

Vintage Radio

By Ian Batty



The Philips model 198 transistor radio



Philips' first Australian-made transistor set

Housed in an attractive leatherette case, the model 198 was Philips' first Australian-made transistor set. It was a 7-transistor design and both it and the later model 199 offered excellent performance.

BEGINNING IN Eindhoven in 1891 and founded by Gerard Philips and his father Frederik, Philips became one of the world's largest technology companies but today it concentrates on lighting and healthcare. The company began manufacturing in Australia in 1931 but produced only two models before temporarily halting production and then resuming in 1934.

Philips then quickly grew to become one of Australia's largest electronics manufacturers, with radios sold

under the Briton, Mullard and Fleetwood brand names. TV receiver production subsequently started in 1956 and continued until the 1980s. In addition, Philips manufactured valves, TV picture tubes and transistors, including the famous OC44/45 and OC70/71/72/74 series that many of us bought to build our first transistor sets.

Design highlights

Described in *Vintage Radio* for April 2015, Australia's first transistor radio,

the AWA 897P, was released in 1957. This was followed just a year later by Philips with their model 198. Like the 897P, this was another 7-transistor design and the case used by Philips was modelled on a previous valve version, the compact AC/battery model 196.

AWA's engineers used three audio stages in the 897P, based on four transistors and three transformers. By contrast, Philips opted for a design that was to become standard, with just three transistors and two transformers used for the audio amplifier. Like AWA, Philips paid attention to Australian conditions, by employing a thermistor-stabilised output stage. They also added adjustable output stage bias, as described below.

The Philips 198 was more compact than the AWA 897P and it looks somewhat like a small cosmetics case. But don't let its "domestic" appearance fool you – it really is a very good radio. The accompanying photos show the set's controls which are, from left to right: Volume, Off, Treble/On and Bass/On along the top and, on the front panel, a tuning control with integral dial.

Philips 198 chassis details

Like Bush's TR82C and AWA's 897P, the Philips 198 uses a pressed-and-punched metal chassis. Its successor (the 199) is similar but with sufficient differences to warrant a separate circuit diagram (the major differences are noted in the text).

The 198 has five of its transistors installed in chassis-mounted rubber grommets, with the leads wired to adjacent solder tags. By contrast, the two output transistors are held in heatsink clips which are screw-mounted on the underside of the chassis.

Unlike the AWA set, the chassis sits horizontally inside the case, allowing some access to the underside where most of the components are mounted on tagstrips. The IF transformers and the LO coil, however, are mounted ver-

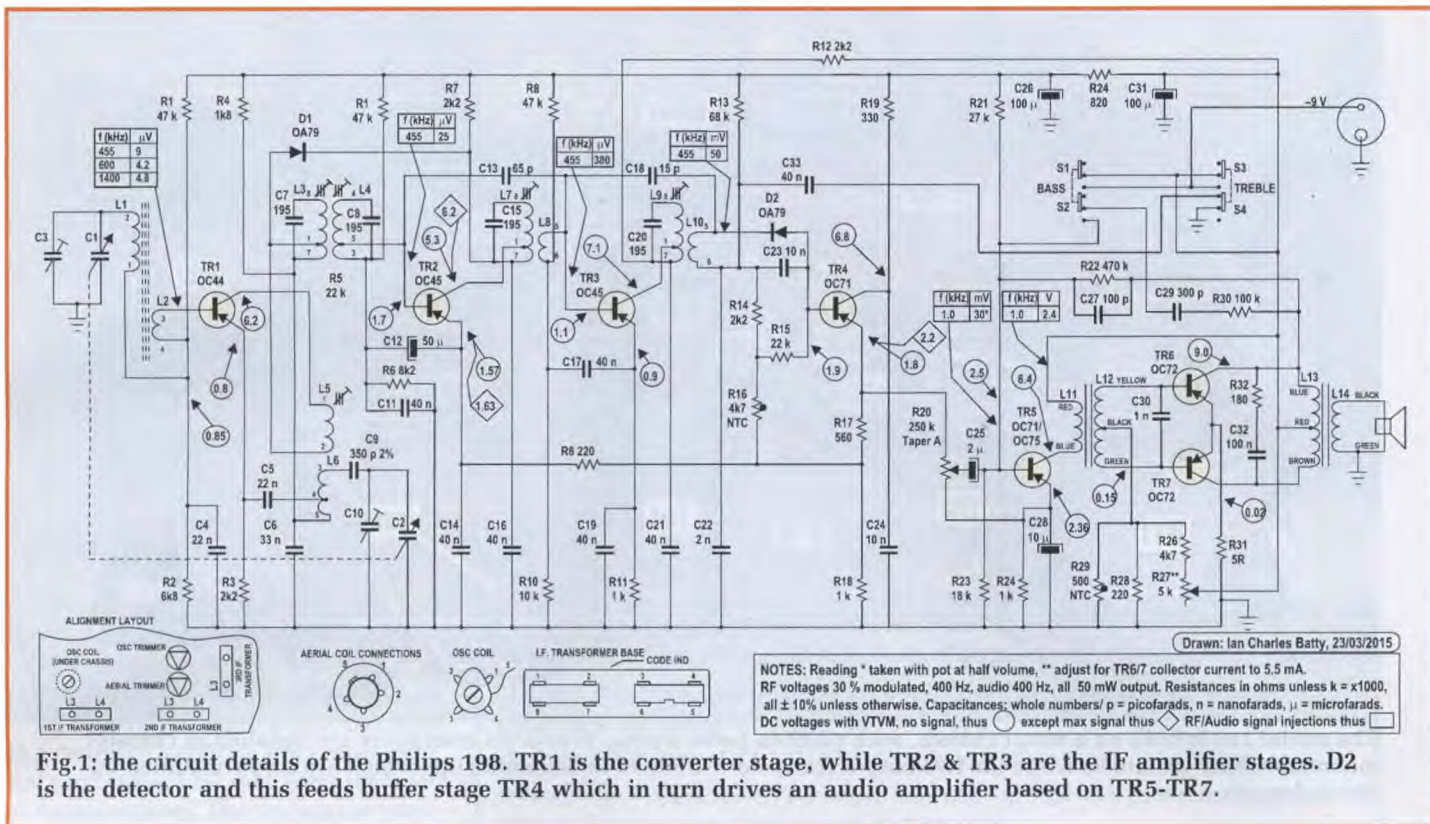


Fig.1: the circuit details of the Philips 198. TR1 is the converter stage, while TR2 & TR3 are the IF amplifier stages. D2 is the detector and this feeds buffer stage TR4 which in turn drives an audio amplifier based on TR5-TR7.

tically, so that the chassis still needs to be removed for any detailed work, including alignment.

The case itself is made from leatherette-covered "composite" material (cardboard), while the front dial at top-right turns easily with a direct drive. To the left of the dial is a large speaker grille. Power is controlled by pushbutton switches, so the volume pot only controls the volume. Because it doesn't also function as an on/off switch, the volume pot doesn't have to be turned down to or up from zero each time the set is turned off or on, thereby extending the pot's life.

Circuit details

Fig.1 shows the circuit details of the Philips 198. Transistor TR1 is the converter stage and this operates as an autodyne oscillator with collector-emitter feedback. AGC is not applied to this stage, so TR1 operates with fixed bias.

As shown, TR1's bottom divider resistor (R2) and its bypass (C4) are connected between the "cold" (bottom) end of the ferrite rod's two windings (tuned and base) and ground. This means that the bottom of the antenna windings are at base bias voltage, thereby providing a handy test point. By contrast, the later 199 model connects both antenna windings directly

to ground, with the bottom of the base bias circuit going to the top of the base winding.

The base-emitter voltage is only 50mV, since converters must operate close to Class B conditions to give the non-linear "modulating" effect needed for frequency conversion.

Because the tuning gang uses identical sections, padder capacitor C9 is included to modify the capacitance range of the oscillator section so that the local oscillator tunes from about 990-2060kHz. The only unusual feature is that the oscillator coil's secondary is held at the converter's collector voltage. While this eliminates any potential difference between primary and secondary, it's not common practice.

Converter TR1 feeds the first IF stage (TR2) via IF transformer L3/L4 which has tuned and tapped primary and secondary windings. TR2 is gain-controlled by the AGC system and due to the high feedback capacitance of alloyed-junction transistors, this stage is neutralised by feedback via C13 from the second IF transformer's untuned (and untapped) secondary. By contrast, in the 199 model, this feedback is derived from an overwind on the second IF transformer's primary. In addition, the second IF transformer has a tuned and tapped secondary.

The second IF stage is based on TR3 and runs with fixed bias. It's also neutralised, via C19, and both the 198 and 199 models derive feedback from the third IF transformer's secondary.

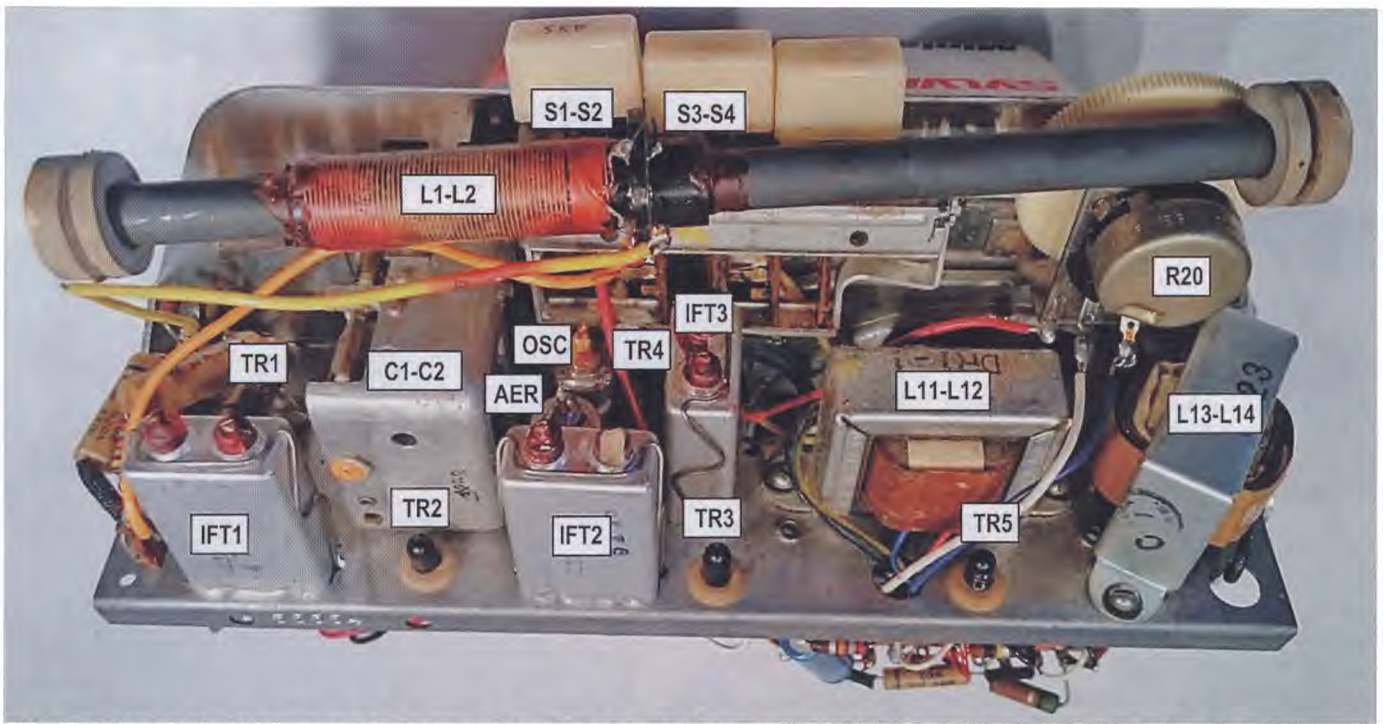
The third IF transformer uses a tuned, tapped primary and a low-impedance, untuned secondary to feed demodulator diode D2.

AGC circuit

Depending on the strength of the incoming RF (and IF) signal, diode D2 provides a negative DC output to the base of TR4, the first audio/AGC stage transistor which is connected as an emitter follower to buffer the detector.

Stronger IF signals will therefore cause TR4's emitter current to increase but it does not amplify the resultant audio, merely passing it to the following volume control potentiometer (R20).

However, the DC signal from TR4's emitter is then filtered by capacitor C14, so that the resultant DC voltage is more or less proportional to the IF signal strength. This DC voltage is applied to the emitter of TR2 and if this voltage increases, TR2's gain will tend to be reduced. As a result, changes in signal strength are counteracted and the set's output remains substantially constant for varying signal strengths.



The model 198 is built on a metal chassis, with point-to-point wiring. Five of its transistors are installed in chassis-mounted rubber grommets while the two output transistors are held in heatsink clips which are screw-mounted on the underside.

As well as AGC, the set also includes an “overload diode”, better described as an “AGC extender”. Simply controlling one stage (such as TR2) only provides a limited range of control. In this set, the stage gain is some 30dB and thus simple AGC can only counteract about this range of input signal. After that, the audio output begins to rise noticeably or the second IF stage goes into overload.

To prevent this, auxiliary AGC diode D1 is connected between the primary of the first IF transformer (L3) and the collector supply to TR2 at the junction of R7 and C16. This latter junction sits at about -5.4V DC but is effectively at signal ground due to C15. By contrast, D1’s anode at L3’s primary sits at about -6.2V DC and is at IF signal level. It’s also connected (via L5) to converter TR1’s collector.

With no signal, D1 has around 0.8V of reverse bias. As TR2’s collector current falls with increasing signal, its collector voltage (developed across R7) rises. This pulls D1’s cathode towards the supply voltage and (importantly) reduces its reverse bias. As TR2’s collector current falls further with increasing signal strength, D1 eventually begins to conduct and damps the IF signal at TR1’s collector, thereby preventing it from increasing.

The result is that the model 198 has

effective AGC and provides consistent audio output levels over a wide range of signal strengths.

Audio stages

The audio stages begin unconventionally with the emitter follower/buffer stage based on TR4. It’s more usual to see a common-emitter stage here but given the AGC design (which feeds some current through NTC thermistor R16 in order to operate), it makes sense. In operation, TR4’s bias is temperature-stabilised by R16, presumably to prevent TR4’s AGC action from being disturbed by high or low ambient temperatures.

Following TR4, the signal is fed to the remaining audio stages via volume control pot R20. Its circuit configuration is also unconventional: its “hot” end connects to TR4’s emitter and its “cold” end goes to TR5’s emitter, which produces about 0.7V DC across the pot. However, because TR5’s emitter is at AC (signal) ground, R20 works just fine as a volume control. The peculiarity is that there is standing DC across the pot, which is usually a recipe for noisy operation.

Audio driver TR5 is a conventional transformer-coupled stage. No treble roll-off is applied here but was added in the 199 model. It is, however, applied in the output stage using R32-

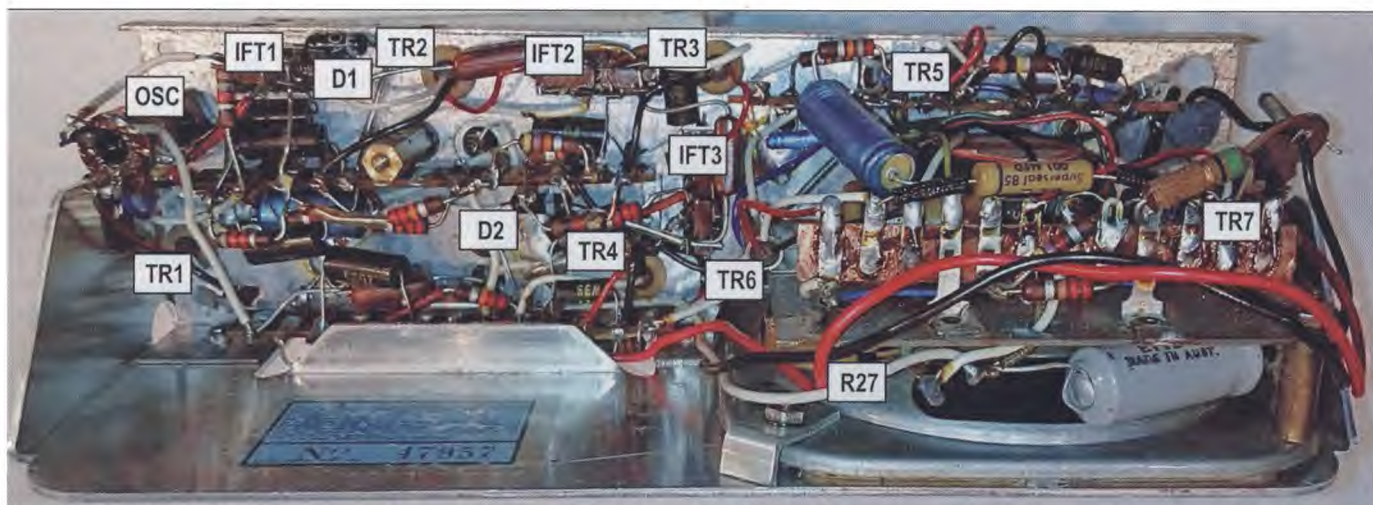
C32, with the 100nF capacitor increased in value for the 199.

Push-pull output stage

The push-pull Class B output stage is based on TR6 & TR7 and has thermistor-compensated bias (R29). This bias can be adjusted using R27. The model 198 also has a shared 5Ω emitter resistor (R31) but this was removed for the 199. At 5.5mA, the bias current is a little higher than in most other sets but I found that I was able to set it to almost zero with no noticeable increase in crossover distortion. The alignment guide, by the way, recommends running the set for three minutes prior to checking or adjusting the output stage bias.

In the model 198, audio stage feedback is applied from TR6’s collector to TR5’s base via two paths. First, there is a permanent feedback path via R22-C27 (the 199 uses a single 220kΩ feedback resistor and takes the feedback from the speaker terminal). And second, Bass switch S1/S2 switches C29 and R30 across the feedback path to apply extra treble roll-off (the 199 uses slightly different values here). In operation, this brings the upper -3dB point down to just 2kHz (the model 199 also derives this “top-cut” feedback from TR6’s collector).

S3/S4 (Treble) switches in C33 to



This is the under-chassis view of the model 198. The set was still in working order and no parts had to be replaced, although the set did require alignment adjustments in order to optimise its performance.

provide extra bypassing for the demodulator (this is absent on the 199). Like the Bass switch, it also turns the set on via its second set of contacts.

By the way, the circuit shown here is a redrawn version, since the original circuit isn't all that clear (at least as found online). The original component numbering has been preserved.

Restoration

The set shown here was quite tatty when I took it out of storage. On the outside, its leatherette-covered composite case and tuning dial were dirty and the metalwork was tarnished and corroded. In addition, the Philips badge on top (just behind the switch well) and the "All Transistor" badge inside the escutcheon were both bent. It's a common problem and of the four 198/199 sets I have, this one was the best preserved.

I attacked the leatherette case first using a microfibre pad but soon noticed that some of the fawn colour was transferring to the pad. I'd also had a similar experience of colour lifting with the Bush TR82C, so I'll use these microfibre pads with caution in future.

In the end, the case was cleaned using spray cleaner, a toothbrush and good old-fashioned elbow grease. I then repeated the exercise on the tuning and volume control knobs. The lettering on the switches was almost absent but I decided to leave restoring them for another time.

The metal strap covers, the switch-bank end pieces and the Philips badge all cleaned up nicely with Brasso but the escutcheon trim was more problematic. Rather than polish it out of

Philips 199 Transistor Radio – Differences

The 199 and 199AC look very similar to the model 198 but incorporate several component and configuration changes, as follows:

- (1) Bypass capacitors C11 & C14 changed from 40nF to 10nF;
- (2) Neutralising capacitor C13 changed from 65pF to 50pF and connected to an over-wind on IFT2's primary rather than to its secondary;
- (3) Neutralising capacitor C18 (15pF) becomes C19 (10pF);
- (4) Audio input coupling capacitor C25 (2µF) becomes C26 (10µF);
- (5) Treble-cut capacitor C25 (10nF) added between TR5's collector and ground (model 199 only);
- (6) Treble-cut capacitor C32 changed from 100nF to 220nF;
- (7) Feedback capacitor C29 (Bass position) changed from 300pF to 200pF;
- (8) Feedback resistor R22 reduced from 470kΩ to 220kΩ and its parallel capacitor C27 deleted;
- (9) Feedback resistor R30 increased from 100kΩ to 220kΩ and resistor R31 replaced with a link.
- (10) As noted in the article, the 199 sets alter the connection from the ferrite rod to the base of converter stage TR1.
- (11) The 198 derives all of its audio feedback from TR6's collector. In the model 199, it's permanently derived from the speaker, while Bass position feedback is still derived from TR6's collector and the Treble switch feedback has been omitted.

existence, I left it with the minimum of treatment.

Unfortunately, the strap stitching had all but disappeared but that's also a job for another time. On the other hand, the electronic circuitry all looked good, with no battery corrosion or other visible issues.

How good is it?

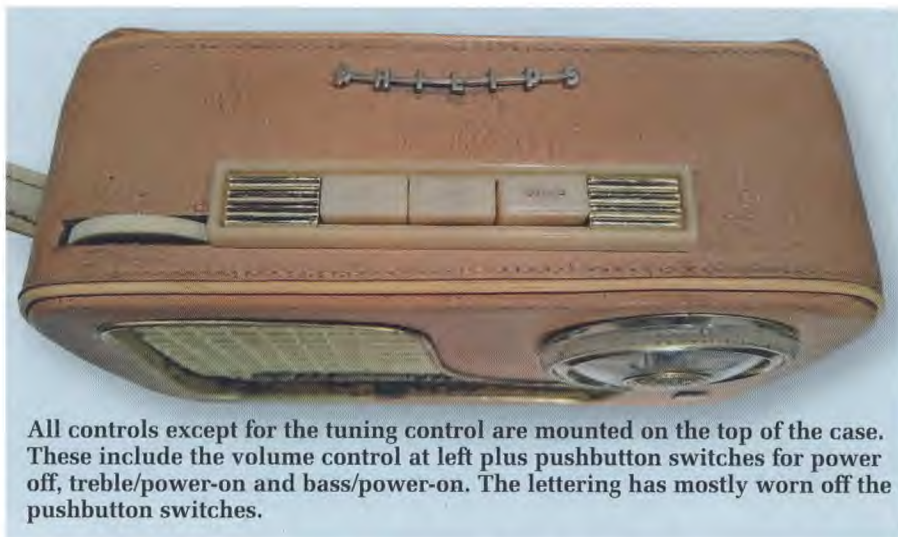
So just how well does the Philips 198 transistor radio perform? The answer is "surprisingly well".

First, the selectivity is quite narrow, being just ± 2 kHz at the -3 dB point and ± 20 kHz for 60dB down. It's wider than

the AWA 897P's with its six tuned IF circuits, however.

The RF performance was so good it had me rechecking my results. During alignment, I discovered that the oscillator coil slug was jammed tight. Another set had the same problem but after some fiddling about with various other adjustments, I managed to obtain 50mW output for a signal strength of just 40µV/m at 600kHz and 42µV/m at 1400kHz (although with only 16dB and 15dB S/N ratios respectively).

In the absence of oscillator adjustment, the classic solution is to adjust the antenna circuit by sliding the tun-



All controls except for the tuning control are mounted on the top of the case. These include the volume control at left plus pushbutton switches for power off, treble/power-on and bass/power-on. The lettering has mostly worn off the pushbutton switches.

ing coil along the ferrite rod. Sliding it towards the centre gives increased inductance, while moving it towards the end reduces the inductance. However, this adjustment on my set didn't offer much improvement.

I then decided on more drastic measures in the form of a hot-air gun applied to the oscillator coil, the intent being to soften the wax covering sufficiently to loosen the slug. It did no good; the slug still wouldn't move. In the end, rather than damage the slug by over-zealous pressure, I left the set with the best alignment possible.

In order to obtain the standard 20dB S/N ratio, the signal strength needed to be about $60\mu\text{V}/\text{m}$ at 600kHz and $65\mu\text{V}/\text{m}$ at 1400kHz. Compared to the AWA 897 and to the even better-performing Bush TR82C, this little Philips set is an absolute gem. It's nearly as good as the most sensitive set I've tested so far, the outstanding Pye Jetliner.

It's also interesting to compare it to

its model 196 valve predecessor. On test, my 196 required a radiated signal of just $25\mu\text{V}/\text{m}$ at 1400kHz for a 50mW output and just $6\mu\text{V}$ at the aerial terminal for the same output.

The Philips 198's AGC control is excellent, with the output rising by just 16dB for an input signal increase of some 66dB. It does go into overload after some 40mV is fed directly into the converter's base. This is equivalent to a field strength of about 500mV/metre, so "overload" for this set means "sitting right under the tower".

Audio performance

Like most small sets, the audio performance is adequate without being outstanding. Its frequency response from volume control to loudspeaker with S3/S4 in the "Treble" position is around 100Hz to 3.9kHz, with a 3dB peak at 250Hz. Switching S1/S2 to "Bass" position cuts the top end response to around 2kHz.

By contrast, the overall response when measured from the antenna terminal to the loudspeaker is only about 150Hz to 1kHz (S3/S4 in the "Treble" position).

The audio stage goes into clipping at about 160mW output, at which point the total harmonic distortion (THD) is around 6%. This increases to about 10% THD at 180mW. At 50mW, it's a bit under 1% and it maintains this figure for an output of just 10mW. This indicates that crossover distortion is well-controlled.

If the battery voltage drops to 4.5V, it clips at around 45mW. However, even at this low supply voltage, the crossover distortion is only just noticeable at 35mW output.

Would I buy another?

So would I buy another model 198 or 199? Well, I did actually. It's the look-alike 199C which is fitted with alloy-diffused OC170/169s in the RF/IF end and OC74s in the output stage.

If you can get either the 198, the 199 or the 199C, you'll have a fine little set that may appear unremarkable compared to other designs. But once you start using it, you'll be reminded of just how good it is. We'll find out just how good the 199C is in a forthcoming article.

Further reading

- (1) For the 198 and the 199 circuits, see Ian Malcolm's Transistor Radio Page: <http://transistor.bigpondhosting.com/circuits/philips198.jpg>
- (2) For information on the 199AC, including service data, see Kevin Chant's website: <http://www.kevinchant.com/uploads/7/1/0/8/7108231/199ac.pdf> **SC**