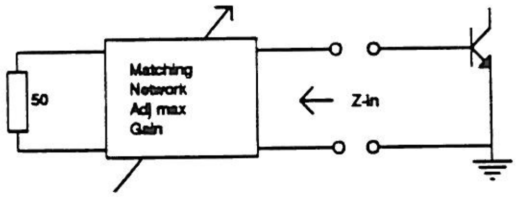
Chapter 2

Receiving

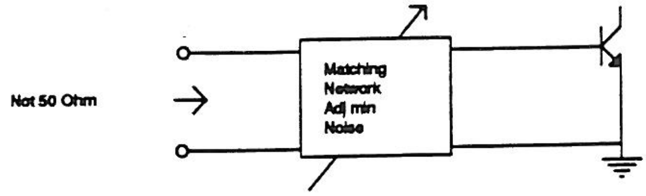
2.1 The Relationship Between Transistor NF and Input Match

Allen Katz K2UYH - September 1976

There appears to be some misunderstanding of the relationship between transistor NF and match. I know of no trick for improving NF on 432. NF depends primarily on the transistor used. The better the transistor the lower the NF. Right now the FMT4575 appears to yield the best NF on 432 although there are many other devices which do almost as well when properly matched. By properly matched I do not mean that the transistor sees an impedance equal to the conjugate of its input (Z_{in}), but the transistor sees an impedance which yields minimum NF (Z_{minNF}). Z_{minNF} does not equal Z_{in} and is normally significantly different.



One consequence of this difference is that the input of a properly "noise figure" matched Preamp does not look like 50 ohms, and it can have an input VSWR as high as 8 or 9. This high VSWR (looking from the antenna into the receiver) normally has no detrimental effect on receiver performance.



However, if a sharp multi-pole filter is placed in between the antenna and the Preamp, problems can develop. Such filters are designed to load into a 50 ohm impedance. But in this case the Preamp does not present a 50 ohm load. This is why Joe, W1JAA (now W1JR) has recommended the use of only simple single pole filters in front of his Preamps and noted that such filters should not be readjusted once they are in place. It has been discovered that one way to get around this problem is to insert a little inductance into the transistor emitter leads. The inductance creates a feedback condition which does not improve transistor NF, but which does change the impedance the transistor wants to see for minimum NF. This new Z_{minNF} can be made to approximate Z_{in} by changing the inductance (for many of the low NF transistors now available). Thus adding emitter inductance does not improve NF of a given transistor, but it does allow a Preamplifier to be proceeded by a sharp multi-pole filter and still have the combination of filter and Preamp function properly. Both W1JAA and WA7TZY have had success using this technique with low noise 432 MHz Preamps.

2.2 Notes on Bipolar LNA Design MRF902 and FMT4575

Joe Reisert W1JR - October 1976

Joe, W1JAA (now W1JR) sends along the following modification for his low noise amplifiers design for the MRF902. (See Ham Radio Magazine March 1975.) Although not as good as the old FMT4575, you cannot beat it for that price. Joe has been working with the FJ201E and says it performs almost identically to the FMT4575 which is no longer available.

2.3 Original V244 GaAsFet LNA Design

Aki Munezuka JA1VDV - December 1976

This special low noise Preamp for 432 MHz has an NF < 0.8 dB and Gain of 15 dB. It uses a V244 GaAsFet. Results obtained with this device are excellent.

Figure 2–1: Bipolar LNA using MRF902 and FMT4575

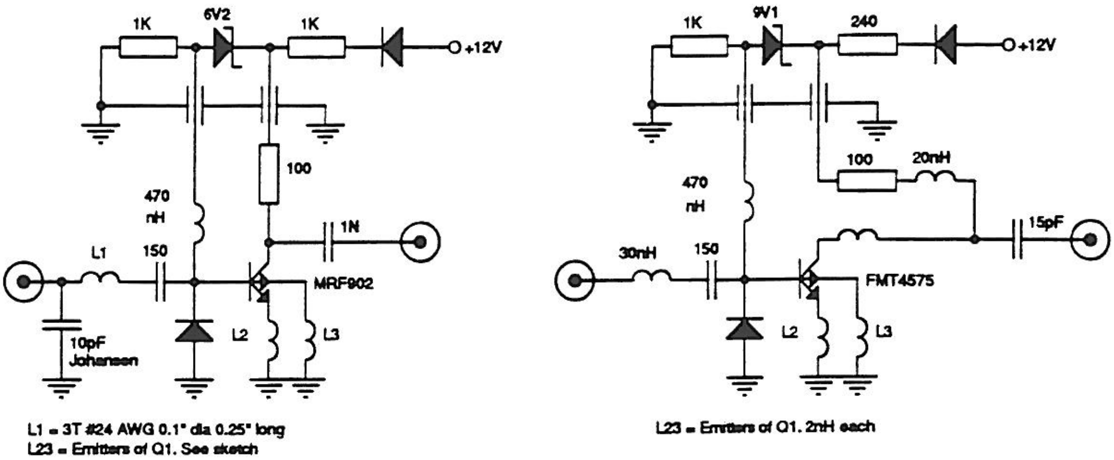
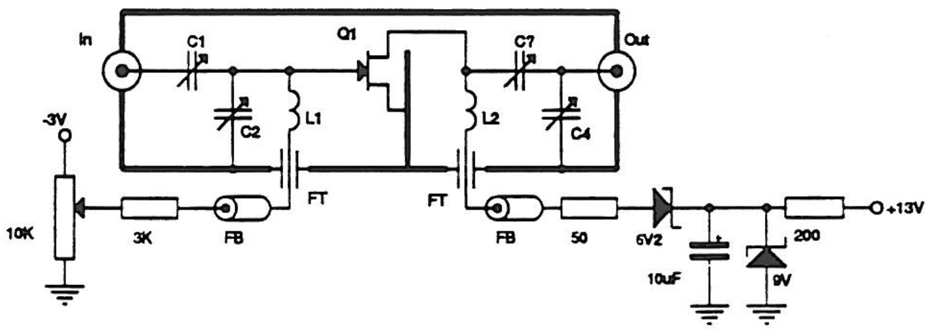


Figure 2–2: V244 GaAsFet Preamp for 432 Mhz



Parts list:

Q1	V244 GaAsFet	L1,2	1 turn #20
C1	3pF Johanson 7274 or 7284	FT	1000pF Feedthru
C2,3	10pF max Johanson 5202	FB	Ferrite bead
C4	15pF max Johanson 5402	J1,2	SMA type

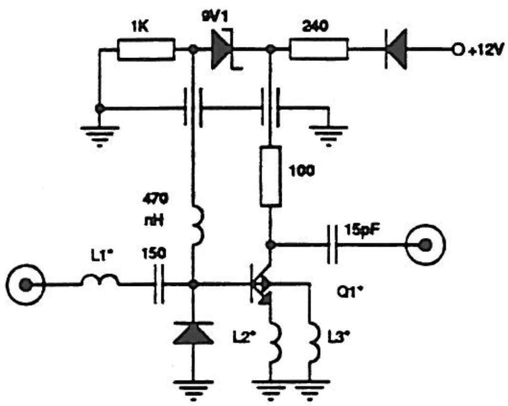
2.4 Update on the 4575 LNA Design

Joe Reisert W1JR - February 1977

Please refer to Ham Radio Magazine March 1975

The FMT 4575/8 transistor used in the reference article is no longer manufactured by Fairchild. Also most of the devices manufactured in 1974 and later exhibited higher than normal noise figures at frequencies below 1 GHz. As a result a search for a suitable replacement was conducted.

Many devices have been tested using the original circuit or with modifications if required. Only the Fujitsu FJ203E has demonstrated the performance once available with the FMT 4575/8 at 432 MHz. Noise figure is excellent (1.25 dB or less) on the devices tested and only minor circuit modifications were necessary. One plus factor was the slightly higher gain. The input impedance match was also improved with the use of reactive feedback in the emitter as previously advocated by this writer. A 2:1 VSWR was measured after L1 was modified and L2 and L3 were added. The improved circuit is also usable with the FMT 4575/8 if you are lucky enough to have a good device.

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All components per original article except as noted by *
L1     3 turns #24 AWG On 0.1" dia. spaced wire dia.
L2,3   Use all but 1/32" of Q1 emitters. It is not a
       critical lenght. Make both leads same length.
Q1     FJ203E or FMT 4575/8
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2.5 Transistor Protection Device

John Yurek K3PGP - April 1977

John, K3PGP sends in the following transistor protection device which should be of interest to just about everyone. It consists of a low Q halfwave filter with diodes at the peak voltage point. The filter, see Figure 2–3, has an insertion loss of only 0.062 dB at 432 MHz and provides a bonus of adequate selectivity (-3 dB points at 412 and 466 MHz) to clean up the garbage at most locations. With 400 W into the filter less than 80 mW was measured at the output. The diodes used are 1N914 but should not be critical.

2.6 More information on the NE244 Design

Aki Munezuka JA1VDV - May 1977

Aki has sent the following additional data on his V244 GaAsFet Preamplifier. See Figure 2–2 and Figure 2–4. We have duplicated Aki's design and can attest to fact that the amplifier does work as he indicates. We had no problem with stability and measured a NF lower than our best Preamp before doing any adjustments. At the north eastern VHF conference our best Preamplifier was measured by

Figure 2–3: Transistor Protector

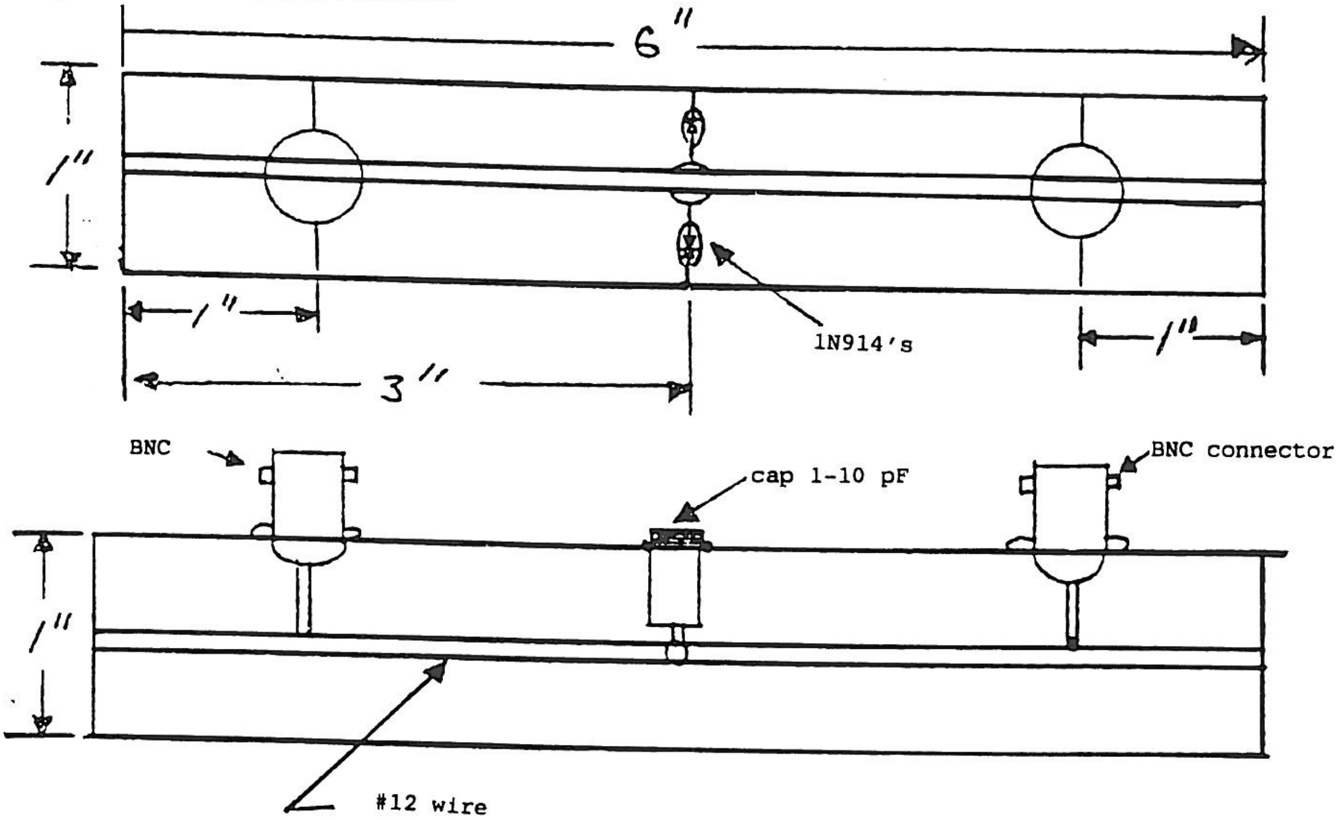
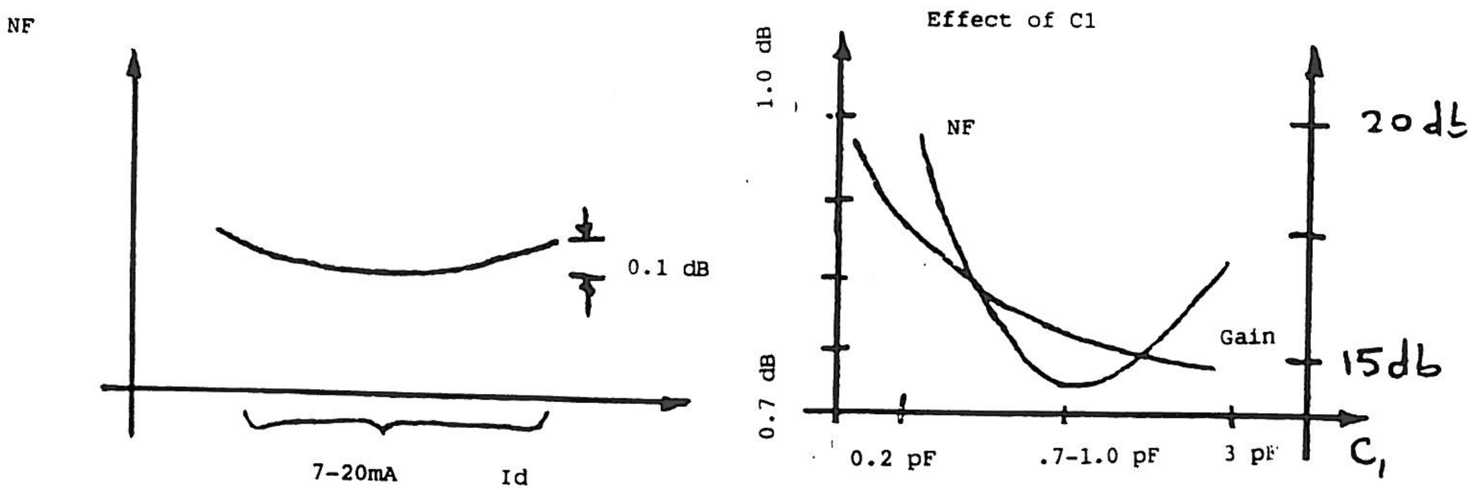


Figure 2–4: NE244 Design Performance



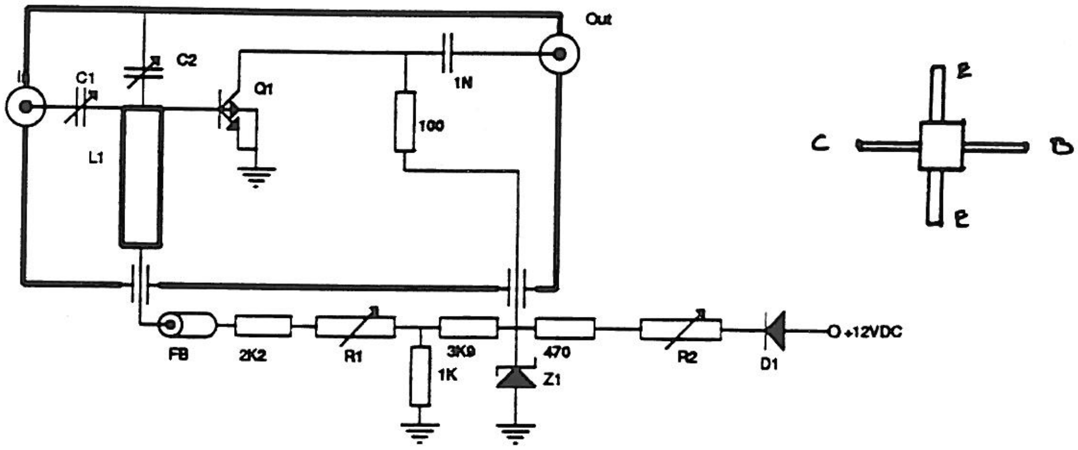
W1JR to have an NF under 0.9 dB almost 0.5 dB better than any other Preamp entered. We hope to have this amplifier at the feed during the next EME tests. To say the least we were very impressed.

2.7 NE645 Bipolar LNA Design

Al Ward WB5LUA - September 1977

WB5LUA's circuit of a NE645 LNA is shown in Figure 2–5. Al says that the stripline resonator at the input provides adequately selectivity to enable him to operate the amplifier without additional filtering. The zener diode Z1 is employed as a protective device as the maximum Vce is only 12 V. The data sheet calls for minimum NF at a Vce = 8 V with Ic = 5 mA. Al found that he gained 0.1 to 0.2 dB by using a Vce = 6V and Ic = 4mA. He strongly recommends the use of an automatic NF meter for optimising the Preamplifier, he got a NF of 0.90 dB with a Gain of 15-16 dB.

Figure 2–5: NE645 Bipolar LNA Design



Q1	=	NEC64580	D1	=	1N914
R1	=	25K trimpot	Z1	=	9V zener (1N757)
R2	=	1K trimpot	L1	=	0.6" wide x 2.2" long microstrip
C1,2	=	0.8-10 pF Johanson			located 0.125" above groundplane

2.8 GaAsFet Protection Circuit

Claus Neie DL7QY - October 1977

Be careful with your V244. We now have received two reports of V244's going bad. While Franck was tuning up F2TU's Preamp, the NE244 blew for unknown reasons. (F2TU is now using F9FT's spare V244). Cor VE7BBG got hold of 2 V244's. One was bad to start with, while the other had a broken lead. In trying to attach a new lead the 2nd one died also. Torsten SM6ETO has sent in the following bias circuit designed by DL7QY for protection of his 10 GHz V244 Preamplifier which was written up in the German Magazine Dubus. The circuit insures that the gate bias is always applied before the voltage (as recommended by NEC) and continuously checks the source to drain voltage. If this voltage becomes to high it electrically shorts the drain to ground and eventually blows a fuse.

Figure 2–6: GaAsFet Protection Circuit

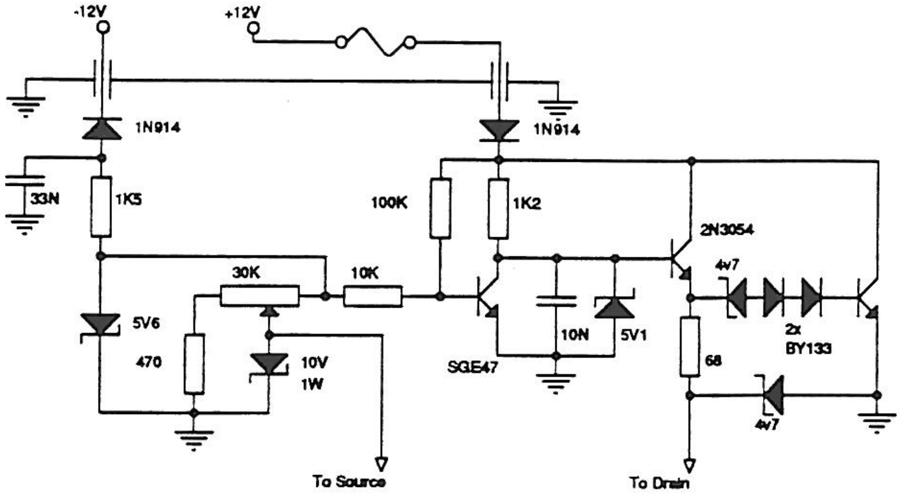
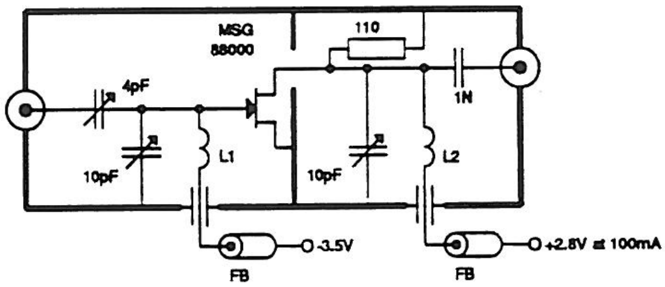
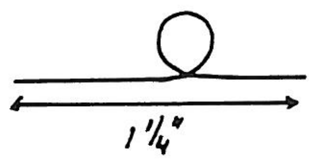


Figure 2–7: 88000 GaAsFet Preamp





2.9 MSC 88000 GaAsFet Design

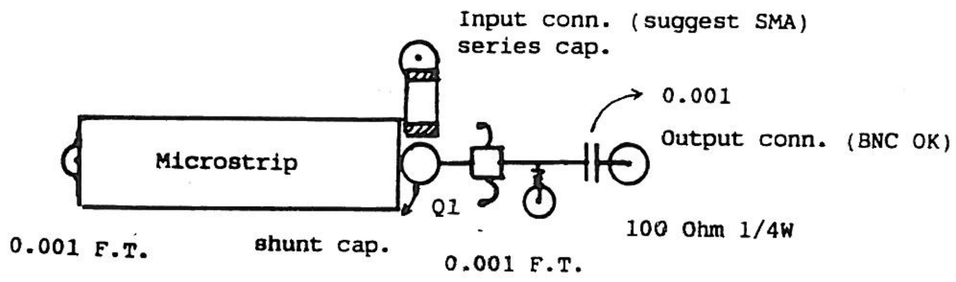
Allen Katz K2UYH - November 1977

We have been experimenting with 88000 series power GaAsFets made by Microwave Semiconductor Corp. These devices were not designed for noise figure, but for power applications. However, when used in the following circuit on 432 they can produce noise figures on the order of 1.0 dB and possibly lower. (Experiments on 2 meters have yielded noise figures as low as 0.6 dB). Their dynamic range is of course phenomenal. The gain is in excess of 20 dB and varies along with bias level and NF from device to device. The 88000 does not provide as good a NF as the V244, however it appears likely that reject 88000 devices (which do not meet power specifications, but which are usable as low noise figures on 432) will become available in the near future. L1 and L2 are 1 turn (single loop) 1 1/4" long (same as JA1VDV design also same layout) FB is a ferrite bead.

2.10 More Information on NE645 Design

Al Ward WB5LUA - December 1977

The following figure suggests a layout to minimise coupling between input and output. Use full length of emitter leads. I mounted all bias components on top side of box.



The design should not require a shield. It actually does increase feedback if not adequately grounded to chassis. If you are using a "minibox" for the enclosure or for that matter any metal enclosure, be sure to scrape off any coating on the covers that might inhibit good grounding.

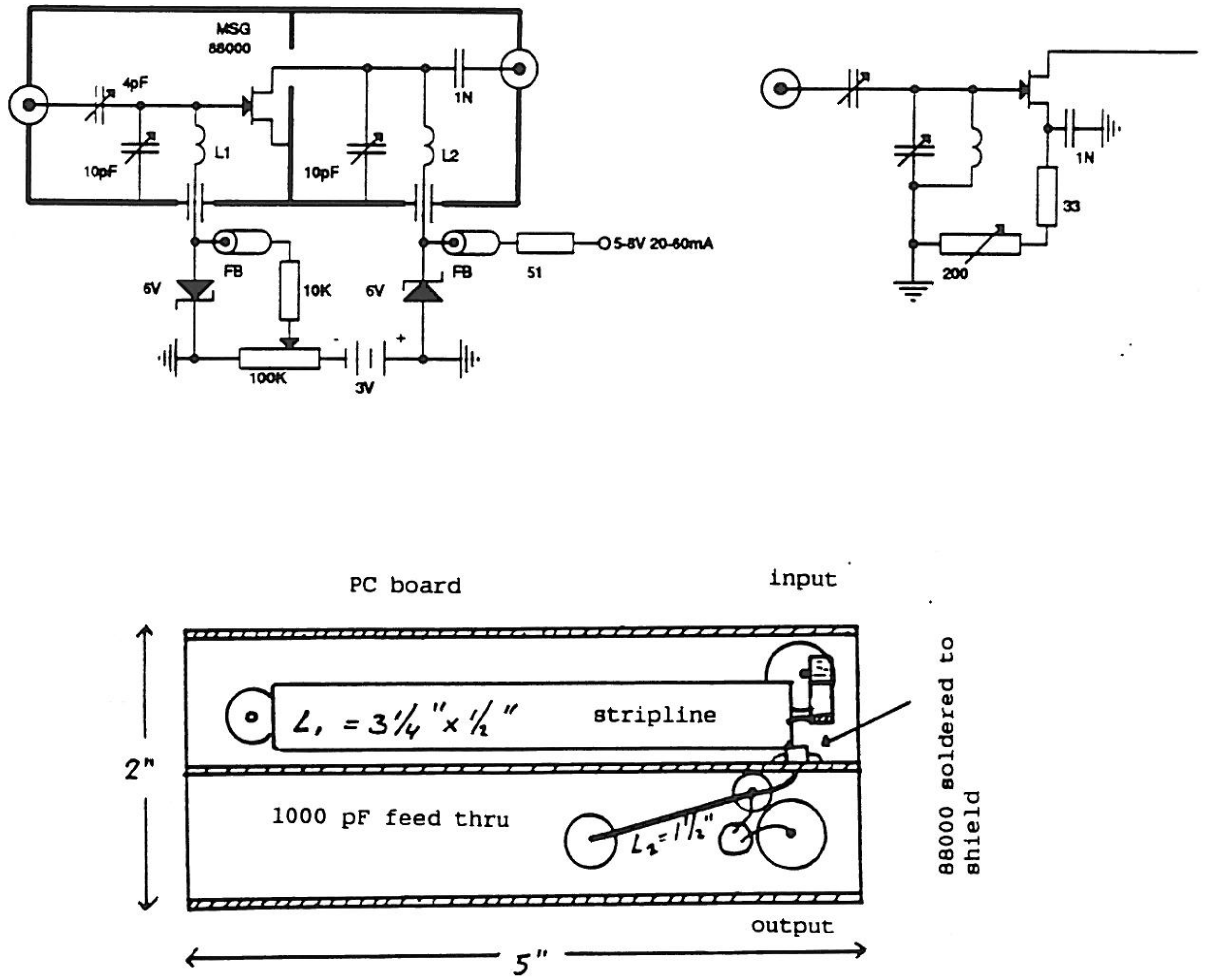
2.11 More on 88000 GaAsFets Designs (1)

Allen Katz K2UYH - January 1978

We have now evaluated more than 20 (reject) MSC 88000 devices. Of these the vast majority provide an NF on the order of 1.0 dB. Two devices, however, were found with an NF of approximately 0.7 dB (comparable with our V244) and several others were around 0.9dB. Most of the devices tested did not require the 110 Ohm drain resistor (shown in the circuit of the November NL) for stability. With the resistor a gain of about 16 dB was produced, without the resistor over 19 dB was provided. Both the level of the gate bias and drain voltage were found to be critical for best NF and varied significantly from device to device. A revised circuit is shown on the following page. Because of the very low noise contribution of these devices, the loss of the input network becomes significant. A low noise strip line input circuit was used in the design shown in Figure 2–8 for this reason. We have yet to destroy an 88000 through handling or soldering. We did blow two devices as a result of improper grounding of our automatic NF meter.

We have been using battery bias for our amplifiers. With the very low gate current the batteries should last indefinitely. K3PGP has come up with the single supply bias circuit also shown on the following page. He reports that no instability was encountered by raising the gate above DC ground potential. He did not even use a shield, but simply placed his input and output coils at right angles to each other.

Figure 2–8: 88000 Preamp Construction



* low loss silver mica
\+ some devices may require 4.5V

2.12 More on 88000 GaAsFet Designs (2)

Allen Katz K2UYH - February 1978

Since last month report on the 88000 GaAsFets we have been trying to distribute these devices as quickly and efficiently as possible. I believe I will eventually be able to fulfil all requests however, the rate of supply is limited. I am thus sending 88000's where I believe they will do most immediate good. This means to stations that are up and running, and whose performance could be significantly improved by a better NF device.

With regard to the amplifier circuit, shown last month. It is perfectly permissible to solder the devices directly to the PC board. We have encountered no problems in soldering any of these devices direct into the circuit. Neither have I used any special soldering iron or taking any special precautions in handling these devices. The input circuit wants to see somewhat less inductance than the output circuit. The length of the input strip could be shortened to 2 1/2" and still be within the tuning range of the capacitor. This line wants to be positioned parallel to and close (about 1/8") to the bottom of the box for proper tuning. L2 is simply a piece of #18 gauge wire. We have made a number of comparisons and there does not seem to be significant improvements in NF with the stripline input circuit as compared to the wire line circuit shown in the November NL. A nice thing about the circuit is that optimum NF and maximum gain occur approximately at the same point. We have also duplicated K3PGP single bias circuit and found his amplifier to be stable but with almost 3/4 of a dB poorer NF than that of the two bias circuit. Those stations that have received 88000's pretty much confirm our results. Russ, W4WD tried his at 144 MHz and reports a 0.6 dB NF. We are now using an 88000 at the feed of our dish. Although its NF is slightly poorer than our V244, a protective filter is not required and thus the overall system NF is superior. With the advent of these very low noise devices, antenna temperature becomes a significant factor. I would appreciate reports on the ratio of received noise with your antenna pointed at the horizon to that of cold sky. This figure will indicate how much a very low noise front-end will gain you.

2.13 Note on Zero Bias 88000 LNA

Allen Katz K2UYH - September 1978

In experimenting with the 88000 GaAsFets in low noise Preamplifiers we have discovered that many of these devices provide their best NF at zero gate voltage. This fact is not always obvious. If you initially set the gate bias to -2 V (circuit previously shown in the Newsletter and June 1978 QST) and then slowly bring the drain voltage up until the NF reaches a minimum, the device may appear to be operating very satisfactory. Reducing the gate bias (after the above adjustment) usually the NF to increase sharply. However, now try readjusting the drain voltage upward. You may be surprised that the NF decreases again and sometimes is lower than NF at the higher gate voltage. (Do not allow the drain current to go much above 110 mA -without a shunt drain resistor max Id is 150 mA). For most devices we have found that the drain current will saturate at higher voltages and that minimum NF occurs at a voltage slightly above the point were the saturation first sets in. Try slowly walking the gate voltage down, readjusting (increasing) drain voltage for minimum NF as you go. Observe the value achieved at each level. Tuning usually does not change during this procedure. (You can try re-tweeking, but we have only once observed a significant change). The bias level which reaches the lowest NF is where you want to operate the amplifier. For many (by no means of all) 88000's this level is 0 V. If this is the case for your device, you can throw away the bias batteries and simply connect the gate Feedthru directly to ground.

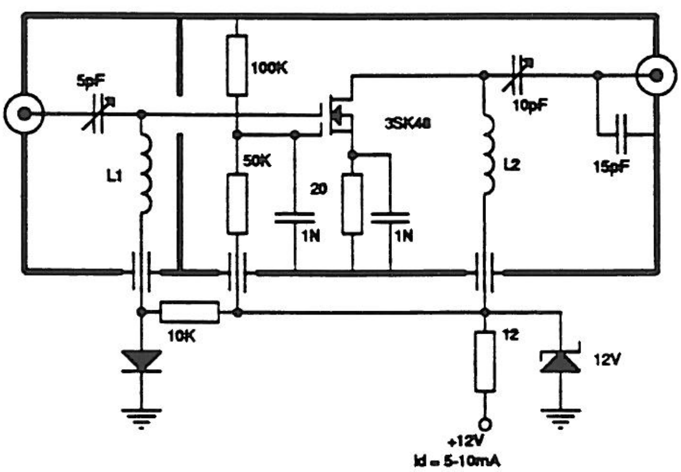
2.14 432 MHz Preamplifiers with 3SK48 & MGF1400

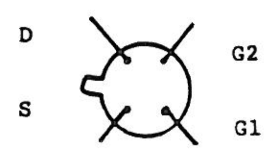
Aki Munezuka JA1VDV, Sichiro Mori JA6CZD - January 1979

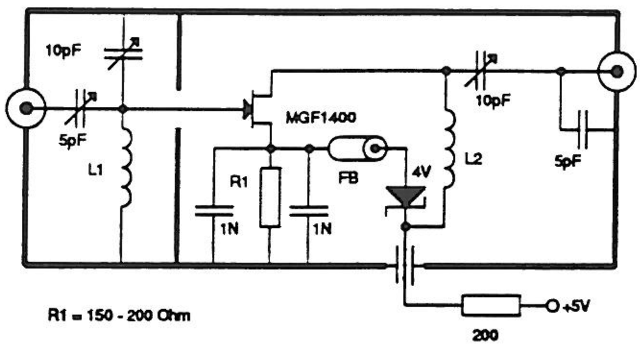
JA1VDV Preamplifier with 3SK48.

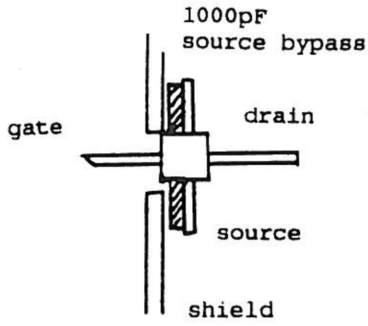
This Preamplifier is built in the same box as the V244 Preamplifier described in the January 1976 Newsletter and updated in the May issue 1977.

L1 = 2turns on 1/8" diameter 3/4" long
L2 = 1 turn on 1/8" diameter 3/4" long





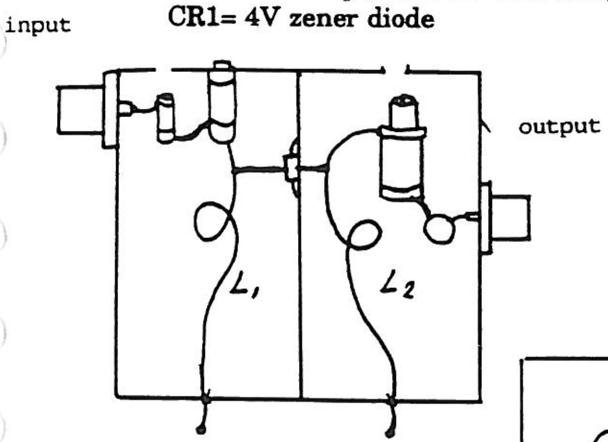


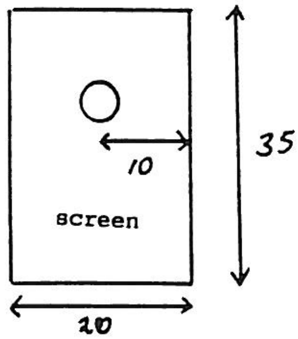


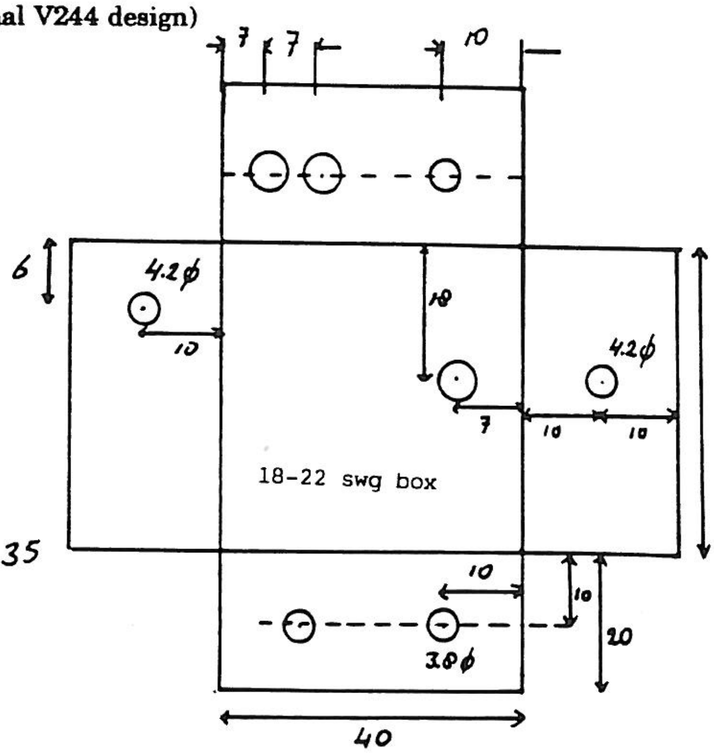
JA1VDV Preamplifier with MGF1400.

Again the mechanical layout is the same as the V244 Preamp.

L1 = 5mm loop (slightly smaller than the original V244 design)
L2 = 4mm loop (same as V244 design)
CR1= 4V zener diode



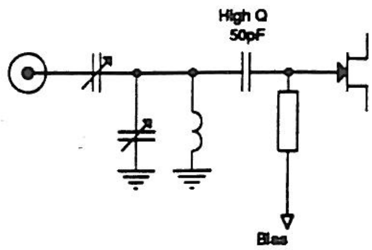




2.15 Note on Low Loss GaAsFet Input Circuit

Peter Blair G3LTF - April 1979

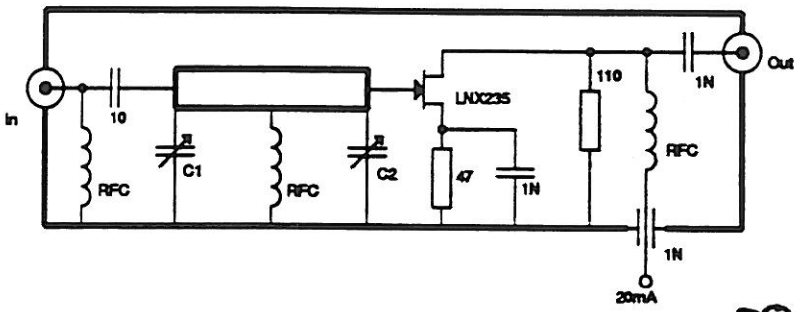
Peter suggests the following modification in the GaAsFet amplifier designs to avoid the problem of lossy Feedthru capacitors - the green ceramic type can introduce several 0.1 ths loss - (we always use the large silver mica type). This circuit eliminates the problem completely.

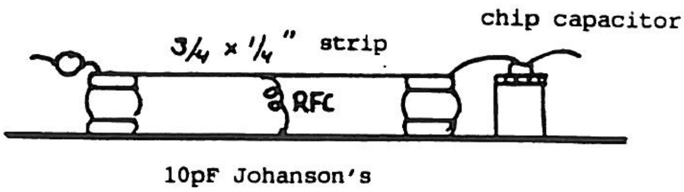


2.16 PI Input Circuit for 1296 MHz

Rusty Holshouser K4QIF - May 1979

Rusty uses a layout similar to the 1296 bipolar Preamplifier shown in the ARRL handbook. PHI network input and output circuits may be used (like the bipolar amplifier) however, Rusty has found that an untuned output works excellently. (NF about 1.2 dB, 13 dB gain).

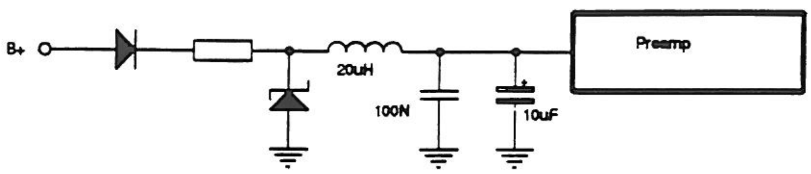




2.17 GaAsFet Transient Protection

Allen Katz K2UYH - September 1979

GaAsFet Preamps are most commonly blown by transients on their DC supply lines. This type of failure is much more common than an overdose of RF input power. A simple way to eliminate this problem is to place a 20 uH choke in series with your DC lines followed by 0.1 and 10 uF capacitors to ground. A series diode and shunt zener diode may be added to eliminate the danger of gross DC voltage errors. See circuit below.



2.18 Notes on Load Dependent NF

Allen Katz K2UYH - September 1979

Last month we ran a portion of an article written by G3WDG on a home-brew automatic NF measuring system. This article was particular interesting in that it purposes the measurement of system performance with the Preamplifier connected to the antenna. It has been a suspicion of many of us that optimising a Preamp into a pure 50 ohm load may yield less than optimum performance when the same Preamplifier is used with a real antenna having less than perfect match. The GaAsFet amplifiers in use today have very high input mismatch for best NF. This means that very small changes in the antenna impedance can greatly affect their performance. The approach proposed by G3WDG seems worthy of further investigation.

2.19 An Alignment Aid for VHF Receivers

J.R. Crompton G4COM - September 1979

The normally recommended technique for aligning the front-ends of VHF receivers is to adjust for maximum signal to noise ratio, which may be, but usually is not, at the same settings for maximum gain. This can be done by ear using a low level CW input from a signal generator or beacon, but it is often difficult for the amateur to obtain the use of a VHF generator with a sufficiently attenuated output, while beacon signals tend to suffer from QSB effects if they are weak enough for the purpose required. The author's ears have not proved sufficiently sensitive instruments for any of these methods to be useful other than for approximate alignments.

Another method makes use of a noise generator which needs not be precisely calibrated. This is potentially the most accurate method but it does call for repeated comparative readings in the "generator on" and "generator off" conditions, and can be laborious and confusing where adjustments to one part of the circuit interact with others. Although one reference suggests "using a noise increase that you can remember", some form of indicator must be used for accurate work, although this could be very simple and make use of the station multimeter or vvm.[1] The instrument to be described would seem to overcome most of the problems encountered in the previously mentioned methods by providing a continuous readout of the difference between the audio output of a receiver with no RF input, and the output when a wideband noise generator is connected to the receiver's aerial terminals. The meter indicates the ratio between the outputs under these two conditions, and the reading is not sensitive to variations in the mean level of the AF signal over quite wide limits. The meter has a logarithmic response and could be calibrated linearly in decibels, but this is probably not justified where the absolute level of the noise generator is not known. The cost of building this instrument excluding the case and meter is about 7 Pounds. (October 1975).

2.19.1 Circuit description

The circuits used in this design are not novel, all of them being taken with only minor modifications from [2] and [3], which are well worth reading by anyone interested in the use of Op-Amps at DC and AF.

IC1 is used in a precision rectifier circuit which gives a DC output from AC inputs down to a very low level, unlike the conventional half-wave rectifier which requires some hundreds of millivolts for satisfactory operation. The gain of the circuit is determined by R2/(R1 + RV1), while D2 and R3 prevent the Op-Amp from saturating on negative half cycles of the input. The output from the circuit is partially smoothed by R4 and C1, and is fed to IC2 which is connected as a logarithmic amplifier by the use of TR1 in its feedback loop (the voltage across a silicon transistor, base shorted to collector, is proportional to the logarithmic of the current through the transistor). This circuit is the "heart" of the instrument. It is fed alternately with two voltages corresponding to the receiver noise output and the receiver signal + noise output. The difference (in millivolts) between its output voltages under these two conditions is a function of the ratio between the two input voltages, and this ratio is independent of the average input level. Hence, provided that the various stages of the receiver and the circuit around IC1 are working within their linear range, the AC output from the circuit around IC2 at the pulse frequency employed will be dependent only on the overall S/N ratio. Since the AC output of this circuit is only a small fraction of a Volt peak-to-peak, it is amplified by IC3 connected as a voltage amplifier, having a gain R8*(R7+RV2).

Figure 2–9: G4COM NF Meter

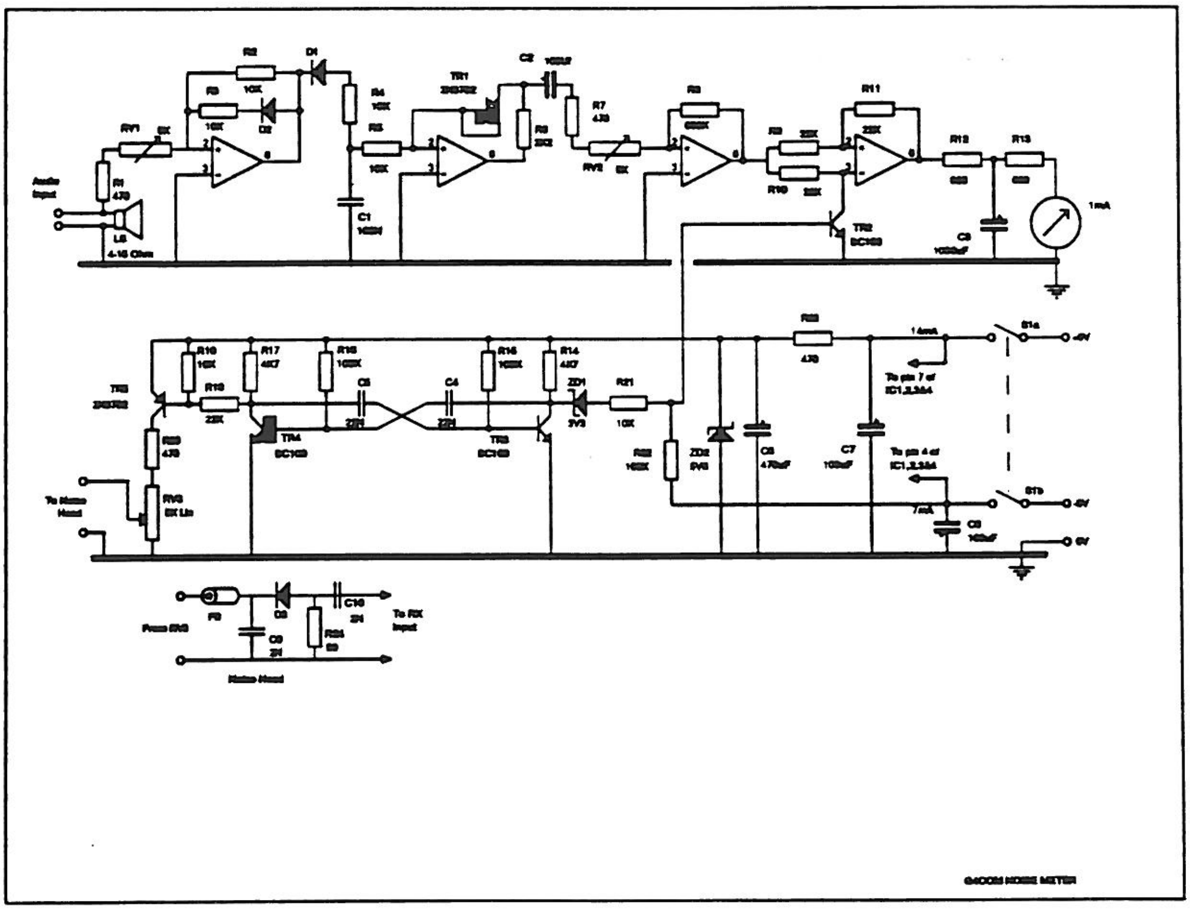
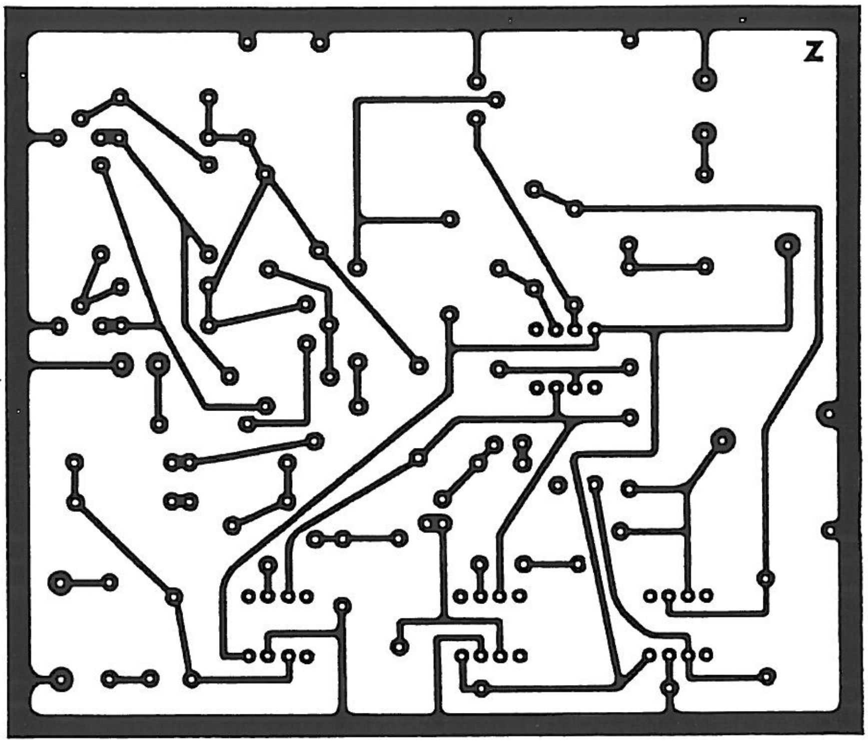
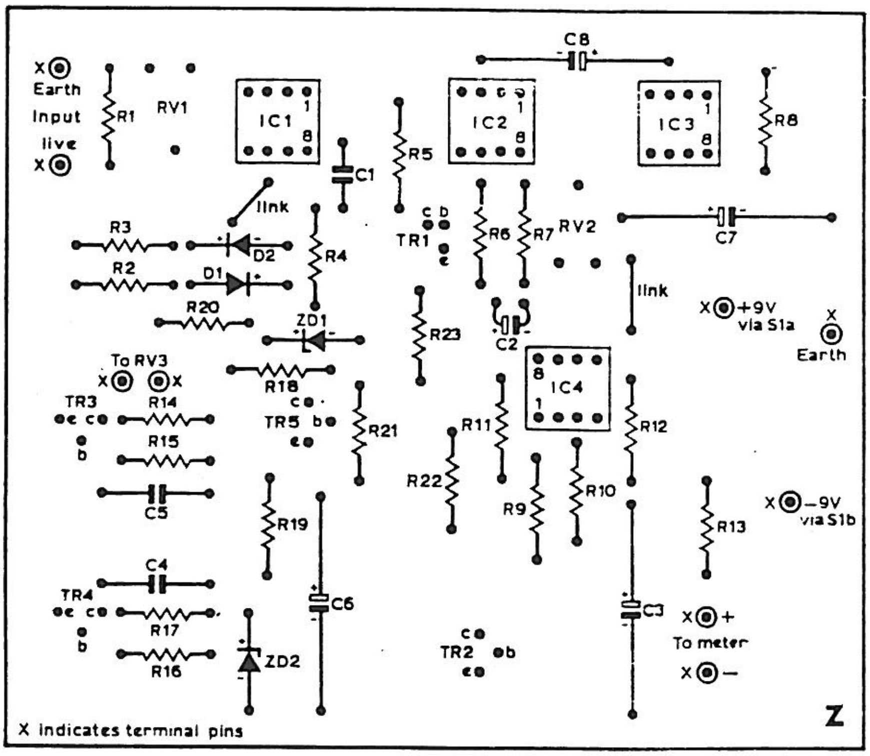


Figure 2–10: G4COM NF Meter Print Layout





The output of IC3 is fed to IC4, a phase-sensitive detector of unity gain. The reference signal is provided by TR2 from the pulse generator TR3, TR4. A phase sensitive detector is ideally suited to applications such as this, where an indication is required of the magnitude of an AC signal which has a known frequency and phase but a high accompanying noise level. In the present applications, the PSD gives a usable output when the signal is accompanied by so much noise that it is undetectable by ear or by examining an oscilloscope trace. Full scale deflection of the prototype was about 10 dB (S+N)/N, with the scale reading linearly in decibels. IC4 has a low output impedance adequate for driving a 1 mA meter. R12, R13 and C3 are chosen to give adequate damping for the meter, which otherwise would have a very erratic response due to the random nature of the noise inputs. The switching device TR2 is a standard general purpose bipolar transistor. In principle a Fet would be more suitable but this would require a larger peak-to-peak switching voltage than is conventionally available, and in practice the simple circuit here is quite adequate.

The pulse generator TR3, TR4 is a conventional a-stable multivibrator operating at about 30 Hz. Its output is amplified by TR5 and fed to the noise diode via limiting resistor R20, the diode current being adjusted by RV3. The pulse generator also provides the reference voltage for the PSD. The noise generator circuit is conventional and can be built into the body of an UHF plug [1]. The power supply to the pulse generator and noise diode is roughly regulated by ZD1.

2.19.2 Components

Few of the component values are critical and 20 percent tolerance will suffice. C2, 3, 6, 7 and 8 can be any convenient value not less than the values shown, while C2 only needs to be 2 V working. D1 and D2 can be almost any germanium diode such as OA79, OA90 or OA81. The NPN transistors can be any low-level audio or switching silicon types of minimum HFE 100. The PNP transistors require a similar specification. Resistors can be rated 1/4 W. In the noise generator head the resistor should be of metal film construction for minimum inductance, 51 ohm or 75 ohm as appropriate , and the capacitors small ceramic. The diode used in the prototype was a CV364 microwave mixer from the spares box. Alternatives are 1N21, 1N25, 1N32, 1N23 or less suitable, 1N82A and 1N34; failing any of these, it may be worthwhile to try assortment of signal, rectifier and zener diodes as available,in the hope of finding one having sufficient noise output over a wide frequency band.

2.19.3 Construction

See Figure 2–10 and Section 2.19.4. Layout is not at all critical. At no time, even in the breadboard stage of development, there was any hint of instability. The prototype was built on an etched circuit board measuring approximately 75 mm by 90 mm and built into a box 220 mm by 130 mm by 130 mm.

2.19.4 Components list

R1, 7, 20, 23	470 ohm
R2, 3, 4, 5, 19, 21	10 K
R6	2.2 K
R9, 10, 11, 18	22 K
R12	820 ohm
R13	680 ohm
R14, 17	4.7 K
R15, 16, 22	100 K
R24	51 ohm or 75 ohm to suit receiver
RV1, 2	5 K skeleton preset 0.1W horizontal
RV3	5 K carbon linear

C1	0.1 uF polyester
C2	100 uF 3V tantalum
C3	1000 uF 3V
C4, 5	0.22 uF polyester
C6	470 uF 6V
C7, 8	100 uF 10V
C9, 10	2 nF ceramic
FB	Ferrite bead
ZD1	3.3 V 400 mW zener diode
ZD2	5.6 V 400 mW zener diode
D1, 2	OA47, OA79, OA90 or similar
D3	see text
TR1, 5	2N3702, 2N3703, 2N4126 or similar
TR2, 3, 4	BC109, 2N2926 or similar
IC1, 2, 3, 4	741 eight-lead dil
LS	replacement speaker 4-15 ohm
S1	switch dpst

2.19.5 Setting up

The unit requires little alignment, and even this can be done without test equipment. Switch on the receiver, plug in the noise diode and adjusted the receiver tuning and audio controls to give an audible noise level. Switch on the alignment unit and adjust the diode current (RV3) to give an audible signal, a rough purring noise.

Connect the audio output of the receiver to the input of the unit. The meter should now give a fairly steady reading which can be varied by adjusting the diode current. Set RV1 so that the meter reading is constant over a wide range of receiver audio gain settings; set RV2 to give FSD on the meter at maximum diode current on the highest frequency band to be required. The unit is now ready for use.

2.19.6 Usage

Connect up the unit as above and adjust RV3 for about half scale deflection on the meter. Any adjustment of the receiver which results in an improved signal gain with no change in the noise figure, or a reduced noise figure with no change in signal gain, or both simultaneously, will result in an increased meter reading. Therefore by noting the meter reading at a given setting of RV3 the effect of various circuit changes in the receiver can be assessed. Although the unit is not especially sensitive to small changes in temperature or battery voltage, it is probably wise to switch on the unit ten minutes before it is required, and to ensure that the ambient temperature is reasonably constant and that the batteries are fresh before using the unit for periodic checks on receiver performance. As mentioned above, the principle of the instrument assumes reasonable linearity of the receiver. It is not suitable for FM alignment. Noise blankers and AGC should be disabled before using the unit for testing. It is recommended that a signal generator or off-air signal be used for initial alignment, as there is a risk that one or more of the front end circuits may be peaked up to resonate at an image or other spurious frequency when a wide band signal source is used.

2.19.7 Modifications

The speaker shown in Figure 2–9 is included on the assumption that the unit will be connected by inserting a jack-plug into the headphone/external speaker jack of the receiver, thereby muting the receiver's internal speaker. If desired the speaker shown may be replaced by a 15 ohm 1 W resistor. A more sensitive meter movement can be used. Should this be contemplated then R12 = R13 = (750000/meter sensitivity in microamps) and C3 = 1000000/R13 where capacitance is in microfarads and resistance is in ohms. This will give slightly greater meter damping than in the prototype.

As it is unlikely that the instrument will be in constant use it was not considered worthwhile to incorporate a mains unit. If desired however, this can readily be added using a miniature transformer rated 9V-0-9V at 50 mA, a small bridge rectifier and two 470 uF, 16 V capacitors. Voltage stabilisation is not necessary, and no change in performance has been noted with changes in supply voltages from less than 8 V to more than 14 V.

2.19.8 Acknowledgements

The author is indebted to numerous members of Southampton Radio Club for helpful theoretical and practical suggestions.

2.19.9 References

1. The Radio Amateurs VHF Manual, ARRL, 1972, pp 320-321
2. "Operational Amplifiers", G.B. Clayton, Wireless World February-December 1969.
3. "Experiments with operational amplifiers", G.B. Clayton, Wireless World June 1972 to September 1973.

2.20 GaAsFet 3SK97 design

Piero Moroni I5TDJ - December 1979

Panasonic Dual Gate GaAsFet are indeed a reality. The price is approximately $4.50 in the USA from Panasonic dealers. Both JA6CZD and I5MSH have independently measured these devices (3SK89) at about 0.8 dB NF and 20 dB gain on 432 MHz. I5MSH's circuit is shown in Figure 2–11.

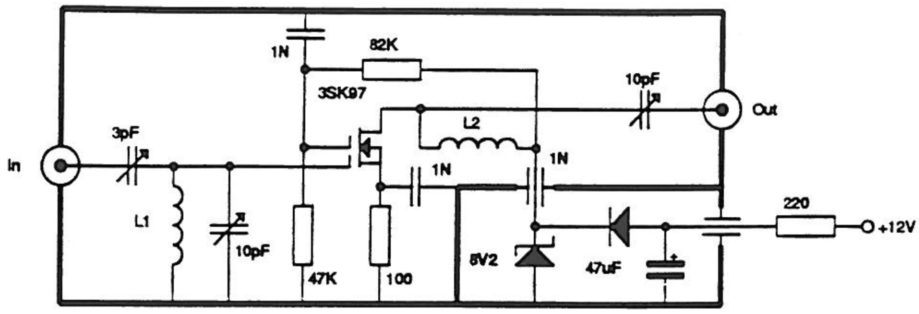
Coils are the same as the JA1VDV circuit (Dec. 1978 NL)

2.21 First Preamplifier for 432 MHz with 3SK98

Allen Katz K2UYH - January 1980

The 3SK98 dual gate GaAsFet is a reality. In Figure 2–12 is shown the circuit diagram and layout for a simple Preamplifier using the 3SK98 which delivers approximately a 0.8 dB NF. The amplifier is build on double sided PCB and need not to be enclosed to function properly. *Note* that the 3SK98 is soldered in place inverted. (Top, as shown in the figure, toward the PCB. This causes G2 lead to point toward the top of the page). All variable capacitors are 1-10 pF Johansons. C4 and C5 are chip capacitors - a low inductance ground at these points is critical. The zener diode is 8.2 V. This value (not critical) is necessary to provide approximately 5 volts source to drain. (8.2 V - 3.5 V source resistance drop). The

Figure 2–11: 3SK97 GaAsFet design

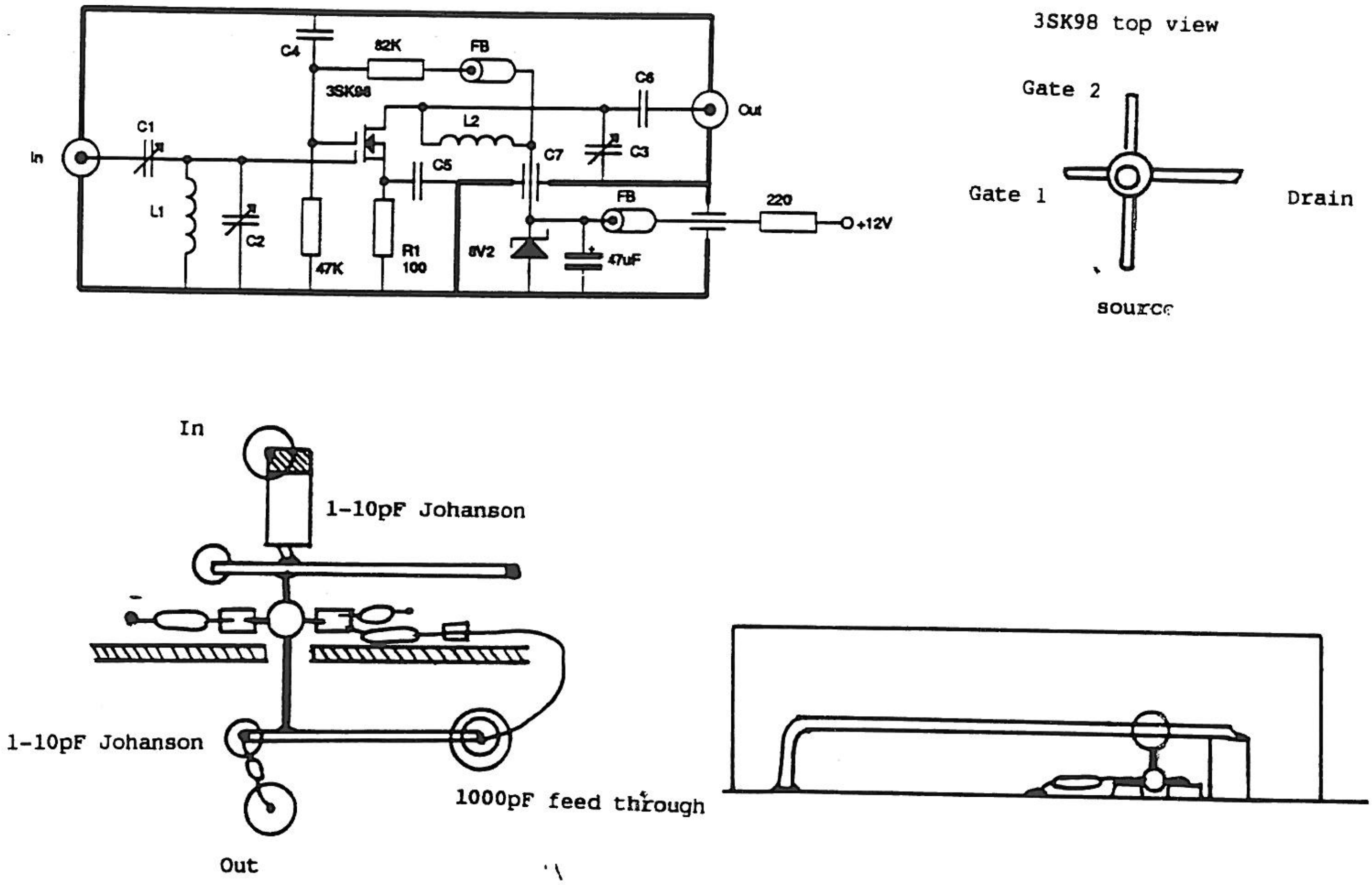


3SK98 draws about 40 mA when biased properly. R1 is not critical to NF (values from 80-132 give the same NF). The R2-R3 voltage divider ratio is also uncritical. A G2 to S voltage of between +1 to +2 V is needed (Don't forget to substract out the -3.5 V source resistor drop). The output circuit is not designed for optimum gain, but was chosen to obtain stability. Increased gain can be obtained at the expense of stability factor by tapping C6 down on L2 (about 3/4 of the way down should be optimum). Note this change should not improve NF.

Since building up the 3SK98 amplifier, I have also constructed a 3SK97 version, but had not time jet to test it out. According to the spec sheets, the 3SK97 should yield identical performance on 432 as the 3SK98. Except that for the same voltages the drain current is cut in half. You want to increase the value of R1 to about 120 ohms and drop the value of the zener diode to around 7.2 V. Drain current for the 3SK97 should be about 20 mA.

C4,C5 are 1000 pF chip caps.
L1,L2 are 3/4" length of #12 wire.

Figure 2–12: 432 MHz Preamplifier with 3SK98



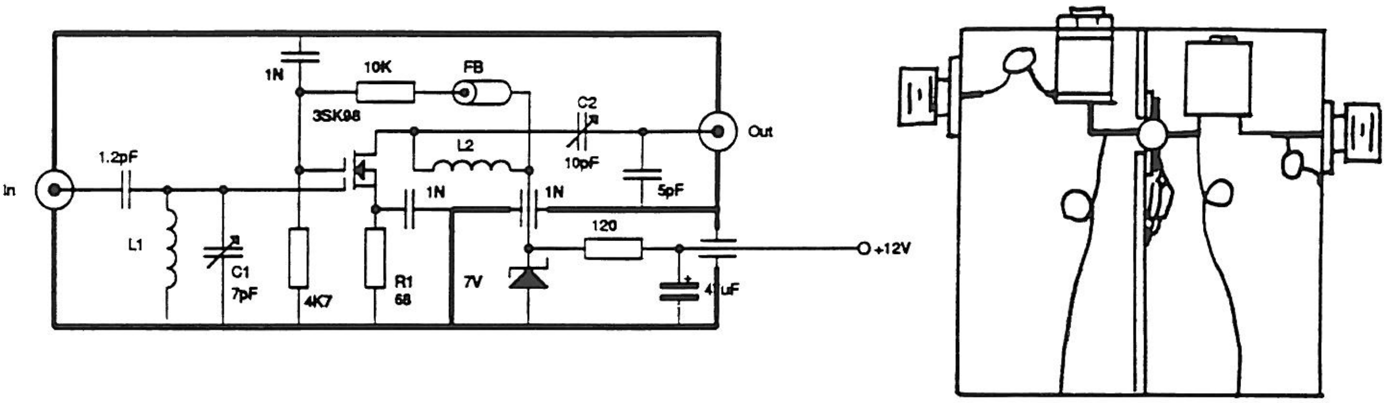
2.22 3SK98 Preamplifier for 432 MHz

Sichiro Mori JA6CZD - April 1980

R1 should be adjusted for Id = 20mA. Adjust C1 for 1/4 increase in capacitance from maximum gain reading. Adjust C2 for maximum gain.

L1 5mm inside diameter, 1 turn, wire 1.2mm diameter
L2 4mm inside diameter, 1 turn, wire 1.2mm diameter

Figure 2–13: 432 MHz Preamplifier JA6CZD



2.23 432 MHz GaAsFet Preamplifier

Jan Bruinier DL9KR - May 1980

The drawing shown in Figure 2–14 is a 432 MHz GaAsFet Preamplifier made by Jan, DL9KR. The drawing is on scale 1:1. on the actual size.

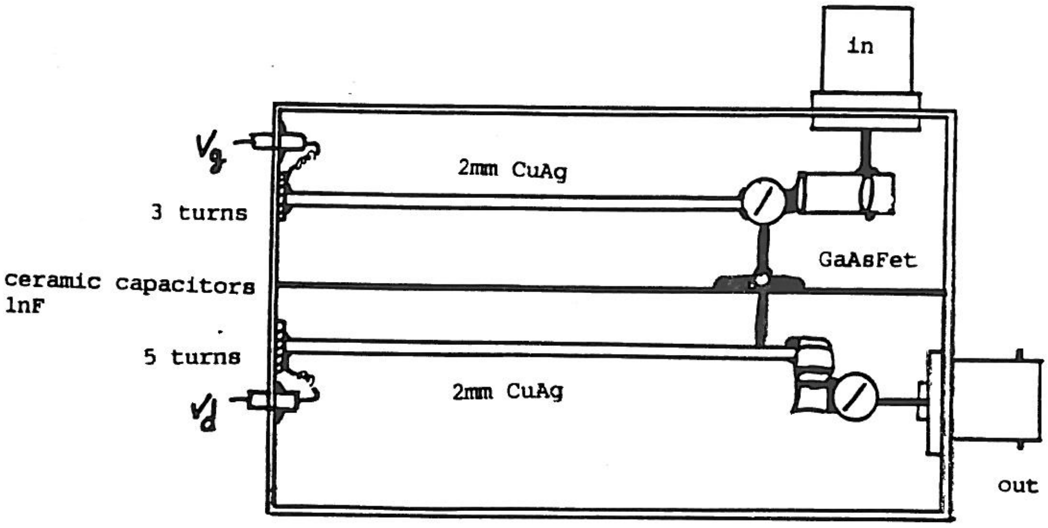
2.24 NE24483 or Dexel 3501/D432 1296 Preamplifier

Al Ward WB5LUA - September 1980

Al measured with this Preamp for 1296 the following results:

NF = 0.7 dB (NE24483)
NF = 0.9 dB (DXL 3501)
Gain = 17 dB (NE24483)
BW (3dB) about 100 MHz
BW (1dB) about 50 MHz
1 dB C.P. > +7 dBm ref. to output (NE24483)

Figure 2–14: DL9KR 432 MHz GaAsFet Preamp



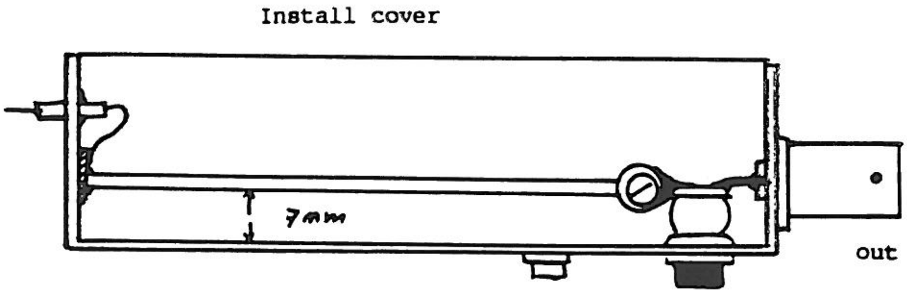


Figure 2–15: NE24483 or Dexel 3501/D432 1296 Preamplifier

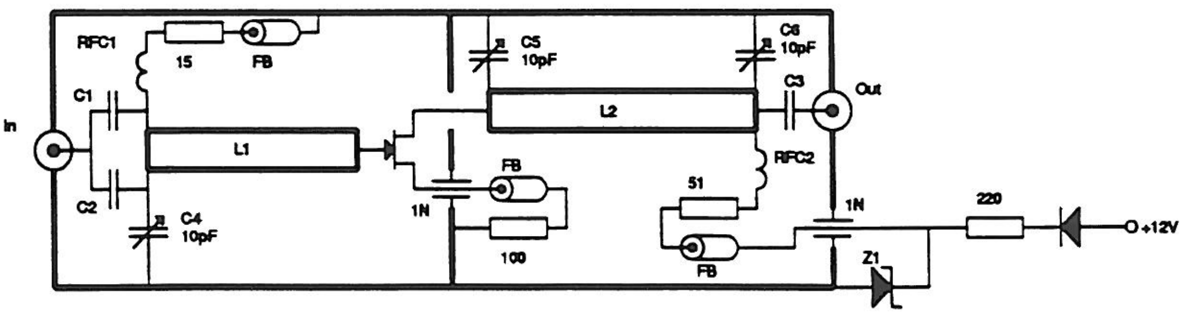


Figure 2–15 Cont'd on next page

Figure 2–15 (Cont.): NE24483 or Dexel 3501/D432 1296 Preamplifier

L1 Microstrip line 0.25" wide by 1.05" long, 0.2" above ground
L2 Microstrip line 0.25" wide by 0.8" long, 0.2" above ground

(Lines suspended between variable cap's. Cap's on 1.1" centres)

FT1-FT3 470-1000 pF feedthrough capacitor (miniature preferred).
C1 -C3 68 pF chip capacitor
C4 -C6 0.8-10 pF variable (piston type)
D1 - 1N914
Z1 - 1N751A 5.1 V
J1 -J2 SMA type connector
RFC1,
RFC2, 6 Turns 1/8" ID close spaced #20 enamel wire

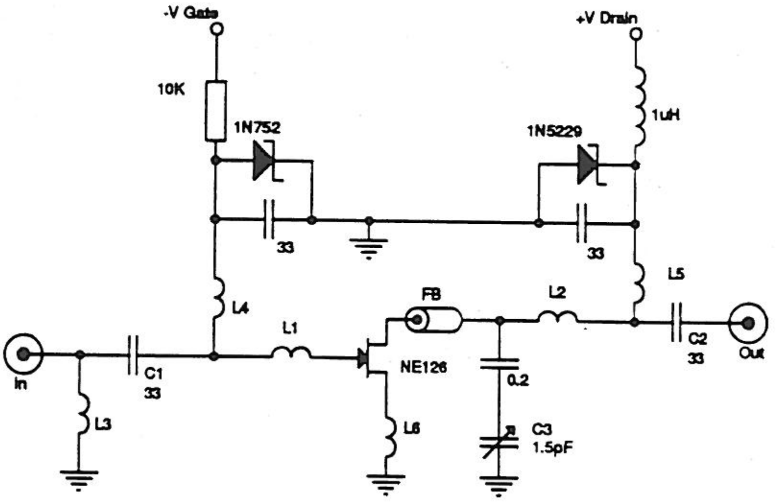
Notes:
Vds about 2.5 V (NE24483)
Id about 17-18 mA

2.25 NRO 1296 MHz Preamp Design

R. Williams, W. Lum, S. Weinreb - February 1981

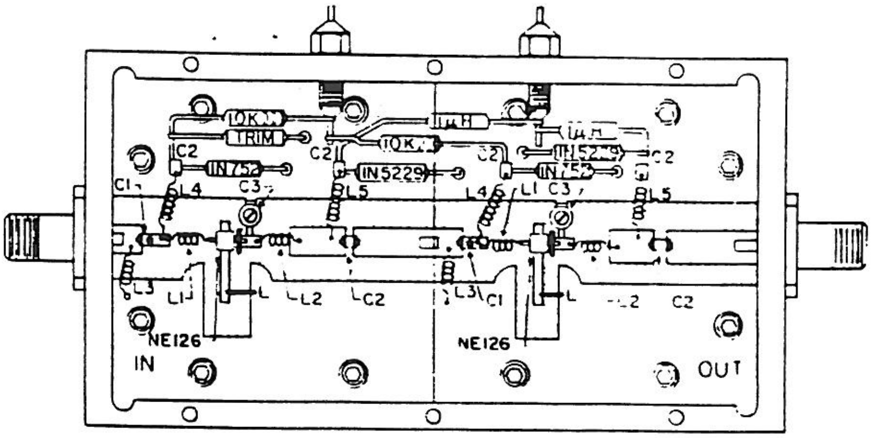
A very interesting article which I have been meaning to mention appeared in the Oct. 1980 issue of Microwave Journal. The article by R. Williams, W. Lum and S. Weinreb describes a cryogenically cooled GaAsFet Preamp used for radio astronomy to receive signals in the vacinity of 1400 MHz. This amplifier has a bandwidth from 1.2 to 1.7 GHz and in the cooled condition has a noise temperature of 10°K at 1300 MHz. Without cooling it still has a noise temperature of less than 50°K. Of particular interest is the use of source inductance to generate negative feedback and decrease the input impedance required for minimum noise match. This technique was used by W1JR and WA7TZY with bipolar devices on 432 several years ago. An NE-126 is used in the design, but it is mentioned that similar results have been obtained with selected NE-388's, MGF1412's and AT8110's.

Figure 2–16: NRO 1296 MHz Preamp Design



Schematic diagram of one of the two identical stages in the cooled amplifier. All inductors are made with 0.008 diameter phosphor-bronze wire wound to make a 0.080" inner diameter coil. L1 and L2 are 3 turns with 0.100" length and about 10nH inductance. L3 and L4 are 4 turns with 0.125" length and about 16nH inductance. L5 is 5 turns and is not critical. Note that L3, L4 and C1 comprise a 500 MHz high pass filter. All capacitor values are in pF. C3 is a Johannson Giga-trim type 7264 variable capacitor. The ferrite bead is Micrometals type T10-6. L is the added source inductance about 1nH.

Figure 2–17: NRO 1296 MHz Preamp Mechanical Layout



Physical layout of the 2 stage amplifier. Circuit board is 0.62" teflon-glass board Rogers Duroid type 5880. Each stage is tested seperately for best noise performance and input and output return loss before assembly into the two-stage amplifier.

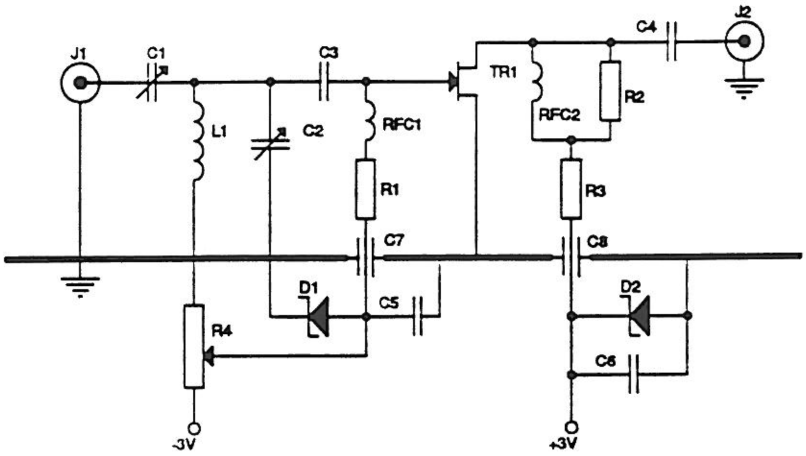
2.26 GAT-6 1296 MHz Preamplifier Design

Charles Suckling G3WDG - May 1981

The input circuit of the Preamplifier is built inside a 52 mm length of 22.86 x 22.86 (inside diameter) copper tubing, as shown in Figure 2–18. In the prototypes, this tubing was manufactured from pieces of copper WG16 waveguide. This square tubing together with a 32mm length of 9.23mm o/d copper rod forms a short-circuited length of coaxial transmission line, to act as a high-Q inductor (L1). The shorting block was a 22.86 x 22.86 x 6.35mm piece of copper. C1 is formed by a 6.4mm diameter copper disc soldered to the inner conductor of a short length of 3.6mm semi-rigid cable, which passes through and is soldered to a length of OBA brass studding. The square outer tubing is tapped so that the studding can be screwed inwards and outwards to adjust the value of C1. C2 is formed by a length of OBA copper stedding, which passes through a tapped 22.86 x 22.86 x 3mm copper block pressed into the square outer tubing.

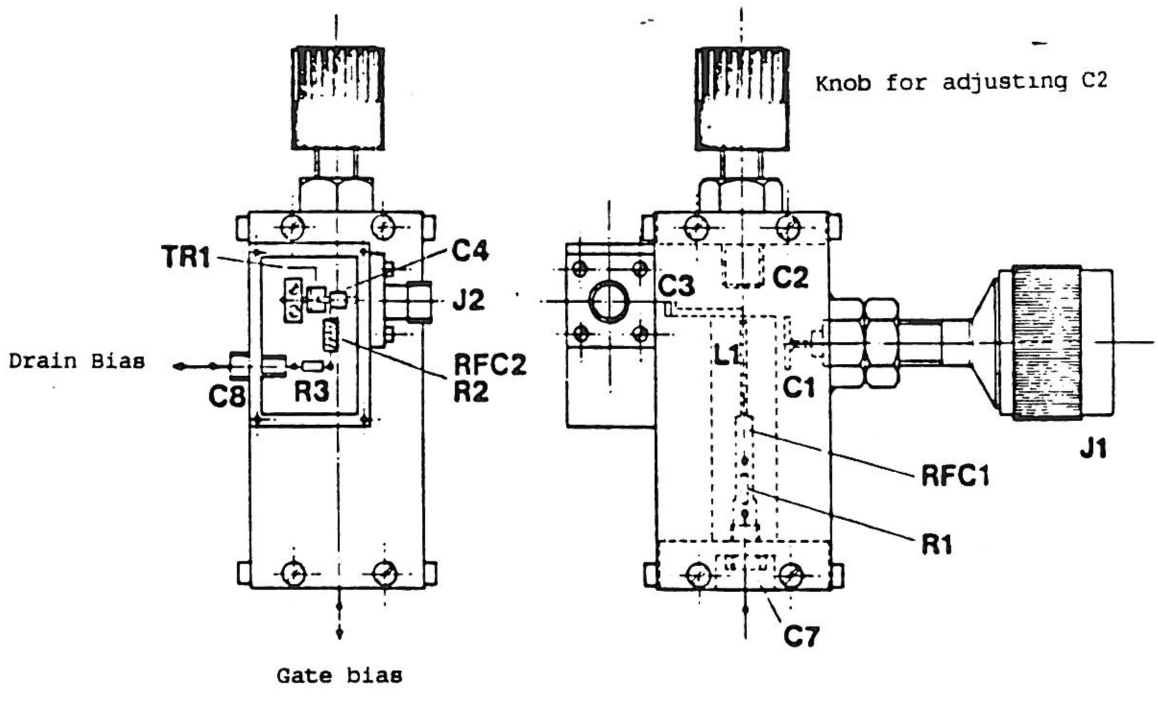
The end of the inner line is connected to the gate lead of the Fet, via the blocking capacitor C3, by a short length of copper foil. The gate bias choke RFC1 is made from a length of 36 swg enamelled copper wire, passing through a hole in the centre of the inner line. One end of this is soldered to the junction of C3 and the gate of the Fet, and the other end is connected via R1 to the feedthrough capacitor C7, which is fitted into a tapped hole in the inner line. This method of using a coaxial feed for the gate bias was chosen to avoid losses or stray resonances which might have occurred with a conventional choke.

Figure 2–18: G3WDG 1296 MHz Preamp



C1,C2 - See text
C3,C4 - 100pF ATC Chips
C5,C6 - 47uF tt
C7,C8 - 1nF Filtercon
R1,R3 - 47 1/8W
D1,D2 - 4V7 Zener

R2 - 68K 1/8W
R4 - 10K Preset
L1 - See text
RFC1 - See text
RFC2 - 5tms 36swg on R2
TR1 - GAT 6 GaAs FET Plessey



Mechanical details of the preamplifier

The GaAsFet device is mounted with the top part of its package located in a 2.6 x 2.2 mm rectangular hole in the wall of the outer tubing, the package stud (source connection) being held against the wall by a small clamp. The output circuitry is built inside a 25.4 x 18 x 12.7 mm box mounted on the main body of the Preamplifier. The transient protection and gate bias circuitry is mounted externally, and is not shown.

2.27 Preamplifier for 432 MHz

Chip Angle N6CA - June 1981

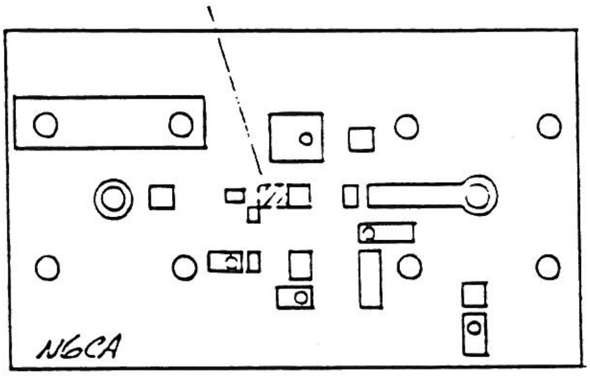
One of the best thought out 432 GaAsFet design we have seen is by Chip, N6CA and is shown on the following page. Chip appears to have taken all factors into consideration. He uses source feedback to bring the input impedance closer to 50 ohm. (This allows the Preamp to be proceeded by a multi-pole band pass filter of modern design.) He also uses a complex input matching circuit to reduce the component losses of the "L-Network" used in most other GaAsFet designs. The schematic shows the relatively expensive NE21889 GaAsFet, however, less costly devices should also work in the circuit with a minimum of tweaking. (MGF 1400, MGF 1200, D432 all should be OK, as most GaAsFets have approximately the same input characteristics at 432 MHz.)

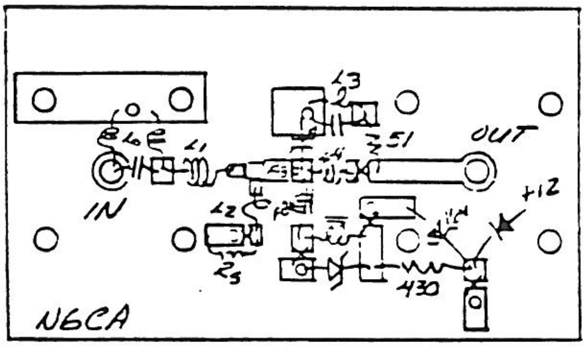
Notes and Performance:

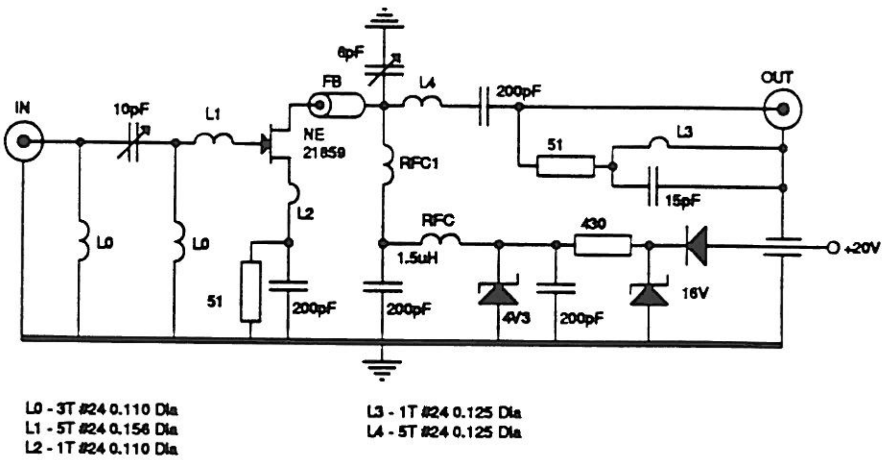
- Noise measure .3 to .4 dB hot/cold.
- Gain 16 to 17 dB.
- Return loss typical 20 dB in/out.
- Board material is not critical.
- Suggest "N" or "SMA" connectors, new if possible.
- Aluminium spacer under board to mate to "N" connector will assure good 50 ohm transitions in/out.
- Don't omit reverse and over voltage diodes.
- Measure source voltage to verify 12 mA IDs, change Rs to get proper current 30-51 ohm typical.
- Measure return loss with < -20 dBm signal.

Figure 2–19: N6CA 432 Preamp

```
Board 6-10 glass Cu both sides
o= eyelet soldered both sides
cutout for FB
```








```
GaAsFet NEC 21889
Lo -3T #24 0.110 dia
L1 -5T #24 0.156 dia
L2 -1T #24 0.110 dia
L3 -1T #24 0.125 dia
L4 -5T #24 0.125 dia
FB Ferroxcube p/n 56-590-65/4B
   slipped over drain lead
RFC1 5T #30 GA on FB core
200 pF Johanson p/n 500R15N201KP
Use 400 mW zeners only
- Carefully shorten gate lead (notched) to .10" length
- Shorten source lead to .10"
- Remove other source lead
- Do not cut drain lead
All resistors 1/8W carbon
```

2.28 1296 GaAsFet LNA Design

Chip Angle N6CA - July 1981

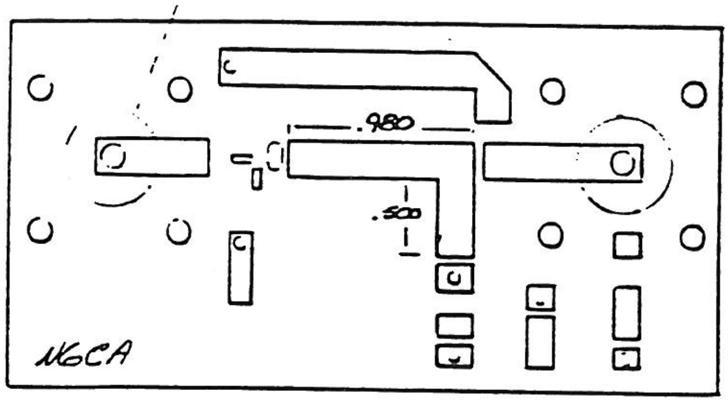
The Performance of this 1296 GaAsFet LNA design by Chip Angle lays between 28-34° Kelvin hot/cold. Which means a 0.4 to 0.5 dB noise measure. The gain 12-14 dB, while the in and output return loss is +/- 15 dB. Construction details can be seen in Figure 2–20.

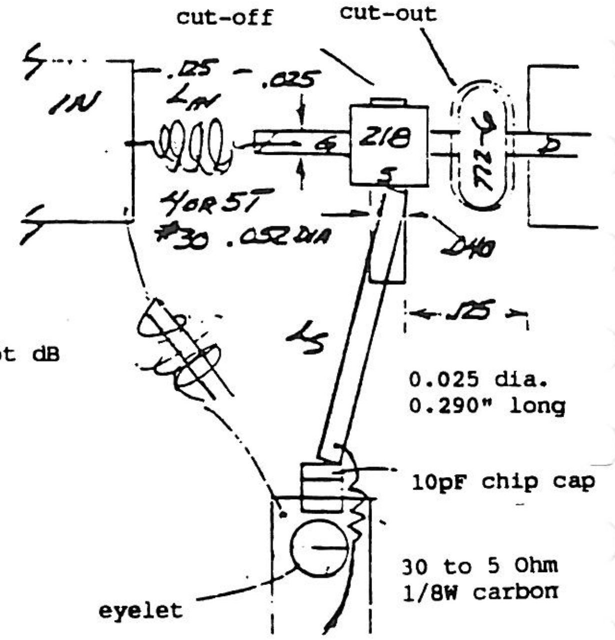
Terminate in and output for all tests with a 50 ohm load. Turn off and remove power supply when selecting resistors. Select R1 for a 20 to 25 mA total current. Typical value is about 430 ohm. Select Rs to have 12 mA Ids. (5 to 30 ohm)

The board is a Teflon PCB (RT Duroid Er=2.2 W=0.62) All resistors are 1/8 W carbon

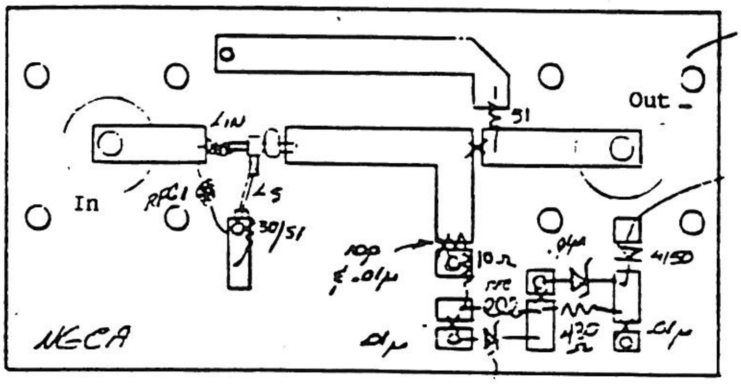
Figure 2–20: N6CA 1296 MHz Preamp

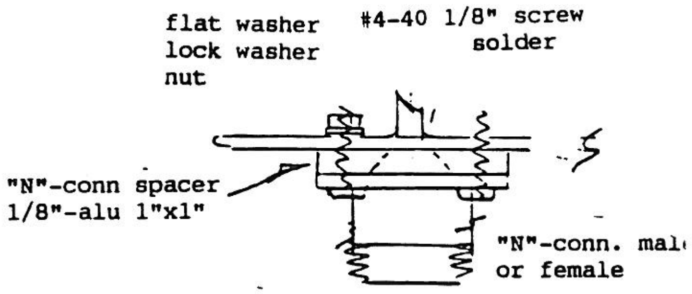
full copper back side
copper removed for "N"-conn. backside





50 Ohm widths = 0.182"





Carefully!
- shorten gate lead (notched) to 0.10" length
- shorten source lead to 0.10"
- cut-off other source lead
- do not cut drain lead

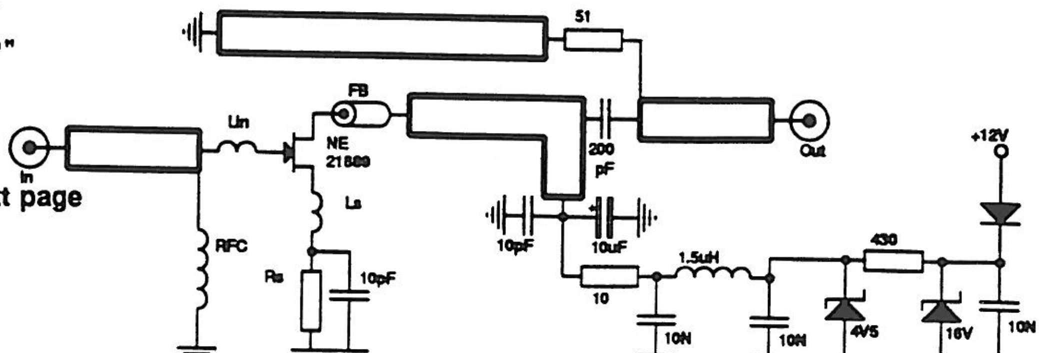


Figure 2–20 Cont'd on next page

Figure 2-20 (Cont.): N6CA 1296 MHz Preamp

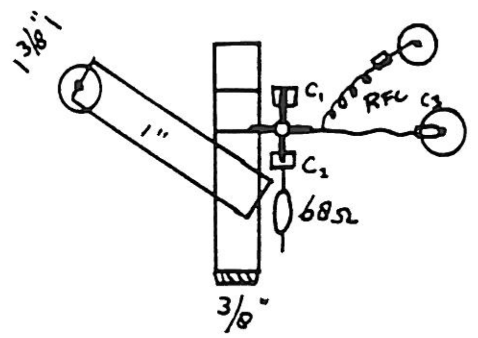
```
o        = eyelets soldered on both sides.
Lin      = 4 or 5 t #30GA Cu, 0.052 ID
Ls       = 0.290" of 0.025" dia. Cu wire.
RFC      = 5t #30GA on Ferroxcube 56-590-65/4B shielding bead.
Chip C's= Johanson 10 pF 500R11N100KP
                   200pF 500R15N201KP
                   0.01 uF 500R15W103KP
```

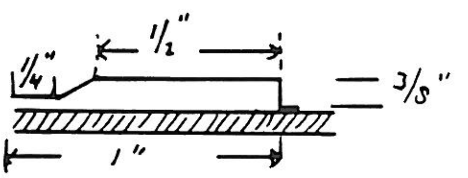
2.29 1296 Mhz Preamplifier

Allen Katz K2UYH - December 1981

In Figure 2–21 you see the layout for a tunable low noise 1296 Preamp which uses no variable capacitors. We have built up 5 Preamps using this design and have tried MGF1200, MGF1400, MGF1402, A1000, and 3SK97 GaAsFets in the circuit. All devices tuned up with a minimum effort and produce NF's equal to or lower then other designs tried. Set the drain voltage for minimum NF. Then adjust the tabs for lowest NF using an automatic NF meter and an insulated tuning wand. Care should be taken here as small changes in spacing can make a big change in NF. The position of the wire in drain circuit can also be varied in respect to ground. This adjustment should have minimal effect on NF, it does effect gain. The box the amplifier is mounted in should have no effect on the NF tuning.

Figure 2-21: K2UYH 1296 Preamplifier





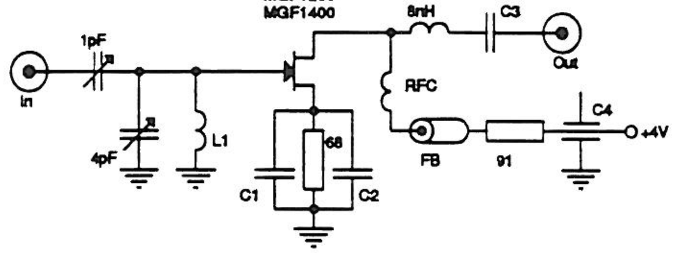


Figure 2-21 Cont'd on next page

Figure 2-21 (Cont.): K2UYH 1296 Preamplifier

```
C1-C3 100-1000pF chip caps
C4    1000pF Feedthru
L2    about 3/4" length #22 wire
RFC   8t 1/8" dia #22 wire
Input circuit 3/8" wide Cu flashing strap
```

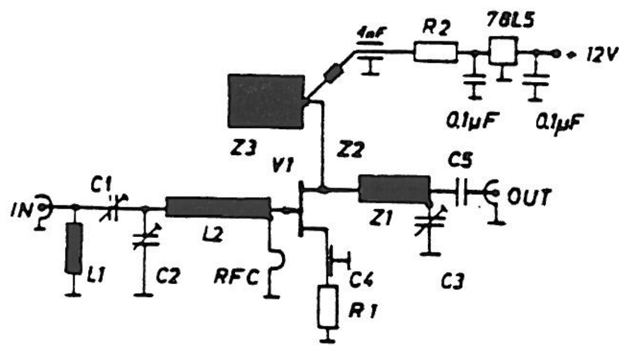
2.30 GaAsFet Preamp for 13 cm

Harold Fleckner DC8UG - May 1982

The Preamp is designed for the MGF 1400. It is built on a double copper clad PTFE substrate, 1.6 mm thick (RT5870). A noise figure of 1-2 dB can be achieved with a gain of 13 dB. Figure 2–22 shows the circuit, while Figure 2–23 shows the arrangement on the PCB. L1 is a wire not a printed line, because its length shall be variable to match the actual source impedance to the transistor input.

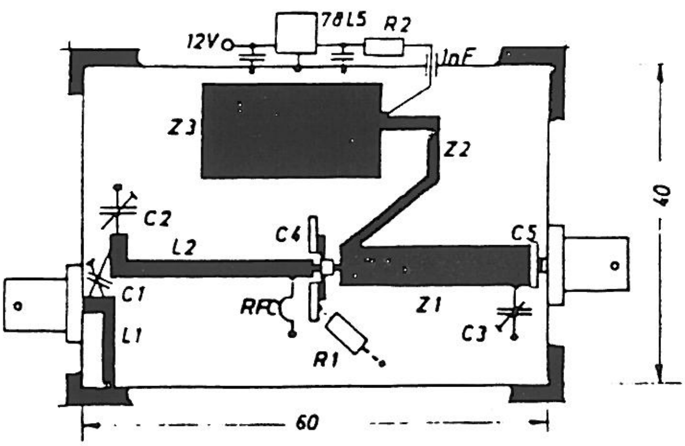
Use low inductive "Gigatrims" as trim capacitors. The disc capacitors are set into slots and soldered to the rear side of the PCB. The resistors R1 and R2 are chosen so that a current of 10-15 mA at a drain source voltage of 3 V will flow (approx. 100 and 150 ohm).

Figure 2–22: GaAsFet Preamp for 13 cm




```
L1  = Wire, 1.2mm diam. 10...15mm long
L2  = Printed inductance Z=90 Ohm
Z1  = Quarterwave line, Z=50 Ohm w=4.2mm
Z2  = Quarterwave line, Z=100 Ohm w=1.2mm
Z3  = Quarterwave line, Z=25 Ohm w=12mm
C1  = 0.5...5 pF, C2=C3 =  0.3...3pF, C4=2x100pF disc, C5=30pF
RFC = Choke 1.5 turns on 3mm diam. rod, wire 0.3mm diam.
```

Figure 2–23: Circuit board layout 13cm Preamp



2.31 Wide Band Noise Source

Manfred Ploetz DL7YC - September 1982

Figure 2–24 shows a wide band noise source which is measured to be usable from 1 MHz up to 12.4 MHz. All dimensions presented in the diagram are in millimetres.

2.32 G4COM Noise Meter Notes

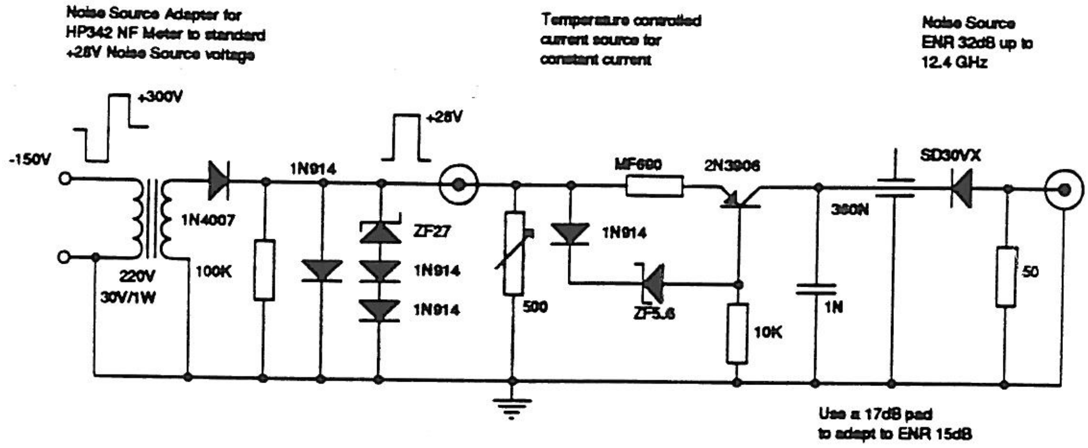
Peter Carey Z25JJ - May 1983

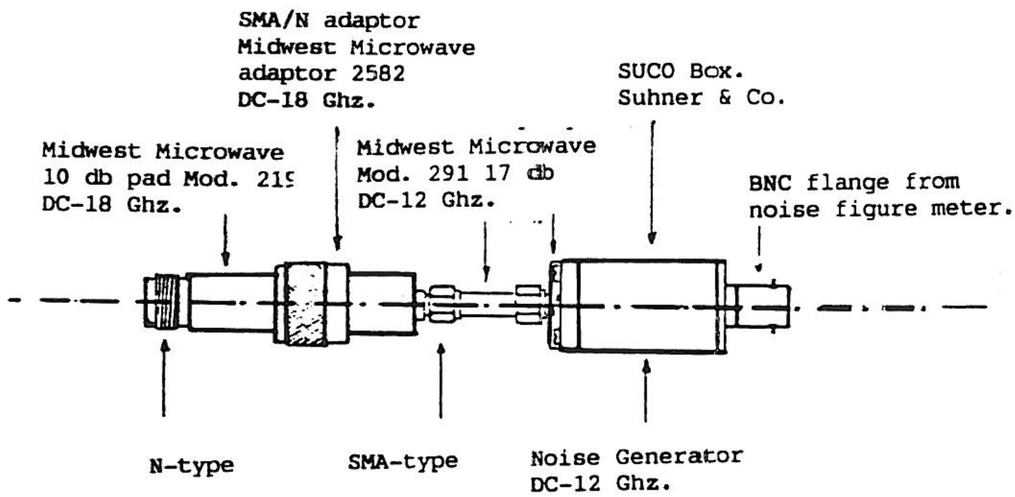
The following material refers to the G4COM HB noise comparator but the idea can be applied to any automatic noise figure measurement gear.

For some time, the inability to optimise an EME receiving system in situ at the antenna has been of concern. Granted, it is possible to do this under laboratory conditions and no doubt very impressive results are often obtained but what is the true picture when the antenna is connected? Can one really accept that the antenna impedance is identical with that of the noise figure instrument? With a different impedance across the input of the first pre- amplifier, there is no doubt that the superb performance may not have been maintained.

Ideally, therefore, after a complete system has been laboratory checked, it should be rechecked in situ at the antenna. A method for doing this has fortunately been made possible by a Britisch amateur G4COM whose brilliant "Noise Factor Comparator" is being used by more and more moonbouncers, particularly on 23 cm. At 23 cm the original noise head is not efficient and so the following circuit Figure 2–25 is suggested, which is capable of noise output in excess of 25 dB. For obvious reasons the noise head must be compatible with the G4COM comparator. Instead of using a 1N21 noise diode, the emitter base junction of a silicon NPN transistor MRF904 is reversed biased and supplied by a 9 Volt transistor battery. A PNP transistor is used to amplify the square wave generated in the noise comparator itself.

Figure 2–24: DL7YC Wide Band Noise Source





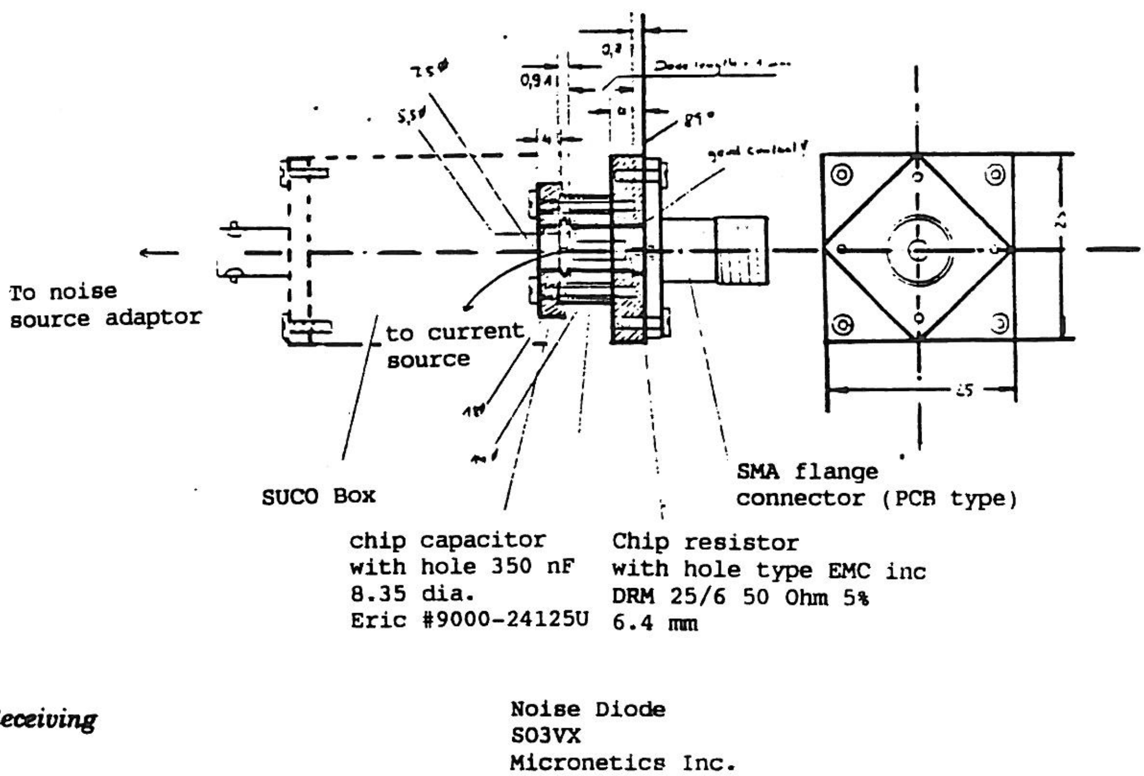
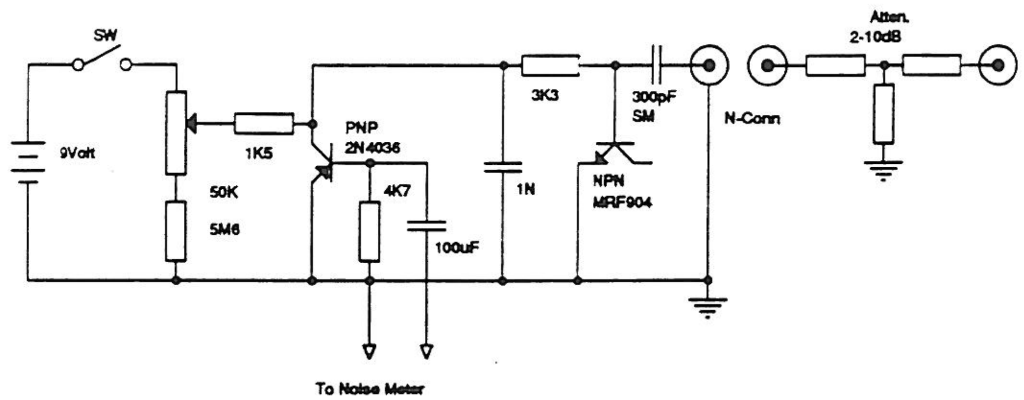


Figure 2–25: Modified G4COM Noise Head



Just about any PNP low power transistor will work in the circuit and the 2N918 may be used instead of the MRF904 but its output may be excessively high and uncontrollable. If the square wave input from the comparator is switched "off" the noise head takes over as an ordinary noise source. To carry out the optimisation test at the antenna, the following conditions are necessary:

- The main station receiver output should be available at the antenna to inject into the comparator.
- The receiver AGC should be off and the RF gain controls set at a level compatible with the comparator and at a low level to achieve linearity.
- The receiver BFO should be off.
- The noise head should be connected to a feed antenna via a precision attenuator.

In the case of the W2IMU horn, the transmit port is ideal for this purpose but the max isolation between TX and RX should not be altered by offsetting the nulling screw in order to get sufficient noise into the RX port to make the comparator work properly. In case of a yagi, a dipole should be placed near the antenna itself so as to obtain sufficient noise input. It is important that no changes are made to the antenna impedance across the first Preamp, in other words, the Preamp should be optimised in situ. In the case of the K3BPP array for 432 MHz, noise may be injected into one pair of dipoles, while the other is connected to the first Preamp.

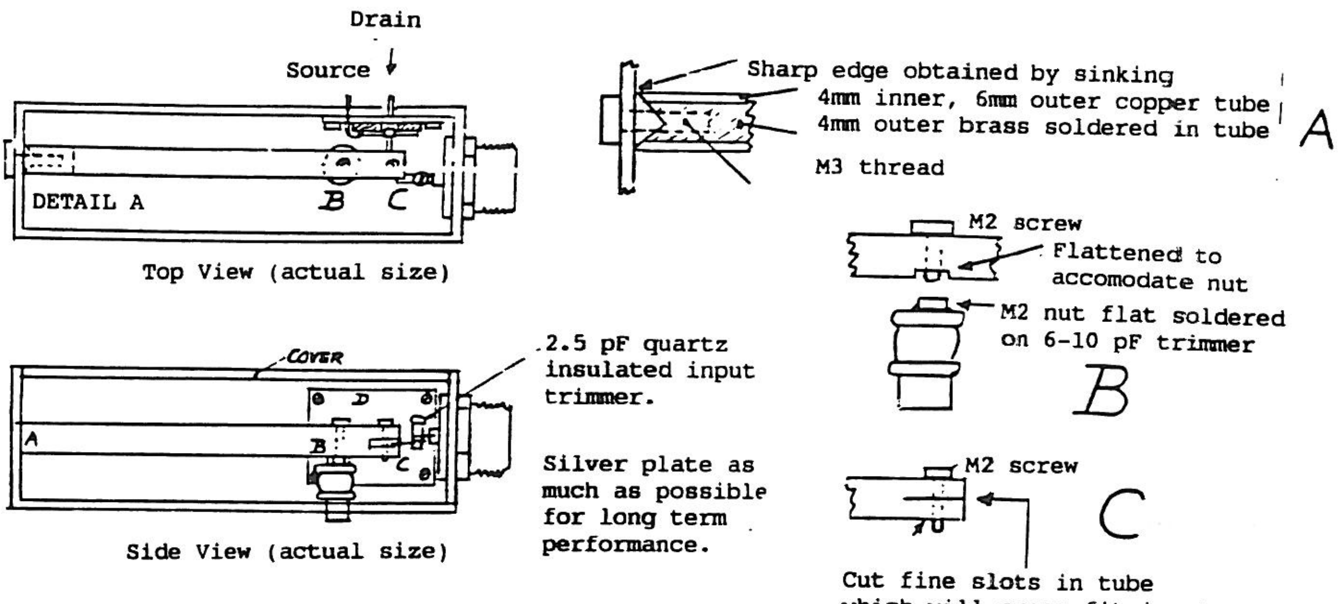
Having satisfied these basic conditions the noise factor comparator should be adjusted (for this information reference should be made to the RSGB RadCom handbook). As the first Preamp's input capacitance and tuning across its gate-source junction are adjusted for maximum meter indication on the comparator which corresponds to the best noise performance of the system, ground noise contribution may tend to blur or mask the max point on the meter. If this is a problem, then the antenna should be elevated a few degrees or so as to move out of the area of ground noise contribution. Ofcourse, it is accepted, that the more modern Preamps may not have facilities for changing the input tuning, in this case the method is negated. At ZS5JJ, ground noise contribution was not a problem. Measured ground noise increased from 2.5 to 3.8 dB above cold sky and solar noise remained essentially the same at 22 to 24 dB. Overall the system is better and the method was well worth the effort. The method is strongly recommended since it can be regarded as the ultimate-be-it 144, 220, 432 & 1296 MHz.

2.33 432 MHz GaAsFet Input Circuit

Jan Bruinier DL9KR - August 1983

This nearly solderless design yields noise figures typically 0.1- 0.15 dB lower than a well built JA6CZD design.

Figure 2–26: DL9KR 432 MHz GaAsFet Input Circuit



2.34 GaAsFet Burn-Out Note

Allen Katz K2UYH - November 1983

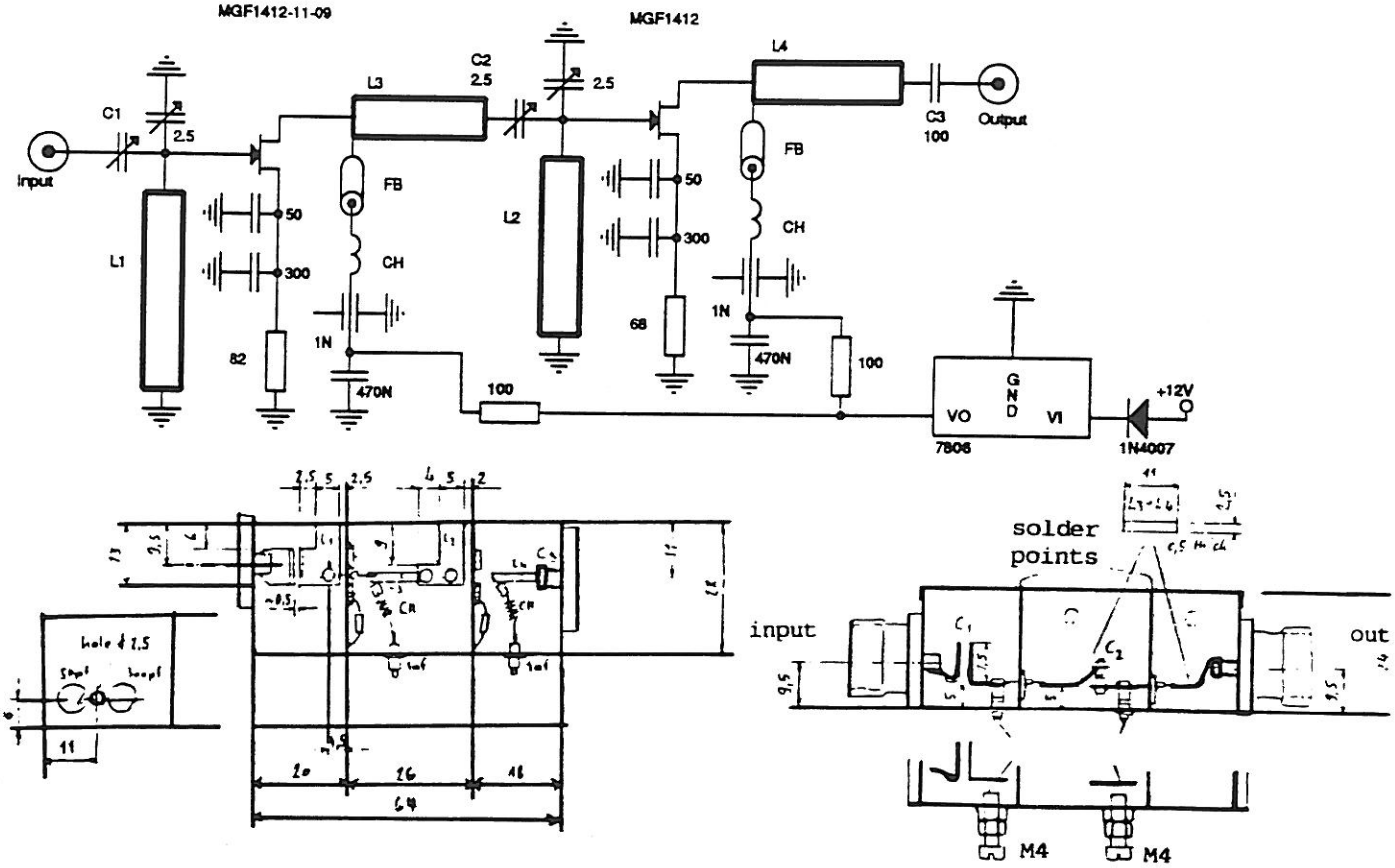
Those interested in what it takes to blow out a GaAsFet with RF should refer to the article "X-band Burnout Characteristics of GaAs-MesFet's" in the Dec. 82 IEEE MTT transactions (page 2206). Among other things it is concluded that NF and gain DO NOT gradually degrade and that it takes 1.5 to 3 W to burnout an AU (gold) metalized Fet at 10GHz, slight less is required for the AL variety (about 1 W)! It seems reasonable to assume that similar figures would apply for burnout at lower frequencies. This supports my own observations that it takes quite a bit of power to destroy a GaAsFet. It is not the power that blows them as much as it is DC voltage transients.

2.35 2300 MHz Preamp

Peter Riml OE9PMJ (OE9XXI) - March 1984

The Preamp in Figure 2–27 measures a noise figure lower than 0.6 dB on 2300 MHz with an associated gain of 32 dB. The case is made completely out of brass sheet, while the striplines are made of silver plated copper sheet. All dimensions are in millimetres. The chokes are 7 turns of emailled 0.3mm wire on a 3 mm rod. For the trimmers Peter suggests 2.5 pF Quarz trimmers or selfmade with a couple of M4 bolds. As devices the MGF1412, MGF1411 and MGF1409 can be used for the first stage.

Figure 2–27: OE9PMJ 2300 MHz Preamp



2.36 Modifications to the W6PO Type 1296 MHz PreAmp

Dave Mascaro WA3JUF - May 1984

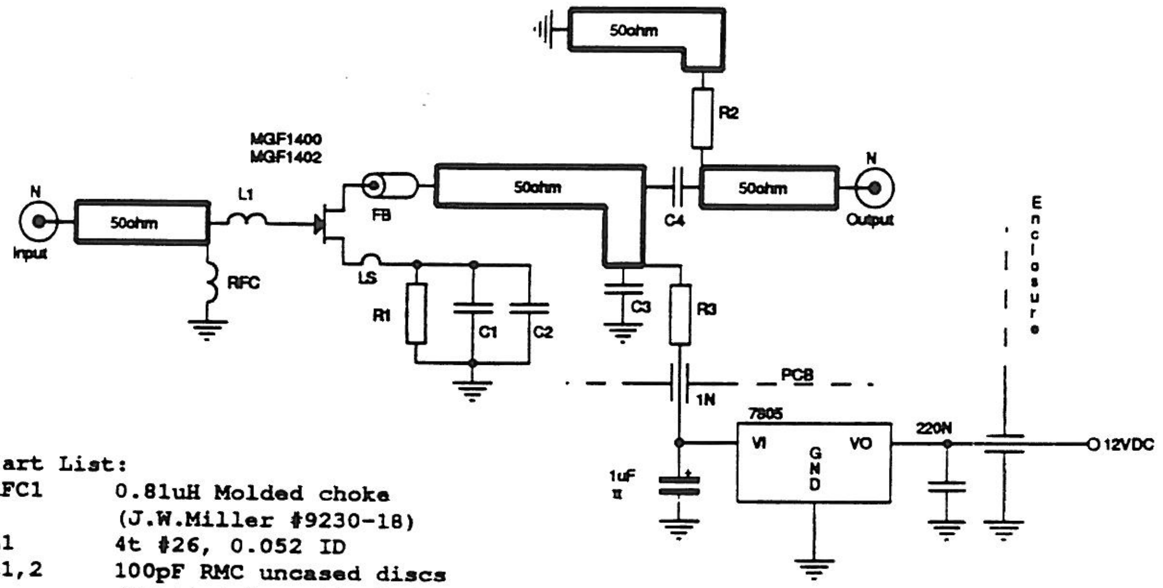
Figure 2–28 shows the modifications WA3JUF is using with the W6PO 1296 MHz PreAmp. Dave reports to have good results with it.

2.37 A W6PO Style Preamplifier for 2304 MHz

Jim Davey WA8NLC/4 - February 1986

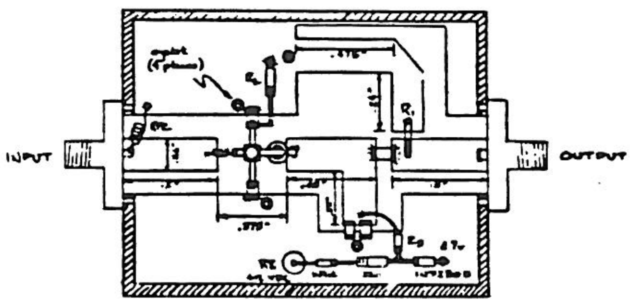
The board is 1/16" double sided PTFE with Er=2.55. All microstrips are 50 ohm, 0.166" wide. The input coil in series with gate is 2 1/2 turns #26e, 0.052 ID closewound. Experiment 1/2 turn at a time to find a good tuning range. Tack solder to gate lead for a temporary short to ground before removing the coil. Chip caps are 10pF porcelain, by Dielectric Labs. Stud additionally bypassed with 0.001 chip cap. (Chip caps are available from Microwave Components of Michigan, 11216 Cape cod, Taylor, MI 48180.) Wrap all edges of board with shim or copper foil and solder top and bottom. Adhesive-backed copper foil available from hobby shops carrying stained glass supplies works great. The circuit was designed for a NE673 GaAsFet although other popular devices should perform equally well: MGF1402, MGF1412, NE710, etc. Without further gate coil adjustment, the Preamp measured 0.74 dB NF with over 15 dB gain at the 1985 1296/2304 Conference, Estes park, CO. Before construction, reference should be made to GaAsFet Preamps for 902 MHz and 1296 MHz by W6PO, Eimac EME notes AS-49-36

Figure 2–28: Modifications to the W6PO Type 1296 MHz Preamp




```
Part List:
RFC1      0.81uH Molded choke
          (J.W.Miller #9230-18)
L1        4t #26, 0.052 ID
C1,2      100pF RMC uncased discs
          (Applied invention) (mount device with LS=3/4 of lead
          length)
C3,4      100pF chip caps (ATC or Vitramon)
          Ceramic caps preferred
R1        68 ohm. (68-100 ohm)
R2        51 ohm 1/8 with no lead length
          (cut slot in board for R2)
R3        68 ohm (68-100 ohm)
```

Figure 2–29: A W6PO Style Preamplifier for 2304




```
RFC= 5t #26 enamelled 1/8" ID
R1 = 51 ohm, 1/8 W carbon comp.
R2 = 68 ohm, adjust for Id = 10mA
Toroid core over drain lead: T12-6
Input and output connectors: SMA
R3 = 100 ohm, adjust for Vds=3V
```

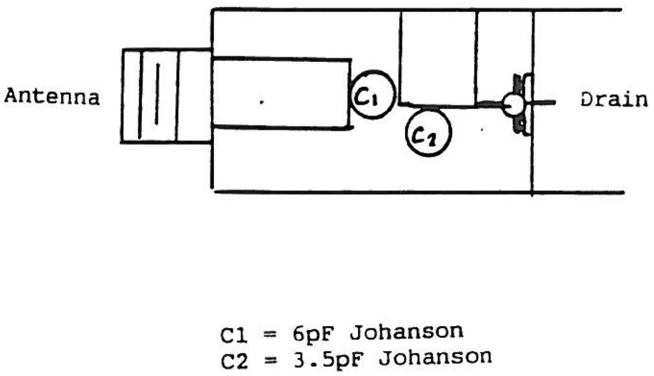
```
Zener = 4.7V
O = small brass eyelet
FT = 500-1000pF
D1 = 1N914
```

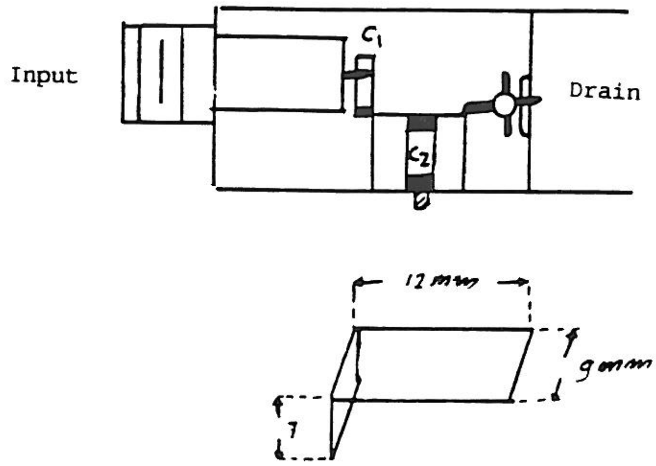
2.38 F2TU 1296 MHz Preamp Input Circuit

Philippe Pierat F2TU - February 1986

With the old device Philippe had about 14 dB of sunnoise and 3.7 dB of ground to cold sky noise. With the input circuit in Figure 2–30, which holds a NE750, he is getting quite an improvement. Philippe now measures 16 dB Sunnoise and 4.85 dB groundnoise.

Figure 2–30: F2TU 1296 MHz Preamp Input Circuit





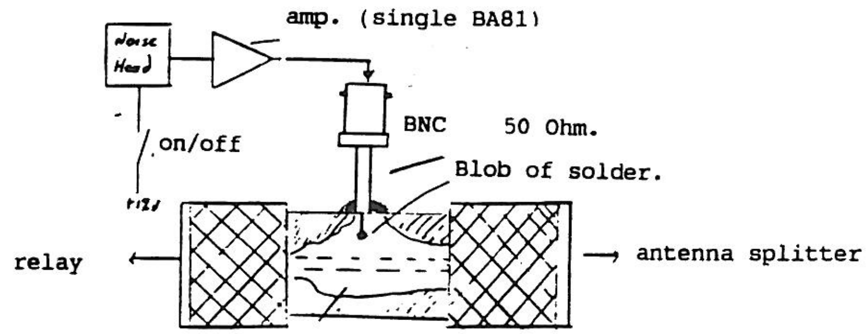
2.39 Coupler To Inject Noise Into Yagi Systems

John Shorland ZL2AQE - June 1987

A method to tune Preamps at the antenna, as described by ZL2AQE in the May/June Newsletter 1987.

1. Point array at 45° elevation.
2. Use the coupler to inject noise in the feedline between the Preamp and the antenna.
3. Use a G4COM noise meter with a cable from the shack to tune for maximum difference between "ON" and "OFF" stages.
4. When not in use, the coupler can work as a power monitor, just by connecting the diode to the coupler.

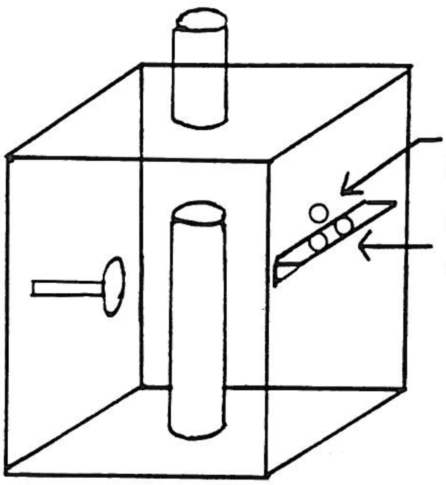
Figure 2-31: ZL2AQE Noise Injection Coupler



432 Mhz. 25-30 db. probe.

Any type of N or even into the
middle of the first power splitter

Figure 2-32: Modification to G3WDG's 1296 Preamp



Output box is not shown.

G3LTF believes the improvement to be 3/4 to 1 db over the normal.

2.40 Modified G3WDG 1296 MHz PreAmp

Peter Blair G3LTF - September 1987

This modification suggests to put the 2 x 200 pF disk capacitors as close as possible to the used device and to the wall of the input cavity. G3LTF estimated an improvement of 3/4-1 dB above the normal performance of the original design.

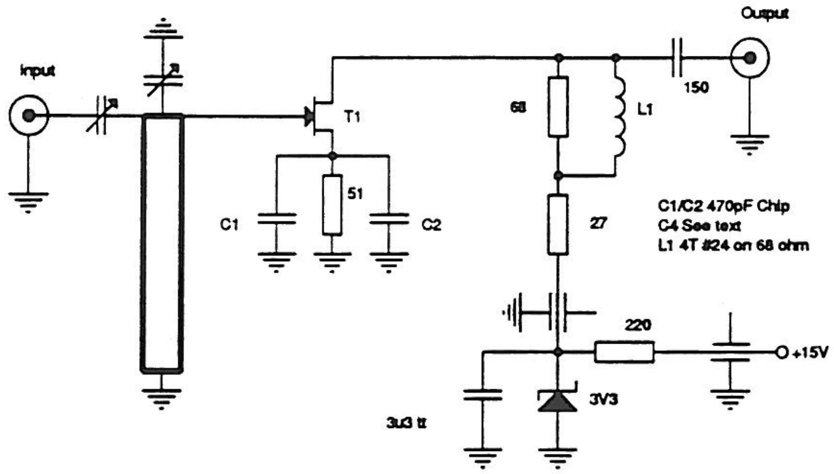
2.41 Solderless 23cm Preamp

Rusty Holshouser K4QIF - October 1987

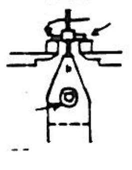
Noise figure and gain were measured using the HP 8970 noise figure meter and a HP 346A noise source with an ENR of 4.95 dB.

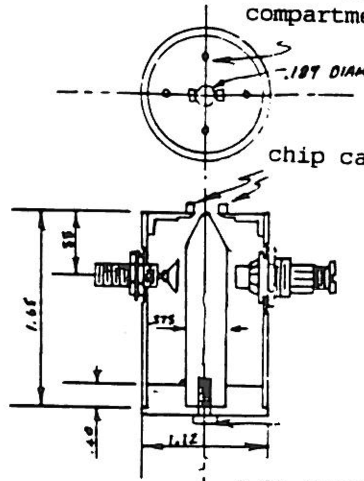
- Frequency 1296 MHz
- Noise figure 0.28 dB
- Gain 18.5 dB
- Device NE045

The outer conductor of the coaxial input circuit is made from 1" copper water pipe. The inner conductor is made from 3/9" brass rod. The end caps are machined from brass to press fit together. All parts are silver plated before assembly. Tight tolerances must be followed since it is very desirable not to use any lead solder in the input cavity.



Fet mounting.
Center conductor slotted to accept gate lead. Cap screw is tighted to secure fet.





C1,C2	470pf chip
C3	3,3 uF tantalum
C4	see text
L1	4T#24 on 68 Ohm resistor

The input tuning capacitor was made from the centre of a piston trimmer. The centre of the piston was filled with solder and sanded flat to provide a tuning surface. The input capacitor is a 5/16" dia. disc soldered to the centre conductor of a threaded SMA conductor. One of the connector mounting nuts is sweated to the outer wall of the cavity and the other nut is used to lock the position of the input capacitor.

2.42 70cm Cavity Preamp

Hubert Hammerle OE9HHV - June 1988

This Preamp design is a variant on similar designs, published before, but has no commercial made capacitors in the input circuit and is therefore a cheap way to make a low noise Preamp. The input capacitor is made from flashing copper and can be adjusted by means of the Teflon screw. The tuning capacitor is made out of an M6 screw which is screwed in and out of the input coil L1. Grounding of L1 should be done carefully by sharping the end providing a lowloss ground path.

The gate of the Fet (2SK406) is attached to the input line by a M2 screw. Care must taken that the gate screw doesn't touches the tuning screw M6. Mechanical construction details are shown in Figure 2–34.

2.43 Tunable Preamp for the 1.2 - 2.5 GHz Range

Paul Chominski SM0PYP - July 1988

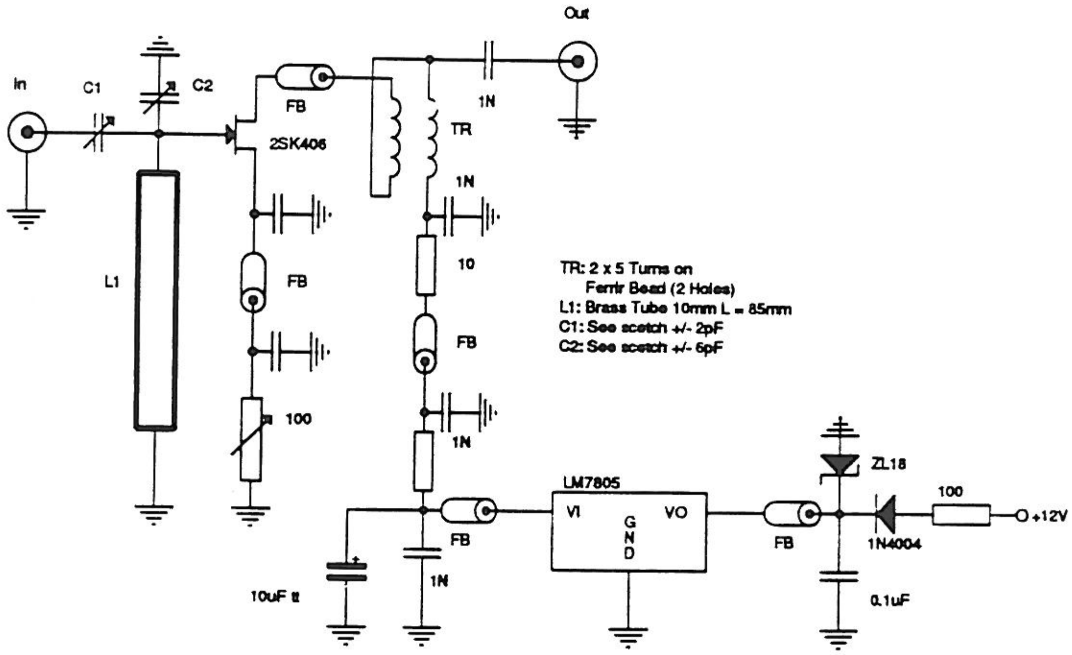
This Preamplifier was developed mainly for the "magic frequencies" of the "water hole" in the range of 1.4 to 1.7 GHz for the SETI project (Search for Extra Terrestial Intelligence). The frequencies of interest are 1420 MHz (Hydrogen) and 1662 MHz (Hydroxylion). The amplifiers cover 1.2 GHz up to 2.5 GHz. Noise temperature was measured by using cold sky to ground method with the feed horn type W2IMU located on the dish of f/D=0.44. Using GaAsFet 2SK280 Cold Sky to Ground on 1296 MHz is 4.7 dB and on 2304 MHz 3.5 dB. The results on 2304 was the same as by using the SM6FHZ design with serial inductance to the gate, inductance in the source for negative feedback and matched output of the transistor, but the gain was abt. 3 dB higher. Described design was based on the previous 1296 MHz G3WDG design. This Preamplifier was used as a first stage on 2304 MHz during QSO with W3IWI/8.

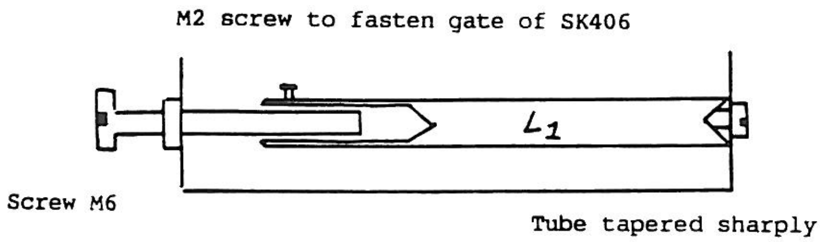
2.44 432 MHz Preamp and Change-over Box

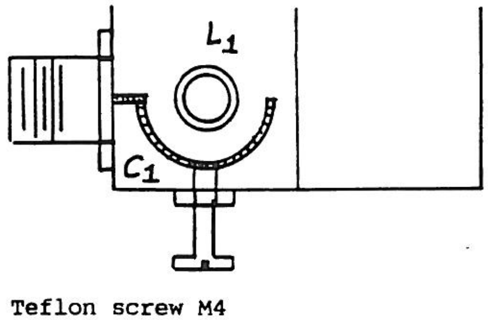
Paul Chominski SM0PYP - September 1988

Results obtained at SM0PYP with this Preamp and 4x8λ DL9KR Yagis: Cold Sky ground: 5 dB +/- 0.2 and Sun noise 12.5 dB +/- 0.5 (average Sun noise 1988) The system has no Cable between Preamp and coaxrelay (HF400). N-connector fits directly on Preamp. The feeding of the Yagis is done with open wire feedline, which is matched by using a 240 to 50 ohm balun which is shown in Figure 2–37.

Figure 2–34: OE9HHV 432 Mhz Preamp







TR 2 times 5 turns
bifilar on FB (2 holes)
L1 brass tube 10mm dia.
85mm long
C1 see scetch abt. 2pf
C2 see scetch abt. 6pf

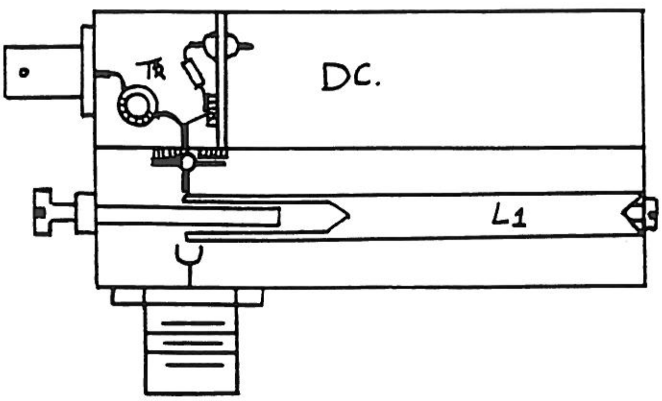


Figure 2–35: Tunable Preamp for the 1.2-2.5 GHz Range

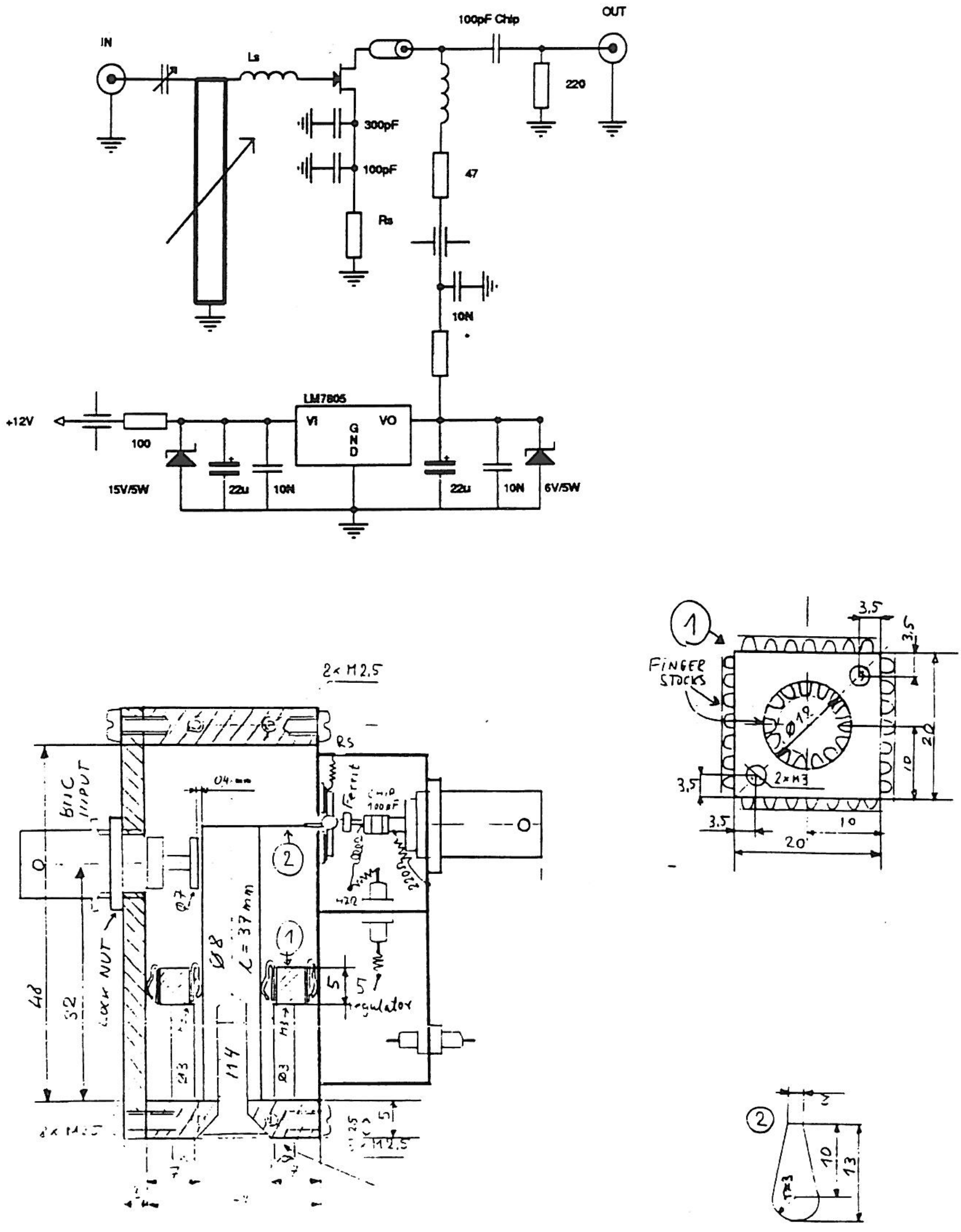
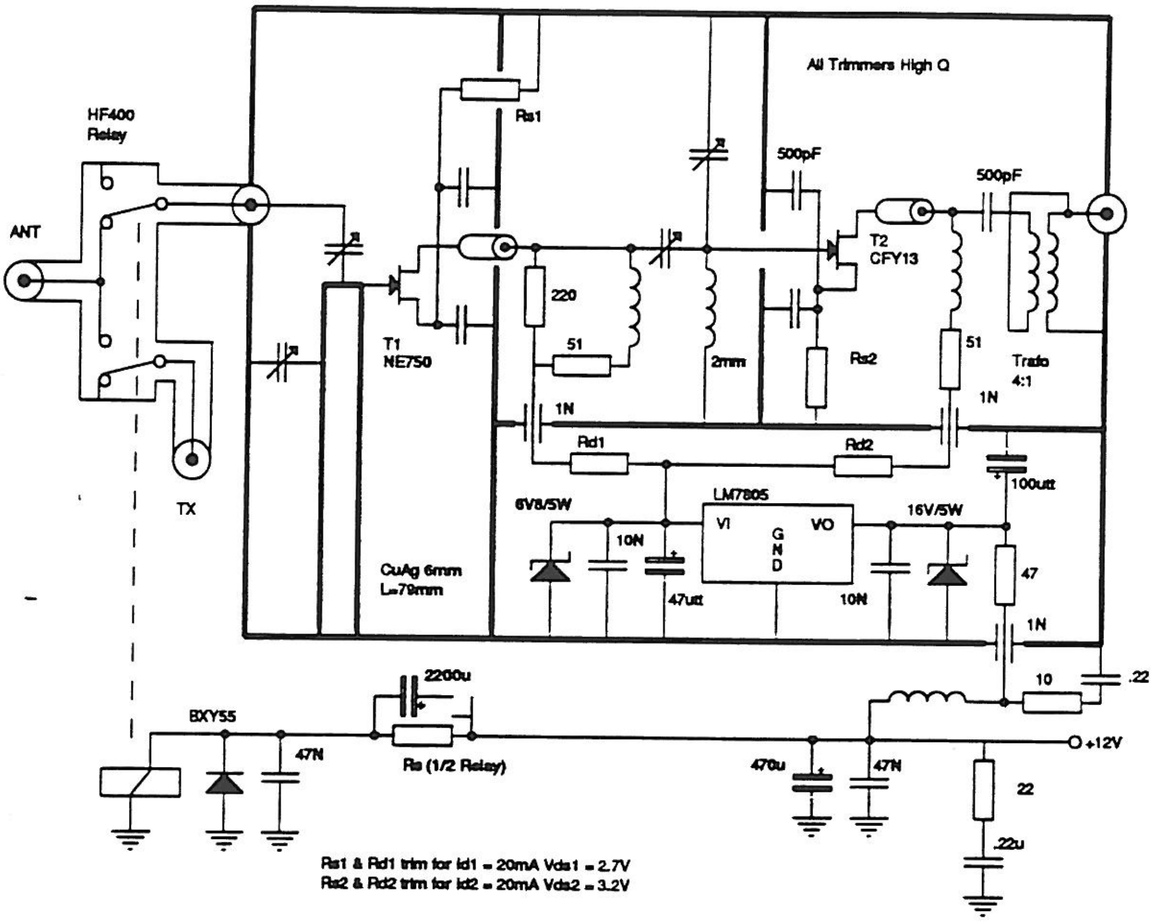


Figure 2–36: 432 MHz Preamp and Change-Over Box



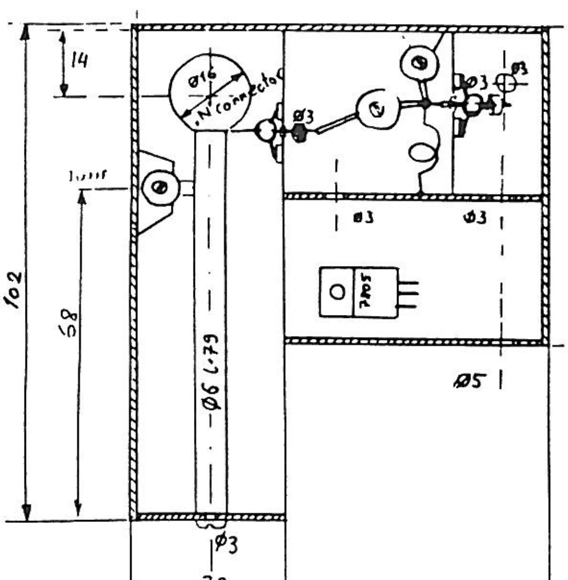
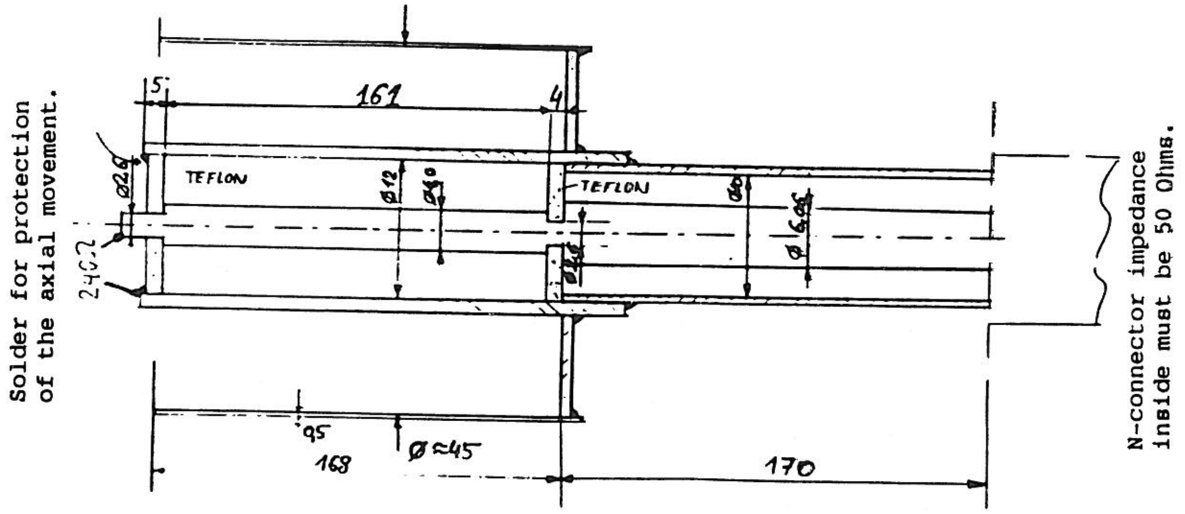


Figure 2–37: **240 / 50 ohm Balun**

Materials: Teflon,
Brass silver plated

Purpose: To match 4xDL9KR with open
wire and the preamp box.



Section at Z1=65,8 Ohm.   Section at Z2=30,05 Ohm.

2.45 Noise Figure Measurement at the Thorn EME Conference

Rainer Bertelsmeier DJ9BV - October 1988

2.45.1 Measurement Setup

2.45.1.1 Equipment

Noise Source: AIL7615 (S/N:4044) with Isolator
432 MHz: Isolation: 26 dB; $|S_{22}|$=0.045; Loss = 0.26 dB; ENR = 15.8 dB
1296 MHz: Isolation: 50 dB; $|S_{22}|$=0.051; Loss = 0.25 dB; ENR = 15.4 dB

PANFI: HP8970B
432 MHz: Front-End-LNA + Isolator (System Noise Figure = 1.2 dB)
1296 MHz: Solo (System Noise Figure = 6.9 dB)

Relative Accuracy: ±0.05 dB typ. / ±0.13 dB max.
Absolute Accuracy: ±0.16 dB typ. / ±0.48 dB max.

2.45.1.2 ENR-Calibration

Five different noise sources have been used on 432 MHz to establish a picture of differences in ENR-Calibration.

Type	Serial-No.	Nominal ENR [dB]	Real ENR: Difference [dB]
AIL7615	4044	15.8	0.0(Reference!)
AIL7615	5212	15.5	-0.22
HP346B	2037A00657	15.46	-0.06
HP346B	2037A0081	15.53	0.0
HP346A	2614A01287	5.30	-0.03

The same picture holds for 1296 MHz.

2.45.1.3 Environment Conditions

Place: Thorn, The Netherlands
Temperature: 20.0 - 22.4 °C (Corrected in PANFI)
Date: 11 th of September, 1988
Responsible: DJ9BV

Table 2–1: Noise Figure Measurement at the Thorn EME Conference

Measured Noise Figures on 432 MHz (Sorted in ascending order of M+1-Value)								
Claims					Measurements			
Owner	Manuf./Type	Design	Device	NF [dB]	NF [dB]	Gain [dB]	M+1 † [dB]	Remarks
DJ9BV	DJ9BV/Z-1302-2	DJ9BV	MGF1302	0.35	0.28	20.0	0.283	HB
DJ9BV	DJ9BV/Z-101-1	DJ9BV	ATF10135	0.35	0.28	18.0	0.284	HB
DJ9BV	DJ9BV/Z-1302-1	DJ9BV	MGF1302	0.35	0.29	19.6	0.293	HB
PA3AEF	PA3AEF	PA3AEF	MGF1302	?	0.32	23.3	0.321	HB
DL9KR	DL9KR	DL9KR	NE75083	0.4	0.34	44.0	0.34	HB
DJ9BV	DJ9BV/Z-750-1	DJ9BV	NE75083	0.42	0.34	19.7	0.344	HB
DJ9BV	DJ9BV/Z-1402-1	DJ9BV	MGF1402	0.4	0.34	18.8	0.344	HB
I5TDJ	I5TDJ	I5TDJ	2SK571	0.5	0.36	20.8	0.363	HB
DL9KR	DL9KR	DL9KR	NE20283	0.42	0.37	46.4	0.37	HB
SM4GVF	SM4GVF	SM4GVF	MGF1402	0.3	0.38	19.3	0.384	HB
DJ9BV	DJ9BV/Y-2	DJ9BV	NE75083	0.42	0.40	17.2	0.407	HB
LA8AE	SSB/DX432-01	JA6CZD-SSB	MGF1302	0.3	0.40	16.0	0.410	CT
SSB-Electr.	SSB/DX432-01	JA6CZD-SSB	MGF1302	0.3	0.41	21.2	0.413	C
DC3XY	DC3XY	DJ9BV	2SK571	?	0.41	17.6	0.417	HB
SM0PYP	SM0PYP	SM0PYP	NE75083	?	0.43	44.4	0.43	HB
YU1IQ	SSB/DX432-01	JA6CZD-SSB	MGF1303	0.3	0.43	20.0	0.434	C
DL7WX	SSB/DX432-01	JA6CZD-SSB	MGF1412	0.3	0.50	22.2	0.503	C
DC9KK	DJ9BV	DJ9BV	2SK578	0.55	0.50	19.5	0.505	HB
PA3AEF	PA3AEF	PA3AEF	MGF1302	?	0.50	18.0	0.508	HB
PA3DZL	PA3DZL	JA6CZD	MGF1402	0.50	0.56	20.4	0.565	HB
PA3DZL	PA3DZL	JA6CZD	2SK571	0.50	0.61	21.6	0.614	HB
LA8AE	LABE	LABE	MGF1202	0.8	0.90	19.3	0.910	C
YU1IQ	ARR/SP432VDG	ARR	MGF1402	0.50	0.90	14.4	0.931	C
PA3DZL	SSB/DX432A ?	SSB	MGF1402	0.70	0.90	14.2	0.932	CM
PA3AEF	PA3AEF	JA6CZD	MGF1501	0.6	1.27	14.5	1.310	HB
PA3CSG	PA3CSG	PA3CSG	?	?	1.43	12.3	1.506	HB
Measured Noise Figures on 1296 MHz								
DJ6MB	DJ6MB	SSB	NE75083	0.7	0.50	18.4	0.507	HB
VE4MA	VE4MA	VE4MA	NE71084	0.49	0.52	36.2	0.52	HB
DF7VX	SSB/DX1296-S/New	SSB	MGF14027	0.50	0.53	22.8	0.533	C
DJ9BV	DJ9BV	DJ9BV	2SK569	?	0.72	15.4	0.74	HB
SM4GVF	SM4GVF	SM4GVF	MGF1402	0.4	0.76	16.4	0.776	HB
DC3XY	DC3XY	DC3XY	CFY13	0.7	0.76	15.8	0.779	HB
PA3DZL	SSB/DX1296-S/Old	SSB	MGF1412	0.5	0.82	16.3	0.838	C
DK0IK	SSB/DX1296/Old	SSB	MGF1400	0.8	0.97	17.2	0.987	C
PE1KXH	PE1KXH	DD9DU	MGF1302	1.0	1.0	10.5	1.087	HB
PA3CSG	PA3CSG	SSB	MGF1400	?	1.48	10.9	1.59	HB
PA3DZL	PA3DZL	PA3DZL	MGF1402	1.0	1.65	12.1	1.739	HB
DF9CY	DF9CY	DF9CY	MGF1402	3.0	2.9	10.2	3.118	HB
YU1IQ	SSB/DX1296-S/Old	SSB	MGF1402	0.5	??	Oscill.	??	C

Remarks:

C: Commercial entry, original condition

CT: Commercial entry, retuned

CM: Commercial entry, modified and retuned

HB: Home built

† $M = \frac{F-1}{1-\frac{1}{G}}$

2.45.2 Comments

2.45.2.1 70 cm Measurements

1. Quality of design

   The JA6CZD design - beside the fact that it leads to instability even for 50 Ohms load impedance - is about 0.15 dB worse in noise figure than designs with High-Q input circuits with the same type of device used.

2. Quality of devices

   The MGF1302 apparantly is the first choice for the transistor and gives a very good cost/performance ratio. Suspected 'good' devices like the NE75083 are inferiour on 432 MHz but better on 1296 MHz.

2.45.2.2 23 cm Measurements

1. Quality of design

   The old DJ8QL-design (PI-Circuit with stripline) is still going strong, but has problems with stability ($K < 1$). The DC8UG-design, which incorporates lossless source feedback, is used for the input stage of the SSB-DX1296-S and delivers a good noise figure. VE4MA uses high-Q quarter wave air lines in the input and achieves a good noise figure with a medium quality device.

2. Quality of devices

   The NE75083 seems to be very good device on 23 cm. The MGF1402/1412 variety seems to be second to this. But the low number of preamps in this group prevents further judgements.

2.45.2.3 Quality of claims

Concerning the claims of commercial preamps there is nearly always a difference between claim and results to the disadvantage of the buyer. To change this unprofessional attitude to data sheets and performance claims some proposals how to specify a commercial product follow:

1. On each preamp there should be a unique serial number and the type designation.
2. Each value for a quality feature in a data sheet should be specified:
   1. as a guaranteed value: Minimum or Maximum value dependent on what direction of better quality is expected - i.e. Maximum for noise figure, because the better quality is given by a small value or Minimum for gain, because the better value is given by a large value. The guaranteed value is what the customer buys and must be valid for all units in a series for which the data sheet is given.
   2. Optional a typical value can be specified for each feature. It should be the mean value of the stated feature for at least 100 units, so the statistical error for this mean value is less than 10 %. The typical value is what the customer hopes for and the producer whants to suggest.

3. The following quality features should be covered by the data sheet:

Sample Data Sheet: 432 Preamp YYY

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
Supply Voltage	V_{Sup}	Total Temp.Range	10	12	25	[Volts]
Ambient Temp.	T_A	—	-20	25	45	[°C]
Operating Frequency	F_{OP}	Total Temp.Range	430	435	440	[MHz]
Noise Figure	NF	F_{OP} = 435MHz	-	0.4	0.5	[dB]
Gain	G	F_{OP} = 435MHz	18	20	-	[dB]

4. Optional quality features for preamps are:

Parameter	Symbol	Condition	Min.	Typ.	Max.	Units
3 rd Order Intercpt. @ Input	IP_3	T_A = 25°C	-10	-5	—	[dBm]
Stability Factor ♣	K	T_A = 25°C	1.2	2.0	—	[dB]
Supply Current	I_{Sup}	T_A = 25°C	20	30	100	[mA]

♣ $K = \frac{1+|S_{11}\cdot S_{22}-S_{12}\cdot S_{21}|^2-|S_{11}|^2-|S_{22}|^2}{2\cdot|S_{12}\cdot S_{21}|}$

The third order intercept point should always be referenced to the input of a preamp, so nobody has to know the gain for calculating the input figure for comparison. The K-Factor tells, wether the preamp is unconditionally stable ($K > 1$) or not. If $K \leq 1$, the user must be aware of potential instabilities (oscillations) dependent on the actual load and source impedances.

2.46 A Two Stage 1296 MHz Preamp

Paul Chominski SM0PYP - March 1989

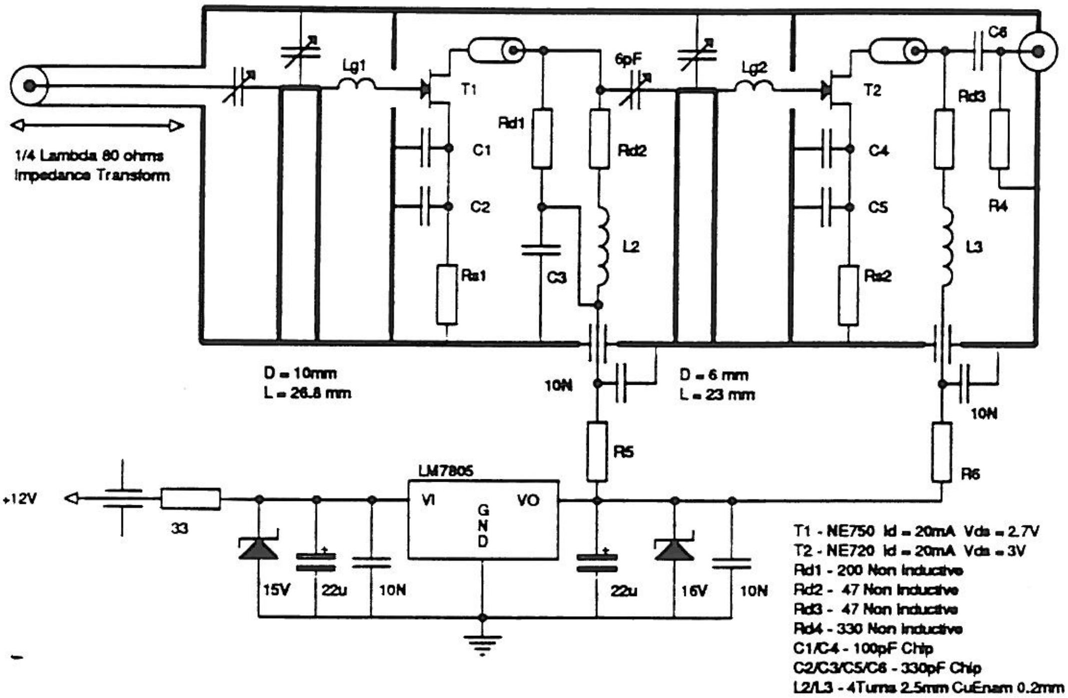
The Preamplifier in Figure 2–38 is based on a single stage G3WDG design. Devices which are used are a NE750 for the first stage and a NE720 for the second stage. The series inductors on the gates are made by 0.1 mm brass plates which are soldered on top of the resonators. After all soldering is done, both cavities are silver plated.

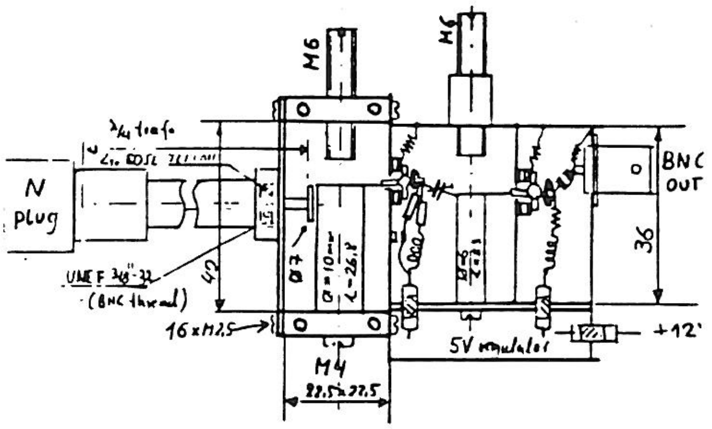
2.47 A Preamp Design For 2 Bands

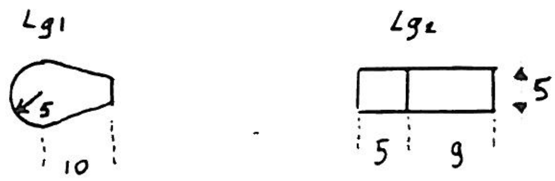
Jim Vogler WA7CJO - April 1989

Used devices are MGF1402, MGF1412 or similar. C1 is formed by a 0.375" diameter Cu. disk attached to the centre conductor of an SMA connector. C2 is similar to C1, except that it is attached to a brass flat head screw. R1 is adjusted to obtain the desired 8-15 mA drain current while R2 is selected to obtain a voltage at CR1 that is somewhat under the zener voltage. Construction details can be seen in Figure 2–39 and Table 2–2.

Figure 2–38: 2 Stage 1296 Preamp





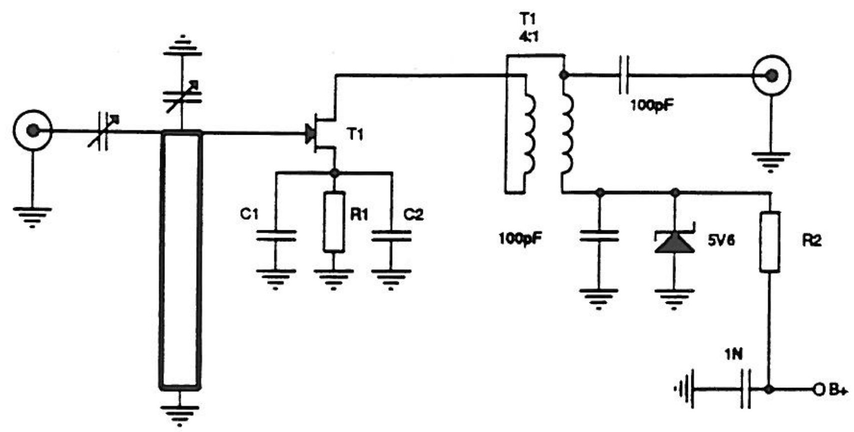


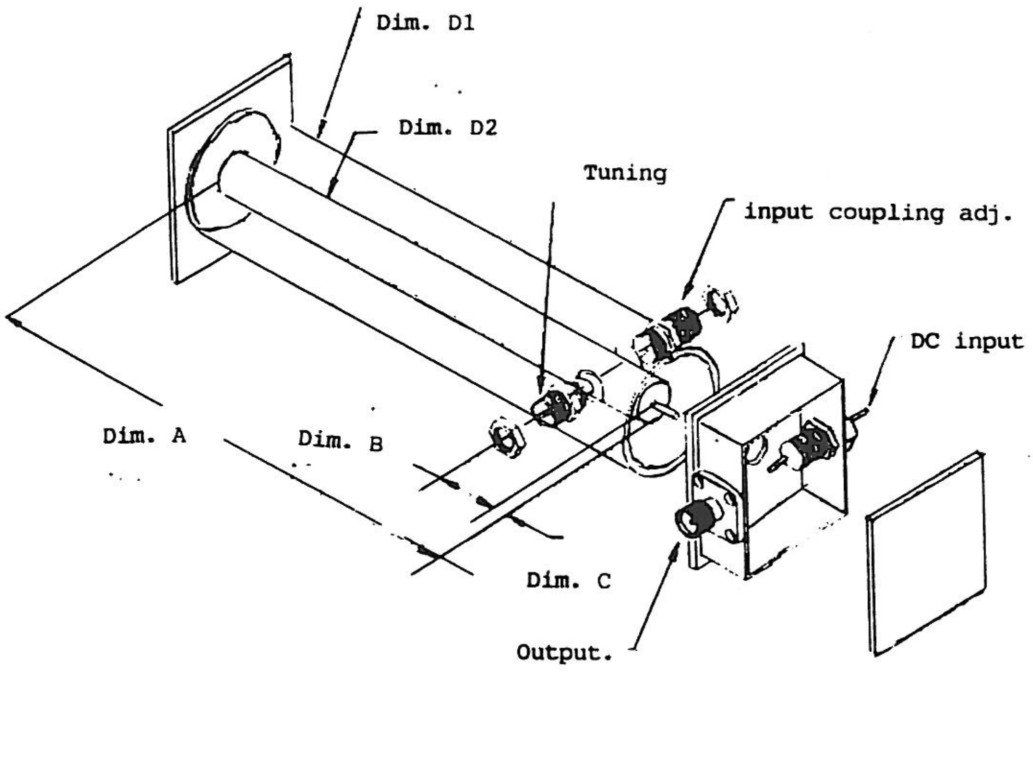
Brass 0.1mm
Soldered on top of the resonator
After all soldering both cavities are silver plat

Table 2–2: WA7CJO Preamp dimensions for different bands

Part	432 MHz	1296 MHz
A	5.00"	1.55"
B	0.50"	0.50"
C	0.10"	0.10"
D1	1.00"	1.00"
D2	0.375"	0.375"

Figure 2–39: A Preamp Design For 2 Bands





2.48 Peltier Cooled Preamp for 432MHz

Fumiaki Akahane JA0IXX - June 1989

Fumiaki gets a 22 to 25°K noise temperature without cooling and a 16 to 18°K noise temperature with cooling (as measured at the Nobeyama Radio Observatory). This corresponds to a 0.1 dB reduction in NF. With a single 15el. 3 wavelength yagi he measures 6.5 dB of Sunnoise and sees an increase in Groundnoise from 5.5 to 6 dB by cooling. He is using two stacked Peltier modules to achieve a temperature of -42°C. (231°K). Because of mechanical difficulties in cooling the whole Preamp, Fumiaki cools only the Fet and depends on the small lead size for thermal isolation. In the 1296 Preamplifier, we (K2UYH ed.) experimented with, we used a triple Peltier cooler. The more cooler sections, the lower thermal temperature and the lower the NF. A 5 section cooler would be very desirable. In our 1296 Preamp we cooled the whole amplifier and used air capacitors to thermally isolate the input and output from the box.

2.49 Noise Measurements at CSVHF

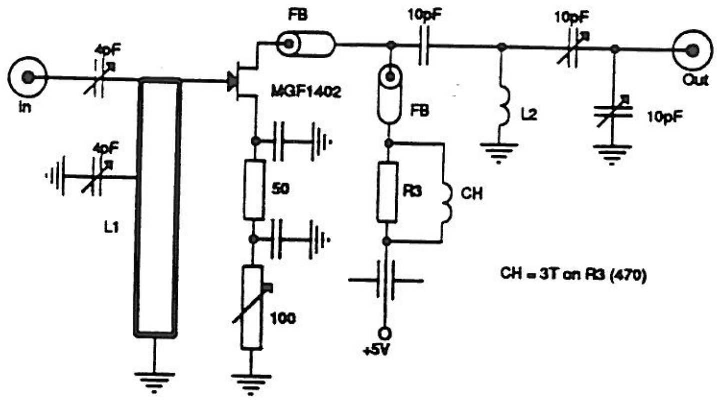
Allen Katz K2UYH - August 1989

Those who watched the 432 MHz NF measurements at the CSVHF conference learned that what had been reported at the Thorn EME conference (Section 2.45) was no fluke. The MGF1302's consistently turned in the lowest NF's. Most were in the 0.2 to 0.3 dB NF range (down to 14°K.)

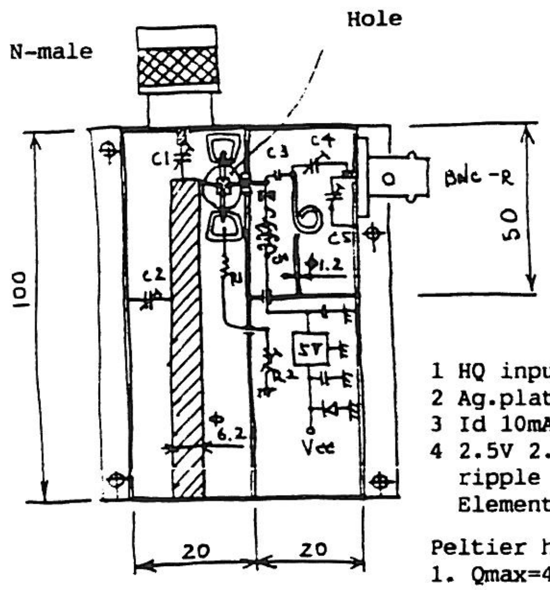
These low NF's raise the question as to how much of the NF is contributed by the device and how much by the matching circuitry? We measured the unloaded Q of a cavity similar to that described by WA7CJO in the April 89 Newsletter. We found that we had to space our probes more than half an inch from the top of the cavity to lightly couple into it. (trying to back out the input coaxial connector and couple in through it, yielded only a Q of 80). With loose coupling, we measured a Q of about 1100 see the graphs in Figure 2–41 and Figure 2–42. We next measured the Q of the Preamplifier in operation, which was near 10. The ratio of the loaded to unloaded Q yields a loss of about 0.075 dB which is significant for a Preamp with a 0.3 dB NF. about 30% of the NF is in this loss.

What does this mean? If the unloaded cavity Q could be increased to 2000 by silver plating and/or better mechanical construction the loss would be reduced to 0.05 dB a reduction of NF from say 0.3 to 0.275. Going to a large cavity with a Q of 10,000 would further reduce the NF to 0.24 dB. If an antenna noise of 30°K is assumed, these changes correspond to a system improvement of 0.16 dB, 0.38 dB and 0.68 dB respectively. If we compare these results to a 0.5 dB NF Preamp, again assuming a 30°K antenna temperature, the initial 0.3 dB Preamp would net a gain of 1.37 dB, and the better cavities 1.52 dB, 1.75 dB and 2 dB improvements. This exercise clearly shows why some stations hear better than others even though they appear to have equivalent antennas and good Preamps. Going to a cooled Preamp as shown in last month's Newsletter can reduce the device contribution to the NF but will not help with the cavity's contribution unless you also cool the cavity as we did with our 1296 design.

Figure 2–40: JA0IXX Peltier Cooled GaAsFet LNA



Mechanical layout

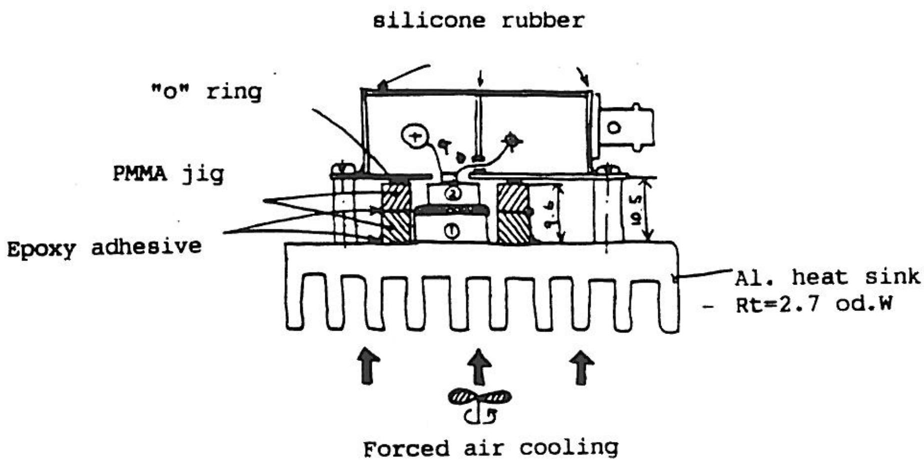


C 1,2 4pF
C 3,4,5 10pF
R 1 50 Ohm
R 2 100 Ohm
Ch 470 Ohm + 3 T

1 HQ input (DL9KR - SM0PYP)
2 Ag.plated 15 uM thickness
3 Id 10mA
4 2.5V 2.5A power supply with no
  ripple as nescesarry for Peltier
  Elements.

Peltier heat pump module:
1. Qmax=4.6W
2. Qmax=1.9W

:Cu plate th. 2.0



Notes:
1. It must be given of thermal grease between boundary surfaces.
2. "o" ring and epoxy adhesive are used to protect the GaAs fet against the frost flower caused by the solid state cooling.

Figure 2–41: 432 Mhz Unloaded cavity

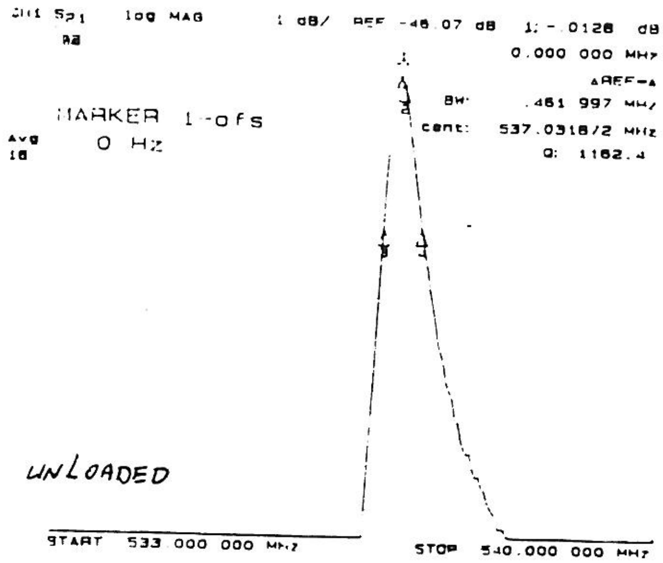


Figure 2–42: 432 MHz Loaded cavity with Preamp