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# **RF Amplifiers**

by

Jim Butler GM3ZMA

# Introduction

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We will discuss:

A narrow band tuned amplifier using an NPN transistor.

A wideband amplifier using an NPN transistor.

A wideband amplifier using two Monolithic Microwave Integrated Circuits (MMICs).

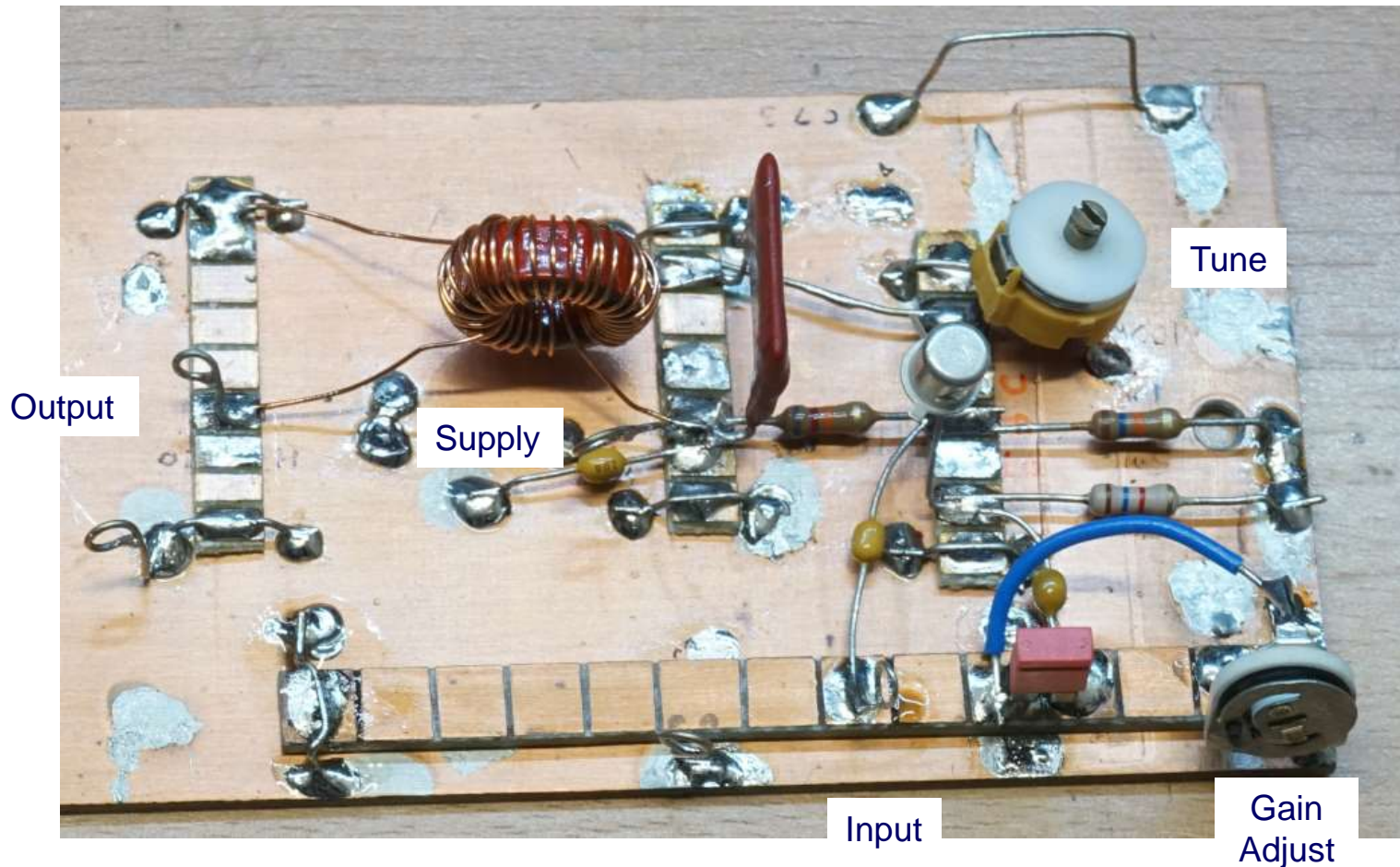
Bandpass filters, as may be used in the RF stages of an HF bands receiver.

A pre-amplifier for the 70cm band using a dual gate FET.

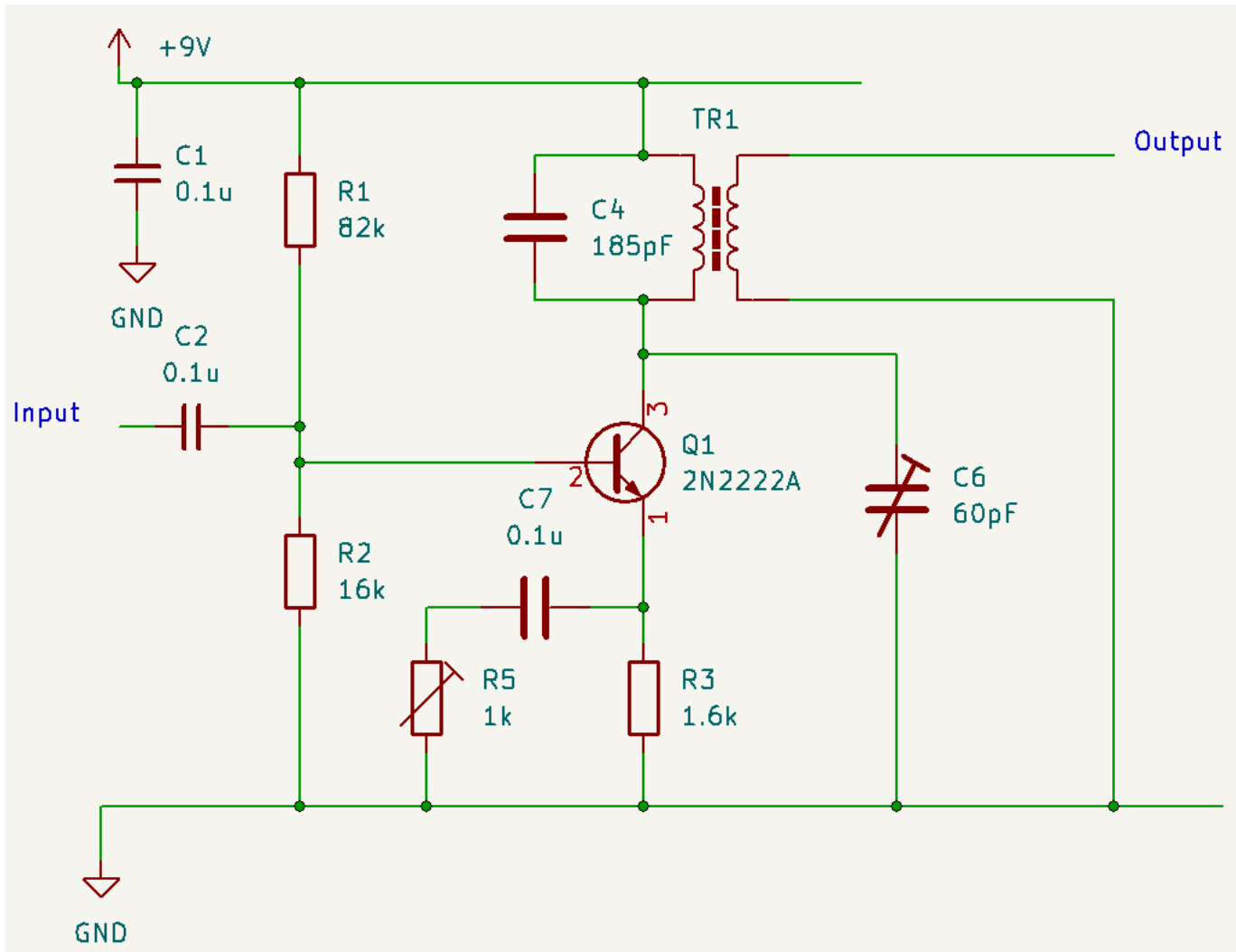
A High Band VHF amplifier/mixer module (ex PMR).

# A prototype tuned amplifier

Built on a scrap of circuit board material which makes a low impedance ground plane to minimize stray inductive effects interfering with the operation of the circuit. This circuit is designed to operate at 5MHz.



# Schematic



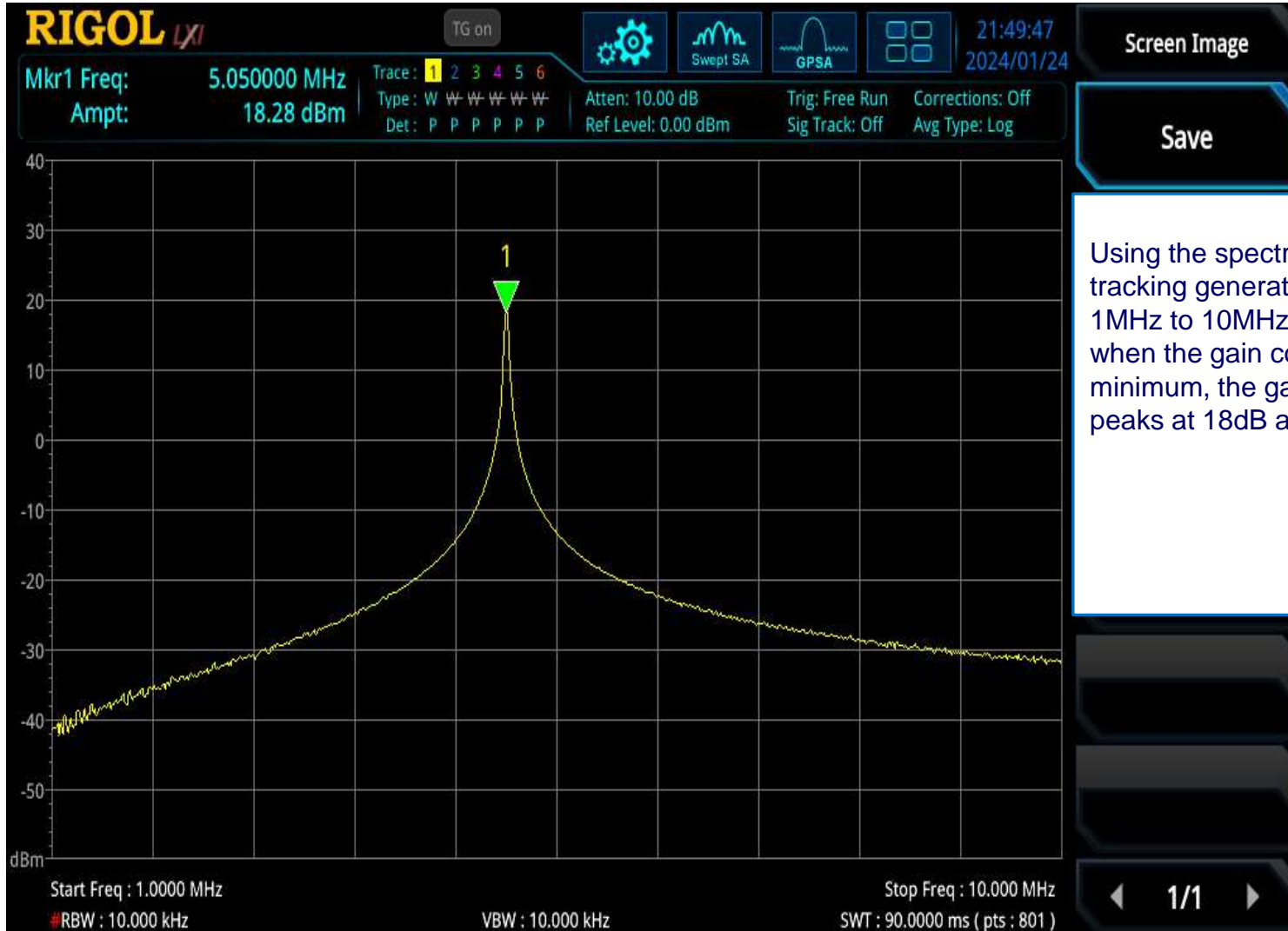
Similar to the common emitter amplifier used in the Audio Amplifiers tutorial.

Here the collector resistor has been replaced by a tuned transformer.

The core is a T50-2 iron powder toroid, primary winding 31 turns, secondary winding 5 turns. Capacitors C4 and C6 and the transformer make the collector circuit resonant at 5MHz.

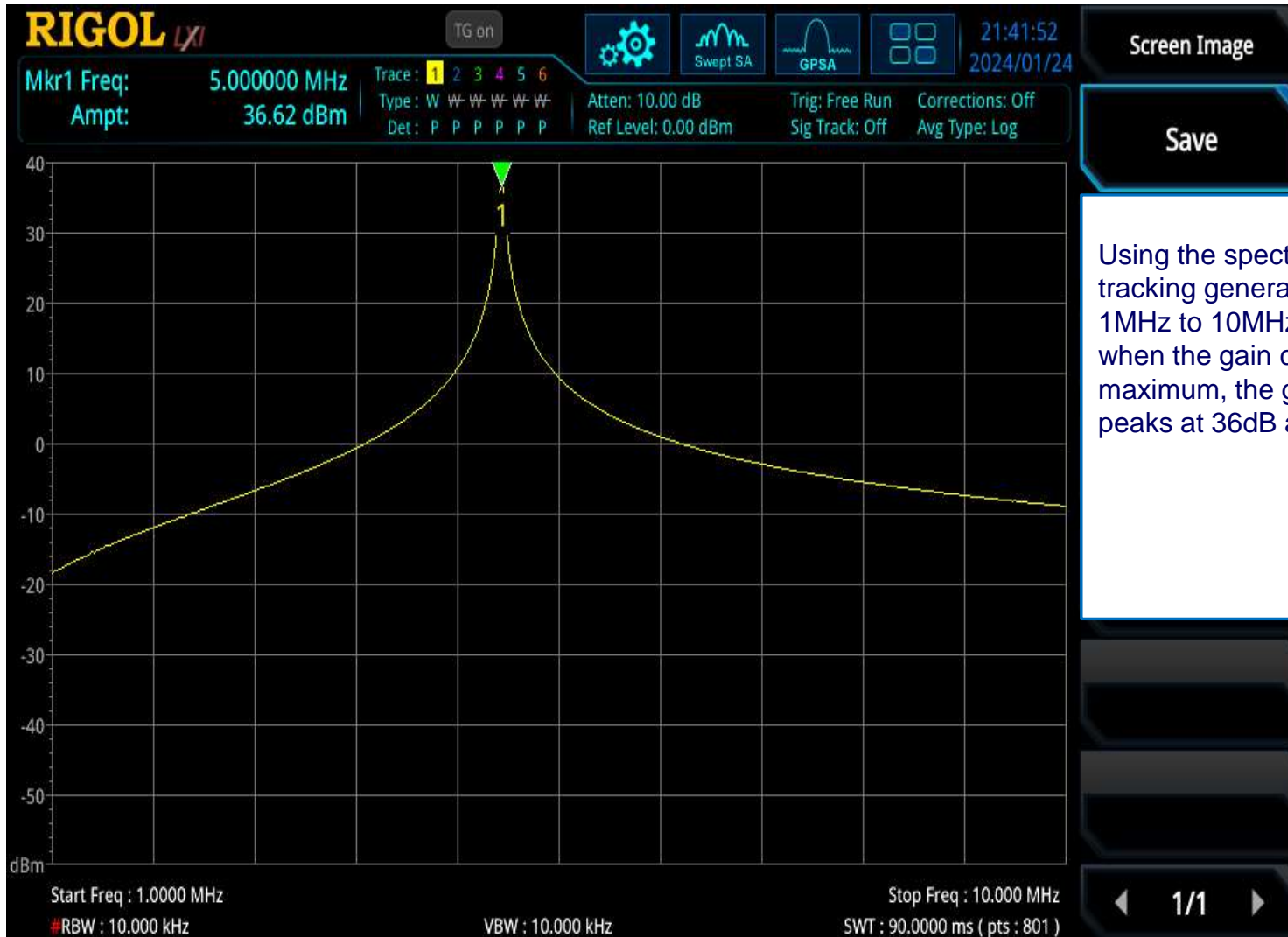
The gain of this amplifier is adjustable by varying R5.

# Gain and Frequency Response - 1



Using the spectrum analyser and tracking generator, scanning from 1MHz to 10MHz, we see that when the gain control is set to minimum, the gain of the amplifier peaks at 18dB at ~5MHz.

# Gain and Frequency Response - 2



Using the spectrum analyser and tracking generator, scanning from 1MHz to 10MHz, we see that when the gain control is set to maximum, the gain of the amplifier peaks at 36dB at ~5MHz.

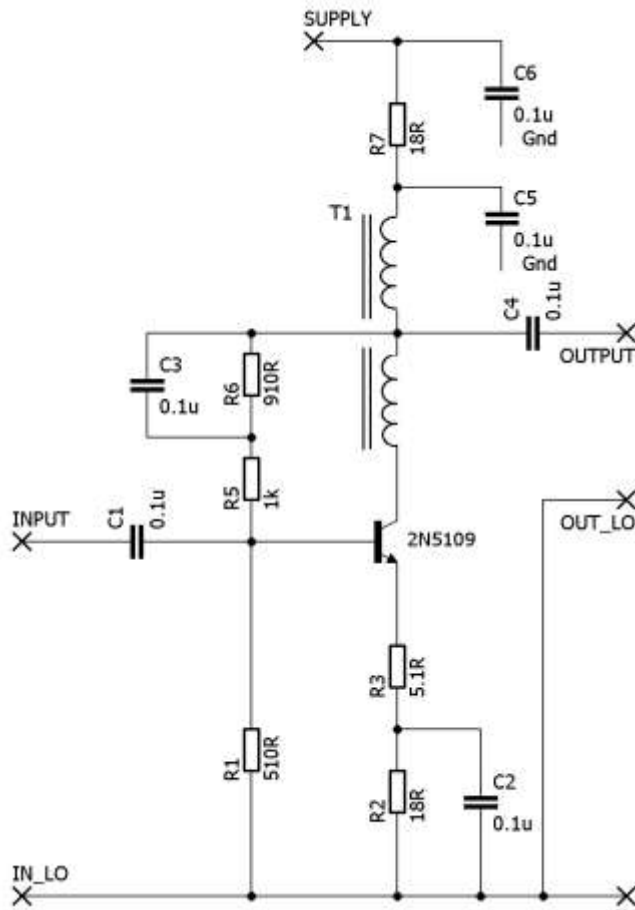
# A 20db Gain wideband amplifier

Based on circuits in ARRL publication Solid State Design for the Radio Amateur, page 147 fig 12 and page 226 fig 11

This unit was built on a custom made “etched” circuit board.



# Schematic

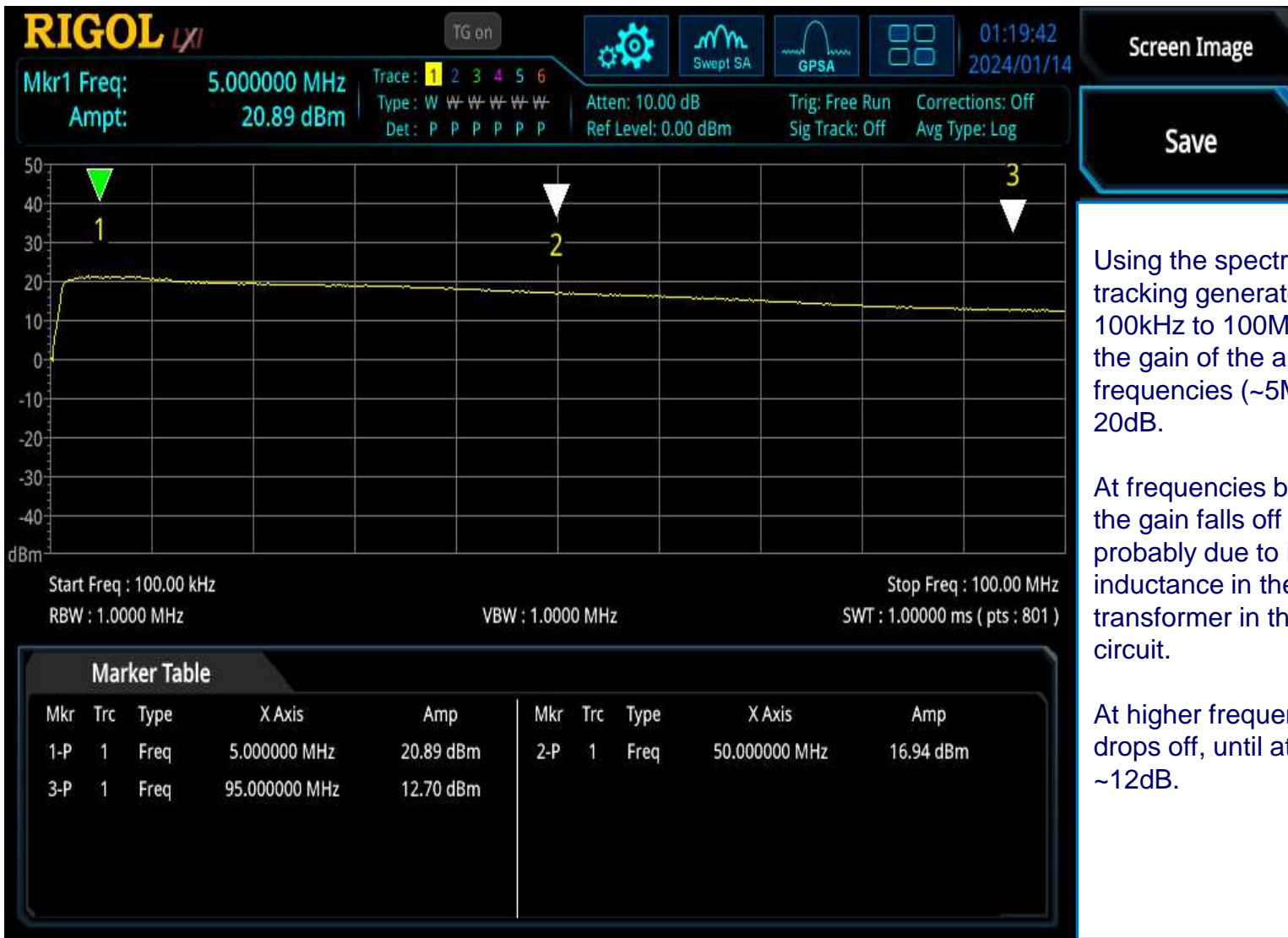


Based on circuits in  
Solid State Design for the Radio Amateur,  
page 147 fig 12 and page 226 fig 11  
(ARRL Publication).

This amplifier is intended for use as the post mixer amplifier and VFO drive amplifier in a receiver.

The use of feedback from output to input (R5, R6 and C3), and emitter circuit feedback (R3), gives wideband gain with constant input and output impedance.

# Gain and Frequency Response



Using the spectrum analyser and tracking generator, scanning from 100kHz to 100MHz, we see that the gain of the amplifier at lower frequencies (~5MHz) is just over 20dB.

At frequencies below about 2MHz the gain falls off quite rapidly, probably due to insufficient inductance in the ferrite transformer in the collector circuit.

At higher frequencies the gain drops off, until at 95MHz it is ~12dB.

# Wideband High Gain Amplifier

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Built many years ago as a learning exercise in using microwave monolithic integrated circuits (MMIC).

The resulting unit has been used a few times as a “gain block” in test set-ups.



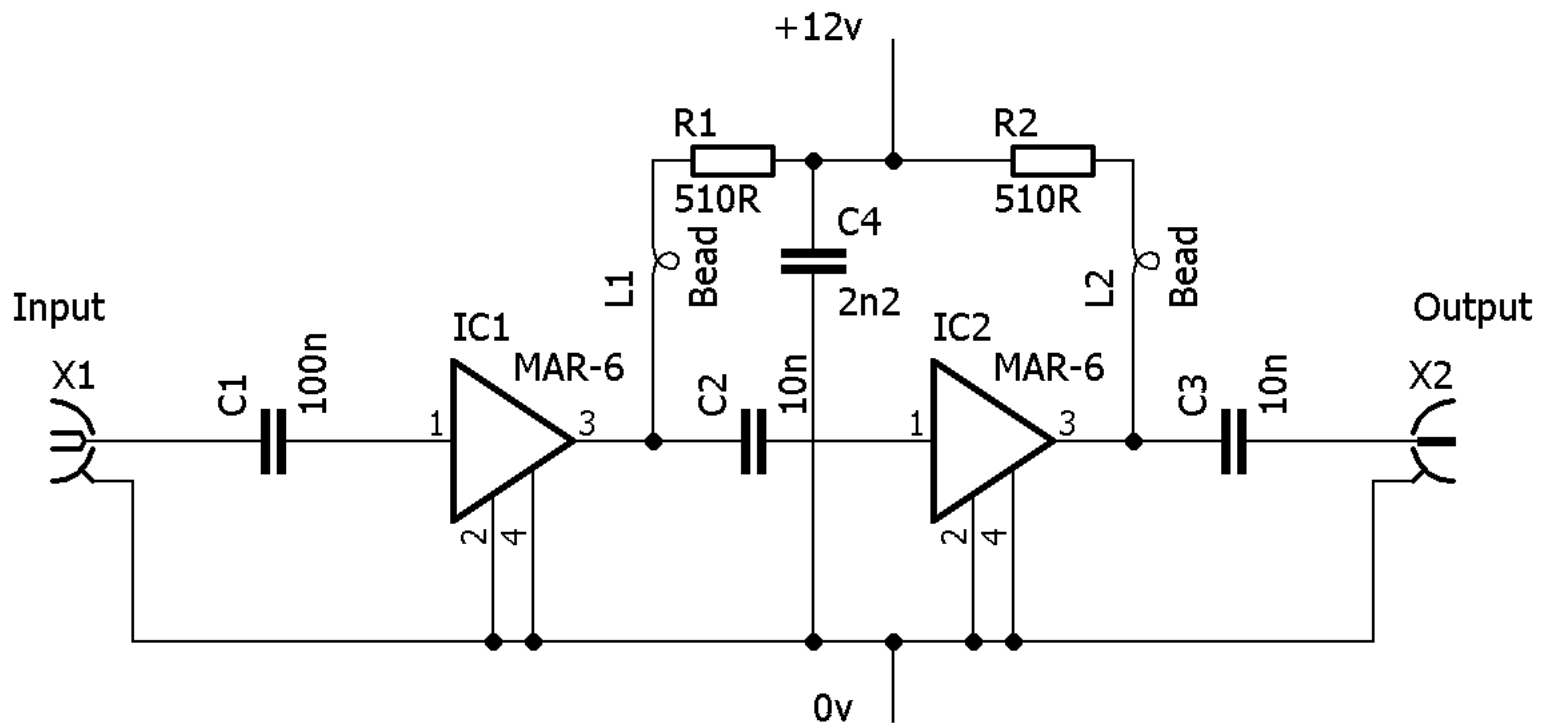
# Schematic

Input and output impedances are 50 Ohm.

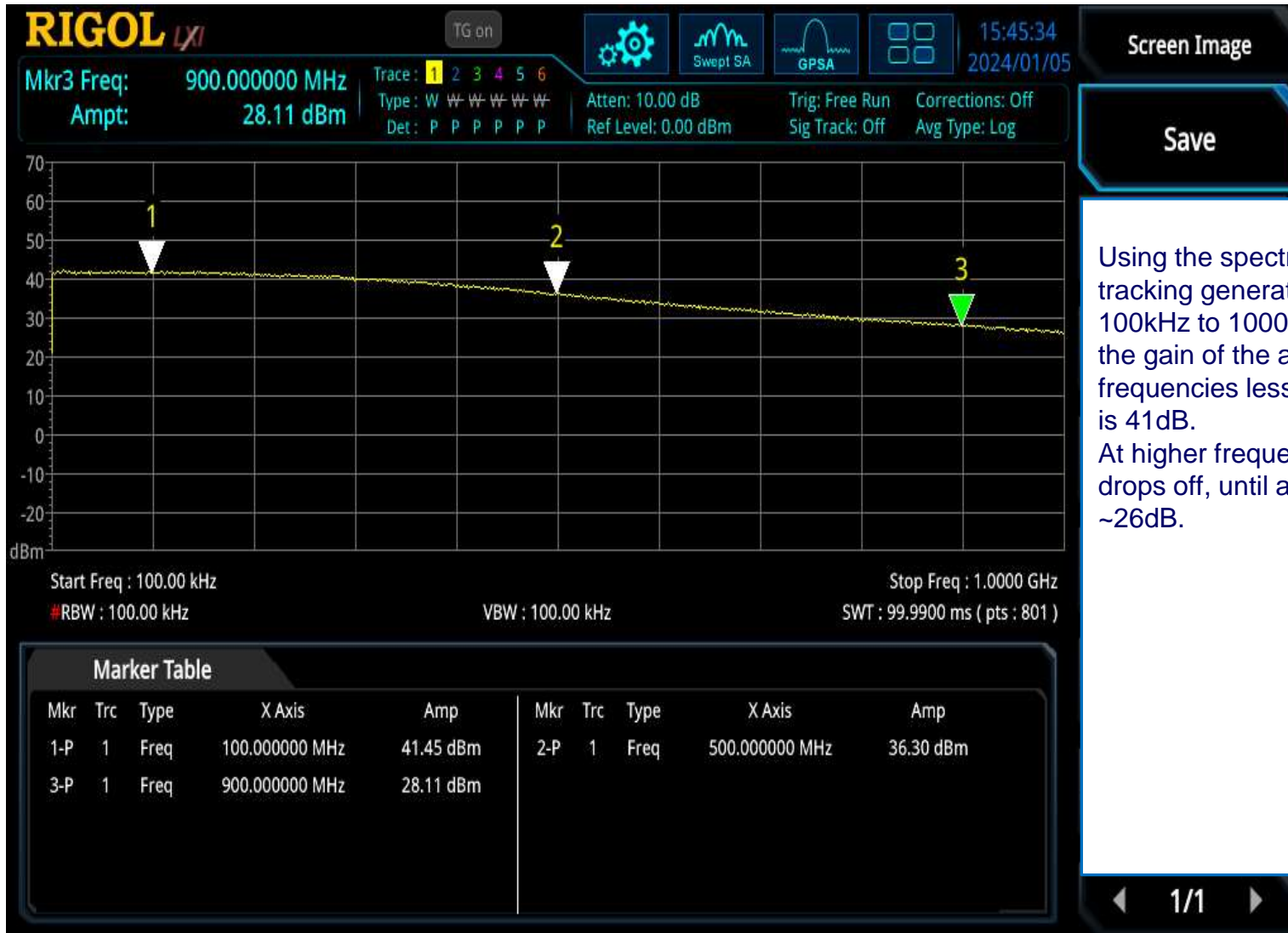
Maximum output power is 1mW (from MAR-6 datasheet).

C4 is a feedthrough capacitor.

L1 and L2 are ferrite beads on the leads of R1 and R2.



# Gain and Frequency Response



Using the spectrum analyser and tracking generator, scanning from 100kHz to 1000MHz, we see that the gain of the amplifier at frequencies less than ~200MHz is 41dB. At higher frequencies the gain drops off, until at 1000MHz it is ~26dB.

# A Bandpass Filter

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Wideband amplifiers with gain from “DC to Daylight” are a bad idea when used in the input stages of receivers. The many unwanted signals from the antenna when amplified and fed into the mixer stage can cause overloading which results in many spurious signals which interfere with the wanted signal.

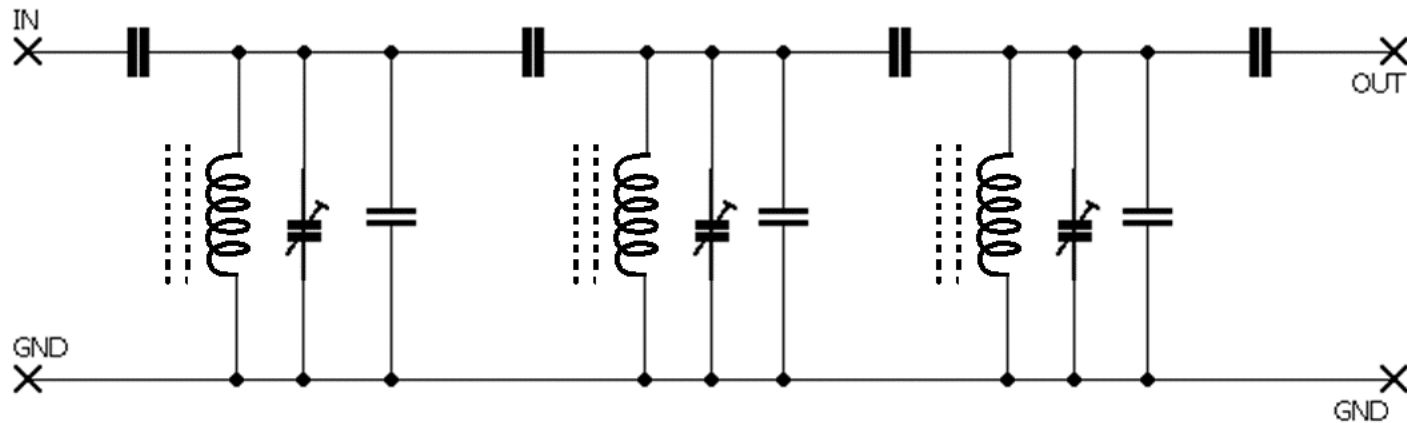


To overcome this problem it is usual to restrict the bandwidth of RF amplifiers using some kind of bandpass filter.

Here we see a three pole bandpass filter often found on the input of a receiver, in this case for the 40 metre band (7.0 to 7.2 MHz)

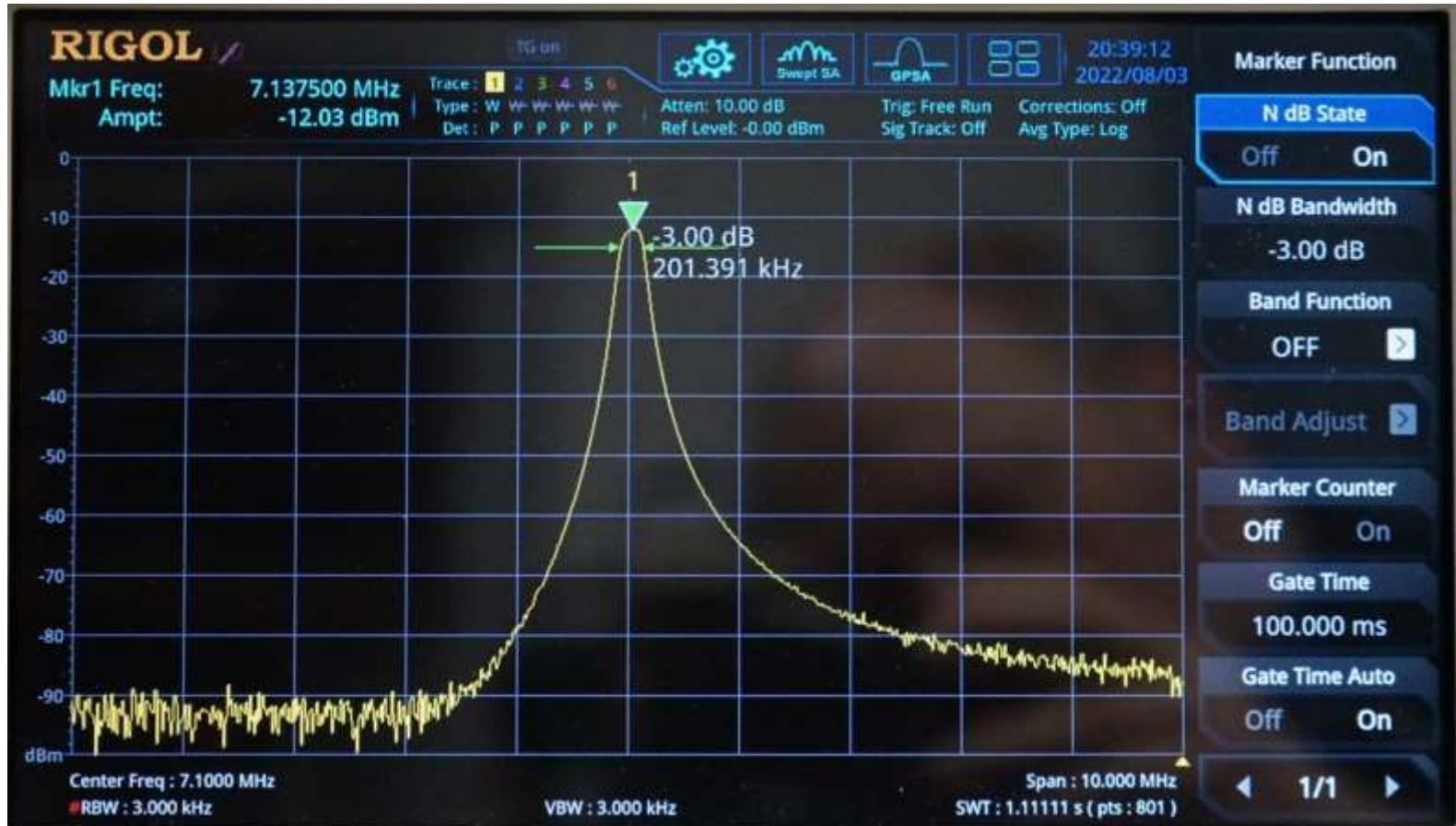
# The circuit

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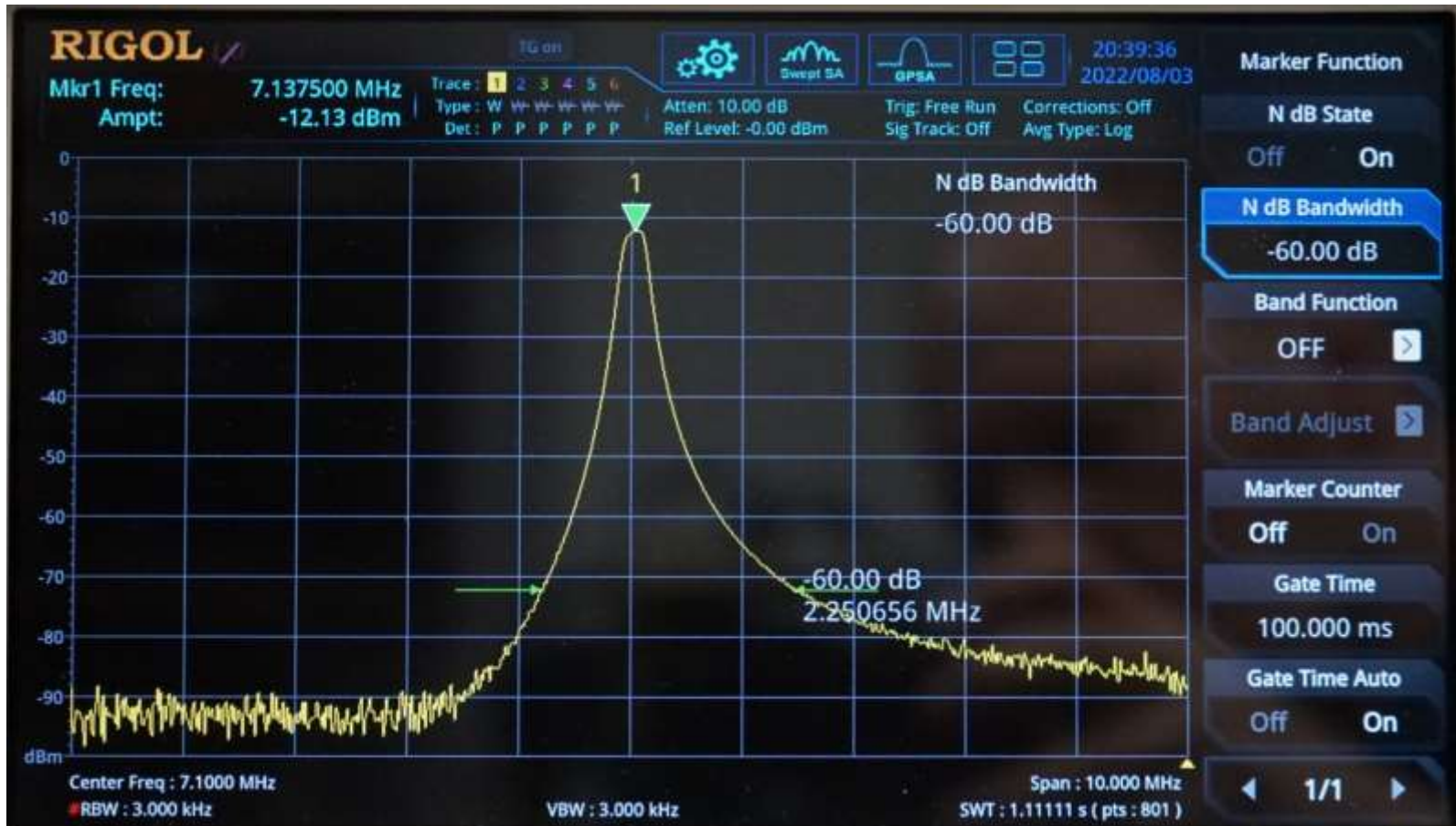
Three capacitively coupled tuned circuits, based on information in *Solid State Design for the Radio Amateur, Appendix 2* (ARRL Publication).

# Bandwidth and Shape Factor



Filters are most frequently defined by their 3dB bandwidth, in this case 201kHz. But how good is it in the stopband?

# Bandwidth and Shape Factor



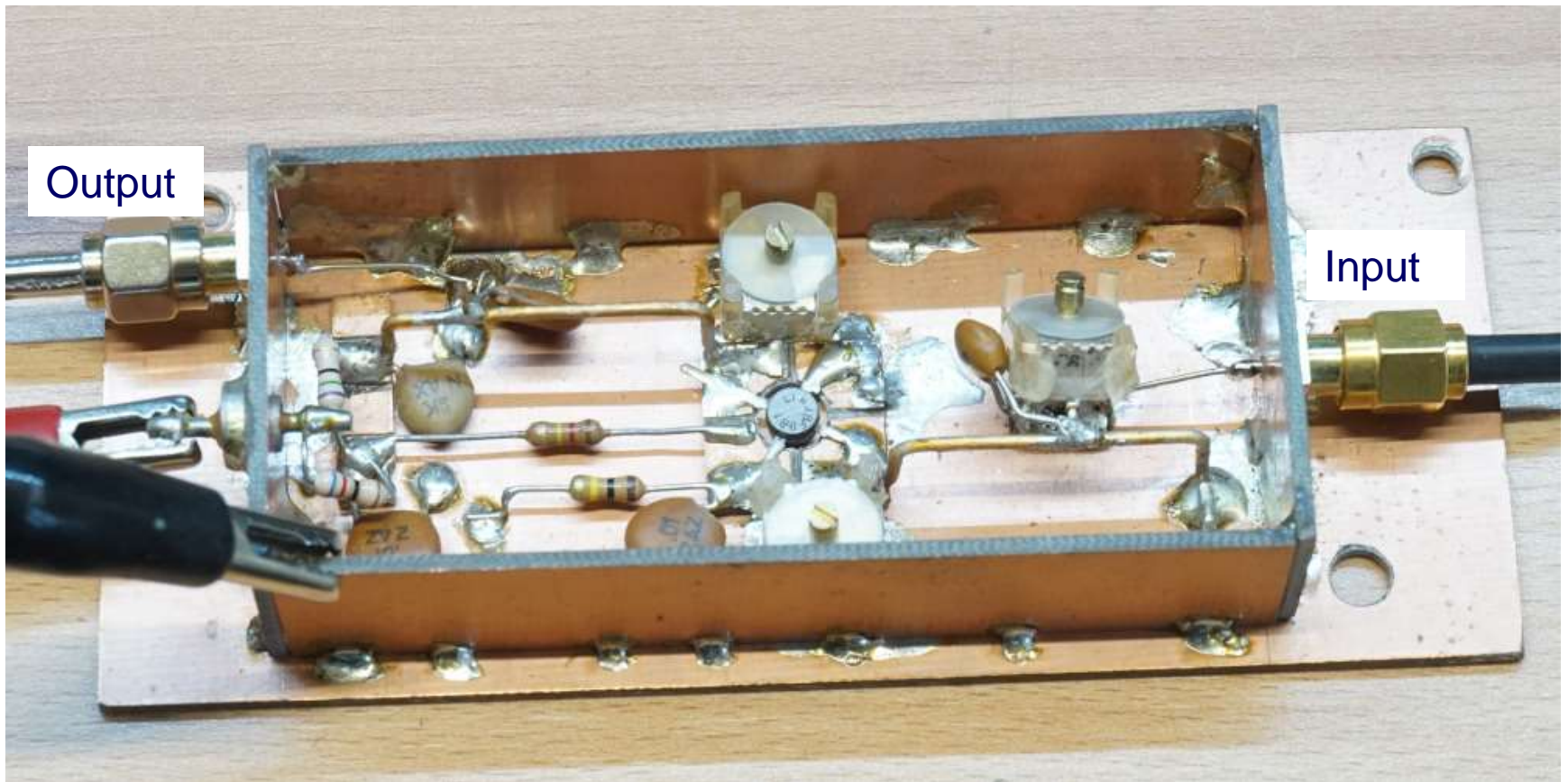
The skirt selectivity is often defined at the -60dB points, in this case 2.25MHz. A high performance receiver would probably use more tuned circuits to reduce the -60dB bandwidth, thus improving the stopband attenuation.

# A 70cm Pre-Amplifier

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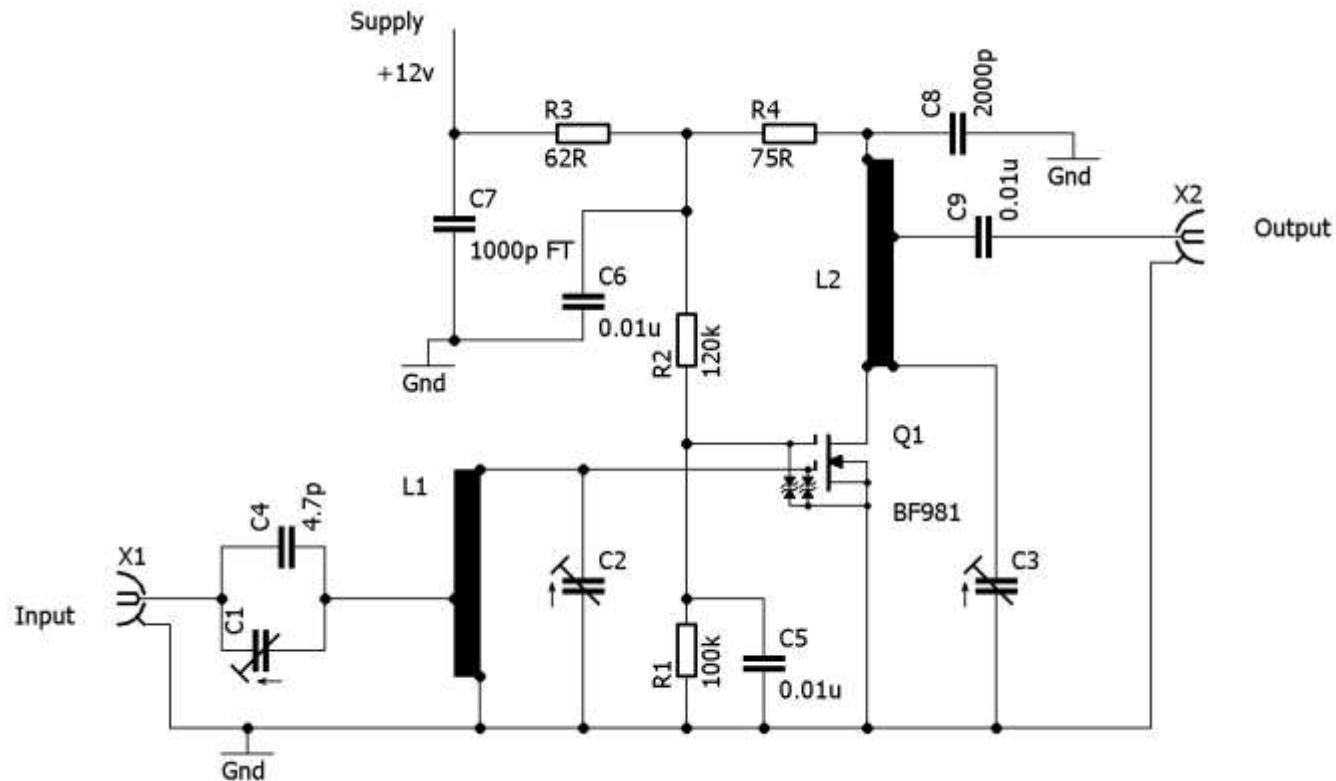
Built many years ago using whatever dubious components were available.

It performed its assigned task “adequately”.



# Schematic

The circuit was based on a design in some magazine or book. It worked reasonably well at the time, but when tested using better equipment available today, the frequency response looks “odd”.



# Gain and Frequency Response



Using the spectrum analyser and tracking generator, scanning from 200 MHz to 600 MHz, we see that the gain of the amplifier peaks at 18.9dB at a frequency of 439 MHz.

The overall form of the frequency response curve is strange and something which I have not seen before.

I built this amplifier many years ago to improve the weak signal performance of some ex-PMR equipment.

The result was a success.

Would I use it again...

No.

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That frequency response curve reminded me of this pyramid.

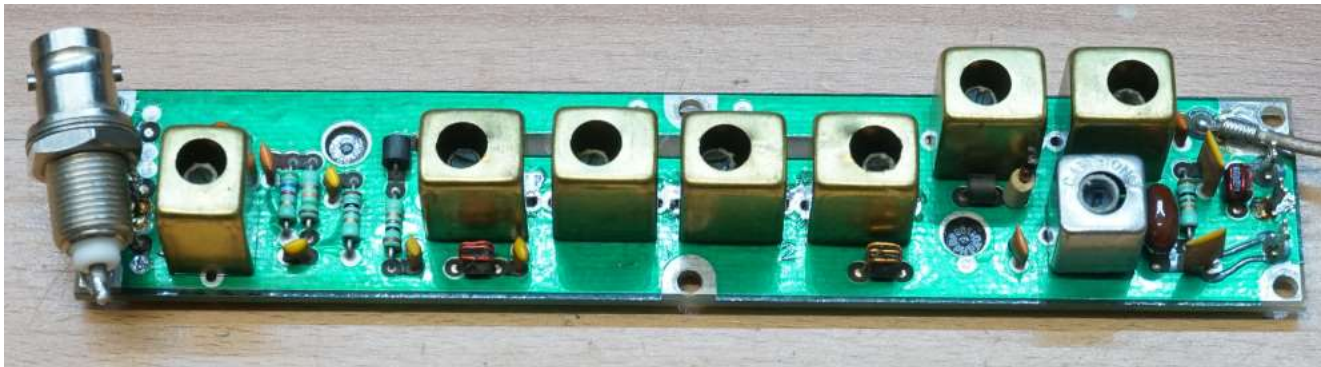


# High Band VHF Amplifier/Mixer Module

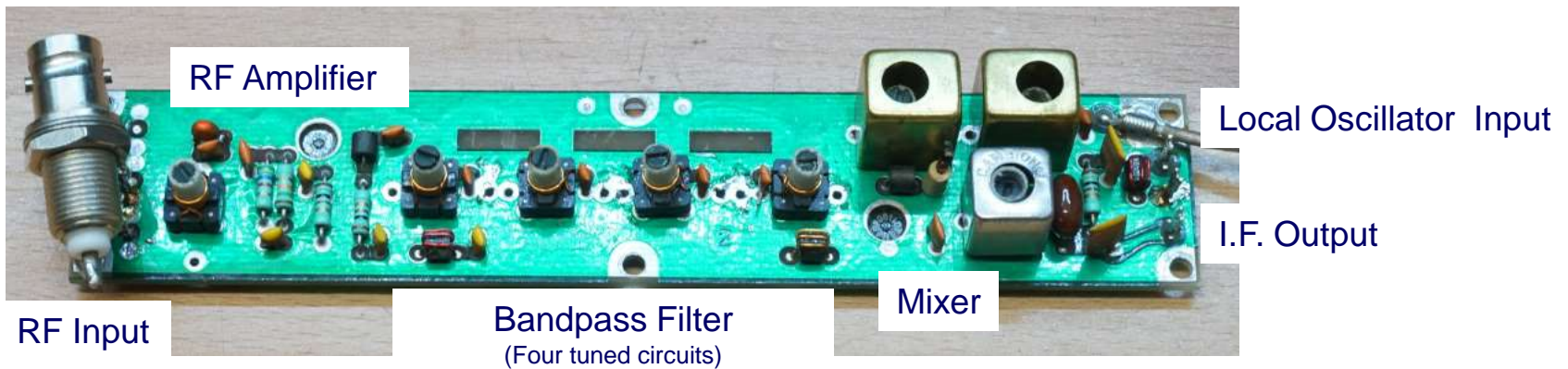
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Removed from a redundant VHF mobile radio transceiver.

As assembled for normal operation

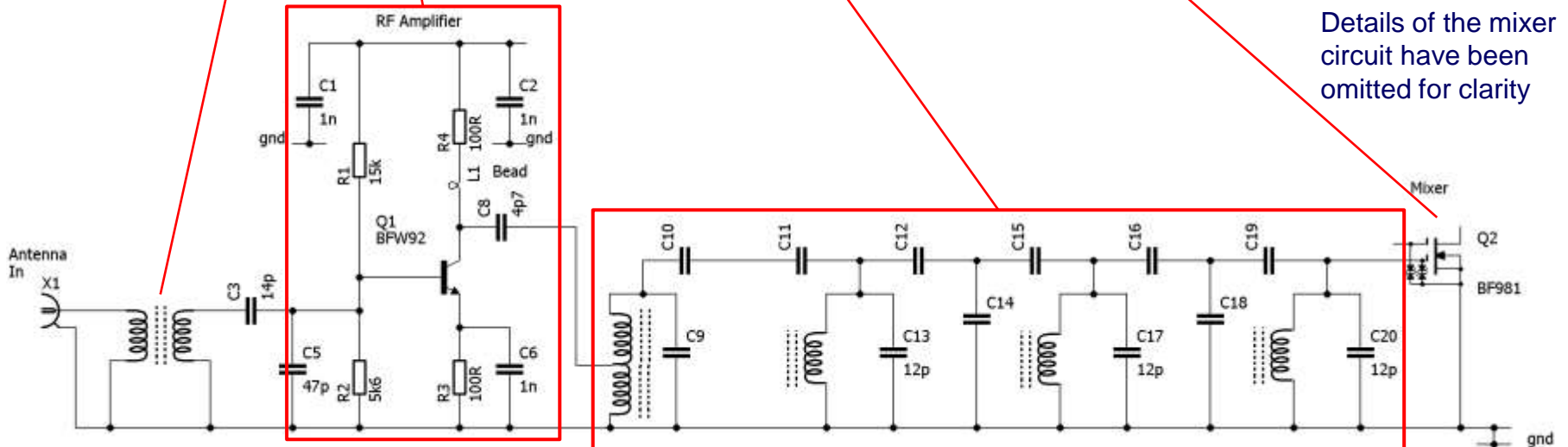
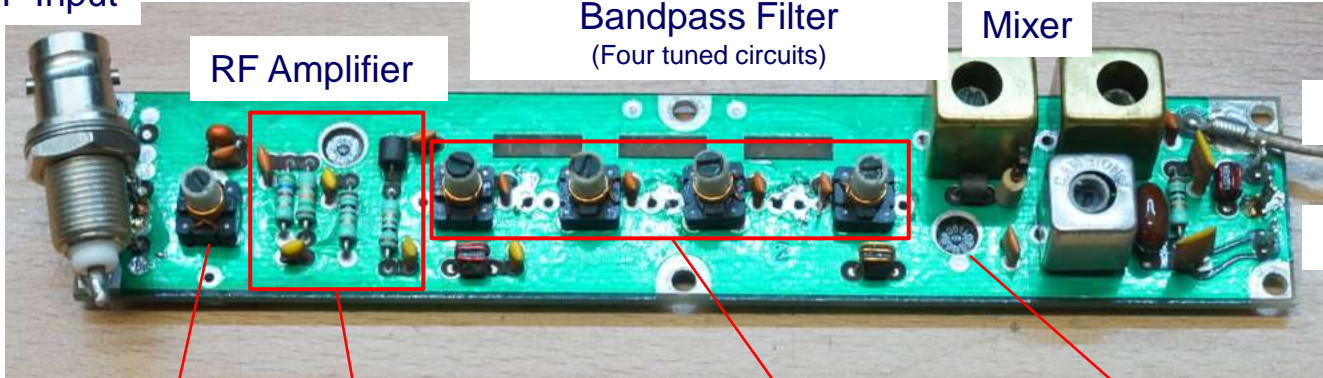


Shielding cans removed to show the signal frequency tuned circuits.



# Schematic

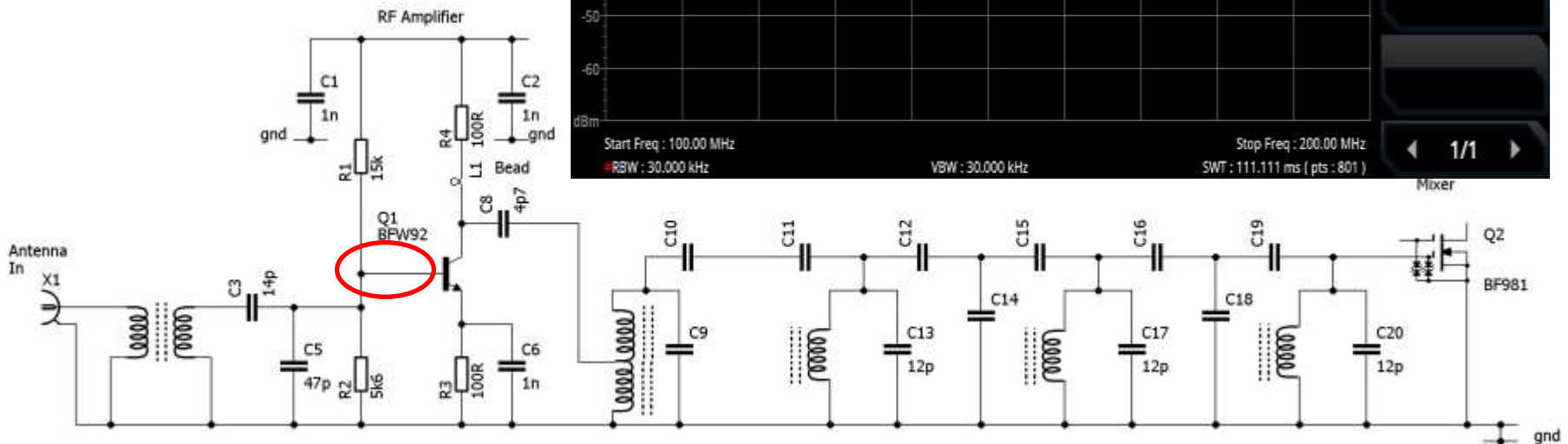
RF Input



# Gain and Frequency Response - 1

Using the spectrum analyser and tracking generator, scanning from 100 to 200 MHz, we see that the response at the base of the RF amplifier broadly peaks at about 180MHz.

(Something seems wrong with this, see next page).

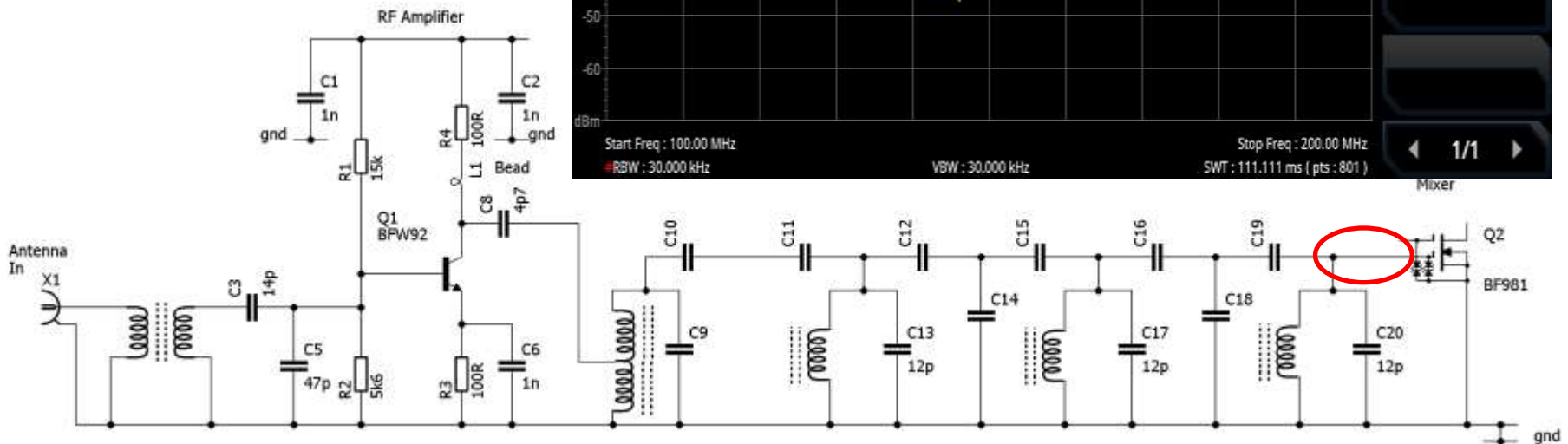
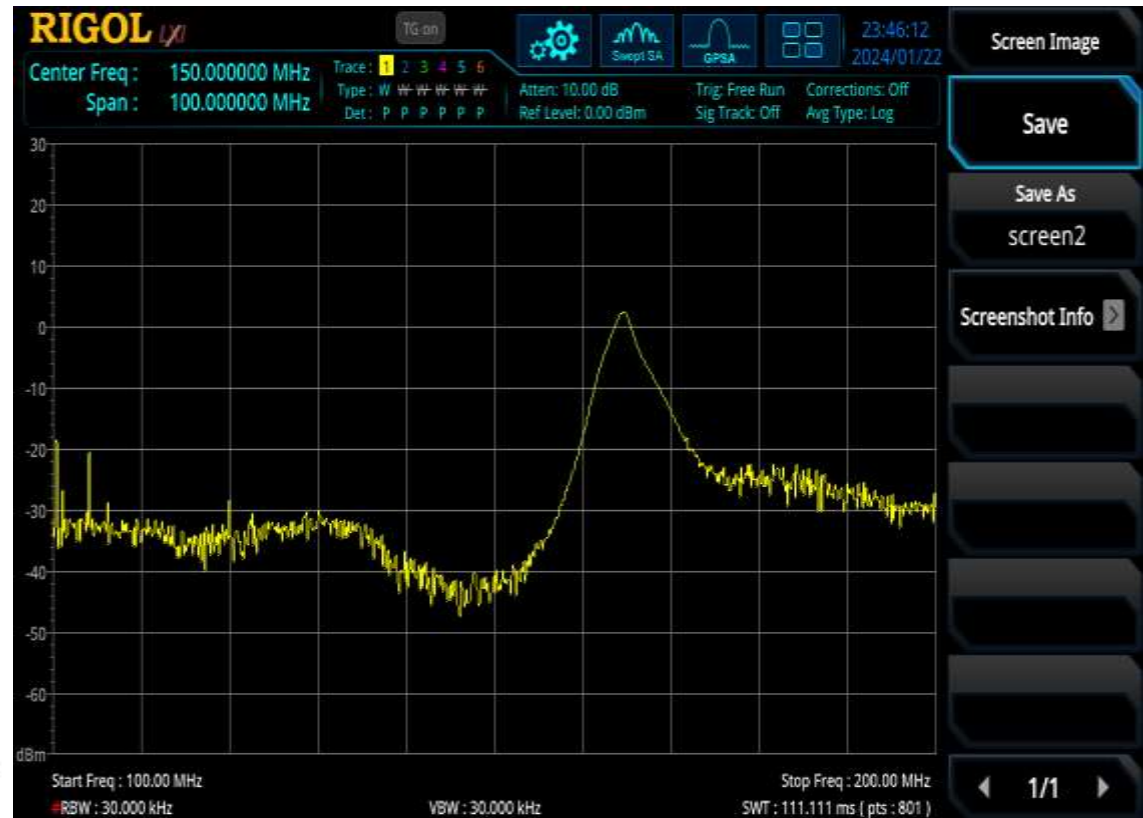


# Gain and Frequency Response - 2

Looking at the input to the mixer stage, after the filter, there is a sharp peak at about 165MHz.

This is more like what we would expect from a high band VHF mobile transceiver (Early car-phone?).

There may be something not quite correct about the input circuit of this board.



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The End