

# Vintage Radio

By Ian Batty



## Sony's TR-712 Mantel Radio

Sony's little mantel set, the TR-712, was a major step forward in performance for transistor radios. Previous models from Sony and other companies could only be regarded as having average sensitivity, at best. Then Sony changed the game with this 7-transistor set.

**I**n Sony's earliest days, the company then known as Tokyo Tsushin Kogyo took a massive leap of faith when Masaru Ibuka looked at the potential for transistor-equipped consumer goods. Ibuka had been advised that transistors of the time were only suitable for hearing aids. But he and his engineers had already showed imagination and enterprise by pioneering the use of valve-equipped tape recorders in schools and classrooms.

Summing up a discussion with his fellow engineers, he famously stated "Let's make radios. As long as we're going to produce transistors, let's make them for a product that anyone can afford to buy."

I've reviewed some eighteen sets so far: English, American, German, Australian and Japanese. With a few more on the bench ready to have articles written about them, nothing I've yet seen can match this modestly-styled set from Sony for sensitivity.

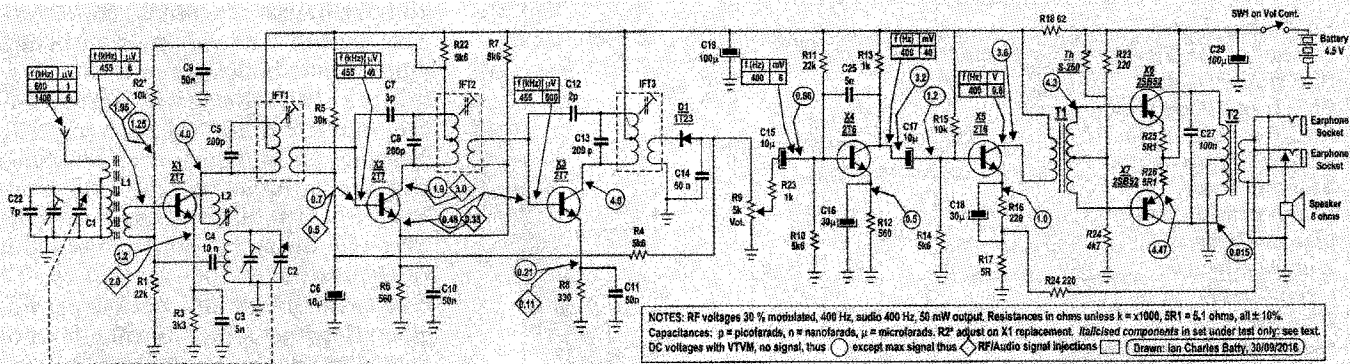
Sony's first radio, the rare TR-55, used only five transistors with a Class-A output stage.

Following that, the Sony TR-63 was more ambitious and it became the classic 6-transistor "trannie". While it was a triumph of miniaturisation and wildly successful with some 100,000 imported to the USA alone, the TR-63 was a pocket set, a personal radio and not particularly

sensitive. (see the January 2016 issue: [www.siliconchip.com.au/Issue/2016/January/Sony%E2%80%99s+TR-63+shirt-pocket+transistor+radio](http://www.siliconchip.com.au/Issue/2016/January/Sony%E2%80%99s+TR-63+shirt-pocket+transistor+radio)).

By that time, the market was ready for a mantel/table set. It would need good output power and sensitivity, to look good and perhaps be battery-powered. Sony's first effort was the TR-72, a fine-but-pedestrian timber-cased set similar to Stromberg-Carlson's, previously reviewed, 78T11 in the July 2015 issue (See [www.siliconchip.com.au/Issue/2015/July/Stromberg-Carlson%E2%80%99s+78T11-79T11+transistor+set](http://www.siliconchip.com.au/Issue/2015/July/Stromberg-Carlson%E2%80%99s+78T11-79T11+transistor+set)).

Then Sony produced the TR-712. Housed in a modest, stylish



**Fig.1: this circuit diagram is for one version of the Sony TR-712 radio. It uses five NPN transistors in the front end (X1-X5) and two PNP transistors in the push-pull output stage (X6 and X7).**

plastic cabinet, it has that late 1950s styling with a hint of Japanese influence.

The main dial is reverse printed into the faceplate on the right-hand side. This means that while minor scuffs may blemish the front, all lettering remains safely protected. The large tuning knob drives the gang through a 6:1 reduction gear, allowing easy fingertip tuning.

Interestingly, the dial sports US CONELRAD markers at 640 and 1240kHz. (*Editor's note: this is an artefact of Cold War paranoia in the USA. CONELRAD [Control of Electromagnetic Radiation] was a method of emergency broadcasting to the public of the USA in the event of enemy attack between 1951 to 1963.*)

The TR-712 features a "new" Sony logo, with the classic Times Roman lettering adopted in 1961 and retained to this day with minor changes. The above-mentioned article on the TR-63 shows the original "lightning bolt" logo used in 1957 by what was then Totso.

The case appears rectangular but subtle curves in the top and bottom relieve what could have been a "shoe-box" effect. It also sounds quite good, with a 5-inch speaker in the cabinet of reasonable size.

**Circuit description**

My sample TR-712 set uses five NPN transistors in the front end and two PNPs in the push-pull output stage. All the transistors were made by Sony. Have a look at the circuit in Fig.1.

X1 is the frequency converter and it uses collector-base feedback via a 10nF capacitor, C4, from the secondary winding of the local oscillator trans-

former, L2 (to provide oscillation). While this works just fine, attempting to inject a signal directly at the base for testing stops the oscillation. So my circuit measurements were made with signal injection at the conveniently-provided aerial coupling coil, L1.

The tuning gang uses cut plates, removing the need for a padder capacitor. The plates are also elliptical, rather than semicircular. This reduces "cramping" at the top end of the broadcast band, spreading out those stations and provides easier tuning. The earlier TR-63 lacked this refinement.

The first IF transformer, IFT1, uses a tuned, tapped primary with an untuned secondary. X1's base bias circuit, involving R2, appears combined with the dropping resistor for the 1st IF amplifier X2. X2's collector current (and thus the voltage drop across collector resistor R22) will change with AGC action.

Since changes in a converter's biasing commonly changes the local oscillator operation, does the TR-712's AGC actually affect the converter? In fact, it does, as discussed later.

X2, the first IF amplifier stage, drives IFT2 and gets its bias via the voltage divider consisting of resistors R5 & R4, with the bottom end of R4 going to demodulator/AGC diode D1. This stage is neutralised by 3pF capacitor C7, from the primary winding of IFT2.

As with IFT1, the second IF transformer IFT2 also uses a tapped, tuned primary with an untuned secondary.

The secondary winding of IFT2 drives the base of transistor X3 and provides its base bias from the emitter of transistor X2. While X3 drives IFT3's tapped tuned primary. IFT3's untuned, untapped secondary

feeds demodulator diode D1's cathode.

D1's anode delivers demodulated audio (filtered by C14) to volume control R9. It also delivers the AGC voltage, via R4, to the base bias circuit of X2. Audio signals on the AGC line are filtered out by 10μF capacitor C6.

X3 is also neutralised, by a 2pF capacitor, from the primary winding of IFT3.

The AGC control appears as a voltage drop at X2's base, from weak to strong signals. The actual change is not large but voltage divider R7-R6 is holding the emitter fairly constant. Given this, X2's base voltage drop from about 0.7 to 0.5V takes it to quite a low collector current.

As X2's emitter current falls, its emitter voltage does drop by some 100mV. This drop, conveyed to the base of X3, also reduces its bias and gain; the fall in X3's emitter voltage confirms this.

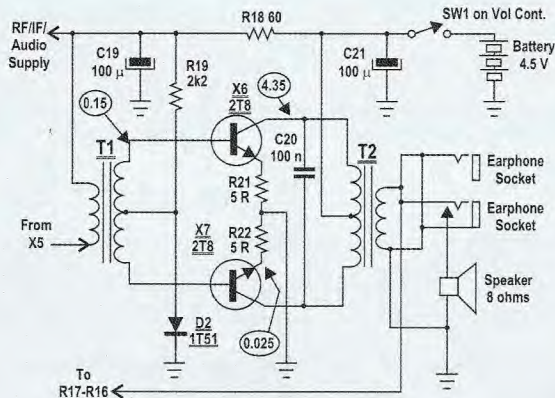
X2's collector voltage, dropped from full supply by R22, rises with AGC action (from weak to strong signals). As noted above, this also affects converter X1, with its collector current rising some 60%.

Audio from the volume control R9 is coupled via capacitor C15 to the base of the first audio transistor, X4. It's a conventional combination-bias circuit, with top cut feedback applied from its collector to base via C23.

X4 feeds the second audio transistor X5, the audio driver. Also using combination bias, its collector load is the primary winding of the audio driver transformer, T1. Its tapped secondary supplies out-of-phase signals to output transistors X6 and X7, to give push-pull Class-B operation.

While Fig.1 shows the output

Fig.2: this shows a variant of the TR-712 that replaced the PNP transistors used for X6 and X7 with 2T8 NPN transistors. The thermal compensation was also changed to a more effective circuit using diode D2 instead of the thermistor Th used in Fig.1.



transistors as PNP types, some circuits found online of the TR-712 show them with NPN output transistors and as it happens, my second sample of the set does have NPN 2T8 transistors as shown in the partial circuit of the alternative output stage in Fig.2.

Either way, the output stage operates in conventional Class B, with temperature compensation supplied by thermistor Th in Fig.1 and with R19 supplying a more effective 1T51 bias diode in the case of Fig.2.

Both circuits have further top cut

applied by a 100nF (C27/C20) capacitor across the push-pull primary of output transformer T2. T2's secondary connects via earphone sockets, to the 5-inch speaker.

In fact, two sockets are provided: the upper one parallels the earphone with the internal speaker, leaving it in circuit. The lower socket supplies output to the earphone only.

### Cleaning it up

The cabinet responded well to a gentle scrub and a polish but as far as

was needed. The volume control and tuning were both very scratchy.

Cleaning the gang's grounding spring and lubricating the bearings cleared the tuning problems but the volume control was more difficult. It refused to turn down to zero volume and cut out above about 80% rotation.

Disassembly of the volume control potentiometer revealed some kind of insulating deposit on the carbon track and no amount of cleaning would remove it.

As well, the track showed a resistance value of 10kΩ rather than the circuit value of 5kΩ. That was fixed by "poaching" a working pot from my other TR-712 which is now my "parts" set.

The set now performed well on the ferrite antenna but the direct aerial connection needed a lot of signal. Careful examination showed a corroded lead on the coupling coil. Fixing this brought the set into full operation.

### Performance

How good is it? Answer: surprisingly good! For a 50mW output, it needs only 9μV/m at 600kHz and 20μV/m at 1400kHz. In fact, I was scratching my head at these outstanding figures. But the respective signal-to-noise (SNR) ratios tell the story: 4dB and 6dB.

For more usual SNR values, it needs 30μV/m at 600kHz (for 15dB) and 50μV/m for 20dB at 1400kHz.

At the antenna terminal, it needs only 1μV at 600kHz (0.5μV at 700kHz!) and 6μV at 1400kHz for SNR ratios of 4dB and 5dB. This is shown in the diagram of Fig.3.

For the usual 20dB ratios, it needs 2μV and 25μV, respectively.

The fall-off in gain above 1MHz implies some input mismatching to my standard dummy antenna at the high end of the band.

All that said, I took it outside one evening and tried to find a quiet spot on the dial. Tucked away up here near Castlemaine, I found it impossible not to pick up some station right across the tuning range.

Its IF bandwidth is ±1.6kHz at -3dB down and ±25kHz at -60dB down. The AGC allows some 6dB rise in audio output for a 35dB signal increase, and I was unable to force



The main dial for this set is reverse printed into the faceplate protecting the lettering from damage. The US CONELRAD markers can be seen in red at 640 and 1240kHz. These were relevant only in the USA where they could be used to receive emergency broadcasts.

it into overload at any reasonable signal level.

Audio response from antenna to speaker is 140Hz to 1700Hz. From volume control to speaker, it's 150~3600Hz.

At 50mW, harmonic distortion is around 6% while clipping occurs at 130mW with distortion of 10%. At 10mW output, harmonic distortion is 7%. Given the feedback in the audio circuit, it's likely the output transistors have drifted and were no longer matched correctly.

At low battery, crossover distortion is obvious on the oscilloscope: maximum output is just 30mW at clipping, with some 9% at 10mW output.

And that link between the AGC circuit (via R22) and the converter's bias? Yes, as shown on the diagram, the converter's emitter voltage (and thus its collector current) does increase on strong signals.

Transistor AGC usually relies on gain falling with lower collector currents. But gain also falls at higher collector currents – it's known as forward AGC.

A test that mimicked this rise showed that the converter's gain fell with increasing bias.

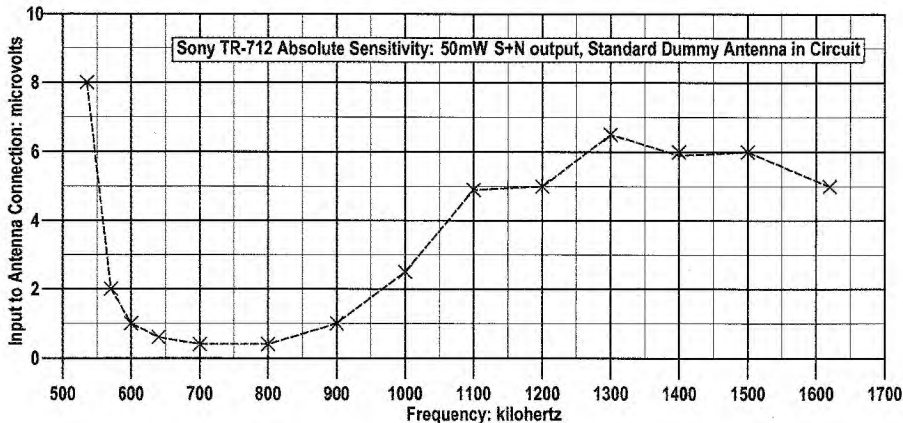


Fig.3: this graph shows the input signal needed at the input terminals to achieve a 50mW audio output from the loudspeaker. This is a very sensitive radio, considering the early development of stage transistors at that time.

One set of circuit notes stated that "converter gain falls with reduced injection voltage", and this is certainly true. That would qualify as a reverse AGC action.

The TR-712 circuit, however, shows a rise of injection voltage with rising X1 bias. So as the effect of X1's unusual bias circuit is to reduce gain by increasing collector current as the AGC takes control of the converter, this is a forward AGC circuit.

It does shift the local oscillator frequency, as I'd expected, by about 1kHz at the low end of the band. Since this only happens with strong signals, there's no obvious detuning effect.

### Gain versus noise figure

The TR-712's outstanding sensitivity comes at a price though; a high noise level. It's a reminder that any set's first stage determines the overall performance.



The rear view of the Sony TR-712. To replace the dry cell battery in the set, the back cover needs to be removed.

Transistor noise, like that in valves, comes partly from random emission of charge carriers (electrons, electrons/holes). But there's also the random diffusion of charge carriers across the base.

In addition, a transistor's base exhibits intrinsic resistance,  $r_{bb}$ . The base is lightly doped, giving high resistance and it's very, very thin; also a recipe for high resistance.

In combination, this  $r_{bb}$  can be some hundreds of ohms and like any resistive component, is a noise source. Prior to advanced diffusion techniques used in Mesa and Planar devices, transistor noise figures, as this set shows, were high.

Theoretically, the TR-712 should give a noise figure of some 22dB at 0.5 $\mu$ V input.

## Output transistor matching

Even with the negative feedback from the secondary of the output transformer to the emitter of transistor X5, this set gave high distortion. Mismatched output transistors would be the main suspect.

So the question was how to improve the distortion performance, without being able to get replacement output transistors? I tried adding a feedback resistor from collector to base on one of the output transistors. Sure enough the distortion fell.

The effect was greater with transistor X6, so I concentrated on it. Finishing with a 1.8k $\Omega$  resistor in series with a 47 $\mu$ F capacitor, I was able to get distortion under 2% at 50mW and about 1.2% at 20mW.

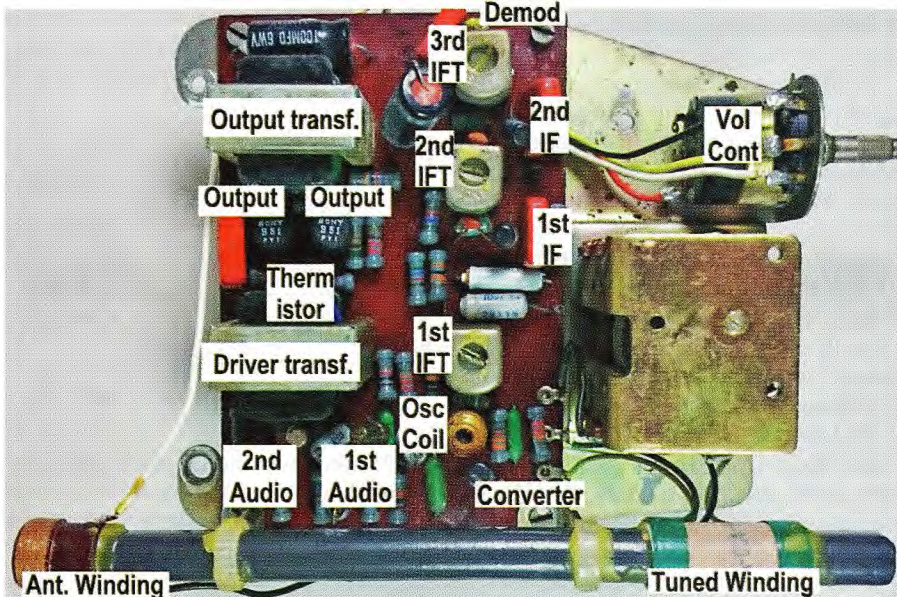
Yes, it does reduce the set's gain but it would be a useful fix where you've got noticeable distortion and no replacement transistors.

Would I buy another? There's a TR-712B that sports medium wave and shortwave. If you see one become available, snap it up before I hear about it!

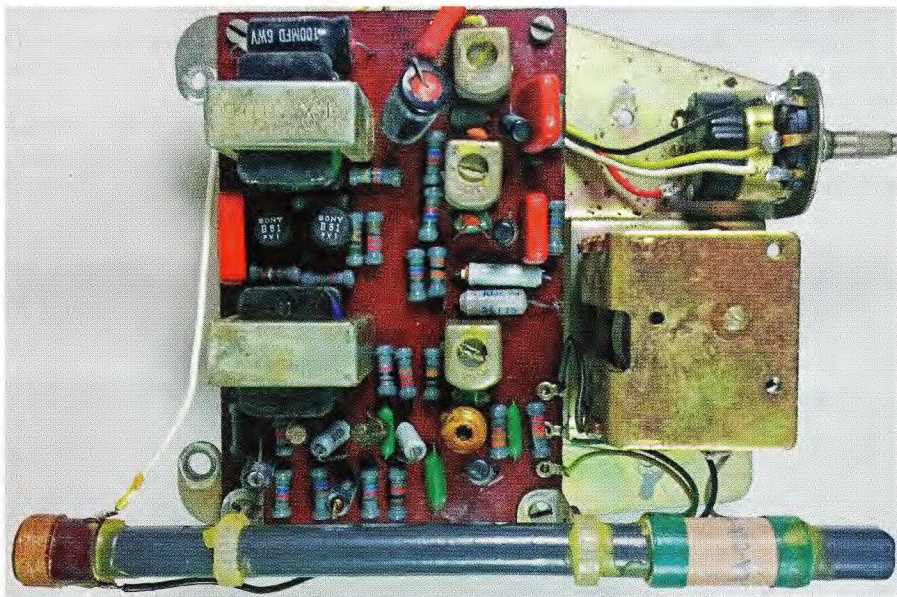
Given my TR-712's outstanding performance, I reckon the 712B will be one hot set on both bands.

## Special handling

The dial pointer sits between the transparent faceplate and the white backing panel. Chassis removal demands that you carefully slide the pointer off its shaft. I made a mini "tyre lever" by bending the end of a stout piece of wire, then eased the pointer's



This labelled picture of the main PCB shows the position of the major components. Note that this is the earlier version with the thermistor used for stabilisation of the push-pull amplifier's quiescent current.



hub forward as I drew the chassis out backwards.

To replace it, find a piece of tubing a little larger than the tuning shaft and gently press the pointer hub into place as you reinsert the chassis. Make sure the gang is fully closed (or open) so you can set the pointer.

## TR-712 versions

Several cabinet colours exist, all in low-key renderings. There's a blue one on YouTube, an off-white/bone TR-712B (and many other Sony sets) at Radiokobo, a beige TR-712B at Jinkei, and my classic olive green parts set at RadioMuseum. **SC**

## Further Resources

Further information on the set can be found as follows:

On YouTube at: [www.youtube.com/watch?v=IK7NPchbaTo](http://www.youtube.com/watch?v=IK7NPchbaTo)

On Radiokobo at: <http://radiokobo.sakura.ne.jp/G/tr-radio1/sony.html>

On Jinkei at: [www.geocities.jp/jinkei/soni-radio/tr-712b.html](http://www.geocities.jp/jinkei/soni-radio/tr-712b.html)

TR-712 and 712B Circuits are available from Kevin Chant at [www.kevinchant.com](http://www.kevinchant.com) and don't forget RadioMuseum at [www.radiomuseum.org](http://www.radiomuseum.org)