THIRD METHOD SSB TRANSCEIVER

Burkhard Kaina, DK7JD, CQ DL 1984.

(An approximate translation by G0UCP)

Direct conversion transceivers using the third method need about the same number of components as those that use the filter method. However, as signal processing is centred in the AF stages, layout is not critical, and the method itself is particularly appropriate for small portable devices. The transceiver described here was housed entirely on a 160 x 100-mm dot matrix board. Further advantages are the absence of a quartz filter, replaced here by a suitably dimensioned AF-filter, and a lack of image frequencies and spurious emissions. Looking specifically at SSB operation, the third method achieves this without the need for difficult balanced amplifier circuits.

The device was built entirely from components found in the junk box. All parts not precisely specified, such as transistors and diodes, are completely uncritical. However, to copy it you will require a few measuring instruments and some experience. The complete circuit is shown in Fig. 2.

RF MIXER

Simple silicon diodes, preferably matched with an Ohmmeter, can be used in both diode ring mixers. The four transformers are wound on 6-mm ferrite toroid cores with 3 x 15 turns, 0.2 mm. diam. The broadband mixer with resistors has proved effective. Slight AM Breakthrough in the receiver and impaired carrier suppression in the transmitter were very easily adjusted with the two trimmers. The two JK flip-flops in the 7473 generate the two 90deg. phase-shifted RF voltages for driving the mixer. You will need a VFO with output at quadruple frequency, from 14.4 to 15.2 MHz.

LOW PASS FILTER

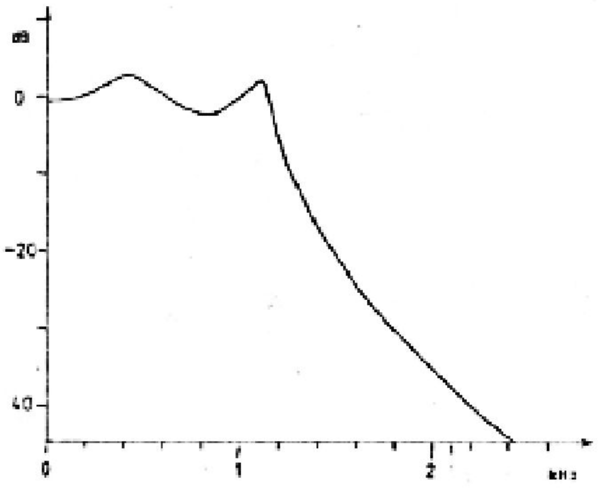

Abb. 1: Frequenzgang der Tiefpaßfilter

The Chebychev filters were designed for 3dB ripple and a cut-off frequency of 1.2 kHz, to achieve the usual 2.4 kHz transmission bandwidth. However, because of non-ideal op-amp behaviour, gain in the second filter stage was too great, and to get a sufficiently flat curve this had to be reduced by adding in the 220kOhm resistor. This value has to be determined experimentally during construction, as it allows some compensation for the very sensitive reaction of the filter curve to component tolerances. The correct value is the one which gives the least ripple. Fig. 1 shows the measured filter curve. It can be seen that the ripple was much larger than the desired 3 dB. However it shows a very steep drop at the cut-off frequency, making for good selectivity in the receiver. The exaggerated ripple has no evident effect. Much more important than precise component values is the exact combination of parts in both branches of the filter. To achieve this, all capacitors and resistors were measured. Resistors were paired within 0.1% and capacitors within about 1%. This accuracy has proved to be sufficient. Poor matching results ultimately in distortion because suppression of the inverse frequency band is no longer adequate. But even then attenuation of the other sideband is not impaired, as occurs in the phasing method.

All LF stages have their own reference potential at + 4V, generated by active voltage division from the stabilized 8V operating voltage. This ensures that all the ICs have a quasi - symmetric supply of +/- 4V, even when using a simple power supply such as a car battery.

LF MIXER

After strong amplification the filtered branch signals pass to the second mixer. These are balanced mixers based on analogue switches. They comprise a clocked 1.5 kHz switch and a differential amplifier. The carrier suppression of this arrangement is so great that with the antenna connected, without any special setting, in receive mode the 1.5 kHz residual carrier is completely lost in the background noise. The analogue switches are controlled by the 4027 which provides the 90° shift in each case to voltages and inverted voltages. The clock inputs get a 6-kHz signal from the RC generator with the Schmitt trigger 4093.

The demodulated signal is already present across the two resistors (from the broadband mixer). Remaining distortions in the region above 3 kHz are largely eliminated by the low pass filter before the signal reaches the LF-output amplifier.

Whether the device is set for the lower sideband, is pure luck. If the upper sideband is received and sent, one can for example reverse the polarity of an RF mixer transformer. If only the RX operates incorrectly, transpose the input to the branch amplifiers. If only the TX operates on the upper sideband, reverse the connections E and F.

RX / TX SWITCHING

The device contains four switches, based on eight analog switches in the two 4066 ICs. Alternatively a mechanical switch or speech relay could be used here to reverse the stage order. The signal from the electret microphone passes through the stages: Branch amplifiers – LF Mixer – Filter – RF Mixer. The SSB signal is produced at the resonant circuit of the mixer. The analog switches receive the voltages A (+ 8V at RX) and B (+ 8V at TX). On Receive, the microphone is shorted by the second changeover switch to the low impedance output of the filter, so no special switch is necessary here. An analog switch transistor inserted before the LF amplifier provides for shutdown of the LF in the TX position. Furthermore, a bi-stable 6 V relay with two windings separates the antenna input from the receiver pre-amplifiers. RF stages that are not required are blocked via the switching voltages A and B.

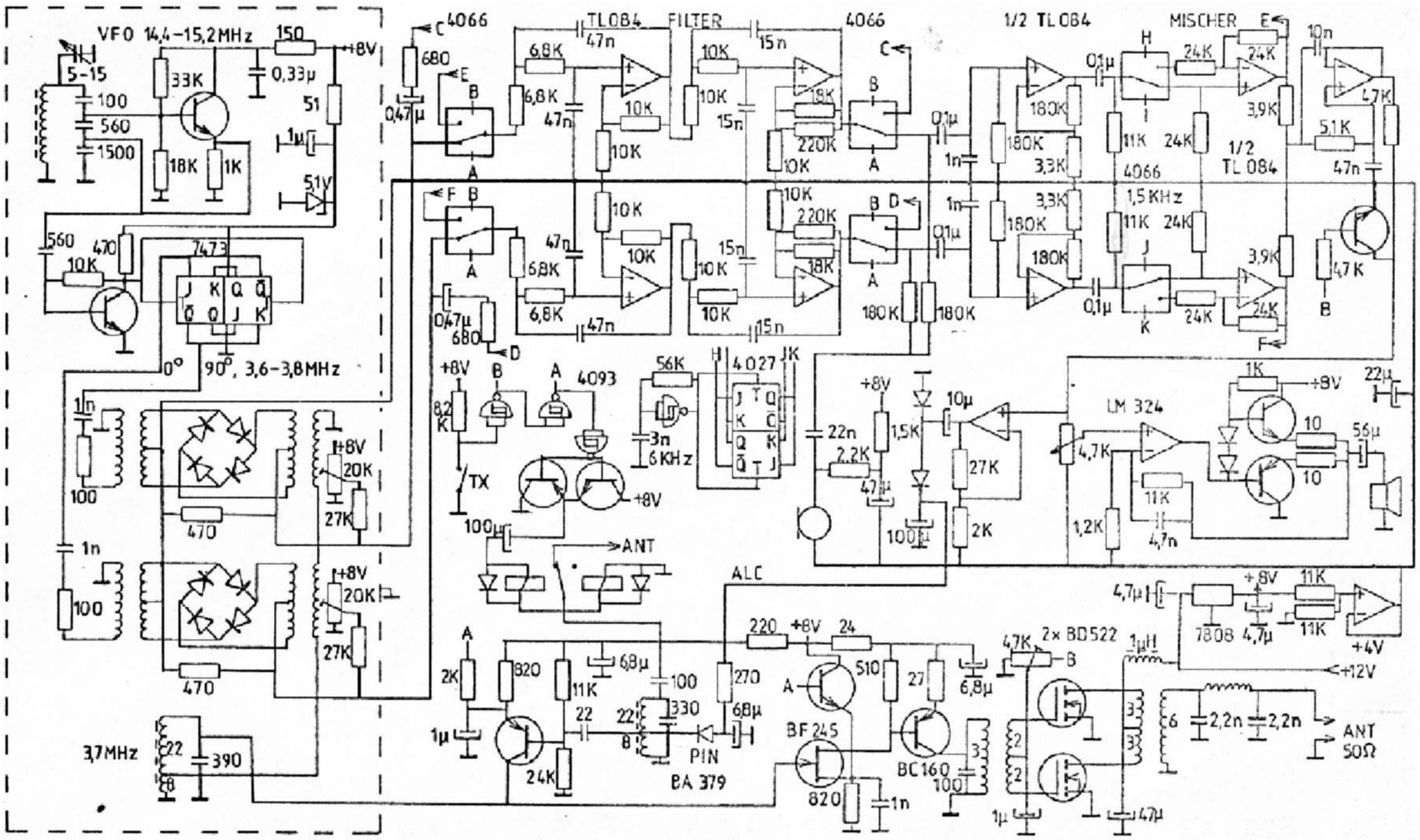

Abb. 2: Schaltbild des 80-m-SSB-Transceivers nach der dritten Methode

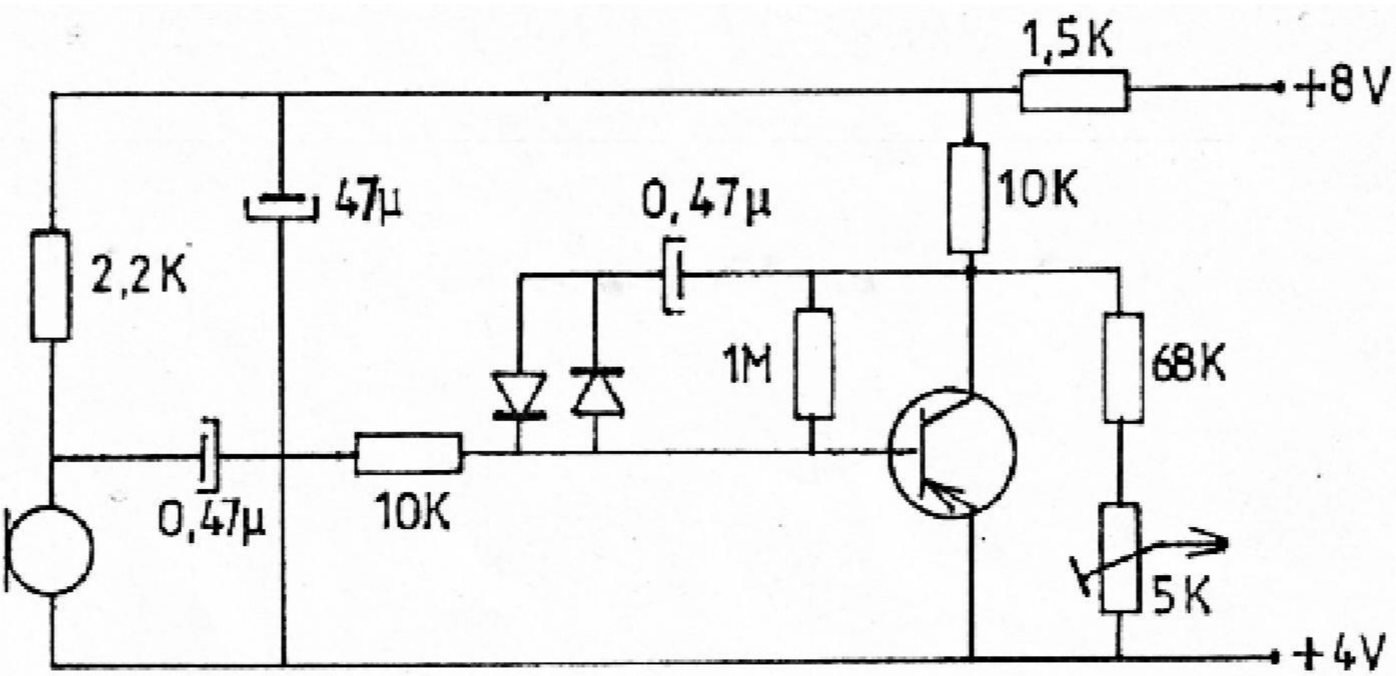

Abb. 3: Schaltung zur Begrenzung der Mikrophonspannung

Fig. 3: Circuit for limiting the microphone voltage.

HF STAGES (A more approximate translation of this paragraph, by Hans G0UPL)

A wideband preamplifier using a PNP transistor is coupled to the antenna. A PIN diode is used to provide a simple ALC.

The transmitter section uses a two-stage pre-amplifier. The RF signal is applied via a broadband resonant filter. A small double-hole core from a television, size 13 x 7 x 7mm is used as transformer to couple to the final stage. The output stage consists of two V-MOS transistors type BD522. The gate bias is adjusted for a quiescent current of about 200mA. This high value is needed because of the strongly curved characteristic of the transistors at low currents, in order to get linear amplification. At full scale, the current rises to 800mA, and the output power is approximately 5W. For the output transformer, a larger double-hold core, sized 13 x 14 x 7 is used. The PI-filter inductor consists of an Amidon toroidal core T68-2 with 16 turns. In order to prevent coupling of the output back to the VFO and RF mixer, they must be shielded.

BUILDING INSTRUCTIONS

The device was built on a 10 x 16 cm large prototyping board with 2.5mm dot matrix. Design of a printed board with these measurements would be very difficult, in view of the many necessary cross connections between stages. Building on dot matrix board has proved to be the best arrangement. Connections between adjacent points are made with solder. Thin tinned copper wire from multicore cable was used for longer uncrossed connections. Component connection wires were cut short and not bent. For crossing connections thin lacquer insulated coil wire was used. The insulation is not damaged by accidental touching with the soldering iron, but melts only on intensive contact with hot solder. Even with very many such cross-connections, all beneath the board, the unit remains uncluttered.

The VFO and RF mixer are enclosed in a thin copper plate shielding box above and below the board. The heat sink for the two output transistors is connected to ground and positioned so that it shields the LF stage of the PA.

The construction of the device is done in stages. First the low-pass filters were built and assessed with a tone generator. This was followed by the remaining stages of the receiver. Only when this was functioning flawlessly was the transmitter started. Function was tested with a loading resistor at the output and a control receiver. A cassette recorder at the input provided a reliable signal source. With high resistance headphones trouble was easily tracked down to individual stages and supply lines.

OPERATING EXPERIENCE

The transceiver has been operated with a W3DZZ antenna. Receiver sensitivity and selectivity were entirely satisfactory. Demodulation of SSB was remarkably clear. At the speaker there was still a fairly faint residual sound from the high-frequency mixing products applied to the second mixer, somewhat comparable in tone to the ringing of a glass. They can be removed by better filtering prior to the output amplifier, but are not disturbing.

The control receiver was unable to detect any signal outside the speech channels. The modulation still contains a remnant of the inverse signal, probably due to lack of symmetry in the two branches. This does not impair intelligibility.

Transmitter power is adequate for German and European contacts provided the band is not over busy. Reports are usually around S7.

Extract from Burkhard Kaina’s blog:

‘Udo, DJ5VJ wrote me: ‘Hans Summers, G0UPL, has revived your design "80-meter SSB transceiver according to the third method," CQ-DL Dec. 1984: http://www.hanssummers.com/weaver .html How about marking the 57th anniversary of the method with a construction manual for example by using Maxim low-pass filtering to keep the component count low?’

Just back from vacation, I was very happy about this news! I have had such a switched filter (? in hand), for this very purpose. And decades later I can see that this was a very modern thing, a predecessor of the IQ mixer-SDR receiver. My short wave transceiver according to the third method is still about. But with software, everything has become so much easier…’