THE AMAZING BARLOW WADLEY XCR-30 CRYSTAL CONTROLLED 30 BAND TRANSISTOR RADIO. (A method to set the AGC) H. Holden, 2018.

Introduction:

The Barlow Wadley XCR-30 radio is well known to amateur radio enthusiasts as a Wadley Loop radio. This article provides another explanation of the Wadley loop with some diagrams to help those unfamiliar with it understand it more easily than shown in the manufacturer's block diagram. The approach is to look at it "open loop" and then see the effect of closing the loop. Also a different method to set the AGC potentiometer is included.

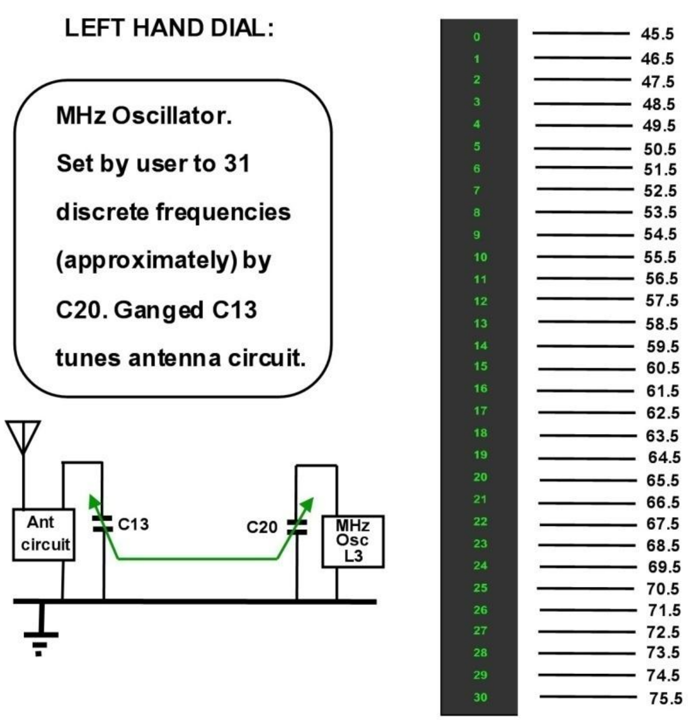
What is a Wadley Loop Radio and how does it work?

This radio is essentially a triple conversion receiver & more. In a receiver like this, the received frequencies are converted three times by three separate mixers, or in one case a mixer oscillator. In this radio though, a frequency cancellation technique is applied to the second mixer. This cancels out the master (MHz) local oscillator drift and the result is stable enough for SSB reception. The radio contains yet an additional mixer to implement the frequency drift cancellation. So it has 4 mixers altogether.

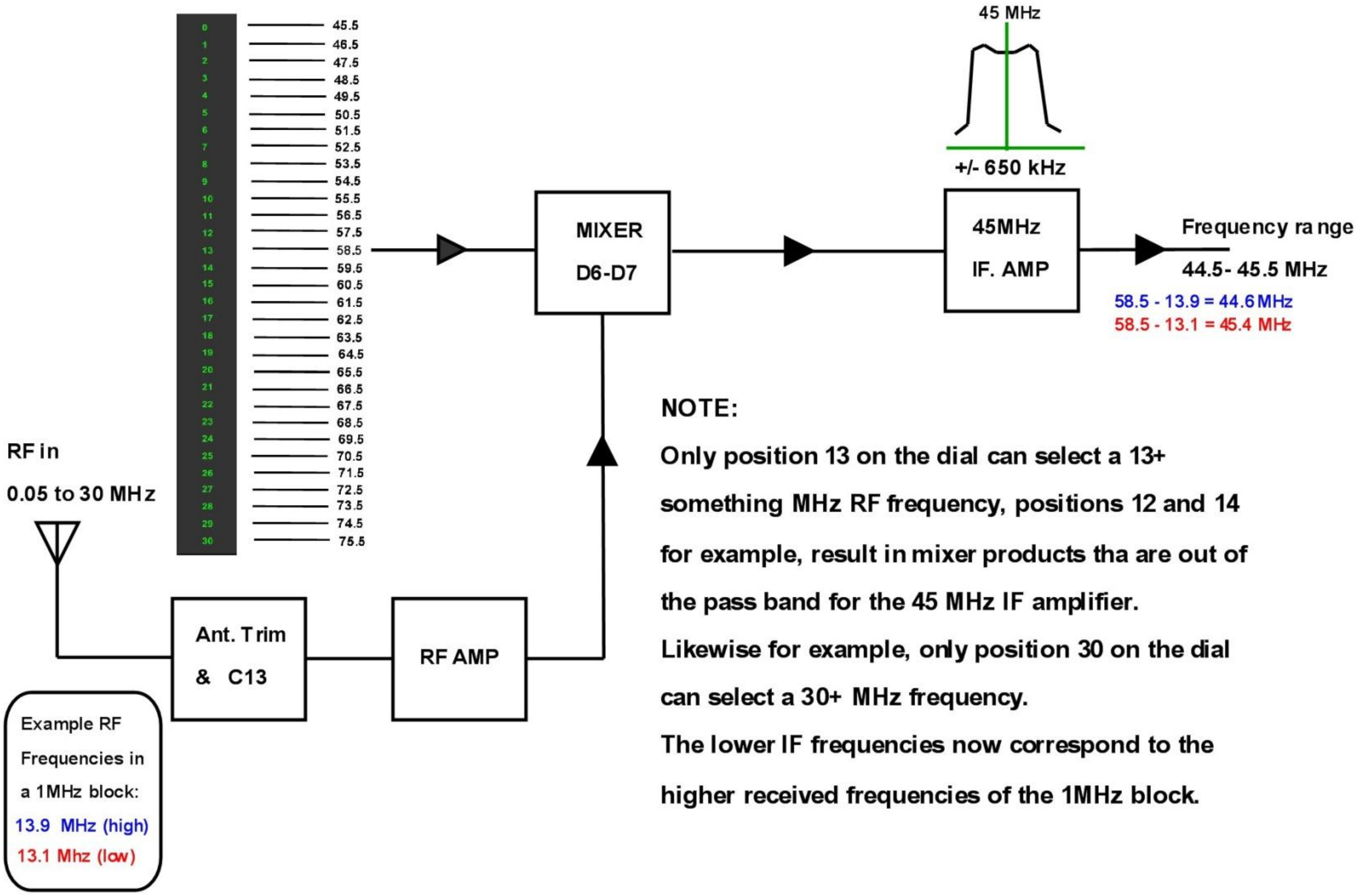
In this radio the first mixer up converts the received frequencies (approx 0.5 to 30MHz) to a 45 MHz IF with a 1.3 MHz bandwidth. That signal is then down converted to the range of 2 to 3 MHz by another mixer which has a 42.5 MHz input that carries the frequency compensation. The 2 to 3 MHz output frequency range is tuned by what amounts to a standard Superhet radio circuit, which tunes over the 2 to 3 MHz range with an RF stage and mixer/oscillator and 455 kHz IF amplifier. This is followed by the usual AM detector and a product detector for SSB reception, USB & LSB as selected.

The radio has two dials, a MHz dial and a KHz dial. The MHz dial is used to select discrete frequency blocks 1MHz apart. It only requires a coarse setting initially and in use its tuning can be optimised for the best output signal by the user.

The diagram below shows the MHz oscillator. Of note, the variable capacitor C20 that tunes the MHz oscillator is also ganged to C13 in the RF input circuitry to assist tuning the antenna input resonant circuits, though much of this is done on the manual tuning control.



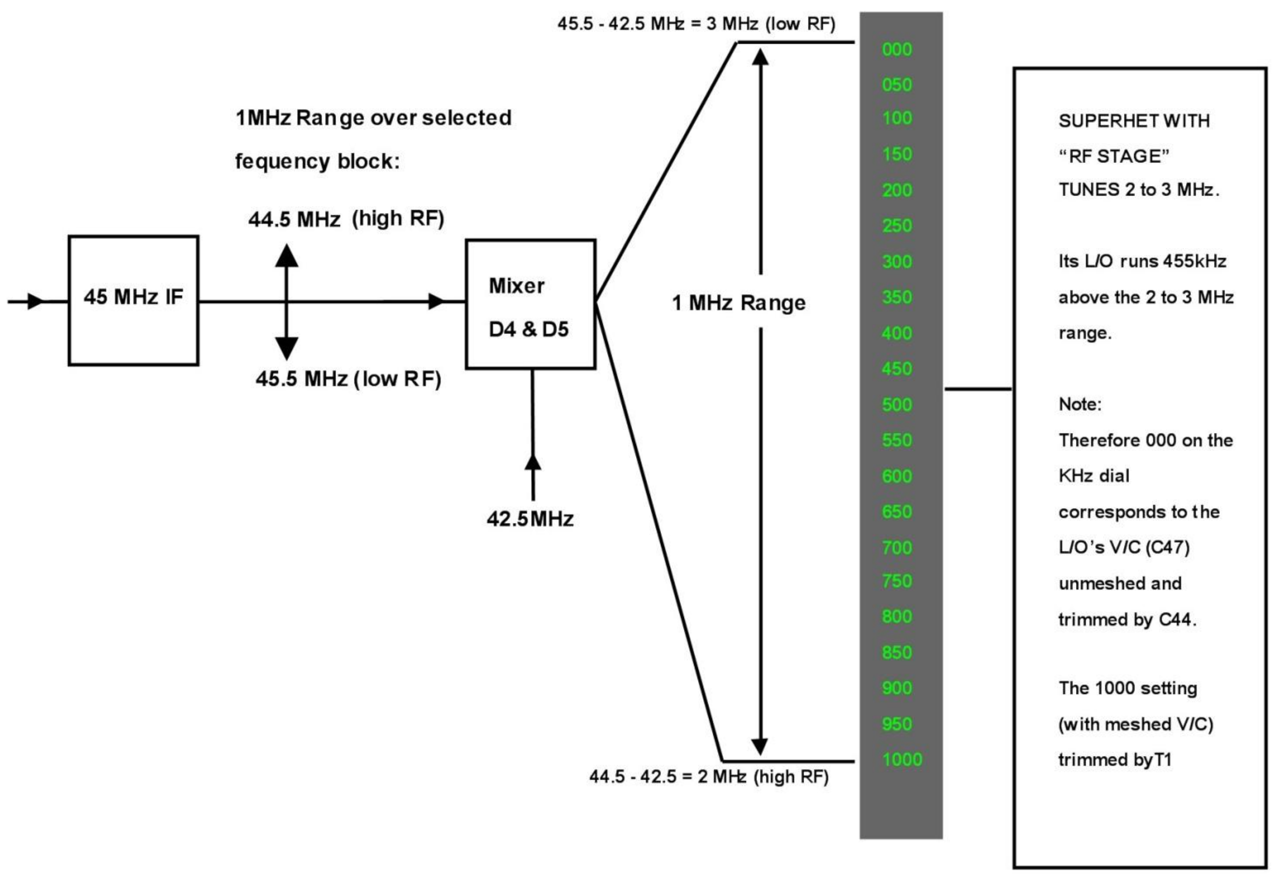
The MHz local oscillator output passes to a diode mixer D6 & D7 along with the incoming RF frequencies:



Example received frequencies are shown in blue & red. Of note, due to the frequency conversion, the higher range of the selected 1MHz block is converted to a lower range of the 1.3MHz bandwidth 45MHz IF output. Also due to the 1.3MHz bandwidth of this IF, only the correct selected frequency block, for the received frequency range, can emerge from the 45MHz IF output.

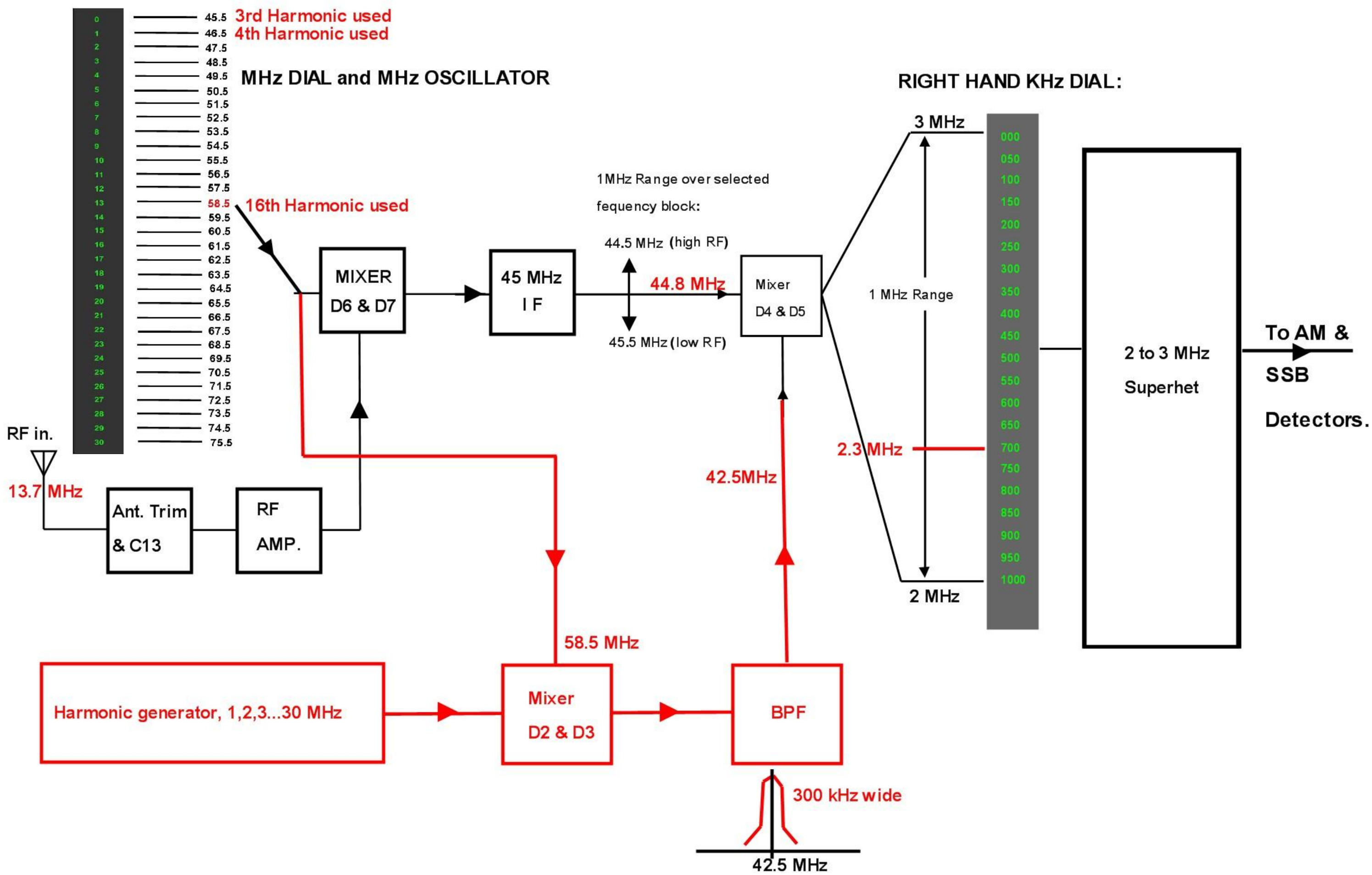
The output of the 45MHz IF amp passes to another mixer. This mixer down converts the signal to a range of 2 to 3 MHz. For now, ignore the source of the 42.5 MHz signal (this is where the frequency correction is described later)

RIGHT HAND KHz DIAL:



The right hand KHz dial is really just the dial of a Superhet radio that tunes over the 2 to 3 MHz range. The output of the 45MHz mixer is down converted to this low range by a mixer (D4 & D5) using a 42.5 MHz reference. The low range of the tuned 1 MHz block corresponds to the higher tuned RF frequencies. So as noted, 000 on the KHz dial corresponds to the Superhet radio tuning the 3 MHz range of its tuning. So if you look in the radio with the KHz dial on 000, the tuning capacitor is largely un-meshed. This is a little counter intuitive for setting C47 and T1, as C47 is set near 000 and T1 at 1000 on the scale for correct calibration.

Putting it all together now and adding in the “loop” and showing an example for a 13.7 MHz received frequency:



CLOSING THE LOOP 13.7 MHz RECEIVED FREQUENCY EXAMPLE

As can be seen what is called a “loop” represents the result of the MHz oscillator being mixed with the output of a Harmonic Generator and narrow band filtered at 42.5 MHz. This effectively selects a harmonic that is, in the example shown, 58.5 – 16 = 42.5 MHz, or the 16th harmonic of the 1MHz Xtal oscillator harmonic generator. Other harmonics are used, as noted, for each 1MHz frequency block.

How does the “loop” help ?

Let us say that the MHz oscillator drifted from 58.5 MHz to 58.6MHz, or 100kHz. This would cause the IF output signal, for the 13.7 MHz received signal example, to shift to 44.9 MHz (instead of 44.8). This would make the output of the D4 & D5 mixer 2.4 MHz. This doesn't happen though. Due to the fact the output of mixer D2 & D3 up shifts also to 42.6 Mhz and 44.9 – 42.6 = 2.3 MHz again, so the MHz oscillator drift is cancelled.

One way to illustrate this helpful feature is to look at an oscillator from the point of view of percentage drift. If a radio's local oscillator drifts 0.1% upwards over an hour and it's a 2 MHz oscillator, the drift is 2 kHz which might be tolerable with a 5 kHz bandwidth IF amplifier and the radio may not require manual re-tuning. However for a 50 MHz oscillator a 0.1% drift is 50 kHz and the received radio station would appear to drop out and require re-tuning. Also this level of drift would be incompatible with keeping an SSB signal tuned in where the tuning is more critical.

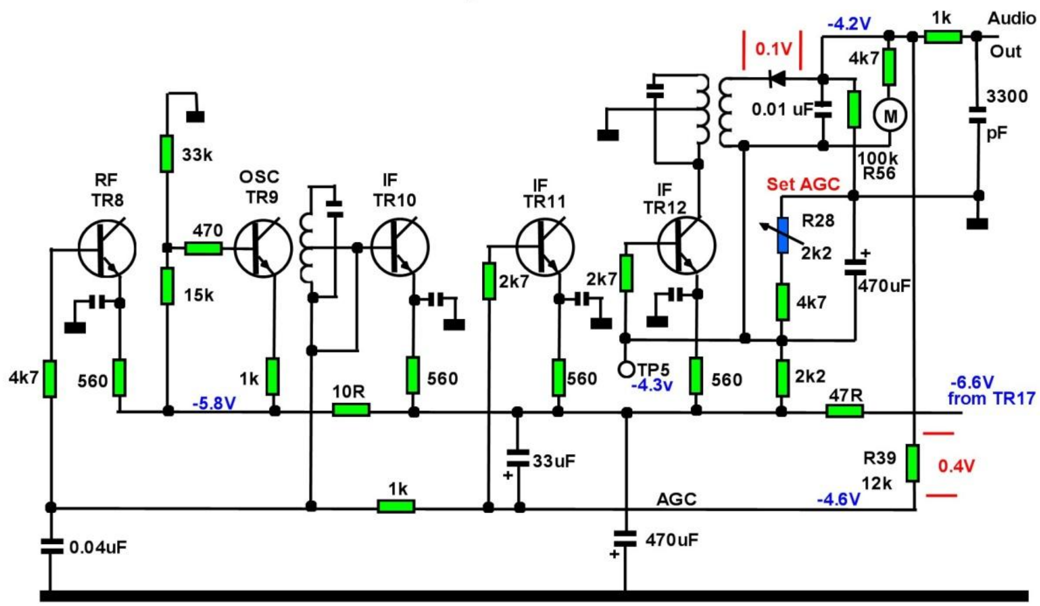
Summary of the Wadley Loop:

This circuit might not have been aptly named. A "loop" in circuitry terminology often implies that something is fed back to control earlier circuits, examples being negative feedback loops, positive feedback loops and AGC feedback circuits and phase locked loops. In the case of the "Wadley Loop" it is really only a loop because it appears to be one drawn on paper. It is really a "feed forward" control system, where the mixer product of the MHz oscillator and a Harmonic Generator is used in the second mixer to cancel oscillator frequency drift at that point in the downstream RF circuitry. By analogy, using a gain control analogy (instead of frequency control) a "feed forward" AGC circuit uses a control signal to influence a gain stage downstream in the signal processing pathway rather than a "feedback loop". Still, this is how it was named and the Wadley Loop has a catchy ring to it.

Setting the AGC in the XCR-30:

The manufacturer recommended AGC setting is to set potentiometer R28 to - 4.3V on TP-5. However, this value relies on the voltage regulator output (from TR17) being exactly - 6.6V, which it isn't always because of variations in the regulator transistor's Zener reference diode. A better method to set the AGC, is to place a digital meter across R39 (12k) and adjust R28 until the voltage across R39 is 400mV. This ensures the correct AGC current of 33uA, regardless of the exact voltage regulator output value. A limited diagram of the AGC circuits is shown below. With this setting, the no signal voltage developed across the AM detector diode is 100mV, which is helpful in the detection of weak signals.

BASIC AGC ARANGEMENTS 2-3 KHz Superhet Part : BARLOW WADLEY XCR-30



Another point: The XCR-30 is a positive ground radio, so voltages are generally measured with respect to ground and have negative values. Do not be tempted to use the easy to get at battery pack's positive terminal as a ground reference. It sits about - 200mV away from ground due to the reverse polarity protection diode (composed of an AC122 transistor with its base and collector connected). So using battery positive as a reference point will create about a 200mV measurement error. The XCR 30 is one of the few transistor radios with a polarity protection diode, a smart idea as it was also made to run off an external power source too. As has been seen with some radios, extensive damage can be caused by reverse polarity accidents from external power packs.

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