

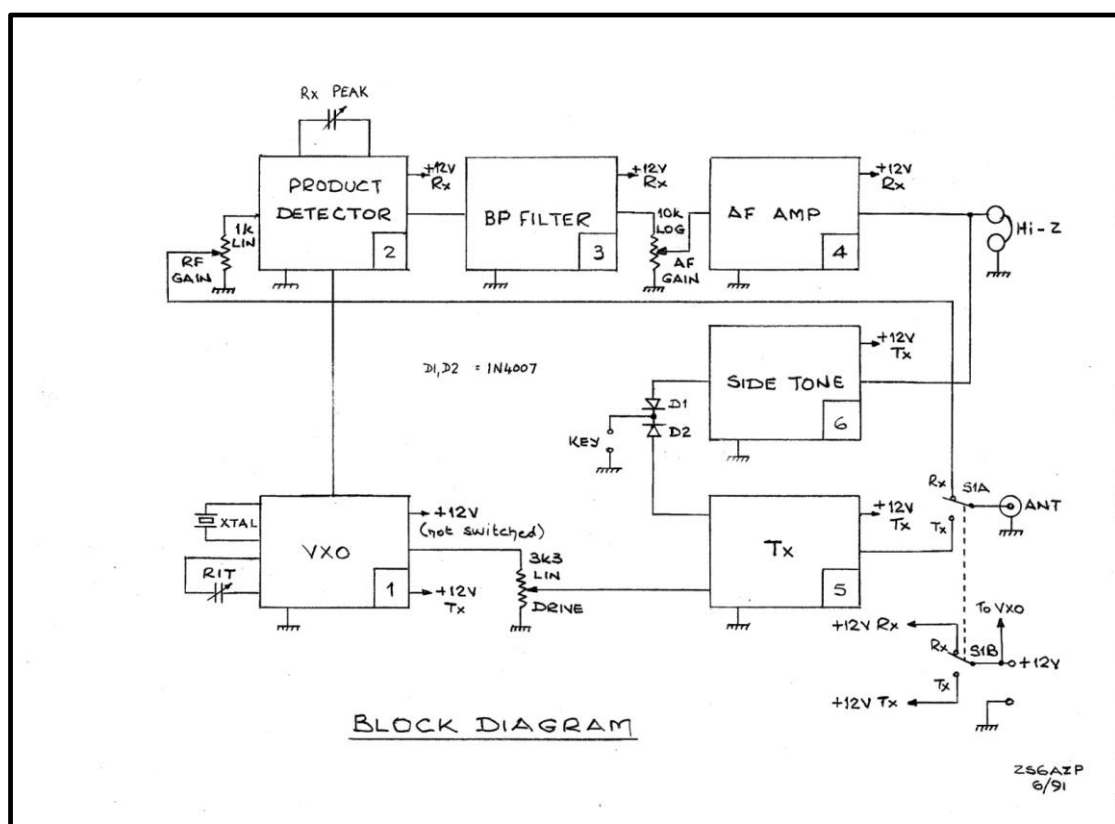
The DCS 401 40m QRP Transceiver Revisited

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Introduction

The transceiver described in this article is basically one which has previously been featured in a club news letter some 20 odd years ago, and was successfully used for many years on the 40m band, both operating from home as well as from field-day type sites and from various locations while on holiday. After a hiatus of 10 years or so when amateur radio took second place to work activities, the rig was dusted off and placed on the air again. It was immediately obvious that the band noise levels had increased significantly from the earlier times when there was no ADSL service to any of my neighbours, and domestic electric fences were only things of the future. Consequently better filtering had to be included (the original audio frequency low-pass active filter was replaced by a multi-stage active band-pass filter arrangement, with a centre frequency of 800Hz) to make the transceiver usable again. For the benefit of those readers who may not have had access to the earlier article, the following descriptions are largely a copy of those in the original.

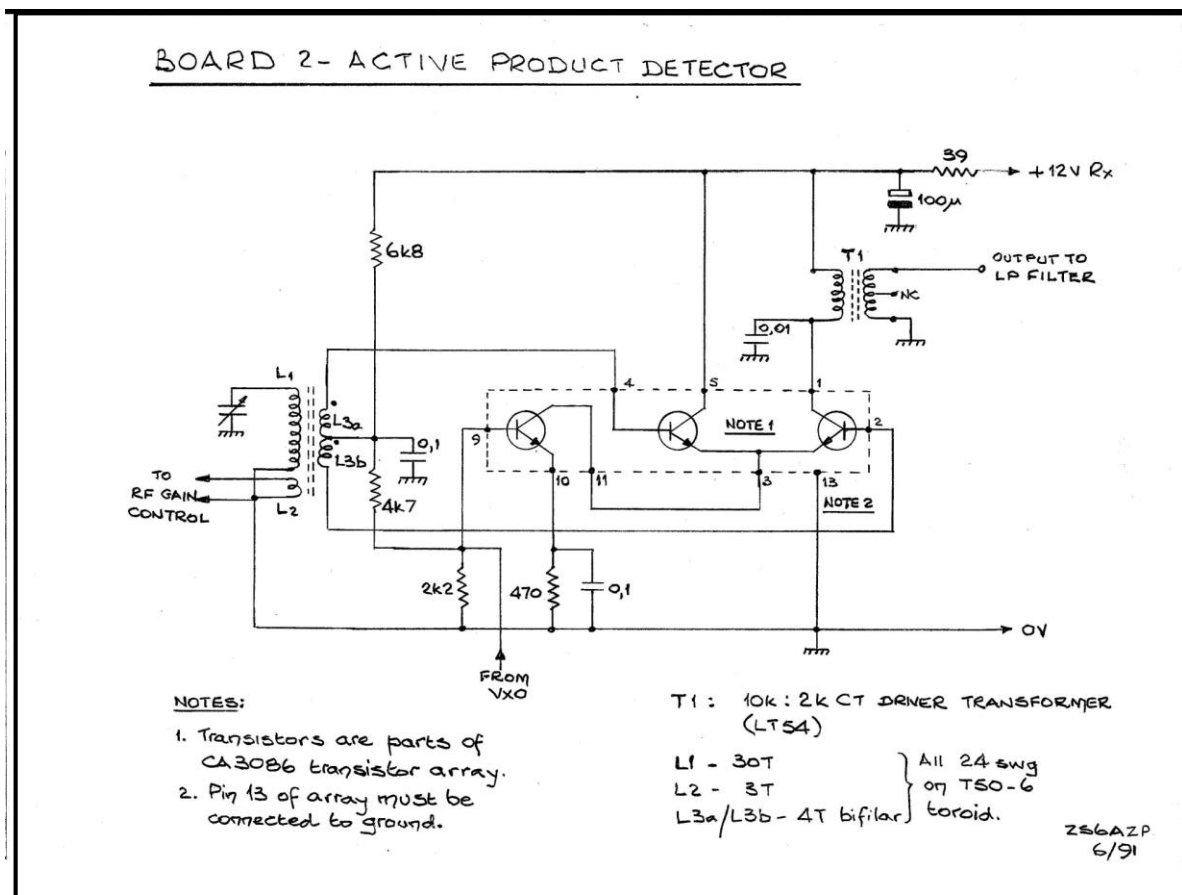
As can be seen from the layout drawing and overall block diagram, a modular construction technique has been used. The reason that a separate PC board was used for each basic function was to give a maximum degree of flexibility – if for example one wanted to experiment with a different mixer stage say, only one board need be replaced. If the new design proved to be a flop, it is easy to put the old one back! The alternative of having everything on one large PC board is more than I can contemplate as I am prone to many whims of fancy and am always trying something new.



The heart of this design is the oscillator stage which is used both as the local oscillator on reception and for carrier generation when transmitting. A crystal controlled oscillator stage was chosen in place of the more usual VFO design for two main reasons, namely uncompromising stability together with simplicity. A crystal oscillator also enables you to know exactly what frequency you are transmitting on irrespective of how the set has been bashed about in transit to that mountain top field day site **and** your friends will know where to listen out for you!

While crystal control has the advantages mentioned when used for transmitting, it is of course less than ideal on "receive" as there is no guarantee that the station replying to your CQ will be on frequency – in fact a degree of frequency off-set is required to obtain a beat note at all. RIT is achieved in this design by operating the oscillator stage as a VXO on "receive". The series connected 75pF "RIT Control" variable capacitor, shown below the crystal on the circuit diagram, is connected in circuit on "receive" and the adjacent BC107 transistor shorts it out when transmitting. The 5-35pF trimmer capacitor between the crystal and base of the conventional Colpitts oscillator stage is for accurately setting the transmit frequency. The oscillator stage drives a two transistor buffer which provides adequate output to drive both the product detector of the receiver and the transmitter driver.

b. Product Detector (board 2)



The product detector (mixer), taken from Ref 1, is made up of three of the transistors incorporated into a CA3086 transistor array IC. The reason for this approach is that I have had a lot of success with a CA3028A mixer in the past, but the IC is no longer readily available and the very cheap CA3086 offers an excellent substitute. Balance (very essential) is assured as the transistors in the array are all identical in performance and track one another thermally as they are all on the same substrate. As can be seen from the

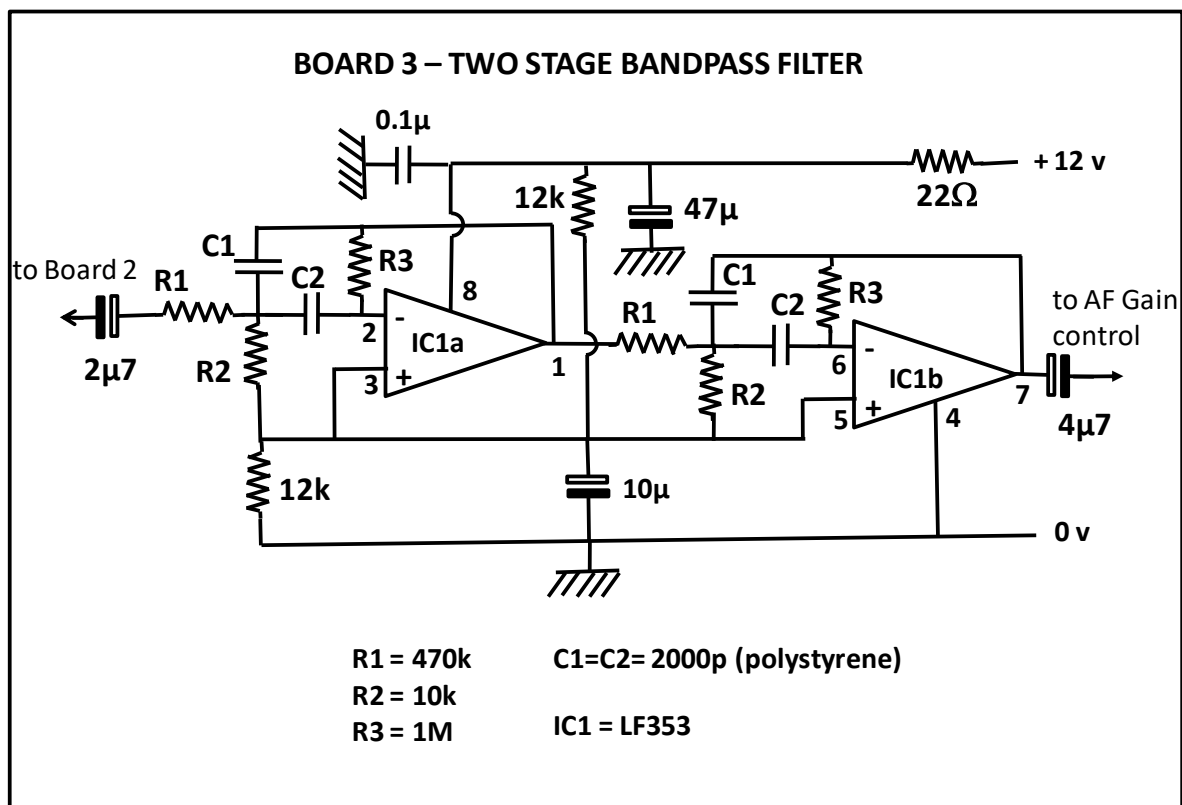
diagram, the input is single tuned with link coupling to the antenna and balanced bifilar output windings. These outputs are connected to a differentially configured pair of transistors with the local oscillator (VXO) signal being fed into their common emitters. The output to the next stage (at audio frequency!) is taken via a small, readily available, driver transformer (Type LT54) which presents a 10k ohm impedance to the mixer for high stage gain and a reasonable output impedance to match the low-pass filter which is next in the receiver chain.

The big advantage of having an active product detector is that the subsequent audio stages are not required to have tremendous amplification factors and hence the major difficulty normally experienced with direct conversion receivers, namely audio instability which leads to oscillation etc, is overcome. Local oscillator re-radiation is also virtually non-existent.

In practice, the judicious use of the RF gain control is more than adequate to cope with AM breakthrough even though only a single tuned RF circuit is used.

c. Band-pass Filter (Board 3)

Although high frequencies are cut off by the driver transformer, some form of audio filtering is required between the mixer and the audio amplifier stages to actually determine the selectivity of the receiver. While a high order low-pass circuit was initially used in the original design, this had to be changed to the two stage band-pass configuration described below to cope with the drastically increased noise levels on the band, as mentioned in the introduction.

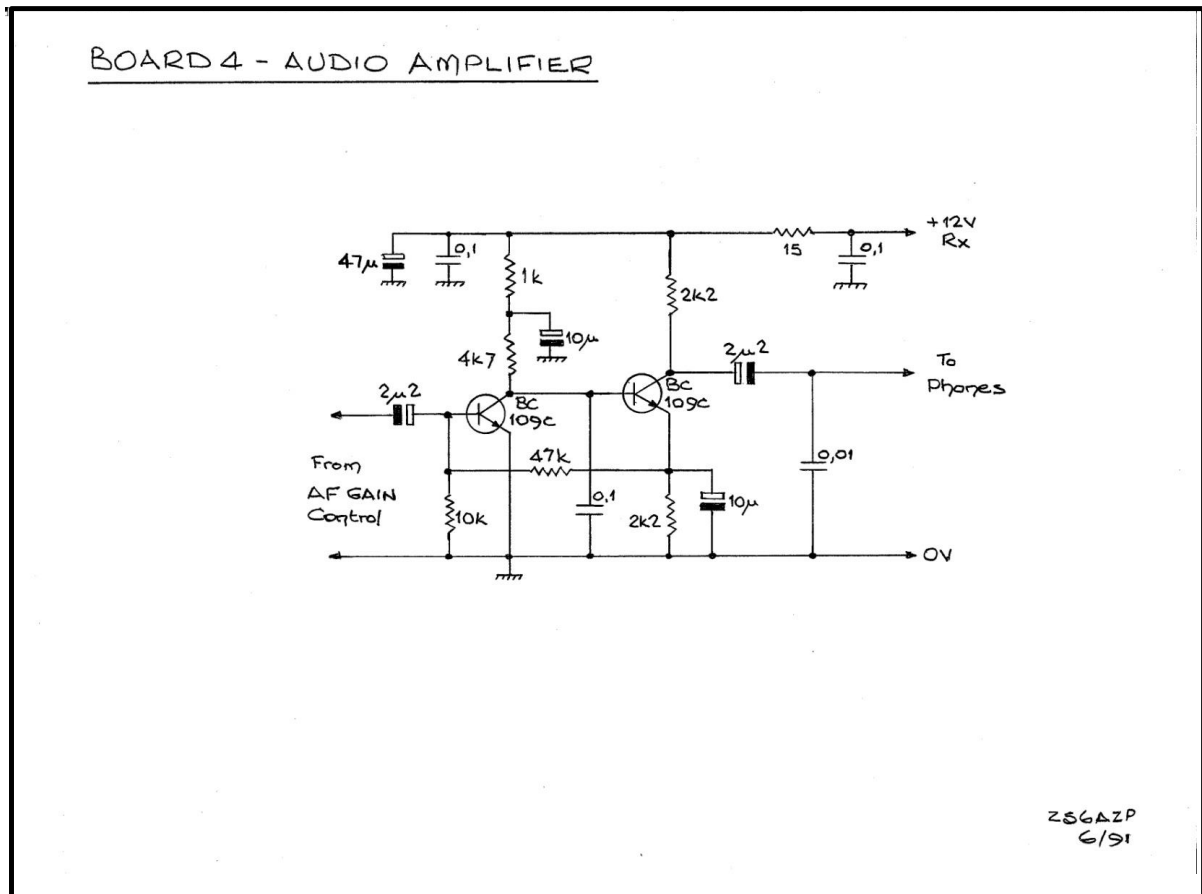


The filter consists of two cascaded conventional multiple feedback active band-pass filter stages consisting of two sections of a dual opamp (LF357). Each filter section was designed to have an overall stage gain of 1, a Q of 5 and a centre frequency of 800Hz. The actual values obtained with the components readily available were a gain of 1.06, a Q value

of 5.05 and a centre frequency of 804Hz. Cascading the two basic band-pass filter stages resulted in a total gain of 1.12, and a Q of 7.85. The design process applied for this type of band-pass filter is detailed in the appendix.

The op-amp used is a FET input low noise device. I used this component because it was to hand, but it could be replaced by an LM1458 IC should you prefer to do so – the receiver noise figure will not be unduly affected.

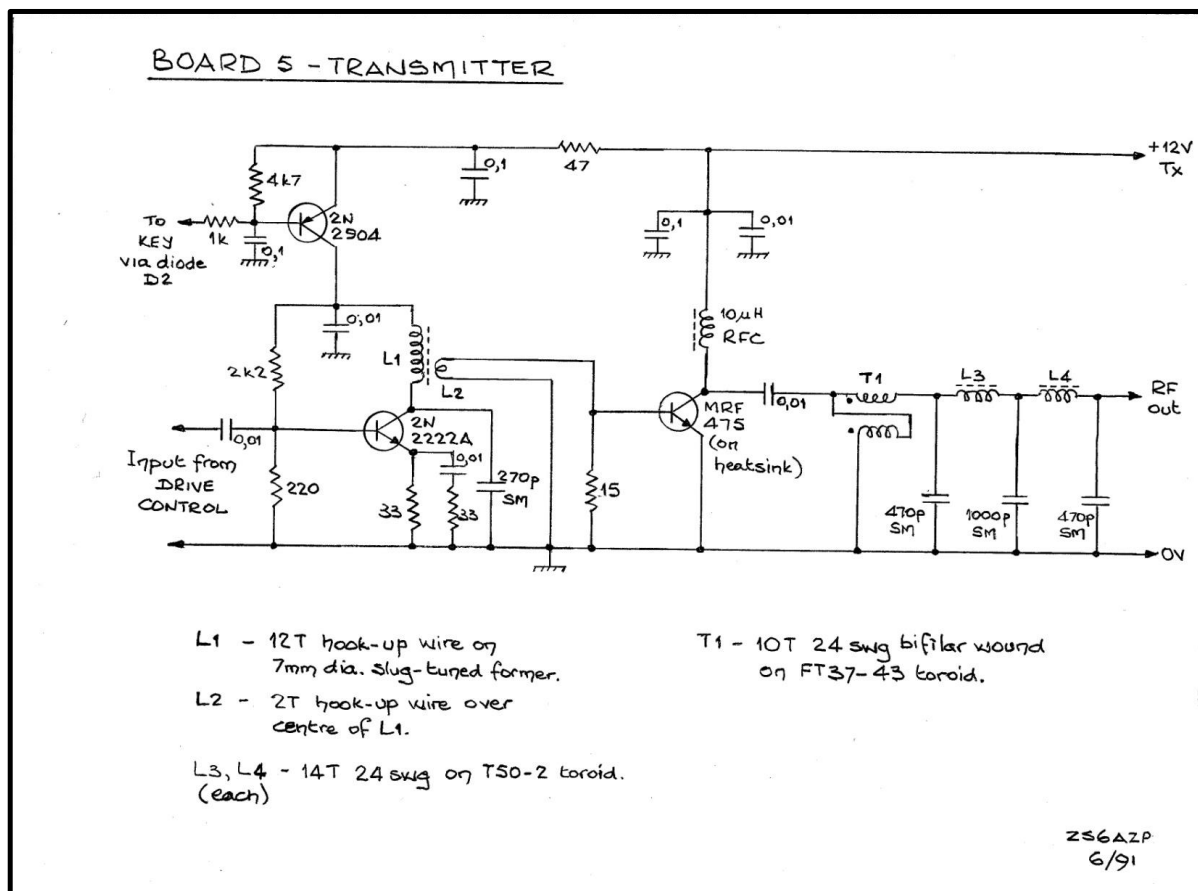
d. AF Amplifier (Board 4)



This stage consists of a fairly conventional directly coupled two transistor audio amp which is designed to drive high impedance headphones. The stage only has moderate, yet more than adequate gain. As can be seen from the circuit diagram, it is very well decoupled, as well as being bypassed at high frequencies, to avoid any possibility the dreaded instability mentioned earlier.

e. Transmitter (board 5)

This consists of a 2N2222A driver working into an MRF475 PA stage. The MRF475 (or its modern replacement the MRF476) is a high gain RF transistor capable of several watts of output power and is often used as the PA in CB sets. As configured, the transmitter output has been "throttled back", by means of the bypass arrangement in the emitter circuit of the 2N2222A as well as by the low value of resistor in the base circuit of the final, to give approximately 3 watts (with the "driver control" pot between the VXO and the transmitter set to maximum) in order to conserve battery life. The PA output is coupled via a 1:4 impedance matching transformer to a 5 pole low-pass filter which gives very good harmonic suppression.



As can be observed, only the driver stage is keyed, via the 2N2904 transistor. While the keying is a bit hard, it is perfect for QRP operation as it gives better readability under weak signal conditions.

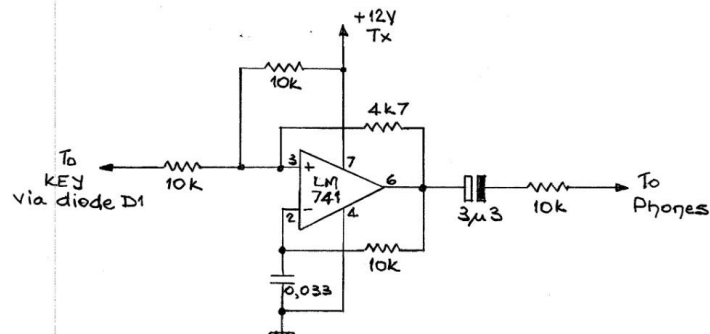
The only tuned circuit in the transmitter which requires adjustment is to be found in the collector of the driver transistor. The circuit is fairly broad-banded and only requires setting up once – adjust the tuning slug for maximum output power and leave it there!

f. Side-tone oscillator (Board 6)

Side-tone is provided by a simple opamp astable circuit operating at a frequency of approximately 800 Hz. The output of the oscillator is coupled directly in parallel with the output from the audio amplifier via a 10k ohm resistor which prevents shorting out the audio when on “receive” and your ears being damaged by an excessively loud tone when on “transmit”.

This arrangement is a favourite of mine – it works very well, has a pleasant tone and requires a minimum of complication when switching from transmit to receive or vice versa.

BOARD 6 - SIDETONE OSCILLATOR



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g. Transmit/Receive Change-over

This could not be much simpler – it is all done by a single switch which changes the antenna between the receiver and transmitter as well as switching the supply voltage between the various boards making up the receiver and transmitter respectively. The supply to the VXO is the only one which is common to both functions and hence is not switched at all except of course for the input which removes the RIT function when going to “transmit”.

Construction

With the exception of the side-tone circuit which is built up on veroboard™, all the individual boards were made up using my brand of pc board construction – the design, drill, paint and etch technique. The final appearance might be a little crude, but the system works well in practice. The transmitter stage was made up on double-sided pc board, with the component side being used as a ground plane, while all the other boards are of conventional single-sided format.

Conclusions

This transceiver is a delight to operate. I have not found being “rock-bound” to be any big disadvantage, but of course there is no reason why the VXO cannot be replaced by a VFO. Another modification which could be considered is introducing semi break-in facilities instead of manual TX/RX change-over. The options are endless. I was very pleased with this basic building block approach to transceiver construction and also built a similar unit for 20m operation some years ago.

Homebrew QRP – you can’t beat the feeling!

Post script – this was the homebrew QRP rig used successfully at the Centurion Radio Amateur Club Open Day on 14 September 2013!

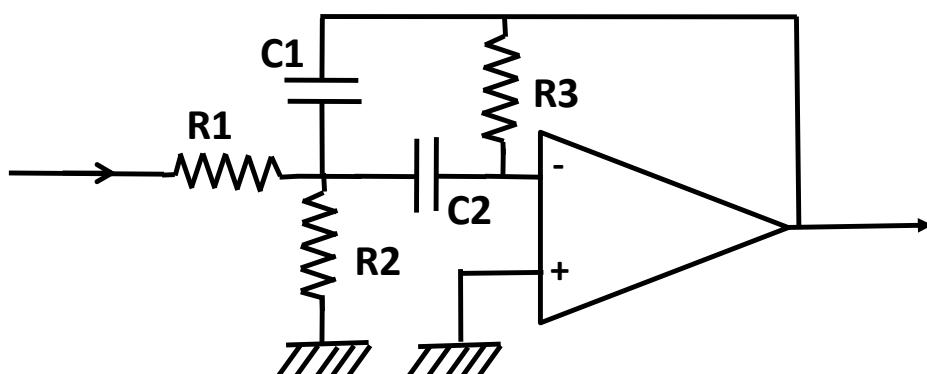
References:

1. "The Hilltopper : A VXO Design for 10 and 14MHz" – GM4JMU, Sprat No. 52, Autumn 1987 - (design of Active Product Detector stage)
2. "Solid State Design for the Radio Amateur" –W7ZOI & W1FB, ARRL Publication (design of most of all the other stages!)

APPENDIX

Design of a multi-feedback Band-Pass filter stage

Design of multiple feedback Band-Pass filter



1. Pick H_0 (gain), Q and f_0 (centre frequency)

2. Choose C ($C1 = C2$)

3. Calculate $R1 = \frac{Q}{H_0 * \omega_0 * C}$ where $\omega_0 = 2\pi f_0$

4. Calculate $R2 = \frac{Q}{(2Q^2 - H_0) * \omega_0 * C}$

5. Calculate $R3 = \frac{2Q}{\omega_0 * C}$

Page 82, Ref 2

Update : The Tx output has been increased to 5W by changing the "throttling" (C and R series arrangement) circuit in the emitter of the driver transistor by replacing the 33 ohm resistor with a 15 ohm component.