest in a system like Liberty's IMP. This is a software/hardware system for the PC that will enable you to measure frequency response, impedance, sensitivity and a whole lot more. It is very accurate and much faster than plotting the results by hand. Contact Marton Music on Tel: 01282 773198 for further information.

DB
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