

TB-1201F

Antenna Amplification Techniques

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Often it is necessary to locate an antenna at a significant distance from a receiver. If the distance is greater than 20 feet, it may be necessary to amplify the signal to offset the losses of the longer transmission line.

The Amplifier must be located as close as possible to the antenna for maximum sensitivity. The amplifier also needs 12V power to operate, so a two conductor wire must be installed along side of the coax from the battery, typically located near the receiver, to the antenna location. For protection from rain, the amplifier will also need to be installed in some kind of waterproof housing.

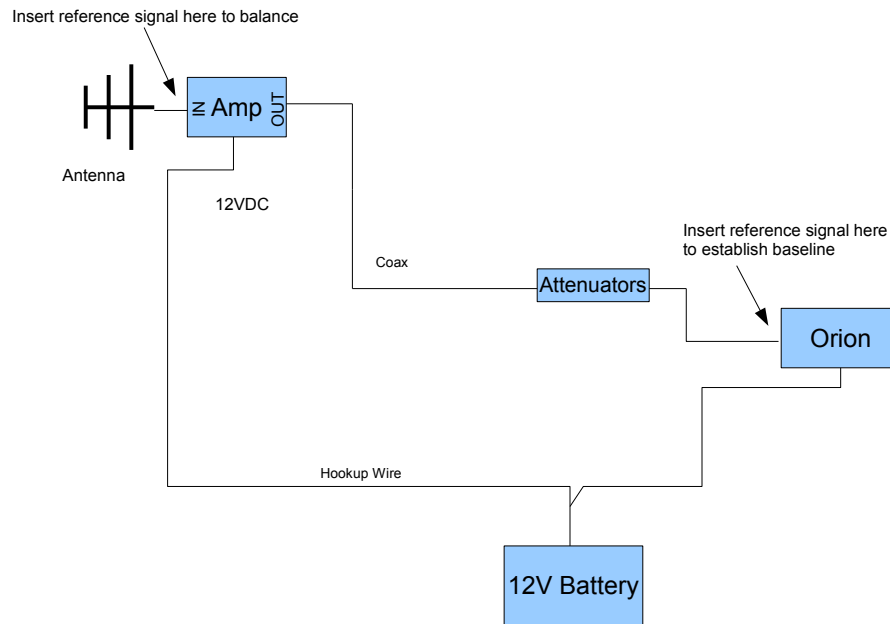


Illustration 1: Antenna Wiring Diagram

Once installed and hooked up, the amplifier will boost the signal and noise level at the antenna by the gain of the amplifier (24dB for the ARR P150VDG). The signal and noise level will attenuate along the length of the coax until the entire gain of the amp is used up (see Illustration 2). After this point, the noise level will stop decreasing because it is limited by the natural noise level, however, the signal level will continue to decrease thus reducing its visibility over the noise. The receiver becomes less sensitive

to weak signals. To maintain maximum sensitivity, the coax should not be long enough to present a loss greater than the amplifier gain. RG-58 cable typically has a loss of about 5dB per 100ft., so the maximum length that a cable can be for a 25 dB amp would be 500ft. If there are other devices, such as combiners, that would add loss, the length of the cable must be proportionately shortened.

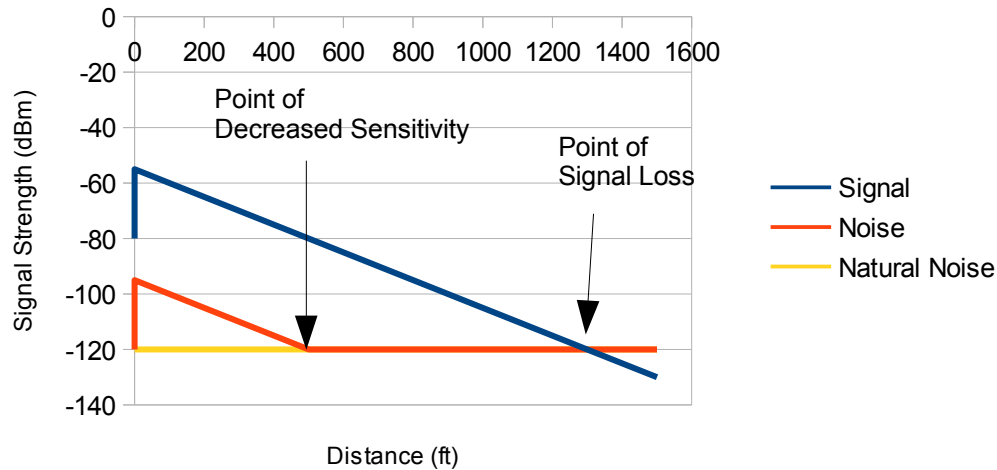


Illustration 2: Signal Amplification And Attenuation Along A Transmission Line

In most cases, the length of cable will be such that the loss is less than the amplification. As a result, the excess amplification should be offset with an attenuator to bring the net gain back to 0dB. The process of finding and inserting the proper attenuation is called balancing.

The best way to balance an antenna system is to use a reliable, fixed reference such as a beacon transmitter with a stable output signal level and a BNC connector. Follow this procedure:

- 1) Connect the beacon to the input of the receiver and note the signal level on the receiver. If the signal is saturating the receiver and providing a signal strength close to the maximum that the receiver can indicate, add attenuation to the beacon or adjust the gain to bring it down into a mid range. On a Lotek receiver, this might be in the 120 to 180 range. On the Orion receiver, -75 to -80dB is a good range. This is your baseline reference.
- 2) Disconnect the beacon from the receiver and connect the antenna system to the receiver.
- 3) Disconnect all antennas from their amplifier inputs.
- 4) Connect the beacon to the input of an antenna amplifier in place of the antenna.
- 5) Note the new reading on the receiver for this amplifier.
- 6) Insert attenuation at the input of the receiver to make the signal match your original reference level. (i.e reference = -75dBm, beacon with no attenuation = -65dBm, insert 10dB)
- 7) Your antenna system is now balanced and you can re-attach the antenna.



Illustration 3: Typical Beacon with Attenuators

If you do not receive a signal when you connect the beacon to the amplifier input, there is a problem on your transmission line. It may be a bad connector, broken cable, bad DC line, etc. The process of balancing your antenna will help verify proper system operation and identify problems before they interfere with your data collection.

It is best to balance your system with a beacon transmitter for accuracy and verification, however, if you do not have one handy, it is possible to roughly balance your system by calculating the proper attenuation. Knowing the gain of your amplifier and loss of your cable, you can calculate the excess gain and insert the appropriate attenuation. For example, if you use a 24dB amp and 180 feet of RG-58, the net gain will be $24 - 9 = 15\text{dB}$. Therefore, you will need about 15 dB of attenuation.

To prepare for balancing antenna arrays, it is a good idea to purchase a good selection of fixed attenuators. Common useful values include 1, 2, 3, 4, 5, 10, 15, 20 and 30 dB. This, however, assumes you do not have a variable gain amplifier as discussed later.

Multiple Antenna Arrays

Often it is desired to have an array of antennas covering a larger detection zone or multiple zones for comparison. In these cases, it is not only important to amplify the antenna signal to offset transmission line and combiner losses, but it is also necessary to make sure the performance of all antennas match providing reliable data that is not biased by the installation.

A typical installation may look like the following.

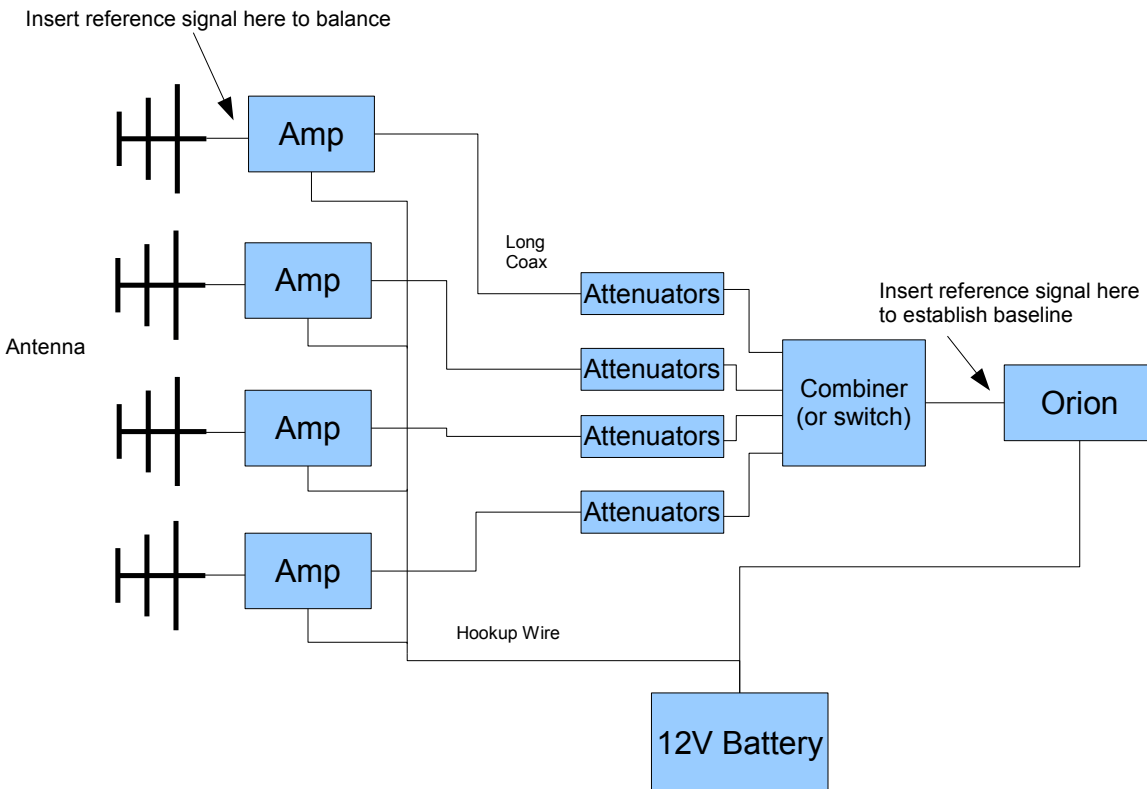


Illustration 4: Multiple Antenna Array Schematic

In this case, the procedure is similar to the single antenna situation above but repeated for each antenna. Usually, the leads to the different antennas will be different lengths resulting in different amounts of attenuation to balance each one. There is also the additional loss in the combiner which will reduce the value of all the attenuators by a common amount. The loss of the combiner (or switch) depends on the number of inputs. A typical 2 way combiner will have a loss of about 3dB and a 4 way combiner will have a loss of about 6dB.

If the loss of the transmission line in addition to the loss of the combiner is more than the gain of the amplifier, it will be necessary to add additional amplification. (See below).

Coax Powered Amplifiers

One handy variation of the amplifier is the coax powered version. This amplifier gets its power from the output coax line instead of a separate wire thereby reducing the amount of wiring that has to be installed at the site. It only requires the addition of a Power Inserter to inject the voltage on to the coax going toward the amplifier while providing a port isolated from the power for connection to a receiver, attenuator or combiner. The above system would be modified as in the following diagram.

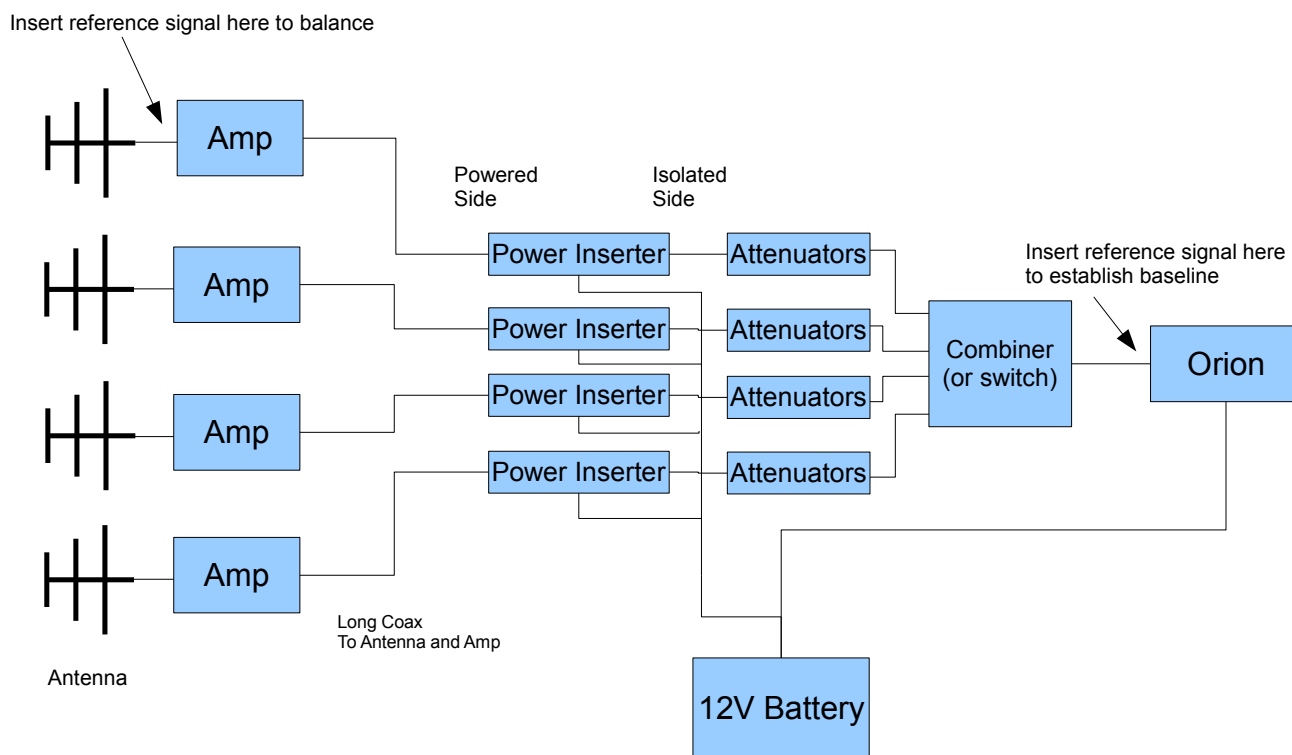


Illustration 5: Multiple Antenna Array with Line Powered Amplifiers

It is important to note that the antenna and the attenuators are on isolated lines and only the line between the power inserter and the amplifier is powered. **IF ATTENUATORS, COMBINERS, OR ANTENNAS ARE ATTACHED TO A POWERED LINE, DAMAGE TO COMPONENTS COULD RESULT.** Suitable care should be taken when putting this type of system together. A voltmeter would be handy to check the lines as well.

Amplifiers with Built In Attenuation

Another handy variation is the amplifier with built in attenuation. This amplifier has a step attenuator built right into the circuit board. By opening up the amplifier and flipping a few switches, the proper attenuation can be added to the circuit thus balancing the system. Expensive external attenuators are no longer required and the inconvenience of trying to find the right combination of attenuators is gone. The following diagram illustrates this arrangement.

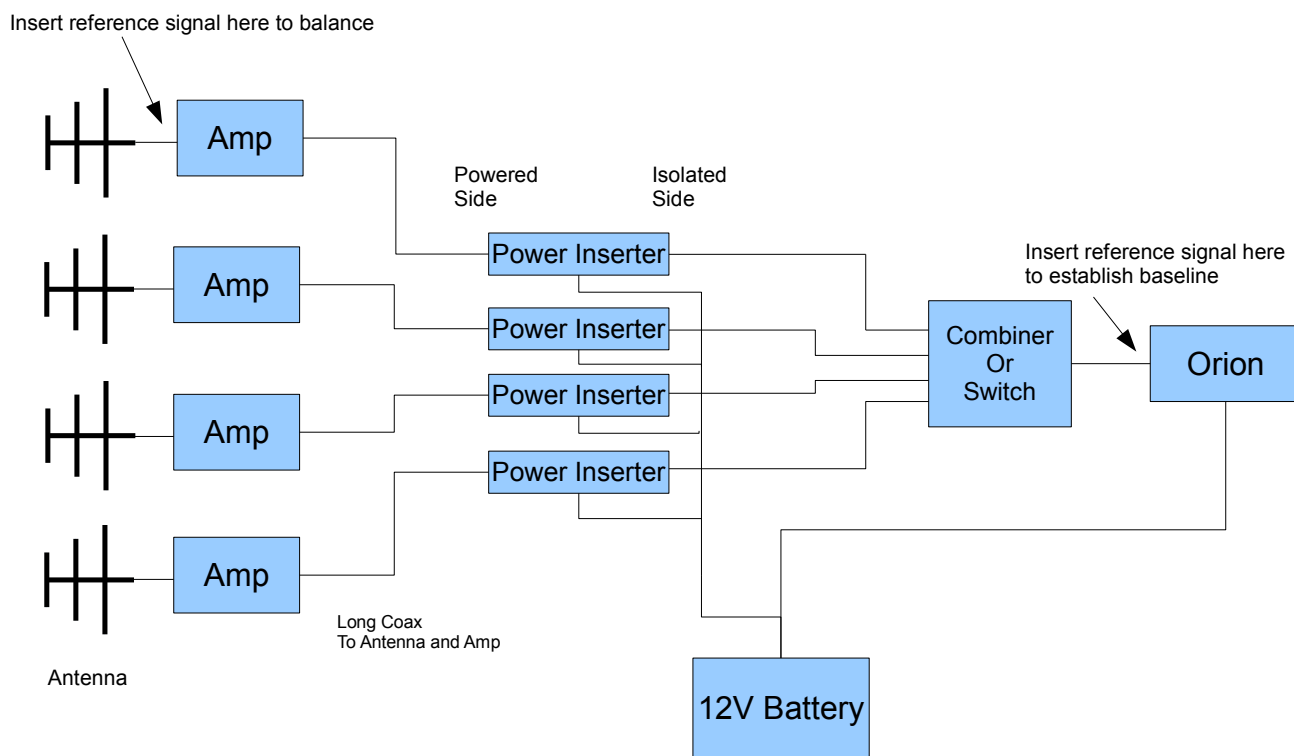


Illustration 6: Multiple Antenna Array with Line Powered Variable Gain Amplifiers

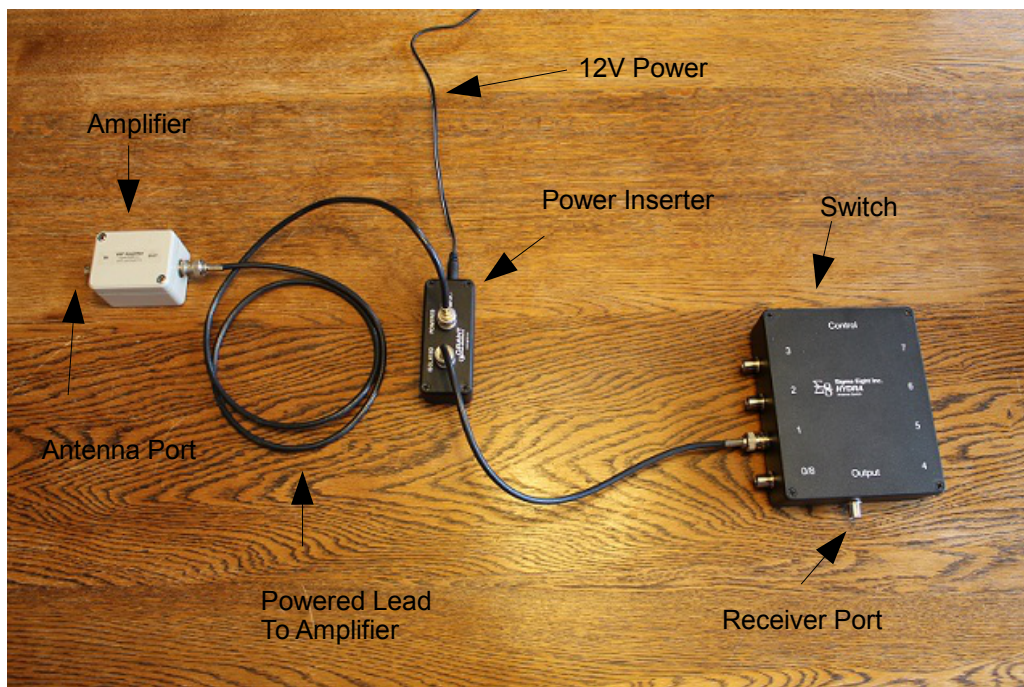


Illustration 7: Single Power Inserter System Hardware

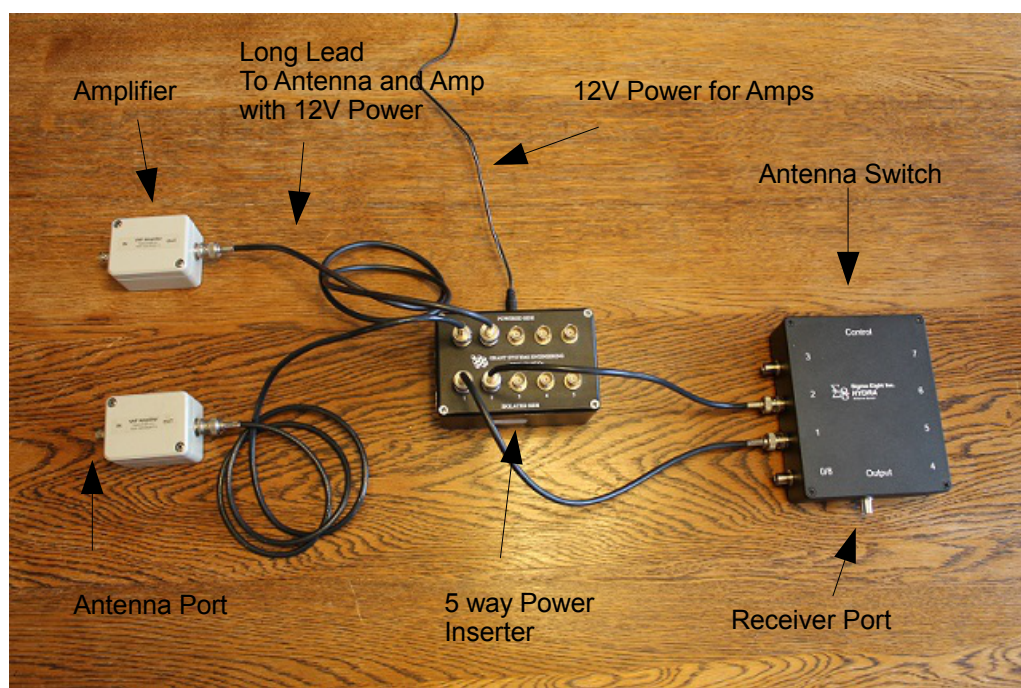


Illustration 8: 5 Way Power Inserter System Hardware

Amplifiers with Pass Through Power

Sometimes an extremely long line is required between the amplifier and receiver. In this case, multiple amplifiers may be necessary if the loss in the coax is greater than any single amplifier. It is awkward to power the second amplifier out from the receiver since the input side is isolated. A power inserter would have to be installed and a power lead run out thus defeating the purpose of the coax power for the first amp. A solution for this is to have an amplifier that can be switched to pass power through. The result is the following.

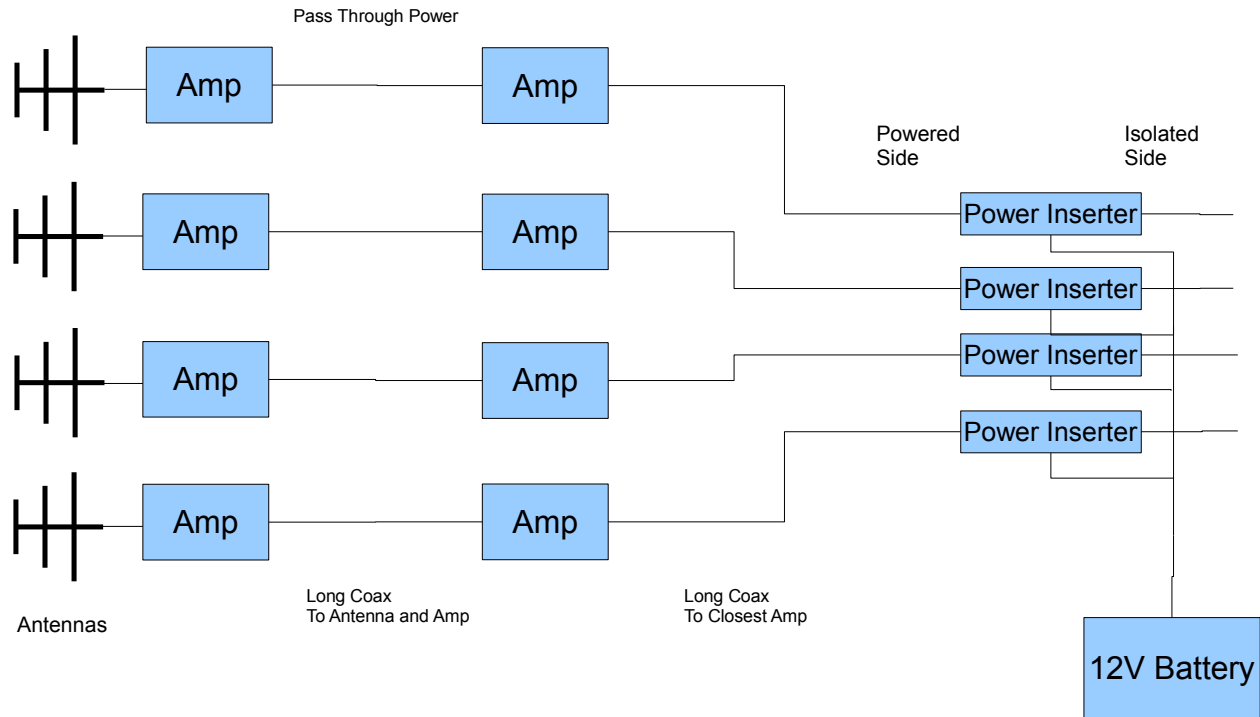


Illustration 9: Multiple Antenna Array with Coax Powered Variable Gain Amplifiers and Power Pass Through

Using Multiple Amplifiers in Series

When using multiple amplifier in series, to preserve the sensitivity as much as possible, the net gain at the input of the middle amps should not fall to less than +10dB from the original antenna input. For example, if the antenna amp has a gain of 25dB and the cable has a loss of 5dB per 100ft, the cable between antenna amp and first middle amp should not exceed 300ft.

The loss on the coax between middle amps can be equal to the gain of each amplifier. This would ensure that the net gain at the input of each amplifier (the lowest level points) would not be less than +10dB thus preserving signal sensitivity. In our example here, we could put up to 500ft of cable between each pair of middle amplifiers.

The available length on the coax from the last middle amp back to the receiver will depend on the combining or switching loss, however you have the additional 10dB that you can now take advantage of since the net gain from the antenna back to the input of the receiver should be zero. If the switch/combiner has a loss of 15dB and the middle amp has a 25dB gain, you can then go up to 400ft from the middle amplifier to the receiver. (+10 (in) +25 (amp) – 15 (combiner) – 20 (cable) = 0).

If any of the lines are shorter, the excess signal can be eliminated with larger attenuators at the receiver.

It is a good idea to roughly calculate what your gains and losses should be throughout your system so you can recognize when levels don't make sense and take immediate corrective action. While troubleshooting, you can inject a test signal at various points with the beacon and compare it to calculated values to track down the problem (plus or minus a few dB). If you need to inject a beacon signal in a powered cable, you could use an extra power inserter to provide isolation for the beacon.

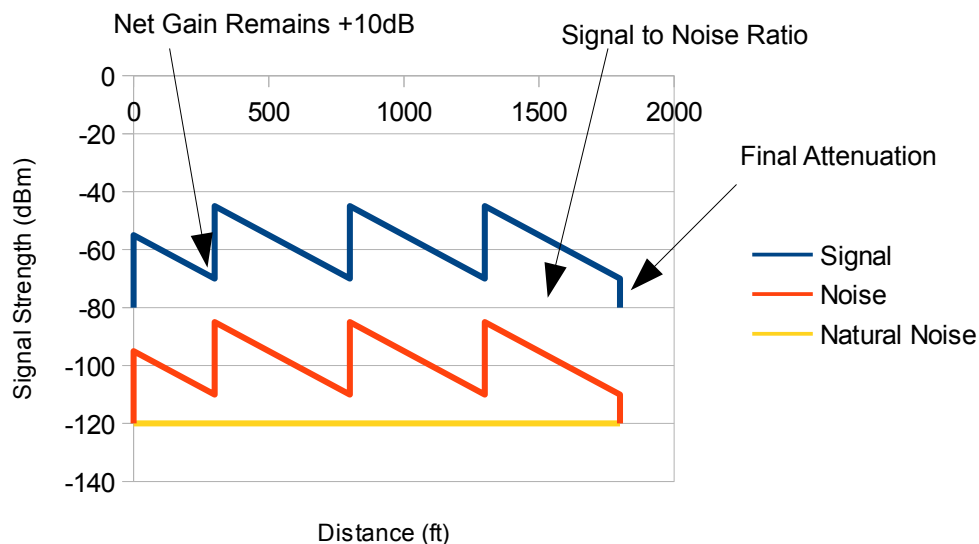


Illustration 10: Multiple Amplifiers And Attenuation Along A Transmission Line

Sources of Equipment

The following are components required for a telemetry receiving system with an amplified antenna. Some components may have long lead times. If it is too long you might find them on ebay.

Component	Make	Model	Supplier
3 element Yagi	Sigma Eight Inc.	ANT-YAG-3	Sigma Eight Inc www.sigmaeight.ca 905-833-0061
Power Inserter 1 way or 5 way	Sigma Eight Inc.	AMP-CPI-1 AMP-CPI-5	Sigma Eight Inc www.sigmaeight.ca 905-833-0061
Variable Gain Amplifier with Power Pass Through	Sigma Eight Inc.	AMP-WR-C-A	Sigma Eight Inc www.sigmaeight.ca 905-833-0061
Amplifiers	Advanced Receiver Research	P150VDG	ARR www.advancedreceiver.com 860-485-0310
Attenuators	Minicircuits	HAT-XX+	Minicircuits www.minicircuits.com 718-934-4500
Attenuators	JFW Industries	50-xxx-BNC	JFW Industries www.jfwindustries.com 317-887-1340
Receiver	Sigma Eight Inc.	Orion RX-ORI-VHF	Sigma Eight Inc www.sigmaeight.ca 905-833-0061
Combiners	Minicircuits	ZFSC-x-1	Minicircuits www.minicircuits.com 718-934-4500
Coax Cable	Belden	8259	www.e-sonic.com (Canada) www.alliedelec.com (USA)
BNC Connector	Amphenol	31-320RFX	www.alliedelec.com
BNC Crimp Tool	Amphenol	CTL-5	www.alliedelec.com
BNC Strip Tool	Paladin	PA1255	www.alliedelec.com
12V Battery	Generic – sized for duration required		Local Hardware or Automotive Store
Automatic 12V Battery Charger	Generic – powers up in charge mode and sized for battery		Local Hardware or Automotive Store
Hookup Wire	Generic	#14 to #18 2 conductor	Local Hardware Store or Electrical Supply Store
Ring Terminals and Butt Splices	Generic		Local Hardware Store or Electrical Supply Store
Crimp Tool for Ring Terminals and Butt Splices	Generic		Local Hardware Store or Electrical Supply Store

