Broadcast stereo coder

Three decoders assessed, a reference decoder circuit, filters, and a v.h.f. oscillator

by Trevor Brook, Surrey Electronics

This article concludes the series on the high-quality stereo coder design with a low-distortion decoder circuit. Performance details of the coder, assessed using this decoder, were given in the October issue.

NEED FOR A REFERENCE DECODER for performance checks on the coder prompted an investigation of some commonly available types of decoder. Some decoders produce their best channel separation from a degraded multiplex signal, such as is likely to emerge from the demodulator of present receivers, and the crosstalk measured in Table 3 using an ideal signal is given as a guide to what to expect when testing decoders fed directly from a coder. The setting of the free-running frequency of the phase-locked loop i.c. decoders can also have a considerable effect on channel separation and the best readings obtained are given in Table 3. The 1310 used was the best of seven selected for low mono distortion. All were very similar in stereo but two of the seven gave mono distortion readings of 0.45% on one of their outputs.

The use of a low-pass filter preceeding the decoder is bound to reduce channel separation if it does not have a linear phase characteristic and low amplitude ripple and this effect can be seen in the Skingley and Thompson circuit (*WW* May 1974 page 124). Though a sacrifice in channel separation results, such simple filtering does achieve its purpose of dramatically reducing "birdy" interference from adjacent stations, which otherwise is subjectively far more irritating.

Two odd effects appeared when testing CA3090 decoders using the RCA data sheet circuit. The decoder would trip out of stereo if full level 15kHz M signal was fed into it and limiting of the audio outputs accompanied by large beat tones occurred with full S signal for 15kHz audio. These effects are presumably due to the 15kHz, or lower sideband of the S signal, confusing the 19kHz phase locked loop.

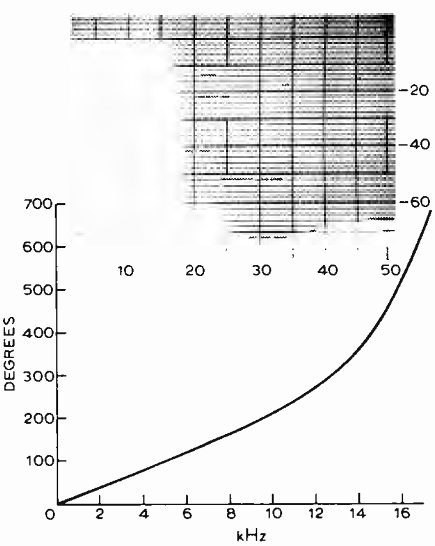


Fig. 13. Response of the audio filters in the coder and their measured phase response. The filters are two Toko BLR-2011-N units, each consisting of a modified π arrangement. Over 65dB rejection is provided at 19kHz and the ripple below 15kHz is less than 1dB.

Table 3. Stereo decoder comparison when fed with ideal multiplex signal.

	Input mV	Distortion (%) mono	stereo 1kHz	stereo 15kHz	Crosstalk dB 1kHz	Crosstalk dB 15kHz
MC1310 CA1310	300	0.09	0.09	0.67	40	37
1310 & filter	300	—	—	—	40	20
CA3090	180	0.17	0.18	1.7 L or R 3 S at −10dB	43	30
Portus & Hayward	600	0.05	0.38	1.3	—	—
P&H modified	600	0.04	0.04	0.35	30	31

Stereo distortion measured at full L, R, M or S level. Worst reading of two channels shown. By altering the pilot phase on the coder channel separation on the modified Portus and Haywood decoder will reach 54dB at 1kHz and 50dB at 15kHz. This has the same effect as adjusting the oscillator trimmers on the 1310 and CA3090 for best channel separation, not necessarily at a free-running frequency of exactly 76kHz.

Finally tested was the Portus and Haywood decoder (*WW* Sept 1970). Needing principally lower harmonic and beat tone distortion, I devised the following modifications, included in the circuit of Fig. 14.

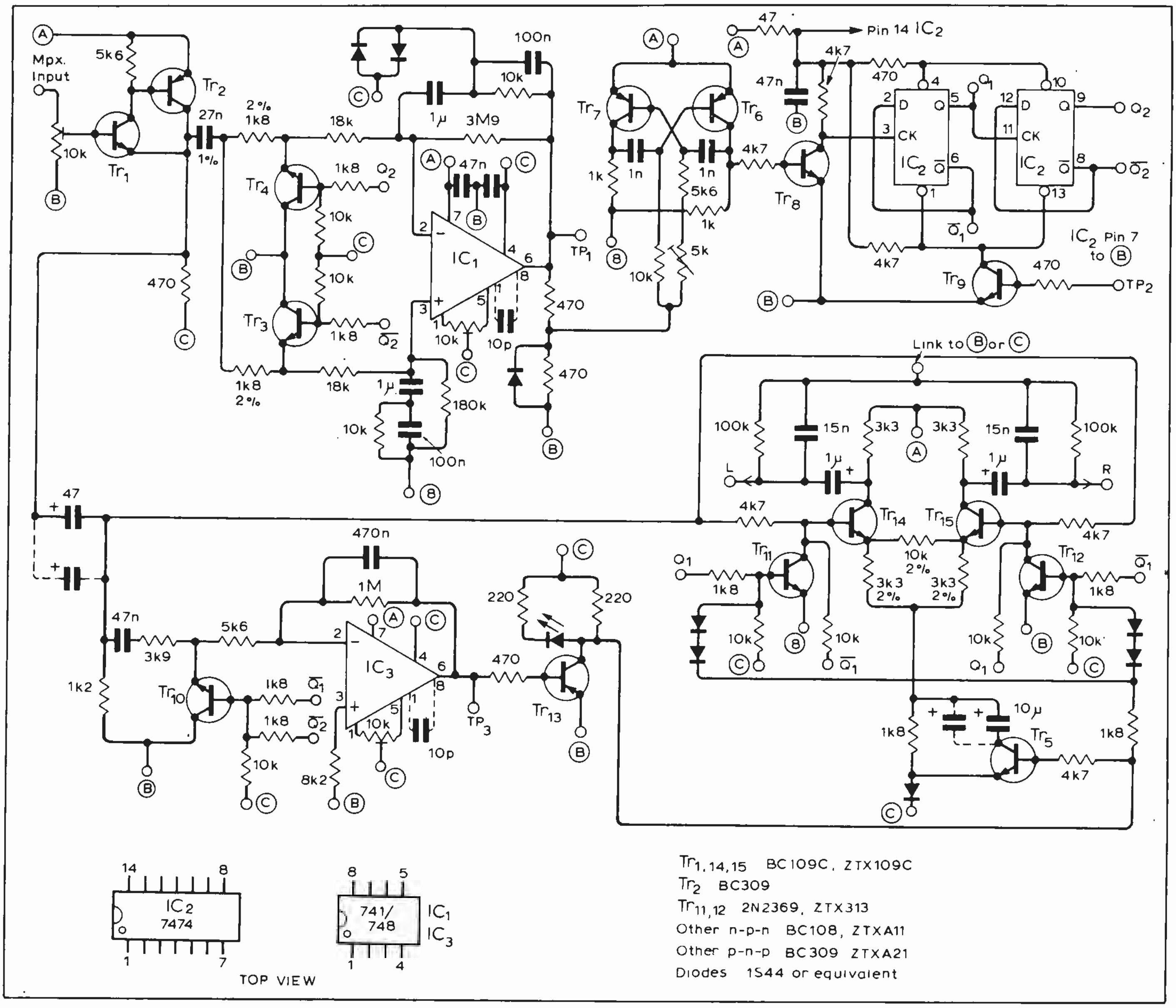
- Change Tr11 and Tr12, formerly BC108 types, for 2N2369, ZTX313 or any high-speed switching transistor.
- Change Tr14 and Tr15 for high-gain audio types, BC109C, ZTX109C, etc.
- Convert the input amplifier to a compound emitter follower, now with a lower emitter resistor and a gain potentiometer at the input. This can be done neatly on the original Integrex p.c. board using only one link. This modification is only suitable if the input amplifier is not required to provide any gain.
- Operate the decoder with only 1.4V at TP2, the pilot level test point, not 1.5V.

These modifications brought the 1kHz distortion in stereo to 0.06% and, with the further suggestion by Mr Portus of fitting pull-up resistors R_{64}, R_{65} onto the bases of Tr14 and Tr15, gives the excellent figures in Table 3 with the only penalties a couple of dB lower audio output and higher switching waveform on the outputs. Low frequency channel separation is easily improved by paralleling 1000μF 10V electrolytics across C_5 and C_{18}. Though irrelevant for normal listening, good separation is desirable when measuring the coder's noise level.

All decoders proved sensitive to supply hum and noise and filtering along the lines shown, Fig. 15, is needed to reduce the noise output from i.c. voltage regulators to allow signal-to-noise measurements beyond 64dB or so.

VHF oscillator

A simple v.h.f. oscillator with a varicap arrangement which has low enough capacity along the multiplex path to avoid h.f. loss is shown in Fig. 16. The oscillator coil is printed on the p.c. board alongside a coupling link which gives roughly 70 ohms output impedance through R_6. Coupling is low en-

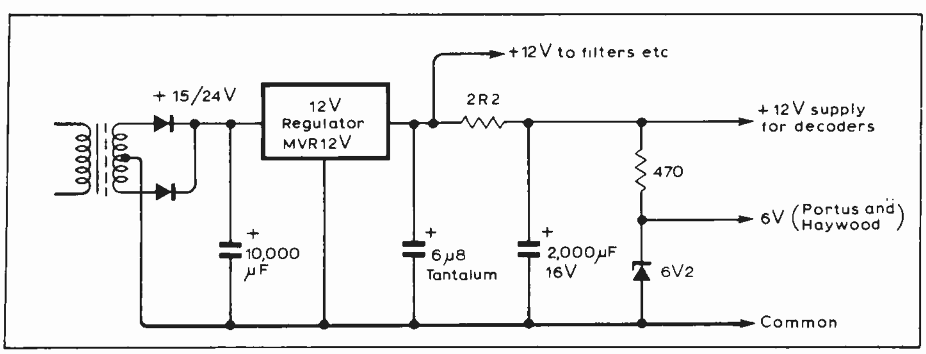


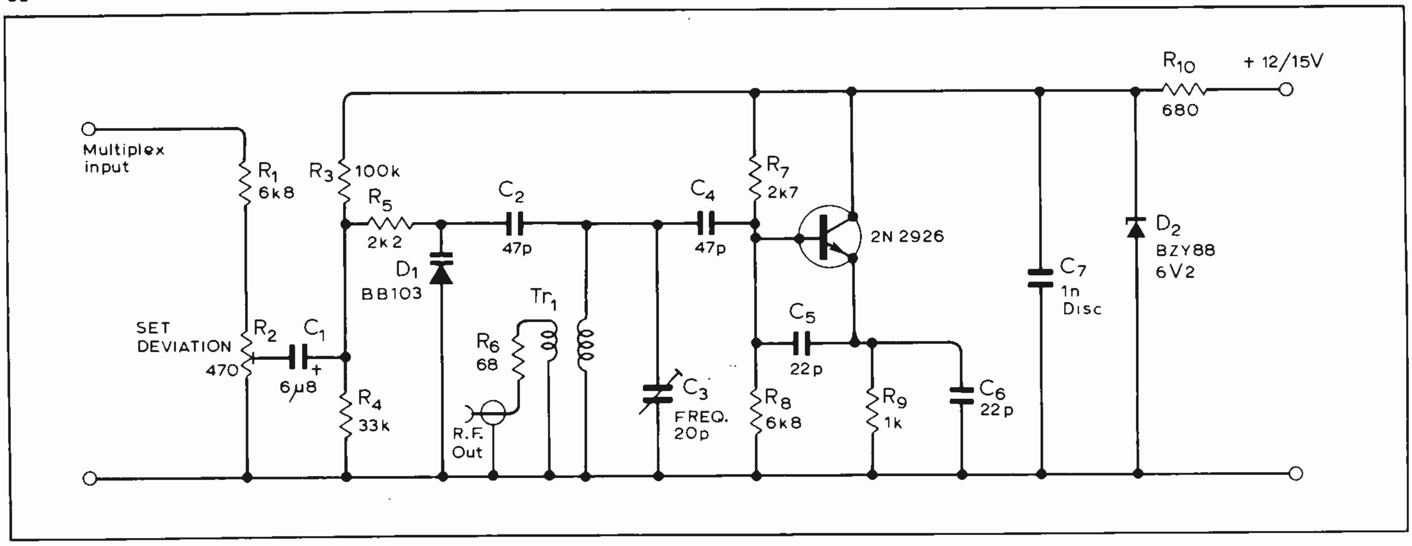
▲ *Fig. 14. Modifications to the Portus and Haywood decoder to improve both distortion and channel separation. Faster switching times and high gain transistors in the matrix with a different input amplifier arrangement give 1kHz distortion better than 0.04%. Voltage levels of points A, B and C can be either +12, +6 and 0V or +6, 0 and −6V respectively.*

ough to avoid frequency jumping with various loads. This device is only intended for use on a fixed frequency and there is no varicap sensitivity or linearity correction. Calculation for this circuit suggests distortion at full deviation of less than 0.5%. For a fully tuneable generator with calibrated attenuator the coder could be fed into the wideband modulation input of the Sound Technology FM1000 signal generator.

On stereo it is important for the deviation to be set correctly. Without an analyser or deviation meter the best way is to measure the pilot tone level before deemphasis when tuned to a BBC stereo station transmitting silence. They tune to the frequency selected for the oscillator and adjust its deviation to produce the same voltage. All the BBC stereo stations I can receive have pilot deviations within 1.5dB of Wrotham Radio 3. The output from the oscillator at around 60mV is adequate to feed a passive distribution system or with coaxial attenuators it can be used for receiver checking. Thirty decibels of attenuation (at 1.9mV) will still keep any reasonable f.m. receiver in full quieting on stereo while a further 6dB attenuation (685mV) will quieten a good tuner.

Fig. 15. Stereo decoders proved susceptible to noise on the supply line and filtering is needed to measure signal-to-noise ratios much above 60dB. Regulator should be mounted out of the transformer's magnetic hum field. 2000μF capacitor should have low internal resistance. ▼





The oscillator will run from either +12 or +15 volts so it can be run from the coder's supply or tapped from the receiver under test. The capacitor types used should be observed as they were chosen empirically to reduce the temperature drift. Wiring inside the box onto the p.c. board should use thin flexible wire with a slight slack left so that microphony is not transmitted from the input and output connectors onto the board.

The phase and amplitude mangling of the S signal which occurs in most receivers is so large that degradation is clearly visible on the demodulated composite signal even without any vertical magnification. Both low S amplitude and phase shift should be seen at 15kHz with S amplitude loss being predominant for 1kHz modulation. Oscilloscope synchronization will be helped by locking to the audio input to the coder or the deemphasized audio output from the receiver's active channel.

15kHz filter

This is just a convenient p.c. board which runs from 12 volts and will remove switching frequencies at decoder outputs without introducing significant distortion, so allowing distortion and signal-to-noise measurements. The resistor from pin6 to supply draws a small current to stop the crossover distortion which 741s otherwise generate with only a 6-0-6V supply. To make distortion measurements below about 0.15% two such filters are needed to completely remove ultrasonic components.

I think the coder design presented here has reached a cost/performance plateau. Many of its identifiable deficiencies can be attributed to the balanced modulator i.c., and £80 or so spent on a precision multiplier will provide some further improvements. The lack of inductors and single p.c. board make for a repeatable unit with stable performance.

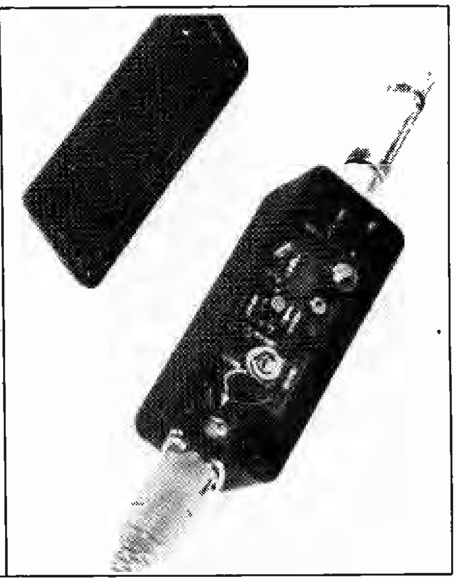
The work described forms the basis of stereo coders for broadcast transmission, outside broadcast radio links and test units. □

▲ *Fig. 16. Circuit of a v.h.f. oscillator using a printed coil and providing a simply repeatable output level. Output voltage into 75 ohms is 55mV at 108MHz and 65mV at 87.5MHz. Temperature stability over 20 to 57°C at 96.4MHz is 4kHz / deg C. Deviation sensitivity at 104MHz relative to 88MHz is +5dB.*

Fig. 17. The v.h.f. oscillator shown just fitting into the smallest diecast box available (RS Components 509-923). Coaxial attenuators provide lower signal levels for receiver alignment. ▼

This series was written by . . .

Trevor Brook, who is keeping quiet for the time being about his latest idea, being a method of reducing noise in cassette tape machines he has decided to approach manufacturers with it first. But starting the electronic side of a new company to make film and tv equipment directly after leaving South London College (then Norwood Tech) must have convinced him that he could do the same sort of thing for himself, for he formed SurreyElectronics five years ago with a capital of £200. So we may see him making noise reduction modules as well as distribution and monitoring amplifiers, peak programme meters, and frequency shifters. His interests are not confined to audible frequencies. Acquiring a transmitting licence in 1966, he looked for good auroral openings by charting a tv sound channel from a transmitter 700km away, and heard a 20 watt repeater at Kilkeel over a 500km path "passing directly through Snowdon with unusual diffraction effects". With the aim of detecting sporadic-E backscatter and aurora he obtained a Home Office licence for an experimental pulse radar, but never quite overcame the problem of receiver blanking with a good noise figure.



▼ *Fig. 18. Circuit of a convenient filter for removing ultrasonic signals when making decoder measurements. Distortion at +11dB, 0.04%. Response −34dB at 19kHz, −45dB at 38kHz; ripple below 15kHz is less than 0.5dB. Crosstalk −80dB at 1kHz, −55dB at 15kHz. Noise −96 to −82dB over gain adjustment range of +4 to +14dB.*