VINTAGE RADIO

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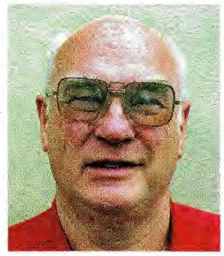

Intermediate Frequency (IF) Amplifiers; Pt.2

Last month, we looked at how the IF stage evolved in early broadcast-band AM radios. This month, we look at high-fidelity IF amplifier stages and describe how to get rid of the 9/10kHz whistle.

PRIOR TO THE introduction of FM into Australia, some radio manufacturers produced receivers that were capable of reproducing the full transmitted audio bandwidth. Typically, this involved designing 20kHz IF (intermediate frequency) stages to give a maximum audio frequency response of 10kHz.

However, the use of a wide-bandwidth IF laid the receiver open to annoying "monkey-chatter" – ie, distorted modulated audio signals from stations close to the tuned frequency. It also gave rise to annoying 10kHz heterodyne whistles from stations on adjoining channels. The monkey chatter couldn't be eliminated but the 10kHz whistle could be and often was.

Basically, the 10kHz whistle was "eliminated" by installing a simple 10kHz audio notch filter. This filter effectively reduced the whistle to an insignificant level.

The 10kHz filter often took the form of a narrow-band rejection filter, as shown in Fig.1. In this case, the filter is physically tuned to 10kHz by varying L1 or C1 and C2, while the depth of the notch was adjusted by VR1. Note that, with the advent of 9kHz channel spacing, these filters had to be retuned from 10kHz to 9kHz.

Variable selectivity IF stages

In most cases, broadband amplifiers did a good job on local stations and gave an audio output which was considered high-fidelity at the time (10kHz compared to FM which has frequencies as high as 15kHz). However, listening to more distant stations was often quite unpleasant at night, due to fading, noise and interference, monkey chatter and 10kHz heterodynes.

To counter these extremely annoying problems, most high-fidelity receivers included a switch that reduced the IF amplifier bandwidth to around 10kHz. This meant that the receiver could produce audio signals up to only about 5kHz when the switch was in the "narrow" position.

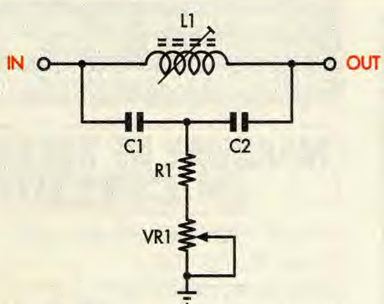

Fig.1: the circuit for a 9/10kHz audio notch filter. It is designed to filter out 9kHz or 10kHz whistles (depending on the station spacing) in a wideband AM receiver.

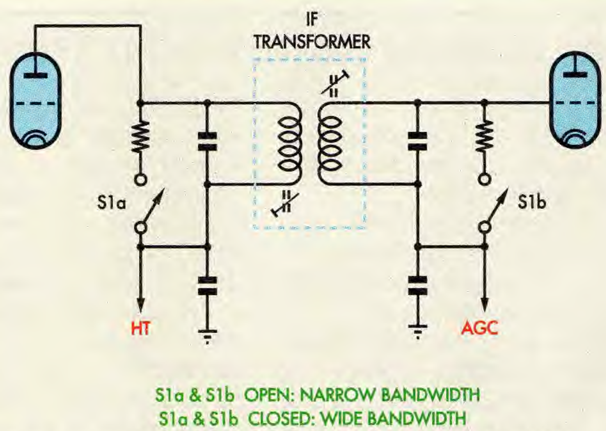

Fig.2: a variable bandwidth IF stage. Switching the resistors across the IF transformer windings increased the bandwidth, while reducing the gain of the amplifier.

This photo shows an assortment of 455kHz IF transformers. They came in a wide range of sizes.

Of course, this meant that the full frequency range was no longer reproduced, so listeners had to be content with less than "hifi" reproduction. However, on the positive side, the 10kHz whistles, monkey chatter, noise and interference were all significantly reduced. This was important because before the advent of TV, the evening's entertainment often involved listening to the radio.

Variable bandwidth

Taking this a step further, some manufacturers designed variable bandwidth IF stages that could be switched to suit the listeners' requirements. This was done in a variety of ways.

One method involved switching resistors across the IF transformer windings. This lowered the Q of the windings and the gain of the amplifier, while at the same time increasing the bandwidth of the amplifier – see Fig.2. Another method involved removing one IF transformer completely, replacing it with an untuned inductance-capacitance network.

Still another method involved switching a tertiary winding in and out of circuit in a special IF transformer. There were even circuits which automatically adjusted the bandwidth according to the strength of the received signal – ie, the bandwidth was controlled by the AGC.

However, although such circuits were around, very few showed up in the average domestic receiver. It's also interesting to note that specialised high-fidelity tuners/receivers often used an IF of 1900kHz (or some other frequency above the broadcast band) to achieve good bandpass shape and 20kHz bandwidth.

Unfortunately, fading – and selective fading in particular – remained as a severe impediment to good quality reception on distant stations. For those unfamiliar with selective fading, it manifests itself as severe distortion and fading of the received signal. It is usually due to multi-path reception, which causes the relative levels and phase of the carrier and its two sidebands to vary.

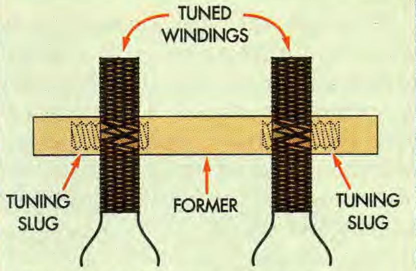

Fig.3: this diagram shows the correct positions for the slugs in an IF transformer. Note that the coils are tuned with the slugs towards the outside ends of the former (not in the centre).

Keeping IF amplifiers stable

It is rare to have instability and oscillation problems in well-designed amplifier stages. By using an IF of 455kHz and normal high-gain IF transformers, a valve with a mutual conductance of around 2000 was all that was necessary to obtain the necessary performance. Valves such as the 6U7G and the 6N8 fall into this category.

To ensure stability under all circumstances, it is necessary to make sure that the layout of the amplifier is such that inputs and outputs are kept well apart. This particularly applies if using high-gain valves. In some cases, such as when using high-gain valves like the 6BA6 (and more so with the 6AU6), a shield may need to be soldered across the valve socket, isolating the input from the output. As a matter of interest, I've found a number of Healing sets using the 6AU6 to be marginally stable.

Neutralisation

Neutralisation was used in circuit design back in the 1920s when triodes were used as RF amplifiers. It was necessary if reasonable gain was to be obtained without the amplifier oscillating. However, with the advent of RF tetrode and pentode valves, neu-

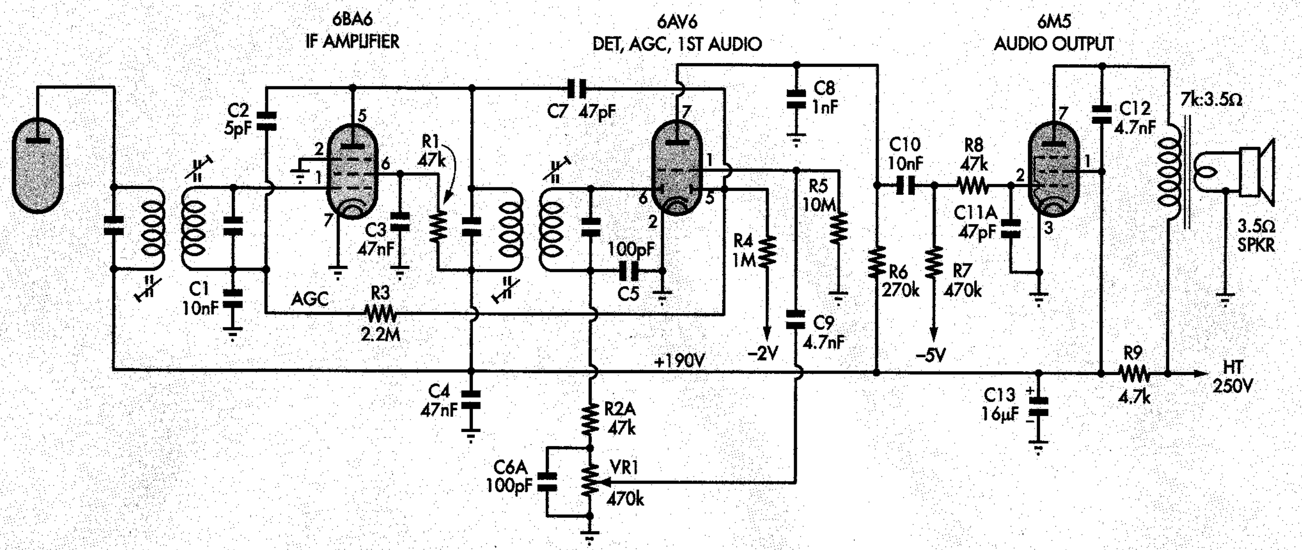

Fig.4: typical IF, detector and audio stages for an AM broadcast band receiver. The components marked with an "A" suffix are often missing but their inclusion improves performance (see text).

tralisation became unnecessary in most circuits, particularly in IF amplifiers with their relatively lower frequency of operation compared to RF amplifiers.

However, I've found that EMI/HMV have been sticklers for doing things right. Fig.4 shows a circuit in which the IF stage is approximately neutralised. The 5pF (C2) capacitor from the plate of the 6BA6 to the bottom of the secondary of the IF transformer acts with the AGC bypass (C1) to form a bridge neutralising circuit.

I had a Little Nipper receiver to restore some time back which had an unstable IF amplifier – it tended to oscillate if I wasn't careful with the alignment. It turned out that someone had been at the set before it came to me and had replaced the .01μF AGC bypass capacitor (C1) with a value of 0.1μF. Replacing this capacitor with the correct value restored the neutralisation and the IF stage was again quite stable.

Detector & AGC leads

The leads from the detector and the AGC diode tend to be treated as having no RF energy on them. In reality, however, they carry quite a bit of RF (IF) energy and this needs to be prevented from radiating and causing instability within the receiver.

For example, resistors R3 and R4 should have minimal lead length on the ends connecting to pin 5 of the 6AV6. Similarly, the 47pF capacitor (C7) lead from pin 5 of the 6BA6 should be as short as possible, as should C5's lead on the IF transformer terminal. By observing these precautions, minimal IF energy will be radiated from the IF amplifier circuits.

The detector lead to the volume control can also radiate energy if it isn't shielded. However, few receivers in the later valve radios have this lead shielded so it isn't always necessary. Note too that some receivers have the volume control directly connected to the bottom of the IF coil as shown in Fig.4 (assuming that R2A is a wire link). In that case, only the 100pF bypass capacitor (C5) provides RF filtering.

By contrast, the better receivers include another section of filtering based on resistor R2A and capacitor C6A. This further reduces the level of RF (IF) energy getting through to the audio amplifier.

Although the audio amplifier favours audio frequencies, it also amplifies any IF signals that find their way into this stage. This signal can then be radiated from the audio amplifier and picked up by the front-end of the receiver, or by other receivers nearby, where it can cause some strange effects.

In some cases, this radiation causes the receiver to perform poorly at the low-frequency end of the broadcast band. It's difficult to describe the exact symptoms. However, the set doesn't have the sensitivity it should and also seems to be a little strange in its alignment, with a certain amount of "swish" heard as the set is tuned across a station.

So what can be done to overcome this problem. The amount of IF signal getting into the audio amplifier has already been reduced by the filter consisting of R2A and C6A. In addition, capacitor C8 from the plate of the 6AV6 to earth also reduces the amount of IF energy in the circuit.

However, if the lead lengths from the plate of the 6AV6 to the grid of the 6M5 are short, it would be better to connect a small-value capacitor (such as C11A) between the grid of the 6M5 and earth. The combination of R8 and C11A would then be more effective at reducing the IF energy applied to the grid of the 6M5 than using just C8.

Most output stages have a capacitor from the plate to chassis or to the high voltage supply. This reduces the amount of IF energy at the output of the audio amplifier, as well as acting as a mild top-cut audio filter. The suggested added components that reduce this problem are shown with an "A" after them in Fig.4 (R2A is normally a short circuit in most sets). By carrying out these modifications, I've found that many receivers offer improved performance.

Another set I looked at some time ago had an extremely unstable IF amplifier. It didn't take long to establish that RF signals were being amplified in the audio stage and were being fed back through the set. In fact, it was so unstable that even bringing the plastic handle of a screwdriver near some of the normal supply wiring caused the set to either go into oscillation or to stop oscillating, depending on the state it was in at the time.

In this case, the problem was found to be lack of proper filtering of the high-tension (HT) supply line. In this particular receiver (from a well-known manufacturer), R9 was not included in the circuit design – there was just a length of wire where a resistor could (should) have been. I decided to decouple the HT line by installing a resistor in this location and the set immediately became stable and proved to be a really hot performer.

Problems can also occur when IF cans are not earthed properly or a shield can is missing from a valve. These are problems that are easily fixed.

Despite a few problems, I have generally found IF amplifiers to be quite reliable. In most cases, all that is necessary to restore the performance is to replace leaky paper capacitors and perhaps the odd valve. The AGC bypass capacitor(s) are particularly important and these should have no discernible leakage. If they do, the normal AGC control voltage will not be applied and this usually results in overloading of the IF amplifier.

An IF amplifier with low gain

It's important that IF transformers be wired the correct way, as reversing the connections on one winding can cause the gain to be quite low. Many replacement IF transformers, such as those produced by Aegis, have the connections marked on the can, so they are easy to identify.

For unmarked transformers (eg, those salvaged from derelict receivers), the windings can usually be identified by taking the transformer out of its shield can. The grid winding is the one furthest from the base. If the performance is poor and you know the transformer is good, try reversing the connections. Also, if an IF transformer is being taken out of a wreck, observe what each lead is attached to and label the leads accordingly.

The following information from the 4th edition of the Radiotron Designer's Handbook (by Langford-Smith) will help in identifying IF transformer windings: "For the capacitance and mutual inductance coupling to be aiding, the primary and secondary windings are arranged so that if the plate connects to the start of the primary, then the grid (or diode plate) of the next stage connects to the finish of the secondary winding; both coils being wound in the same direction . . . the grid and plate connections should be as far from one another as possible".

Aligning the IF amplifier

The standard IF transformer usually has critical coupling between the two tuned circuits. Critical coupling provides maximum gain with the transformer adjusted by simply tuning for a peak.

IF transformers employ a variety of methods when it comes to adjusting the slug-tuned types. Older types have an earthed metal screw thread which can be adjusted with a normal metal screwdriver. Conversely, if the tuning tool has to be inserted into the IF

A selection of plastic alignment tools will be necessary if you intend restoring vintage receivers.

Photo Gallery: Eclipse Monarch DKL

Manufactured by Eclipse Radio (Melbourne), the 1947 Monarch DKL is a good example of the 4-valve reflex superhet designs that were popular during that period. The set was available in a number of different cabinet colours, including white as shown here. The following valves were used: 6A8-G frequency changer; 6B8-G IF amplifier/reflexed 1st audio/detector/AVC amplifier; 6V6-GT output; and 5Y3-GT rectifier. (Photo and information courtesy Historical Radio Society Of Australia).

transformer, you use a non-metallic alignment tool.

It is also important to use the right tool here for two reasons: (1) so that the slugs are not damaged; and (2) so that the transformer is not detuned by the presence of a metallic adjustment tool. Plastic alignment tool kits are available from various electronics stores or you can use knitting needles which have their ends filed to a screwdriver blade shape.

The older type IF transformers that use trimmer capacitors across the tuned winding are also best adjusted with a plastic alignment tool. That's because the plate voltage (ie, the HT) is usually present on at least one trimmer – use a metal tool and you could get a nasty shock.

The alignment procedure is as follows: first, with the set turned off, connect a digital multimeter (DMM) across C1 on the AGC line and switch to the 0-20V range. That done, connect a signal generator to the antenna terminals of your set and tune the set to the low-frequency end of the broadcast band.

The next step is to apply a high-level signal modulated at 1kHz at around the expected IF frequency and tune the generator across the band. If the set hasn't had its IF tuning adjustments fiddled with, a response should be heard at or near 455kHz (or what ever the nominal IF of the set is).

If the signal through the set is quite strong, the DMM will register an extra -2V along the AGC line. Adjust the output of the generator so that only -1V or so of extra voltage is shown on the meter.

If the frequency is some way away from the expected IF (eg, 20-30kHz), it is possible to "walk" the IF adjustments onto the required frequency. To do this, first tune the signal generator just to the side of the spot where the maximum response is (ie, towards the wanted frequency). That done, adjust each of the IF slugs for a peak, then go through the whole procedure again until the maximum response is at 455kHz (if this is the target frequency).

Now it is necessary to accurately tune the IF amplifier. Once again, adjust the signal generator so that the DMM reads a volt or so above the standing bias on the AGC line. Adjust each of the internal slugs or external screws for a maximum reading on the DMM, except for the tuned winding going to the detector diode. This one, at the top of the transformer, is adjusted for maximum audio, not maximum meter reading.

If the DMM is connected across the volume control (VR1), peak all adjustments for a maximum reading. Reduce the generator signal level if the DMM reading is above about -4V, as the IF amplifier tunes (peaks) slightly differently with a strong signal compared to a weak signal. Note that for best performance on weak signals, it is necessary to align the set on weak signals.

Note particularly that the slugs or screws should adjust to the correct frequency with the slugs and screws away from the centre of the former, as shown in Fig.3. If they are close together (ie, towards the centre of the former), the coupling between the two tuned circuits will be upset and the performance will be compromised.

If you don't have a signal generator it's still possible to align the set, although not quite as accurately. Once again the DMM is connected to either the AGC line or to the detector output.

All you have to do then is tune to a relatively weak station and peak the signals as described in the previous paragraph. Of course, you won't know if the IF stage is tuned to exactly 455kHz but that doesn't really matter. Note that this job should be done in the middle of the day, to avoid signal fading which would make it difficult to accurately align the IF amplifier.

So there you have it – a straightforward method of tuning the IF amplifier stages in most sets. In times gone by, when high impedance voltmeters were scarce, the audio output was measured and the IF adjustments peaked for maximum audio. However, I believe that the method I've described is more appropriate today as it also gives an idea as to whether the AGC system is working as it should.

Occasionally, one slug in an IF transformer will be stuck. If you strike this, don't force it as broken slugs are hard to get out. Instead, just adjust all the other slugs so that all tuned circuits are on the same frequency as the circuit that's tuned by the stuck slug. Being precisely on 455kHz isn't at all necessary.

Finally, for anyone who wants to know more about IF amplifiers, take a look at the relevant chapters in the "Radiotron Designer's Handbook" by Langford-Smith. **SC**