

CLEAN & FAST!

GARY HOLLAND DESIGNS A COMPACT, SENSITIVE NEAR-WALL LOUDSPEAKER THAT SUITS BOTH VALVE AND TRANSISTOR AMPLIFIERS.



With KLS-14 we set out to design a compact loudspeaker that will work happily in most environments and with all types of amplifiers. In particular, it must be suited to valve amplifiers.

Designing a loudspeaker to work with both valve and semiconductor amplifiers raises several extra considerations. The output impedance of valve amplifiers is higher and the output power lower than their semiconductor counterparts. Consequently, a loudspeaker designed for valve amps must first of all be sensitive, and secondly present a friendly load impedance with as little reactance as possible to minimise risk of audible coloration. Happily, there are no trade-offs here. Solid-state amplifiers also prefer a friendly load and give a better performance too, so it's a worthwhile design aim.

Good sensitivity and even load impedance are just two of the requirements for our loudspeaker design. The others are as follows:

- 1) Compact but with good bass extension.
- 2) Room friendly; can be used close to walls.
- 3) Sounds good with semiconductor amps and valve amps.
- 4) Straightforward to build.

A Butterworth alignment is usually considered optimal for bass rolloff, but a higher target Q of around 1 was chosen to give a peak in the bass response. This will give the loudspeaker's bass a touch of slam and it will still sound good working away from walls.

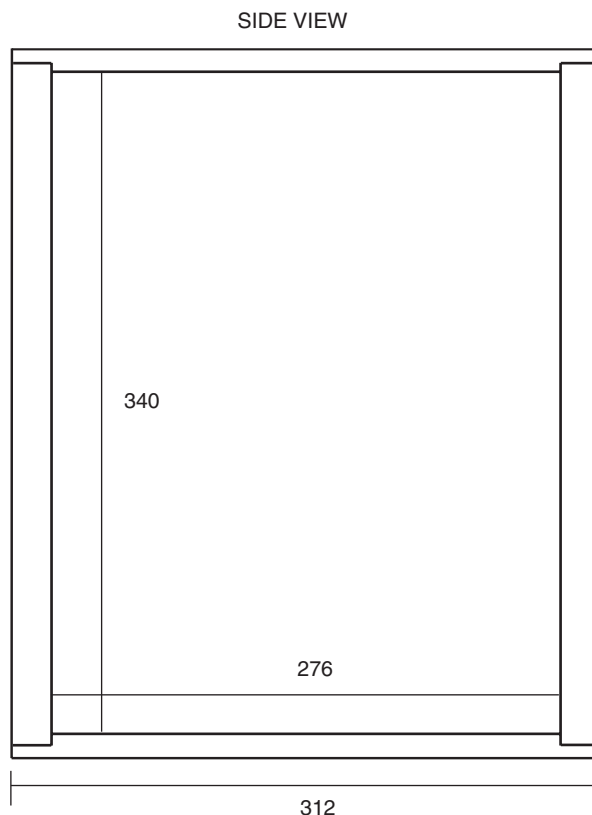
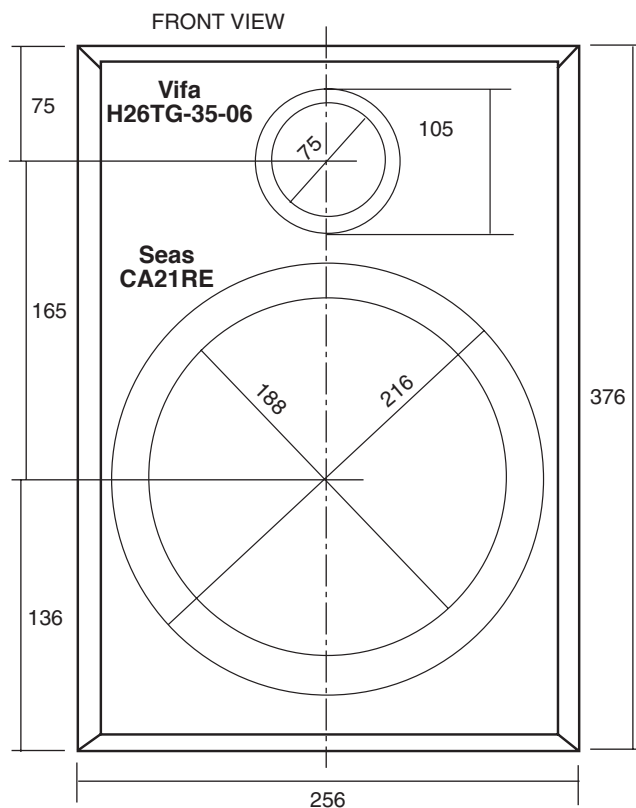
The next step is to find a bass unit that will work in the chosen cabinet. It has to be sensitive (powerful magnet and efficient motor) and well controlled in its working range, and also have electrical and mechanical parameters suitable for closed box working. These include a long voice coil travel because, unlike reflex loading, coil excursion in a sealed box design increases at system resonance. A higher Q unit is also needed for closed box systems to prevent over-

damping the bass.

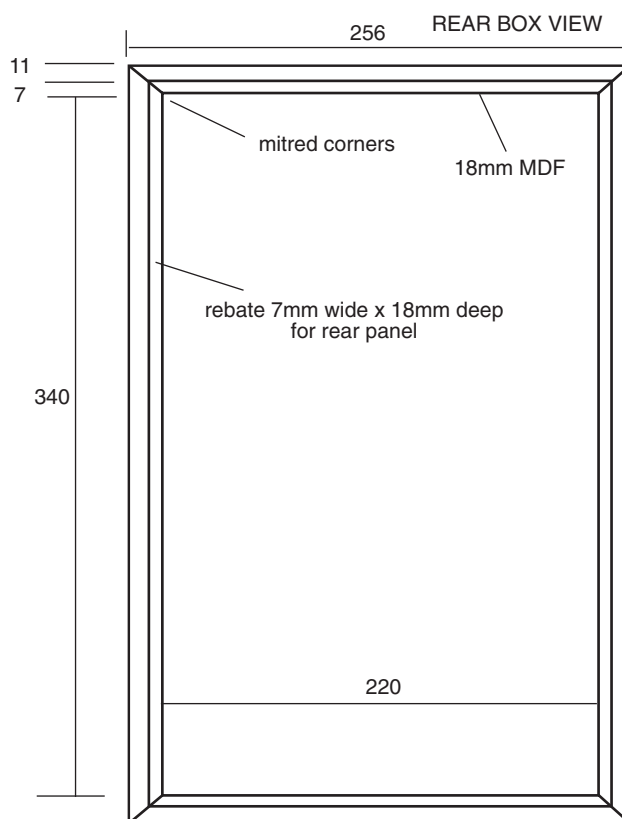
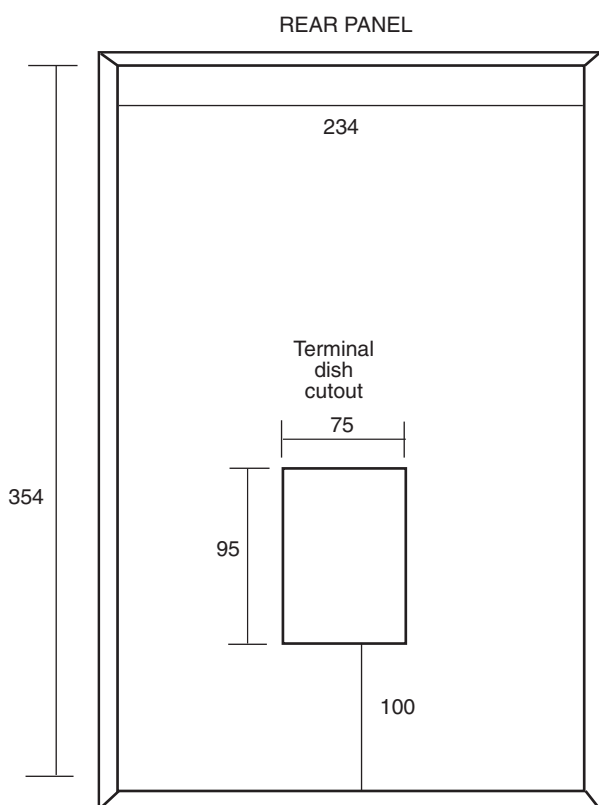
The first decision to make is what type of cabinet system should be used, reflex or sealed box? While reflex designs offer deep bass, they can suffer with pipe resonances that extend right up into the midrange. This spurious noise can be as much as -10 dB below the main output, adding noticeable coloration. The problem of port resonances can be overcome, but at the expense of greater complexity, this design must be as straight forward as possible. I also want to exploit the lucid midrange that is one of the great strengths of valve amplifiers. Bass extension for a closed box design is not a great problem as long as the right drive unit/box combination and alignment is chosen. For the optimum choice between compactness and bass extension I chose 20 litres for the cabinet volume.'

After some searching an 8 inch unit from Seas emerged. It has a doped paper cone with a low loss rubber surround mounted on a low resonance magnesium chassis. A large diameter

feature



ALL DIMENSIONS IN mm



voice coil with a 'T' cut pole piece ensures high power handling and low distortion.

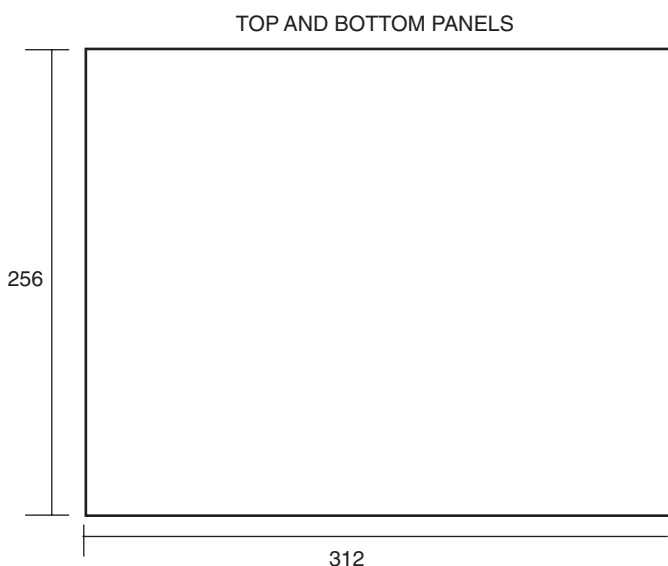
Finally we need a tweeter. It has to be sensitive but also smooth and detailed to reflect the properties of valve amplifiers. There are also the additional requirements of greater directivity to reduce reflections when working close to walls and a low resonance so that the bass unit can be rolled off as early as possible. This gives

the benefit of a more cohesive off-axis response. The winning tweeter in this case is the Vifa H26TG-35-06, a 26 mm fabric dome unit. It's a horn loaded tweeter with 95 dB sensitivity; the horn loading not only increases sensitivity but also limits off-axis output. To achieve a low resonance this unit has a rear chamber added which drops the resonant frequency from 1500 Hz of the standard

tweeter to 940 Hz with the H26TG-35-06.

CABINET CHOICE

The parameters of the Seas unit show that it will work in a box size of 15 to 25 litres. A size of 20 litres gives the best compromise between damping and bass extension. It also provides the slight peaking at the bass roll off point we



NOTES

Materials are to be 18mm MDF.

Sides and top panels mitre joined.

Front and back panels drop into rebates to lie flush with side and top panels.

Front edges to have 1/4 round bevel.

External dimensions

Height = 376mm.

Width = 256mm.

Depth = 312 mm.

Internal dimensions

Height = 340mm

Depth = 276mm.

Width = 220mm

Gross internal volume = 20.6 litres

require to add a little solidity to the bass.

Trying to dimension the cabinet to suit a golden ratio in this case is difficult given the drive unit sizes and the target volume of the box. Instead, the priority here is to go for a baffle size as small as possible to reduce its influence on the overall response and enhance the imaging ability of the KLS 14. The downside is that a couple of the dimensions are close enough together to give potential problems with standing waves. These problems are easily dealt with through the use of good strategic bracing to break up the standing waves and generous wadding to absorb them.

With the cabinets built the first thing to check is that the bass unit performs as expected. Measuring the nearfield response reveals that the predicted response is nearly spot on - see Graph 1 showing LEAP and LMS plots comparing simulated and real measurements on p10. Now we can move on to designing the cross over.

CROSSOVER

We've now selected the cabinet and drive units according to our design aims. They have to be integrated into something that sounds good by the crossover network.

There's a lot to bear in mind when designing crossovers. It's rarely possible to achieve good results using text book formulas alone. This is because of the infinite variations of baffle sizes and dimensions, the relative positions of drive units and so on, as well as the complex impedances of the individual drive units. It must be borne in mind that the baffle and ports also become radiating elements and contribute to the overall system response.

The response of the Seas unit rises with frequency and under measurement looked increasingly ragged above 1.5 kHz due to cone break-up and directivity. On axis the frequency response extends out to 4 kHz but off-axis dies away after about 2 kHz. Ideally, for a smooth off-axis response and consistent behaviour close to reflective walls the place for the

crossover point is around 1 kHz, but will the tweeter permit this?

At the low end the H26TG-35-06 presents a gentle and smooth roll off, aided by optimised ferrofluid damping. The response is quite flat to 8kHz where there is evidence of phase loss. After this there is a resonant peak at about 15 kHz.

Generally, it's not advisable to place the crossover point for a tweeter closer than an octave away from its resonance due to power handling restraints and the increase in distortion at higher power levels. This leaves us with about -3dB at 2 kHz as the lowest point for the treble unit. So, 2 kHz is the target crossover point, but what type of crossover rate do we need?

A 2nd order network offered the best compromise. The fast, natural sound of a 1st order network has the disadvantage of allowing too much out-of-band driver output.

The other possible choice is a 3rd order

network, which would give better integration, but at the cost of slightly degraded transient response and greater complexity, which may blur detail.

In this design, to reduce the rise in response of the Seas unit in its upper frequencies the crossover is damped with a resistor in series with the shunt capacitor. This has the effect of damping the knee of the slope and allowing a gentler roll off. The cost is slightly increased out-of-band driver output - see Graph 2 showing the individual response of bass and treble sections on p10.

MEASURED PERFORMANCE

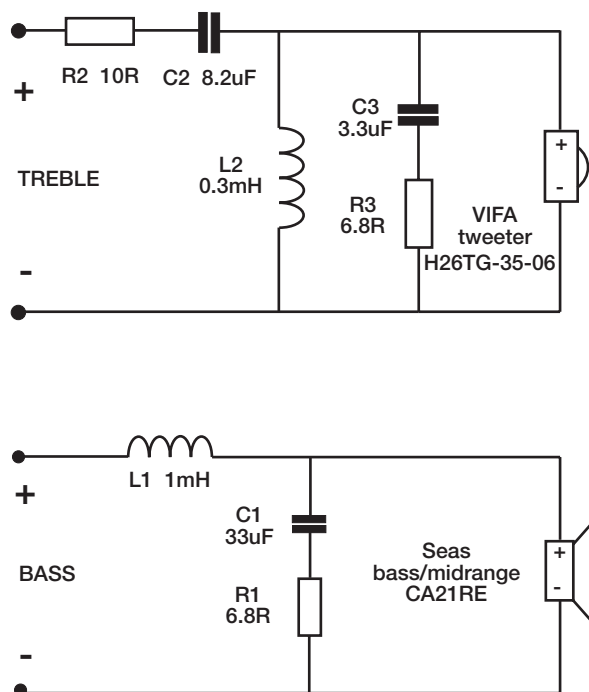
The on-axis frequency response at 1 metre shows KLS-14 stays within ± 3 dB limits from 50 Hz - 18 kHz.

Nearfield measurement at low frequencies reveals slight peaking of the upper bass before roll off, confirming that the target response has been achieved.

CROSSOVER

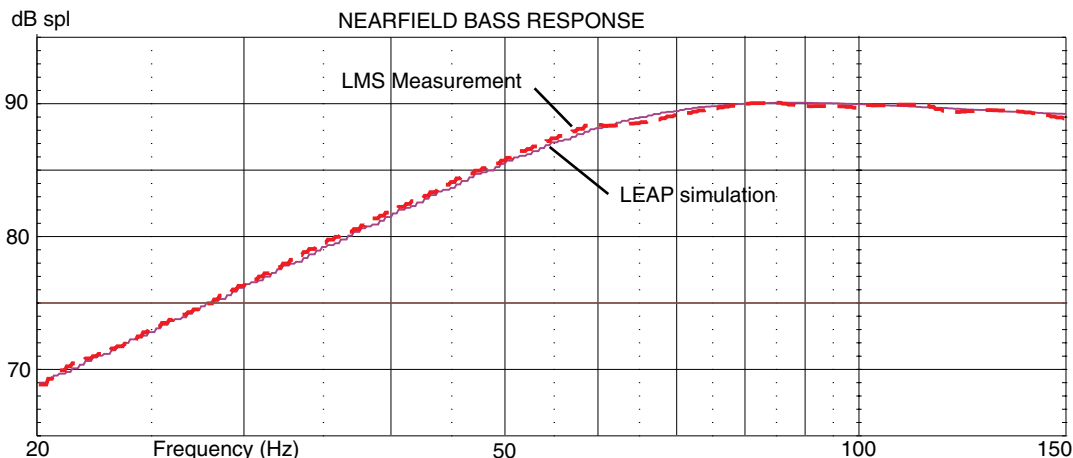
The treble unit is fed from a second order high pass section (C2, L2) and the tweeter has impedance compensation (C3, R3).

The bass unit is fed from a second order low pass section (L1, C1) with damping by R1.



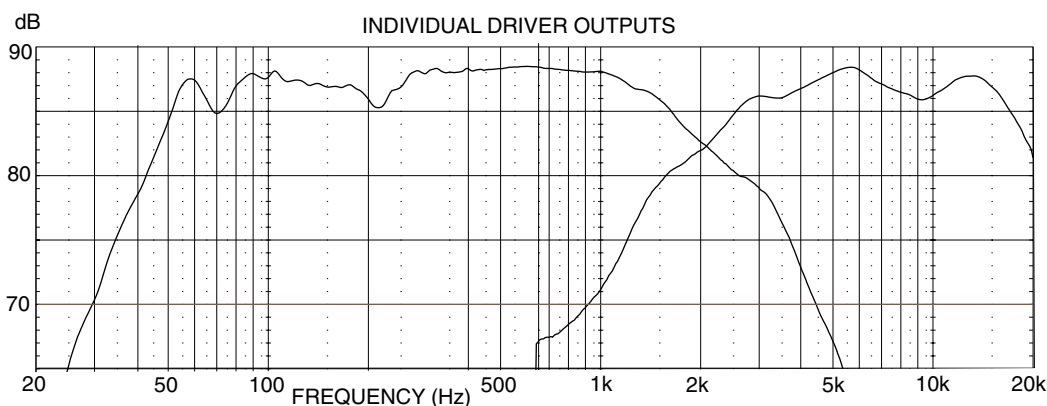
MEASURED PERFORMANCE

GRAPH 1



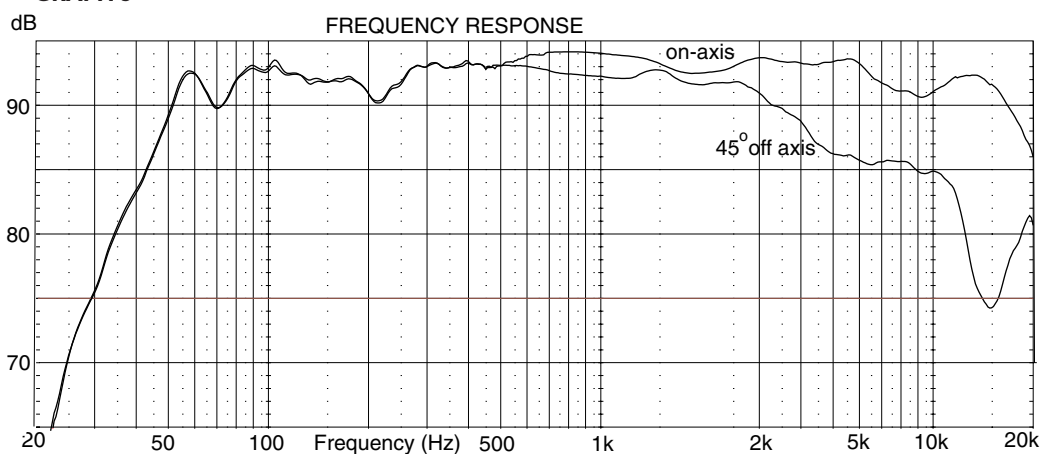
LEAP design software predicted a well damped bass response rolling off smoothly below 55Hz (-3dB). Nearfield measurement (LMS) showed real life response correlated perfectly. In use wall placement will lift bass level a little.

GRAPH 2



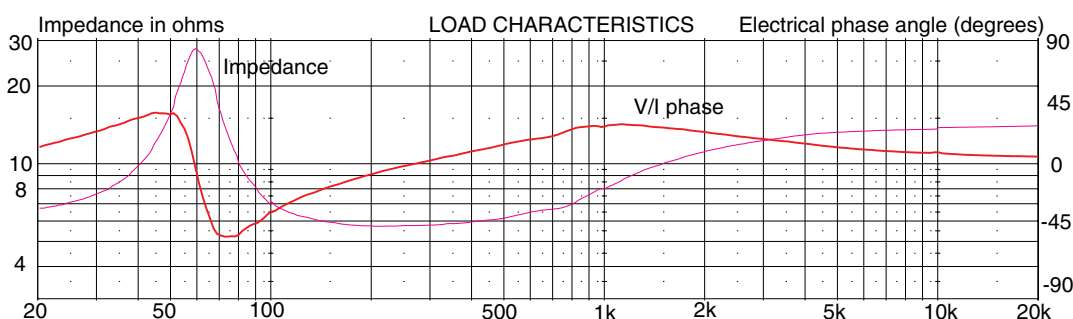
Measured at one metre the individual drivers roll in and out smoothly. It is important that there are no "throw ups" in the roll off region, to avoid colouration.

GRAPH 3



Overall frequency response of KLS-14 at one metre runs evenly from 55Hz up to 18kHz. Because the cabinet is "infinite baffle" bass rolls off less quickly than reflex, so low bass output is substantial for a compact cabinet. The horn tweeter rolls down above 2kHz, when measured off-axis.

GRAPH 4



Impedance of KLS-14 is smooth, demonstrating low reactance (energy storage) and phase angles. The load is resistive where there is no rate of change of impedance (point of inflexion), as this twin trace shows.

PERFORMANCE FIGURES

Frequency response	50Hz - 18 kHz +/- 3dB
Sensitivity	89dB
Nominal impedance	8 ohms
Minimum impedance	5.75 ohms
crossover frequency	2.1 kHz
Rec. amp power	10 - 100 watts

The crossover region has a slight but fairly minor dip, this is due to the bass unit response dropping a little and then continuing its natural roll off. The treble unit takes over in the upper mid/lower treble region and runs quite smoothly up to 8 kHz, then dips a little. The 3dB resonant peak that existed has now been pulled down to the same level as the rest of the treble with the use of a Zobel network across the treble unit - see Graph 3 on p10.

The off-axis response (45degrees) shows the same on-axis trend until the tweeter cuts in. The increase in directivity caused by horn loading shows as falling response above 2 kHz. This means there will be less reflected energy from room walls, floor and ceiling, so conversely direct energy will be in greater proportion. Consequently the speaker will be more tolerant of nearby surfaces. The amount of treble energy in this case can be altered by merely adapting the angle of the speakers - see Graph 3 on p10.

Treble level will sound neutral with a valve amp. However, with brighter sounding semiconductor equipment there may be a need to lower the level, which may be adjusted by varying the value of the resistor R2 in the treble section. A value of 10 ohms sets the output at 88 dB. If the value is increased to 12 ohms the treble output is lowered by 1 dB to 87 dB. Dropping the value to 8.2 ohms increases output to 89 dB.

LOAD IMPEDANCE

As a load KLS-14 is reasonably friendly. The box/driver resonance shows up at 60 Hz with a Q of about 1.0. From here the impedance drops to just under 6 ohms in the mid range area. At around 500 Hz the impedance curve starts climbing and levels out to about 14 ohms in the treble region. Overall there are no dramatic changes for an amplifier to cope with, which means little reactance - see Graph 4 on p10.

CONCLUSION

Nearly all the design goals I set out at the beginning have been achieved in this design. Although the KLS-14 loudspeaker has been

conceived with valve amplifiers in mind, this design aims are equally suited to semiconductor amplifiers. The KLS-14 is easy to build and versatile, and will perform well with almost any amplifier in most normal environments with the minimum of fuss.

Gary Holland is a professional loudspeaker designer acting for companies worldwide.

Using industry standard techniques his work gives readers access to a professional design, as well as showing how commercial designers develop a modern loudspeaker, through theory and all-important measurement.

KLS-14 crossover components.

Bass unit	Seas CA21RE	x1
Treble unit	Vifa H26TG-35-06	x1
Wire	1mm stranded core	x1
Terminals	Bi-wire cup	x1
Wadding	Foam/long hair wool	

* All drive units/terminals to have gaskets *

Inductors

1mH	0.3ohms DCR, 1mm wire	x1
0.3mH	1ohm DCR air core	x1

Capacitors

33mF	50v +/-5% DF 4%	x1
8.2mF	50v +/-5% DF 4%	x1
3.3mF	50v +/-5% DF 4%	x1

Resistors

10 R	10 watt	x1
6.8 R	7 watt	x2

KLS14 Speaker Kit is available as a kit from World Audio Publishing Ltd

	UK (inc. vat & p&p)	Overseas (exc. vat & p&p)
KLS14D Drive unit pack	£125.00	£107.00
KLS14C	£165.00	£140.00
(drive unit pack with crossover etc., but not the wood)		

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