Adding Squelch to the Soviet R107.

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It has long been a mystery to me how any FM transceiver can be used operationally without any sort of squelch system, because, as we all know, FM receivers emit a high volume of 'white noise' when no signal is present. Yet many early military FM sets such as the WS31 and WS88 have no such system.

Back in 1999 in an article describing the WS31[1] Richard Hankins suggested two reasons why squelch wasn't used (and indeed was removed from the early WS31's) –

i. The squelch control could be misadjusted (or accidentally knocked) and the operator would be unable to tell that this had happened (the only way to check is to readjust it properly). As a result vital messages could be missed.

ii. All squelch systems have the unfortunate habit of emitting a loud noise burst at the end of a transmission, before silencing the audio system. This noise burst might have been overheard by an enemy in close proximity.

A third possibility is that, because of the high rate of battery consumption of these equipments, they were only intended to be switched on when a message needed to be passed, the loud noise would remind the operator to switch off when not required. Indeed I remember, during school CCF operations, arranging to listen out for calls at specific times, leaving the radio switched off otherwise.(31 set batteries were becoming a scarce commodity by this time).

In the above article, Richard also points out that the American used squelch in the BC1000 (from which the 31 set was derived), and in the sets that succeeded it such as the PRC8-9-10 series.

Although a later design, the Soviet R107 doesn't have squelch either, possibly for any of the above reasons. I'm sure that the Soviets would have "had the technology", and as these sets are part transistorised there's no technical reason for omitting squelch, such as space or battery consumption considerations, also some of the required circuitry is already there – see later.

Requirements

A squelch system requires a way to detect whether a signal of sufficient strength to be readable is present and, if it is, to switch on the audio in some way. There are two common ways to detect the presence of a signal: to detect the presence of a carrier ("carrier squelch"), or to detect a reduction in the noise level caused by the signal ("noise squelch") The former is usually used on AM receivers, as they already have an AGC system which detects the carrier strength and uses it to reduce the receiver gain to prevent overloading. It is usually very simple to add an audio switch, which can be triggered when the AGC rises above a pre-set level. Noise squelch is normally used on FM receivers because they rarely have any form of AGC, and also the noise is usually considerably louder than the modulation on a received signal. Such systems are more complex though, because the noise itself has to be detected, and precautions taken to ensure the squelch doesn't close because of modulation peaks on the signal, or if a slightly off-tune signal causes 'splattering', etc. The usual way to do this is to make the squelch circuit sensitive to frequencies above the normal voice range.

'Squelching' the R107

As I wished to use an R107 for local 6 metre operation I decided to look to see if there was a relatively simple, non-destructive way to add squelch. I wanted to add the squelch as an external unit to avoid modifying the receiver as far as possible. Noise squelch was experimented with but ruled out at an early stage for two reasons: the audio at the output has been filtered to a fairly narrow bandwidth, to get unfiltered audio would mean digging deep into the innards of the set, and only a negative 2.4 volts is available at the audio socket (for the transmitter microphone pre-amplifier), and it was difficult to get the necessary noise amplifier to work at this low voltage using conventional components and transistors, even germanium ones.

A study of the circuit diagram and the set revealed that, when no signal is being received, a low frequency sawtooth waveform is applied to a varicap diode in the receive local oscillator to make the receiver scan a couple of channels either side of the set frequency, presumably so that off frequency signals would not be missed. (Like the 31 set, the R107 is tuned by a free running oscillator) When a signal is received, the sawtooth stops and the AFC takes over. The sawtooth is

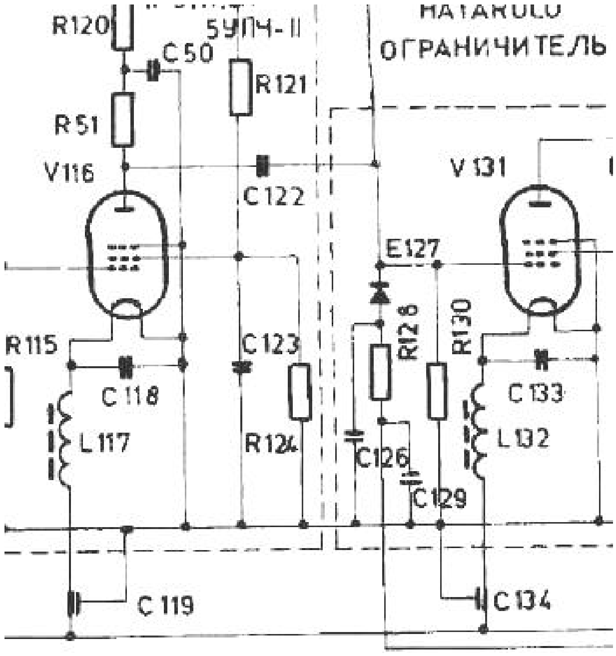

Fig. 1 – Part of the IF amplifier circuit, showing where the carrier level voltage is derived from.

generated by a valve oscillator built into the calibrator module and is stopped by a negative voltage applied to its grid when a carrier is present. Tracing the source of this negative voltage led me back to the IF module, and a diode (carrier!) detector fed from the anode of the last IF amplifier (V116 Fig.1). I also discovered that this voltage is brought out to the front panel on the middle of the three small single pin sockets located next to the mode switch. This socket is marked OGR on the Russian labelled sets (The other sockets here are the discriminator positive and negative outputs). Here then was the key to a method of carrier detection that didn't require any connection to the

[1] (VMARS *NL issue 7, "The Wireless Set No. 31 – Boring!*)

interior of the set. Measuring this voltage revealed that its source is a very high impedance; there is a 220k (R128) resistor in series with the diode, and the source of the IF,

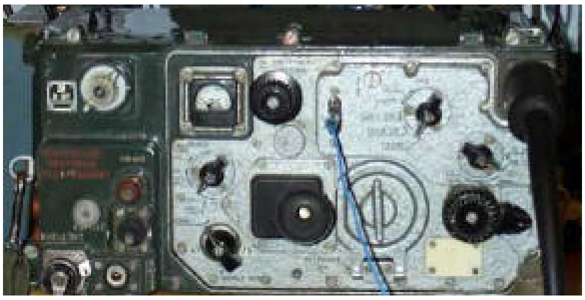

Fig. 2 The lead connected to the OGR socket can be clearly seen

the anode of V116, is also a high impedance. Measurement with an ordinary 20KΩ per volt multimeter didn't show a lot, but measuring with an electronic meter revealed that there was a standing voltage of between 2 and 6 volts, which could be peaked sharply with the ATU control when no signal was present, rose to 9 volts when a readable signal was applied and reached as much as 20 volts on a fully quieting signal.

What was needed, then, was a circuit that would detect when the voltage rose over 6 volts without imposing any loading on the detector, and would switch on the audio output, and would work from a negative 2.4 volt supply.

Switching the audio

Turning first to switching the audio, I figured that a relay would be required, as the audio here is at headphone level and any form of electronic switching would be too lossy. A relay would be required that would energise reliably at just two volts, allowing for some loss across the transistor used to drive it. I have never come across a relay with a 2 volt coil so I experimented with various 5 volt relays, lightening the spring and adjusting the contacts: whilst most would operate directly off the 2.4 volt battery they weren't reliable when driven by a transistor.

My old friend Gordon G3MMS suggested winding some fine wire around a reed relay: he calculated that nine yards of 45SWG wire would have a resistance of 20Ω would therefore pass a current of 100mA and produce the necessary magnetic field to operate a standard 1" long reed switch, so a relay was constructed as in Fig.3. (I sometimes wish I'd paid attention to all that boring electromagnetic theory at college!) This did indeed prove to work reliably. With a little further experimentation I arrived at the remarkably simple circuit shown in Fig.4.

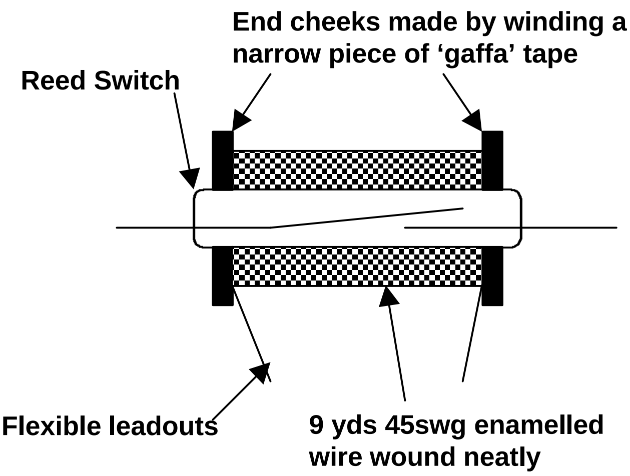

Fig. 3 Construction of the relay

The final arrangement

The input to the squelch circuit is taken via a 7.5 volt zener diode ZD1 to the base of Tr1, which with Tr2 forms a "Darlington" emitter follower. This arrangement has a very high impedance input and is biased on when the input voltage exceeds that of the zener plus the vbe of the two transistors, almost 9 volts which on my set represents a signal that is just about readable. The voltage appearing at the emitter of Tr2 switches on Tr3 which operates the relay. Note that all the transistors are PNP types, to fit in with the negative supply voltage available from the audio socket, I used BC558's but almost any silicon pnp type would do. The relay contacts are simply wired in series with the headphones, with SW1 across the relay to act as an override switch. The 0.1µF capacitors were added to decouple any stray RF that might have been around.

Construction

I built the circuit on a piece of Veroboard just ½ by 1", with the relay mounted "vertically" and incorporated it into the audio interface unit described in NL 25. All the connections needed are already available in the interface unit except for the input from the detector. I used a spare core in the interface to audio plug lead, then brought an extension of this lead out of the plug. A wander plug with a shortened pin fits exactly into the OGR socket and completes the connection.

Operation

This addition makes the set useable! When the signal disappears, there is a short burst of noise then the audio is muted, for all intents and purposes it appears just like any other squelch system. It does occasionally open for no apparent reason, this is to be expected of a simple carrier squelch system, it also responds to noise! It must be remembered though, that if the wander plug becomes disconnected the receiver audio will remain muted so it pays to make sure it is a firm fit.

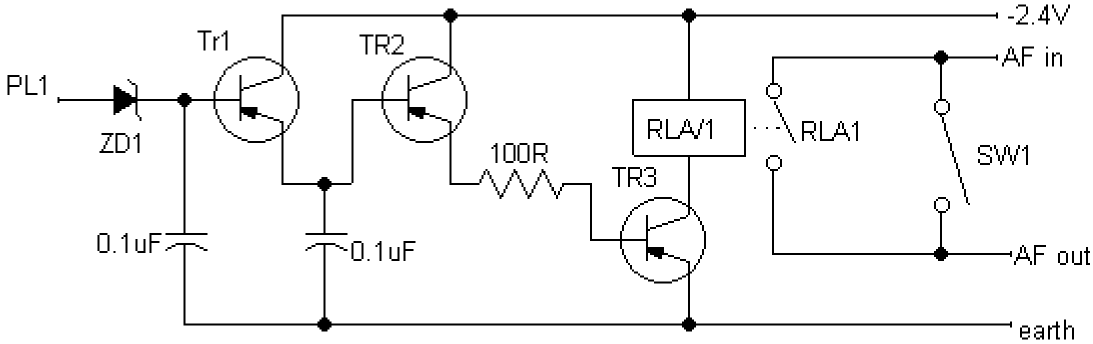

Fig. 4 The remarkably simple circuit of the squelch unit for the R107.