Better Low Band Reception for DXpeditions

Noise reduction techniques and low band receive antenna systems for DXpeditions.

V.1

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Introduction

Most DXpeditions enthusiastically announce160 meter CW operation. Too often they don’t deliver. They spend valuable days battling noise, but eventually fall back to FT8, or just work 80 meters. But that does not satisfy the demand for 160m CW.

What does it mean to be effective on 160m CW? In my opinion, a 14-day DXpedition should make at least 500 CW DX contacts on 160m. Of course, a lot depends on the location – and many other factors – but 500 QSO-s would show good performance for a top 20 - 40 most wanted entity. For top 20 and higher, 1,000 – 2,500 QSO are needed to meet demand. Because on a DXpedition receiving is the challenge (they know your call), improving the RX signal-to-noise ratio (SNR) is the key to success.

You may think that by going to a small tropical island you will escape the noise of modern "civilization". Far from it! There will be noise! If the island is populated, people will be using generators, solar panels or even solar farms, inverters and electronics of the cheapest kind, with zero or very little filtering. If the DXpedition goes to an uninhabited island it will bring its own noise sources: generators (especially inverter-generators), computers, switch-mode power supplies, inverters, routers and so on.

Thunderstorms are also a significant source of 160m noise in the tropics. All this noise will combine with the background noise to make 160m (and 80m) reception of weak signals difficult. A DXpedition that is serious about handing out that rare one on 160m CW, should prepare in advance to fight noise; with plans, materials, pre-assembled equipment, as well as time allocated to deploy them. A haphazard approach like “if we have noise, we will deal with it” will likely result in disappointment. Often, more time is wasted on tracking down and eliminating noise sources than would be used to implement a comprehensive plan from the outset.

This paper is based on my experience of 20 years and many DXpeditions, some small, some large. I have learned from my mistakes, so you won’t have to. And if you do everything right, you may get emails like this: "incredible ears on E5-N this morning at 1107 UTC, just before local SR, I worked E51D QRP, using a ‘nothing special’ Inv-L."

Do You Need a RX Antenna?

Yes, you do! Without a good RX antenna, you may work a couple of hundred big guns on the first few nights, but after that your QSO rates will fall off and you won’t be able to work the 100 watt stations with small antennas, who probably need you most.

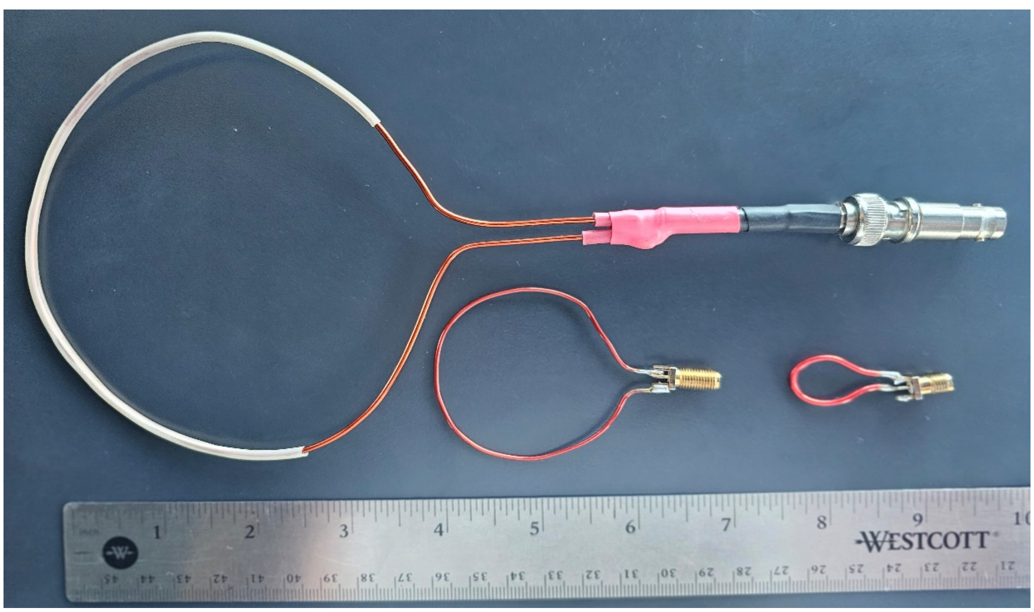
Noise Expectations:

On a DXpedition the task is to work as many callers as possible -- not only the big guns, who probably have your entity (unless you are in N. Korea). The weak ones are likely to have S1 to S3 signals (-120 to -110 dBm). To work them you will need a positive signal-to-noise ratio. Since the signal is a given, your only way to improve the signal-to-noise ratio is by reducing the noise.

On an island in the South Pacific, on 160m under ideal conditions, you can expect a noise floor of around -120 dBm on a TX vertical and a 300 Hz wide RX filter. That equates to about S1 to S2 noise. With a higher noise floor of -110 dBm (S3) you will still be able to work a lot of DX, but anything higher than that will seriously hamper your ability to hear the weak ones. Even if you are lucky enough to have -120 dBm of noise on your TX antenna, you will not be able to hear some callers.

On a tropical DXpedition we normally deal with four types of noise: locally generated noise, noise from other stations, background noise and thunderstorm noise. Your first goal is to minimize the local noise. Do your noise hunting and mitigation during the day, when the 160m background noise is the lowest and local noise stands out.

For locating local noise sources, use a small portable receiver with two or three untuned loop antennas. Use the larger loop to find the approximate location of the noise source. Then use a small loop to find the port or cable with the noise. Just be careful poking around power supplies! A portable AM radio with a ferrite antenna could also be useful.



Tools of the Trade

Inter-station noise, which is an issue on multi-station DXpeditions, mainly comes from the nearby transmitters of other stations. This isn't limited to harmonics or spurious emissions. Some transmitters generate wideband noise when transmitting. Although this noise is way down from the main signal, it will be amplified by the PA. For 160m (and 80m) the PA's low-pass filters will not help in reducing this noise. If the TX antennas of the other stations are close enough to the 160m antenna, you will experience a jump in the noise floor whenever another transmitter is transmitting. You don't need much to go from S2 noise to S3, which can prevent you from hearing some weak signals.

Bandpass filters are essential on multi-station DXpeditions, as they reduce out-of-band noise, harmonic and spurious emissions, and act as RF pre-selectors for the receivers. They effectively solve this problem. But be careful: bandpass filters with poor shielding can pick up noise because of their high impedance tuned circuits. Sometimes extra shielding is needed.

Improvised shielding of a multi-band bandpass filter.

Testing all transceivers, ahead of the DXpedition, for harmonic and spurious outputs, and for both out-of-band and in-band noise, is a recommended practice.

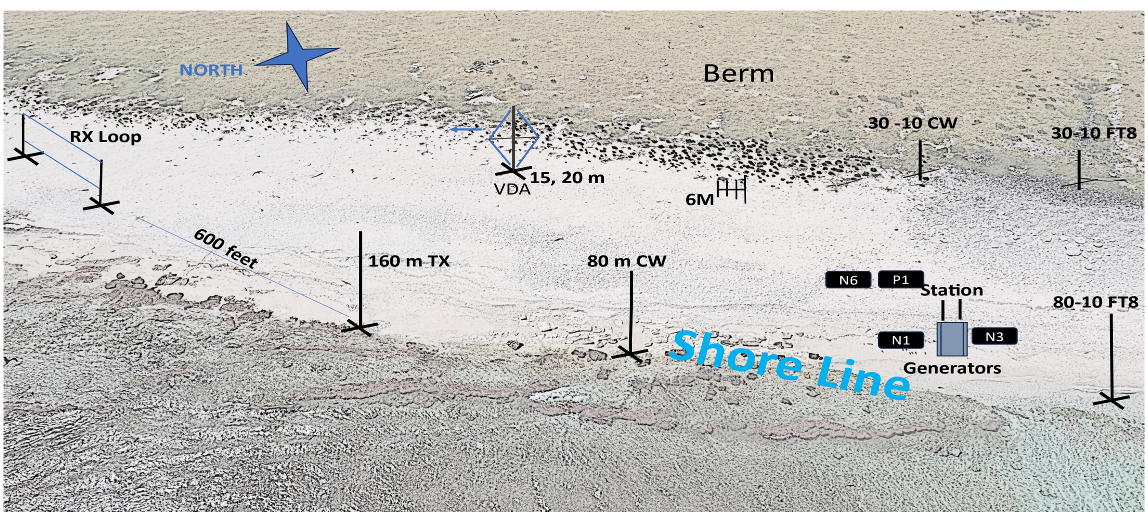
Background (ambient) noise tends to come from all directions. This is where a good RX antenna can make a crucial difference.

Thunderstorm noise is especially a big problem south of the equator. The best 160m months in the Northern Hemisphere, October to March, are also summer months in the Southern Hemisphere, which means a lot of thunderstorms, particularly in the Inter-Tropical Convergence Zone (ITCZ). The ITCZ is close to or just north of the Equator at that time of the year. This is also the monsoon season in most of Southeast Asia, Papua New Guinea and Northern Australia. In most of the South Pacific, this noise gets troublesome three to four hours after local sunset, when the terminator reaches the monsoon areas, probably around 1000Z. The only way to mitigate this noise, which comes from the west, is with a directional RX antenna pointed east or northeast.

Station and Antenna Layout:

The station and antenna layout can have a big impact on the amount of local and inter-station noise you will have to deal with. Locating the generators and antennas as far from each other as practical is a good start. Grounding is much easier at the edge of the water and a good ground can make a big difference. Ideally, coax cables should not be running close to and parallel with each other. If they must cross, bury one of them to create a "spacer". Once the station is built, it is very hard to move things, so plan carefully! When on a large DXpedition, it is possible to further separate the CW, SSB and FT8 stations to allow in-band operation. This can also reduce noise.

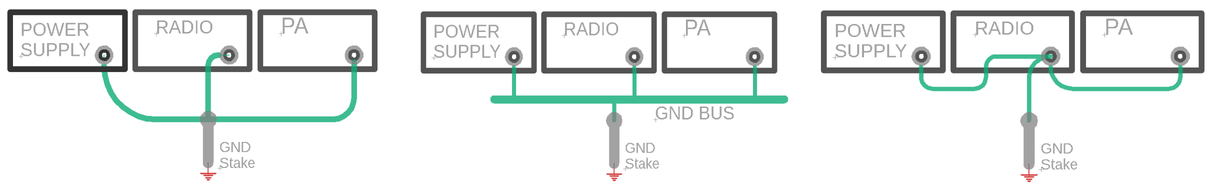
The illustration below shows the N5J DXpedition layout. The low band antennas are along the shoreline where they take advantage of the good ground offered by the saltwater. The station and the generators are also close to the water. The RX antenna is the farthest out, about 600 feet from the 160m TX antenna.



N5J Jarvis Island Station and Antenna Layout

Grounding:

Good grounding is your first line of defense against noise. Ground the generator chassis, the radios – anything with a ground lug. Each device should have a direct run ground wire to the grounding-stake or a ground bus. Multiple parallel wires will give you a lower impedance ground connection.



Good Good Poor

Grounding Arrangements

Routing ground wires from one piece of equipment to another is a poor practice because noise can be carried by the grounding wire, especially from the power supply to the receiver. Remember, even an excellent saltwater ground will have some resistance and reactance (more than 2 Ohms).

The best RF ground you can get is with grounding-stakes in the water, driven into the sandy bottom or wedged under rocks. Do the work at low tide to ensure that the stakes are always covered by some water. Grounding wire(s) connecting the ground-stake(s) should be short and straight, and minimum AWG #16 diameter.

When a short connection to the salt-water ground is not possible, the quality of RF ground that you can obtain will strongly depend on the composition of the beach or shoreline. If it is a beach with soft sand, it will be easy to drive a stake deep enough to reach the water table and get a good RF ground. The water table can reach surprisingly far under a sandy beach. But make sure you reach saltwater – drive the stake past the layer of freshwater that often floats on top of the heavier saltwater. You will need ground stakes that are at least 5 feet long. (Take a heavy mallet.)

On beaches or islands that have coral rubble, rock base, or dry sand, obtaining a good RF ground will be much harder. When there is a layer of sand on top of hard rock, it is sometimes possible to bury a horizontal ground stake in wet sand above the rock. With coral rubble, you may have to try many locations to drive a stake deep enough. Where rock or coral rubble prevents the driving of a ground stake, laying ¼ wave radials on the ground may provide an RF ground substitute. However, these grounding wires are just as likely to carry or radiate noise as to conduct it to ground.

Throwing wires with rocks tied to their ends into the water may or may not work. They often end up in a tangle, washed ashore by the surf as the tides change. Any wires that go into the saltwater for grounding should be tied to something solid, preferably a grounding stake either driven deep or solidly wedged into rocks. Insulated wires are fine, especially when tied to a grounding-stake.

Aluminum Grounding Stake

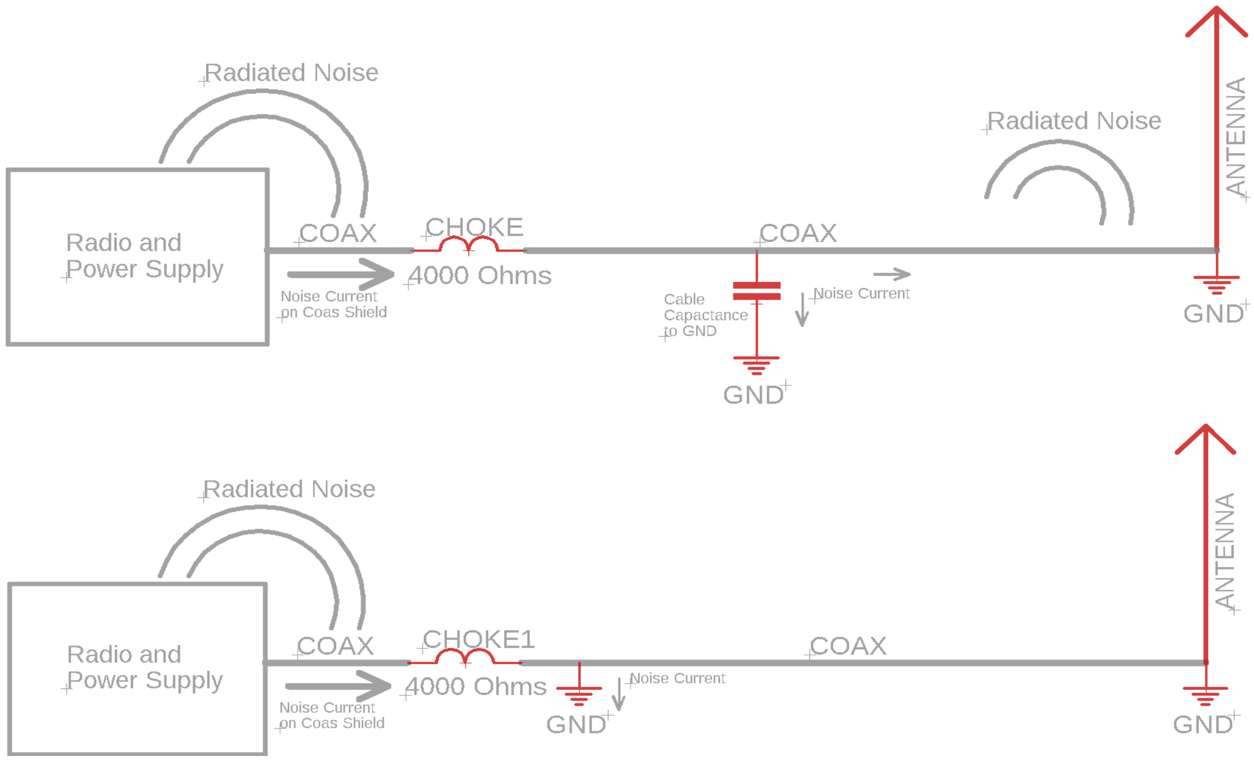
Use grounding stakes made from L shaped aluminum profiles. These are better than copper clad steel because they don't corrode and are lighter. Sharpen their tip so they easily push small rocks aside when driven into the ground.

In a saltwater environment an unprotected copper to aluminum contact will corrode within days, adding a significant amount of resistance. Use Noalox grease where the wire connects to the stake. Apply generously.

Noalox prevents corrosion between the aluminum stake and the grounding wire.

RF Chokes

Chokes add a series RF impedance to the cable. They will be most effective when combined with a low impedance path to ground, preferably right at the choke.



Grounding at the Choke shunts the noise current to ground.

In the top configuration the choke (or clamp-on ferrite) adds a series impedance to the outside shield of the coax cable. Its effect is limited because the noise current is only reduced by the small shunting effect of the cable's stray capacitance to ground. In the lower example, the noise current is fully shunted into the ground, eliminating the conducted and radiated noise from the rest of the cable. Even better with additional chokes at each end.

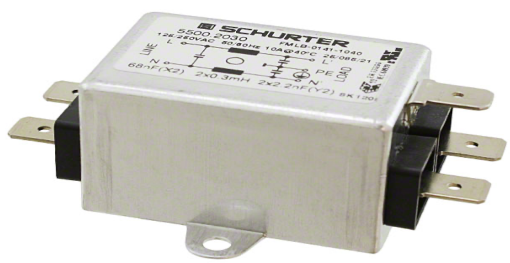
Effective RF chokes can be made by winding coax, power or control cables through ferrite toroid cores. Clamp-on ferrites are less effective but easy to apply without pulling the system apart. A source of essential information on chokes is Jim, K9YC's cookbook. http://k9yc.com/2018Cookbook.pdf .

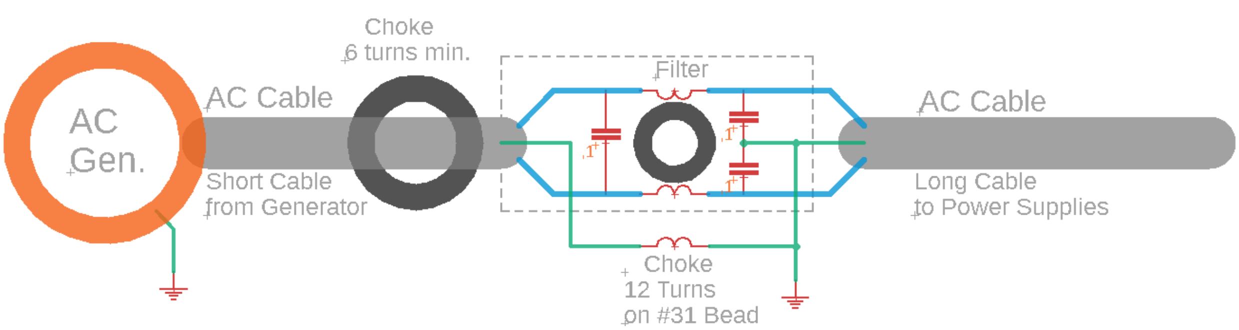
You can't have too many chokes or ferrites! Place them on all the coax feedlines to limit RF currents travelling on the outside of the coax shield. Data lines should also have chokes. Use shielded cables, especially for Ethernet wiring (CAT6). Connect both ends of the shields to ground, unless substantial AC currents are likely to flow through the shield, in which case you should only connect one end of the shield.

Generator Noise

The main source of noise in most generators is the ignition (except diesel generators). Grounding the generator can help, provided you have a good ground. Radiated ignition noise can be reduced by shielding the spark-plug cable. Also, a small capacitor from the chassis ground to the primary of the ignition coil can help. Be careful though – anything over 10 nF may weaken the ignition! Also, wrapping the ignition coil with copper tape, and grounding it, can make a difference. In any case, locate the generator as far as practical from the radio and other equipment (10m, or more). Note that a generator that may sound noiseless when tested in your suburban backyard will likely splatter noise all over the low bands once you are on the island with a quiet background. Don't be fooled!

A good filter should be installed between the AC outlet of the generator and the power cable going to the station. Such a filter is a must with an inverter generator (such as the Honda EU22i)!





AC Line Filter

The AC Line Filter consists of three parts: A common mode choke wound using a 2.4" #31 ferrite toroid, a commercial filter, and a separate ground wire choke. The ground wire choke is especially important as noise often travels on this wire. The filter and ground wire choke can be easily spliced into the power cable and sealed with tape. Alternatively, they can be installed into a water-tight box and connectorized. The ground lug of the filter (PE) is on the load end (the cable going to the station) and is grounded. Coil up any excess cable to form an additional choke. To save time, filters (and chokes) should be pre-assembled and tested ahead of the DXpedition.

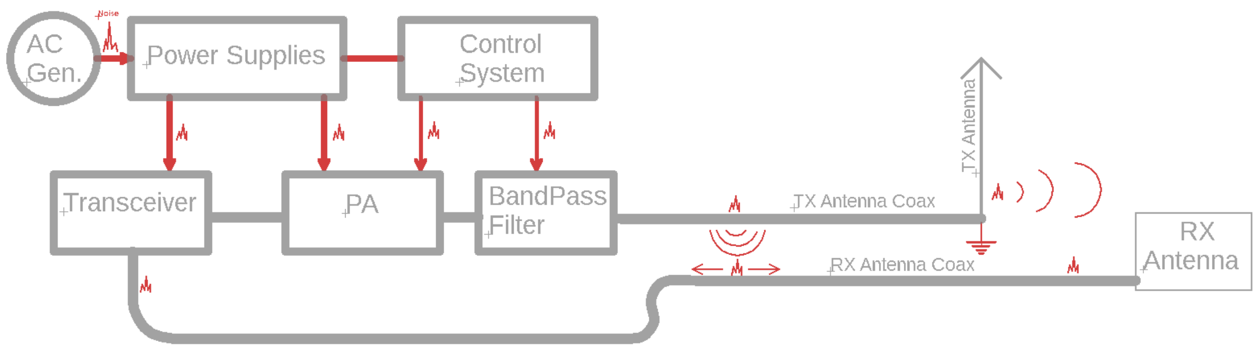
As a last resort, burying the AC power cord in wet sand can reduce its radiated and conducted noise. I believe that some benefit is derived from not making the cable run straight. Do the work at low tide and bury the cable deep enough for the water to cover it at most tides. Just make sure that the cable jacket does not have nicks or cuts that could allow water ingress. High voltage AC and saltwater are not a good combination.

Burying the power cable in wet sand can reduce conducted and radiated noise

Note the long distance at which the generator(s) are located. The further the generators are from the antennas the better, provided the voltage drop on the cable is not excessive. An additional benefit of locating the generators at a distance is the lower audio noise, which you will appreciate when trying to copy -120 dBm signals.

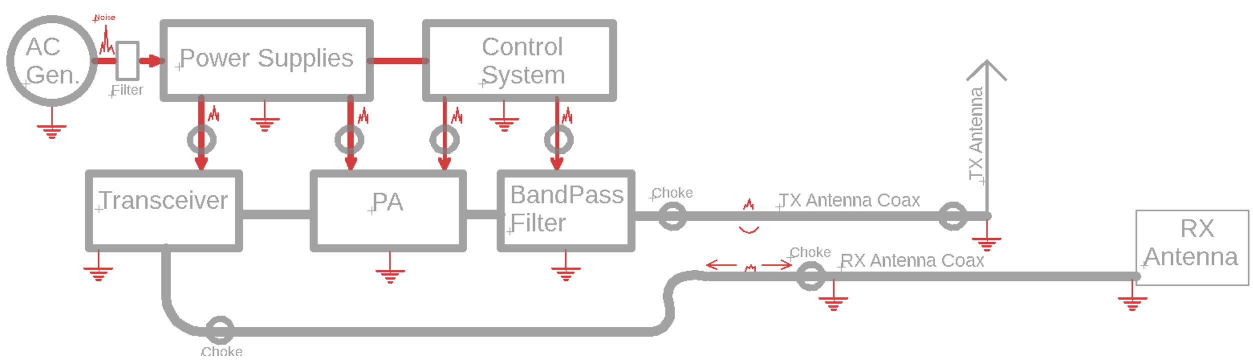
On DXpeditions, I exclusively use 240 V AC instead of 120 V. With 240 volts the current is halved for the same power delivered. This means a smaller (and lighter) cable for a given voltage drop. Or for the same length cable half the voltage drop. A thinner cable is advantageous from a noise perspective because it allows more turns on a given toroid core. More turns will result in an increase in the choking impedance (the square of the number of turns).

On tides: On all ocean islands you will have tides, with daily water levels rising and falling from 1 to 8 feet, and sometimes much more in coastal areas. Study the tide tables to determine when and where to place antennas and grounding stakes. Ideally, you want antennas and grounding stakes at the low tide water line, where they don't go dry, but you don't want the antenna getting knocked down by the waves at high tide.



Noise Sources and Coupling

In addition to the inverter generator, switch mode power supplies are the main sources of noise. Their noise is compounded by other equipment that contain microprocessors. Noise conducted on the outside of the main antenna coax shield (common mode noise) can couple into the main antenna, which then can radiate it. That in turn can be picked up by a nearby RX antenna. Inserting a filter into the output of the generator and adding chokes to the power, control and coax cables, combined with thorough grounding will go a long way in reducing the noise that gets into the receiver.



Noise Mitigation with Filter and Chokes

After you have done all the obvious things and reduced local noise a great deal, it is likely that some noise will remain. Your problem is the diminishing return on time spent tracking down the remaining noise sources. Unlike with your home station, you don't have weeks or months -- every night is precious on 160 meters, so you must move on. Your next step is to build an RX antenna, which, when far enough away, will likely not hear the residual local noise, or at least reduce it to a level you can live with. You have gone to a lot of trouble to get to that rare location. It is worth going the extra mile to make your low band operation count. Build an RX antenna system.

RX Antenna System

It is a system because it is not just about the antenna. The coax feedline, the pre-amplifier, chokes and grounding all play important roles. They all must be done right to get satisfactory results! A good RX antenna can be rendered useless if its feedline couples noise into it, or if it picks up re-radiated noise from the TX antenna.

Coax Feed Line

I use 75 Ohm RG-6 type quad shield coax (DX Engineering Part Number: DXE-RG6UQ-1000), terminated by F type compression connectors. Due to the 1.5 SWR mismatch between the 50 Ohms receiver input and the 75 Ohms coax there will be slightly more loss (3.3 dB vs. 3.0 dB on 1000 feet) than on a 50 Ohms coax. The 0.3 dB of additional loss is not significant in a receive system. In a receive system, it is the Signal-to-Noise Ratio (SNR) that we care about. It is far more important to have good shielding to prevent noise from coupling into the center conductor. But, if you are a purist, you can install a 75:50 Ohm transformer at the receiver. Just make sure its loss is less than 0.3 dB!

Ensure that the center conductor of the coax, which acts as the center pin of the F connector, is clean. I use a very small amount of Conducto-Lube (Cool-amp #240-200) silver paste to coat the bare copper clad center conductor to ensure a good connection and prevent oxidization of the copper. Makes sure the paste does not get onto the insulator (https://www.cool-amp.com/conducto-lube). Cheaper copper-based lubes are available on Amazon.com. Also add to the outside thread of the F female connectors a small amount of Conducto-Lube or a small amount of DeOxit dielectric grease and tighten the male connectors with a wrench. Cover with electrical tape to prevent water ingress (even with connectors advertised as “waterproof”). This is especially important when the coax is used to power a remote pre-amplifier. Any leakage current between the center conductor and the shield can generate noise, especially when some corrosion is present. Flooded coax resists moisture better, but that may not be important for a two-week operation.

When using old coax (you shouldn’t but…), cut off the old connectors and about 3 feet of cable. Examine the cable for signs of corrosion and if clean, spray the braid with a small amount of DeOxit and re-terminate with new connectors.

Curl up any excess coax into a coil and lay it on the ground. It will act as a choke and its capacitance to the ground may help in reducing conducted noise. Keep the RX coax away from any other cables, especially high-power TX or CAT6 data cables. When crossing another cable is unavoidable, make the crossing at right angles. Bury the RX coax in sand or add spacer to reduce coupling.

The Receive Antennas

I will focus on four simple receive antennas: The Flag, the Delta Loop, the DHDL and a short Beverage. There are many other good receive antennas, some commercially available, most of which can do the job well, or indeed better. I picked these four because they are easy to build and don't require a lot of material. Of course, an Eight Circle Array would have better performance than any of the antennas described here, but can you afford the time on a 14-day DXpedition? Beverage antennas also have great performance, but they do not always work on islands surrounded by water.

All of these antennas improve the received signal-to-noise ratio by favoring one direction at the expense of other directions. Because atmospheric noise tends to come from all directions, the antenna will not "hear" some of that noise and its total noise output will be lower. Signals coming from the "favored direction" will be attenuated less, resulting in improved signal-to-noise ratio (SNR).

The quality of a receive antenna is expressed by its directivity factor (DF). DF is the difference between the average antenna gain and the gain in the main lobe. DF starts to become useful above 6 dB. A good flag antenna will have a DF of around 7 dB and a decent Beverage may have a DF of 11 dB. (A very good one 12 dB, but...)

All these antennas are low gain antennas, only suitable for reception. Their gains range from -15 to -40 dBi. They produce weak signals that can be easily swamped by noise picked up either from the transmission line or any other place between the antenna and the receiver.

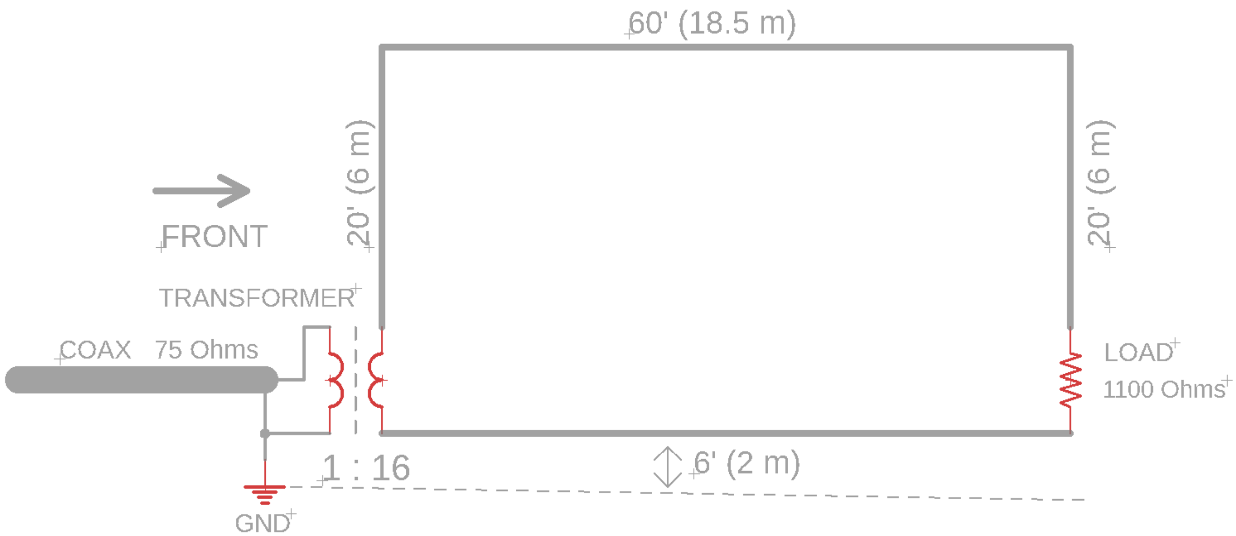
Because all these antennas have sharp nulls in the back, and fairly broad lobes in the front, they may be pointed to reject a noise from a given direction, even if that means not getting the strongest receive signal. Remember, it is the SNR that we care about. Losing 2 dB of receive signal while eliminating 20 dB of noise, is a good trade.

A good receive antenna will also be more comfortable to listen to because of the lower overall noise. Comfort means longer endurance and more QSOs. Additionally, a suitably aimed RX antenna can even out signal levels between different regions. For example, in the Western Pacific a RX antenna aimed NE will hear NA and JA callers at about the same level, while JAs would be much stronger on the omni directional TX antenna and would be making it harder to work NA stations (JA wall).

The W8JI website https://www.w8ji.com/antennas.htm contains valuable information on receive (and other) antennas and related subjects.

The Flag

The Flag is a rectangular, non-resonant loaded loop. It is fed at one corner and is loaded by a resistor at the other corner. This antenna is a workhorse, with enough gain to work without a pre-amplifier, although one is strongly recommended. The directivity factor (DF) of this antenna is around 7.3 dB.



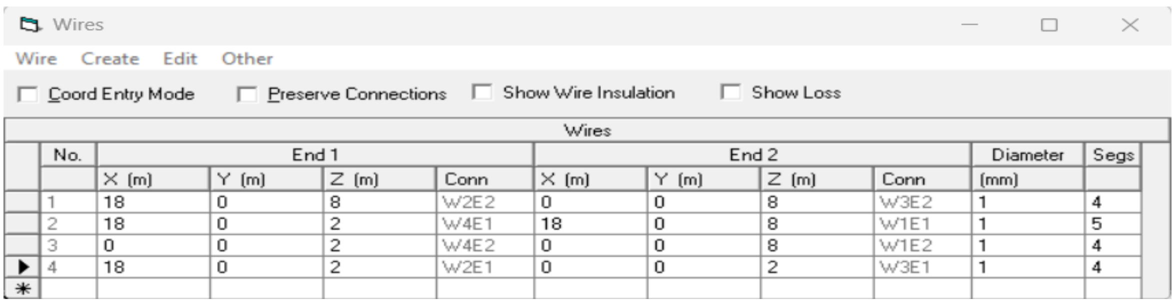
Flag Receiving Antenna

The transformer matches the 75 Ohm coax to the (approximately) 1,100 Ohm loop impedance. It also isolates the antenna from common mode noise on the coax. A 1:16 transformer can be easily wound on a binocular or toroidal core of #43 ferrite material. Three turns of primary winding (low impedance side) and 12 turns of secondary winding will give a winding ratio of 4, resulting in an impedance ratio of 16. Ideally, you should minimize the inter-winding capacitance. The loading resistor must be a non-inductive, carbon, ceramic, thick film or metal oxide type, rated for 1 to 2 Watts.

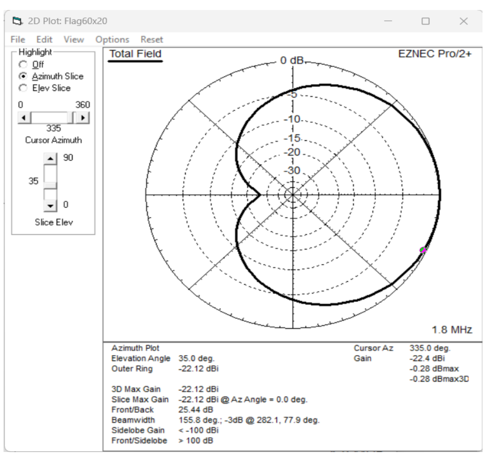
There are several important aspects to the Flag (and other loops). First, the dimensions are not critical. Nor are the transformer ratio or the loading resistor value. A 1:9 transformer will work, and the loading resistor can be anything between 900 and 1200 Ohms, unless you need a very sharp null in the back. The values given here are what I use and modelled. You can make the antenna 10’ shorter and it will work almost the same. However, do not make it too small because it will stop working below a certain size! The signal level the loop will produce is proportional to the area enclosed by the wires. When the antenna is too small (-50 dBi gain or less) the received signal will be low to the point where it will be close to the thermal noise of the loading resistor. You may still hear S9 signals, but weaker signals will be swamped by the resistor noise. You can’t correct that with a preamplifier!

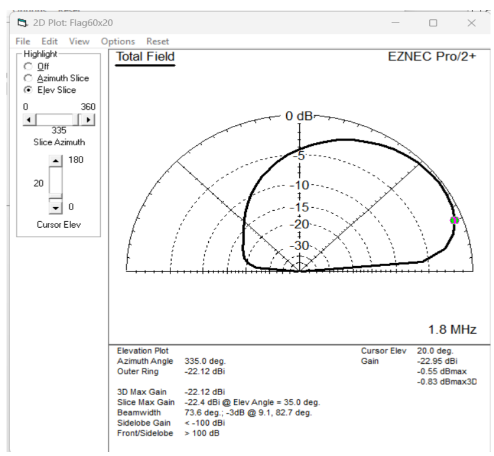
The antenna receives from the feedpoint end (front), where the transformer is located. The flag requires two supports, which could be two 25-foot fiberglass push-up masts. The wire should be insulated. The wire diameter is not critical either but should not be thinner than #20 AWG for physical strength and to prevent stretching.

The Flag shown above has a gain of -22dBi, which is due to its relatively large size. A smaller version will have lower gain, and slightly better front-to-back ratio and DF. Additionally, the original size antenna is less useful on 80 meters. If your goal is to maximize 160 m performance, this antenna, with its higher received signal level will be better. If 80 meters is important for you, a 40 x 14-foot version may be more suitable.



No.	End 1 X (m)	End 1 Y (m)	End 1 Z (m)	End 1 Conn	End 2 X (m)	End 2 Y (m)	End 2 Z (m)	End 2 Conn	Diameter (mm)	Segs
1	18	0	8	W2E2	0	0	8	W3E2	1	4
2	18	0	2	W4E1	18	0	8	W1E1	1	5
3	0	0	2	W4E2	0	0	8	W1E2	1	4
4	18	0	2	W2E1	0	0	2	W3E1	1	4



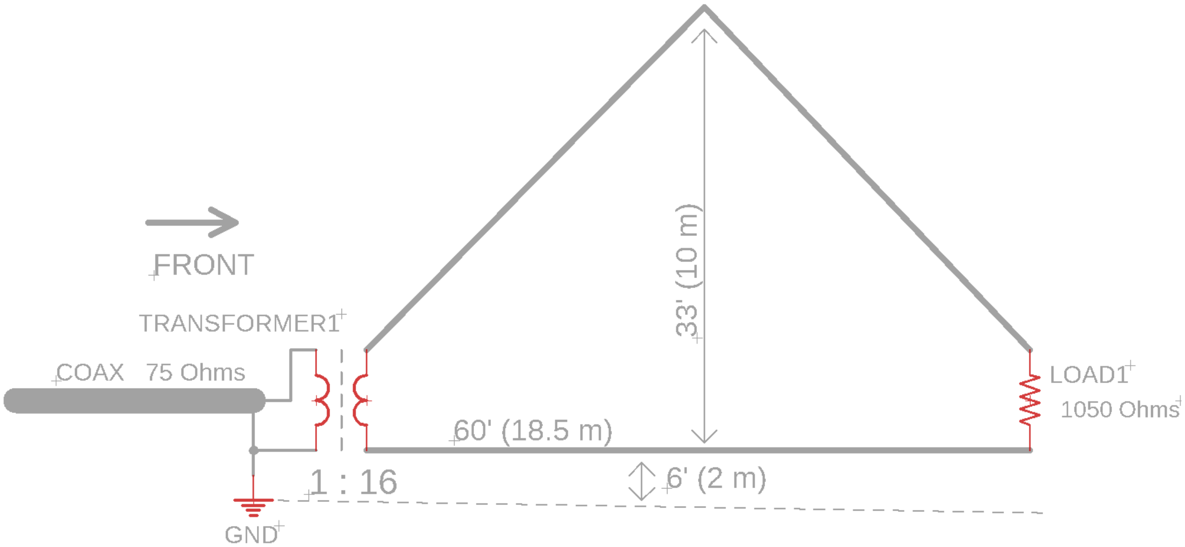


EZNEC model and radiation plots of the 60 x 20-foot flag

The Flag at N5J, Jarvis Island, 2024

Delta Loop

The advantage of this antenna is that it only requires a single support. At -25 dBi the gain is 3 dB lower than a similar sized Flag, but the DF is 7.5 dB, which is pretty good. The same principles apply to this antenna as to the Flag.



The Delta Loop

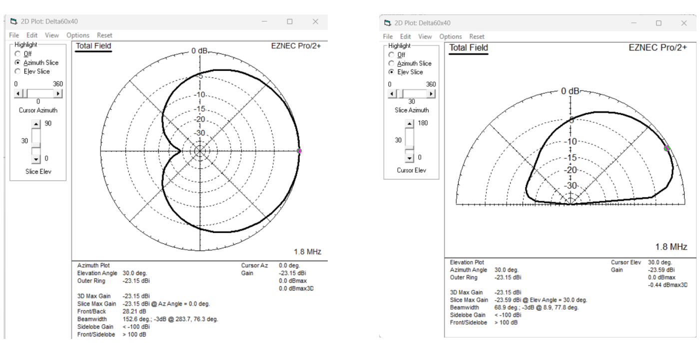
Dimensions are not critical. A smaller antenna will produce a smaller signal but will have a slightly higher DF. But the higher signal level from a larger antenna will give you a better SNR when you have local noise.

Wires

Wire Create Edit Other

Coord Entry Mode | Preserve Connections | Show Wire Insulation | Show Loss

No.	End 1 X (m)	End 1 Y (m)	End 1 Z (m)	End 1 Conn	End 2 X (m)	End 2 Y (m)	End 2 Z (m)	End 2 Conn	Diameter (mm)	Segs
1	0	0	2	W3E2	9	0	12	W2E2	1	12
2	18	0	2	W3E1	9	0	12	W1E2	1	12
3	18	0	2	W2E1	0	0	2	W1E1	1	12

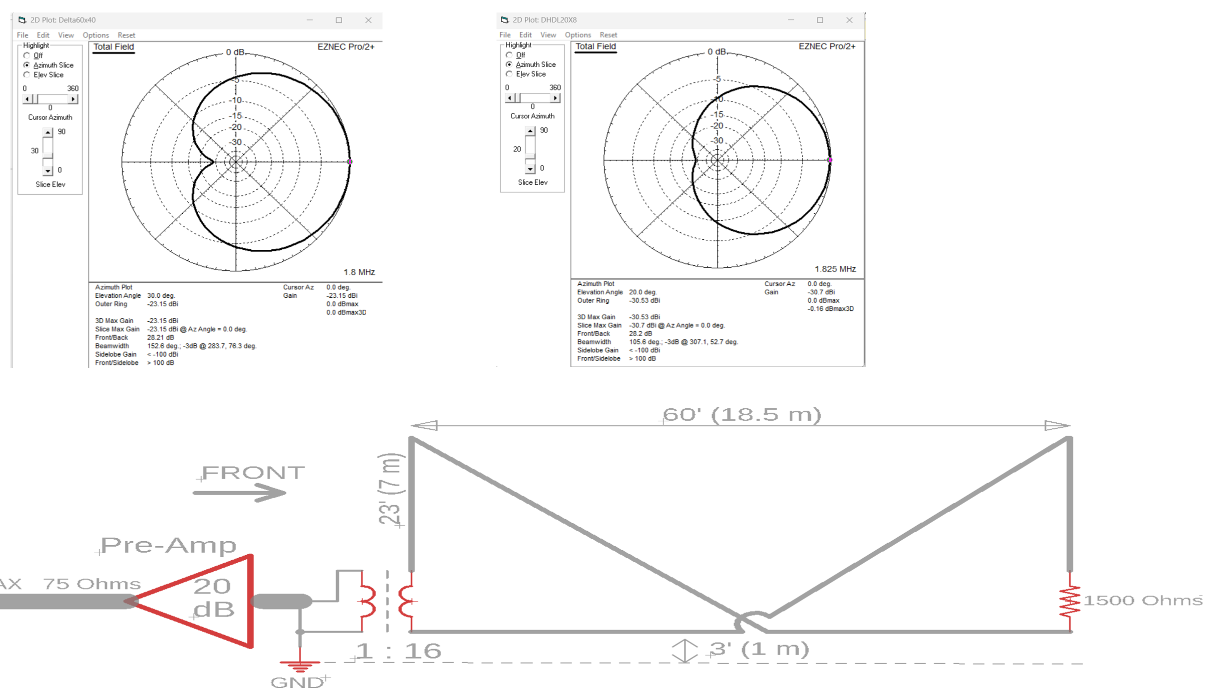


Model of 12 m Tall Delta Loop

The DHDL

During the TX3A Chesterfield DXpedition we had strong thunderstorm noise from Papua New Guinea, which was 1000 miles to our northwest. We needed something narrower than a Flag. We knew that two phased Flags could produce a narrower front lobe. We could point the array towards the northeast, which would put the source of the thunderstorm noise on the side. With the array pointed NE we would still hear NA well but would be less bothered by the thunderstorm noise. However, we did not have the parts needed. What we had were two supports, one transformer and some resistors.

The DHDL is essentially two half delta loops with the wires crossed in a way that forms a phased array. It uses two tall and one short support, a single transformer and one loading resistor. The two plots below show the improvement: On the left is the azimuth pattern of a delta loop and on the right is the DHDL. There is about a 5 dB improvement on the sides and even more on the back. The DF of the DHDL is about 9.3 dB, which is better than a Flag's DF of 7.3 dB.

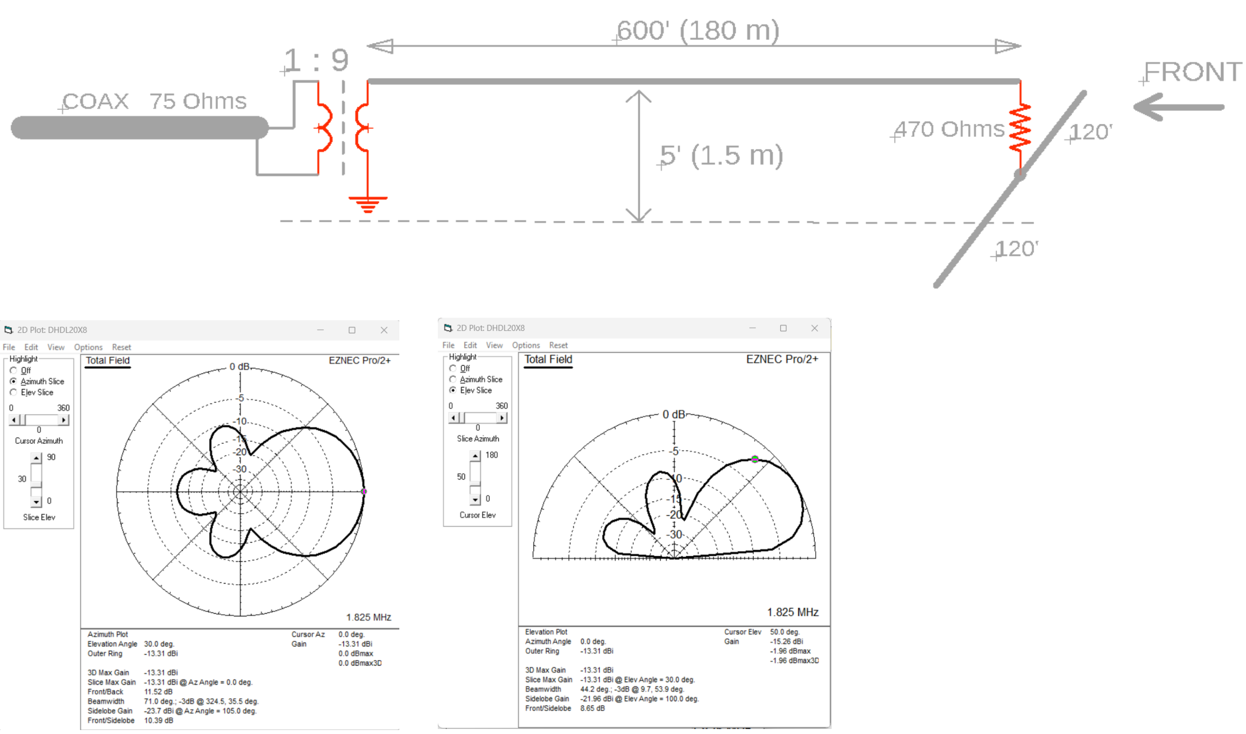


A 60' DHDL. The left plot is a delta loop for comparison

A DF of 9.3 dB is excellent. You may ask, where is the catch? The catch is the much lower gain: -31 dBi vs. -23 dBi. That is almost 10 dB lower signals (and noise) than on a delta loop. A lot of people who have tried the DHDL were disappointed thinking “the antenna is deaf”. It certainly sounds that way. A signal that would be -120 dBm on the TX antenna will produce an output of -145 dBm on the DHDL. That is a very small signal and a low noise 20 dB pre-amplifier, located at the antenna, is essential.

The Beverage

I had mixed results with Beverages on islands. On Willis Islets we had a 500-foot-long Beverage that was quite good, but I could not get a Beverage to work on Wood Cay in the Bahamas (C6AGU), despite plenty of room and seemingly dry sand. A 300-foot-long Beverage kind of worked on Chesterfield Reef, but virtually the same antenna did not work on Mellish Reef. We had an excellent 600-foot Beverage on Navassa Island (K1N) but that was over rocky terrain and far from the water. I have not tried a Beverage for some time, but here is a description of the one we used on Navassa. Good luck!



600’ Beverage used on K1N

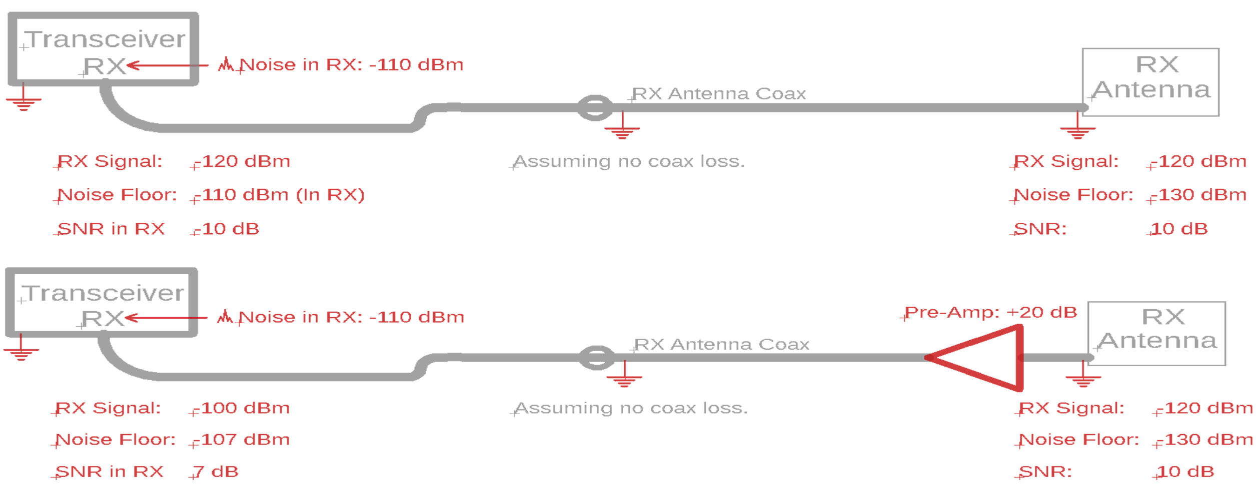
With an 11 dB DF this would be a superior antenna – if you can make it work. The -13 dBi gain produces strong signals that could overcome local noise. Note the counterpoise wires at the far end, which were needed because we could not drive a ground stake into the rocky ground. Instead of a ground stake, counterpoise wires were laid on the ground. The Beverage wires were draped over bushes to hold them approximately 1 to 1.5 meters above ground. The transformer was from DX Engineering, similar to https://www.dxengineering.com/parts/ums-bt-75#overview .

Preamplifiers

A low noise (2 dB NF or lower) 20 dB gain preamplifier is essential for a DHDL. I strongly recommend a preamplifier with the Flag and Delta Loop too. The preamplifier should be at the antenna. This is not merely to overcome the coax loss, although it does that too. The preamplifier is located at the RX antenna because that is where you get the best SNR. The preamplifier helps to preserve that SNR. Further back, the SNR can deteriorate as noise gets into the receive path. An amplifier back there would also amplify that noise and would do nothing for the SNR.

I prefer the preamplifier to have a selective front end, i.e. a bandpass filter. While with low gain RX antennas, like the Flag or Delta Loop, overloading by out-of-band signals from nearby transmitters is not likely, a low loss selective front end ensures that. This is important because it is easier to achieve low noise and low power consumption with a lower IP3 amplifier that would be more susceptible to overloading.

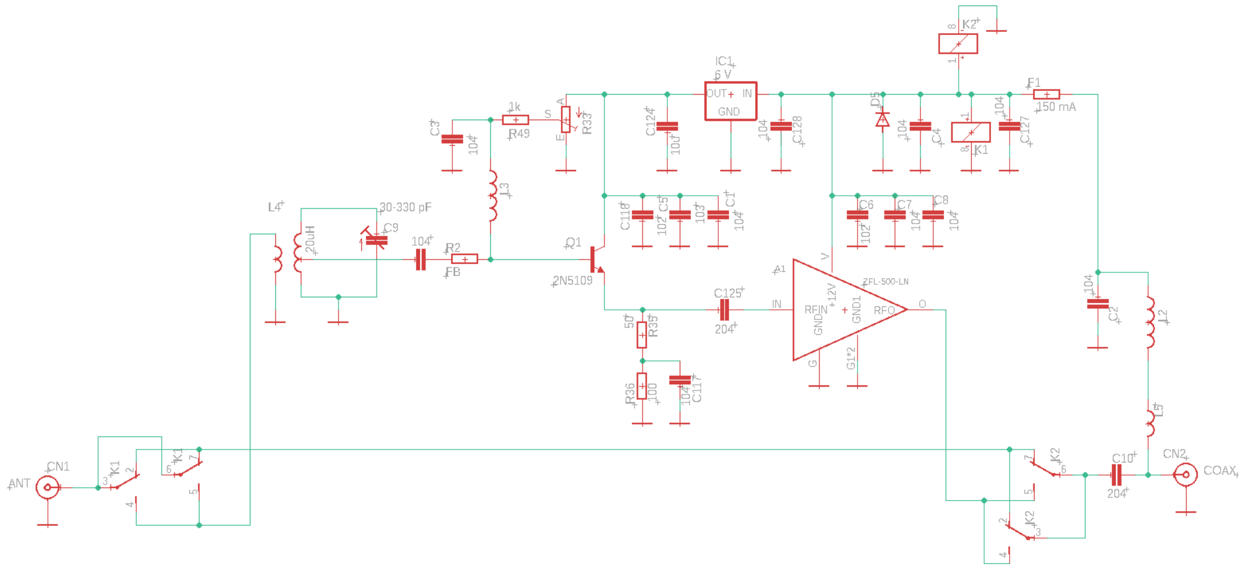
An important function of the preamplifier is to raise the received signal level where it is above the noise picked up further back in the receive chain. Here is an example. Let’s say there is -110 dBm of noise leaking into your receiver. You could spend days trying to get rid of that noise, with no guarantee of success. Instead, you add a 20 dB remote preamplifier which will amplify the RX signals (and background noise) to levels well above the local noise in your receiver.



Signal to Noise Ratio without and with Preamplifier

Without the preamplifier the -120 dBm signal is totally swamped by the -110 dBm noise in the receiver. (You are using a low gain RX antenna whose output is more than 20 dB below the TX antenna.) The preamplifier raises the signal by 20 dB, which gives you a 7 dB margin. (The preamplifier also raises the background noise by 20 dB to -110 dBm. The total noise on the receiver will be -107 dBm. (Actually, a little less than -107 dBm but I am too lazy to do the proper math.)

The circuit diagram below shows the preamplifier that I have been using lately. This is an improvised amplifier we built on the 2023 E51D DXpedition when our high-priced commercial preamplifier died. We had a spare 2N5901 transistor and a Mini Circuits ZFL-500-LN amplifier module. This improvised preamplifier turned out to have very low noise and a gain of 20 dB –the best preamplifier I've ever had! The tuned input circuit is set for 160m, and the preamplifier is bypassed when the 12 V power is removed. For 80 or 40 meters you don't need a preamplifier with the antennas shown.



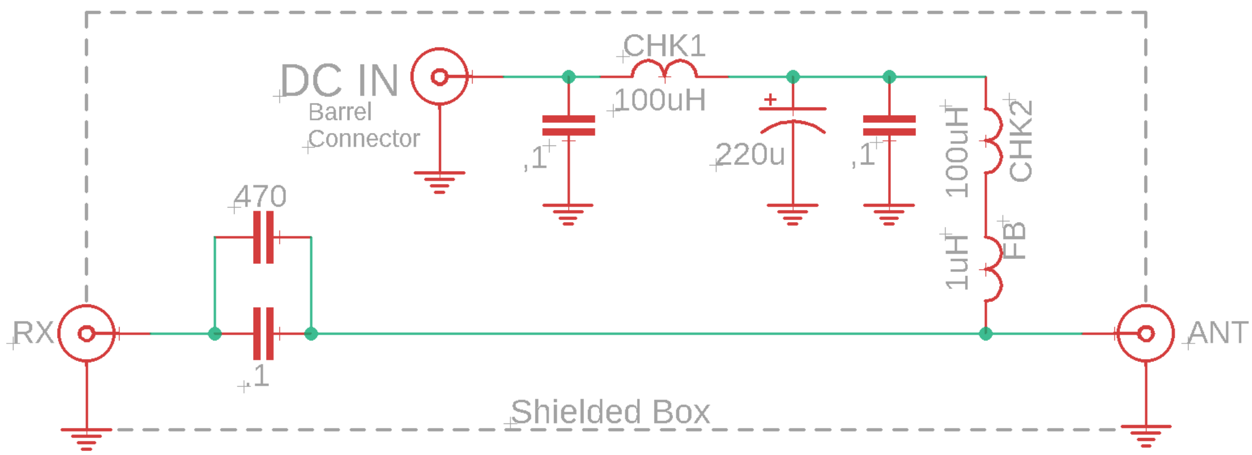
Improvised Low Noise Preamplifier

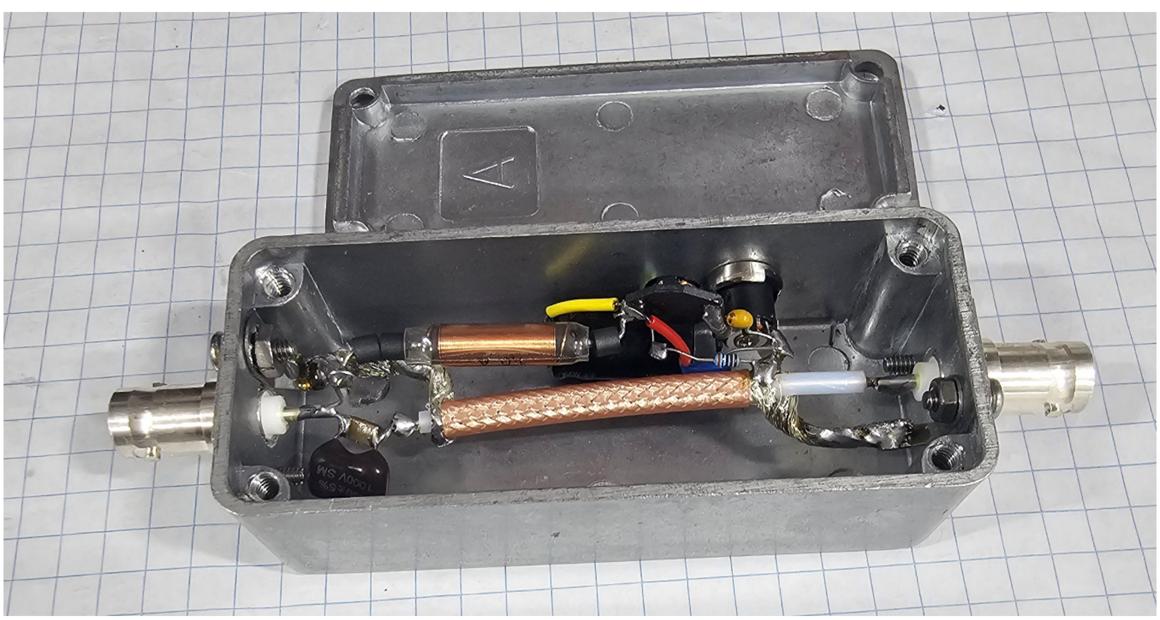
The above preamplifier has been mounted in a watertight Pelican case. Adding it between the antenna and the coax only takes a minute.

If you don't want to build your own preamplifier, the DX Engineering SV-BF-994x5 preamplifier (https://www.dxengineering.com/parts/svp-sv-bf-994x5#overview) will work nicely. You will have to build the DC power extraction circuit (see DC Injection circuit below) and put it in a water-tight box. Just don't turn the gain up! The amplifier can be set for up to 40 dB gain, but at that gain it can be easily overloaded and will generate a lot of intermodulation products. Keep the gain at 20 dB, where it has a reasonable IP3 and its best noise performance.

Powering the Preamplifier

To power the preamplifier (and any bypass relays) the coax center conductor can be used to carry +12 V (or other) DC power. A DC injector (also called bias T) can be used at both ends. It is extremely important to ensure that the DC voltage is well filtered before it is injected into the coax. Switch mode power supplies are great because of their low weight and small size, but they can have substantial noise on their outputs. You must prevent that or any other noise from getting into the coax. As a very obvious first step, any power supply output should be well bypassed and filtered. (Choke plus capacitor.) The diagram and pictures below show the DC injector I have been using. Note the additional filtering of the DC (CHOKE1 and 220 uF capacitor).





DC Power Injector

When powering a remote preamplifier through the RG-6 coax, the voltage drop caused by the resistance of the copper-clad steel center conductor must be kept in mind. The combined DC resistance of the center conductor and shield is about 30 Ohms for a 1000-foot-long RG-6 cable. With 100 mA of preamplifier current, the voltage drop will be 3 Volts. Ensure that the preamplifier can function with 9 Volts or feed the cable with 14 Volts to ensure adequate voltage for the preamplifier. A lower current preamplifier is advantageous in this regard.

Here is a lesser-known fact. Having DC power on the coax is a potential source of internally generated noise. When moisture or other contamination causes leakage currents between the shield and the center conductor, noise can be generated by, what some call, micro-arcing. You must make sure that no moisture gets into the connectors or the coax. On the other hand, having a continuous DC current across a number of connectors (and maybe even relay contacts) ensures a better connection and less noise by "wetting" those contacts. Contact materials other than gold tend to develop a thin oxide layer which can resist very low voltage signals. The wetting current breaks this oxide layer down and ensures a good continuous connection.

When using relays in the receive path, you should only use relays with gold-plated bifurcated contacts. However, if the relay contacts also carry some DC current (5 mA or more), cheaper contact materials, like silver-palladium, will work fine.

(Sometimes adding wetting current is a good fix for a PA T/R relay that is unreliable when switching back to RX. Use a 100k resistor, from a low noise voltage source, to feed a small amount of current through the normally closed contact of the relay. This current will "wet" the contacts (break down the thin film of oxide). This is sometimes easier than replacing the relay – which is likely to go bad after a year or two for the same reason.)

Conclusion

A DXpedition is a race against time. Time spent chasing noise sources is time not spent making QSOs. On the other hand, if you want to make a difference on 160m CW, you need a low noise receiving environment. The right amount of noise mitigation and a good receive antenna will get you there. But you must be prepared, both with material on hand and time allocated.

In my experience, on most DXpeditions you get one or two magical nights on 160m, when propagation is just right, thunderstorm and background noise are low, and you have a pileup going almost all night. It is a dream experience operating from somewhere in the South Pacific working 160m stations continuously all night, following the grayline from NA in the evening to Europe at sunrise. That does not happen often on 160m. Be ready for it!