Broadband
Active
Receiving
Loop

PA0SIM
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1 Broadband amplifier circuit

This is an update of the 2003 design and the 2019 update.
It is first published in the VERON periodical:
Electron February 2004, pp 60-63 and Electron April 2004, pp 157-160
See also:
http://www.pa0sim.nl/Published%20Articles.htm

For more info:
http://www.pa0sim.nl/Broadband%20amplifier.htm

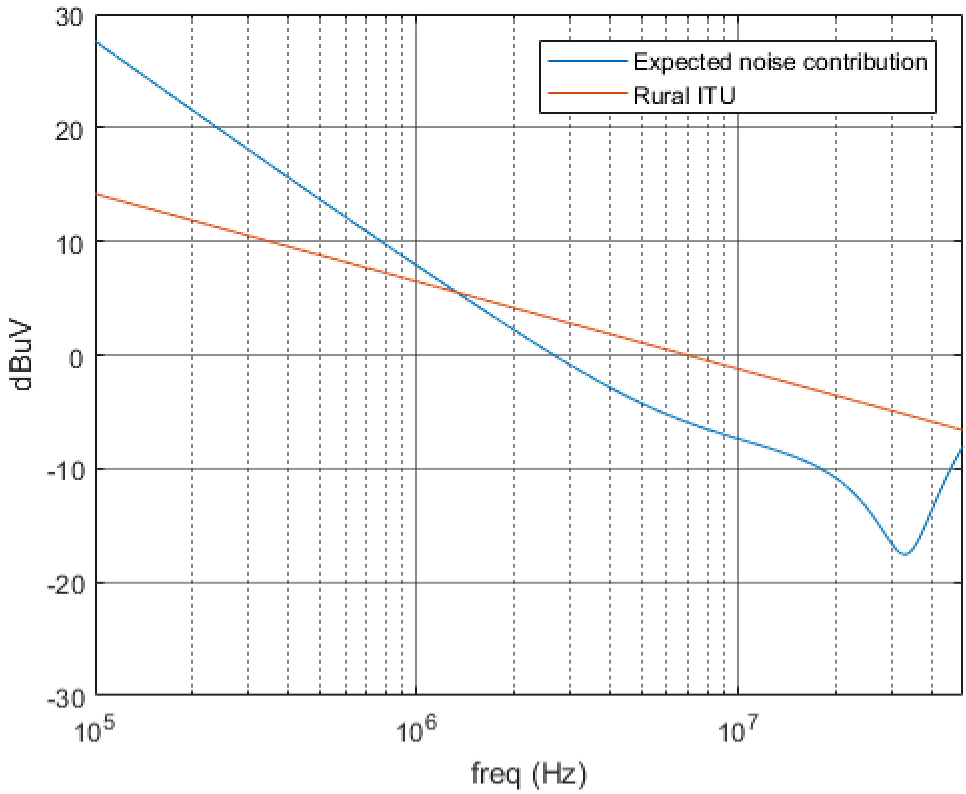
Geert PA3CSG has designed the PCB, thanks Geert!

2 Performance

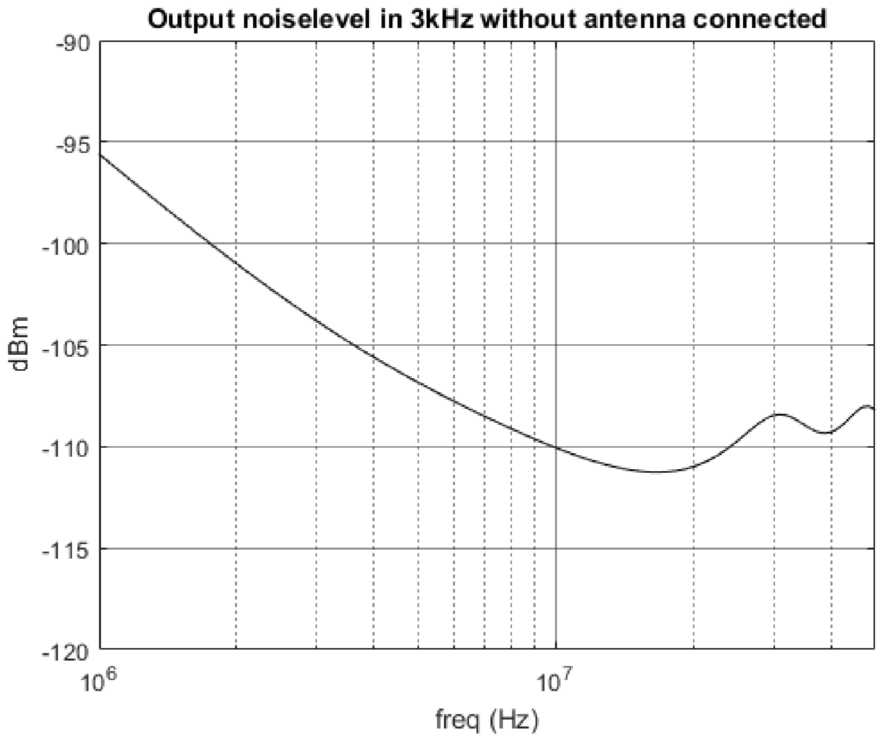
Design and specification bandwidth: 1MHz-30MHz
Simulation behavior model of the loop will be less accurate for frequencies >14MHz:
http://www.pa0sim.nl/Broadband%20amplification.htm

2.1 Expected noise contribution (simulation)

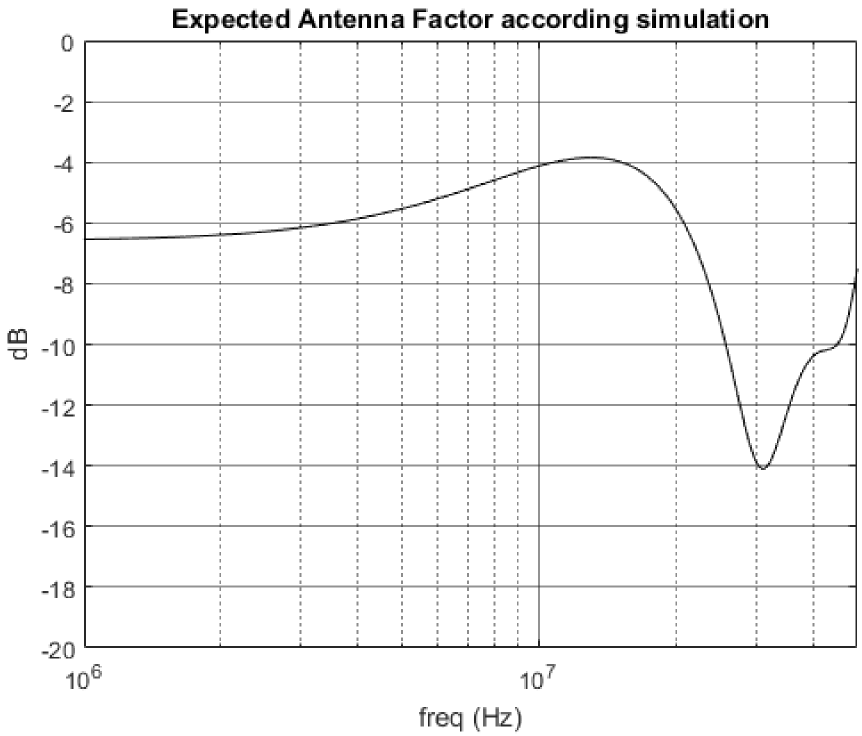
Noise contribution 5-6dB lower than ITU rural noise level. As far as the used antenna behavioral model is accurate.
Measured noise increase at a better than rural location: 4dB.



2.2 Output noise level



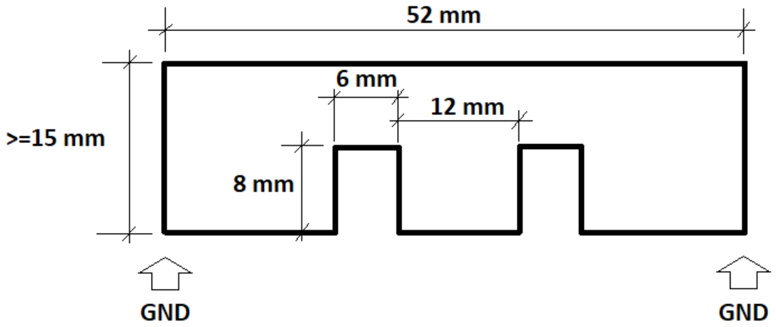
2.3 Antenna factor (simulation)



Note: measured gain 1MHz-30MHz of the amplifier is according simulation within 1dB.

2.4 Common mode rejection and Faraday shield

Measured common mode rejection > 50dB without Faraday shield.
Rejection is measured as voltage difference between the loop and the amplifier ground to output voltage.
With the loop at ground level and amplifier ground connected to ground, this voltage difference is about equal to the electrical field E.
An **E-shaped Cu Faraday shield** can be applied at the transformer improving common mode rejection by another 6-10dB. **Shield soldered to ground only at the outer legs.**

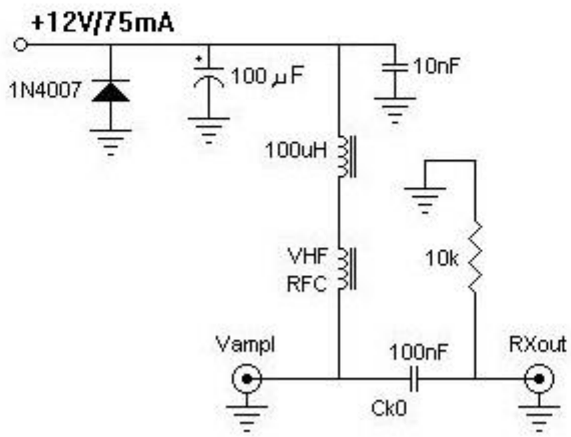


2.5 Large signal behavior

IM3 >+40dB and IM2>+70dB for frequencies <10MHz

3 BiasT

Measured attenuation biasT <0.25dB (measuring without 12V!)
You can add a fuse for short circuit protection.



4 Bleeders

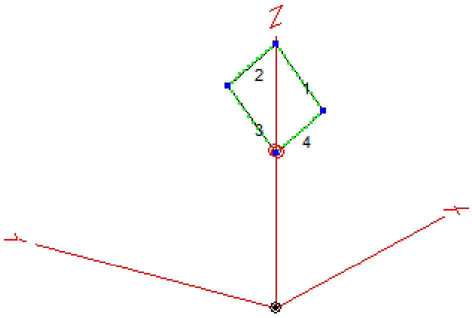
If no Faraday shield is used, it makes sense to add bleeders (1MOhm to GND) to both loop connections. Bleeders prevent static build up on the loop antenna and static discharge.

5 Routing the coaxial cable

The coaxial cable can and will pick up noise in the shack. It will act as an antenna and reradiate this noise. The resulting electromagnetic field can be pick up by the loop.
There are several ways to minimizing receiving this noise by the loop:

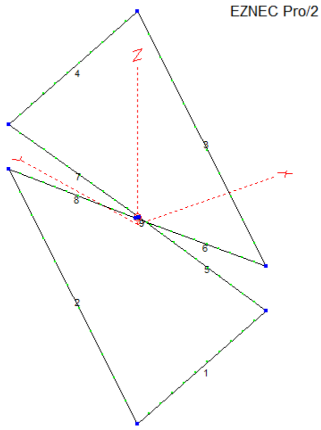
- keep the coaxial cable perpendicular to the loop, preferably straight down
- run the coaxial cable underground to the shack
- add current baluns (not preferred, work around)

6 Recommended loop dimensions



Recommended is a square loop 1.3m*1.3m using (insulated) 2-3mm diameter wire. The contribution of plastic insulation to the inductance is negligible (few %). On urban locations a smaller loop (e.g. 1m*1m) is an option.
Lowering the inductance by using tubing with a much larger diameter for higher signal levels and better SNR will affect large signal behavior of the amplifier. The loop gain decreases.
Note: the series inductance as a result of the coupling factor 0.8 of the transformer limits the extra gain in SNR!

7 Alford loop

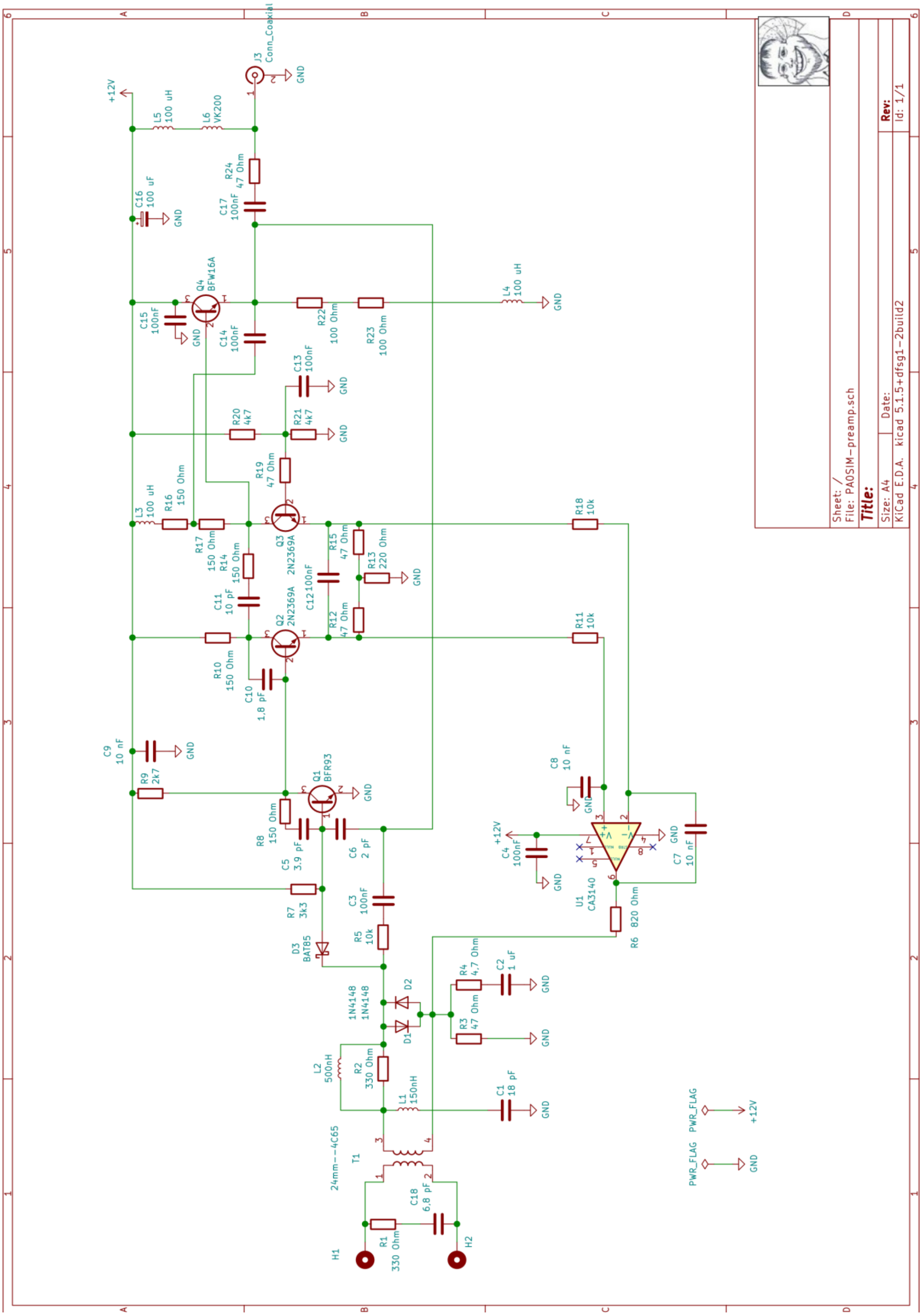


The Alford loop can improve "nulling" a noise source at higher frequencies. That is the main goal of using an Alford loop:
http://www.pa0sim.nl/Alford%20loop.htm

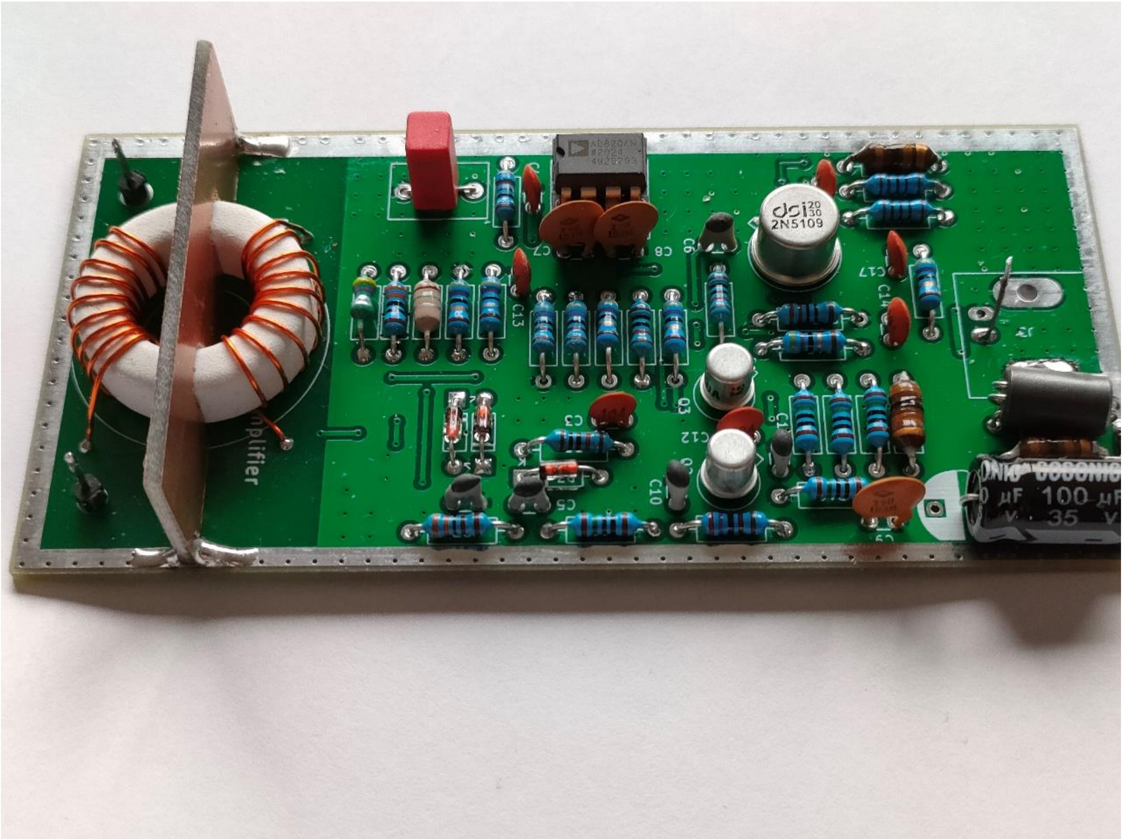
The inductance of the Alford loop is about 0.5 times the inductance of the normal loop. However the induced current is not doubled, but only about 1.4 times the current in the normal loop. *The Alford loop will not pick up more energy of the field, so the product of the inductance and the current squared has to be the equal!*
The lower inductance affects the large signal behavior of the amplifier. The amplifier loop gain decreases. Lowering R5 compensates for that, but a much lower R5 will also increase the noise contribution of the amplifier.

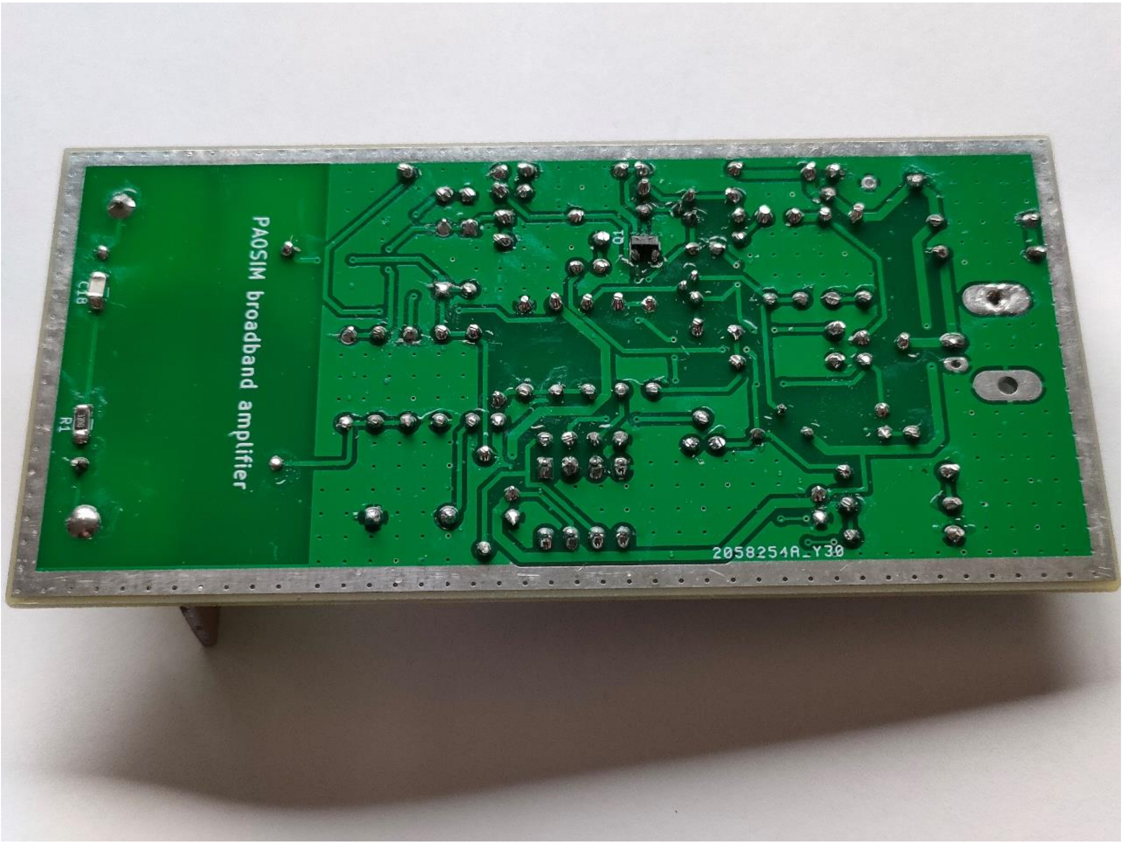
The 1.4 times higher current can lower the noise contribution of an amplifier. However at higher frequencies (>=10MHz) the Alford loop doesn't take advantage of the horizontal polarized dipole mode as does the normal loop. As a result received signal strength at low elevation angles is lower perpendicular to the loop and average SNR will not improve.
<u>Note:</u> *radiation patterns will deviate for increasing frequency >10MHz.*

8 PCB and schematic



8.1 PCB pictures with Faraday shield





C18, R1 and BFR93A are mounted on the solder side.

8.2 Component list

Check first before mounting:

- BFR93A pinout (AR version base and emitter are swapped)
- 2N2369A pinout
- All components for correct value

R1	330 (1206 SMD)	C1	15pF
R2	330	C2	1uF
R3	47	C3	100nF
R4	4.7	C4	100nF
R5	10k	C5	3.9pF
R6	820	C6	2.2pF
R7	3k3	C7	10nF
R8	150	C8	10nF
R9	2k7	C9	10nF
R10	150	C10	1.8pF
R11	10k	C11	10pF
R12	47	C12	100nF
R13	220	C13	100nF
R14	150	C14	100nF
R15	47	C15	100nF
R16	150	C16	100**uF**
R17	150	C17	100nF
R18	10k	C18	6.8pF (1206 SMD)
R19	47	L1	150nH
R20	4k7	L2	470nH
R21	4k7	L3	100uH
R22	100	L4	100uH
R23	100	L5	100uH
R24	47	L6	RFC (VHF)

D1/D2	1N4150 (1N4148)
D3	BAT85

Q1	BFR93A (BFU520W)
Q2/Q3	2N2369A (BSX20)
Q4	2N5109/BFW16A

Opamp:
output 1V from rail capable, preferably rail-to-rail e.g. AD820
FET input for very low bias current. Possible alternative: TLE 2081 CP

24mm 4C65 or **FT82-61** toroid core, Primary and secondary **4C65: 8 windings, FT82-61: 9 windings.** Cu wire diam. 0.5mm.
Note: R1 and C18 compensate for the 0.8 coupling factor for frequencies >14MHz
It is only usable in combination with this transformer design.

8.3 Mounting components and checks.

Check first if the PCB fits the box.
Take your time, check values before mounting, debugging will need more time.
Mount the BFR93A first. Makes it easier to check if all 3 pins are soldered correctly.
Don’t let the 2N2369A and BFW16A/2N5109 rest on the PCB. Keep a short distance to the PCB.
Total DC current should be about 75mA. Opamp output about 6V (between 1V and 11V).
Check +12V voltage at the collector case of Q4 for voltage drop caused by biasT and coaxial cable.

9 PCB in metal box and weather proof box.

Loop connections on left and right side of the box. Low capacitance input connections. Of course a lid on both sides of the box. Solder the borders of the PCB on several location to the box on both sides. Spray both sides of the PCB with plastic coating for moister protection.
If spraying also the box: both lids have to make good electrical contact with the box.
And don’t ever use these BNC connectors: