VINTAGE RADIO

1961-65 Bush VTR103 AM/FM Radio

By Ian Batty

The VTR103 was manufactured by Bush Radio, based in the UK and founded by former employees of Graham Amplion. This set incorporates a complex circuit design, utilising nine transistors to provide the AM and FM bands. The set is shown here with its partly-opaque dial cover removed.

Bush Radio began in 1932, becoming part of the Rank empire in 1945. Along with the standout DAC90 and DAC10 valve radios, they released the distinctive TV22 television.

The VTR103 case is based on that of the TR82C from the early 1960s (see September 2013; siliconchip.com.au/Article/4395). The TR82C was itself based on an earlier valve portable, the MB60, released in 1957. Designed by the brilliant young David Ogle, this case just screams 'retro' (although it would have been considered very modern at the time!).

It is such a popular design that the same case was re-used for the modern Bush TR82DAB radio, also reviewed in our September 2013 issue. You can't really blame them as it's such a classic shape, evoking the era of Rock 'n Roll.

The elegant moulded cabinet has clear, bold lines. The large dial dominates the front, its anodised red scale set back in a well behind the tuning knob. The volume, band change and on/off-tone controls sit in a well at the top of the case.

Placing a hand onto the set, one's fingers easily engage with the controls. The volume and on/off-tone knobs are well-knurled and easy to operate. The band change switches respond positively. Ergonomically, this is one of the most pleasant sets I have in my collection.

The dial cover/knobs, regrettably, have hazed with age. That rather dims the bright red anodising of the tuning scale.

Face-off: VTR103 vs TR82C

Given the visual appeal and ease-of-use established by the TR82C, why change anything? That seems to be the approach Bush designers took. Side-by-side on a shelf, differences are the necessary minimum: three pushbutton switches for band changing (LW/MW/VHF), and a dial with three wavebands.

The only other clear difference is the "output to tape recorder" socket at the lower right of the case at the back. Bush seems to have anticipated this in the TR82C, which carries a moulded dimple in precisely the same position.

The TR82C came in a variety of trims. The metal parts are chrome-plated, while the plastics are either in original colours or "flashed" with bright finishes. Control legends are recess-moulded and filled with dark paint.

The earlier TR82C used a combination of alloyed-junction OC44/45 transistors in the RF/IF end and OC71/OC81-class transistors in the audio end, offered longwave (LW) and medium wave (MW, ie, broadcast) reception, and was a creditable performer.

Frequency modulation (FM) broadcasting was introduced in the United Kingdom by the BBC in 1955, followed by commercial broadcasters in the early 1970s. BBC transmissions were in the range 88~94.6MHz, with commercial stations taking up 94.6~97.6MHz. This explains the VTR103's restricted FM tuning range of just 88~100MHz.

General description

The Bush VTR103 is an LW/MW AM/FM radio using nine PNP transistors and three diodes. FM reception is monophonic; there is no provision for FM stereo. The AM sections of the VTR103 are similar to those of the TR82C, including the use of double-tuned IF transformers. The audio section is also much the same.

Frequency coverage is 158~280kHz (LW), 526~1605kHz (MW) and 87.5~100MHz (FM). The AM intermediate frequency (IF) is 470kHz, while the FM IF is 10.7MHz.

The long wave/medium wave section is a conventional design with a converter, two IF stages and a four-transistor three-stage audio section using a Class-B push-pull audio output stage. All transistors are made of germanium; the RF transistors are alloy-diffused types, while the audio transistors are junction types.

Band changing is managed by one of three pushbuttons setting a multi-section rotary switch to the appropriate position. S2A removes power from the two AF114s in the VHF front end for the AM bands, leaving it inactive except for FM operation.

The dual-frequency IF design amplifies either IF signal frequency presented to it without needing switching or other intervention. Dual, separate demodulators are used: a peak detector for AM and a ratio detector for FM.

Readers may be familiar with the passband characteristics of a typical intermediate frequency amplifier: a single 'hump' at the design frequency. The VTR103's passband responds to signals at both intermediate frequencies, as shown in Fig.1.

Would it be possible to receive an AM and an FM broadcast simultaneously? The IF channel is capable of this, but the front end/tuned design ensures that only one signal (either

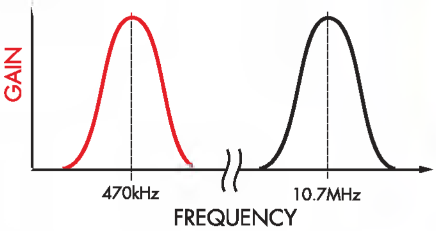
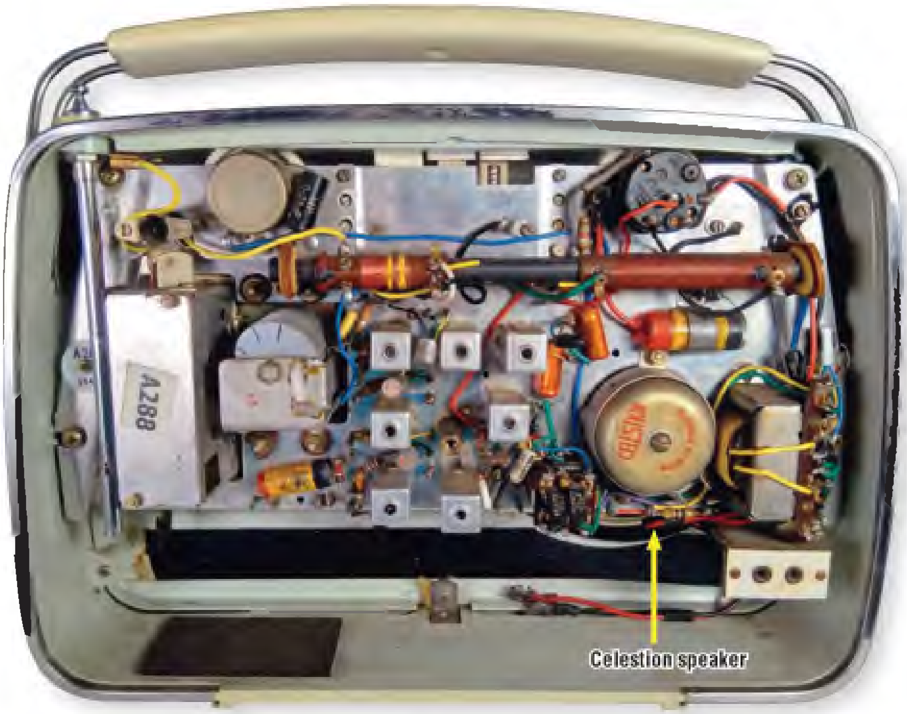


Fig.1: graph of the VTR103's passband response at the AM (470kHz) and FM (10.7MHz) IF frequencies.

It looks fantastic and has fantastic sound quality. The VTR103 is shown at right, next to the LW/MW-only TR82C.

The top view of the case shows the volume control (which doubles as the power switch), band change selector, tone control, and the telescopic aerial.

The rear of the set has a socket for an external aerial and a connector for a tape recorder. There is a socket on the left-hand (right from this angle) side of the set which is used to connect a pair of earphones.



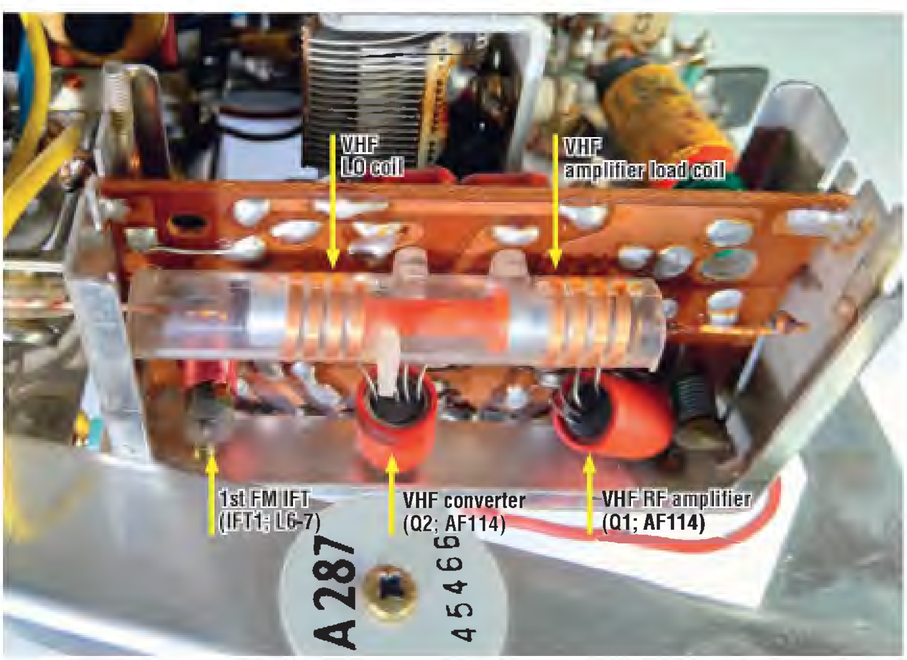
The VTR103 uses an aluminium chassis, with the germanium transistors mounted via insulated pins. The chassis is held in placed by four screws along the outside edge, and the tuning knob

AM or FM) is converted at a time. The following description will make this clear.

Construction

Like the TR82, the VTR103 uses a conventional aluminium chassis with transistors mounted to it via insulated pins. The transistors are mounted on the exposed side of the chassis, allowing easy access for measuring electrode voltages, and easy replacement by desoldering/resoldering.

The FM VHF tuner sits in a separate metal case. This allows all VHF components to be shielded, reducing the likelihood of radiation interfering with other services. The parts are mounted on a printed circuit board (PCB), making the assembly compact and controlling circuit inductances and capacitances.



A close-up of the FM VHF tuner which sits in a separate metal case for shielding and is mounted on a PCB.

Tuning is by a cord-driven mechanism that adjusts the position of tuning slugs in the RF transformer and LO tuning coil. Both coils are wound from copper straps that provide low RF resistance, and thus high Q and low losses at the operating frequency.

Although trimmers CT1 and CT2 are provided, as is an adjustable slug in antenna coil L1/L2, the manufacturer describes all of these as factory-set and advises against user or service adjustment. Aligning of this section is confined to adjusting of the dial mechanism to give correct tuning near midband, at 94MHz.

Circuit diagram

The full circuit of the set is shown in Fig.2. Unusually, the circuit diagram for this set is drawn with a negative ground. Emitters connect to the positive supply and collectors to ground. While this does not affect its operation, most PNP sets were drawn with a positive ground, so you need to be aware of this when reading the circuit diagram.

Of course, most modern circuits use a negative ground, so interpreting this one should not be too difficult for most readers. Additionally, the original circuit diagrams show chassis returns either to a common ground rail (thick common bar in the diagram), or to individual earth symbols for illustration clarity.

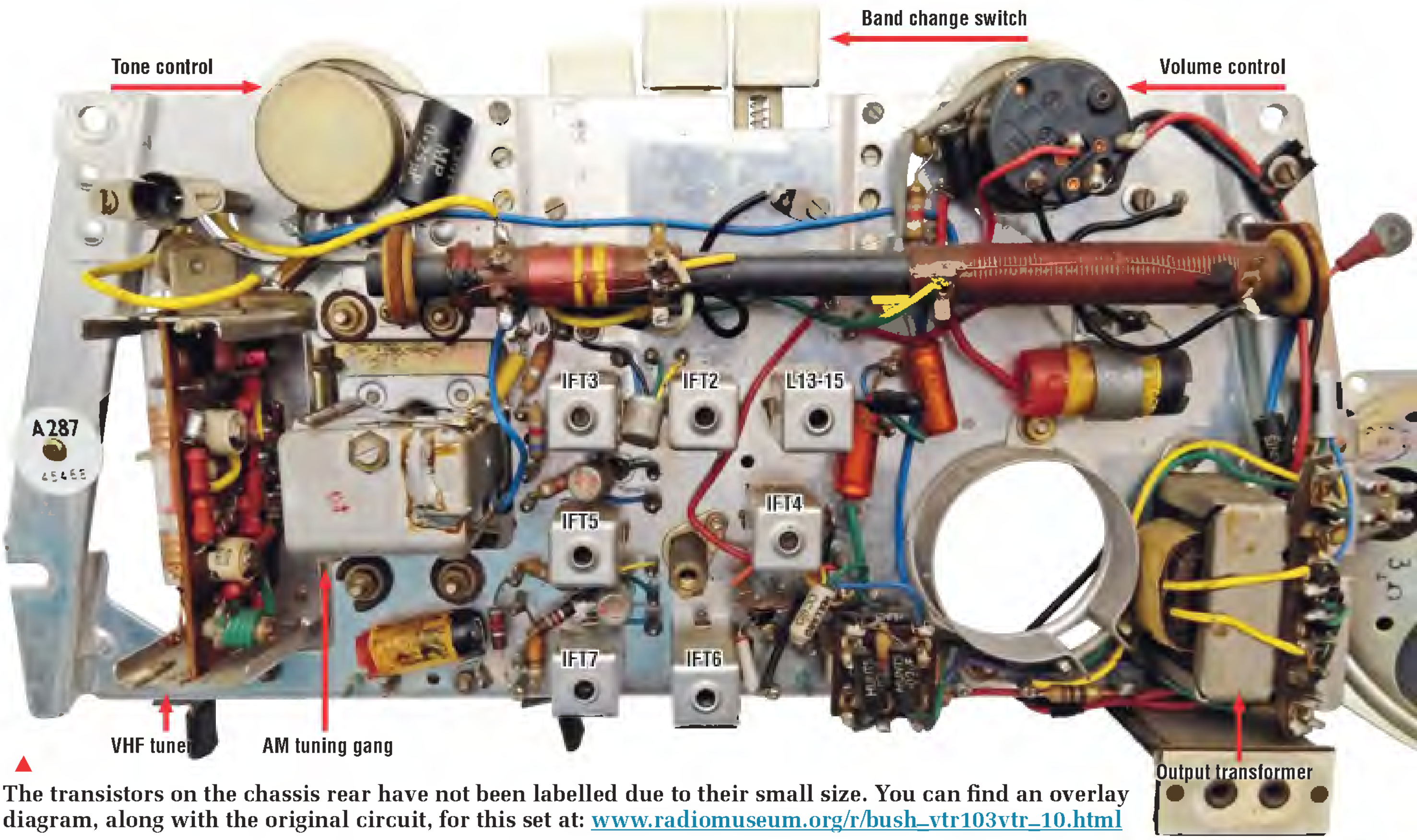
I drew Fig.2 because both schematics I found online were hard to follow. The Trader 1549 version is a dog's breakfast; the band change switch is broken out into individual make/break contacts, demanding that you get out the pencil and try to work out what is on (or off) for each band. Pity the poor service technician!

The Engineering Report's circuit at least seems to have had the service department looking on, but the erratic and inconsistent placement (for example) of biasing and tuning components in the IF strip is frustrating. I trust that my efforts will be more readily understood.

Circuit operation

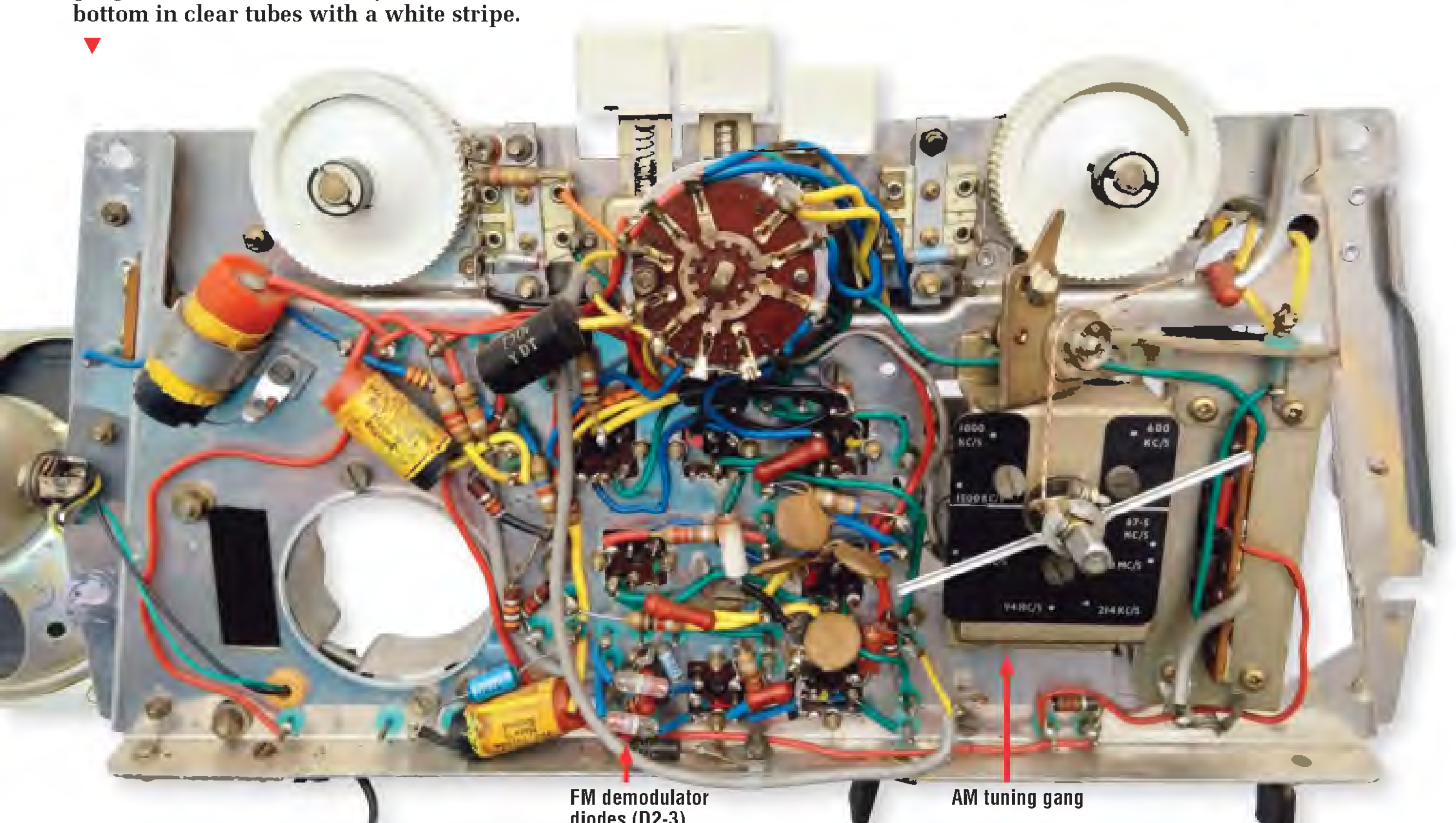
Taking the LW/MW section first, Q3 operates as a self-excited converter with collector-emitter feedback. The ferrite rod antenna receives external signals from the antenna socket via primary winding L8.

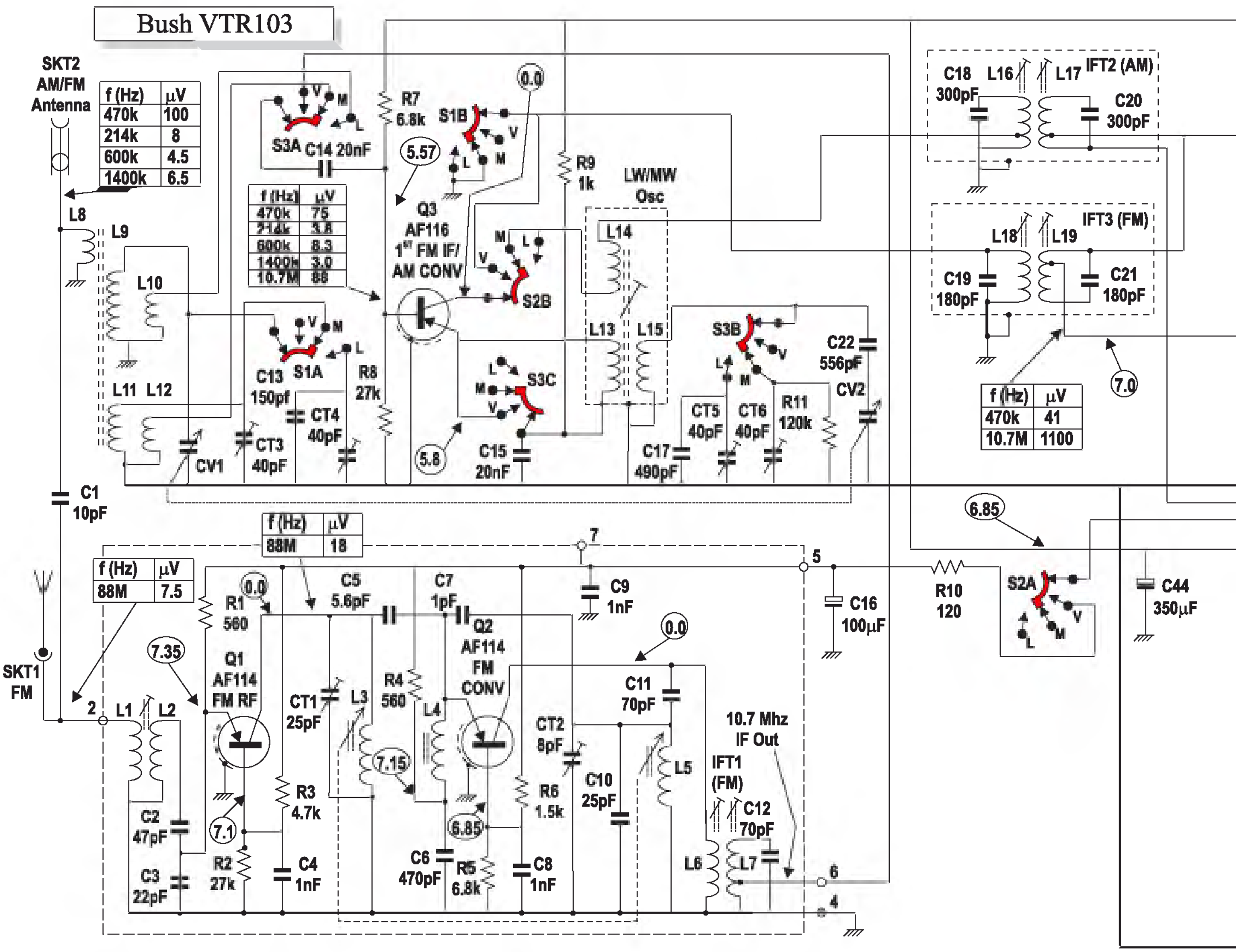
All band switching is done by just



▲ The transistors on the chassis rear have not been labelled due to their small size. You can find an overlay diagram, along with the original circuit, for this set at: www.radiomuseum.org/r/bush_vtr103vtr_10.html

The front of the chassis doesn't showcase anything new compared to the rear, apart from the markings on the AM tuning gang and the sockets used by the transistors. You can also see the two OA79 diodes, used for FM demodulation, at the bottom in clear tubes with a white stripe. ▼





NOTES: RF voltages 30 % modulated, 400 Hz, audio 400 Hz, 50 mW output. DC voltages with VTVM, no signal, thus ◯ except max signal thus ◇ RF/Audio signal injections ▭ . Frame Ground symbol ⫽⫽⫽ used for convenience is supply negative. (Drawn: Ian Charles Batty,11/02/2020)

one switch assembly. The original diagram labels it as S1A, S1B, S2A, S2B, S3A and S3B, according to the positions of the three separate wafer sections on the common shaft. I have omitted the usual dotted "common control" lines (such as those I have used for the tuning capacitors and inductors) to avoid cluttering the drawing.

For LW operation, the antenna section of the LW/MW gang (CV1/CV2) connects to the LW antenna tuned winding L9 on the ferrite rod. The signal is derived from antenna secondary winding L10 and fed to the base of the converter via band change switch S3A and coupling capacitor C14. Antenna padder capacitor C13 and LW trimmer CT4 are connected in parallel with CV1 via band change switch S1A.

Converter Q3's emitter connects to the positive supply via oscillator coil feedback winding L13, then emitter resistor R9 (bypassed by C15). The oscillator coil's L15 tuned winding connects, via band change switch S3B, to LW padder C17 and LW oscillator trimmer CT5.

Capacitor C17 adds enough capacitance to the oscillator tuned circuit to force it to cover the lower LO frequency range of 628~750kHz for longwave reception.

Q3's collector connects, via band change switch S2B, to oscillator coil L14's primary, and thence to the L16 primary of the first AM IF transformer (IFT2) primary, then to signal and supply ground. This primary is tuned and tapped.

IFT2's secondary L17 is tuned and tapped, with the tap feeding signal to first IF amplifier, Q4. Band change switch S1B shorts the primary of the first FM IF transformer (IFT3) to ground, preventing IFT3 from affecting AM operation.

MW converter operation

Returning to the converter, for MW operation, S1A connects the MW tuned winding L11 and associated trimmer CT3 in parallel with the LW tuned winding L9 and antenna tuning capacitor CV1. Paralleling L11 and L9 reduces the total circuit inductance, allowing the circuit to tune over the 535~1605 kHz broadcast band range.

Signal pickup from the ferrite antenna is derived from the MW

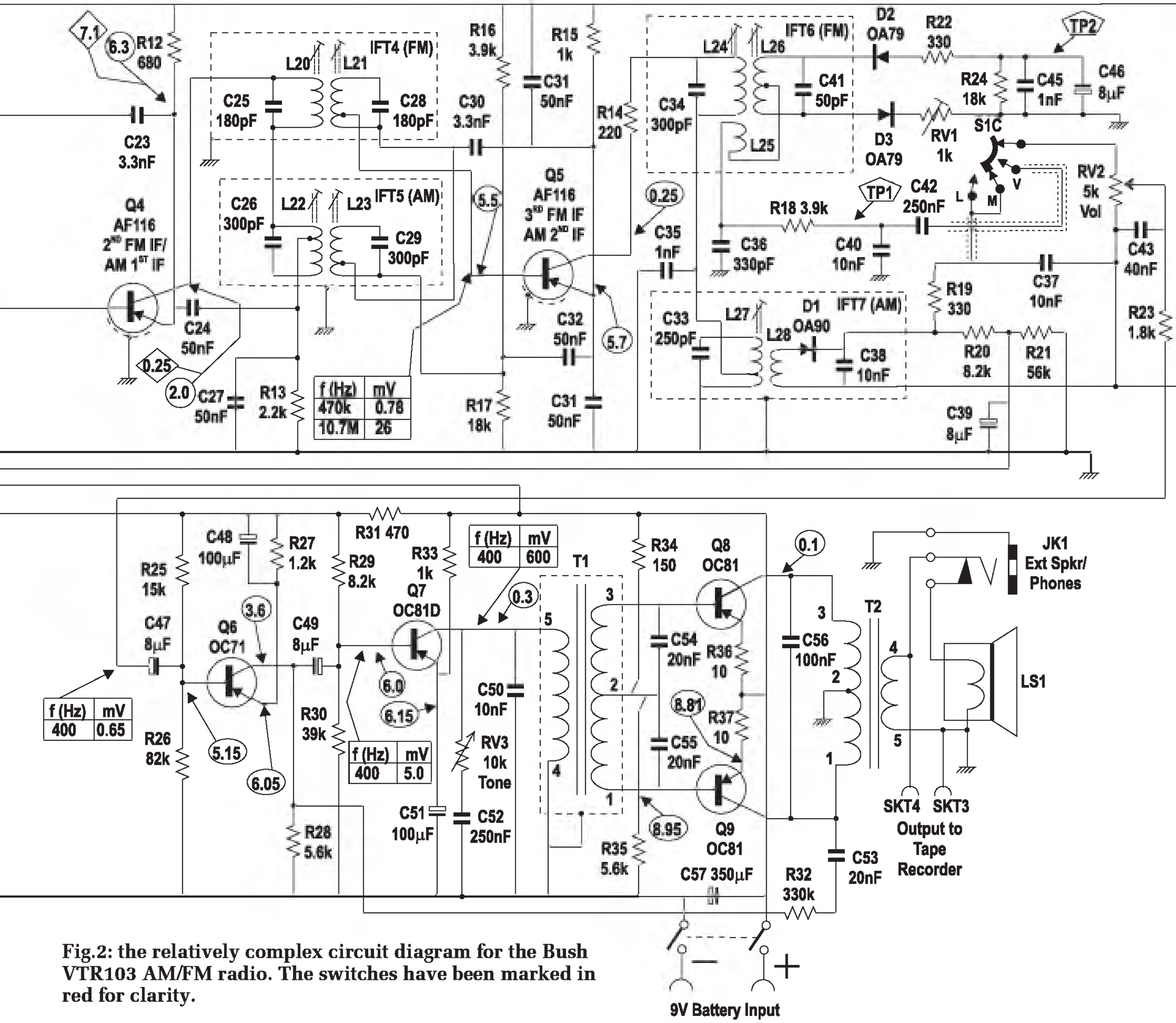


Fig.2: the relatively complex circuit diagram for the Bush VTR103 AM/FM radio. The switches have been marked in red for clarity.

secondary L12, and switched to the converter base via S3A and C14.

In the oscillator circuit, S3B disconnects the LW capacitors C17 and trimmer CT5, connecting MW trimmer CT6 and damping resistor R11 into the circuit, in parallel with oscillator tuning capacitor CV2 and the L15 tuned winding of the oscillator coil.

Note that, for both AM bands, 556pF capacitor C22 is in series with gang section CV2; you could call C22 the "master" padder.

Band change section S2B maintains the connection from the converter's collector to the L14 primary of the oscillator coil. S1B maintains the short across the L18 primary of first FM IF transformer IFT3 to prevent it affecting LW/MW operation.

As with LW operation, S2B connects the output from the converter (via L14 oscillator coil primary) to the L16 tuned, tapped primary of AM IF transformer IFT2 and thence to ground.

FM tuner operation

FM tuning is done using movable slugs. This method is more compact than capacitor tuning (as we need the coils anyway), and less liable to deterioration over time due to vibration or contamination.

In the FM position, S2A connects power to the VHF tuner module. This uses Q1 as a common-base RF amplifier. The input circuit is broadly fixed-tuned, with capacitive voltage divider C2/C3 tuning antenna secondary L2 and matching the tuned circuit to the low input impedance of Q1's emitter. Q1 uses combination bias.

Since this is a common-base stage, Q1's emitter is unbypassed (to allow signal coupling), but C4 bypasses its base to RF ground. As with the rest of the set, Q1's emitter returns (via emitter resistor R1) to the positive supply/RF ground, while its collector returns, via RF tuned circuit L3/CT1, to DC ground (the negative supply).

The amplified signal from Q1's collector is coupled to the converter's input via C5. Converter Q2 uses a self-oscillating design, and operates in common-base mode both for conversion and for oscillation. Like the RF amplifier, Q2's unbypassed emitter returns to the positive supply via RF choke L4 and emitter resistor R4.

L4's high reactance improves the converter stage's input impedance, to ensure successful oscillator operation.

Local oscillator (LO) feedback, from Q2's collector to emitter, is provided by capacitor C7. Notice that there is no phase inversion in this circuit; since a common-base circuit has a gain of around +1, collector-emitter feedback has a 0° phase shift, and thus is positive feedback that will provoke oscillation.

Converter Q2's collector connects to ground via oscillator tuning coil L5. The converter's FM IF signal is picked off via the series-tuned primary circuit of the first FM IF transformer, L6/L7.

While there's no 'law' against this, it's unusual. As a parallel-tuned circuit has very high impedance away from resonance, the C11/L6 combination will present virtually zero loading at LO frequencies of 98.2~110.7MHz. This allows Q2 to act as a converter, providing simultaneous LO oscillation and extraction of the 10.7MHz IF signal from its collector.

Secondary L7's tap connects to switch S3A. This disconnects the AM tuned circuits from the converter circuitry and conveys the 10.7MHz FM IF signal to the base of Q3.

Band change switch S3B disconnects some of the AM tuning circuitry from AM LO coil set L13~L15. More importantly, S2B disconnects Q3's collector from AM LO primary L14, while S1B removes the short across the second FM IF transformer IFT3 and allows signals from converter Q3's collector to pass directly to second IFT3's tuned, untapped primary L18. Thus, Q3 acts as the first FM IF amplifier.

Q3's AM LO circuitry is disabled by S3C's shorting of the AM LO transformer's L13 feedback winding.

IF operation for AM

For AM operation, IF signals are fed to first AM IF transformer IFT2 from the converter's collector into tapped, tuned primary L16, and are coupled to tapped, tuned secondary L17.

L17's tapped winding feeds the 470kHz AM IF signal to the base of first AM IF amplifier Q4; however, this winding is (for DC) in series with second FM IF transformer IFT3's secondary, L19. Since L19 and C21 resonate at 10.7MHz, they present very little impedance at 470kHz, thus allowing the 470kHz AM IF signal from L17's tap to be conveyed to the base of Q4.

At 10.7MHz, we also have the 10.7MHz tuned circuit in RF series with IFT2's secondary. A quick calculation shows that C20's reactance at 10.7MHz is around 50Ω, creating signal loss at 10.7MHz. The solution is 3.3nF capacitor C23; at 10.7MHz, its reactance is only about 4.5Ω, putting the 'cold' end of L19 close to IF ground.

It may appear that C23, with a 470kHz reactance of only about 105Ω, would severely shunt the AM signal at Q4's base to emitter, ie, to IF ground. This would severely limit the AM IF channel's potential gain.

However, C23, connected to a tapping on L17, forms a tuned circuit with L17's tapped section, and thus develops maximum AM IF signal. This is confirmed by the VTR103's stage-by-stage AM gains being pretty much the same as its predecessor, the TR82.

In AM operation, Q4's bias is supplied by series resistor R21 from the negative supply; more on that below. Ground is negative with respect to Q4's base, and thus it acts as a conventional series-bias circuit. This bias is also acted on by the AM automatic gain control (AGC) circuit, which will be described shortly.

Q4's emitter returns, via bypassed emitter resistor R12, to the positive supply, and its collector connects via the primaries of third FM IF transformer ITF5 and second AM IF transformer IFT4 to ground. As these two windings are in DC and RF series, it's vital that neither affects the resonance of the other; interaction would compromise the stage gain.

Considering the third FM IF transformer IFT4's primary L20, its reactance at 470kHz is very low, and thus it appears as a near short-circuit, allowing maximum AM IF signal to develop across the tuned, tapped primary L22 of second AM IF transformer IFT5. Its tapped, tuned secondary L23 connects, via the third FM IFT4's tapped tuned secondary L21, to the base of second AM IF amplifier Q5.

Second AM IF amplifier Q5 operates with fixed combination bias via R16/R17 and bypassed emitter resistor R15. The emitter returns to the positive supply while its collector returns via fourth FM IF transformer IFT6's coil L24 and third AM IF transformer IFT7's coil L27 to ground.

As with previous stages, the FM IF transformer's inductance is low enough to appear as a near short-circuit at 470kHz, allowing the AM IF signal at Q5's collector to develop across IFT7's tuned, tapped primary L27.

Q5 would usually operate with "starvation" bias so that it would easily overload in FM operation. This is a limiting action, and is the principal reason for FM's outstanding impulse noise rejection (of car ignition noise, lightning etc). The designers have not taken this course though, relying instead on the noise rejection inherent to the ratio detector (described below).

As with Q4's input circuitry, 3.3nF capacitor C30 resonates with the AM IF transformer's secondary, allowing the AM circuitry to operate at full gain while (when in FM operation) effectively shorting out the AM circuitry at the FM intermediate frequency of 10.7MHz.

Untuned, untapped secondary L28 feeds demodulator diode D1. This develops the demodulated audio across C38 and feeds it, via R19, to band change switch S1C on AM bands.

AM band AGC

The DC component of the 470kHz AM IF signal, filtered by R20 and C39, is applied to the biasing circuit of first AM IF amplifier Q4 as the AGC control voltage. The AGC voltage is positive, and this counteracts the forward, negative bias applied to Q4 via R21.

Stronger signals reduce the forward bias on Q4, reducing its gain and allowing the set to deliver a relatively constant audio output with varying received signal strength.

This set does not use an AGC extension diode, despite the provision of dropping resistor R13 in the first AM IF amplifier's collector circuit. So expect AM AGC to be only moderately effective.

FM IF operation

AM band converter Q3 is switched to operate as the first FM IF amplifier, as described above. S3A connects the L7 output of the VHF FM tuner module to Q3's base via C14. S3C and S3B disable the AM LO circuits while S2B and S1B connect Q3's collector directly to the tuned, untapped primary of second IF transformer IFT3's primary L18, and thus to ground.

Biasing conditions remain unchanged from AM operation.

IFT3's tuned, tapped secondary L19

delivers the 10.7MHz IF signal to the base of second FM IF amplifier Q4. To prevent first AM IF transformer IFT2's L17 secondary from affecting FM operation, it is bypassed by capacitor C23 as previously stated above. The signal from Q3 is coupled from the second FM IF transformer's L18 primary to its L19 secondary, and is delivered to the base Q4.

Although Q4's series biasing (R21) is potentially affected by the AM circuitry's AGC loop (via R20/C39), no AM signal will appear at the cathode of AM demodulator D1 in FM operation. There is no AGC action with this set for FM operation, and Q4 operates at constant, maximum gain without the need to disable the AM AGC circuit.

Q4's collector connects to ground via third FM IF transformer IFT4 and second AM IF transformer IFT5 (L20 and L22 respectively). As with Q3's collector circuit, the AM IF transformer primary presents very little impedance at 10.7MHz, allowing Q4's 10.7MHz signal to be developed across L20.

Q4's circuitry is decoupled from other parts of the circuit by dropping resistor R13 and bypass capacitor C27.

IFT4's tuned, tapped secondary L21 couples to the base of third FM IF amplifier Q5. Although this secondary is in series with second AM IF transformer IFT5's secondary L23, capacitor C30 bypasses L23 for 10.7MHz signals, allowing the FM IF signal from L21 to appear at Q5's base. Q5 operates with fixed combination bias via R16/R17, and emitter resistor R15, which returns to the positive supply.

Q5's collector connects to ground via fourth FM IF transformer IFT6's primary L24 and third AM IF transformer IFT7's primary, L27. The 10.7MHz IF signal developed across L24 is coupled to centre-tapped secondary L26 and tertiary winding L25. AM IFT7 has no circuit effect at 10.7MHz.

The FM demodulator circuit is a conventional ratio detector comprising, mainly, fourth FM IF transformer's secondary L26/tertiary L25, diodes D2 and D3, resistors R22/R24/RV1 and capacitor C46.

At exactly 10.7MHz, signals at the two diodes are of equal amplitude and phase, so they deliver a constant DC voltage to capacitor C46, and the intended audio voltage at C36 is a constant DC value.

For an IF signal that deviates above and below 10.7MHz, circuit action delivers unequal signals to D2 and D3. The output voltage at C36 will vary in sympathy with the variations in the IF signal's frequency above and below 10.7MHz, to produce the demodulated audio signal.

But, for a constant amplitude signal, the DC voltage across C46 will remain constant; C46 will neither charge nor discharge. So far, this is a conventional FM demodulator.

Should the IF signal amplitude increase or decrease, however, the DC voltage across C46 will decrease or increase correspondingly. This charges or discharges C46 to some extent. The resulting extra loading – or reduction of loading – acts to suppress any AM component in the received signal, such as car ignition noise or other interference.

Demodulated audio has deemphasis applied by R18/C40 to remove the pre-emphasis from the transmitted signal. The resulting audio signal is coupled to band change switch S1C via 250nF capacitor C42. Deemphasised audio is selected by S1C and routed to volume control RV2 and via R23 to the audio section.

Audio section

The audio section operates identically for all bands. It is a conventional three-stage design with preamplifier, driver and push-pull Class-B output.

Preamplifier Q6 operates with combination bias. It amplifies the demodulated audio from volume control RV2 and delivers it to driver stage Q7. Q7 also uses combination bias, and delivers its amplified signal to driver transformer T1's primary winding. As with all other stages, Q7's collector connects to ground via its load – in this case, T1's primary.

A variable top-cut tone control (RV3/C52) is connected between Q7's collector and ground.

T1's secondary provides antiphase signals to the bases of Q8 and Q9. These operate with a small amount of forward bias applied by divider R34/R35. There is no bias adjustment, and there is no temperature compensation in this circuit. Q8/Q9 drive push-pull output transformer T2's centre-tapped primary. T2's secondary connects, via earphone socket JK1, to the internal speaker.

Negative feedback is applied from the collector of Q9, via C53/R32, to the collector of Q6/base of Q7 to reduce audio distortion.

Two single-pin jacks (SKT3/4) allow audio pick-off for tape recording. While this is useful, standard practice would see this connection taken off before the output stage, averting the likely crossover and other distortion products common to Class-B output stages.

The battery supply is bypassed for stability by C57, and the audio preamp, AM converter and all IF stages are decoupled by R31/C44. The FM section's VHF tuner module supply is applied via S2A (FM only) and decoupled by R10/C16.

Cleaning up the set

Despite being sold "as is", this set was in tip-top working condition. A bit of contact cleaner and a quick tweak of the alignment had it going just fine. The band change pushbuttons had lost much of their labelling, but this was restored using a fine-tipped marker. Oh, for the days of Letraset!

The case responded well to polish. As for the electrical restoration, it only needed contact cleaning and a quick alignment.

How good is it?

Very good. In a typical British understatement, a 1963 British Broadcasting Corporation Engineering Report stated "the quality of reproduction is pleasing" (see the references below).

Its AM performance is as good as its predecessor, the TR82, rivalling Sony's outstanding TR-712 (see March 2017; **siliconchip.com.au/Article/10588**). FM performance is also excellent, achieving 40dB of quieting with just over 20µV at the input, as shown in Fig.3, and hitting 60dB+ well before the accepted standard of 500µV.

AM performance is also plotted for comparison. Yes, FM radio really is better than AM.

Test results

AM performance saw the standard 50mW output for 3.4µV at 600kHz, 2.4µV at 1400kHz, but for (signal+noise)-to-noise (S+N/N) figures of 18dB and 12dB respectively. For the standard 20dB figures, the input levels were 3.8µV and 5.3µV.

Off-air sensitivity was 100µV/m at 600kHz and 90µV/m, for S+N/N ratios of 21dB and 16dB. At 20dB S+N/N, the set needed 120µV/m. Its RF bandwidth was ±1.7kHz for -3dB, ±14kHz at -60dB.

Lacking an AGC extension diode (as did the TR82), AGC action is only adequate with a 30dB range. AM audio response is 40Hz~1.8kHz at -3dB from the antenna to the speaker; from the volume control to the speaker, it is 55Hz~4.2kHz.

Total harmonic distortion (THD) is commendably low, with less than 0.5% at 50mW and at 10mW (where crossover distortion would usually worsen performance).

The set goes into clipping around 150mW. At low battery voltages, it clips at about 35mW, with 2.8% THD, and noticeable crossover distortion.

FM performance, as noted above, is excellent. At 88MHz, an input of 7.5µV gives an S+N/N figure of 16dB for 50mW output. More usefully, the VTR103 provides an S+N/N ratio of 40dB with about 30µV at the input, and the standard 60dB with about 60µV at the input.

Audio response from the antenna to the speaker is 40Hz to around 8kHz. While it doesn't meet the full 20Hz to 15kHz broadcast specification, it does sound very good. My preferences, classical music and metal (both of which demand the full audio spectrum for good reproduction) come through well.

An external speaker really does show off this set, and points to the outstanding audio performance that FM broadcast offers.

Signal-to-noise ratio (SNR)

FM broadcasting was introduced as a high-quality service. We expect a S+N/N ratio of 60dB or better for a +54dBµV (500µV) signal, and a frequency response of 20Hz~15kHz.

Measuring the frequency response is complicated by the receiver's deemphasis circuitry that compensates the high-frequency preemphasis introduced by the transmitter. Its purpose is to improve the system's high-frequency noise figures.

Fig.4 shows the VTR103's actual response versus the standard response due to deemphasis. Notice the excess loss of high frequencies after about 5kHz, caused by top cut components such as C56 and confirmed by the "volume control-to-speaker" figures. This drop-off confirms my opinion that the tape recorder output would have given better fidelity if picked off before the speaker connection.

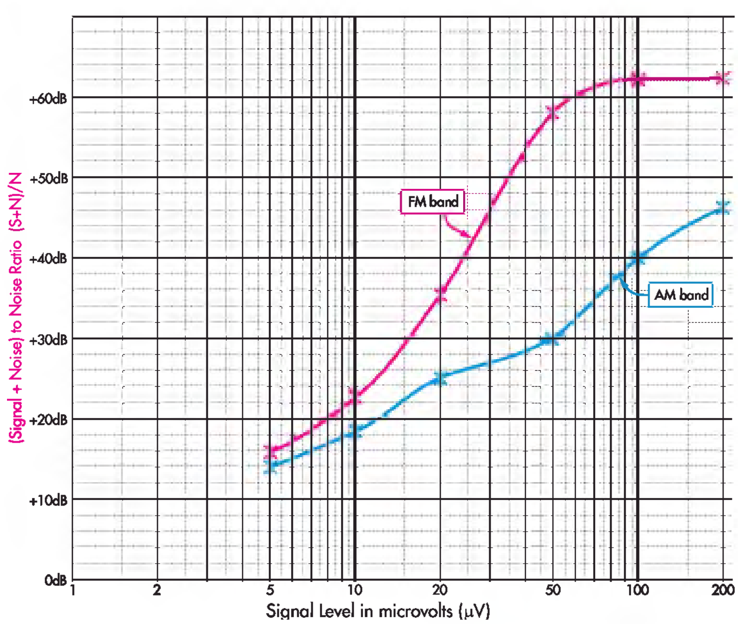


Fig.3: AM and FM SNR response.

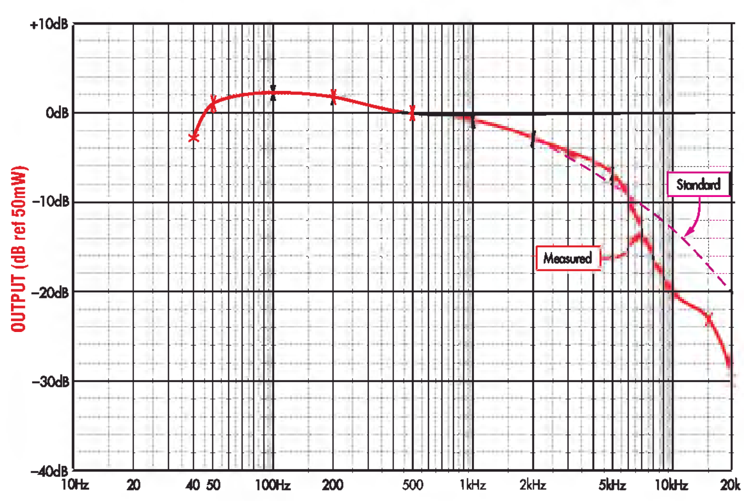


Fig.4: FM frequency response.

Collectability

The one I bought had been used by a video/film production company as set dressing – something to put in the shot for a "sixties vibe". As it worked just fine, I am pleased with the purchase.

As mentioned in the intro, modern reproductions are available. While they look superficially similar, I wouldn't spend maybe $100 when I could get an original online for less. Let me put it this way: I am not a fan of DAB+ radio.

VTR103 versions

As with the TR82, the VTR103 came in several different colours. Like my TR82C, my VTR103C has blue trim. There's also one in brown, and one with an entirely brown case.

Special handling

As with the TR82C, the VTR103's tuning knob is a press fit. Bush's servicing manual recommends using a suction cup (such as a "plumber's helper") to draw the knob off. The Bush manual clearly advises against attempting to apply pressure "from screwdrivers or other levers". Sound advice.

Another method is to wrap string around the centre boss to make a lifting rig. Take your time.

Further reading

As usual, Ernst Erb's site is the go-to: www.radiomuseum.org/r/bush_vtr103vtr_10.html

Engineering report: www.bbc.co.uk/rd/publications/rdreport_1963_42 SC