# TRK – The Rhythm King *(Part 1)*

MARTIN COLLOMS PRESENTS A RADICAL NEW BMR-BASED KIT LOUDSPEAKER, DESIGNED WITH CHRISTIEN ELLIS AND MILES O'CARROLL FOR THE HI-FI CRITIC READERSHIP

Leaf through a 1958 copy of the *Hi-Fi Yearbook* and you'll find a chapter headed 'Speakers & Enclosures'. Then follows a 12 page section on what we now call 'raw drive units', 11 pages on 'enclosures' and a bit more than a page on crossover networks. Back then, 'loudspeaker systems' were the exception rather than the rule, and although some would buy enclosures, drivers and crossovers separately, others took satisfaction in exercising their carpentry skills by building their own boxes to house the active bits.

DIY speaker building remained popular well into the 1970s, but enthusiasm for the genre steadily waned thereafter, and the 'roll your own' approach seems to have been in virtual hibernation for many years. However, as hi-fi moves away from the consumer mainstream and back to its hobbyist roots, and as the internet dramatically expands global communications, so interest in DIY speakers has seen a revival

Today, a huge diversity of designs has been published on the web, and the amateur speaker building fraternity demonstrates a wide range of ambition and achievement. Indeed, some can put many commercial products to shame: for example, the dynamically impressive multi-way and actively-driven horns by Jack Bouska (http://jgbouska.tripod.com/audio/), or the subtly voiced and carefully worked examples by the versatile Tony Gee (see www.humblehomemadehifi.com, or his article on loudspeaker voicing in *HIFICRITIC Vol4 No2*).

So what can the resources of this publication offer the home constructor? Independent electroacoustic designer Christien Ellis and I examined the possibilities some months ago, and agreed on certain elements which would create something a little different, with qualities not available from established solutions. We were then joined by Miles O'Carroll, who undertook the industrial design and construction drawings.

While more resourceful home constructors will always find the components they need, we felt that a single source of supply for all the components would be useful and also help ensure consistent performance in the end result. There's little point in designing and voicing to a good standard if no clear and reliable route is provided for putting together the correct ingredients.

Well established kit supplier Wilmslow Audio has agreed to supply the various components, and we also arranged for it to be the approved and exclusive source for that difficult to obtain 'full-range' BMR (balanced mode radiator) drive unit from Cotswold Sound Systems. (This driver unit is normally only available as an OEM design for speaker manufacturers.)

We decided that the bass quality of the *TRK* ought to be rather better than that which is normally encountered, with good consistency, low distortion, low coloration and a tolerance of room placement. It would therefore use sealed-box loading, with low group delay and thus potentially good rhythm. There's no room here for those commercially popular, undersized, overcooked reflex-ported designs, where the bass is all too often dependent on loudness and programme content.

**The BMR mid/treble unit**

For the mid and treble we wanted to explore a patented BMR new-technology full-range planar unit, invented by British engineers Bank and Harris. In 85mm form this is well suited to small, low powered full-range systems, but it also has a role as a powerful, single acoustic source mid/treble driver.

The 'balanced mode radiator' (BMR) typically describes a fairly rigid, flat, circular diaphragm that is pistonic at lower frequencies, but which has a small number of inevitable, predictable yet allowed circumferential bending resonant modes. In a cone driver, such resonances are generally regarded as faults, and are called 'breakup', due to the loss of idealised piston-like rigidity, and often result in awkward response peaks with attendant audible coloration. Conversely, with a BMR the few resonant modal radiation components are accurately and dynamically balanced to deliver a substantially uniform axial frequency response, and one which may extend beyond 20kHz, yet with good directivity (*ie* good off-axis responses).

In the *TRK*, the BMR is operated as a wide-range mid/treble driver, which may be crossed over anywhere between 200Hz and 800Hz, a flexibility which greatly assists the design and voicing of the speaker. Furthermore, there is no crossover in the critical presence zone, around 3kHz, where almost all more conventional designs are forced to place it, resulting in that awkward changeover of power feed between the loudspeaker drivers, *eg* from the midrange or the bass/mid unit to the tweeter, in a part of the audio frequency range where the ear is most sensitive.

While this promised continuity through the audibly critical 3kHz zone is a certainly an advantage, we actually believe that the specific appeal of the BMR driver lies in its operating principle. It uses a direct-coupled, single voice-coil, with a planar

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diaphragm which is naturally free from a resonant cavity, and works more or less without a break in energy response over nearly 5 octaves. It provides an intrinsically very time-coherent response, and if handled well, potentially high transparency, judging by our listening tests.

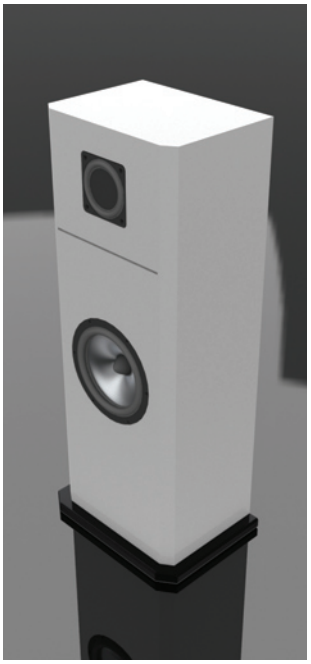
There is little choice amongst BMR driver types as yet, so we are using an 85mm CSS driver type *BMR85DD/4*, designed by Bank and made under license by Tymphany. The natural sensitivity in this class of system is a modest 86dB SPL (give or take a dB or so), and this sets the stage for the rest of the design. This rather modest sensitivity figure defines the bass design or alignment, which for our chosen sealed-box, infinite baffle type allows for a very powerful, medium sensitivity bass driver with a very long cone throw or excursion, which gives useful low frequency extension. An extended bass system design target of 33Hz, -3dB was set for room-loaded conditions.

## Design work

The intention was to voice the system for a natural sound balance that works well with both classical and rock program; to reveal plenty of detail; and to have good timing with superior rhythm and listener involvement. Christien undertook several stages of electroacoustic modelling, using *Akabak* (http://www.randteam.de/AkAbak/Index.html) and *LSPCAD* (*www.ijdata.com/*) software suites. He also guided the choice of suitable bass driver and assisted in the balancing. Auditioning and balancing was carried out at Christien's facility, which includes a good wall location arrangement, and at my listening rooms in London.

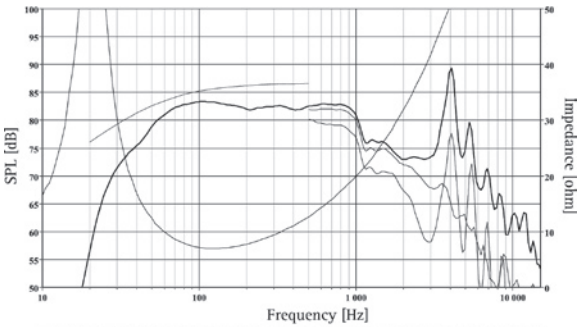
## The Bass Unit

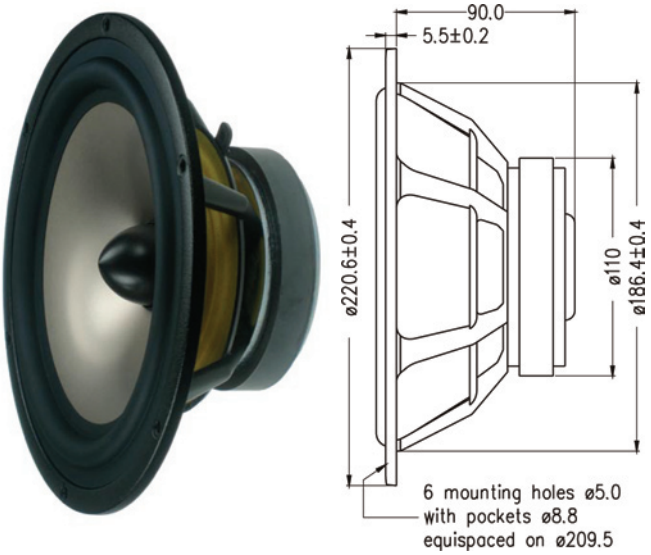
Both 8in and 10in low frequency drivers were modelled. These needed to match the low coloration and linear phase standard set by the BMR unit, and ideally operate pistonically across the chosen working range. A number of bass drivers were considered, including classic units from ScanSpeak, Peerless and Volt. There was also an option to use custom Rega drivers. This selection process was based on key Thiele/Small parameters such as Qt (the total Q factor), Md (the moving mass), and also the linear throw. Towards the end of the process, two SEAS units became available, built on cast chassis', with a long linear throw of 14mm (21mm max) and just the right combination of very low Qt (0.27), a low system Qm for low loss and good timing, appropriate sensitivity, and the desired 8ohm impedance (6.1ohm DC). They also have a very low 21Hz free air resonance, all of which makes them ideal for our chosen sealed-box alignment. [In fact the theoretical Qb for the overall system is a target, critically damped (*ie* no bass overshoot) value, of just under 0.5.] Taking into account diaphragm depth, enclosure volume, width, diaphragm size and directivity issues for the two available versions, the 8in (220mm chassis) type *L22RN4X/P* seemed ideal; modelling indicated this should produce nearly as high a bass output level as the 10in. (A 10in version of this driver is used in the Wilson Audio *Sophia 3*, which is capable of prodigious bass power for its size.)



The SEAS cone is a curvilinear alloy of magnesium and aluminium using a proprietary thin-wall casting method. Its first resonance mode is deferred to a high 4kHz, well beyond our target crossover point. Rising a moderate 7dB above the mean level, that mild peak is addressed by a notch filter of modest Q, as is usually done with such alloy cone drivers. While such peaks may appear to be buried in the overall frequency response once the crossover is installed, critical listeners can sometimes hear some residual signature and a simple notch filter set at the response peak then chases it down to inaudibility.

Frequency Response



**Contact:**
**Wilmslow Audio**
**www.wilmslow-audio.co.uk**
**Tel: 01455 286603**

### The Crossover

We decided to position the crossover network externally. While there is no particular difficulty in locating it conventionally internally, there are also good arguments for keeping it separate. The most compelling is that an external crossover provides easy access for fine-tuning after assembly, to compensate for any small production tolerance differences between the drive units. Accurate pair matching is significant for sharp stereo focus, and the experienced constructor may make adjustments to maximise performance at two stages during the build of the speaker, though this should not be done until the speaker has had 50 hours or more of running in.

Besides facilitating fine-tuning, an external crossover is spared the electromagnetic fields and vibrations of the drivers and enclosure, modestly increasing dynamics and clarity. Subsequent changes, alternative crossovers and component choices may also be readily compared. If a constructor wishes to 'go active', the transfer functions of the crossover as connected to the system are readily obtained and the required connections to the amplifiers are easily accomplished.

The crossover is not based on 'by the book' standard formulae, but is specifically synthesised to take account of enclosure diffraction and intrinsic driver responses, to achieve optimum integration of the overall acoustic output in the room locations. This procedure matters far more than considerations of crossover component type. Once well under way, tonal balance and clarity may be fine tuned with superior components, taking care that the overall balance of the system is not disturbed. That said, good electrical connections are worth more than costly capacitors. The crossover alignment is essentially third-order, tweaked for the smoothest phase and power response given the optimally connected driver phase for best integration. Incidentally, we consider that a perfect response on one axis is fallacy. Ideally, well matched and balanced responses over a wide range of axes is required.

The *TRK* is designed to be positioned with its back to a wall, so the design axis for the frequency response is about 10 degrees laterally off-axis (*ie* in the listener direction). Because the BMR's radiation pattern is axi-symmetric, the system is not critical of exact height, though there will be the usual path differences between the vertically separated drivers, so a listener on a higher seat will be a little nearer the mid/treble axis and the speaker will sound relatively brighter, and vice versa. Our off-axis optimum design target also helps performance by reducing the influence of the on-axis diffraction signature on the perceived sound.

### Enclosure and Wiring

Some 35 litres internal enclosure volume seemed about right for a speaker of reasonable size and this resolved to a floorstanding enclosure that's 33cm wide, 25cm deep and 90cm high, and intended to be placed at or near the wall boundary. Moderate anti-diffraction facets are chamfered from the front-edge sides, and a rigid 25mm HDF base increases the stability footprint and provides a firm lock for the floor-coupling hardware.

Cotswold Sound Systems

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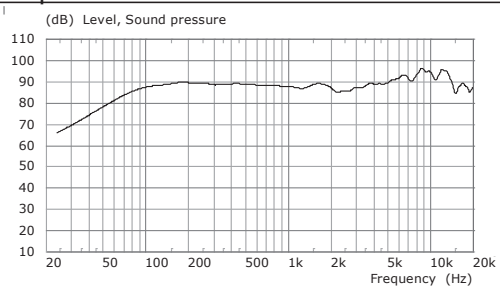
Specification Sheet — BMR85DD – 4½ inch – 4ohm

| T/S parameter | value | unit |
|---|---|---|
| Re | 4.14 | ohm |
| Le | 0.075 | mH |
| Re2 | 4.67 | ohm |
| Le2 | 0.112 | mH |
| Bl | 4.772 | Tm |
| Mms | 7.545 | gm |
| Cms | 0.297 | mm/N |
| Vas | 1.472 | litre |
| Rms | 0.65 | Ns/m |
| fs | 106.32 | Hz |
| Qms | 7.254 | |
| Qes | 1.003 | |
| Qts | 0.848 | |
| Sd | 59.5 | $cm^2$ |
| Max. excursion (pk-pk) | 12 | mm |
| Power handling (IEC268-5) | 20 | W |

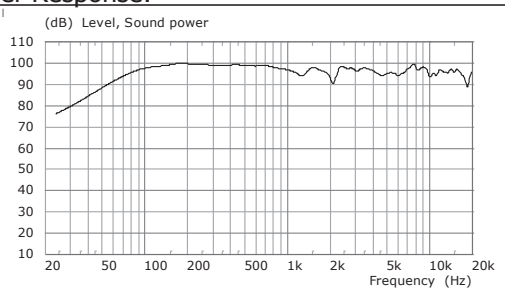
Features

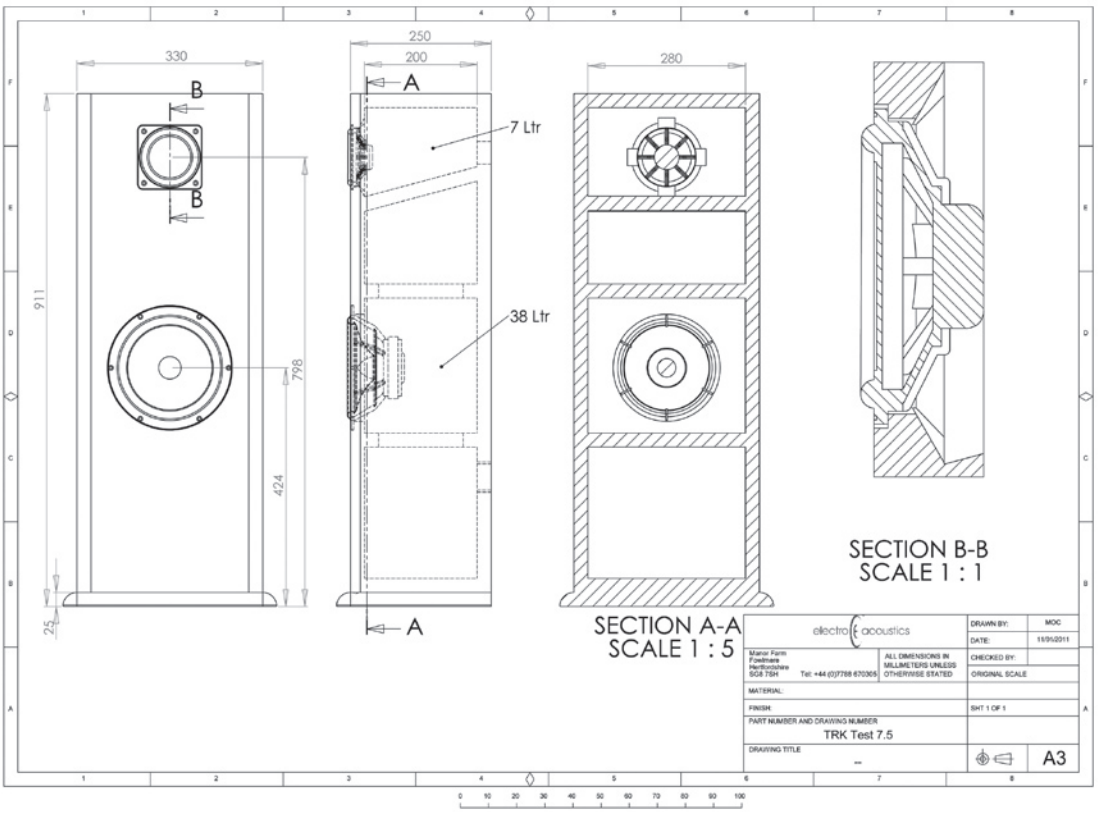
- **Dual Drive BMR, Internationally Patented Technology**
- **Black finish, with chassis moulded in Engineering Grade plastic**
- **High temperature magnets, with full magnetic shielding**
- **Overall dimensions:** 112 mm x 112 mm x 39 mm deep (43.4 mm deep inc. surround)
- **Weight:** 225 gm

Frequency Response: 2.83volts/1m




Sound Power Response: (calculated)






To ensure minimal coloration we've adopted a deliberately cautious approach to the enclosure construction, by using 25mm HDF with extensive bracing. The bass driver is located at about 0.55 of the effective internal height, to minimise excitation of the vertical pipe mode, potentially the dominant acoustic interaction for this driver.

The mid/treble BMR unit has its own part-tapered, lightly damped enclosure, which also has controlled venting. This is not to increase the low frequency response, but rather it provides some compensation, *via* a controlled vent or leak, for the enveloping low frequency pressure field from the bass driver. This should improve clarity by reducing unwanted cone excursion at low frequencies, which will otherwise mildly intermodulate with the midrange.

The drivers are physically quite robust, so there's no need for a grille and its attendant losses. (The defects of these devices are easily measured, and include unwanted sympathetic vibration, diffraction, plus high frequency attenuation.) The constructor may of course add one if desired, or drag a lightweight woven polyester 'stocking' over the whole lot, and tuck this under the the enclosure as the base plate is bolted on.

DNM has agreed to supply approved wiring looms and umbilical cables from its well respected *Precision* range of single strand copper cables, factory terminated and following multi-contact 4mm connector practice. This provision helps to control yet another variable, and will deliver helpful colour coding for the assembly.

*(Part 2 will cover the detailed design and voicing, release the plans and notify availability from the supplier. Note: pricing is estimated at this stage.)*

**HIFICRITIC Loudspeaker in kit form**

| | |
|---|---|
| Model | The Rhythm King |
| Size (w x h x d) | 90 x 33 x 24cm |
| Weight | 27kg (est) |
| Type | Two-driver, two-way, infinite baffle |
| Bass driver | 1x 220mm unit with cast alloy cone |
| Mid/treble driver | 1x 85mm BMR planar driver |
| Sensitivity for 2.83V | 86.5dB @ 2.83V |
| Amplifier loading | 8ohms nominal, 6.2 ohm min |
| Frequency response, axial | 40Hz - 22kHz +/-3 dB (listener axis) |
| Frequency Response, off-axis | Good power response |
| Bass extension | 33Hz for -3dB wall boundary matched |
| Max loudness | 105dBA for a stereo pair in-room |
| Power rating | 25 to 150W |
| Placement | Floor standing, near to wall |
| Prices | Est. £950/pair kit with flat-pack enclosure<br>Est. £1,250/kit with factory built veneered enclosure |

**Christien Ellis**
Developing a fascination for sound from a very early age, Christien Ellis took a BEng at the University of Westminster followed by an MSc in Acoustics at South Bank University. At NXT he developed new loudspeaker technologies, and was cited as co-inventor on several patents. In recent years Christien has operated his independent design consultancy, CE Electro-Acoustics (www.christienellis.co.uk).

**Miles O'Carroll**
O'Carroll is an audio enthusiast and design engineer who has worked in R&D for several Hi-fi manufacturers, including IAG (Wharfedale and Quad), NXT, and most recently as a mechanical design engineer at Arcam. He currently undertakes freelance projects for a diverse range of clients. (milesocarroll@hotmail.com)