5760 MHz Preamp

Simple and Cheap

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The recent Simple and Cheap 10 GHz preamp that WA1MBA and I developed has shown good performance and repeatability. Except for 5760 MHz, a good preamp for all the lower frequency cheap and simple transverters is my Unconditionally Stable VLNA[1] from 2023. The next obvious step is to try a 5760 MHz preamp using the same inexpensive device as 10 GHz.

The goal is a preamp that will considerably improve the 5760 MHz transverter, that can be built by anyone who can build the transverter, and cost around $10. Low cost is easier since most common components, including cheap SMA connectors, work fine at 5760 MHz.

Good Low Noise Amplifiers (LNA), often referred to as preamps by hams, are available, but at a cost of more than the whole transverter. The CE3512K2, rated at 0.3 dB NF at 12 GHz at a price under $3 works well at 10 GHz. Using the same design technique, I looked at the S-parameters and noise parameters, and then designed some PC boards that might work, using ordinary FR-4 type material for low cost. Rather than using the thinnest readily available boards, 0.6mm thick, I chose to use the more common and less expensive 0.8mm (1/32 inch) thick material. The first test board, with 50Ω lines, had a noise figure a bit over 2 dB – not as good as 10 GHz, so a better circuit is required.

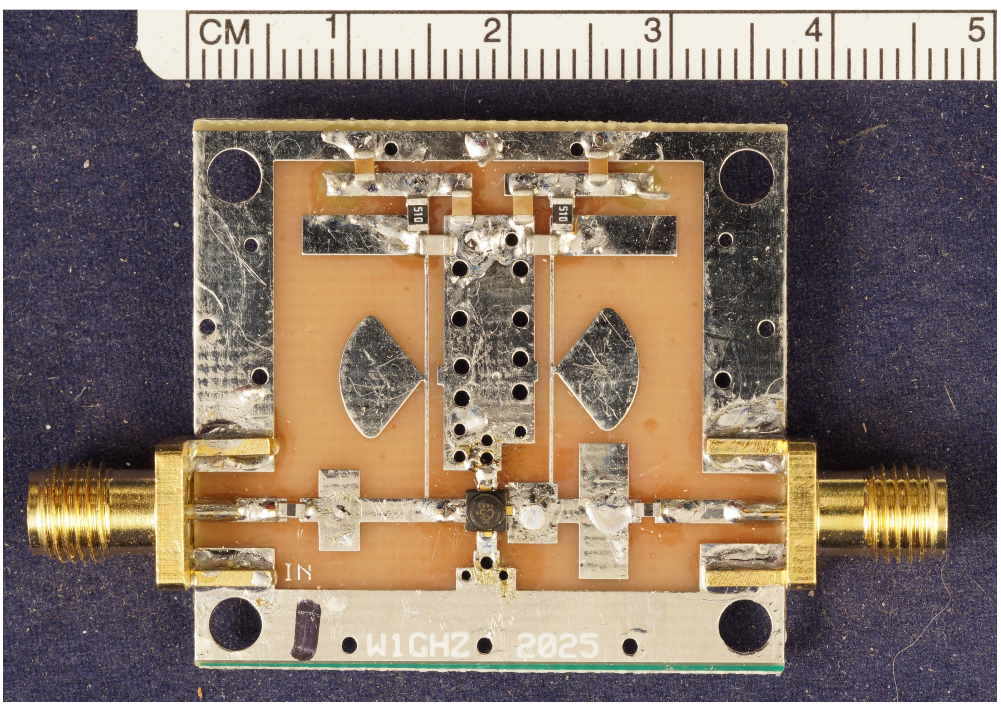


Figure 1 – 5760 MHz Preamp – *Simple and Cheap*

Design Process

I don’t have fancy RF software that can optimize for noise figure, so design was done the old fashioned way. I took the S-parameters and noise parameters, plotted them on a Smith Chart, and made some guesses about microstrip circuits. Since I was using a common PC board thickness, I was able to fit some prototypes into another board order.

With some serious snowflaking, I found a circuit came up that gave pretty good noise figure, around 1 dB Three copies of the same snowflake circuit shown in Figure 2 provided similar performance, so I copied the dimensions in PCB artwork and ordered some boards.

These are low cost PC boards, on ordinary FR-4 type material. Ultimate performance was not the goal, just a noise figure consistently around 1 dB with no tuning, to improve receive performance at low cost, so that folks with minimal test equipment can improve their system (and hear me better!). Hams with test equipment may be able to make further improvement.

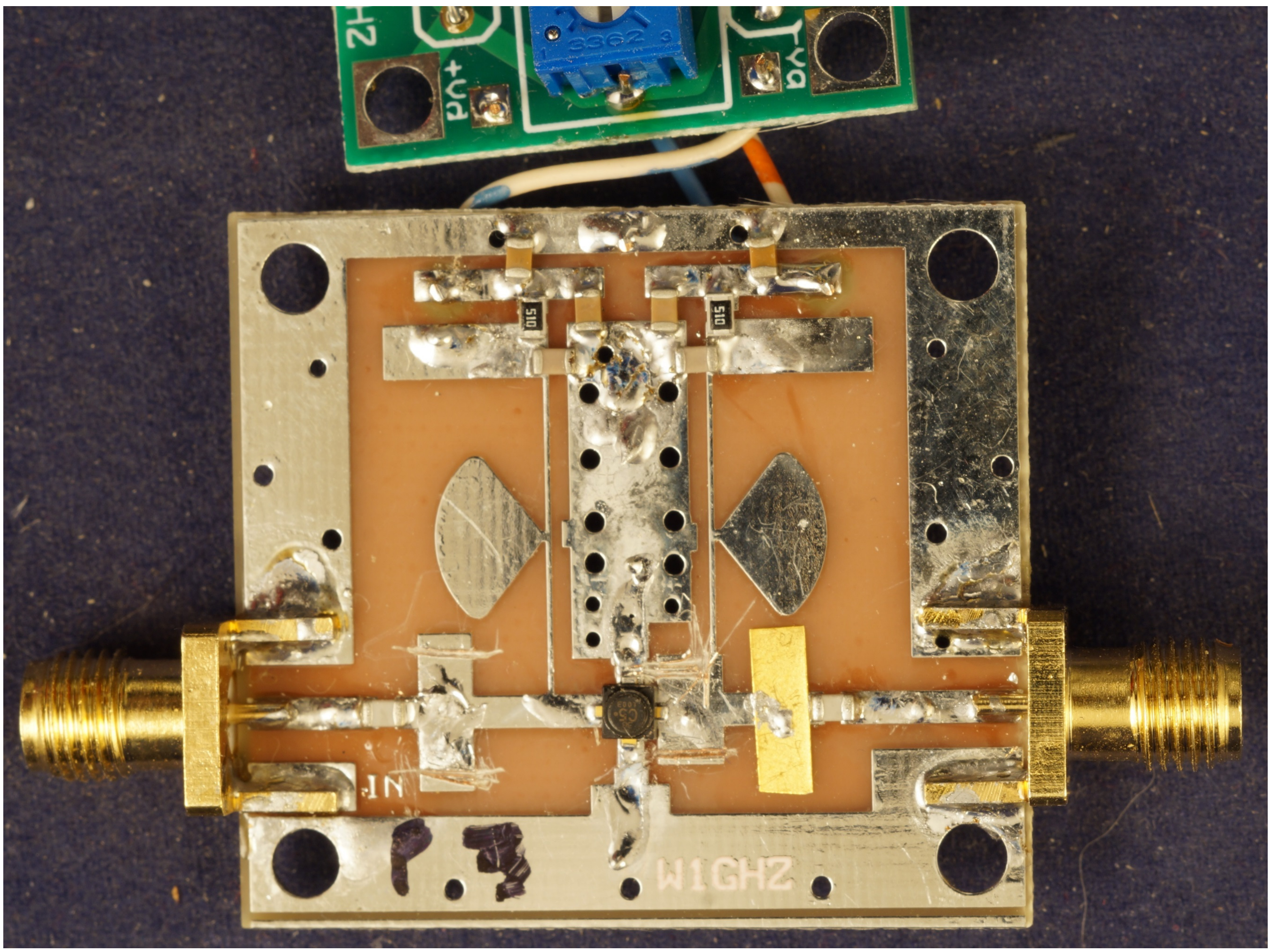
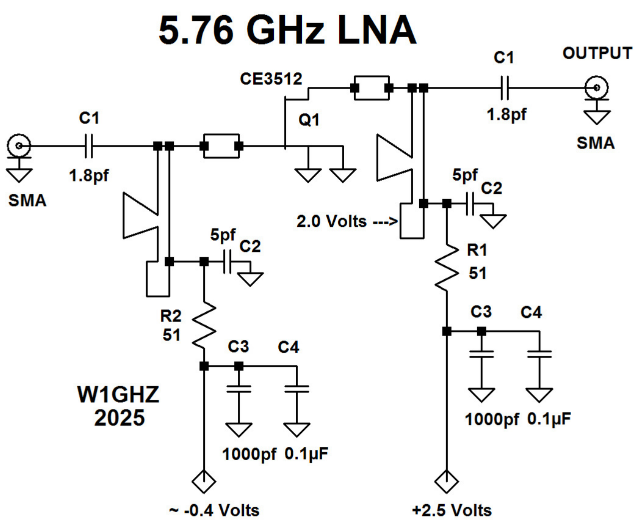


Figure 2 – 5760 Prototype after tuning

When the new boards arrived, I assembled five units. All have good performance, NF around 1 dB or lower, and about 15 dB of gain. I tried some more tuning, but couldn't find any real improvement.

The schematic diagram and assembly photo are shown in Figure 3. The bypass capacitors at the radial bypass stub position on the printed circuit make no difference at all, so they are not installed. The radial bypass stub does a fine job of removing the 10 GHz RF from the bias line.



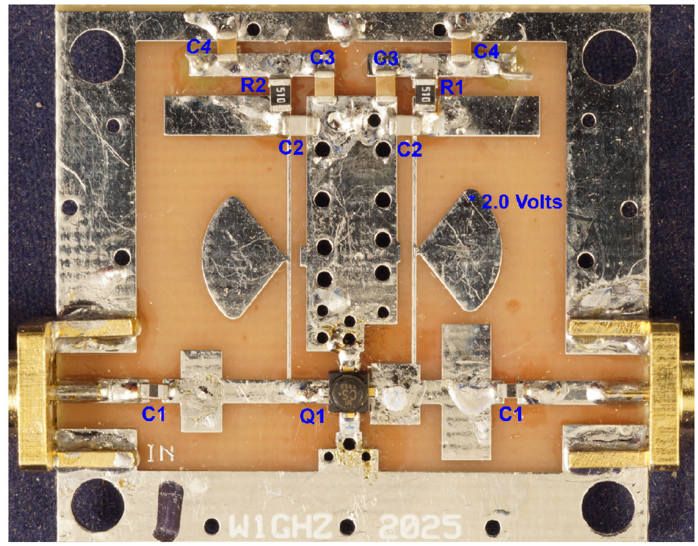


Figure 3 – 5.76 GHz Preamp schematic and assembly photo

Negative Bias Voltage

One problem with GaAsFETs and their fancier cousins has always been the need for negative gate bias, and insuring that the negative voltage is always available to prevent damage. I recently read a paper about using an optoisolator to produce a negative voltage and developed a fool-resistant bias circuit using one (separate paper[2]). The bias board powers the preamp as shown in Figure 4.

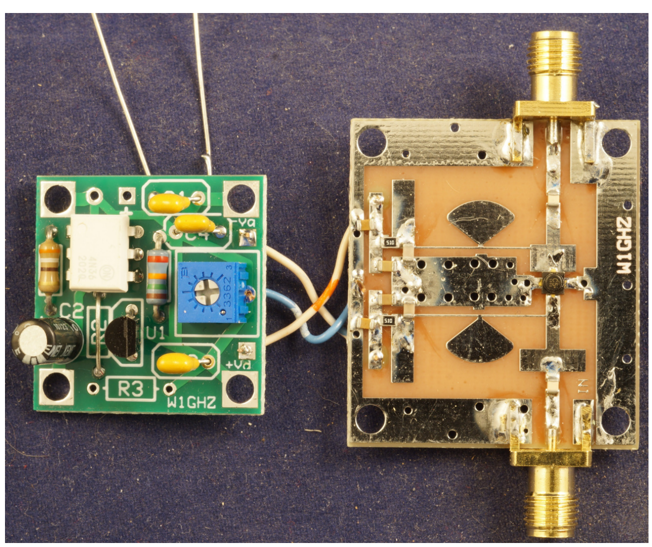


Figure 4 – 5.76 GHz LNA with Negative Voltage Optoisolator Bias Board

Capacitors

I had measured some ordinary chip capacitors for 10 GHz, and selected some promising ones for intitial assembly. These seem quite adequate – the special microwave capacitors that improved 10 GHz preamp performance made no discernable difference at 5760 MHz. The thicker PC material has wider 50Ω transmission lines that the 0805 size chip capacitors fit well.

Construction

The small thin PC boards heat up quickly and get rather hot while soldering the connectors, which takes a while. I suggest installing the connector first to minimize heating of the FET. Then solder the small passive SMT components, and the FET last.

The input trace and ground metal on the board should come to the edge of the board – the thin board is easily trimmed with an X-Acto knife. For the 0.8mm thick PC boards, ordinary SMA edge connectors fit well and are easy to assemble. I trim the center pin to about ½ length, then slide the connector in place and solder the pin. Next are the top-side ground pins, followed by the bottom of the board.

These FETs in their standard plastic package are not hermetically sealed. For the most part, this is not very important, but care should be used if cleaning up soldering residue with alcohol. I generally use low-residue solder and minimal cleanup.

Tuneup

The safest way to tune up is using the optoisolator bias board to power the preamp, shown in Figure 6. The bias board limits current and voltage to the FET to prevent damage – you can reverse voltage, mix up the connections, or short out the circuit while tuning. Before powering up, make sure that both RF input and output are terminated with 50 ohms or the preamp may oscillate.

Apply power to the bias board and adjust the pot for 2.0 Volts on the FET drain – measure on the radial stub, near point * on the assembly photo, Figure 3. If the voltage will not adjust, the preamp is probably oscillating – make sure it is terminated.

Now it is time to try it with RF. Listen to a signal and see if the preamp makes a difference. If you can measure noise figure, go ahead. Poke around with a small snowflake twiddlestick, like a bit of copper tape on the end of a wooden Q-tip, or on a toothpick for fine tuning. If you can find a spot to improve, go for it.

Housings

The PCB construction is quick and easy for experimenting. The 0.8 mm thick boards are slightly more robust and might be OK if mounted to something solid. We are probably going to connect them with semi-rigid coax and put some stress flexing the PC board. One solution I have used for thin small boards is to mill out an aluminum clamshell package like Figure 5. The slots for the SMA connectors are very slightly undersize so that the connector is clamped behind the threads and the PC board is suspended inside, isolated from stress from cables. Great if you have a milling machine. N1JEZ and I made some at our local Makerspace, The FoundryVT.

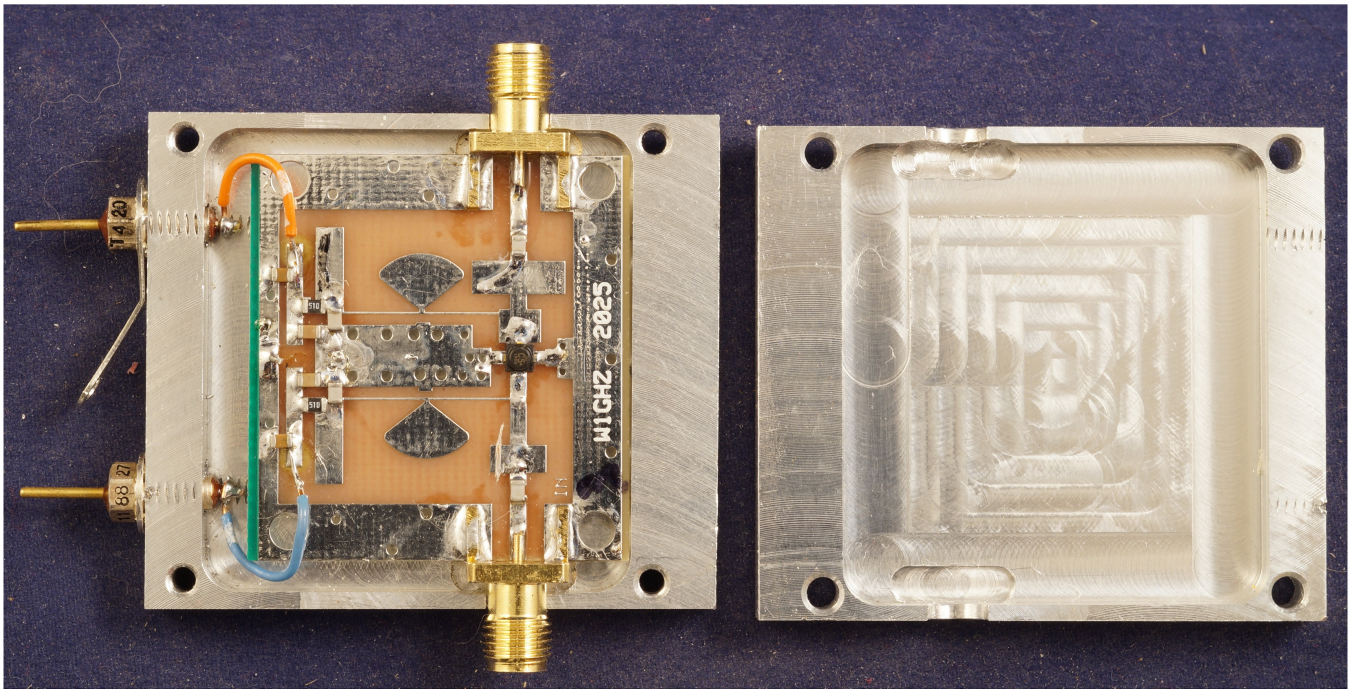


Figure 5 – Clamshell housing to reduce stress and flexing of thin PC board

The bias board can be mounted on the outside for a complete assembly, as shown in Figure 6. It could be inside as the housing, but that would require more machining and more metal.

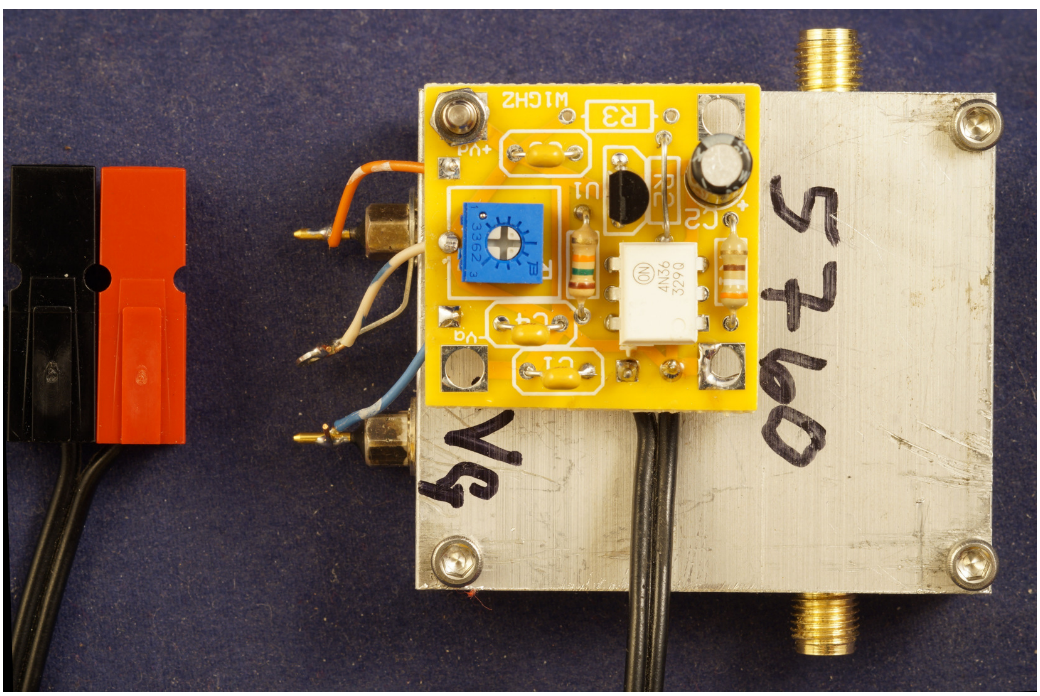


Figure 6 – Optoisolator bias board mounted on clamshell housing

Another assembly technique that microwaves have been using for years is to wrap the PC board with thin brass and solder the perimeter of the board. An old Zack Lau (W1VT) preamp using this technique is shown in Figure 7. It works fine, but it takes a lot of heat and flux to assemble, and a lot of cleaning to get the flux out of the box.

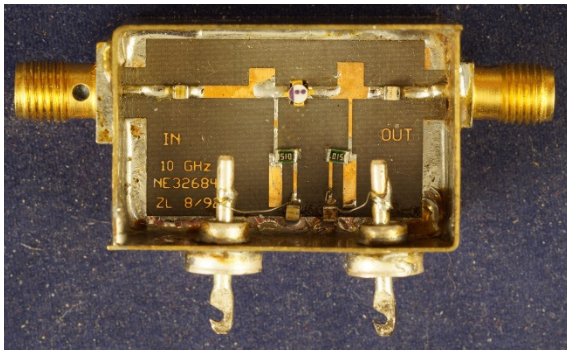


Figure 7 – Amplifier assembly wrapping thin brass around PC board and soldering perimeter

A simple assembly like bolting the PC board to something more rigid, like a scrap of thicker PC board, might be robust enough for some systems. Amateur ingenuity can probably find a solution.

Noise Figure

Disclaimer: *Measuring low noise figures accurately is difficult. Few of us have recent traceable NF calibration. Our noise sources have calibration tables or charts with big increments, so we use our best estimate.*

Actual Noise Figures will be updated after measurement on good equipment at a conference.

System Noise Figure

For weak signals, one of these preamps, with a noise figure around dB, will be a significant improvement over the barefoot simple and cheap transverter, and some older transverers as well. The transverter noise figure is perhaps 6 to 8 dB. A cascade calculation (https://www.microwaves101.com/calculators/859-cascade-calculator) with roughly 15 dB of preamp gain suggests a system noise figure under 1.5 dB, excellent for terrestrial work. This works best if the LNA is very near the feed. Even with the best preamp, a long cable between the feed and the LNA will add a couple of dB of loss and raise the system noise figure to a higher number

An impedance mismatch, especially at the input can make a difference, and so your antenna feed match, if not 50 ohms resistive is likely to result in a different system noise figure than you would calculate (it could be worse or better).   Paul makes all NF measurements with an isolator at the LNA output.

Adding a second preamp stage can improve the system noise figure, but I wouldn't dare put two in the same box.

Stability

As mentioned under Tuneup, the preamp will probably oscillate if the input and output are both unterminated. More important is that it does not oscillate with an antenna connected – an antenna is usually a good match near the operating frequency, but is an unknown impedance out of band. As a test, the noise source is connected through a 10 dB directional coupler, so the indicated noise figure is 10 dB higher with a 50 ohm load at the input. Then the load is replaced with a short and an open, representing worst cases – a sliding short would be better to check all phases. The indicated noise figure changes with the short and open, as expected, but if there is no oscillation the preamp is reasonably stable

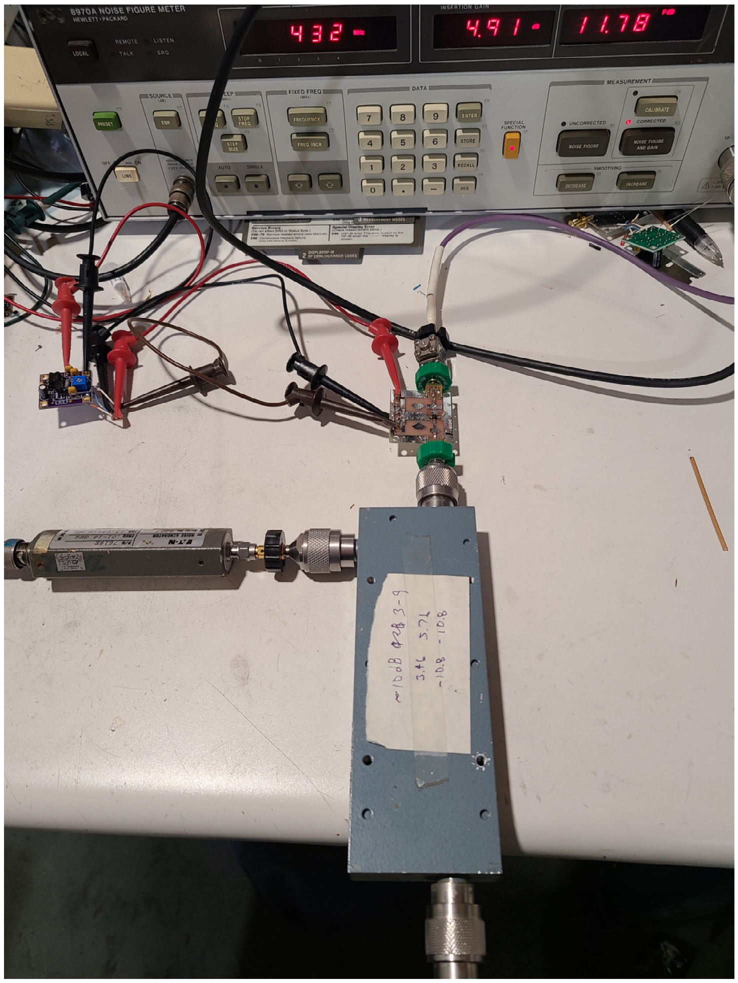


Figure 8 – Stability test setup

Summary

This simple and cheap preamp can help you hear better on 5760 MHz. It is easier to build than the transverter. Assembly is within the capability of anyone doing microwave circuit board assembly with SMD parts. Total cost, including bias circuit, is in the neighborhood of $10. PC boards are available for both preamp and the bias circuit.

NOTES:

1. Paul Wade, W1GHZ, “Very Low-Noise Unconditionally Stable MMIC Amplifiers,” 47th Eastern VHF/UHF/Microwave Conference (2024), http://www.newsvhf.com/conf2024/PresPapers/W1GHZ-Very_Low_Noise_Unconditionally_Stable_MMIC_Amplifiers.pdf
2. Paul Wade, W1GHZ, “GaAsFET LNA Bias – Simple, Cheap, and Fool-resistant,” *Proceedings of Microwave Update 2024*, ARRL, 2024, pp. 113-115. Also https://www.w1ghz.org/Preamps/GaAsFET_LNA_Bias-Simple_Cheap_and_Fool-resistant.pdf

Suggested Parts List for 5760 MHz Preamp Boards

Designator	Value	Mouser #
C1	1.8 pf	77-VJ0805A1R8BXJPBC
C2	2 to 10 pf	Not critical – could be sams as C1
C3	1000 pf	80-C0805C102K2GEAUTO
C4	0.1 uf	80-C0805C104K1REAULR
R1	51	660-RK73B2ATTDD510J
Q1	CE3512K2	551-CE3512K2-C1
SMA	12.4 GHz	960-EMPCB.SMAFSTJBHT

Note – cheap 0.8mm edge mount SMA from ebay work fine