Low Band Preamp
by W7IUY
0.1uF
1.0uF
4.7uF
+ 13VDC -
Gnd
Gnd
0.1uF
2N5109
Gnd
0.1uF
0.1uF
Layout by MTM 7/5/2012

Low Band High Performance Preamp

Larry – W7IUV

Revision 5 copyright 1998-2009

Note: Please read the entire document before starting to build this project. There is data contained within that is necessary to obtain maximum performance from this circuit.

My search for a low band preamp started many years ago. When I started using RX antennas for 160 meter work, it became necessary to increase the signal levels obtained from the small RX antennas. After many false starts with Nuvistors, JFETS, and MMIC's, the following circuit was adopted. It has gone through a number revisions over the years.

The circuit was originally "borrowed" from a project published in the ARRL Handbook. It was verified with Spice analysis, then built and tested. It worked better than anything I had tried previously. As the RX antennas became larger and more efficient, the IMD performance proved to be insufficient. Some "tweaks" were made and performance was improved to the point where further work was unnecessary. About that time I lost access to the Spice application and was unable to verify performance with computer analysis.

After being asked about my preamp many times, I finally published it on my web page. The design had quite a few "bugs" that were not of any consequence in my shack, but it was obvious from feedback over the years that others did have problems. I always meant to look into some of these reported issues, but never could find the time and energy to do it.

At the urging of Ed, W4EDS, I started looking into a surface mount replacement for the favored 2N5109 transistor used in the original design. Although several months of work produced very few suitable replacements, I did manage to fix most, if not all, design deficiencies known to be in the original circuit.

In this document I will attempt to provide some insight into preamp requirements and design as well as provide a guide to insure the resulting preamp design is used properly.

Any licensed amateur radio operator is free to use the material contained in this document for his own use. Please do NOT copy this document on your web page. Feel free to show a link to my web page. I advise you to link to the main page rather than this document as the document URL WILL change from time to time. Commercial interests should contact me for permission to use.

I don't sell parts, kits, or assembled units. Don't bother asking. I'm not making a penny on this design. My only desire is to promote better RX capability on the low bands for everyone. If you find this document helpful, let me know. Likewise, let me know if you find an error.

Design Requirements:

The ideal low band preamp should have sufficient gain to allow use of the typically low output RX antennas with most modern transceivers. At the same time, the Noise Figure must be sufficiently low as to not degrade the SYSTEM noise temperature. (SYSTEM noise temperature includes your receiver, the antenna, the transmission line, and all the noise sources the antenna sees!) In addition, it must be a relatively high power amplifier so that local AM BC stations do not cause IMD products to be generated in the preamp. Two more very desirable virtues would be low cost and ease of construction.

Gain is easy. Getting gain without compromising the other requirements is not. 20 dB seems to be a good overall compromise figure. Seldom will more be needed. Less can be easily accomplished by using fixed attenuators. A “knob” to provide continuously variable gain is not an option. There is no easy, economical way to adjust the gain on a feed back amplifier like this one without severely compromising one or more important performance parameters.

Noise figure is elusive, misunderstood, and generally over rated at HF. The Noise Figure of a device and/or circuit is difficult to measure accurately. The measurement requires expensive specialized equipment. It is actually easier to measure Noise Figure at microwave frequencies than at 1.8 MHz due to the lack of calibrated noise sources at the low frequencies. Commercial preamps that I have seen claim incredibly low Noise Figures. I really doubt they have ever been measured and verified. I say this because the numbers are the same as the published NF numbers for the transistor used. Those specs are determined by using the part in a circuit that has been optimized for NF alone. That circuit is, in general, not suited for a low band preamp because the input impedance is not very good and the OIP3 is terrible. When the circuit is modified to enhance the other, more important, parameters, the NF will always be a lot worse.

The NF of the preamp only needs to be good enough so that the noise (local power lines, computers, etc., plus propagated QRN) the RX antenna sees dominates the system NF. By virtue of extensive experimentation, I know that the Noise Figure of the preamp described here is low enough that when a low output antenna, such as a Flag, is used on the end of 400 feet of good coax, the band noise still dominates the system.

While I cannot measure the absolute Noise Figure of these preamps, I do have the capability of comparing the performance of various devices and circuits. Using the Y-Factor method and the equipment I have available, I can measure the difference in NF between devices accurately. By having done this on a large number of devices, I am sure the absolute NF of this 2N5109 is better than 6 dB and better than most of the commercial preamps that claim better numbers. Again, it really makes no difference what the absolute number is, as long as it does not adversely affect the SYSTEM performance.

By far the most critical parameter of a low band preamp is the OIP3 (output 3rd order intercept point). This is the parameter that determines whether or not a preamp will go toes up when subjected to large signals from “out of band” AM BC and other sources. If large signals are applied to a device that is operated in a non-linear region, IMD products will be generated. The IMD products caused by “out-of-band” signals are not the same as the IMD products caused by “in-band” signals that roofing filters and other RX internal devices minimize. A low band preamp must be able to handle very high level

signals without going into the non-linear region of the device. OIP3 is a measure of how strong the offending signals can be before they cause trouble.

OIP3 is also a parameter that is very difficult to measure accurately. I have seen some claims made that I just don't believe. Since I used to do this measurement on the job before I retired, I have little faith in some of the test setups I've seen described. My personal test equipment is just barely capable of making OIP3 measurements at the high level this preamp operates at. In fact, I really think the preamp is better than the test equipment, but since I can't prove that with the setup I have, I don't really want to claim such a thing.

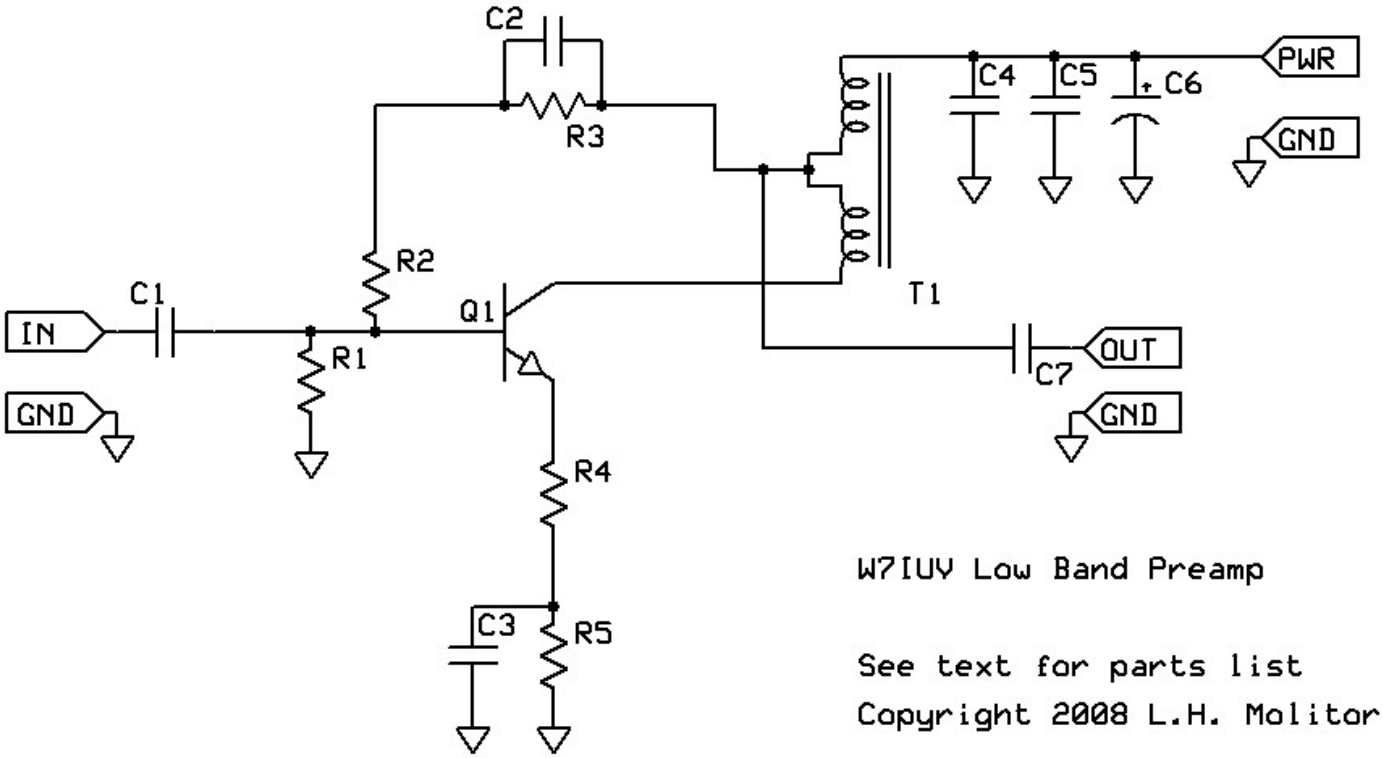
The OIP3 of the "original" circuit was good enough to work with a Flag in a typical urban environment without a front end filter. However, if a RX antenna was used that had a higher output level, a filter was required. I was always trying for better OIP3 numbers but couldn't get them until this last revision. I'll go into more about that later. Suffice to say that OIP3 (IMD performance) is the most important parameter of a preamp used on 160 meters.

Reliability is essential. This basic circuit is bullet proof. I have built dozens of these and know of hundreds more that have been built worldwide. If you have a problem with it, it's because of something you did wrong. My daily use preamp is connected and powered up 24/7. It is always connected to an RX antenna, during TX period, during lightning storms, always. I have over 60,000 hours of near continuous operation on the same device with no failures of any kind.

Bandwidth or frequency response should be determined by the intended use of the preamp. This design is primarily intended to be used for 160 and 80 meter work. It turned out that more bandwidth was obtained easily and used without compromising other performance parameters. In this circuit, the operational bandwidth is limited on the high end by the gain/bandwidth product of the transistor used and on the low end by the coupling capacitors. In practice, when using a high frequency device like the 2N5109, high end roll off at around 30 MHz is due to the ferrite core. When using a low frequency device like the DCP68, the high end starts rolling off around 7 MHz.

Schematics and Parts:

Enough background for now, here is the nitty-gritty stuff. The circuit below is the “original” with a parts list at the bottom. Be aware this is included for reference only and I do NOT recommend this version. If you have it and it works for you, great, but if starting from scratch, be sure to build the latest version.



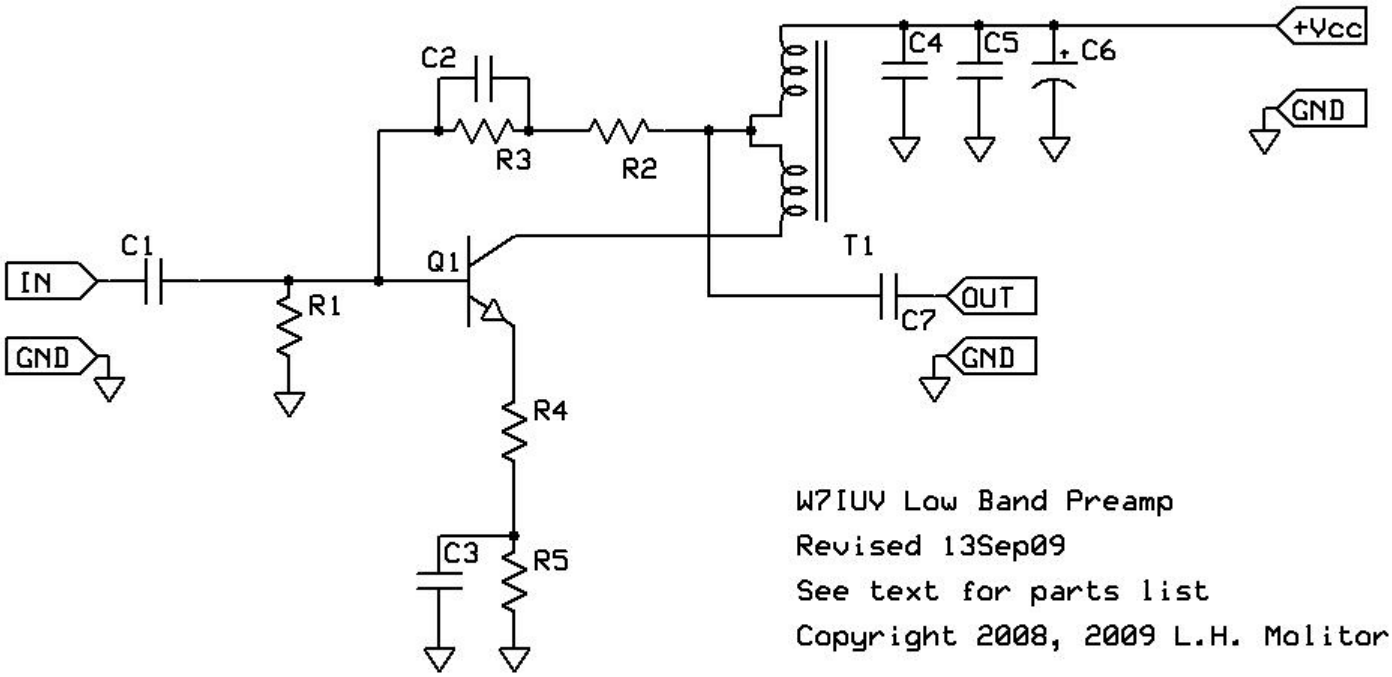
C1, C2, C3, C4, C7 = 0.01 uF ceramic
C5 = 0.1 uF ceramic
C6 = 2.2 to 10 uF 50v
R1 = 1K
R2 = 560 ohm
R3 = 3.3 kohm
R4 = 4.7 ohm
R5 = 10 ohm
T1 = 10 turns bifilar on FT37-43 core
Q1 = 2N5109, or 2N3866

The “old” circuit shown above suffered from several design deficiencies that were of no concern to me but seemed to give a few other builders some troubles. Of note was the requirement for 12.00 VDC power. More than that would cause problems. Operating temperature of the device required a very good heat sink. Some folks had issues with the 0.01 uF coupling caps that I had deliberately specified to limit low frequency response below the band. One thing that annoyed me was the input impedance not being as close to 50 ohms as I would like.

When W4EDS challenged me to find a surface mount replacement for the 2N5109, I set up the bench for preamp work. That was something I had not done in more than ten years and was long overdue. I had to recreate the setups for measuring OIP3 and NF and verify accuracy of the measurements. In parallel with that task, I also searched data books and catalogs for likely devices.

As part of the search effort, I looked at possible TO-5 and DPAK replacements as well. Turns out there are a lot of parts that will “work” but not give very good performance. While looking at how these various parts actually perform, I made a few discoveries about some of the component parts I was originally using. One of the most interesting things I discovered was that the type 43 core material used in the transformer was a limiting factor in the overall performance of the circuit. Changing to a type 75 mix solved a lot of annoying little problems I had in the past. Most importantly, the OIP3 came up significantly and I was able to reduce the collector current without loosing performance. That opened up a lot more possibilities for devices. Unfortunately, while a lot of devices produce the required gain and OIP3 numbers, they don’t produce good NF. If NF is not an issue in your installation, even the old faithful 2N2219A will work in the “new” circuit. I’ll elaborate on this later.

Presented below is the schematic diagram for the current version. The parts list follows the schematic. Included, as part of the parts list, is a discussion of each part, what it does, and what possible substitutions could be made. Please read and understand the information presented BEFORE ordering parts or building the circuit.



Parts list:

Vcc = 12.6 to 13.6 volts DC. See installation section for more info.

C1, C2, C3, C4, C7 = 0.1 uF 50 volt ceramic capacitor - These are coupling and bypass caps. Disk ceramics work well as do ceramic chip caps. I have found that while some of the more common

plastic encapsulated capacitors work OK, some do not. If you have any doubt as to the RF properties of the plastic caps you have, don't use them. C1,C2, C3, and C7 have an effect on the frequency response as well as the input impedance of the preamp. Although the circuit as is will work OK down to 100 kHz or so, you can improve the low frequency performance by making these four caps 2.2 uF ceramic or tantalum.

C5 = 1.0 uF 50 volt Bypass cap, not critical, can use ceramic or tantalum. Some "plastic" caps are also OK

C6 = 4.7 to 22 uF 50 volt - Power supply bypass. Value not critical. Tantalum preferred but quality electrolytic OK also.

R1 = 1000 ohms, ¼ watt, 1% metal film preferred - This is part of the bias network. The value is somewhat critical for optimum performance. 2 % metal film or carbon film can be used if necessary. 5% parts can be hand selected with an ohmmeter if you are desperate.

R2 = 680 ohms, ¼ watt, 1% metal film preferred - This is part of both the bias network and the feedback network. It is a critical part. 2 % metal film or carbon film can be used if necessary. 5% parts can be hand selected with an ohmmeter if you are desperate. DO NOT attempt to change this value, it will have adverse effects on all performance parameters!

R3 = 3300 ohms, ¼ watt, 1% metal film preferred - This is part of the DC bias network. . 2 % metal film or carbon film can be used if necessary. 5% parts can be hand selected with an ohmmeter if you are desperate. It's value is not particularly critical and can be adjusted up or down somewhat to alter the collector current drawn by the transistor. It should be adjusted to set the correct collector current if you use a transistor different from that specified.

R4 - 6.8 ohms, ¼ watt, 1% metal film preferred - This is part is critical. It has an effect on both the DC operating point and the RF gain as well as the input impedance and OIP3. DO NOT under any circumstance change this value. 2 % metal film or carbon film can be used if necessary. 5% parts can be hand selected with an ohmmeter if you are desperate.

R5 - 12 ohms, ¼ watt, 1% metal film preferred - This is part of the DC bias network. DO NOT change this value. 2 % metal film or carbon film can be used if necessary. 5% parts can be hand selected with an ohmmeter if you are desperate.

Q1 - 2N5109 preferred, 2N3866 also OK. (Heat sink required!) For surface mount, use DCP68. Many different parts can be used in this circuit but most will have lower levels of performance. For instance the 2N2219A can be used if NF is not an issue. The NF using the 2N2219A is about 2 dB higher than using the 2N5109. Should not be a problem with high level RX antennas like a long Beverage but might limit the system with Flags, Pennants, etc. MM2003 and MM2009 transistors seem to work OK. Any device with 1 watt or more total dissipation capability and with a gain/bandwidth (transition frequency) greater than 350 MHz will function but the NF may suffer. It's up to the user to determine if the part is suitable or not. The DCP68 device is a surface mount style that has a transition frequency of 350 MHz. That causes it to have less operational bandwidth in the preamp circuit but it is still quite good on 160 and 80 with just a small bit of performance degradation on 40. The parts I tested had good NF but varied quite a bit from part to part. The best were about 1 dB better NF than the "gold standard" 2N5109 and the worst were about the same as the 5109. This

is a very cheap part and seems to be readily available. I recommend using it if you cannot find 5109's or 3866's in your locale. I also looked hard at the BFG591 device but it needs a slightly different circuit, see below. Note: recent feedback seems to indicate that late date code 5109's have a higher DC gain than earlier date codes. If you find the collector current to be high and you are sure that everything else is correct, increase the value of R3 to get the proper collector current.

T1 - 5 turns bifilar on a type 75 core. Wire size not important, use what ever fits on the core, I use #28 magnet wire typically. (You can use 10 turns bifilar on a type 43 core as in the old design but the IMD performance will suffer dramatically.) Type 75 material (or equivalent) is the only core mix I now recommend! Suitable cores are:

FT50-75 (Amidon)
5975000301 (Fair-Rite)
35T0501-10H (Steward, DigiKey # 240-2524-ND)

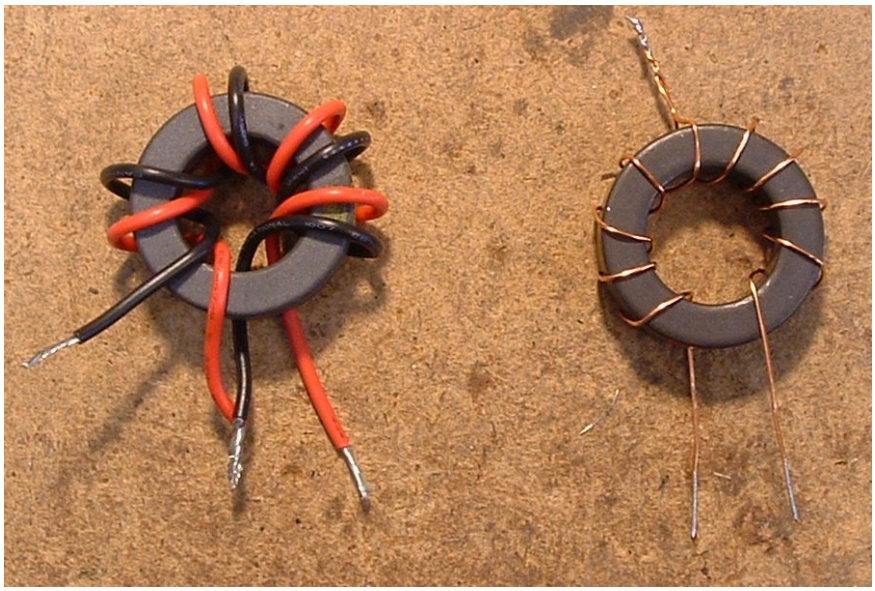
The above are ½ inch diameter core. If you want to use smaller 3/8 diameter cores:

35T0375-10H (Steward, DigiKey # 240-2522-ND) (this is what I usually use)

Although I say "bifilar wound", they do not need to be "bifilar". The windings are not critical. I wind them that way because it's easier for me. You may find it easier to wind 10 turns on the core and center tap this winding. Either way produces the same result electrically. The wires should NOT be twisted. Note that this transformer is not a "transmission line transformer" or any other "magic device" you might see in other projects. It is just a simple auto-transformer, wound and connected to provide a 1:4 impedance transformation. Bifilar winding instructions for the "transformer challenged" follow:

Take a piece of red wire and a piece of black wire. (color not important, used for reference only) Put tape on both ends of both wires. Mark one end of each wire with an "A". Mark the other end of each wire with a "B". Take the two ends marked "A" and hold them together. Take the two ends marked "B", hold them together and then pass them through the core five times. Take the end of the RED wire marked with an "A" and connect it to the end of the BLACK wire marked with a "B". This common connection is now your center tap. The RED "B" and the BLACK "A" are the wires you connect to the collector and the +VCC. It does not matter which goes where.

Some photos might help. Note that the transformers shown in this photo are for instructional purposes only and are larger than the correct cores and use larger size wire. These are only meant to illustrate the winding methods.



BFG591 surface mount transistor:

Before moving on to “assembly, test, and installation”, I’d like to talk about the BFG591 device. I don’t really recommend using this part but I present it for those that want to experiment. If you are not interested in experimentation, jump ahead to the next section now.

I spent dozens of hours searching data books and catalogs looking for a substitute for the 2N5109. There are few parts that are even close. The BFG591 stood out among hundreds of RF parts I looked at and seemed like a really good solution for SMT work. I bought a bunch of different parts that had even a remote chance of working and tried them all. The DCP68 and the BFG591 were the only transistors that came out even close to what I wanted.

The BFG591 is a 9 GHz part with great NF specs and reasonable power capability. It did not work well in the original circuit. It proved to be very delicate as you might expect from a part that had that bandwidth. To get that bandwidth, the die size must be small and the bond wires small. None of the above is conducive to reliable operation in low band preamps! As I should have expected, I destroyed a lot of these parts during testing.

I finally came up with the following values that, when used in the schematic above, show good OIP3 and great NF but poor reliability. I have to date a 50% failure rate during testing. However I suggest the following as a good place to start if you want to “push the limits”!

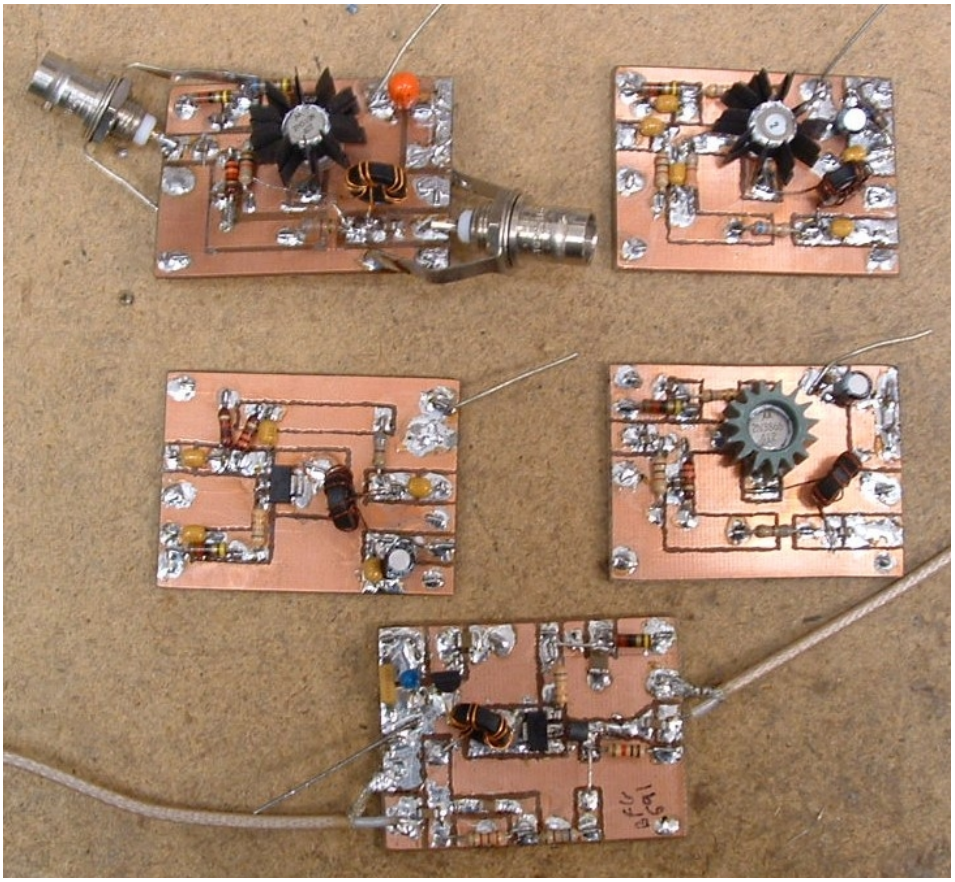
Use Vcc = 8.0 volts DC for this device. I suggest an on board 78L08 three terminal regulator running from a 13 volt DC input. At 8 volts on the collector, none of the device breakdown voltages are exceeded and reliability is much better than at higher supply voltages but still poor.

The schematic is the same and all parts are the same as the 2N5109 version EXCEPT R3 = 2200 ohms. This value should be adjusted, if necessary, so that the measured collector current is 65-70 ma.

Install a ferrite bead between the base lead and the rest of the circuit. The bead can be type 43 or type 61 material. Place it as close to the device package as possible. Without the ferrite bead, it is very likely that the device will oscillate up in the GHz region and all performance parameters will be seriously degraded.

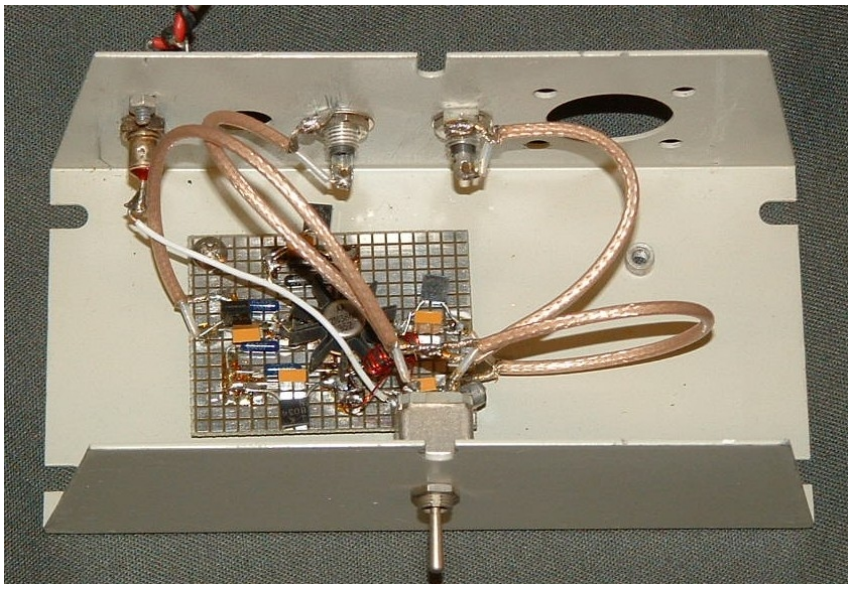
Assembly:

Layout is not really critical. Use common sense to locate parts, I.E., separate input and output, keep leads reasonable short, allow for heat dissipation, all the usual things you would do for an RF circuit. Be sure to use a slip on heat sink like the ones shown in the photos. Surface mount parts use the PC board as the heat sink so be sure to make the collector pad large enough to do this efficiently. I usually build a small board with miniature coax for the input and output so that the preamp module can be easily installed in a larger shielded box or chassis. Shown below are some of the modules I've built up:



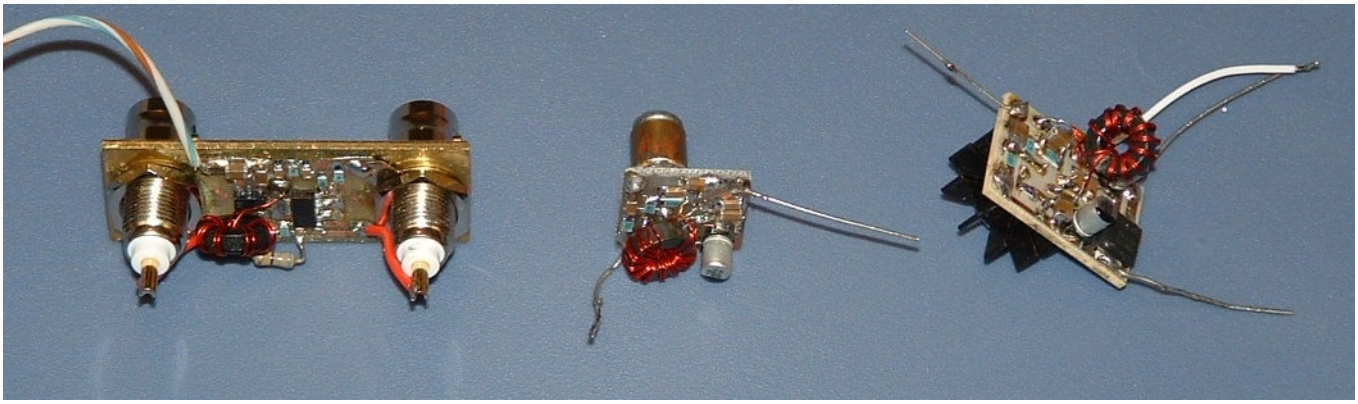
The photo above shows preamps built on double sided PC board. The board layout was drawn on the copper with a pencil. Using the pencil marks as a guide, a Dremel tool with a small carbide burr was used to cut the tracks. I can make small boards like this in about ten minutes. Upper left is a 2N5109 with BNC connectors tacked on for testing. Upper right is a "unmarked" RF transistor that was specified for use as a 1.8 GHz LO. Seems to work great in this application but I have no idea at all what the part number might be! Center left is a DCP68. Center right is a 2N3866. Bottom is a BFG591. Note that some of the boards use ceramic chip caps and some use leaded ceramic caps. I use what ever is handy. The resistors are mostly salvaged from discarded electronics chassis. The magnet wire used has been salvaged from the deflection yokes of computer CRT monitors. Ground traces are connected to the back side copper with "Z" wires through the board. Note that the transistor can is "hot" and so is the small heat sink. Be sure they don't contact anything else. The surface mount transistors depend on a large collector trace for heat sink. The DCP68 works well with a 3/8" square pad at the collector when using 0.062 thick, 1 oz, double sided board material.

Of all the various combinations of layouts, boards, and parts, I have come to like the combination of PCB, chip caps, and axial lead resistors the best. It allows easy assembly, test, troubleshooting, and repair/modification.



The photo above shows a preamp assembled on “checkerboard” and installed in a small salvaged chassis. The toggle switch is used to bypass the preamp. This unit was used for some VLF SWL’ing.

The above photo shows the preamp system I have used daily on the low bands for the last 10 years or so. It has a rotary switch that allows selection of various RX antennas. There is a high pass filter and attenuators built in which can be inserted or bypassed with the small toggle switches. The toggles on the right end allow selection of different radios and cable routing. More info on this box will be given later. Some of the labels are missing in this photo.



The above photo shows a few of the surface mount assemblies produced by W4EDS. Ed submitted them to me for evaluation. They performed superbly. Contact W4EDS directly for availability of his products. Note the size of these modules. The core diameter is 3/8 inch. Variations using 2N5109 as well as the DCP68 are shown. The wires hanging off the edges are mine and used for testing on the bench, usually input, output, Vcc, and ground.

No matter which assembly form you decide to use, I suggest that you shield the preamp in a metal box or chassis of some sort. The shielding in necessary to prevent incursion of unwanted hash from local computer equipment, switching power supplies, and motors, etc.

Test and Performance Verification:

Testing the newly assembled preamp is straight forward. Before applying power, double check your work. The most common problems are solder shorts and resistors inserted in the wrong place. Once you are satisfied you have correctly assembled the circuit, place 50 ohm terminations on the input and output. Apply 13.0 +/- 0.6 VDC to the Vcc terminal and ground. Measure the current drawn with a digital ammeter. It should be 75 mA. +/- 5 mA. Remove power and then remove the 50 ohm terminations. Re-apply power and measure current again. It should be the same as it was with the terminations in place. If not the device is oscillating and you need to fix that before proceeding. Oscillations are usually in the GHz region and are caused by poor layout and/or poor quality capacitors. Bypass caps with very long leads could also be a cause.

With power applied and the specified current being drawn, the transistor should be very warm to the touch, but you should be able to hold the tip of your finger on it indefinitely. If you cannot, either you have insufficient heat sinking or the device is drawing too much current.

At this point, if you do not have access to more test equipment, the preamp can be tried on the air so proceed to the “installation and use” section. If you do want to do more testing, here are some things to look at.

Vcc = 13.0 volts +/- 0.6 volts DC. More will work but reliability might suffer do to increased heat. Less will work (down to about 9 volts) but the OIP3 will be decreased significantly.

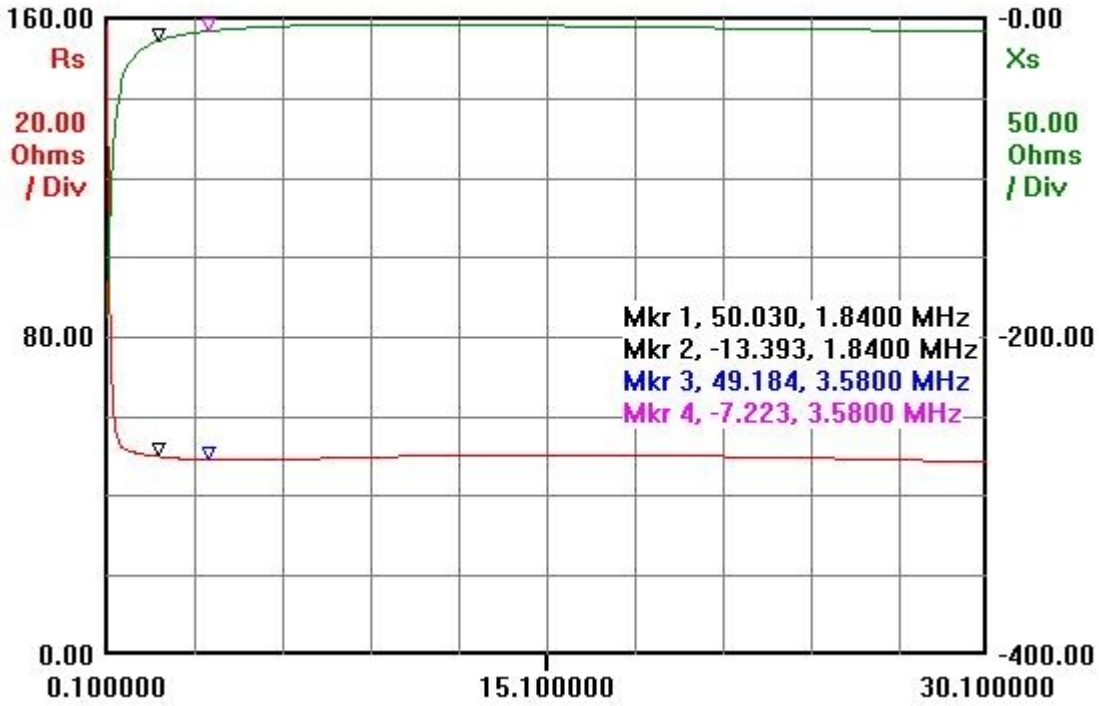
Current should be 75 mA. +/- 5 mA. If you use a transistor with grossly different DC gain, you will need to adjust the value of R3. Increase R3 to decrease current, decrease R3 to increase current.

P1dB (1 dB output compression power) should be greater than +21 dBm. Usually runs about +24 to +27 depending on parts used.

OIP3 (output third order intercept point) should be +41 dBm or greater. I’ve seen +44, which is as high as I can accurately measure with my test setup.

Frequency response, see the plot below (typical 2N5109 response, DCP68 will show gain dropping off at about 7 MHz):

Input impedance: (typical for 2N5109, DCP68 similar):



Installation and Usage:

This preamp should be installed between a low output RX antenna and your radio. The fixed 20 dB or so of gain is optimum for RX antennas such as Flags and Pennants. Slightly less gain is optimum for K9AY and EWE RX antennas that have a bit more output level. Decent Beverages have even more output and require less gain in the preamp. The proper way to reduce gain is to use fixed attenuators placed either at the input or the output of the preamp. Where they are placed depends on what kind of RX antenna you use. The lowest output type RX antennas will require the best Noise Figure and the least IMD performance so the attenuator should be placed on the output of the preamp as required. Higher level antennas such as a one wavelength Beverage should have the attenuator placed at the input of the preamp. Even though the system Noise Figure will be reduced it will be of no consequence and the IMD performance will be increased by the value of the attenuator. One last bit of info: the source impedance can vary wildly with no impact on the IMD performance of this preamp. However, the load impedance can have serious effects on the IMD performance. Receiver inputs are notoriously bad and can be almost anything except 50 ohms. Primarily for this reason I prefer to install at least some of the required attenuators at the output of the preamp.

This is a good place to talk about what the input level to you receiver should be. Modern receivers show approximately 20 dB difference between the minimum detectable signal level and the signal level which starts producing AGC action. As soon as the AGC circuit starts limiting gain, the RX performance is reduced. Old timers like to turn off the AGC and use the RF gain control. Since in a modern radio the RF gain control uses the same means of reducing gain as the AGC does it seems kinda dumb to do that. Over more than 50 years of weak signal operating, I've found that the maximum weak signal performance of any modern receiver occurs when the AGC is left on and the input level is adjusted so that background noise is just below the level at which the AGC starts operating. That means that normal band noise should NOT cause the S-meter to move off zero. If you use a combination of preamp and attenuators as described in the preceding paragraph to set the input level to this condition, you will be operating the radio at the maximum possible weak signal performance condition. You will find that the AGC will come into play when you tune across a very strong signal or a static crash and the speaker volume will be limited nicely. But, when you tune across a weak signal it will seem to jump up out of the noise. Once again, if your S-meter moves on background noise, you are not operating your receive system at it's maximum weak signal potential!

This preamp should be installed at the auxiliary RX antenna input on your radio. Do not use a relay scheme to put it in the TX coax. This preamp will function as a protection circuit for your RX in that the output is limited to a maximum value that is well under what it takes to break the radio. The transistor used is a power device and has a base-emitter structure that can handle far more than the input circuits in your radio. I never disconnect my preamp from the RX antenna. It's connected 24/7, during TX and lightning storms and anything else that fate sends its way. I have logged more than 60,000 hours on a single transistor under these conditions! It will not break unless you take a direct lightning strike, transmit directly into it, or do something stupid. DO NOT put back to back diodes on either the input or output thinking you will be protecting something. The only thing the diodes will do is generate IMD products from the strong BC stations, exactly what you are trying to avoid by building this high performance preamp!

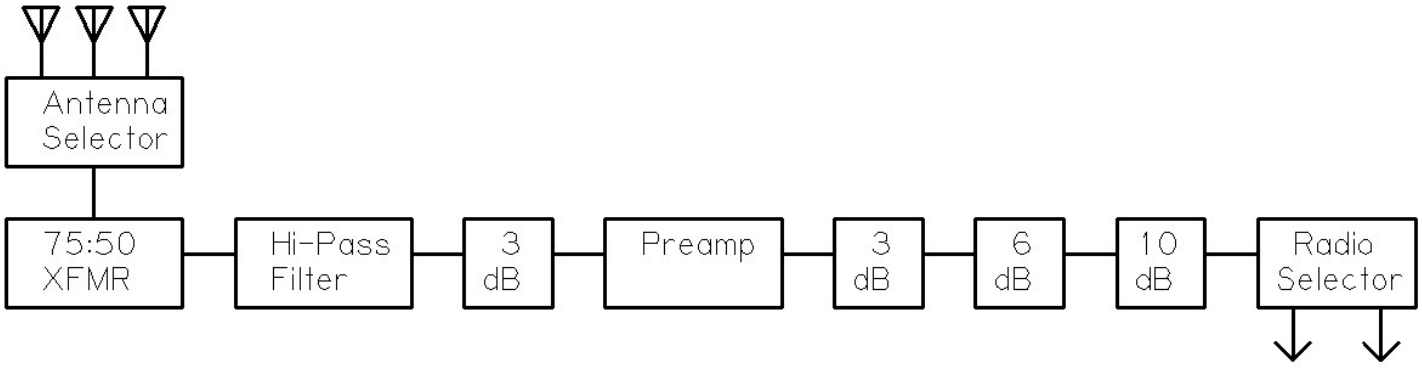
The high IMD performance is "out of band", that is to say it is not the same as the "in band" performance so highly valued by hot shot contesters. "Out of band" IMD is caused by very high level signals that are not in the ham bands such as AM broadcast. These out of band signals can cause

problems that cannot be cured by magical roofing filters. If the preamp generates IMD products, there is nothing you can do in the radio to eliminate the resulting spurs. Thus the need for a high performance preamp in front of the radio. In some cases, usually when a low level RX antenna such as a Flag is used, you won't need a filter in front of the preamp if you didn't need one in front of the radio.

In extreme cases, especially when a high level RX antenna such as a long Beverage is used, a filter will be required ahead of the preamp. In many cases, the preamp doesn't need the filter but the radio does! In either case a high pass filter should fix the problem. I don't recommend complex filters such as band pass types or elliptic function types because component values are too critical and operating conditions such as input and output impedance are also critical. They seldom, in practice, provide the performance enhancements claimed for them. Simple high pass filters are easy to build with common parts, usually don't require any "alignment" to function properly, and don't care much about exact input and output terminations. A 7th order Chebychev high pass, with a 0.1 to 1 dB pass band ripple, will normally be all that's required to use with this preamp. (Unless you operate on the same property as your local 50 KW BC station!)

Accessories:

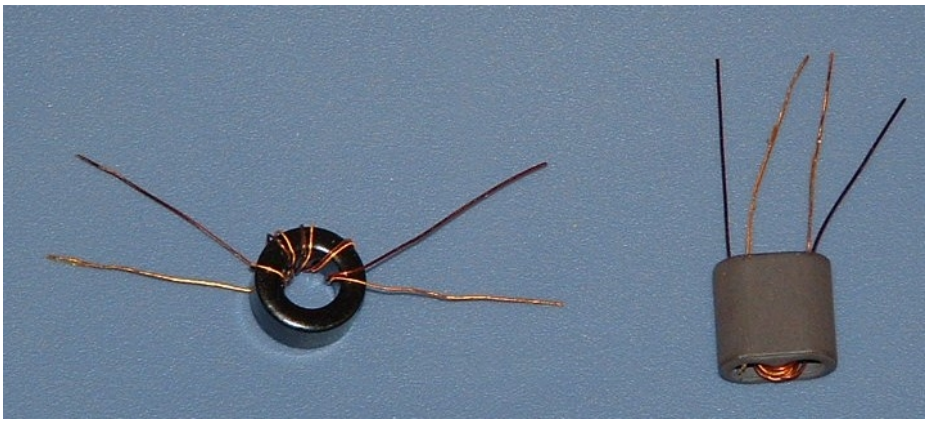
In the Assembly section above, I showed my preamp/switch box. In this section I'll show some of the internals so that a builder may incorporate them in his own preamp project as desired. Shown below is a functional block diagram of the preamp/switch box I'm using:



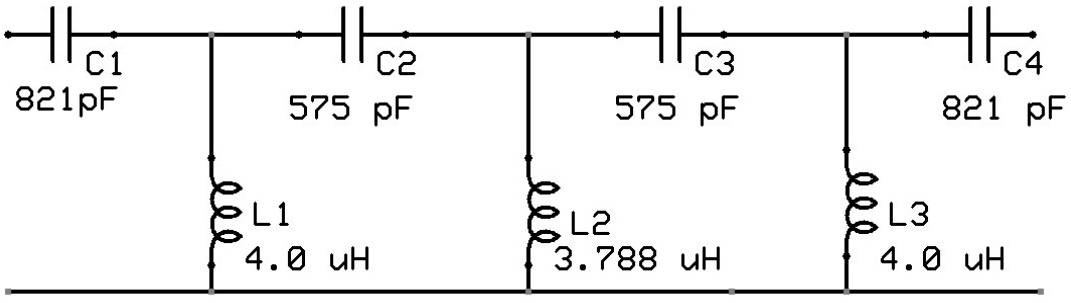
In the diagram above, each "box" defines a functional module. Except for the selector switches at the "input" and "output", and the 75 to 50 ohm matching transformer, each module has a mini-toggle switch associated with it so that it can be bypassed. In other words, I can use the preamp or not, use the filter or not, and switch in or out the attenuators as required. These functional modules can be built in a single enclosure or as separate modules with connectors. This arrangement has allowed me to use and evaluate many RX antennas of all types over the years with no re-wiring of the shack required. If the builder doesn't have a need for one (or more) of the functional blocks above, just delete it.

My antenna selector switch is a 10 position rotary switch and is wired up with mini coax to ten assorted connectors. With a selection of "F" and "phono" connectors on the rear of the chassis, I can adapt to most any coax feed easily.

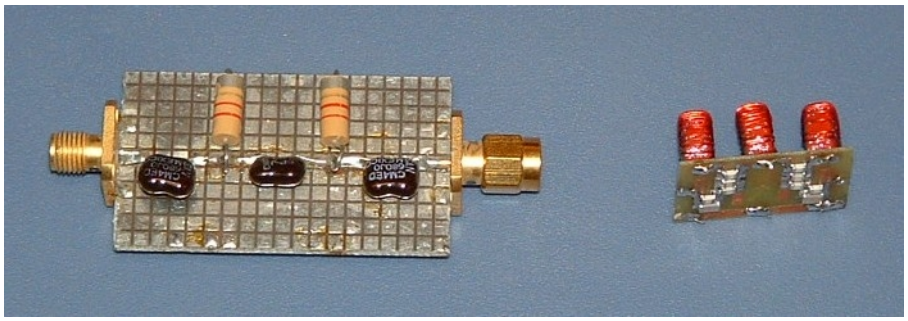
The matching transformer is usually not required. For many years I just ran the 75 ohm RG-6 type coax from the RX antennas directly into the 50 ohm high pass filter. It wasn't until I started experimenting with small vertical arrays that I needed to be concerned with exact impedance matching. My advice is to use it only if you need to use it. The transformer should consist of a 5 turn winding (75 ohm side) and a 4 turn winding (50 ohm side). I use #28 because I have it but any size wire that fits on the core can be used. You can use either one of the same type 75 cores specified for the preamp or a type 73 binocular core. If you use the binocular core, make sure all the wires come out the same end of the core. See photo below:



My choice for a BC band reject/ Hi-Pass filter is a 7th order Chebychev. I've built a lot of these over the years and have always been pleased with the performance. While I believe this design will be sufficient in most cases, be aware that your individual situation may require a different design for maximum performance. The filter shown below should produce about 33 dB attenuation at 1.38 MHz. Note the part values are not standard. Capacitor values should be made up from paralleled combinations. Capacitors should be good quality ceramic chip caps or dipped silver mica. They must be GOOD RF quality! The inductors should be wound on T50-2 cores. Inductance should be checked at 1.8 MHz with something like the MFJ-259B or Autek RF-1. DO NOT rely on measurements made from inductance meters such as the AADE.



Some types of construction are shown in the photo below. The filter on the left is a poor quality 5th order filter build on prototype board. This is NOT the circuit shown above, but merely presented as a way to assemble the filter. (Don't ask about the board material, it's not available!) DO NOT use the molded chokes shown for this simple filter. They will NOT work in the recommended Hi-Pass filter design. Shown on the right is the filter built with correct parts in surface mount form by W4EDS. Contact W4EDS directly for info on boards and parts kits.



The filter should be in a shielded enclosure. It can be in the same box as the preamp. Separate modules will allow some extra versatility and if connectors are used, will allow changing filters designs easily.

The attenuators are simple PI or T section and the values can be calculated from any of the on-line tools. Google attenuator calculator and take your choice. The resistors should be ¼ watt metal or carbon film. Exact values are not real critical and will only effect the exact attenuation seen. I won't bother with schematics or values because this is so simple and subject to much variation due to user preference. I usually wire the resistors directly to the toggle switch but other options are possible. Builders may want to check with W4EDS for surface mount solutions.

The radio selector switch is a common mini toggle switch. If you need more than two positions, use a rotary switch. If you need simultaneous reception, use a splitter. If a splitter is used, be aware that you may need more preamp gain due to the "loss" in the splitter. Nice "magic-T" splitters are described on the W8JI web site along with how to use them.

Summary:

Optimum low band operation requires specialized receive antennas. Few, if any, of these RX antennas have sufficient output level to insure maximum receiver performance. A preamp is used to increase the low signal levels from these antennas to the point where the receiver is operating in it's "sweet spot" for weak signal reception. Due to the proximity of the AM broadcast band, the preamp is required to work in the presence of very high out-of-band signals. A preamps which does not handle these out-of-band signals well, will generate spurious signals in band that cannot be processed out by the receiver. The design presented in this paper has been shown by experience to meet these requirements in the vast majority of operating situations and do so better than most commercial options. Emphasis has been placed on the practical aspects of home building this circuit and using it on-the-air.

Feedback welcomed: w7iuv@yahoo.com

Note: Time and money prevent me from testing all possible transistors in this circuit. If you have a transistor type that you think will work and want it tested, contact me. I may be able to do that for you if you send me a part. I can then report back to you on the performance and list the part in this document as well.