By Ian Batty

Best Of British: the Bush TR82C Mk.2 transistor radio

A classic 7-transistor set from the early 1960s

Bush Radio began in 1932, becoming part of the Rank empire in 1945. Along with the iconic DAC90 and DAC10 valve radios, they also produced the distinctive TV22 TV set. Here we take a look at their distinctive TR82C Mk.2 7-transistor radio.

IF THE BUSH TR82C's classic styling evokes the era of rock'n'roll, it's with good reason. But it's not exactly unique, the styling having been based on an earlier valve portable designated the MB60.

Released in 1957 and designed by the brilliant David Ogle, the MB60 just screamed "modernity". It set a benchmark for style which was well-matched by its performance and sound quality.

Background to the TR82C

With the 1950s transistor revolution well under way, Bush responded in 1959 with the TR82. Initially kitted out with alloy-junction OC44/45 germanium transistors in the front end, it was a solid performer. By contrast, the TR82C Mk.2 described here used alloy-diffused AF117 transistors in the front end.

A Mullard design brief in 1960 for a 6-transistor set with three alloy-diffused transistors described it as offering "outstanding performance". So was Bush TR82C based on this circuit? A quick check in my Mullard "Reference Manual of Transistor Circuits" revealed that the Bush set is almost identical to Mullard's design.

In addition, having previously given Raytheon's T-2500 (also a 7-transistor set) a thorough going-over, I was curious to see what differences there were between it and the TR82C.

Face-off: T2500 vs TR82C

Whereas Raytheon used a craftsman-built timber cabinet, Bush settled for an elegant moulded cabinet with clean, bold lines. A large dial dominates the front, with its anodised red scale set back in a well behind the tuning wheel. As a result, unlike the Raytheon's "fiddly" dial, the TR82C is easily tuned using either a single finger or a thumb and fingertip spanning across the dial wheel. In addition, the TR82C uses a slow-motion dial for ease of tuning (as does the T2500).

The volume, wave-change and on/off-tone controls all sit in a well at the top of the case. The volume and on/off-tone control knobs are well-knurled and easy to operate, while the MED(ium) and LONG waveband switches are easy to access and respond positively. Ergonomically, this is one of the best sets in my collection.

By contrast with other sets, the cabinet uses a variety of trims. The metal parts are chrome-plated and the plastics are either in their original colours or "flashed" with bright finishes. The control legends are recess-moulded and filled with dark paint, making them highly wear resistant. In my set though, the dial wheel has yellowed and grazed with age. This badly dims

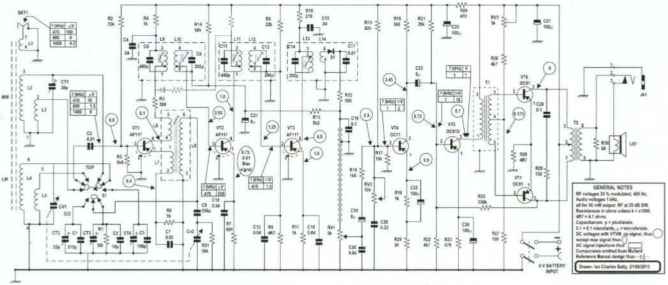


Fig.1: the Bush TR82C is a 7-transistor superheterodyne set with a push-pull audio output stage. Transistor VT1 is the converter stage, VT2 & VT3 are IF amplifier stages and VT4-VT7 form the audio amplifier with T1 acting as a phase-splitter. Switch S1 selects between the AM broadcast band and the long-wave (LW) band.

The TR82C's volume, wave-change and on-off/tone controls sit in a recessed well at the top of the case. A large dial "wheel" on the front of the set is used for tuning and is easy to operate.

the appearance of bright red anodising on the tuning scale.

In summary, in the design and usability race, the Bush TR82C is the clear winner over Raytheon's T-2500.

Design basics

Like the Raytheon T-2500, the Bush TR82C uses a conventional metal chassis. It's made from aluminium and is fitted with insulated mounting pins for the transistors (somewhat reminiscent of valve sockets). The transistors are mounted on the rear side of the chassis, allowing easy access to measure pin voltages. It also makes it easy to desolder and replace individual transistors.

On the design front, the TR82C uses a fairly conventional front-end: a self-oscillating mixer (converter) followed by two IF stages and a diode detector which also applies AGC to the first IF stage. By contrast, some competing designs (including Mullard's 1960 proposal) employed an auxiliary AGC diode to reduce converter gain on very strong signals.

This refinement is absent on the TR82C, so it was interesting to see how it handled strong signals (see "Performance" section below).

Circuit description

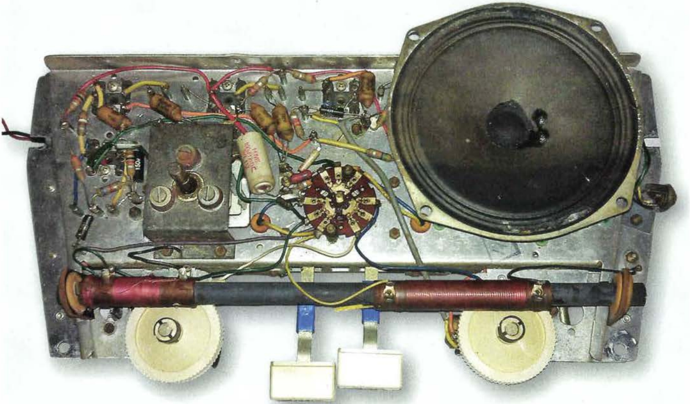
Fig.1 shows the circuit details. The Bush TR82C is a 2-band set covering both medium-wave (MW) and long-wave (LW) frequencies. These bands are selected using a somewhat unusual inductor/capacitor switching method.

The tuning gang (CV1, CV2) uses identical sections for the aerial and local oscillator (LO) circuits. Note that many single-band sets use a simplified LO section without a padder capacitor. However, this is impractical with a multi-band set such as the TR82C, as the LO would not track on any band other than the MW (broadcast) band.

For MW, both tuned sections of the ferrite rod antenna (L2, L4) are in parallel. This gives better signal coupling but yields a total inductance lower than either section alone.

The MW antenna trimmer (CT1) is permanently connected across the MW tuned winding (L2), while the tuning gang's antenna section (CV1) is wired across the LW tuned winding. When the LW band is selected, the MW tuned winding is disconnected and the LW winding (L4) only (still with the tuning gang connected) is used. In addition, the LW antenna trimmer (CT4) and shunt capacitor C5 are also now switched into circuit.

S1 switches the input to the converter between the two low-impedance



This view shows the speaker (front) side of the chassis. Note the large ferrite rod antenna and the point-to-point wiring method used (ie, no PCB). All the parts are easy to access.

antenna windings, depending on the band selected, ie, winding L3 for MW and winding L5 on LW.

The LO uses a single coil assembly, with L6 acting as the primary, L7 providing feedback and L8 used with CV2 for tuning. This means that a single adjustment affects the low-frequency end of both bands.

Basically, the designers have relied on correct alignment for the MW band, with padding and shunting capacitors added to correct for the LW band. For MW, a 556pF padder (C9) ensures correct LO tracking over the 995-2075kHz range, ie, a consistent 470kHz (the IF) above the MW band's range of 525-1605kHz. The trimmer capacitor is CT3, with C3 in parallel.

Alternatively, when the LW band is selected, shunt capacitor C1 (515pF) restricts the LO range to about 528-650kHz, ie, 470kHz above the 158-280kHz LW band.

Self-oscillating mixer

Transistor VT1 is basically configured as a self-oscillating mixer. This is an AF117 transistor and uses collector-emitter feedback, thereby reducing radiation from the LO.

As mentioned, the intermediate frequency (IF) section operates at 470kHz which is slightly more than the customary 455kHz. The IF section begins with IF transformer L9/L10 which has tapped and tuned primary and secondary windings.

Transistor VT2 is the first IF amplifier stage. This is another AF117 and is biased via the AGC circuit, with R14 supplying a bias current. The rectified output from diode detector D1 (an OA90) "bucks" the bias (via R12 & R13) with an opposing positive voltage that increases with increasing signal strength.

This AGC voltage changes the base bias and hence the current gain of VT2, thereby helping to maintain near-constant volume regardless of the signal strength.

The second IF transformer (L11/L12) also uses tapped and tuned primary and secondary windings. This in turn feeds the second IF amplifier which is based on transistor VT3, the set's third AF117. This stage operates with fixed bias for maximum, constant gain.

Note that neither IF transistor uses neutralisation/unilateralisation to combat the effects of collector-base feedback (Miller Effect). This is quite low in alloy-diffused transistors and gives no problems at low radio frequencies (such as 455-470kHz).

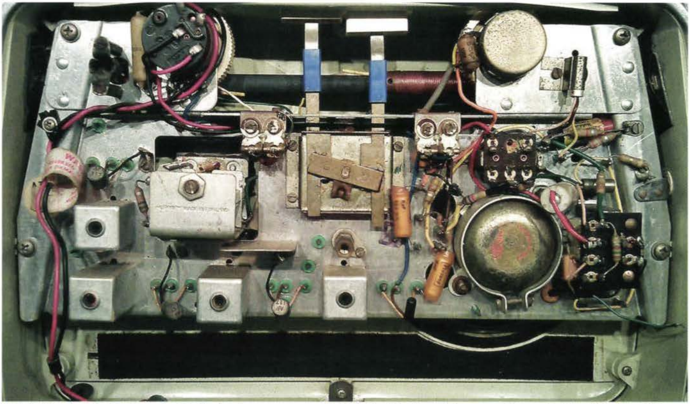
The third IF transformer (L13/L14) has a tuned, tapped primary and an untuned, untapped secondary. This secondary winding matches the low impedance of the detector diode (D1).

Thus far, the design is similar to the Mk.1 version, except that the Mk.1 used lower-performing alloy-junction transistor types, ie, OC44/OC45. However, these did require neutralisation networks for proper operation.

Audio stages

The audio section in the earlier Mk.1 version was unusual, with the first two stages being direct-coupled. It achieved good thermal stability and dispensed with one coupling capacitor, thereby improving low-frequency response.

The Mk.1 set also used an unusual "local" feedback scheme in the Class-B output stage. This involved using two extra windings on the output transformer, one for each emitter connection, with the resulting feedback reducing distortion in the output stage.



This is the view inside the set with the back cover removed. Note that the transistors are all mounted on this side of the chassis, with their leads terminated on insulated solder pins, making it easy to desolder and replace them if necessary. The method of construction used is reminiscent of that used for valve sets.

By contrast, the TR82C Mk.2 circuit ditches the direct-coupled audio preamplifier stages and reverts to the more common 2-stage configuration with resistance-capacitance coupling.

As shown on Fig.1, the detected signal from D1 is fed to volume control (RV1) and from there to the first audio stage (VT4, OC71) via capacitor C19 (8μF). Tone control RV2, connected to the base of VT4, applies adjustable "top cut" to this audio signal. This tone control also integrates the power switch, unusually switching both positive and negative battery leads.

VT4 in turn drives the second audio stage (VT5, OC81D). This transistor operates with a collector current of about 2mA and only dissipates about 20mW, yet it is mounted in a clip heatsink. This heatsink would appear to be unnecessary and may be there simply to provide a convenient way of anchoring the transistor in place.

Transistor VT5 drives the primary of transformer T1 which operates as a phase splitter. Its centre-tapped secondary then drives a push-pull output stage based on transistors VT6 & VT7 (both OC81D) and these in turn drive the centre-tapped primary winding of speaker transformer T2. T2's secondary then drives the speaker or a set of headphones (or an external speaker) via a headphone socket.

Unlike the Mk.1 version, the TR82C Mk.2 includes trimpot RV3 to allow the output stage bias to be adjusted to minimise crossover distortion. It also includes a common emitter resistor (R28) to provide a small amount of feedback. The Mk.2 version also provides a feedback loop from the collector of output transistor VT7 to the base of driver stage VT5, ie, via R25. This feedback further reduces the audio distortion.

The output power is quoted as 325mW at 10% distortion. It's fairly modest but enough to provide comfortable listening levels.

Cleaning up

Despite its age, the chassis was still in good condition and was operating normally. All that was required was a quick touch up of the alignment adjustments. During this process, I discovered that both aerial trimmers needed extra capacitance for optimum performance and I ended up adding a 10pF capacitor in parallel with each one.

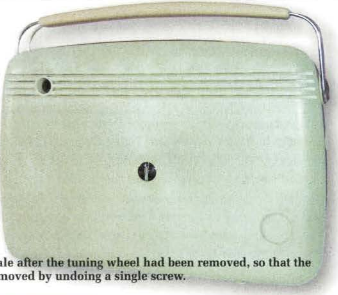
As obtained, the set also needed a good clean, both inside and out. I began this process by first dismantling the case, separating the front and back covers and the central section.

These two covers were in good shape physically but were grubby and had dirt lodged on the bottom lands of the grilles. A little "elbow-work" with some widow cleaner and a toothbrush soon had them sparkling again. The dial well was also grubby and this responded to a careful once-over with a cream cleanser.

In addition, the chrome bands were covered in some form of hardened grease/dirt composite. They were cleaned up with some judicious scrubbing and came up looking like new.

Unfortunately, the cabinet's blue middle section was a different matter. It was covered with some kind of brown, greasy film (probably from a kitchen) that proved to be quite stubborn to shift. After using a sponge wetted with a liquid kitchen cleaner to little effect, I tried using to a microfibre pad. This had proved to be effective in the past for removing all kinds of accumulations, including marker pens and paint.

It did a reasonable job but the blue colouring gradually built up on the



The photo at left shows the appearance of the bright red dial scale after the tuning wheel had been removed, so that the chassis could be removed from the cabinet. The rear cover is removed by undoing a single screw.

pad, showing that part of the plastic surface was coming off with the grease. Rather than wreck it, I didn't push my luck too far and left it before I was really happy with it.

Performance

The audio frequency response from the volume control to the loudspeaker is 170Hz to 12kHz but the RF/IF section crops the upper frequency limit to just 2.2kHz. A measured selectivity figure of -60dB at ±13kHz confirms this narrow RF/IF bandwidth, a result of the two double-tuned IF transformers

The audio performance is quite good: at 10mW output, the total harmonic distortion (THD) is 1.6% at 1kHz. This falls to 1.1% at 50mW, implying some crossover distortion or transistor mismatch at very low levels. At 250mW, the THD is just 1.7% and the set easily bettered its 10% quoted distortion at full output, giving just under 5% at 325mW.

The sensitivity is outstanding, the set delivering 50mW output (for a 20dB signal-to-noise ratio) for an RF input of just 7.5μV at the aerial terminal. Note that this is with the volume control "backed off" to give the 20dB noise figure. At full volume, this set needs just 1.5μV at 600kHz and 2.5μV at 1400kHz for 50mW.

It's pretty noisy at full gain though, with a signal-to-noise ratio of just 3dB at 600kHz and 8dB at 1400kHz. Its long-wave performance is quite impressive – a sensitivity of 2.5μV for a 20dB signal-to-noise ratio approaches the 1μV "gold standard" for valve sets using RF stages.

The signal strength received by the ferrite rod antenna needs to be around 100μV/m at 600kHz and 80μV/m at 1400kHz for an output of 50μW and a 20dB signal-to-nose ratio. At full volume, the sensitivity is around 20μV/m. These measured values closely agree with the figure in the original 1960 Mullard design paper.

The "noisiness" at full gain justifies the claim that converter noise is a limiting factor in weak-signal performance for superhets of all kinds.

The AGC control is excellent for moderate signals, with a 30dB increase in signal giving just a 6dB increase in output power. The set does, however, go into RF/IF overload for signals over about 20mV/m. This is confirmed by the collector current for the first IF amplifier stage (VT2) falling to near zero at this point. The Mullard design's additional damping diode and two resistors (shown in dotted lines on Fig.1) would reduce (or prevent) this problem.

Removing The Tuning Knob

The TR82C's tuning knob is a press fit onto the tuning gang shaft and Bush's servicing manual recommends using a suction cup to pull the knob off. It also clearly advises against attempting to apply pressure using "screwdrivers or other levers'.

Another method is to wrap three or four lengths of string around the centre boss to form a simple "puller" arrangement. The above photo shows how this is done.

Would I buy another?

Given the opportunity, would I buy another one? The answer is "yes".

In fact, there's also an FM/MW/LW version, the Bush VTR103, which I've ordered. It uses the same stylish case as the TR82C Mk.2 and an equally impressive circuit design, so I expect it to also be a good performer. There's also a quite rare version that uses a miniature valve as the converter and transistors for the IF and audio stages.

Yet another version, the TR82D, is identical to the TR82C except that it has a different cabinet colour. My TR82C has a light olive-green front and back, with a blue intermediate band and a cream handle. By contrast, the TR82D is cream with a tan band.

Resurrection

Finally, the Bush TR82C's classic look has just been revived with the release of the Bush TR82DAB, a modern DAB+/FM/AM/LW radio. The TR82DAB's cabinet looks virtually identical to the earlier 1960s design and a full review appears elsewhere in this issue.

Further Reading

(1) There are several discussion threads on: http://www.vintage-radio.com/

(2) For a company history and listing of sets: http://www.bushradio.co.uk/

(3) The original service data is available (along with many other UK sets) at: http://www.service-data.com/ **SC**