

Some Techniques for Building Ultra-Low-Noise Preamps

Part 1

The following is the first part of a series of articles in which WA2ODO describes his insights into his success in building ultra-low noise preamps.

By Pete Manfre,* WA2ODO

Many have asked how I am able to obtain such low noise figures with my design of LNAs. My standard answer is usually “with smoke and mirrors.” However, in fact, it is somewhat simple. Simple, yes. Easy, no. Simple, yes—after you do all the research and experimentation testing and sorting parts as per their noise figures, which is the “easy, no” part.

The best I can explain it is that certain rules must be strictly adhered to. The major rule I advise is the attention to the slightest detail. For example, never solder anything unless it first is making good electrical contact. Solder is a holder, not a conductor (at best a conductor that does add a little noise). I always use solder that has a percentage of silver in it, as I find it quieter. An additional rule is that all parts generate noise. Therefore, use as few parts as possible to accomplish what you want without circuit-performance compromise.

Not all parts are created equal in the eyes of the noise-figure meter. Two identical values of parts but of different manufacturers generate different noise. Therefore, experiment and pick the best for your purpose. The most expensive is not always the best. This goes for FETs, caps, and resistors. It very much applies to piston capacitors, too, with sapphire being the quietest and ceramic being a close second.

Component layout can have a considerable effect on the noise figure and gain, as does the choice of connectors. Certain connectors are very noisy. Preamp enclosure also have a varying effect on the noise figure due to internal self-resonances. Enclosures are cavities, which can impact the noise figure for good or bad.

*e-mail: <pmanfre@gmail.com>



Image 1. These results are possible with attention to details and the use of low-noise parts.

With respect to the “front end”—the input of the circuit—there is an ideal Q that will yield the lowest noise figure. Too low or too high and the noise figure goes up. All coils on the front end should be silver-plated. (I rhodium-plate mine on top of the silver to prevent tarnishing.) This tarnishing affects the noise figure adversely over time, so this application of rhodium prevents degradation. I have tried many sizes and materials for the coils. The best I have found is not the biggest or smallest, and 18g to 14g seems to yield the best results.

As for materials, the best seems to be silvered copper. I have tried pure copper, gold-plated copper, and sterling—all inferior to silver plating. The best dielectric material for PCBs I have found is air. Therefore, hand-build all preamps with components above the board, especially on the input side of the schematic. Minimize losses wherever you can.

Not all FETs are created equal—even the same type, brand, and batch. Some are just plain better than others. Sometimes you might have to waste a few to get a “hot one.” And since they are not all the same, be sure that you can adjust the source currents and drain voltages independently to squeeze out the best you can for that individual device. Additionally, and very important, just because the manufacturer has cut-off frequencies does not mean the device will not work below or above those frequencies. In most cases, it performs better but the stability suffers (K below 1). Therefore, an additional problem needs to be addressed: making it stable if possible. Sometimes this is harder than obtaining a lower noise figure.

Once I find a specific part that has an exceptionally low “noise additive” (as I call it), and have done my homework and proved it through multiple builds and



Image 2. This is also attainable with attention to details, details, details.

substitutions, then I try to buy a sufficient quantity of that identical part to last a lifetime. A perfect example is that not all bypass capacitors are created equal. I have found some that are exceptionally nice and quiet also, so I bought several thousand of them because they were priced ultra-low. I will not have to search for those any further. I did the same with the FETs. I still have 13,000 remaining, which should last a lifetime or two (or

three or a hundred). The point is I will not have to go through this exhaustive testing and searching for them again. It does not mean, however, that I stop looking for better. Rather, I do it with less vigor.

Most importantly, do not attempt to make a super ultra LNA without a good calibrated noise-figure meter. Some examples of good meters for the purpose and also affordable to amateurs are the HP-8970A and B, HP-8970S, and the



Image 3. Notice the calculated noise source and 10 dB attenuator—a must only for accuracy, but not necessary for tuning and comparing several preamps.

From **MILLIWATTS to KILOWATTS**
More Watts per Dollar™

Taylor TUBES

Quality Transmitting & Audio Tubes

• COMMUNICATIONS
• BROADCAST
• INDUSTRY
• AMATEUR

Eimac
Svetlana

Immediate Shipment from Stock

3CPX800A7	3CX10000A7	4CX3000A	812A
3CPX5000A7	3CX15000A7	4CX3500A	813
3CW20000A7	3CX20000A7	4CX5000A	833A
3CX100A5	4CX250B	4CX7500A	833C
3CX400A7	4CX250BC	4CX10000A	845
3CX400U7	4CX250BT	4CX15000A	866-SS
3CX800A7	4CX250FG	4X150A	872A-SS
3CX1200A7	4CX250R	YC-130	5867A
3CX1200D7	4CX350A	YU-108	5868
3CX1200Z7	4CX350F	YU-148	6146B
3CX1500A7	4CX400A	572B	7092
3CX2500A3	4CX800A	805	3-500ZG
3CX2500F3	4CX1000A	807	4-400A
3CX3000A7	4CX1500A	810	M382
3CX6000A7	4CX1500B	811A	

— TOO MANY TO LIST ALL —

VISA **MasterCard** **DISCOVER**

ORDERS ONLY:
800-RF-PARTS • 800-737-2787
Se Habla Español • We Export

TECH HELP & DELIVERY INFO: 760-744-0700
FAX: 760-744-1943 or 888-744-1943

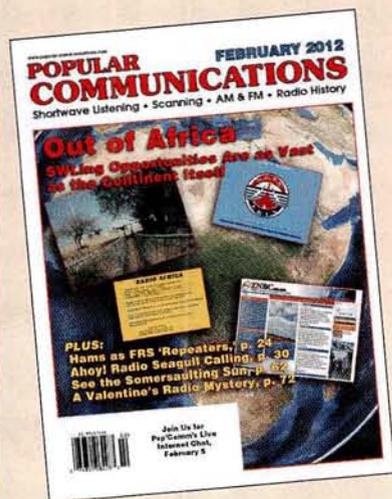
An Address to Remember:
www.rfparts.com

E-mail:
rfp@rfparts.com

RF PARTS COMPANY
Since 1967

Listening is only half the fun...

POPULAR COMMUNICATIONS is the other half!



The World's most authoritative monthly magazine for Shortwave Listening and Scanner Monitoring.

You'll find features on scanner monitoring of police, fire, utility, and aircraft communications; international shortwave listening; CB radio; amateur radio; FRS; GMRS; monitoring radio digital communications; AM/FM commercial broadcasting; weather and communications satellites; telephone equipment radio nostalgia; clandestine and military radio.

Choose the PRINT Edition or New DIGITAL Edition!

Buy both at a SPECIAL price!

1 year	Print	Digital	Both!
USA	\$32.95	\$24.00	\$47.95
CN/MX	\$42.95	\$24.00	\$57.95
Foreign	\$52.95	\$24.00	\$67.95

Sale ends 01/31/12

Popular Communications
25 Newbridge Road, Hicksville, NY11801
Phone: 516-681-2922; Fax 516-681-2926
Visit our web site:
www.popular-communications.com



Image 4. My travel case of conference preamps for entry into noise-figure-measuring contests. Notice the many bands and layouts within each band.

2075 series by Ailtech/Eaton/Maury. Almost any noise source will work, but it must be stable and you must know the excessive noise ratio (ENR). When testing and adjusting LNAs, never use an ENR higher than 5 dB. You might need to add a calibrated 10-dB attenuator to your 15-dB ENR noise source (readjusting the ENR table to reflect this). Good noise sources are made by HP, Noisecom, Ailtech, Eaton, Maury, MSC, Micro-netics, etc.

Having a vector noise analyzer (VNA) handy is great for the initial development, but not as necessary as the noise-figure meter to squeeze out every last part of a dB noise figure. A hundredth here and a hundredth there starts to add up.

Summary

I have not given many specifics here, as I cannot, because obtaining the same exact parts and materials is not always possible. The rule is experiment and try.

This has been a never-ending project for me. My first 144-MHz preamp was in the 0.5-dB range. I just kept trying ideas and different brands of parts until I found the proper combination for my design.

There are hundreds of well-designed and easy-to-build schematics all over the web. My design is nothing special. It is my choice of parts and details that allows obtaining the ultra-low noise figures. Naturally, being a retired watchmaker and jeweler (as well as a retired elec-

tronics instructor) certainly does not hurt in working with very small and delicate parts and being cognizant of the details. However, with practice you can be proficient. "Practice makes perfect."

To duplicate one of my current preamps would take about \$78± (labor not included), using newly ordered components. I sell the preamps for \$85 and use the profit to supply free preamps to legitimate EME DXpeditions and to give them as gifts at conferences.

You have probably noticed the absence of any specifics for building any of my preamps. The main reason, in my opinion, is that you must learn to walk before you learn to run. Therefore, almost every preamp design that has been published can be made to obtain close to what I obtain using the correct and quiet parts and proper techniques. Conversely, you can take my schematic and having built it without following basic techniques; it will be no better than any other generic preamp. In subsequent articles I will give additional hints and specifics for obtaining lower noise figures, but for now try these with what you have and see what can be accomplished.

Hopefully, I will be attending the 2012 EME conference in Cambridge, England. I will look forward to meeting several of you there to further discuss this heated preamp topic. I will be bringing preamps to sell, as well as FETs for sale and some of both as dinner prizes.