Coupling External Antennas To Portable Receivers

Modern portable receivers, such as the Tecsun PL-310 with its DSP filtering and other features, are a major step forward in terms of performance and value. Still, for many DXers with external antennas such as a Beverage, Super Loop or other type, being able to couple these antennas to an Ultralight or other portable receiver is highly desirable. In this article, I compare the effectiveness of various means of coupling antennas to portable receivers.

External antenna coupling can be accomplished in one of two ways. The first method is to wind a coupling coil directly onto the internal ferrite, which is discussed in thorough detail in John Bryant's excellent article “Ultralight - Adding an Antenna Port” which is available here at the Dxer.ca web site. This direct method adds extra circuitry to the radio, and so would take an Ultralight radio out of the “barefoot” class and into the “unlimited” class. At right is what the modification looks like when installed in a Sangean DT-200VX receiver, with the red coupling coil terminated in a standard 1/8” jack.

The other coupling method is to wind some sort of ferrite or air-core coupler, which is either placed near the receiver or around it to passively couple the two. In the testing described below, I used the following couplers, seen from left to right in the picture below:

- A 4x5” air-core loop with 8 turns of wire wound as a solenoid, supplied as an AM antenna for a home stereo, into which a small receiver can be placed. The receiver may also be placed outside of the loop, although with reduced signal transfer. Spiral-wound air-core couplers are also available (discussed below).
- An 8-turn coil of wire, wrapped around a folded index card, which goes directly around each of the radios used. This is equivalent to simply wrapping a few turns of wire around your radio.
- 12 turns of wire around a 2” ferrite bar. As discussed below, the number of turns is not critical, and anything between 8 and 16 turns seems to work equally well.
- 12 turns of wire around 20 ferrite bars, held together in a brick.
- A ferrite coupler from a C Crane Twin-coil antenna, estimated to be 10 turns of wire on a small ferrite rod.
Receivers Used

I was able to borrow two internal coupler-equipped receivers, a Grundig G8 (Tecsun PL-300WT) and a Tecsun PL-310, from John Bryant for this test. I was therefore able to compare them with unmodified versions of the same receiver which I already owned. The direct digital readout of signal strength on these is ideal for coupler testing.

Testing Procedure

Two coupling methods at a time were compared to each other using a splitter, which provided the same signal to each coupler/receiver combination. In this way, I was able to compare direct coupling to the various passive couplers, as well as passive couplers against each other. The two models I was testing (the Tecsun PL-310 and the Tecsun PL-300WT/Grundig G8) responded identically to the couplers, so the results below apply to both models.

Connection to the directly-coupled receivers is easy – just plug in the cable (above, right). To use the 8-turn air core coupler, the receiver was placed inside of the coil (below, left); exact positioning of the receiver was not critical. For the ferrite-based couplers, they were placed on/next to the receiver at the position where signal transfer was observed to be the greatest, generally where the coil of the coupler was closest to (opposite) the coil of the receiver's internal antenna. The picture below (right) shows the C Crane coupler being used.

In general, all of the couplers performed well enough to completely overwhelm the receiver's internal ferrite antenna, such that the normal directional nature of the internal antenna was completely done away with. This was verified by rotating the receiver through 360 degrees and noting that there was no difference in signal strength.
Daytime Testing with an Active Whip

The antenna used for this was an LF Engineering H-900 active antenna, mounted approximately 30 feet up on my roof. I did not switch on antenna's preamplifier (which produces too many mixing products and images), and the output was fed directly to the input of the splitter.

Using weak signals on 550, 920, 1330 and 1550 khz, each with steady daytime signal strengths, the direct-coupled receivers experienced severe images and/or overloads from local stations. I live within 15 miles of several 10-50 kilowatt stations, and their daytime patterns are such that mixing products can be found at various places all over the dial. While there were parts of the band which were relatively free of these effects, much of the band was rendered unusable. Interestingly, on problem frequencies the indicated signal strength was steady at 50 dB, with 0 dB signal-noise ratio; it is possible that the receivers became desensitized by the massive input.

With the passive couplers, similar problems resulted if the coupler were touching the receiver. However, by holding the couplers an inch or two away from the receiver, the problem was cured, and the following were the results:

- The 12-turn flat ferrite bar coupler produced the best results, with slightly better signal strength and signal-noise ration than the 8-turn air core coupler. The 8-turn air-core coupler actually worked best here with the receiver outside, next to the coil.
- The 20-ferrite brick had the same performance as the 12-turn bar, and the custom-wound air core coupler had the same performance as the 8-turn 4x5” coupler. As a result, these two couplers were not used in later tests, since the ferrite brick was cumbersome to use, while the custom-wound coupler made the controls and LCD screen on the receiver inaccessible.
- The C Crane coupler pulled up the rear, with signal strengths down approximately 5 dB compared to the other passive couplers.

To see if the receivers being used were part of the mixing product/image problem, I also tried an Tecsun R1212a analog receiver, and the results were the same: massive mixing products and images when directly placed in/next to the couplers, and satisfactory results with an inch or two of separation. Therefore, it appears that portable are often not designed to accept such large broadband antenna signals. Connecting the antenna feed to an Icom R75 communications receiver yielded only the occasional mixing product, normal for daytime conditions here.

Daytime Testing with a Super Loop

I have a 9x10 foot “Super Loop”, corner-fed with the new Wellbrook FLG-100 antenna head. The antenna is pointed north, generally away from most of the high-power stations near my home. Unfortunately, there are two local stations within 5 miles of me which nevertheless provide ample RF input, such that they mix with the other ) somewhat attenuated) stations up and down the dial.

As a result, coupling the Super Loop to the receiver produced essentially the same results as with the active whip: the directly-coupled receivers were severely overloaded with mixing products and images, while the passive couplers had similar performance relative to each other as with the whip if separated from the receiver an inch or two. The C Crane coupler, the weakest of the passive couplers, was able to be held directly against the receivers on most frequencies.

To see if lowering the input to the receiver would help, I fed the Wellbrook antenna output to a Quantum Phaser, which has a continuously variable RF gain control. This enabled all of the passive couplers to work well, in that backing off of the gain to certain point resulted in clean reception. I noted that, because of the unique AGC circuitry on the Tecsun radios, if I started out with too much gain, I had to cut the gain all the way to near zero and then gradually increase it until the right level was attained; otherwise, without this “reset” of sorts, the receiver would not readjust if coming down from strong signal levels. Unfortunately, even by carefully adjusting the gain, I could not preclude images and mixing products from swamping the directly-coupled receivers.
Daytime Testing with a Tuned Antenna

After realizing that broadband antennas do not work well here in my RF-rich environment, the next antenna I used was a Quantum Loop based unit mated to a Crate Loop (see picture, right). The construction of this “Active Passive Loop” antenna is discussed in an article [available here](#).

By being able to tune the antenna to the desired frequency, the images and mixing products which plagued the broadband antennas above were cured, and I was able to tune to each frequency for precise measurements. Since the Quantum Loop base unit has an RF output, this was connected to the various couplers.

The results were as follows:

- The directly-coupled receivers were consistently 2-4 dB above the passively-coupled receivers, with no sign of overloads, images or mixing products.
- The 12-turn ferrite bar was the best of the passive couplers, being just a dB or two better than the 8-turn air-core.
- The C Crane coupler again pulled up the rear, consistently being 5-6 dB lower than the 12-turn and 8-turn couplers above (and 7-10 dB behind the directly-coupled arrangement).

The results would have been similar if I had used the stock ferrite head with the Quantum Loop. Also, in listening environments where overloads and mixing products are not an issue, the above results are likely to be typical.

Couplers versus Traditional Passive Coupling

Since the Crate Loop is a traditional air-core loop that can be passively coupled to the receiver without the need to use the coupling devices being tested here, I compared the two methods of transferring signal to the receiver. In virtually every station tested, up and down the dial, connecting the output of the Quantum Loop base unit using the various couplers above was between 5 and 12 dB better than passively coupling the receiver to the Crate Loop itself (i.e., holding the receiver close to the Crate Loop). Therefore, as good as the active/passive Crate Loop is as a passively coupled loop, it performs even better when a coupler is attached to the RF output of the base unit as the feed to the receiver.

Nighttime Testing

Once the sun went down, coupling to a broadband antenna was much more satisfactory. With the directly-coupled receivers, strong locals still required some attenuation in order to prevent problems, although full gain was able to be used on DX stations without any sign of images and mixing problems, even if a strong local was only 10 khz away.

As expected, the direct-coupled method delivered 2-4 more dB than did the ferrite and air-core couplers, with the C Crane coupler being several dB further down. Since the signals on the receivers were generally well above the receiver's noise floor, there was no real discernible difference in the final result. However, if one were using a weaker antenna (I was using the Wellbrook FLG-100), those extra few dB may or may not make a difference.
Resistance to Noise

In addition to transferring signal to the receiver, the ideal coupler would also be relatively immune to nearby RF noise. In my testing, I used an operating laptop computer, with its prodigious noise from the LCD display and hard drive, over and around each of the receiver/coupler arrangements to see how immune they were to this noise.

- The direct-coupled receivers fared the best, and I could bring the laptop within 4-6 inches of the receiver before significant interference and noise resulted.
- The surprise second place finisher was the 8-turn air core loop, which was just a little bit more susceptible to noise than the directly-coupled receivers. The difference was primarily that the air core picked up more noise when the laptop was in the end-fire of the coupler (i.e., perpendicular to the coil).
- The 12-turn ferrite bar and the C Crane coupler were measurably worse than the air-core coupler, in that the laptop had to be at least 1 or 2 feet away from the coupler to avoid noticeable interference.
- The 20-ferrite brick coupler fared the worst, presumably because its massive ferrite core is much more susceptible to nearby RF noise, especially in the end-fire.

Ergonomic Notes

The directly-coupled method, with the coupling coil wrapped directly around the internal ferrite antenna and a 1/8 jack being used to connect the receiver to the external antenna, is probably the easiest method, and is aesthetically (to my tastes) the most attractive option. However, it does involve a somewhat delicate surgical operation on your radio, one that will permanently change it cosmetically.

The 12-turn ferrite bar and the C Crane coupler can be rigidly attached to the underside of the radio using double-stick foam tape (see picture, right). This arrangement is nearly as presentable as the direct-coupled method above, and the coupler fits nicely under the flip-out stand. The C Crane coupler has an RCA jack that allows the cord to be disconnected, which is a nice feature.

The 8-turn air-core coupler is the bulkiest and most awkward to use. However, it is certainly more usable than wrapping wire around the receiver, as the latter option interferes with the controls and display of the receiver. Since the results are the same, the pre-made 8-turn coupler appears to be the best choice. The receiver sits on the inside frame of the coil; therefore, some sort of support would be advisable so the receiver doesn't rock back and forth.

Another form of an air-core coupler is also often supplied as the AM antenna for home electronics equipment (see picture at left). It is available commercially as the Quantum Coupler, and is a spiral-wound coil of perhaps 6-8 turns on an approximately 3x6 inch form. I personally find this style of loop to be more difficult to use, in that the coupling “sweet-spot” is somewhat difficult to find and maintain. Also, the signal transfer is several dB below that of the solenoid-wound coil used above. However, it lies flat and can be attached to the back of the receiver, which may make it a better choice for some.
Summary

Each of the three basic types of couplers have their pluses and minuses, and which one will be the best option for you will likely depend on your particular situation.

**Direct Coupling**: for pure signal transfer, directly coupling the external antenna to the receiver via a coil around the receiver's ferrite is the optimum choice. However, the extra 2-4 dB over the other couplers may not be noticeable, since the signal is generally well above the receiver's noise floor. Additionally, the direct coupling arrangement may render a broadband antenna useless during the daytime, as it did in my urban location. Also, this may make sunrise listening, such as with trans-Pacific DXing, very difficult once strong local stations shift to day power. Those in more rural areas may not experience this issue. As discussed above, this coupling method is, by a modest margin, the most immune to local RF noise sources such as laptop computers. This method will involve making a permanent and somewhat delicate cosmetic change to your receiver, although the ease of connection and use, and the ability to still use the internal ferrite antenna by simply unplugging the external cable, may well be worth it. As discussed earlier, by adding new circuitry, this modification would move an Ultralight radio into the “Unlimited” class. The article describing the procedure, “Ultralight - Adding an Antenna Port”, is available at the Dxer.ca web site at this link, and it will be updated in the very near future to include how to install the coupling coil into the recent Kchibo and Tecsun DSP receivers.

**Ferrite Coupler**: this option may be the happy medium. Signal transfer is very good, and the coupler can be separated an inch or two from the receiver in order to use it during the daytime with broadband antennas in urban areas. It is fairly immune to local RF noise, and a small ferrite bar will tuck behind the receiver nicely. Further, it does not involve making any modifications to your receiver. These are easy to make (see example at right), and if you do make your own, the number of turns is not critical: with the ferrite bar I used, varying the numbers of turns of wire between 8 and 16 turns produced no real difference.

The commercially available C Crane version can be purchased for approximately $15 from the manufacturer. Another commercial option is the Quantum Stick; I note that its coupling section appears to be designed for high-impedance antenna inputs such as a long wire, since I have not had good success with it when trying to couple a 50-ohm antenna as the input.

**Air Core Coupler**: while these are rightfully disdained as woefully inadequate antennas, I was surprised at how well they work as a coupler. Signal transfer and immunity to local RF noise are excellent. It may be used with broadband antennas in high-RF daytime conditions, and this ready-made unit does not require any receiver modifications. It will, however, likely require some sort of ergonomic modification in order to keep the receiver from rocking back and forth, and its physical size means that it is the bulkiest option. Still, for $1.00 at your local thrift shop, it's tough to go wrong! While mine had 8 turns of wire, the number of turns is likely not critical. As discussed above, a spiral-wound air-core loop like the Quantum Coupler, though it has reduced signal transfer and can be difficult to position, lies flat and may be a better choice for some.

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