Variomatrix adaptor for System 45J and Matrix H

Phase shift circuit allows Variomatrix to decode Matrix H and System 45J

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Many hi-fi enthusiasts have Sansui Variomatrix decoders, and the present article describes an adaptor suitable for converting the Variomatrix for decoding signals encoded via the NRDC System 45J or BBC Matrix H systems. While such a decoder cannot by psychoacoustically optimal, it does permit existing owners to extend the usefulness of their equipment.

The adaptor essentially does the job of converting the 45J or Matrix H signals into a form which the Variomatrix is designed to handle, i.e. into signals which are good approximations of Regular Matrix signals. The optimum method of conversion is slightly different for these two systems, but fortunately involves in both cases the use of a 58° phase-shift network, so that the circuit is kept fairly simple despite its two-fold function.

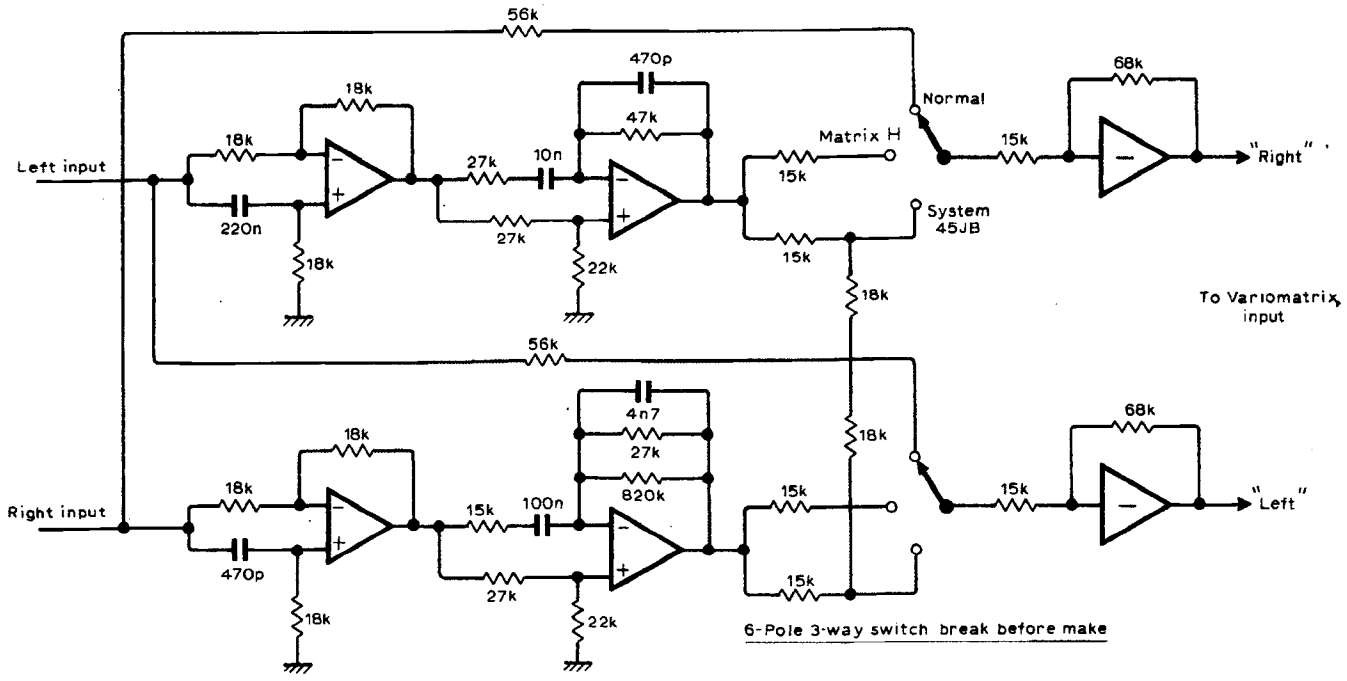
Essentially, the Matrix H adaptor consists of a 58° phase lead put into the right-channel signal relative to the left channel. The System 45J adaptor adds to this a −15dB blend circuit at the outputs of the phase shifters. The six pole phase shifter described gives a 58° shift with ±4° error over the frequency range 44Hz to 17kHz if precision components are used, and so is suitable for use even with a studio-quality Variomatrix. In practice for domestic applications, 5% tolerance components may be used, although the use of 2% resistors will give better results.

The input circuit of the adaptor is shown in Fig. 1. Depending on the quality desired, the operational amplifiers may be 741 types or special audio types. The circuit is designed to offer a fairly high and resistive input impedance (18k or 14k depending on switch position), and gives approximately unity overall gain in all modes. The mode switch offers three positions: normal (i.e. conventional use for stereo and Regular Matrix), Matrix H, and System 45J.

An odd feature of the way the adaptor is connected is that (except in normal mode) all left input signals are fed to the inputs labelled right on the Variomatrix, and vice-versa as shown in Fig. 1. Similarly, all outputs labelled left on the Variomatrix are connected to the corresponding right quadraphonic inputs on the preamplifier, and vice-versa. The reason for the switching shown is to ensure that the left/right interchanging of the Variomatrix inputs and outputs does not occur in the normal switch position, and for this reason, the mode switch is six-pole three-way. Also shown in Fig. 2 is a +2dB gain for the back channel outputs in the System 45J mode only; such a +2dB gain is necessary for best results. However, constructors may omit these gains from the circuit provided that the front/rear balance control of their system is adjusted to give this +2dB rear gain when decoding System 45J.

Owners of Sansui equipment in which the Variomatrix is integrated with the preamplifier and amplifier may not always find it convenient to use the output switching circuitry of Fig. 2, since this would involve breaking into the equipment. For such users, we

Fig. 1. Circuit of pre-Variomatrix adaptor. For best results, components should be 2% tolerance, though 5% should be acceptable.



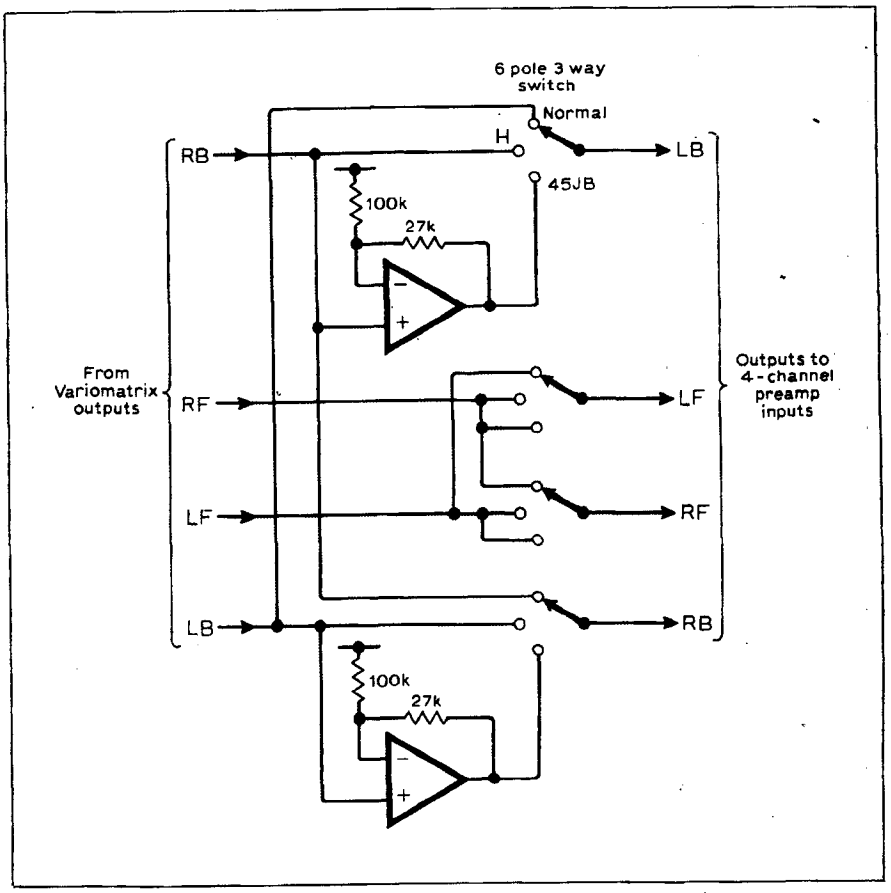


Fig. 2. Post-Variomatrix circuit, includes rear channel switched gain compensation. Resisting 5 or 10% tolerance.

suggest that they use the circuit of Fig. 1, for example in the tape monitoring circuit, but with the following modifications.

Connect the top output of Fig. 1 to the left Variomatrix input (and not the right), and the bottom output of Fig. 1 to the right Variomatrix input (and not the left), and

Feed the two 56kΩ resistors connected to the normal switch position from the left input for the top switch of Fig. 1, and the right input for the bottom switch of Fig. 1.

When used in this way, no left/right interchanging is used, and the switch need only be two-pole three-way. This method of use does not handle "interior encoded" sounds quite so well, but still generally works. For best results with System 45J with this simplified method of use, the front/rear balance control should be set to give +2dB gain to the rear speakers.

The Matrix H switch position will decode existing BMX discs (e.g. the UD-4 discs of Nippon Columbia) with reasonably accurate results, so that in practice the circuit allows decoding of Regular Matrix, Matrix H, System 45J and BMX.

As the author is connected with the NRDC Ambisonic project, in order to avoid possible misunderstandings it is pointed out that the use of a Variomatrix with the adaptor described will not give proper NRDC Ambisonic decoding with optimal psychoacoustic results, but is merely a means of enabling Variomatrix owners to use their existing equipment with some of the newer systems.

Also, the method of using the Variomatrix described is solely the author's responsibility, and neither Sansui Electric Company Ltd nor the BBC would necessarily regard such use as being according to their own recommendations.

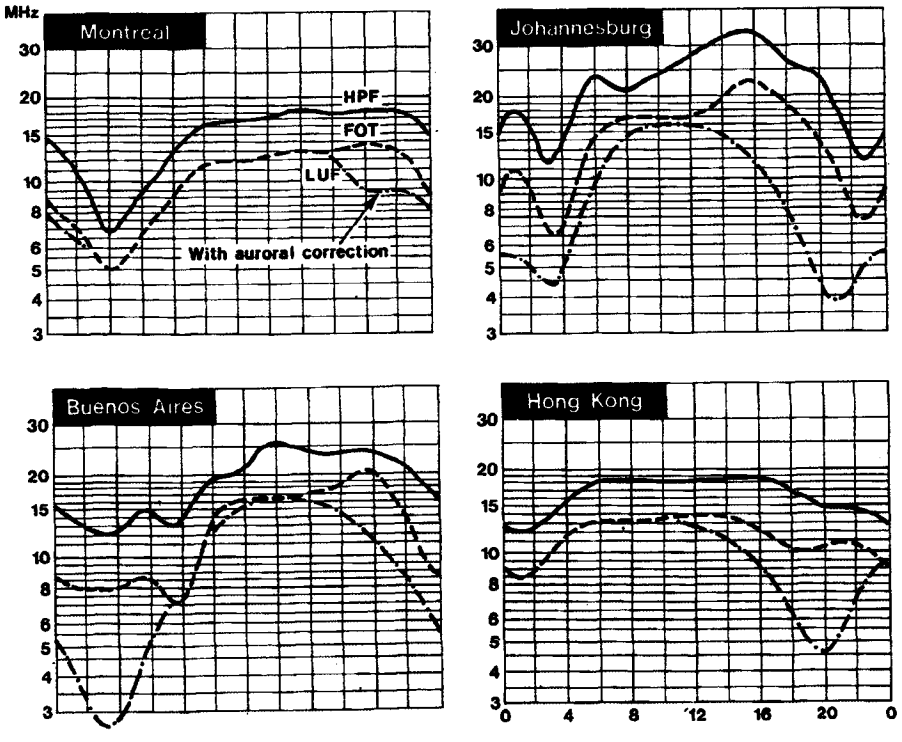
The BBC have applied for a patent (34839/74) on the use of a Variomatrix decoder with a prior phase shifting circuit of about 60°. — Ed.

HF predictions

Ionospheric conditions this month are about the same as they were in 1974 except that solar activity then was decreasing and now is increasing.

Magnetic disturbance is likely to occur over the whole of the second half of the month.

Sporadic E propagation is forecast on at least 20% of the days and should modify the FOT curves as follows: Hong Kong peaking to 21MHz at 10 GMT; Johannesburg rising to 22MHz at 09 GMT and remaining so until 15GMT; Montreal maintaining 10MHz from 23 through 08 GMT; Buenos Aires dip between 06 and 10 GMT smoothed out.



Time scale on right is 2-hour divisions GMT, midnight to midnight.

DECODING BBC MATRIX 'H'

Rodney Tietjen examines the possibilities

Experimental transmissions of Matrix 'H' encoded quadraphonic broadcasts are being started at the end of April (precise details not available on going to press). The following article describes how the Sansui Variomatrix decoder can be simply modified to produce good results. The BBC have examined this article and agree that results should be very good, with the qualification that an entirely purpose-built unit should produce a slight improvement. We have also been in touch with Michael Gerzon who is involved in the NRDC Ambisonics project, which may be reaching fruition soon. A further extremely simple switchable modification will enable their 45j matrix to be decoded accurately according to Variomatrix principles.

THIS article describes how a Sansui Variomatrix decoder, with the addition of a phase difference network to its input, can be used to decode the proposed BBC 'H' matrix system. Patent no. BP 34839/74.

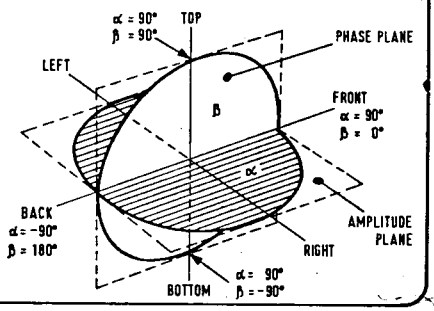
The 'H' matrix and the QS matrix both come under the general heading of phase/amplitude matrices (1). These matrices have two parameters which define how an audio signal can be encoded into a 4-2-4 matrix system: the phase difference between the left and right transmission signals which is called β, and the amplitude ratio of the two signals which is called α, both $\alpha+\beta$ can be expressed as angles:

$$|\alpha| = 2\tan^{-1}\left|\frac{L}{R}\right|$$

$$\beta = \theta_L - \theta_R$$

The most convenient method of representing these parameters is graphically on a Scheiber-sphere (1) see fig. 1. A more generalised form of the Scheiber-sphere is shown in fig. 2 (2). Only the right-hand view of the sphere needs to be shown, because both the 'H' matrix and the 'QS' matrix are symmetrical left to right.

FIG. 1 SCHEIBER SPHERE



Plotted on the sphere in fig. 2 are the locus of the 'H' matrix and the QS matrix; also shown are the stereo compatibility impairment zones (z). These impairment zones can be described as follows:

Negligible impairment: no impairment of tonal quality but slight image widening.

Slight impairment: slight 'phasey' quality and/or significant image widening.

Severe impairment: extreme 'phasey' quality and/or unlocatable image.

As can be seen from the plotted locus, the 'H' matrix lies within the negligible area for all signals except centre back, which is in the slight area. The QS locus, however, has two signals in the negligible area and two signals in the severe area. The higher stereo compatibility of 'H' matrix is desirable to ensure that minimal loss of signal quality will be experienced by listeners who do not have

FIG. 2 SCHEIBER SPHERE WITH BBC H MATRIX LOCUS AND QS LOCUS. STEREO-IMAGE IMPAIRMENT ZONES ALSO SHOWN

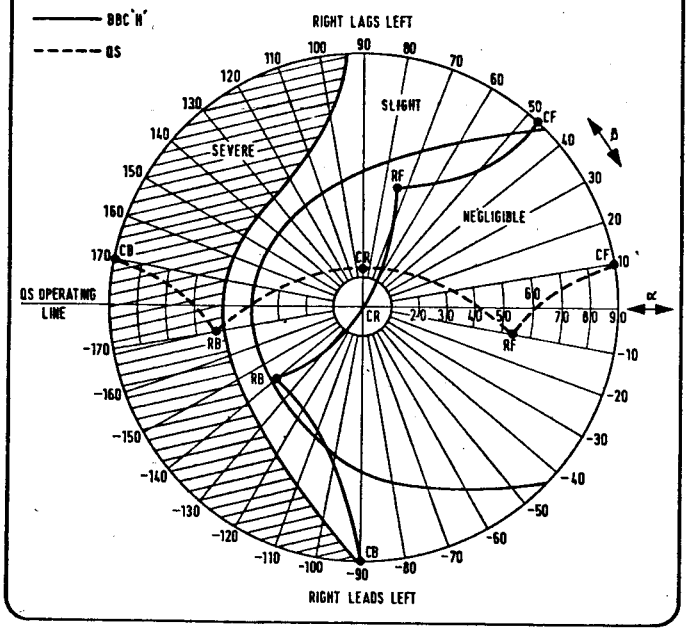
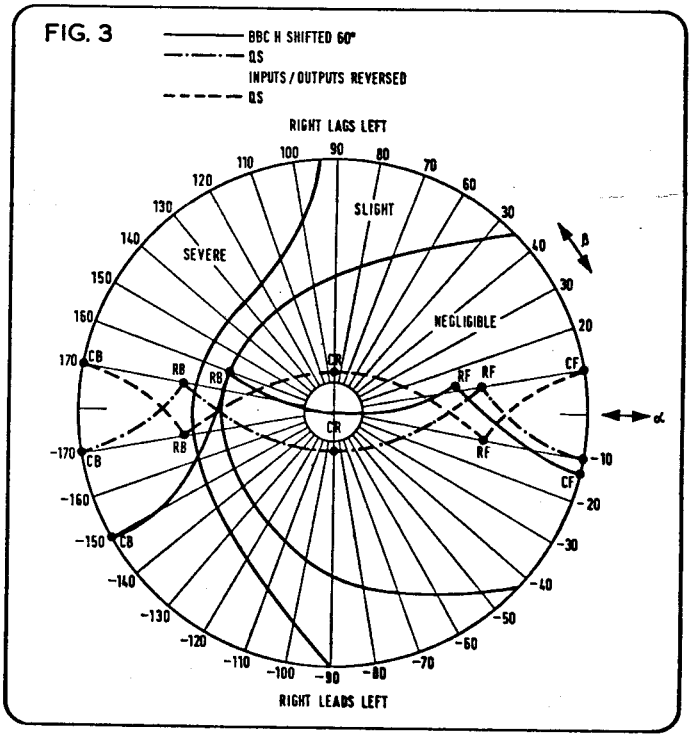


FIG. 3



quadraphonic equipment.

Mono compatibility can be compared in a similar way: large values of β will cause a reduction in mono level; however as the locus of 'H' matrix does not approach $\beta = 180°$, good compatibility is retained.

It is now accepted that Variomatrix decoding is the best approach to obtain an increase in subjective separation with 4-2-4 matrix systems. In order to obtain maximum theoretical separation the Variomatrix should work along the horizontal axis of the Scheiber-sphere; as shown in fig. 2, the plotted QS locus represents the nearest practical approach to this. Considering the 'H' matrix locus it can be seen that to decode directly with a Variomatrix decoder would not give optimum results, with both positional and amplitude errors occurring. However, if the locus of 'H' matrix were to be 'rotated' in a clockwise direction on the sphere, as shown in fig. 3, the loci become more coincident and the Variomatrix can be used to achieve successful decoding. This clockwise rotation can be achieved by putting a $-60°$ wide-band phase-shift in the left stereo channel.

A wide-band phase-shift network provides a fixed phase change independent of signal frequency. Unfortunately no circuit can be designed to achieve this between the input and output of one signal path. Circuits can be designed to have a linear phase/frequency relationship, and if two of those circuits are used and the pole frequencies carefully chosen, then a fixed phase difference can be realised between the outputs of the circuits (fig. 4). It can be shown that the greater the number of poles, the more linear the characteristics and hence the smoother the error in phase difference. If four poles are used a $\pm 10°$ error can be achieved for a 60° phase difference, and this has been shown to give good matrix 'H' decoding.

The circuit diagram of a suitable phase difference network is shown in fig. 5. The circuit comprises a phase difference network formed round amplifiers A_1 and A_2 and two buffer amplifiers A_3 and A_4. The phase difference obtained by this circuit is 60°, with a phase error of $\pm 10°$ in the range 200 Hz to 16 kHz. The circuit has unity gain and a frequency response of 40 Hz to 16 kHz ± 1 dB.

This circuit has been used to monitor the experimental broadcasts made by the BBC during 1976 and has given excellent results.

Returning to the Scheiber-sphere, it can be seen that although the matrix 'H' locus has been shifted and now lies approximately on the horizontal axis, the cusps of the locus are the inverse of those on the QS locus. It is possible to make these cusps coincide by interchanging all the left/right inputs and outputs of a Variomatrix decoder board, the results of which are shown in figure 3.

FIG. 4 REPRESENTATION OF PHASE DIFFERENCE NETWORKS

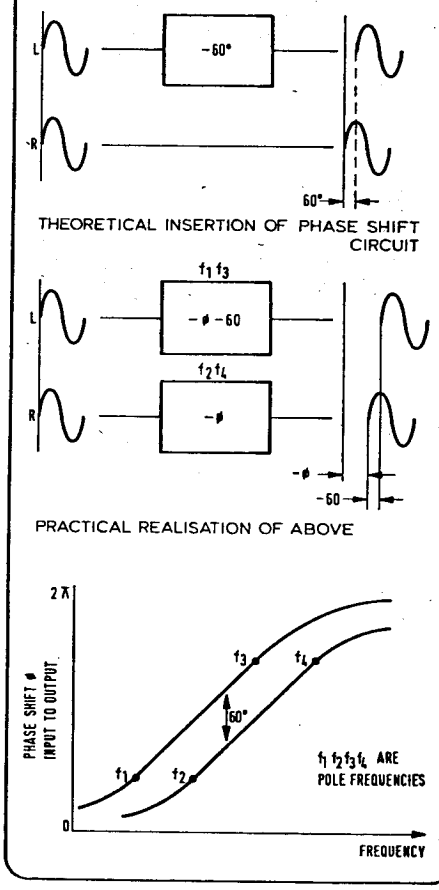


FIG. 5 CIRCUIT DIAGRAM OF 60° PHASE SHIFT CIRCUIT

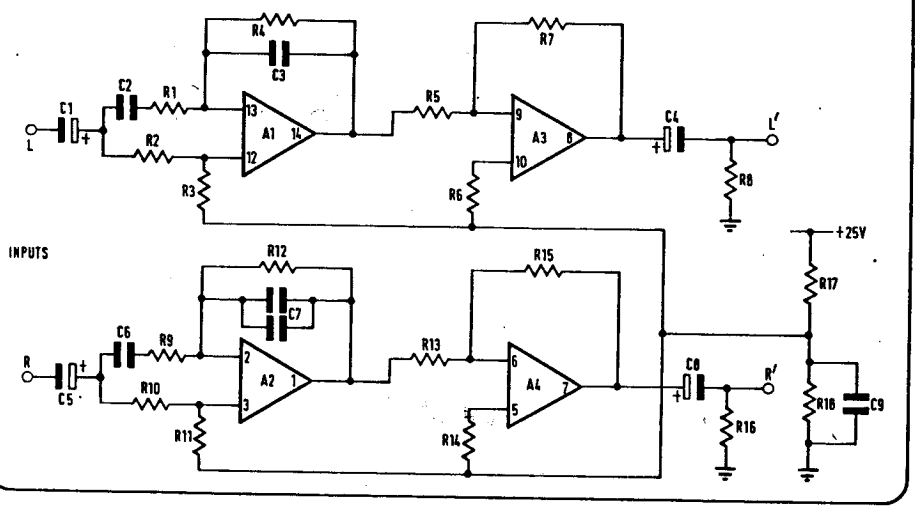
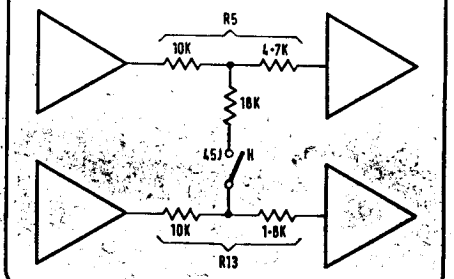


FIG. 6 MODIFICATION TO ALLOW MATRIX 'H' AND SYSTEM 45J DECODING.



Theoretically this gives more accurate decoding, but subjective tests have shown there is little to be gained by this procedure, and due to the complex switching required to restore the Variomatrix board to its original wiring positions to decode QS material, this procedure cannot be wholly recommended. It is important also to remember that the phase-shift networks must be switched out of circuit when using the Variomatrix to decode QS material or for synthesising stereo material.

A printed circuit board is available to enable the circuit to be easily constructed. However, as the tolerance of the components is critical, only the specified types should be used. Alternatively a fully built and tested board is available price £7·00 from Lintek Electronics[3] A six-pole version of the above phase difference network is also available. This circuit gives a phase difference of 60° $\pm 5°$ in the frequency range 50 Hz to 16 kHz, is suitable for use with studio quality Variomatrix decoders and is priced at £7·50. The above prices include VAT and post and packing.

Postscript

It is possible with the system described above to decode the proposed N.R.D.C. ambisonic system, 45j. To do this a small modification to the phase difference network is required as shown in fig. 6. The addition of the 18 K resistor provides a -15 dB blend to the outputs of the phase difference network. For best results in system 45j decoding it is also recommended that the level of the rear speakers be increased by 2 dB.

The above modification will allow Variomatrix owners to decode system 45j. However, it will *not* exploit the psychoacoustic properties that are part of the ambisonic system. ●

References:

1 Scheiber, P. Analysing phase amplitude matrices. J.A.E.S. No. 10, Nov. '71, pp. 835–839.
2 Meares, D. J. & Ratliff, P. A. Development of a compatible 4-2-4 matrix system, BBC type H. E.B.U. review, pp. 213.
3 Lintek Electronics, 2 Adam Close, Coxheath, Maidstone, Kent.

PARTS LIST

R1 8·2 K	R10 6·8 K	C1 10 µf 16 v
R2 6·2 K	R11 2·7 K	C2 0·1 µf Siemens B32560
R3 3·6 K	R12 10 K	C3 0·0033 µf Siemens B32560
R4 10 K	R13 12 K	C4 10 µf 16 v
R5 15 K	R14 10 K	C5 10 µF 16 v
R6 10 K	R15 47 K	C6 0·022 µf Siemens B32560
R7 47 K	R16 100 K	C7 1,100 pF
R8 100 K	R17 47 K	C8 10 µf 16 v
R9 12 K	R18 47 K	C9 10 µF 16 v

All Resistors ±2% A_1–A_4 LM 348

* +25 volts available on Variomatrix Boards.