Broadcast stereo coder

3—Setting up

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A practical design for a high quality coder suitable as a test instrument was described in the April & June issues. Apart from the audio filtering, inductors have been avoided and a compact board layout produced. A v.h.f. unit, for servicing checks on receiver performance, could also be used by demonstration showrooms to feed programmes of their own choice to stereo tuners.

Part 1 examined the stereo multiplex system and established tolerance limits for signal components. Channel separation was considered as this would assume increased importance if a matrix system of surround sound broadcasting were adopted. Part 2 gave construction details and alignment details follow in this part. Part 4 gives modifications to the Portus and Haywood decoder to provide a low distortion reference decoder.

In this setting-up procedure 0dB level refers to 0.775V.

—With the coder in mono, set A and B gains, by means of R_{44}, R_{54}, so that 0dB input at 1kHz gives —7dB at the output. Check that the amplitude response is +0.5, —1.0dB from 20Hz to 15kHz relative to the 1kHz level for each channel.

For measurements near 15kHz, a frequency counter will prove most useful if the audio signal generator calibrations are not accurate.

—With a grounded crocodile lead on the "oscillator defeat" pin, IC_3 pin 6, check the distortion for each channel with 0dB output at 1kHz. A reading of better than 0.03% will confirm that all is well.

—To align the 38kHz path, set presets R_{23}, R_{32} and R_{87} to mid-position and remove the "oscillator defeat" link.

—Looking at the output of IC_5, pin 6 on an oscilloscope, adjust R_{23} for a rough null in 19kHz content on the 38kHz waveform.

—Connect a nulling distortion meter, tunable to 38kHz, to pin 4 of IC_{10}. (Many distortion meters only cover up to 20kHz, but generally they are easily modified by soldering an extra parallel resistor in each arm of the null bridge so that the upper frequency becomes 40kHz. For the job here accuracy is not very important; all that is required is good rejection of the 38kHz so that the remaining 19kHz component can be nulled.) Looking at the distortion meter output on a 'scope adjust R_{32} and R_{87} alternately to achieve the best rejection of 19kHz.

—Final trimming of R_{23} as well should leave no 19kHz visible amongst the noise, and better than 60dB below the 38kHz level.

—The 38kHz amplitude at this same point may now also be checked as +8dB ±0.5dB.

—With the oscillator system now set up properly the distortion of the 19kHz at pin 6 of IC_3 can be checked as below 0.1%.

—Switch the coder to stereo and look at the 38kHz at the output, with only the S switched on at the d.i.l. switch. Adjust for minimum carrier with R_{22}. Using broadband metering the 38kHz null will be masked by the residual 76kHz generated by IC_{10}, which does not null out.

—Feed 1kHz at around 0 to +6dB into the left channel and defeat the oscillator. Still with only S switched on adjust R_{23} for a null of audio leak through in IC_{10}.

—Allow the oscillator to run and feed 1kHz at 0dB into the left channel with A, B and S turned on at the d.i.l. switch. Lock the 'scope to the audio and adjust R_{72} for the roughly correct M/S amplitude relationship seen in Fig. 11(a).

—Repeat for the right channel input but this time leave R_{72} alone and adjust the B difference pot, R_{59}.

—Switch the pilot on at the d.i.l. switch and, with no audio input, set its level to —21dB at the coder output, using R_{16}.

—Feeding 1kHz at around —10dB into either left or right channels, turn on only the S and pilot at the d.i.l. switch. Locking the 'scope to the audio should display an "eye" pattern, as in Fig. 11(b). The correct pilot phase is when the eye appears symmetrical and this is more easily seen with some vertical magnification arranged as shown in Fig. 11(d). Resistor R_{14} adjusts the pilot phase and the effect of a slightly incorrect setting is seen in Fig. 11(e).

Table 2: Measurements on prototype coder

No pre-emphasis	
Frequency response +0.5 dB, —1.0 dB	20Hz to 15KHz
Rejection of 19kHz	68dB
Rejection of frequencies above 19kHz	58dB
Crosstalk at 20°C 20Hz-15kHz	55dB
Crosstalk 10-40°C 20Hz-15kHz	45dB
Residual 38kHz	50dB
Pilot phase accuracy	1°
Beat tone distortion, 15kHz full M, full S or L or R overdriven 6dB	0.1%
Spurious responses above 53kHz, full M, full S or L or R overdriven 6dB:	
sidebands of 57kHz	—63dB
carrier and sidebands at 76kHz	—48dB
carrier and sidebands at 152kHz	—84dB
Measurements using reference decoder (part 4) and 50μs de-emphasis:	
harmonic distortion, 1kHz full M, S, L or R	0.04%
signal-to-noise ratio, 20Hz to 15kHz, mean reading meter, unweighted:	
mono	79dB
stereo	71dB

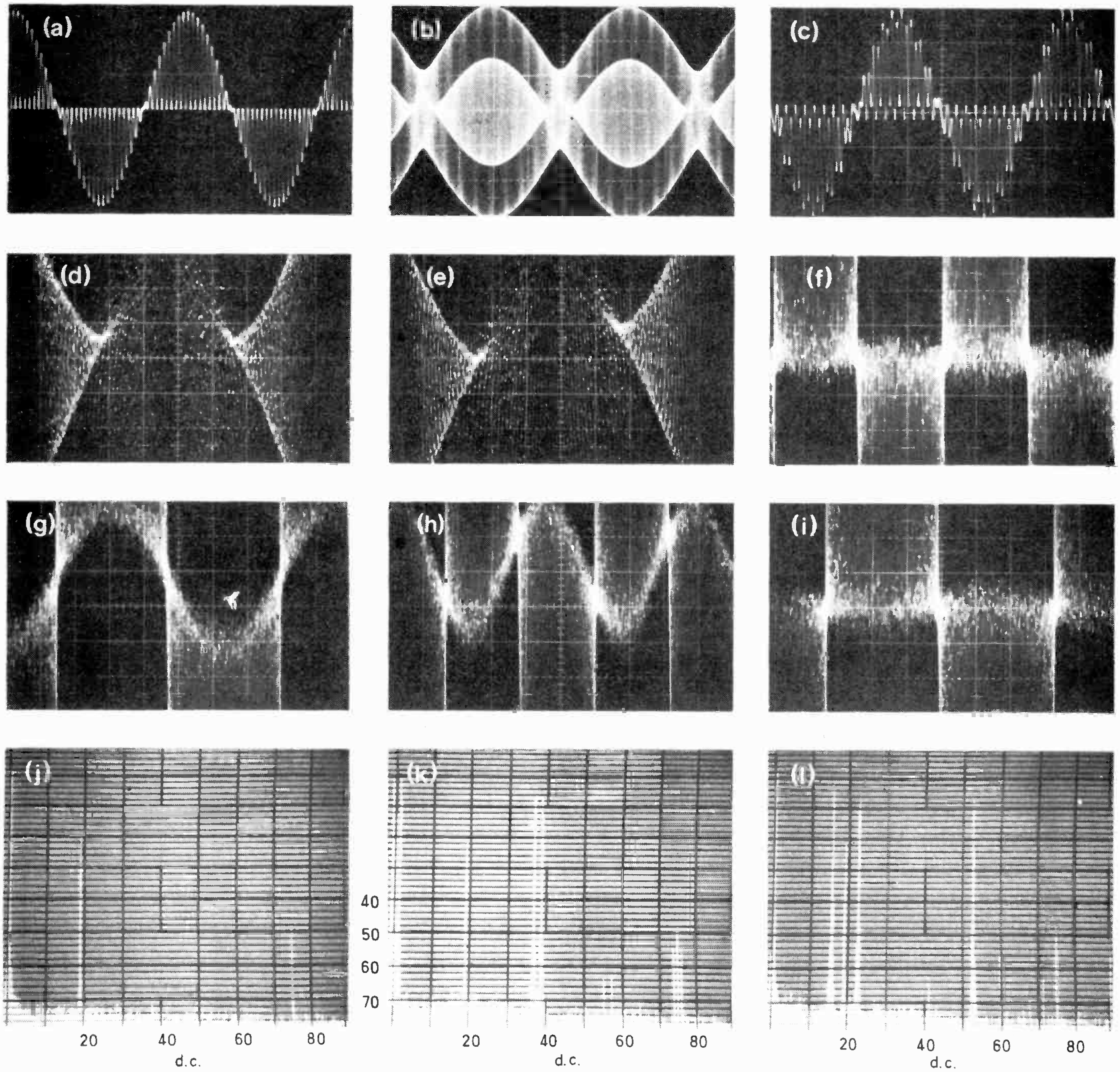

Fig. 11. Correctly set-up coder, with full 1kHz A signal and no pilot is seen at (a) which indicates the flat zero line. The pilot phase "eye" is at (b), with only S and pilot, while (d) shows the zero crossing region of (b) magnified virtually by a factor of 100 – (e) is the same but with an incorrect pilot phase setting. Zero line ripple at (f), with full 1kHz A signal, is obtained by X100 vertical gain and clipping amplifier shown in Fig. 12. Result on zero line ripple of low S amplitude is at (g), while (h) shows too high an S amplitude in wrong phase. Photo (c) is of composite multiplex signal with pilot and full 1kHz signal. Zero-line ripple at (i) is that obtained for 15kHz with coder correctly set up. Spectrum analyser photo at (j) shows noise spectrum when in stereo mode but with no audio. Pilot at 19kHz and main spurious response – 76kHz at –48dB can be seen. Stereo spectrum with A overdriven by 6dB with 1kHz is at (k) and with 15kHz at (l). Analyser measurements were performed by Marconi Instruments TF 2370, 50Hz bandwidth, direct into 50Ω input via 3.3kΩ resistor, not using high-impedance probe.

—Pilot amplitude and phase adjustments are very slightly interdependent, so repeat the last two adjustments.

Clipping amplifier

If all is well to this point, then channel separation will exceed 40dB at 1kHz, but to see the M/S amplitude and phase error more easily for greater separations requires × 100 vertical magnification compared with that in Fig. 11(a). Some 'scopes may manage this without overloading, but most do not so a useful amplifier and clipper circuit is given in Fig. 12. This is simply a 20dB amplifier with diodes arranged to bring the gain below unity as soon as the output swing exceeds 0.6 volts. The amplifier has quick recovery from the clipping so does not degrade the interesting zero voltage area of the stereo waveform.

The clipping amplifier can conveniently be built on a scrap of Veroboard and placed inside a metal 35mm film can. The output resistor stops r.f. instability when driving capacitive loads in the clipping condition. Used in conjunction with a directly-coupled 'scope giving 20dB gain (which should not cause overloads) and at least 5MHz bandwidth, the required × 100 magnification with low phase shift is achieved and a correct stereo waveform appears in Fig. 11(f).

—Using the clipper arrangement repeat first two items in column 3, page 89.

The only limitation to correct setting should be the noise along the zero line of the waveform. Figure 11(g) shows the in-phase zero-line ripple caused by low S signal amplitude corresponding to a loss in S of 2.7%.

—Now change the input frequency to 15kHz and adjust the M/S phase accuracy (C_{26} adjusts for the A and C_{28} for the B channel).

Phase errors appear on the 'scope

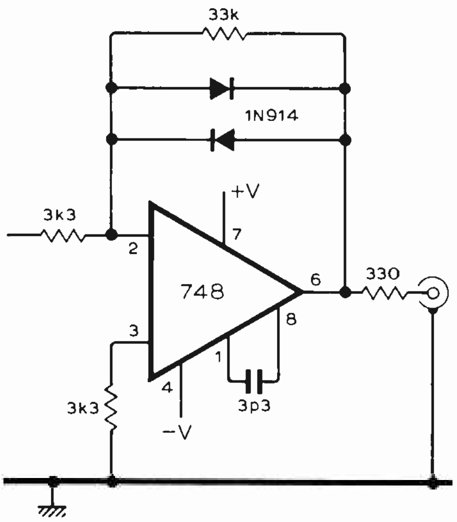

Fig. 12. Amplifier with 20dB gain and clipping arrangement to allow large vertical magnifications of the zero-voltage region without overloading oscilloscope Y amplifiers.

display as a sine-wave zero-line ripple shifted in phase relative to the main pattern and Fig. 11(h) shows the appearance of amplitude and phase errors combined.

—Check now that M/S accuracy is maintained over the whole audio frequency range.

If an audio signal in antiphase and of precisely the same level is available the initial adjustment can be improved upon.

—Feed antiphase audio at 1kHz into left and right channels at 0dB and with the A and B signals only switched on make a very slight trimming adjustment to either R_{44} or R_{54} so that the output nulls. This gives a more accurate channel balance than setting channel gains up on a millivoltmeter.

The audio leakthrough set on p.89 with the oscillator stopped can be adjusted under working conditions for the multiplier if a 15kHz low-pass filter is available.

—Connect to the coder output and with only the S signal turned on at the d.i.l. switch feed left or right input with 15kHz at +6dB (or feed both left and right with antiphase both at 0dB). Potentiometer R_{23} is adjusted for a null in 15kHz leakthrough. Correct setting of R_{23} is important, otherwise false settings in R_{72}, C_{26} and C_{28} can be produced.

Without a spectrum analyser or decoder an estimate of the beat-tone distortion may be made with the aid of a distortion meter.

—Continue as above for the audio leakage check but switch on A, B and the pilot as well as S. Use the distortion meter to null the 15kHz and some of the beat tones will give a reading below 0.1%. (This reading is only an indication that all may be well as no account has been taken of beat tones above 15kHz which will be heterodyned into the audio range in decoding. If a frequency counter is available a check can be made that the pilot frequency is 19kHz ±2Hz.)

—Check temperature stability by feeding 1kHz at 0dB into the left channel, with A, B and S turned on at the d.i.l. switch. Lock the 'scope to the audio and with the × 100 vertical magnification arrangement view the change in relative M/S amplitude and phase. With a temperature rise from 20 to 40°C the S amplitude should fall by 0.8%, i.e. 24mm on a pattern magnified to 6000mm.

Allow at least half an hour for all components on the board to reach the new ambient temperature. What S amplitude loss there is can be shown to be predominantly due to the balanced modulator i.c. by briefly holding a soldering iron on its case. With the methods described here no phase error between the M and S components should be visible over the whole temperature range +10 to +45°C. Incidentally it is quite impossible to align a coder for channel separation by using a decoder, as apparently good separation can be achieved on a particular decoder with quite the wrong phase and amplitude settings.

Three checks on performance can be made using a suitable reference decoder, such as the modified Portus and Haywood design described in Part 4. Using 50μs de-emphasis the noise level referred to 1kHz full level (−1dB at the coder output) should be ⩾−70dB, unweighted, mean reading meter, 20Hz to 15kHz. Again with de-emphasis, readings of coder-decoder harmonic distortion for 1kHz full A, B, M or S should be 0.04% and the 15kHz beat tone under the same conditions 0.35%.

Some of the distortion above is contributed by the decoder and the only satisfactory way of assessing the purity of the coder output is by spectrum analysis. Figure 11(j) shows the coder noise spectrum when switched into stereo. The 19kHz pilot tone is at −21dB and the slight mark at 38kHz is the suppressed 38kHz carrier at −71dB. The spurious 76kHz double frequency output from the balanced modulator is at −48dB.

Figure 11(k) shows 1kHz in left or right channels overdriven by 6dB. The baseband signal is at −1dB, normally only reached for full M signal, i.e. full A and B in phase. After the pilot are the two S signal sidebands at −7dB, normally only reached for full S signal i.e. full A and B in antiphase. Above this are two spurious responses, sidebands of 57kHz and the 76kHz signal again. For 1kHz, the 57kHz components are harmless, but for higher audio frequencies the lower sideband of the pair falls into the S signal band. On this photo it is also interesting to notice the slight noise modulation effect (about 4dB) which only becomes visible when the S signal is within 3dB or so of full amplitude.

Figure 11(l) shows the situation as above (6dB left or right overdrive) but with 15kHz input. Apart from the lower sideband of 57kHz, 42kHz at −64dB, other minor beat tones are visible at 4kHz, −67dB, and 7kHz, −68dB. The line at 27kHz seems to have been a noise peak, since it bears no obvious arithmetical relationship with the frequencies involved and does not appear in other photographs taken at the time. The 42kHz component will demodulate to 4kHz at −63dB in the left and right channels and this would indicate a beat tone figure for the coder of 0.1%, and with 50μs de-emphasis 0.07%.

Not covered on the photographs, the only component observed above 100kHz was 152kHz and associated sidebands at −84dB. For decoder and receiver measurements the 76kHz outputs are not troublesome — the presence of odd harmonics would have been more worrying — but for some purposes the use of a precision multiplier might be desirable.

To be concluded.

Correction. In the circuit diagram (on page 76, June issue) capacitors C_{25} and C_{26} should have been shown earthed, rather than returned to the −15V rail, and C_{28} shown variable. The G lead should have R_{77} inserted, and the junction of C_{16} and R_{39} should connect to lead B. Resistor R_{75} should be taken to the upper end of R_{59}, and not Tr_8 emitter, which itself should connect to Tr_9 collector through a 33μF capacitor. Emitter of Tr_8 should have R_{91} connecting it to the −15V rail. Capacitor C_{22} should be short-circuited. In the components list R_{49} is 47kΩ, R_{91} is 3.3kΩ, and C_6 is 4.7μF ±1% and not 47μF. Resistor R_8 can be 2%.

Books Received

Radio TV & Audio Technical Reference Book edited by S. W. Amos.
This chunky reference (60mm thick) is the work of 31 contributors who have written 35 chapters using information provided by 47 companies. The result is a very comprehensive publication which is directed at the technician or student. Most of the information is presented in a practical form with a minimum of mathematics and all of the symbols in the diagrams conform to the recommendations of BS3939.

The first few chapters deal with fundamentals of electronics and following chapters cover specific topics such as antennas, sound receivers, test equipment and radiotelephone communications. There are four chapters dealing with installation and servicing of transmitters, receivers and tape recorders. The final two chapters discuss electrical interference suppression and formulae. Although the price of £24.00 makes it an expensive purchase, the large amount of information (all in one place) makes it a worthwhile addition to any technical bookshelf. Newnes Butterworth, Borough Green, Sevenoaks, Kent.