VINTAGE RADIO

Toshiba 9TM-40 "robot" radio

By Ian Batty

Where could a portable radio that looks like a robot have possibly come from? Japan, of course. This 9-transistor superhet radio from 1961 even comes with its own leather case.

Early transistor radios followed safe design principles: a rectangular layout, thumbwheel tuning with engraved markings or a dial behind a cutout window and a thumbwheel volume control. But cranking out functional design after functional design can quickly become tedious.

While some people look for a gizmo which encapsulates the latest advances in electronics, many consumers are more attracted to eye-catching designs.

Toshiba, lagging Sony in transistor radio technology by a few years, decided that they could get a leg-up by taking a more unusual visual approach. Their 6TR-127 looked pretty much like a small valve portable with a top-mounted tuning scale and a circular speaker grille on the front.

Come the Swinging Sixties, we got the visually spectacular 7TH-425 wall radio that I described in the March 2020 issue (siliconchip.com.au/Article/12589). We also got this quirky 9TM-40, known to some collectors as the "Robot Radio".

Japanese comic books, generally known as manga, brought Astro Boy to the world in 1952, which was broadcast on TV in 1963 (1965 for Australia). The 9TM-40 also has clear references to the robot/cyborg aesthetic.

And the addition of a pushbutton light to illuminate the dial, a kickstand for convenient use on flat surfaces and a leather case meant that this set was practical, not just pretty, An earphone/external speaker socket is pretty standard on portable trannies, but a microphone input socket is not. This allows the 9TM-40 to be used as a mini public portable address (PA) system!

Toshiba Design Studio

The 9TM-40 is unique, but it isn't Toshiba's only standout design. Among others, there's the 6TR-92 "Rice Bowl" pictured below.

The 9TM-40 is reasonably hefty for a portable; it certainly isn't a shirt pocket set.

It isn't just an interesting looking design; it's also very functional. The tuning dial is large and easily read, with the thumbwheel driving the tuning through a reduction drive. So tuning is easy and precise. With the tuning thumbwheel on the right and volume on the left, it's a natural two-hander.

Circuit description

The circuit for this set is shown in Fig.1. I've used the SAMS components numbering to reduce confusion, in case readers have copies of the SAMS circuit for this set.

RF amplifier X1 is a germanium 2SA72 in a four-lead can. It's a drift-field type, the third generation of junction transistors that used graded doping across the base for better high-frequency operation.

Another unique Toshiba design is the 6TR-92 "Rice Bowl" from 1959.

These devices exhibited lower feedback capacitances than their alloyed-junction predecessors, so this stage can operate without the neutralisation usually seen even in alloyed-junction intermediate frequency (IF) amplifiers. The fourth (shield) lead on the 2SA72 also reduces feedback capacitance.

The circuit begins with the tuned, tapped ferrite rod antenna. The secondary (bypassed to ground by 50nF capacitor C9) connects via 10kΩ resistor R3 to the AGC line. As X1 is an RF amplifier, this first stage of the 9TM-40 is gain-controlled. Such variable bias would be disastrous if applied to a converter, as the alterations in bias conditions would push the local oscillator off-frequency when a station was tuned in.

X1's collector feeds a tap on the tuned primary of RF transformer L2, with the entire primary shunted by 180kΩ resistor R5. It's there to ensure moderately wide bandwidth by reducing the Q of L2, so that small misalignments between L1 and L2 don't compromise the set's front-end gain.

L2's secondary feeds 2SA52 converter X2, a similar transistor to the OC45. This part of the circuit uses base injection, similar to that used in the previously described 7TH-425. In fact, the rest of the front end is similar from here on. In common with compact transistor sets, the tuning gang uses a plastic dielectric rather than air spacing, with a cut-plate oscillator section removing the need for a padder.

The only difference here is the three-gang construction due to the added RF stage (one gang each for tuning the antenna, RF stage, and converter).

X2 operates with the usual minimal bias, ensuring that it is into cutoff over

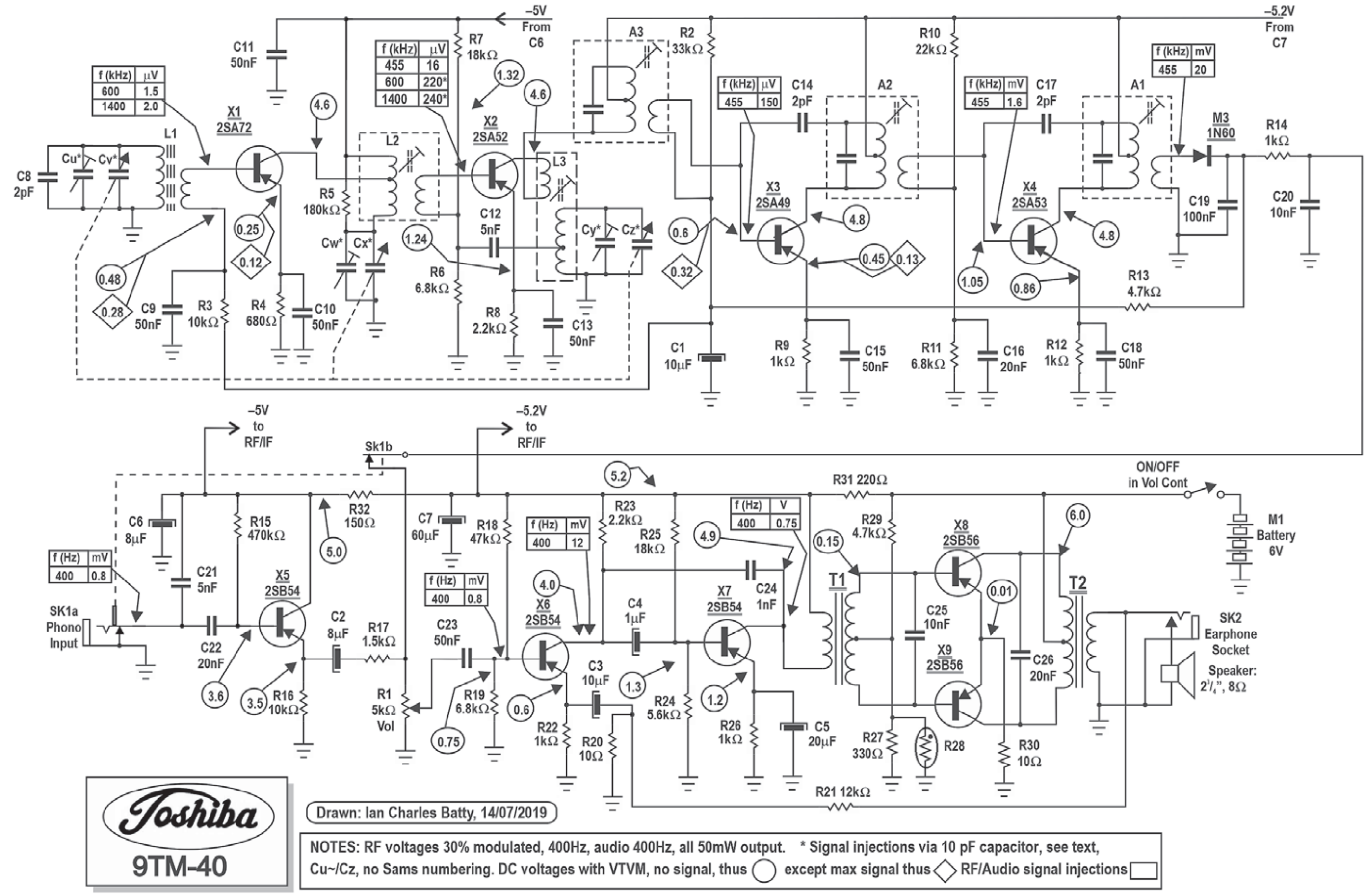


Fig.1: the circuit diagram for the Toshiba 9TM-40 shows a grand total of nine germanium transistors, quite a lot for a portable set. The 6V battery is used to derive -6V, -5.2V and -5V rails for the circuit, with a separate 1.5V battery used to power the dial lamp.

part of the local oscillator's cycle so that it can provide mixer action.

The 455kHz signal is developed across the tuned, tapped primary of the first IF transformer, A3. Its untapped, untuned low-impedance secondary feeds first IF amplifier (X3), a 2SA49, also similar to the OC45. It's an alloyed-junction type with significant collector-base capacitance.

Neutralisation is therefore applied from its collector to base by 2pF capacitor C14. X3's collector feeds second IF transformer A2's tapped, tuned primary.

A2's untuned low-impedance secondary feeds second IF amplifier X4, a 2SA53, again similar to the OC45. It also has significant collector-base capacitance. Neutralisation is applied from its collector to base by 2pF capacitor C17.

As usual for second IF amplifiers, this stage has a fixed bias. X4's collector feeds third IF transformer A1's tapped, tuned primary, and A1's untuned, untapped secondary feeds demodulator M3, a 1N60 diode. M3's output goes via the IF-rejecting low-pass filter C19-R14-C20 to volume pot R1.

The DC voltage at M3's cathode feeds the AGC line via R13 (4.7kΩ), with the AGC voltage filtered by 10µF capacitor C1. It goes to the base of the first IF amplifier transistor, X3. Forward bias for the RF amplifier (X1) and first IF amplifier (X3) transistors is provided by 33kΩ resistor R2 from the positive rail, counteracted by the AGC voltage.

Increasing signal strength will therefore reduce the forward bias on X1 and X3, and thus their gains. Unlike the 7TH-425's first IF amplifier, X3 is not decoupled from the supply to operate an AGC extension diode. This is not needed, as the application of the AGC control signal to both of these stages gives satisfactory overall AGC action.

A five-transistor circuit handles audio amplification. The microphone/phono input is buffered by the high-impedance emitter follower formed using X5, an alloyed-junction 2SB54 (similar to the AC125, which was the successor to the OC71).

As the two screws on the front panel were easily over tightened, it was common for this panel to crack.

Using simple series-bias from 470kΩ resistor R15, its high input impedance of around 135kΩ is hinted at by 20nF input coupling capacitor C22, a low value you'd expect to see in a valve circuit, but not a transistor set. Note that the SAMS circuit shows incorrect voltages at the base and emitter of X5, corrected in Fig.1.

Plugging a 3.5mm jack into SK1 disconnects the audio stage from the RF/IF section's demodulator and allows only the mic/phono signal to feed 5kΩ volume control R1, via C2 and R17.

In the main audio section, preamp and driver transistors X6/X7 (both 2SB54s) operate with combination bias. X7 has top-cut feedback applied, between its collector and base, via 1nF capacitor C24. X7 drives the primary of phase-splitter transformer T1, and T1's secondary feeds anti-phase signals to the low-impedance-base output transistors X8 and X9.

These are both 2SB189s, similar to the OC74. Shared 10Ω emitter resistor R30 helps to equalise the gains of X8 and X9, as well as providing some local negative feedback. The bias circuit, comprising 4.7kΩ resistor R29 and 330Ω resistor R27 (in parallel with thermistor R28), provides about 150mV of Class-B bias for X8 & X9. The quiescent (no-signal) current is about 5mA through this pair.

More top-cut is applied between the two output bases (10nF capacitor C25) and collectors (20nF capacitor C26).

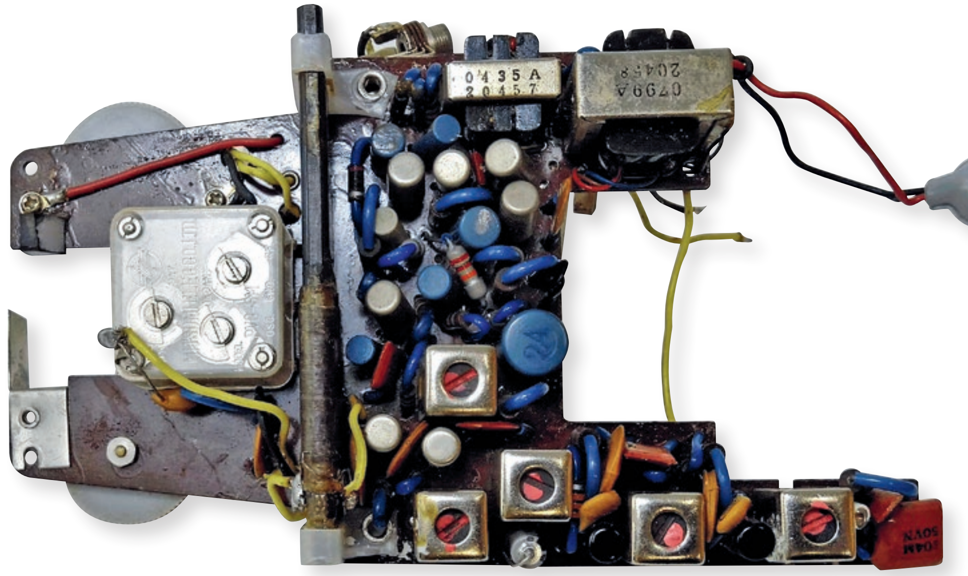
The output transistor collectors drive the primary of output transformer T2 in a push-pull manner, which provides conversion to a single-ended signal for driving the speaker voice-coil, and also matches to its impedance.

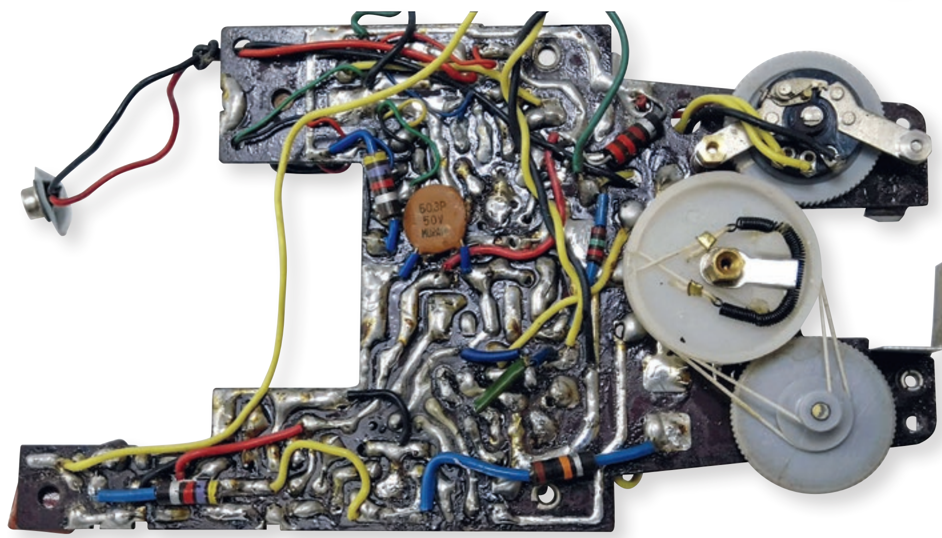
T2's secondary also applies feedback via 12kΩ resistor R21 to the emitter of preamplifier transistor X6. Unlike in the 7TH-425, the audio section's response due to feedback is designed to be flat.

Earphone jack SK2 is a simple change-over between the internal speaker and an external earphone or speaker.

Cleaning it up

I acquired this set unexpectedly. Having left my car at a local garage for service, I popped into a nearby second-hand shop. And there was this set! I'd seen one in as-new condition complete with display box and microphone for





The top of the 9TM-40 (above) is packed tightly with the majority of the components. The underside has a few loose components and the gears for the volume (which also acts as power) and tuning control (lower two gears), both adjusted via the side of the case.

around US $600 online, but I managed to snap this one up for a fair bit less. Not quite the 'roadside emporium', but a nice find nonetheless.

It was a bit scrappy, with the common problem of cracking around the two top screws holding the dial. The case was worn but complete, and importantly, it worked.

How good is it?

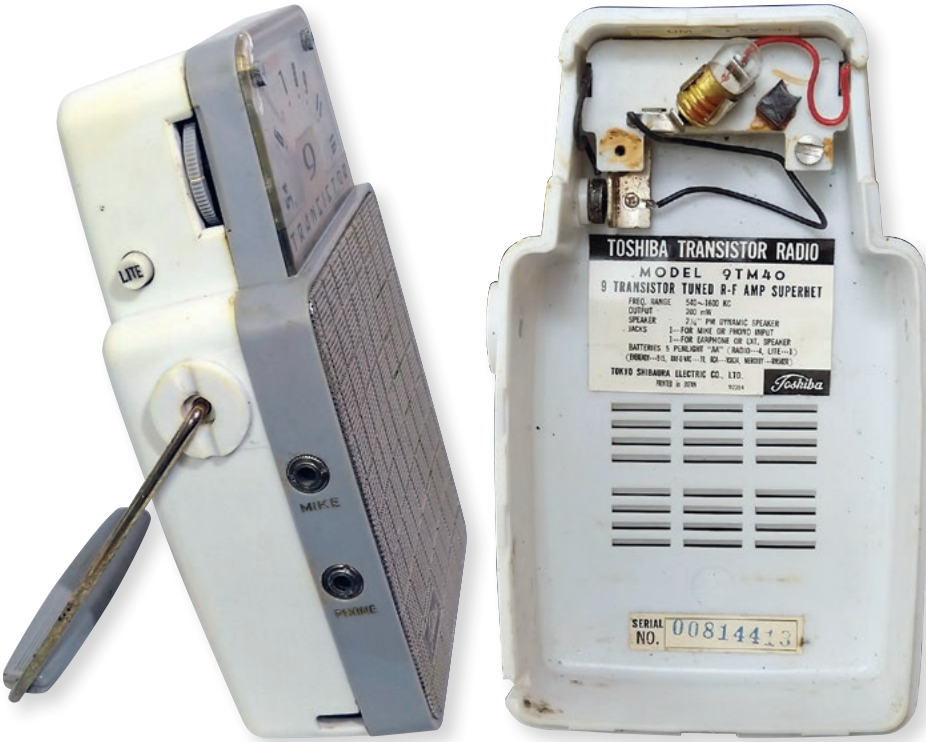
It's good without being outstanding. The surprises come from specifications not commonly examined.

Superhet radios are vulnerable to image interference. This happens when one station is tuned in, and another nearby station exists that's two times the IF up the band.

For example, 3WV in Horsham, Victoria, broadcasts on 594kHz. There's a Melbourne community station, 3KND, on 1503kHz. For a set with an IF of 455 kHz, we get 1504kHz (2 × 455kHz + 594kHz), just about 3KND's frequency. So it's possible to tune in 3WV and get 3KND instead, depending on their relative signal strengths!

Circuits tuned to the signal frequency improve image response, and most sets use a single signal-frequency tuned circuit – the antenna circuit. Such sets give an image rejection ratio in the 40-60dB range. That's good enough for most situations, but the extra tuned circuit of a tuned RF stage should improve image rejection.

The 9TM-40's 88dB Image Response Rejection Ratio (IRRR) at 600kHz is around 30dB better than radios with



On the side of the 9TM-40 is the knob for volume control and a switch labelled "LITE" which switches the on dial lamp shown at right. There is also a connector for a microphone (upper) and external speaker (lower).

no RF stage, putting it into the high-performance club.

Under my test conditions, and for the standard 50mW output, it needs around 110µV/m at 600kHz and 150µV/m at 1400kHz for signal-to-noise ratios (SNR) of 12dB and 16dB respectively. For 20db SNR, sensitivities were 175µV/m and 200µV/m. On air, it was able to pull in my reference 3WV over in Western Victoria with ease.

RF Bandwidth is ±1.85kHz at -3dB; at -60dB, it's ±29kHz. AGC action is acceptable; a 40dB increase at the input gave an output rise of just 6dB.

Audio response is 200Hz~7kHz from volume control to speaker; from the antenna to the speaker, it's 160~1800Hz.

Audio output is about 100mW at clipping, with 110mW out at 10% THD (total harmonic distortion). At 50mW, THD is around 5%; at 10mW, it's about 4%.

With a low battery voltage of 3V, it clips at 25mW, with 8% THD at 20mW output. There was notable crossover distortion, confirming the voltage-divider bias circuit's failure to apply correct bias at low battery voltages.

Special handling

If you are buying one of these sets, be sure to get photos of both battery compartments. The main battery (four AAs) is held in a case, easily replaced if corroded. The single AA for the dial lamp is held in a compartment inside the set that needs the back removed for access, and mine looked like it was the original from the factory. It was severely corroded. Some sellers may not even know of its existence.

Further reading

As with the 7TH-425, I found a SAMS Photofact online. These are excellent guides available at fair prices, but be alert to postage costs; postage can exceed the purchase price, depending on the supplier and postage service. Do be aware of occasional mistakes, and of their peculiar drawing layout and component numbering styles.

Conclusion

It would be nice to find a complete 9TM-40 with accessories, especially the small crystal microphone that came in the presentation case.

Toshiba's design studio continued with distinctive styling in following sets, such as the 6TP-309, 6TP-31 and 7TP-303. But I'm not too optimistic about finding them in a local second-hand shop. SC