By Maurie Findlay, MIE Aust, VK2PW

AWA R7077 Beat Frequency Oscillator

It was 1939 and Australia was at war. Its future seemed far from secure and every industry in the country was geared to support the military effort. Amalgamated Wireless Australasia (AWA) played a key role by designing and producing vital communication equipment.

THE R7077 Beat Frequency Oscillator (BFO) described here was a very small part of the company's output during the early 1940s. This well-made piece of test gear provides a good example of the techniques that were available at the time. Vacuum tubes (valves) were by then well-developed and reasonably reliable but the transistor hadn't been invented.

Indeed, it would be another 20 years or so before equipment using semiconductors became available.

As a radio amateur after the war, I acquired a number of pieces of AWA equipment through the disposals outlets and adapted these for use on the amateur radio bands. I also remember having a famous American communications receiver (HRO) and an AWA receiver made in the same general format (AMR100). The workmanship and general quality of the Australian-made set was better than the original.

AWA's associated company AWV manufactured valves locally and many, particularly those designed for battery operation, were more reliable than overseas types intended for the same job.

The R7077 BFO

A handbook describing the R7077 BFO at the time lists the features, applications and design of the instrument and these are summarised in the accompanying panel. It is interesting to note the technical style used in the 1940s, long before terms such as "Hertz" were introduced, both in the panel and in the following text which is also derived from the leaflet:

The audio output is produced by mixing the outputs of two high-frequency oscillators, selecting the lowest frequency component of the output and amplifying it to a suitable level.

One oscillator remains fixed at 100kc, and the other is variable from 100kc to 86.5kc by means of a variable condenser. The plates of this are shaped to give an approximately logarithmic law to the beat frequency scale calibration.

Frequency drift, due to variations of temperature and supply voltage, is reduced to a minimum by using silvered mica condensers and robust coil formers in the tuned circuits. In addition, a symmetrical layout is used for the two oscillators.

Both oscillators are of the resistance stabilised tuned grid type, using a triode oscillator electron coupled to a heptode buffer amplifier. A type 6J8G valve is used in each oscillator circuit, which allows the oscillator and buffer amplifier to be accommodated in the one valve. The output of each oscillator is fed to the mixer valve, the variable oscillator output being taken directly and the fixed oscillator output reaching the mixer through a filter.

A low-pass filter placed between the

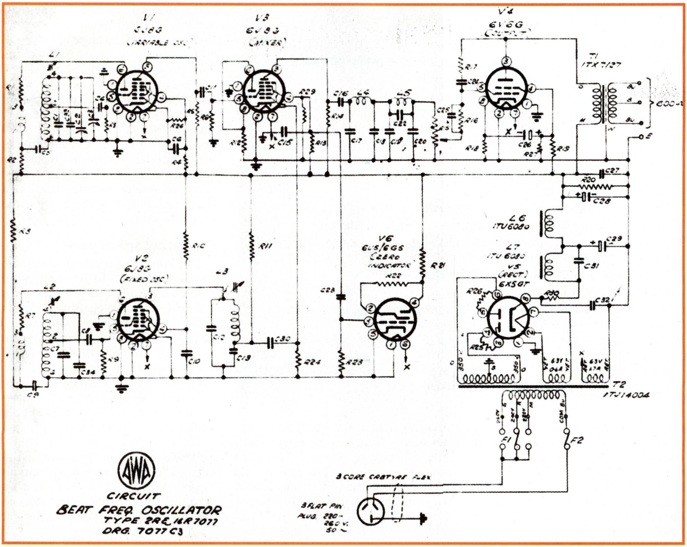


Fig.1: the original circuit from the AWA handbook. The signals produced by the variable and fixed oscillators (V1 & V2) are mixed in V3 and fed to a 6V6G audio output stage (V4). V5 is the rectifier, while V6 is a "magic eye" beat indicator.

mixer and the output stage effectively prevents high-frequency components in the mixer output from reaching the output valve.

Inverse feedback is applied to the output stage, which is a beam tetrode (6V6G). This results in a reduction of the output harmonic content, improvement in frequency response characteristic and stabilisation of output impedance.

Specifications

The specifications also make interesting reading, as shown in a second panel. It's not so impressive by 2011 standards but that's only to be expected. And remember, this was wartime and in addition to applications in the military, the instrument was also quite usable for general audio work, just covering the audible frequency range (10Hz – 13.5kHz).

By contrast, modern audio signal generators have a much greater frequency range (eg, up to 200kHz) and distortion across the range is better than 0.5%. An attenuator and meter to allow low-level signals to be generated accurately would also be included in some of the more expensive models. In addition, a total power consumption of 5W and a weight of about 3kg would be typical of a modern audio generator.

Getting it going again

My R7077 BFO was picked up in a

Features

Frequency range 10 cycles to 13.5 kc.
Directly calibrated 9-inch diameter semi-circular frequency scale, with direct and 44 to 1 reduction drives.
Low relative frequency drift of oscillators.
600 ohm output impedance.

Application

Typical applications of Beat Frequency Oscillator R7077 are the measurement of audio amplifier characteristics and modulation of transmitters and signal generators. The oscillator is also suitable for use in the operation of AC bridges and in conjunction with Cathode Ray Oscillograph R6673 forms part of the equipment for frequency measurement.

Specifications

Frequency Range: 10 cycles to 13.5 kc.

Accuracy: 2% from 30 cycles to 13.5 kc; 10% below 30 cycles

Power Output: 250 milliwatts maximum.

Output Impedance: 600 ohms balanced.

Harmonic Distortion: For 2V across 600 ohms: 4% at 50 cycles, 1% at 400 cycles and higher.

For 10V across 600 ohms: 10% at 50 cycles, 3% at 400 cycles and higher.

For 10V across 50,000 ohms: 10% at 50 cycles, 1.5% at 400 cycles and 1,000 cycles, 2% at 7.5 kc.

Frequency Response: 2db from 30 cycles to 10 kc.

Noise Level: 40db below a reference level of 6 milliwatts.

Radio Frequency Content: From fixed oscillator – negligible. From variable oscillator – 0.05 V across 600 ohms.

Power Supply: 200-260 V, 50– 60 cycles.

Consumption: Approximately 36 watts.

Valves: The following valves are supplied with the instrument: 3 – type 6J8G, 1 – 6V6G, 1 – 6X5GT, & 1 – 6U5/6G5.

Finish: Case – grey wrinkle. Front panel – polished grey with white lettering. Control protecting handles fitted.

Types: 2R7077 – Portable 12" x 8" x 8" case weight 24lbs. 3R7077 – Rack mounting type, 19" x 10" x 8 ¾"

junk store for a few dollars. Externally, it looked to be in good condition except for the power flex which had lost so much insulation as to be dangerous. Inside, all seemed original and with the schematic diagram stuck inside the case, the chances of getting it to work seemed good.

When it came to the minor components, I reasoned that the 14µF electrolytic capacitors in the power supply (C28 & C29) were the most likely to have deteriorated. By now, they probably had low capacitance and high leakage and so they were disconnected and modern types wired into place under the chassis. The power cord had also deteriorated and this was replaced with a 3-way flex/plug combination, with the earth lead securely connected to the metal chassis.

Checks of inductors L1-L5 indicated the expected resistance but the primary of the output transformer was open circuit. As a result, a speaker transformer (5kΩ:3Ω) that had been salvaged from an old broadcast receiver was wired in place of T1. This was connected in a temporary fashion so that the screen of the 6V6G would not be damaged with the high-tension applied.

The resistance from the cathode of the 6X5GT (pin 8) to the chassis measured about 20kΩ (due to voltage dividers across HT line), while the resistance from the primary winding of power transformer T2 to the chassis was greater than 10MΩ. This indicated that the power transformer was probably OK, so the 230V power was applied and all the valve cathodes glowed an encouraging dull red. However, the 6U5 zero beat indicator at the front panel gave only a hint of its normal green colour.

What's more, an oscilloscope connected across the output terminals indicated that there was no audio output from the instrument. The time had come for a systematic check through the circuit with a multimeter.

Troubleshooting

The high-tension (HT) line measured about 250V and the cathode of the 6V6G about 3V, suggesting that both the 6V6G and the 6X5GT rectifier were in good order. Next, the plate and screen voltages of V1 (the 6J8G variable oscillator) were checked and these gave readings close to 170V and 80V respectively, suggesting that the valve was doing its job.

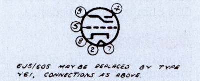


Fig.2: this diagram shows the connections for the alternative octal-base Y61 zero-beat "magic-eye" indicator.

It was a different story, when the voltages on the plate and screen of valve V2 (another 6J8G) were checked. They were much higher than they should be, indicating that its emission was low. I had a spare and when this was substituted, the voltages returned to normal and the scope then indicated the presence of an audio signal at the output terminals.

Obtaining spare parts

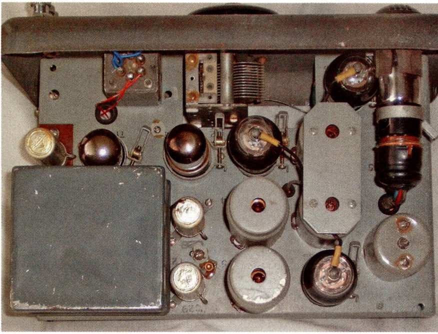
Obtaining replacement electronic parts for the R7077 BFO is usually not a problem. All but one of the valves were made in large quantities and are still generally available. Most valves made even 60 or more years ago seem to still be in good working order if they have not had a great deal of use. The best source is a friend who is an enthusiast but you can also find dealers on the internet who can supply valves at a reasonable cost.

The exception is V6, the 6U5/6G5 zero beat indicator, which tended to have a short working life. The circuit diagram suggests that a Y61, which has an octal rather than a 6-pin base, can also be used. I didn't have either but I did have a similar type with a 12V heater and an octal base (1629/VT-138). But where could I get the 12V?

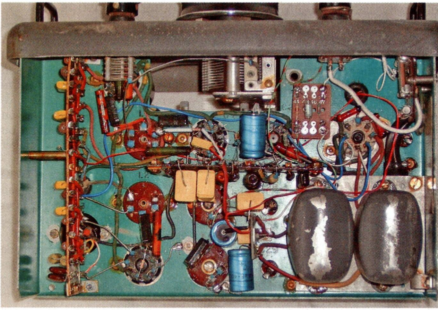
Fortunately, AWA engineers at the time tended to be very conservative and I was able to come up with a solution. The 6X5GT rectifier is provided with a separate heater winding, despite the valve being rated to withstand the high-tension voltage between heater and cathode. I took advantage of this and connected the 6X5GT's heater in parallel with the other valves. This left a 6.3V winding free to connect in series with the main 6.3V winding to provide 12.6V for the 1629 (its connections are the same as for the Y61).

A general check around the circuit revealed a few resistors which were high in value and these were replaced with modern types, using the closest resistance from the preferred value series. The output level control (R15, 0.1MΩ) proved to be intermittent and was replaced with a unit incorporating a double-pole mains off/on switch.

Coils L1-L5 are unlikely to go open



This top view of the chassis shows the robust construction techniques used in the R7077. The valves are all held in place by clamps, so that they cannot come loose as the unit is moved about.



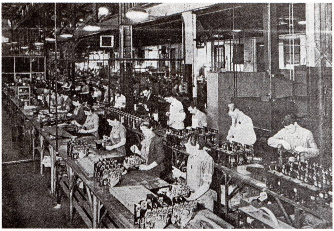
Only a few parts under the chassis required replacement. These included the power supply electros, a few resistors which had gone high and the output level control. Valve V2, the zero beat indicator (V6), the power cord and the output transformer also required replacement .

circuit but it would be possible to hand-wind replacements if necessary (a rather messy job). Filter chokes L6 and L7 are also unlikely to be faulty but their inductance is not critical and something to do the job will be found in many junk boxes. If they are not doing the job, there will be 100Hz hum at the output terminals.

A replacement for the power transformer (T2) is no longer available from parts suppliers but it is similar to the transformers used in many valve AM receivers. So scrounging a working unit from an otherwise defunct radio receiver shouldn't be too much of a problem.

Finding suitable replacements for the mechanical parts may not be so easy. However, it's worth remembering that the 75mm control knob, with the 44:1 reduction mechanism, was

This war-time photo shows the AWA Works Cafeteria at Ashfield. Meal breaks were staggered to cater for the large staff numbers involved and for shift workers.



A general view of one of the assembly lines in the Radio Electric Works, at AWA's Ashfield factory. Many types of transmitters and receivers were built here during the war.

used in several pieces of equipment manufactured by AWA in the 1940s. If this proves faulty, it should be possible to find a replacement although it may take some tracking down. This usually won't be necessary though because it has proved to be reliable.

Output transformer

That leaves the serious problem of the output transformer, T1. It is unlikely that an exact replacement for this unit (type 1TX7127) can be found. The temporary speaker transformer that I installed worked but the output from the BFO was much lower than the specified and fell off even further at lower frequencies.

The specification for T1 is not given in the literature and all I can do is to go back to fundamentals. The 6V6G is operated with a low screen voltage and the plate current is only about 15mA, which means that the optimum load resistance is not the usual 5kΩ. To determine the best load, a set of curves for the valve for a screen potential of around 50V would be needed and as far as I know, no such curves have been published.

As a result, all I can do is rely on experience and make an informed guess. In my opinion, the optimum load would be around 15kΩ and so the impedance ratio of the transformer would then be 15,000 divided by 600. This gives an impedance ratio of 25, while the turns ratio would be five.

The easiest solution is to find a speaker output transformer with the highest primary impedance rating possible. The output of the instrument would still be much lower than specified but it would still would be useful for jobs such as checking resonances in loudspeakers.

This photo shows workers building sub-assemblies on another of AWA's war-time production lines.

Modifying an existing unit

Modifying an existing speaker transformer is also within reason. It would need to be of the open type, using E & I laminations, and the rated primary and secondary impedances would have to be known. The low impedance winding is always on the outside – if you remove this, counting the turns as you go, you can then calculate the number of turns on the primary.

The number of turns for a 600Ω secondary can then be calculated and wound on, obviously using finer wire than in the original (so that the turns fit).

Note that speaker transformers made with E & I laminations have a gap between the two to prevent saturation of the magnetic materials due to the direct current flowing in the primary winding. This gap is provided by a piece of insulating material. The plate current of the 6V6G is only 15mA and the best result will be obtained by replacing the material with something as thin as possible, even tissue paper.

Modulation source

In my case, I often use the restored R7077 BFO as an external modulation source for a signal generator, when checking the audio response of radio sets. The audio range is covered in one sweep of the dial. Besides, it is interesting to preserve some Australian electronic history. **SC**