THE WEST RAND AMATEUR RADIO CLUB

November 2004
Volume 5, Issue 4

ANODE

Inside this issue:

Editor's Comments

November 2004 Volume 6 Issue 04

I didn't notice many fireworks this year maybe the attraction has worn off. Just like amateur radio since the advent of cellular radio technology. The use of this technology though has had a great many spin-offs which in general benefit us all. At last Monday's 'bring & fix ' meeting I listened to a conversation about the rejuvenated repeater. Noting that the repeater and its performance was still not monitored by the club. We still rely on the radio amateurs that use the repeater to complain about poor performance or signal. Later that night I used cellular technology to call for a friend to pick me up next to my car which had died on the way home. Not so many years ago I would have shouted on the local repeater for anyone who could help. I can remember a time when a long QSO after the meeting was typical and the drive home would take very little time as a result.

The spin-offs from cell phone technology are numerous. Just the other day I noticed in a computer magazine a small helicopter powered by an electric motor and battery. It was the November issue of

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Very High IP3 LNA for 144 MHz

[Translation: A very high Third Order Intercept Point Low Noise Amplifier for 2 Metres]

The 2xbf998

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

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Special points of interest:

- Contact details on back page (updated)
- New email address for Anode and ZS6WR. See back page

Editors Comments & News

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PC Pro that detailed the Seiko Epson's12.3 gram helicopter which would probably be controlled by using Bluetooth wireless technology.

When we used hand-helds ("walkie talkies"), we suffered the use of nickel cadmium batteries. Having to treat them like a "previously disadvantaged woman" to keep the charge and to prevent the memory from forming. Recently I found Nickel Metal Hydride types available in our local hypermarket with a capacity of 2.1 Ampere / hour for AA size and 600 mA hour in AAA size. These also were at a reasonable price compared with the prices seen by me in the shops in the UK in June.

The monitoring of the repeater had me research an area in 'Windows' program development that I have never looked into before. What I thought would be an easy exercise turned out to be a very complex subject indeed. A simple voice recorder bought in the shops for about R150 which is voice activated could do this job. Its tape would have to be changed on a regular basis and the recorded QSO's assessed for quality of reception/ transmission by a human.

I thought that a PC based recorder would be ideal for this as the recordings could even be 'measured' by software for signal to noise and amplitude (deviation). Voice recognition could also be used to transcribe the QSO to text. The first thing then was to get the PC to record audio from the line input to disk as a 'WAV' file.

Also considered as part of this investigation was the ability to sound morse from the speakers in a similar manner to the old DOS method using the PC speaker.

I think this is going to be the subject of an article don't you?

Newsgroup 'stuff'

Uo-22 May Soon Be S.k.

AMSAT U-K says that the UO-22 ham radio satellite is not in good shape, and its looks as though its useful life may be over. Bill Pasternak, WA6ITF, has more:

The AMSAT News Service which brought the first worked of the problem says that the cause if the satellite's demise is unknown. Bit says A-N-S, it may be related to problems with the satellites batteries which have been in space for more than 10 years.

UO-22 was launched in July 1991 from Kourou, French Guiana. It served for many years as the store and forward satellite for Amateur Radio packet and the world wide Sat Gate service. The latter is a linked series of packet radio networks in many countries.

The Ground Station control centre at the University of Surrey has attempted several times in recent weeks to reactivate the UO-22 After one attempt it did come back to life, but only briefly. Other attempts have failed completely.

As time permits, the Control Station at the University of Surrey may make further attempts at reviving the ailing bird, but says AMSAT U-K it seems unlikely that they will be completely successful. (ANS)

Pc Sat Recovery Successful

Meantime, better news about another ham radio satellite. The P-C Sat ham radio bird continues to work perfectly following it's recovery two weeks ago.

To use P-C Sat, just QSY your APRS mobile station to 145.825 during a pass. You should not have to change any parameters. PCsat digipeats the aliases of RELAY and WIDE just like terrestrial digipeating. (ANS)

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Editors Comments & News

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Cost Prohibitive To Keep Repeaters On The Air

Several repeaters down-under are now off the air. This after Australia's telephone provider Telstra put site rental beyond the economic reach of ham radio. Felix Scerri, VK4FUQ, of the WIA News Service reports:

From 22nd October the UHF repeaters co sited on the Black Mountain Telstra Tower in Canberra have been removed from service. Telstra recently carried out an audit of the site and discovered there was no rental agreement that could be found for this ham gear to be on site.

After negotiations with Telstra, the rental offer made by Telstra is beyond the economic resources of the Canberra Region Amateur Radio Club and, sadly they had no option but to remove the equipment by Today October 31st .

Better news however is at Black Hill the ACT's 146.900 MHz service is on air however it may subject to further interruptions. Following last years bush fires there has been a considerable amount of work done by the Tibinbilla tracking station staff to get the site fully operational. The task of the refurbishment and repairs is almost complete.

The repeaters that lost their home operated on 438.025 MHz and 439.950 Mhz. They served the greater Canberra area. (WIA)

Uk 5 Mhz Beacons Coming Soon

The Radio Society of Great Britain says that is close to installing and operating two new beacons on 5 point 290 kHz. The new beacons will operate under the call signs GB3WES and GB3ORK. GB3WES will be located in Cumbria and GB3ORK in the Orkney Islands. Both will have a stepped transmit power sequence and a 30-second sounder sequence of 0.5ms pulses at 40 Hz and identical to that of the Oxfordshire GB3RAL beacon.

The new beacons will have transmit times will follow GB3RAL by one and two minutes respectively. Together the three beacons will provide an excellent spread of signal source from across Great Britain and offering experimenters worldwide a unique opportunity to study propagation effects at 5 MHz from their own QTH. (GB2RS)

Scientists Predict Early Solar Minimum

And some possible god news for hams tired of the rather poor High Frequency band conditions these days. It comes from the GB2RS News Service which says that American physicist David Hathaway believes that the next solar minimum could arrive sooner than previously predicted.

GB2RS News quotes on an article on the 'Science at NASA' website. It predicts that the next solar minimum could occur in late 2006. That's about a year earlier than previously thought

Dr. Hathaway bases his prediction on data from the last eight solar cycles, which show that solar minimum follows the first sunspot-free day on the sun by 34 months. In this solar cycle, the first spotless day was on 28th January this year and more recently, on 11th and 12th October, there were two more spotless days.

Hathaway goes on to state that the next solar maximum might also come early. He is quoted as saying that solar activity intensifies rapidly after solar minimum. That in recent cycles, the Solar Max has followed Solar Minimum by just four years. If that is the case, the next solar maximum could be not all that far away in 2010 and a Solar Max is good news for D-Xing. (GB2RS)

Ham Radio History - A Zl Milestone Qso

And finally this week, a bit of history from right here, down-under. Its the story of the first ever two-way radio communication between New Zealand and England made on the 18th of October 1924 by Frank Bell of Shag Valley Station, Otago.

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Editors Comments & News

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Back then, Frank held the call-sign Z4AA and on that date, using some rather primitive home-brew ham radio equipment, he made contact with Cecil Goyder, G2SZ at the Mill Hill school in London. The CW QSO lasted for about 1 hour and dealt mainly with issues of signal quality. It was also the start of the first scheduled contact -- or 'sked' -- between hams in the two nations. For several nights after the historic contact the two radio amateurs kept in touch.

Further details of the activities leading to the historic QSO can be found on pages 40-41 of the NZART publication Ham Shacks, Brass Pounders & Rag chewers, A History of amateur Radio in New Zealand. Detailed information on the actual QSO, complete with a transcript, can be found on the web pages of the Otago, Branch 30 of NZART. To read them, just point your browser to www.qsl.net/zl4aa/ and follow the index for more. (NZART News)

Very High IP3 LNA for 144 MHz

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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 below) 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 of gain, 0,8 dB of NF, P1dB of 17 dBm and IP3in of 0 dBm. This is not bad but it should be better.

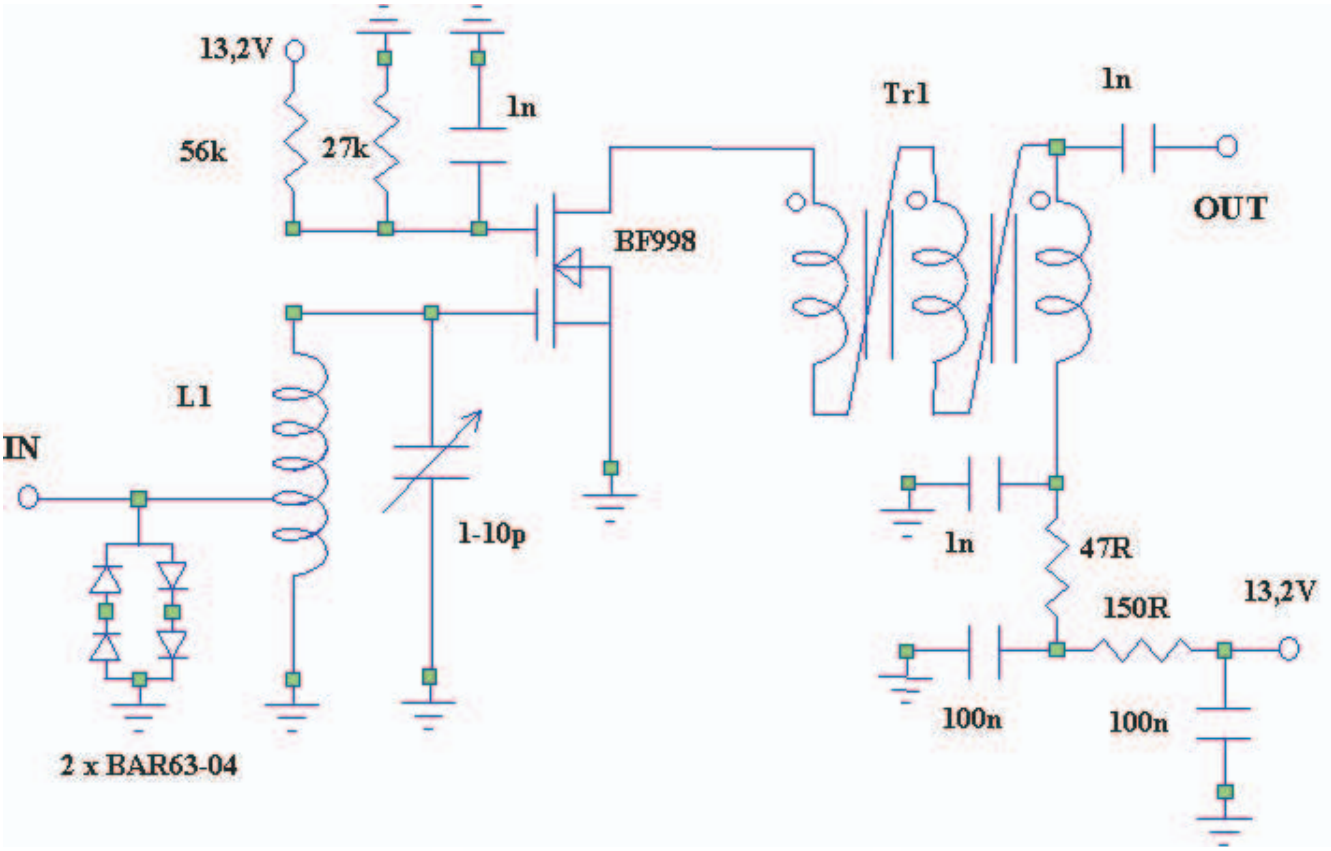

Fig. 1: standard configuration for the dual-gate MOSFET LNA and maximum output power matching. The FET operates at Idss as this is the best operating point for lowest noise (Idss is specified to be between 2 to 18 mA - I never got the 2 mA devices, the most common Idss was from 10 to 15 mA). Input coil 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

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Very High IP3 LNA for 144 MHz

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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 (above, 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.

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).

	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

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

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Very High IP3 LNA for 144 MHz

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This data is from feb.2003 after a measurement of more than 40 LNA's as RF input stage in a transverter JAVORNIK-144/14 .

It turned out that the amplifier has stability problems when terminated with narrowband filter as this is the case in XVRT.

After a lot of experimenting it turned out that increasing the number of turns on output transformer but maintaining the turns ratio heals the problem.

As a by-product of this modification the 1dB improvement in input IP3 was acheived.

Fig. 4: Photo of built LNA without the housing (download the PCB file).

Fig. 5: Four FET's mounting detail.

3. Push-pull LNA with BF998

When you construct the push-pull amplifier from two single stage amplifiers you can get 3 dB higher IP3 as with the parallel configuration . So I thought that with two BF998 LNAs arranged in push-pull (see Fig. 6) one could get the +6 dBm IP3in (that was before I tried the parallel configuration). First experiment was great - IP3in was +6 dBm (P1dB of +23 dBm) but the NF could not be pushed lower than 1,3 dB! After redesign of the input coupling I finally got the 0,9-1,0 dB of NF with solid IP3out of 32,5 dBm and gain of 26,5 dB (when tuned for minimum NF). The

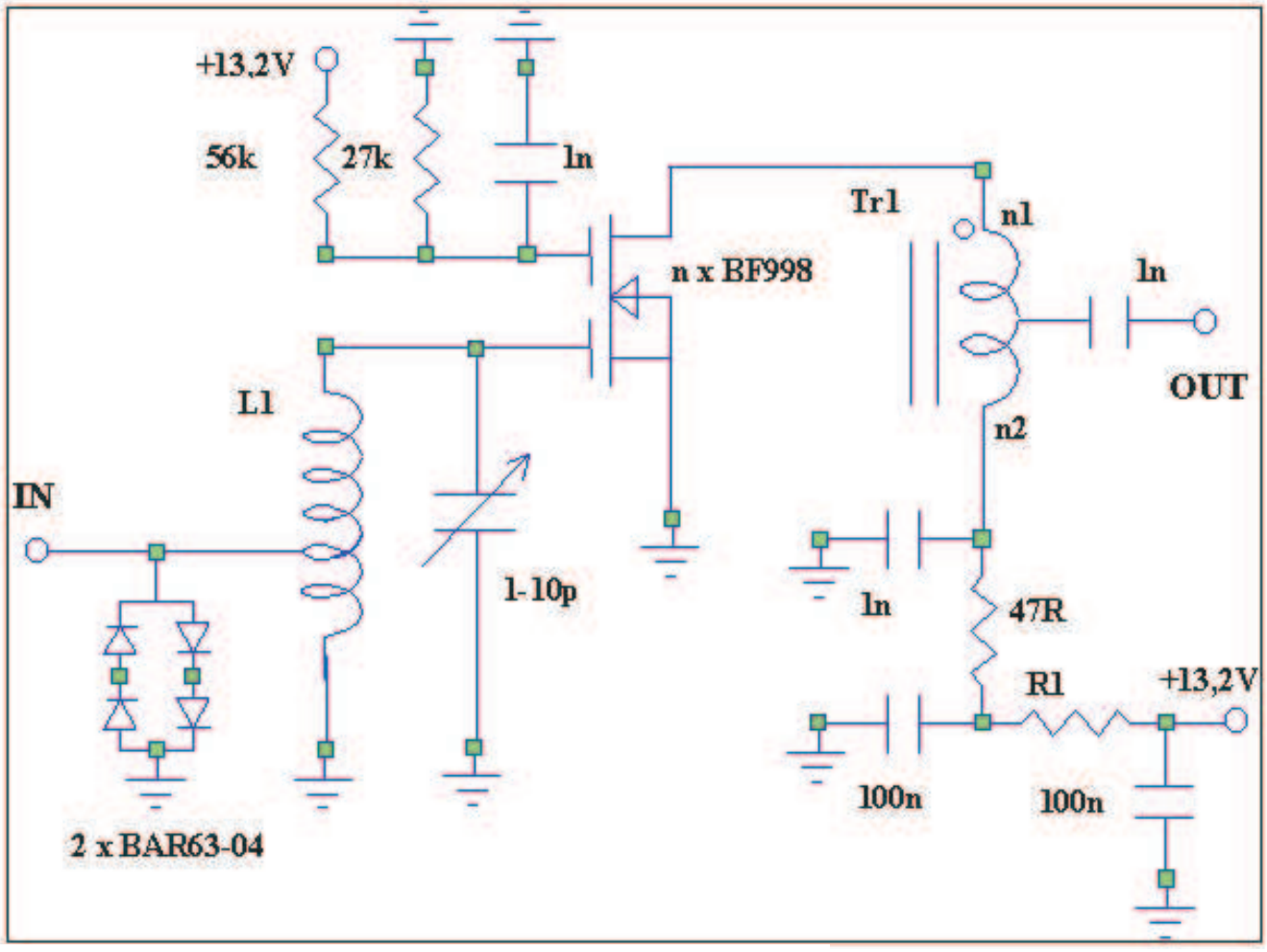

Fig. 2: generalized scheme for n x BF998 (it also covers the design shown in Fig. 1 with one BF998). The variable values are given in the Table 1.

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Very High IP3 LNA for 144 MHz

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circuit is actually the push-pull arrangement of two circuits from Fig. 1.

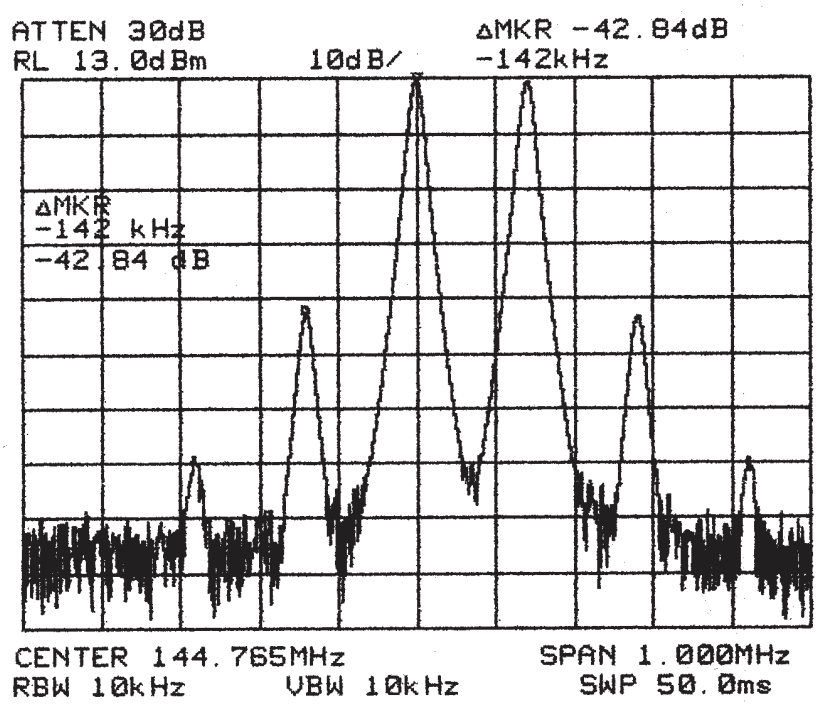


Fig. 3: IP3 measurement of the 4xBF998 amplifier - the IP3out is 13 dBm + 42,8/2 dB = 34 dBm.

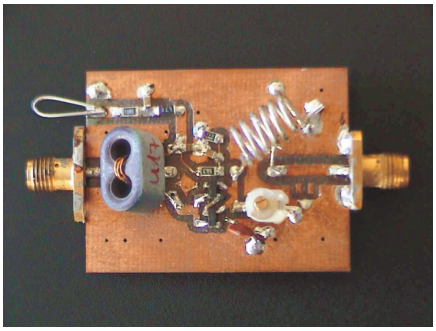
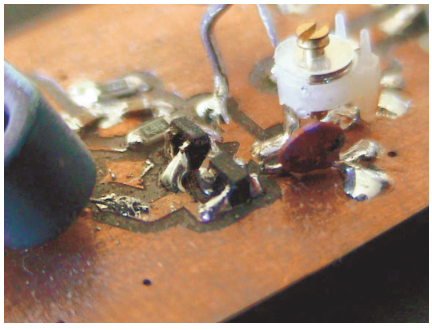


Fig. 6: push-pull configuration of two BF998. Input coil L1 is wound on 11 mm diameter core with 1,0 mm AgCu wire; it has 4 turns with a total length of 7 mm.

The input coupling is done with a single turn coil wound on the same diameter as L1 with enamelled Cu wire so that the shorting of the L1 winding is prevented.

The transformers Tr1 and Tr2 use the same core as described in Fig. 1 (size A7, material U17, Epcos). The output combining transformer Tr2 has 2 turn bifilar winding.



Then I tried the push-pull configuration of four BF998. The intention was to get the IP3in of +9 dBm with some 0,8 dB of NF. After some experimenting I realized that I was not able to find the proper input match for the minimum NF although I got the +9 dBm of input IP3. The NF was always above 1,3 dB what I found as unacceptable for my XVRT design. For other purposes the obtained NF could well be tolerable. Anyway, the circuit stays open for further optimization ...

NOTE:
Those amplifiers are not well suited for preamplifiers in front of receiver or xverter as they have much too much gain. In order to use them effectively (although I don't recommend using preamplifiers at all) one should add an attenuator at the output to lower the gain. In most occasions 6-10 dB of gain is enough for a preamplifier if it really has to be mounted. With an attenuator of 20 dB the overall NF will be degraded from 0,5/0,6/0,8 dB to 1,3/1,4/1,5 dB. With an attenuator of 16 dB the overall NF will be degraded from 0,5/0,6/0,8 dB to 0,8/0,9/1,1 dB. So I recommend installing of 16 dB post-LNA attenuator (values for PI attenuator are 68 ohm toward GND and 150 ohm in between).

For other high performance VHF&up preamplifiers I recom-

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mend visiting the Dragan's/ YU1AW homepage at www.qsl.net/yu1aw/low_noise.htm. Six LNA's were built so far (09.2002) with the NF results of 0,5-0,6 dB (Philips FET's, marking MOp) and three with the NF of 0,8-0,9 dB (Infineon FET's, marking MOs). The latest bad news is that EPCOS discontinued the U17 material, so it is already very hard to get the U17/A4 binoculars. No substitution is available yet, but any core of similar size and material with initial permeability

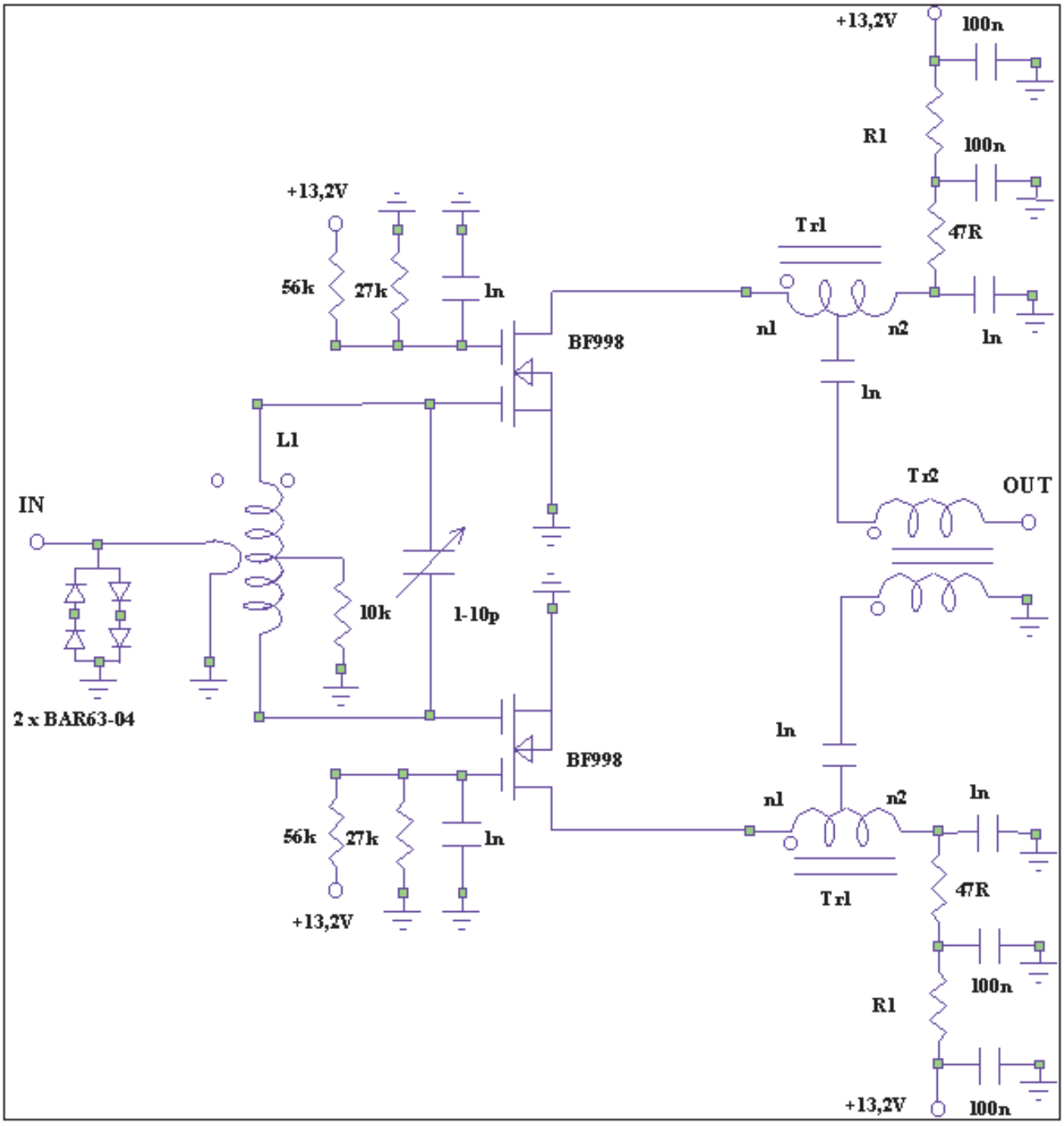

Fig. 6: push-pull configuration of two BF998.

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Very High IP3 LNA for 144 MHz

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from 20 to 30 should work …

After the measurements of this 9 LNA's a straightforward procedure for tuning the LNA (4xBF998) for minimum noise can be given: tune the C trimmer for maximum gain (the value should be 27,5 dB +/- 0,5 dB, otherwise something was not done properly), then increase the capacitance of the C trimmer until gain drops for 1 dB! That's it! Tuning is not critical as the input is very broad in the sense of minimum noise (something like 10 MHz).

More than 40 LNA's were measured in feb.2003 as a part of transverter JAVORNIK-144/14.

The results are excellent, NF, G and IP3 figures are as declared above.

Stolen from ….

http://lea.hamradio.si/~s53ww/4xbf998/4xbf998.htm

Last modification: 01.03.2003

See Also :-

http://www.qsl.net/yu1aw/low_noise.htm

http://lea.hamradio.si/~s53ww/xvrt/xvrt.htm

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Bulletins (Sundays at …)
11h15 Start call in of stations
11h30 Main bulletin start

Frequencies
439.000MHz 7.6MHz split
(West Rand Repeater)
145,625 MHz (West Rand Repeater)
10,135 MHz (HF Relay)

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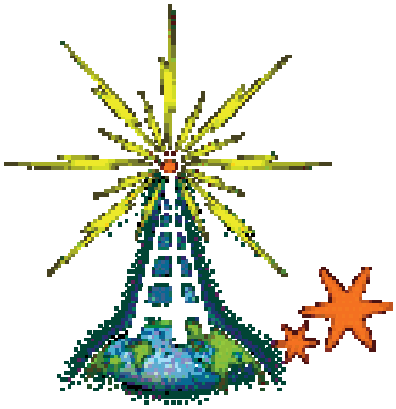
West Rand members - we need your input!

To make this the best ham radio magazine in South Africa we need your input. Please submit articles, comments, suggestions etc.

Please send plain text with no formatting to the email address below.

In July 2003, we re-published an Anode Compendium on CD. It has the issues from July 2000 until June this year. This included the new Adobe reader. It has been updated, check with the chairman for details.



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