White Paper
Diversity for Better HF Reception
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We hams, SWLs, and others are trying to find better ways to receive HF radio signals during a poor and declining sun spot cycle. Within limits, we can improve our ability to successfully transmit a message by increasing our transmitter power. However, there is no equivalent to increase our receive capability…or maybe there is.

High budget government radio systems use spatial diversity to improve radio reception. They have multiple antennas and receivers spread out over hundreds of miles with sophisticated computer systems to intelligently combine all of the received signals for the best possible signal-to-noise ratio which provides the best possible message reception. Skip distance, polarization rotation, man-made and natural radio interference, and other factors change at different times at different locations. Signal reception can be dramatically improved with the ability to selectively combine signals from multiple locations.

While most of us don't have government budgets for spatial diversity systems spread out over hundreds of miles, we can still take advantage of diversity benefits. The key is to combine signals from different antennas and receivers that have different location, polarization, and noise reception characteristics.

Even without separation of hundreds of miles, two antennas located even less than a wavelength apart will have different receive characteristics. If the two antennas also have different polarization and noise reception, the diversity benefits will multiply.

Let's assume that your primary transmit/receive antenna is horizontally polarized like a dipole, beam, long wire, or most other wire antennas. There will still be benefits if the primary antenna is a vertical or other vertically polarized antenna but just not as great. Brace yourself for a commercial message. A great second antenna is an amplified receive-only magnetic loop, and by the way, I just happen to sell one. A magnetic loop is vertically polarized which provides polarization diversity to a horizontally polarized primary antenna.

Improving reception is determined by either increasing the received signal and/or reducing noise, i.e. increasing the signal-to-noise ratio. A loop not only responds differently to signals you want to receive but also to the noise you don't want. A loop has the ability to null noise by more than 30 dB in both directions along its axis.

Either with a helper or an inexpensive light-weight TV rotator, the loop can be rotated either to maximize a received signal or to minimize noise. In some cases signal optimization can help but my experience is that noise reduction is much more effective. For conventional receivers, pick an open spot on the band near where you plan to operate and rotate the loop until the sound of the background noise is minimum. For SDR receivers, rotate the loop until the baseline noise level on the spectrum display is minimum.

The spatial diversity benefit of any antenna pair increases with the distance between the two antennas. However, I live on a small lot with limited ability to separate my two antennas. Even with 40 feet of separation between my loop and the center of my dipole primary transmit antenna, I still achieve significant diversity benefit.

The type of diversity that I am describing requires two antenna connected to two receivers that will convert the received RF into baseband voice, CW audio, or digital tones. I know of very few hams without a backup radio so suggesting that two receivers are required to implement diversity doesn't seem like much of a burden to me.

Let's assume that you have two antennas – ideally horizontally polarized for primary transmit and receive and an amplified receive-only magnetic loop for diversity receive. I hope you are using my loop but there are a couple of other good loops as well. These two antennas need to be connected to two receivers which can be your primary transceiver plus a second transceiver. You can also use a receiver-only for the second device and there are number of inexpensive but very capable SDR receivers such as the SDRPlay.

The key to making diversity work is combining the signals, whether they are SSB or AM voice, CW audio, or digital tones. There are at least a couple of software attempts at intelligent combination of two received signals. Linrad and PowerSDR_mrx are two SDR software programs that have features to intelligently combine signals from two receivers. However, both require that the receivers be synchronized SDR receivers such as those from Apache Labs or Afedri. The best software solution is Linrad with a long list of features but its user interface dates back to MSDOS and is quite difficult to master – at least it was for me.

Turns out that we already own a computer system that is much more powerful than any PC – our brain. We can use our brain to intelligently combine two signals quite easily.

For CW and AM/SSB, the solution is quite simple. Connect the audio from the two receivers and their different antennas to left and right sides of your headphones. Your brain will do a very good job of picking the better signal.

For digital modes diversity, the setup is a bit more complex but still uses your brain as the intelligent combiner. My preferred digital mode software is FLDIGI but this technique will work for any digital program. You need to implement two copies of the digital mode software. For FLDIGI, this is done by creating a second copy of the shortcut on your desktop that you use to launch FLDIGI and then editing the shortcut details to actually launch a second copy. Check the FSLDIG user documentation for the details. Another way to implement a second copy of your digital mode software is with a second computer. You could have one copy running on your desktop computer and a second copy on a laptop. Once you have two copies of your digital mode software running, the audio input to be decoded needs to be connected to the audio output from your two receivers. For SDR, this is often done with virtual audio cables. Several newer transceivers such as the Icom IC-7100 and 7300 have built-in audio cards to accept digital audio. For others, a digital interface such as the SignaLink USB connects a radio to the PC and your digital mode software.

Once you have the two receivers connected to two copies of your favorite digital mode software running either on the same computer or on two computers, the decode window for the two copies of software needs to be displayed. Just as your ears provide the input to your brain for CW and SSB/AM diversity, your eyes provide the diversity input for digital modes.

I am mostly a digital mode operator and I find this diversity technique to be very effective. I have seen times where the decode accuracy from either antenna/receiver is unreadable. However, by scanning my eyes between the two displays, I can stitch together nearly 100% accurate copy.

Manually switching between two antennas to select the better signal has some benefit but QSB, noise, and polarization rotation change at a fairly rapid rate so manual tracking would be hard. Visually picking between two simultaneously available sources is much more effective – often times on a character by character basis.

With a declining sunspot cycle and increasing noise from man-made sources, I hope you find this diversity setup helps.