The new WF antennas family demands a high gain low NF preamplifier; the apparent gain on those dual flag antennas is very low around -30db to -40db. The directivity is achieved subtracting the signal from two identical terminated loops.

This project started several years ago when I was looking for a low NF preamplifier for 6m and it is based on the work done by Robi S53WW on the high performance transverter for 2m called JAVORNIK-144/14 , and the projects published by YU1AW.

I am including part of the original Robi's article at the end of this document.

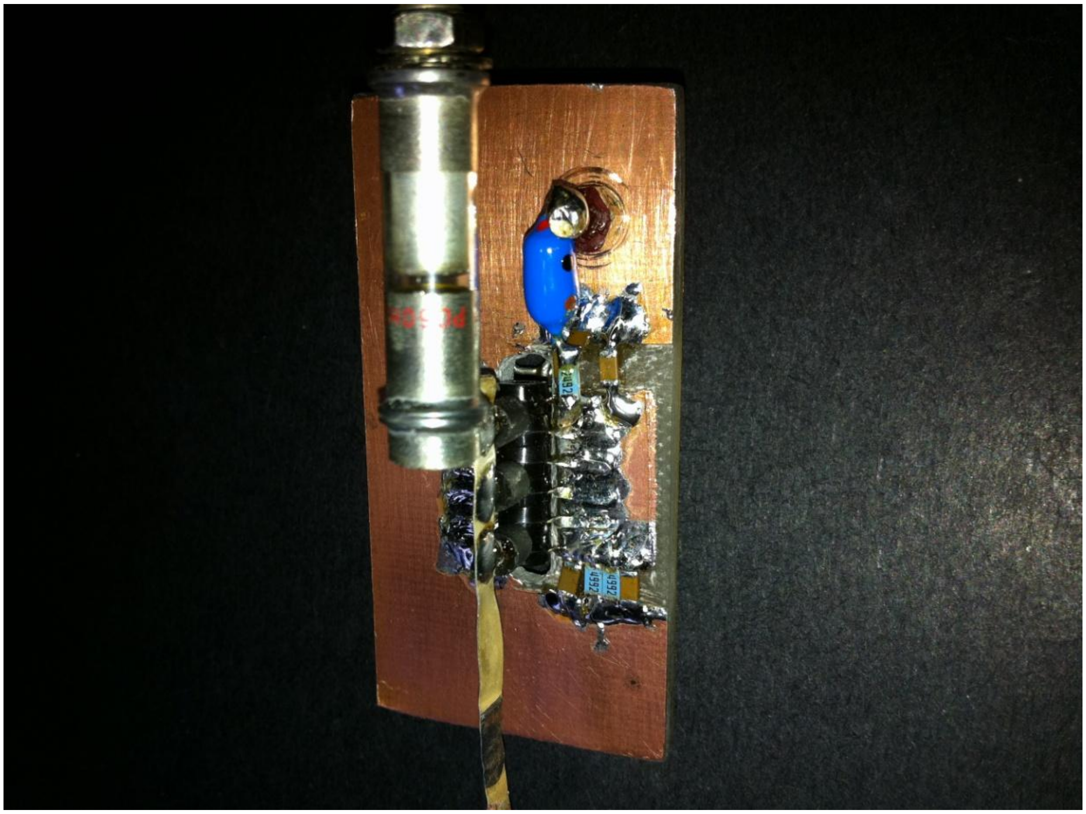
The idea of paralleling six BF981 Dual Gate MosFET is based on the fact that the gain and the noise figure of a FET transistor is only dependable on the forward transadmittance. MosFET does not have Jonson noise or junctions. Paralleling several devices reduces the internal resistance and the Ids current increase with the same voltage at the gate input.

This preamplifier conditions is based on well know best performance of BF981 2m preamplifiers publication Vds=10 V and Vg2s= 4V.

Each BF981 has the source directly connected to ground and the drain has a 100 ohm resistor each.

The output impedance is around 50 ohms and no impedance transformer is necessary, just a 1 mH choke and a 10nF capacitor are used to the output.

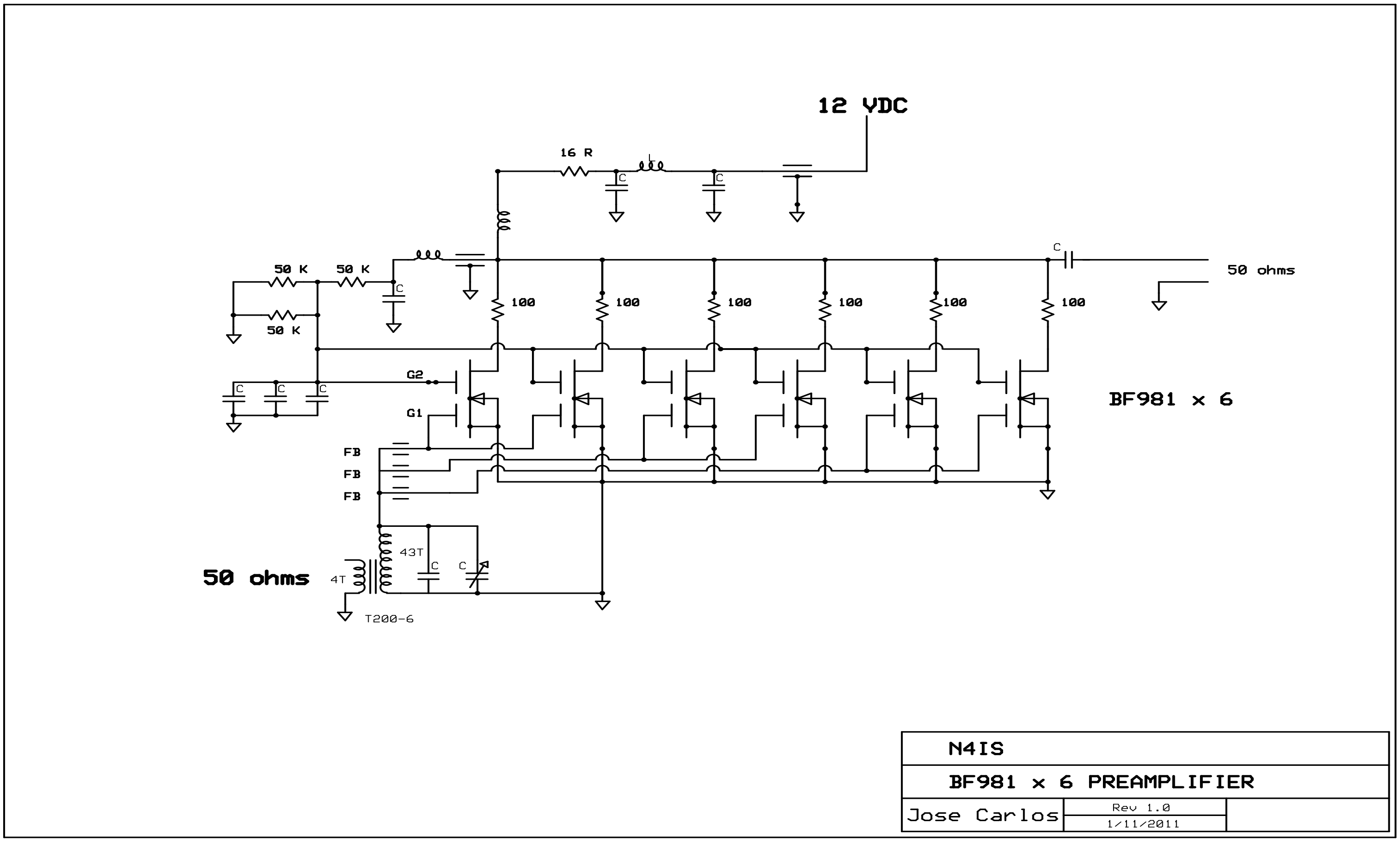
The input G2 must be very well grounded and protect to avoid oscillation and noise injection. Remember that you can use G2 as a mixer input. I used SMD resistors and capacitors to keep inductance very low, also the dual face circuit printed board also works like a capacitor to ground G2.

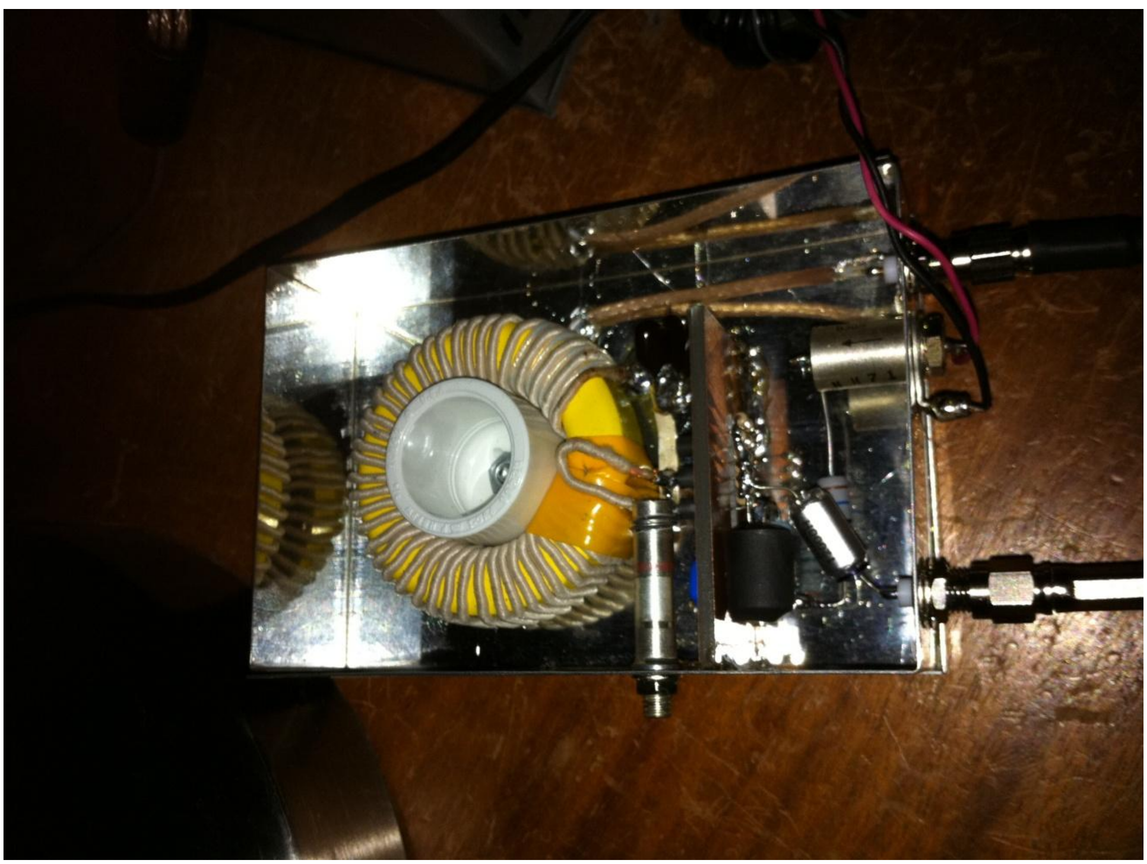


The gate G1 is the input and must be loaded with a ferrite bead, because of space limitation I joined two leads at time inside one bead. A high Q variable trimmer was used to tune the input circuit. Here is the caveat to achieve low noise figure, any loss at the input adds to the noise figure, to keep the LC tuned circuit loss you need maximum Q. The best inductor I was able to measure was a T-200-6 core with 43 turns of Litz wire 669/43. This inductor has a Q=519 and the input circuit loss is around 0.3 dB.

The NF of the total RX system, measured at 1.8 MHz, was 1.4 dB NF, this mean that the preamp itself has 0.7 db NF including the tuned circuit loss. The IP3 should be very high based on Robi's article. I used it for few days and there is no noise or oscillations.

Here the big surprise the gain is above 39db! the only explanation I have for this amazing gain is based on the fact that a typical MosFET gain increases at low frequency; like this new device SPF-3143Z chat shows gain around 33dB close to 1 MHz. Paralleling 6 devices the Ds current is 6 times and this cause additional gain.


12 VDC
16 R
50 K
50 K
50 K
100
100
100
100
100
100
C
50 ohms
G2
G1
FB
FB
FB
BF981 x 6
43T
4T
50 ohms
T200-6
N4IS
BF981 x 6 PREAMPLIFIER
Jose Carlos
Rev 1.0
1/11/2011



The circuit is very close to Fig one, with these modifications

1- G2 has a voltage divider with 25K to ground and 50K to Vds
2- Vcc (12 vdc) is feed into a feed through filter and a 16 ohms resistor to drop the voltage by 1V.
3- Each BF981 has 100 ohms resistor to provide 10 mA per device.
4- The output has not transformer, just a 1 MH choke and a 10 nf capacitor,
5- Front the choke I there is a 10 ohm resistor connecting the choke into a feed through capacitor that connects with the G2 divider.
6- L1 has 43 turns on a T200-6 (Q=519) core, the input has 4 turns to ground and the resonant capacitor is 370 pF silver mica.
7- I am not using the diodes to protect the input.

The input circuit with high Q has a BW of 50 KHz. I measured the 1.4 db NF from 1.800 to 1850.

This is a preliminary report from the first prototype. I have a lot of work to do however the initial tests are very motivating, the first SS I was able to copy Europe 30 min before my local SS and 9M2AX long path using my HWF for 5 min around SS.

Regards
JCarlos
N4IS

Very High IP3 LNA for 144 MHz

1. Introduction

After careful inspection of different designs that could be used as the front end amplifier of my new 144/14 MHz transverter design I finally stopped at the Infineon's BF998 MOS FET tetrode. I have very good experience with the old BF981 so I started to test the BF998. This transistor is very cheap, easy to obtain and has very good characteristics. I ruled out various microwave power GAAS FETs as they are hard to get and are not among the cheapest.

Detailed analysis of the XVRT architecture gave the result that the front end amplifier linearity sets the linearity of the whole transverter (when you use +17 dBm mixers with 20 dBm of LO drive, the post mixer amplifier with IP3out > 36 dBm and neglect the IF stage - HF receiver)! OK, the commercial HF receiver linearity should not be neglected (IP3in < 15 dBm for the normal rigs and IP3in < 25 dBm for the best ones (30 dBm for the AOR-7030)) but one can homebrew high performance HF receiver with IP3in > 30 dBm. At that point the IP3out of the XVRT should be also at least at that level (+30 dBm). Taking into account that the commercial HF receivers have the NF of roughly 16 dB (when in high IP3 state, the homebrewed rig would have something like 13 dB of NF), adding the 0,5 dB of antenna-to-XVRT cable loss and setting the target system NF to about 2,2 dB one finds out that the gain of the XVRT should be at least 24 dB (with the NF of 1 dB). That means that the IP3in of the XVRT should be more than +6 dBm (= 30 dBm - 24 dB). And that is not so trivial because this figure must belong to the front end LNA ...

2. LNA with parallel configuration of n x BF998

After checking the BF998 in the same circuitry as the BF981 (see Fig. 1) I found that the results are quite the same, only the NF was something like 0,2 dB lower. The LNA from Fig. 1 has **26,5 dB** ofgain,**0,8 dB** of NF, P1dB of **17 dBm** and IP3in of **0 dBm**. This is not bad but it should be better.

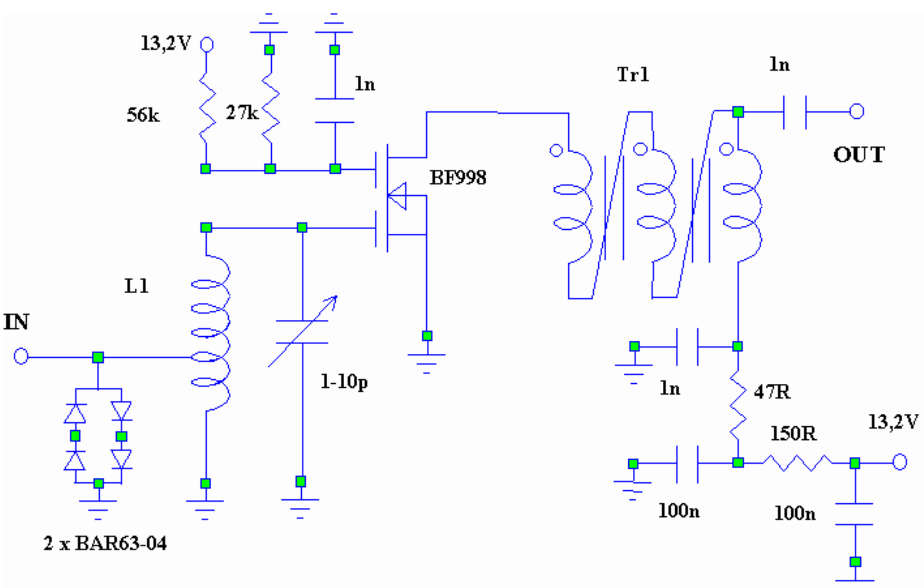


Fig. 1: standard configuration for the dual-gate MOSFET LNA and maximum output power matching. The FET operates at Idss as this is the best operating point for lowest noise (Idss is specified to be between 2 to 18 mA - I never got the 2 mA devices, the most common Idss was from 10 to 15 mA). Input coil L1 is wound on 5 mm diameter core with 1,0 mm AgCu wire; it has 6 turns with a total length of 11 mm. The coil should be mounted 1-2 mm above the ground and at least 10 mm from any metal wall. Trimmer capacitor should be of high quality. Diodes (Infineon BAR63-04 or BAR64-04 or BAR14-1) are for the protection of the MOSFET and have no influence on NF nor IP3 but are well proven (and of a value!) in a real life operation. The most critical part of the design is the transformer Tr1: it should be wound on the binocular core, size A7, material U17 (Epcos, former Siemens&Matshushita). Other materials of other manufacturers could be tried but special attention should be given to the obtained gain and P1dB. The transformer has two turns of trifiliar winding - it is even better to wound it as an autotransformer with 6 turns (=2x3) on the primary and tap at the 2-nd turn from the cold side (in practice you would wound 4 turns first, make a tap by twisting the wire and then proceed with last two turns). The wire lengths from Tr1 to the FET and capacitors should not be longer than 5 mm and should be run near the PCB ground or oscillations can occur.

After a lot of experimenting I found another interesting characteristic of FETs (well known in the audio amplifier scene as I found out latter) - when you parallel two identical FETs you get lower NF than with a single device! So if you piggy-back another BF998 to the original one (both should have the same Idss) you can get **0,6 dB** of NF, **26,5 dB** of gain and the same or worse (!?) IP3in! The IP3 problem was solved with proper output matching - the 3:1 transformer was changed to 2:1. In that way **+28,5 dBm** of output IP3 is obtained (P1dB is +19 dBm). The circuit is shown in the Fig. 2, generalized for **n** times **BF998** (the variable values are given in the Table 1).

Of course I tried to parallel four BF998 (who wouldn't) and the result is that the NF is still going down to **0,5 dB**, gain stays at **26,5 dB** (when tuned form minimum NF) and IP3out is **+34 dBm** (see Fig. 3)**.** To obtain this value of IP3 the Tr1 should be changed into 1,3:1 transformer. To get the 0,5 dB of NF the input should be tapped to the L1 at the middle (that is at the 3rd turn). At the first attempt I just piggy-backed four BF998's but some weak oscillations occurred above 3,5 GHz not affecting the amplifier characteristics on the working frequency. Then I made new arrangement with two times 2xBF998 (piggy-backed) side-by-side; both pairs are connected together with short wires, and have separate G2 bias network (the circuit layout and G2 bias blocking is very critical). After that modification the oscillations disappeared but it should be noted that all the designs described here are only conditionally stable. Overall component layout is **very** critical, specially the 1nF G2 blocking C.

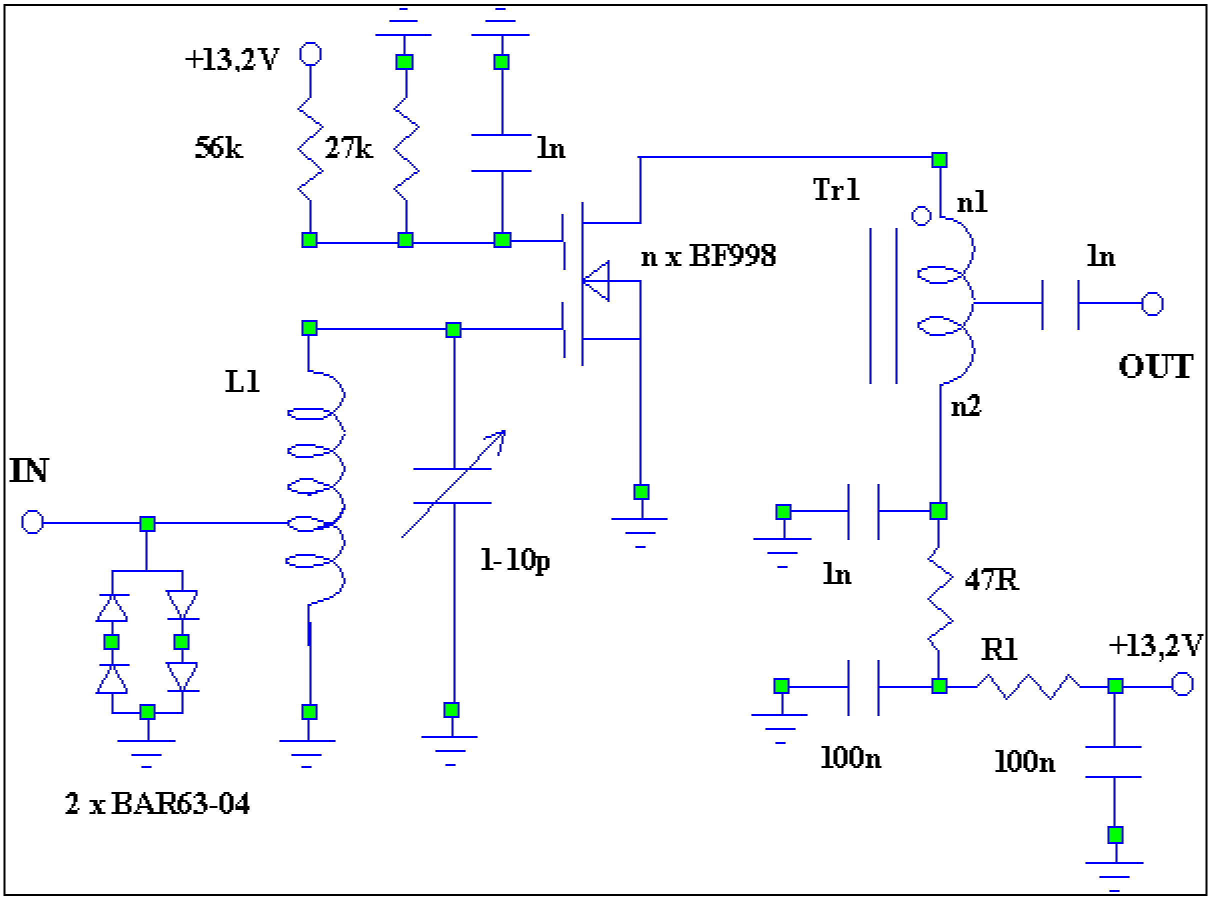


*Fig. 2: generalized scheme for **n x BF998** (it also covers the design shown in Fig. 1 with one BF998). The variable values are given in the Table 1. The input and output matching are different (see text). The core for the Tr1 should be of a larger size (material U17, size A4) when more than one BF998 is to be installed. The amplifiers can be approximately tuned for minimum NF without instruments with a little trick: they should be tuned for the maximum gain at 136 MHz (the minimum NF tuning point is quite broad).*

Table 1: variable values for the design shown in the Fig. 2.

	n1	n2	R1	NF [dB]	T [K]	G [dB]	IP3in [dBm]	P1db [dBm]
1 x BF998	4	2	150	0,8	61	26,5	0	17
2 x BF998	2	2	100	0,6	44	26,5	2	19
4 x BF998	1	3	10	0,5	36	26,5	7	23
4 x BF998	2	6	10	0,5	36	26,5	8	24