The PVC Loop—Low Cost Ticket to High DX Gain!

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The DX will flow when your use this common water pipe material to construct a dream antenna, from 18 inches to 9 feet on each side. Don't be afraid to dream big. It's lightweight, rugged, waterproof, completely symmetrical—and dirt cheap!

Introduction What began here as a casual project to construct a couple of small tuned passive loops was suddenly transformed into a fascinating experience in designing and building a series of monster antennas—all because of the accidental discovery of the perfect frame material. Symmetry, weight and cost suddenly all became manageable for every conceivable loop size, despite the unrealistic expectations of the author. Not only was the frame material ideal, but it was available in extremely strong fittings with multiple angles, assuring complete flexibility in designing both the antenna frames, and support structures. Truly a DXer's dream!

The Benefits Tuned passive loops have been with us for decades, and many fine designs have been published in the IRCA and NRC technical guides. Popular with hobbyists because of the significant DX signal boost provided by a simple loop and tuning capacitor, tuned passive loops are available in either ferrite or air core form, and many small commercial designs are available. For Ultralight radios, the degree of the DX signal boost provided by passive loops is related to the quality and size of a portable's loopstick, with the greatest benefit given to the radios with the smallest loopsticks. In addition, DXers using communication receivers who are unable to erect external antennas often choose the 3' or 4' tuned passive loop as their best option, due to the attractive combination of significant gain and excellent nulling capability.

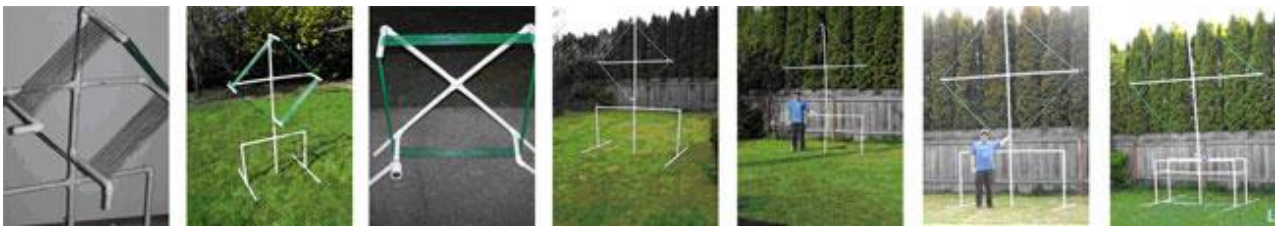
A Few New Design Ideas Most of the traditional passive air core loop designs seem to have a support frame in the center of the loop coil, or even have the entire loop wound around a form. Based on transcontinental QRP contact experience, however, I was eager to follow the amateur radio goal of

having an antenna “high and in the clear,” which in the case of a tuned passive loop would mean that the loop would have minimal contact with any support frame, and approach the situation of being isolated in space. Also, the tuning capacitor should be connected exactly at the electrical ends of the symmetrical loop (without going off on any tangents), and be both of minimal size and of a vernier design, for tuning ease. These were challenging objectives, but I was convinced that they were necessary for the best sensitivity, cleanest electromagnetic reception patterns, and the sharpest nulling ability. The biggest challenge was in finding a suitable frame material to make the “isolated loop” concept a reality, without upsetting the design objectives of complete symmetry, light weight, and extremely low cost..

PVC as a Frame Material PVC-framed air core loop designs have been increasingly popular among MW and LW DXers, primarily because of their unique combination of symmetry, light weight, and structural strength. Large frame designs that would be impractical with wood are easily constructed with PVC, even up to the 7, 8 and 9 foot side dimensions.

In choosing my own design objectives, I examined the plans of James Dale (of the Minnesota DX Club) and others, in which the PVC frame was at the center of the loop, using spreaders to maintain tension on the coil windings. This seemed to be the “standard” box loop design, a PVC adaptation of the classic wood-framed designs of the 70’s and 80’s. No doubt these loops provided much exciting DX for their builders, but I personally thought that PVC had potential for greater things, especially in the design of monster loops that would be absolutely impractical to construct with wood. As mentioned previously, I also wished to offset the PVC frame from the electromagnetic center of the loop, so as to isolate the coil in relatively free space for maximum performance.

One Standard Design This project was simplified by the choice of one standard frame design, which could give optimum performance regardless of the side dimension. The only differences would be in the side dimensions, coil turns, and in the diameter of PVC used to maintain rigidity. Special variants such as tabletop, collapsible frame, long wave and waterproof loop models were developed which have specialized parts, but all models follow the same basic frame design. Ten loops were constructed, with side dimensions of 18”, 2’1”, 3’4”, 4’, 5’3”, 5’6”, 6’3”, 7’7”, 9’1” and a Longwave model of 6’5”. As interested hobbyists will soon discover, once you have built one of these standard-design PVC loops, you will have the experience to build any one of them-- a fascinating ability that (as the author has discovered) can turn a casual hobbyist into a fanatic.



Choosing Your Dream Antenna Although even a small tuned passive loop will provide a significant DXing boost over a stock portable, the antenna gain from these loops is directly related to the size of the loop. Larger sizes will provide more gain, and greater DXing performance. Within the limits of practicality in each hobbyist’s own unique situation, it is the author’s recommendation that DXers choose to build the maximum size of loop that their situation will allow.

Both the 18” and 2’ PVC Loops can be constructed in a “tabletop” design, where they can be placed on desk tops, and picnic table surfaces. These loops will provide a significant DXing boost for typical Ultralight radios, and also have great portability for travel situations.

The 3’, 4’ and 5’ PVC loops are more suitable for use on a support stand, either of a custom wood design, a basic PVC design, or of the all-PVC altazimuth tilting system (more later). These loops provide the best gain for DXers limited to indoor antennas, and should perform superbly whether

inductively coupled to Ultralight radios, or directly connected to table receivers.

The 6', 7.5' and 9' PVC Loop models are most suitable for outdoor DXing away from house wiring and computer noise, where their high gain and excellent nulling capabilities can really shine. These monster loop antennas have the capability of taking fringe AM signals completely inaudible on stock Ultralight radios and boosting the signal gain to the point that the same Ultralight radios start to overload! Of serious size but moderate weight, these antennas do require stable and strong support structures (of non-conducting materials), weather-resistant construction, and tolerant family members (and neighbors).

Since the author was fascinated by the performance of these large loops and greatly desired similar DXing gain during ocean beach runs, experimentation was undertaken to create a 6' (side) collapsible-frame variant that would fit in a small car, and have foolproof assembly within a minute. That model is also now an exciting reality, the first of the "Pipe Dream" traveling monster loops.

Whereas these PVC loop antennas can provide high gain and highly directional nulling capabilities, they are not substitutes for large external antennas with cardioid reception patterns. The typical "figure 8" reception pattern of loop antennas means that the user must expect situations where QRM from unwanted stations comes from the back direction. The loops can be made highly symmetrical and can be tilted to optimize nulling of pest stations, but this will be of limited value if your target DX station is very close to the opposite bearing of the pest. Fortunately, there are also many situations when the bearing of the DX station is significantly different from that of a nulled pest, leading to easy receptions.

<u>The PVC Construction Primer</u> There is a short learning curve involved in becoming an expert PVC frame builder, but after a few simple lessons, even a total novice like the author can assemble like a journeyman plumber. The PVC pipe, fittings, and glue are all dirt cheap, making it easy to practice until complete skill is attained. Perhaps the only downside will be the multiple requests from family members for PVC-framed projects like soccer goals and storage racks, after building expertise is gained. A few simple precautions will ensure maximum strength and symmetry in your dream antenna:

1) Choose the correct diameter of PVC for the size of your antenna frame (recommendations will follow). The most common novice mistake is to use PVC which is too small to rigidly support itself. This leads to a sagging frame, and sagging DX potential.

2) Always make a "dry run" to ensure that the PVC pipe will mate solidly with the PVC fitting, before reaching for glue. The time to discover that the pipe needs sanding is not when you are attempting to glue it to the fitting! Before gluing, ensure that the pipe "bottoms out" in the fitting slot during the "dry run," for maximum strength and symmetry in all loop designs.

3) PVC glue is very easy to use, and is strong and waterproof. Work outdoors, however, since the fumes are too potent for household venting systems. PVC glue also "grabs" very quickly, so know exactly what you plan to do, before applying it.. Make sure the pipe is of the correct length, and that if you need to glue a pipe at a 90 degree angle (such as the wire notch pipes), a 90 degree guide is available. PVC glue "grabs" about 5 seconds after the pipe is twisted into a fitting, so you have about that long to "get it right."

4) Woodworking tools (and experience) are extremely useful in PVC frame construction. A miter saw can cut all types of PVC pipe cleanly, usually leaving clean edges that require no sanding. A circular saw with an edge guide (and multiple wooden spacers) can cut perfectly symmetrical wire slots. Skills in measuring and cutting identical parts will be extremely useful in this project. Carpentry experience is helpful, and perhaps even a plumber might find his skills useful :>)

5) Use "Schedule 40" PVC pipe for all these projects. This is the thickest, strongest type of pipe for frame construction, providing maximum symmetry and rigidity. "Schedule 40" is always stamped on this kind of pipe, usually with the date of manufacture.

6) Learn the PVC fitting lingo. A "cross" has four openings, and is shaped like an "X." A "tee" has three openings, and is shaped like a "T." An "elbow" has two openings, and is shaped like an "L."

There are other PVC fittings, but these are the main ones used in building antenna frames.

7) Have fun! PVC assembly mistakes are never fatal—the pipe can always be recycled to make smaller frames. Do your best to learn the skills, and if you have an unexpected "lesson," you can easily write off the cost of a few cheap fittings as "education." Before long, you will be fully qualified to build any size of PVC loop!

Cutting of PVC Pipe The easiest and most efficient way of cutting PVC pipe is by using a power miter saw, with the blade (preferably a "finishing" blade) set at a 90 degree angle. All the pipes for any PVC loop (and its PVC support stand) can easily be cut within a few minutes this way. If you don't have access to such a saw, however, don't despair. A manual miter saw box can also be used to cut perfectly straight pipes, and any hardware store has manual PVC cutting tools, which work very well once you get the hang of them. The trick with these manual cutting tools is to use a repeated cylindrical rolling motion on the PVC to cut through the pipe, rather than attempting to chop the pipe with brute, macho force in a hand grip (as the author quickly discovered). Before purchasing any PVC cutting tool, make sure that it will cut the PVC diameter size that you are planning to use in your project, and practice cutting a few scrap pieces of PVC before you make the important cuts on your dream antenna frame. Practice making clean, perpendicular cuts, which will give your PVC loop the maximum possible strength and symmetry.

If you plan to use a hacksaw (or other manual saw) and lack a miter cutting box, it is recommended that you mark a perpendicular cutting line around the PVC pipe at the exact dimension you wish to cut, and score this line with the saw to start off your cut. This will help you avoid the angular cuts which tend to creep in with this cutting method.

After choosing your desired size of loop and cutting your pipe lengths according to the "Table A" dimensions, ensure that the pipe ends will fit easily into your PVC fittings for gluing purposes. Rough edges should be sanded with 150 grade sandpaper (on the edges only, not on the smooth sides of the pipe) to ensure easy fitting. Always make "dry runs" before reaching for PVC glue.

Cutting the Coil Wire Notches The PVC loop design places a high priority on great coil symmetry, which comes from perfectly spaced coil wire notches. The easiest and most efficient way of cutting these symmetrical notches is by using a circular saw with an edge guide, and multiple wooden spacers to cut evenly spaced wire slots (see photo). The author used several 10" long pieces of ¼" and 3/8" wide mahogany firring strips for this "spacer" purpose, which worked very well. Any experienced woodworker or carpenter should be able to cut highly symmetrical notches this way, but this method requires experience, and should not be attempted by novices (see note below).

If you don't have access to such a saw, you can still make highly accurate coil slots by carefully using a hacksaw on marked cutting lines, which are drawn using a straightedge. Use a ruler to mark out parallel cutting lines spaced exactly .3 inches (or whichever other space is directed in "Table A") apart, and cut the slots wide enough so that your wire size can fit inside the slot for "nesting." This will ensure that your coil turns can be highly symmetrical, to optimize your loop's DXing performance and nulling ability.

Note: Use of a circular saw is not recommended if you lack experience. In preparation for this article, the author has pre-cut many sets of wire-notch PVC pipes for various sizes of loops. If you wish to build a PVC loop but have no interest or ability to cut wire notches, feel free to contact the author to check on the availability of a pre-cut set of 4 wire-notch pipes ("Pipe B", in the Table A loop dimension list) for your chosen PVC Loop design, which can simply be glued to four "spreader" pipes to make your loop. If available, a set will be sent for the cost of USPS Priority Mail shipment.

Professional Glue Joints The symmetry and strength of your PVC Loop will be optimized when you make accurate, secure glue joints between the PVC pipe and fittings. Although all loops will benefit from skillful gluing, the larger loop sizes in particular need strong bonds at various points of stress, such as at the center "cross" fitting, and at the lower "tee" fitting where the loop will be mounted on a support frame. Read the instructions on the glue can and follow them carefully—both for the maximum strength of the joints you make, and for maximum personal safety.

Inside every PVC fitting is a recessed slot, designed to securely hold the pipe after gluing. The fitting's maximum strength comes when a generous amount of glue holds a "bottomed out" pipe securely, in this slot. You can ensure gluing skill by making several practice PVC joints with cheap, scrap pieces of pipe and fittings. After gluing the scrap pieces to fittings, check the opposite end of the fitting to see if you "bottomed out" the pipe in the slot. Practice making glue joints at various angles between pipe sections. Remember that PVC glue gives you about 5 seconds before starting to "grab," so you need to know exactly what you are doing (and what angle you want) before reaching for glue.

When preparing to glue a fitting in your PVC Loop frame, during the "dry run," ensure that the pipe will come close to "bottoming out" in the PVC fitting, before applying glue. If it will not, clean the dirt or other debris off the pipe and fitting slot, and try again. Sand the pipe end with 150 grade sandpaper if necessary. Although PVC glue will often dissolve dirt, stains and other debris to "bottom out" a pipe in the fitting slot, it is best to have smooth, clean PVC material before gluing.

Gluing the four "spreader" pipes to the "cross" fitting is easy, since there are no angular glue joints. Simply ensure that the four pipes "bottom out" in the "cross" fitting (see photo). Gluing the four relatively short "wire slot" PVC pipes to the spreader pipes requires that the "wire slot" pipes all be pointing straight upward, perpendicular to all the "spreader" pipes (see photo). During these glue-ups, it is best to have a guide for a 90 degree angle, such as an unglued "wire slot" pipe set at a 90 degree angle in the fitting at the opposite end of the loop frame. Within 5 seconds, the builder should be ready to get the "wire slot" pipes bottomed out in the fittings, and set them at an angle of 90 degrees before the glue "grabs."

PVC glue forms strong, waterproof bonds when used properly, but will give off a pretty strong smell for about 24 hours after use. Plan to keep your glued PVC pipe project outdoors to vent off the fumes for at least a day after construction, to avoid irritation to yourself and others. Once again, be sure to read all the safety precautions on the glue container, and follow them carefully.

PVC glue also is also known to make interesting, psychedelic patterns when excess glue runs out of joints, especially when it is used as specified on the glue can. If you don't wish your PVC loop to resemble some counter-culture art from the late 60's, use masking tape, and clean rags to wipe up.

Choose your loop size(s) according to the following information. **All of these loops have actually been built and tested by the author**, and should perform as specified when instructions are followed. PVC diameter instructions must be followed exactly, to ensure symmetrical frames. Larger PVC diameters than those recommended may result in unnecessary, excess loop weight.

Table A – PVC Loop Dimensions, Pipe Lengths, Weight and Cost

Side Dimension	18.5”	25.5”	40”	48”	63”	66”	75”	91”	109”	77” (LW)
Diagonal Dimension	25.5”	35.5”	55”	69”	88”	93”	108”	125”	153”	107”
PVC Diameter ***	1”	.75”	1”	1”	1”	1”	1.25”	1.25”	1.25”	1.25”
Pipe “A” length	10.75”	16.4”	26”	32”	42”	44”	51”	60”	73”	51”
Pipe “B” length	8.75”	7”	7”	7”	7”	7”	7”	7”	7”	10.5”
Loop Turns	20	12	9	7	6	6	6	4	4	22
Coil Turn Spacing	.3”	.3”	.3”	.3”	.3”	.3”	.6”	.6”	1”	.3”
Wire Length	123’	102’	120’	112’	126’	132’	150’	121’	145’	564’
Wire Size	#18	#18	#18	#18	#18	#18	#16	#14	#14	#18
Cost of Frame*	$6	$7	$8	$9	$10	$10	$14	$15	$18	$11
Cost of Loop**	$40	$41	$42	$43	$44	$44	$48	$49	$52	$146
Weight of Frame	2 lb.	2.5 lb.	4.5 lb.	5.5 lb	6.5 lb.	7 lb.	9 lb.	12 lb.	14.5 lb.	9.5 lb.
Weight of Loop	3.5 lb.	4 lb.	6 lb.	7 lb.	8 lb.	8.5 lb.	10.5 lb.	13.5 lb.	16 lb.	15 lb.
Start Frequency (kHz)	500	530	510	530	550	530	530	670	590	148
End Frequency (kHz)	1710	1750	1710	1700	1500	1470	1450	1720	1480	374

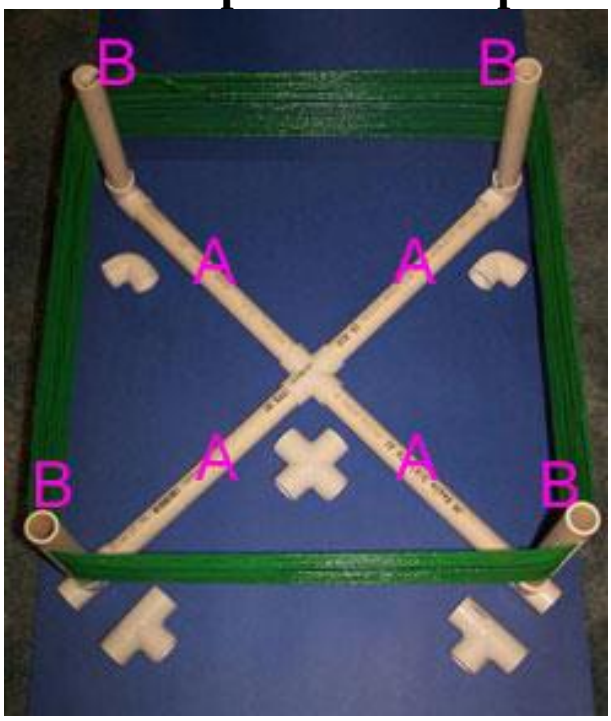
*Pretax cost of PVC pipe, fittings and glue (retail prices in western Washington state, August 2009)
**Pretax cost of PVC pipe, fittings, glue, wire, plus high quality “N50P” 381 pf variable capacitor
***For the 18.5” side PVC loop (and all loops smaller than 24” per side), 1” diameter PVC material is recommended to stiffen the frame, to avoid bowing due to multiple tight wire turns on the frame.

Practical Considerations in Building Your Dream Loop Although most DXers would probably wish to have as much DXing gain as possible from their antennas, the monster-sized loops larger than 4’ per side are unwieldy animals when used in indoor locations, and are impractical to rotate and transport in such environments. RF pollution and multiple conductors in walls, floors and ceilings compromise the indoor performance of these monster loops, which have the potential to cause serious stress in marriages (and serious doubts about the builder’s sanity). It is the author’s sincere hope that no broken relationships or other such negative consequences arise from a DXer’s unrealistic choice of loop size.

Preparing to Build Your Own PVC Loop After choosing the size of loop(s) you wish to construct (when viewing Table A), the next step is to gather your materials.

1) Secure a high quality variable capacitor to use in your loop. The author strongly recommends the compact, 384 pf variable cap from Mike's Electronic Parts, which has 8:1 reduction gearing for smooth, hassle-free tuning from 530 to 1700 kHz. Mike's Electronic Parts - 384pf Air Variable Capacitor with 8:1 planetary reduction drive (mikeselectronicparts.com) It is also compact enough to fit inside a 1.5" diameter PVC pipe, for complete waterproofing of an outdoor loop. It's true that you can recycle an old variable cap from a junk radio and make a tuned loop, but the hassles of hair-trigger high band tuning (and extra hand capacitance) just aren't worth it, in the author's opinion. The final quality of your loop will only be as good as the quality of your variable capacitor—so choose a high quality capacitor from the beginning, and avoid the tuning hassles.
2) Purchase PVC pipe for your chosen loop, making sure it is "Schedule 40" pipe in the diameter size specified in Table A. PVC pipe is commonly sold in 5', 10', 15' and 20' lengths in major hardware stores, and it must be cut to the "Pipe A" and "Pipe B" lengths specified in the table. Each loop will need at least four "Pipe A" lengths and four "Pipe B" lengths, so add up these total lengths to find how much pipe you will need for your loop. Remember to purchase some extra PVC pipe for cutting and gluing practice, and to make a PVC support stand for your loop, if desired.
3) Purchase at least one "cross" fitting, two "tee" fittings, two "elbow" fittings and three "cap" fittings in the PVC diameter specified for your loop (in Table A). Purchase some extra fittings to practice gluing, if desired. All of these PVC fittings should be "slip" (flat mating surfaces), and **not** "threaded" (screw-on type). If you wish to waterproof your loop, purchase an additional 1.5" PVC "coupler" fitting, and a "slip bushing" PVC fitting matching your loop's diameter (.75, 1, or 1.25") to the 1.5" coupler fitting.
4) Purchase stranded insulated wire of the type specified in Table A for your chosen loop, with 25' more than the length specified. Be advised that copper prices have become quite outrageous, and that you can expect to pay about $18 for 125' of #18 wire. Recycled #18, #16 or #14 stranded wire may be used, but sizes larger than these are impractical for winding highly symmetrical loops.
5) Purchase PVC glue, in cans with a built-in applicator brush. The author recommends Oatey "Rain-R-Shine" medium blue PVC cement (8 ounces), which retails for $5.48 and is enough for one loop.
6) Purchase silicone rubber sealant to lock in the symmetry of the coil you wind, at the coil ends. The author recommends DAP 100% Silicone Rubber Sealant for windows and doors (2.8 fluid ounces), which retails for $3.50, and has a 50 year durability guarantee.
7) Gather tools and materials necessary to construct the loop. You will need a pipe cutting tool (power miter saw, miter box manual saw or hacksaw), coil notch cutting tool (electrical circular saw or hacksaw), needle-nose pliers, diagonal cutters, insulation-removing tool, scissors, strapping tape, a tape measure, soldering iron, screwdriver and hardware for connecting the variable capacitor chassis lead, and rags to clean up excess glue. For checking loop performance and adjusting the new loop's tuning range, you will need a portable radio with some type of tuning indicator (bar graph, signal strength LED(s), etc.
8) The author strongly recommends that you build a PVC (or other type) support base for your loop, prior to constructing the actual loop. PVC material of the same diameter as your loop makes an ideal, insulating support structure to allow rotation of your loop for DXing purposes, and elevation of your loop away from ground obstructions. Support bases with electrical conductors (steel, aluminum or other conducting metals) should **not** be used, since they will upset the symmetrical reception pattern of the loop More information on PVC support bases will follow.
9) Remember to work **outdoors** during all cutting and gluing operations. The PVC glue has a very potent smell, which can fill an indoor space within seconds. After any gluing, make sure to keep your loop project **outdoors** for at least 24 hours, to vent out any remaining glue odor.

Building Your Own PVC Loop—Basic Loop Construction Article



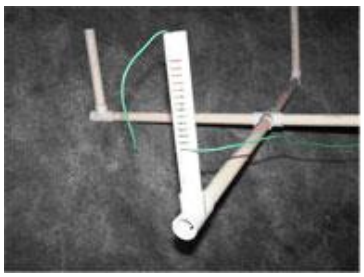
Step By Step Construction (Note: The instructions below are suitable for building a standard PVC waterproofed loop with a fixed frame, ready to mount on a PVC support stand which allows loop rotation. They are not suitable for building a collapsible frame loop or a tabletop loop, for which basic instructions will be follow later in this article, and detailed instructions in subsequent articles.

Observe the "loop turns" number in Table A for your chosen loop size. Using your wire notch cutting tool, cut one more than this number of parallel notches (of .75") length in four PVC pipes, with the first notch 3" from the end of a pipe, and the remaining notches getting closer to the center of the pipe. Ensure the spacing between these notches is close to the "coil turn spacing" specified in Table A, for your chosen loop. Experienced users of a circular saw may set the blade depth to one "tooth" of a finishing blade, clamp the pipes in a horizontal position, and use wooden spacers to quickly cut multiple notches with perfect symmetry (as shown on page 5).

1) After all the notches are cut in four pipes, use your pipe-cutting tool to cut these four pipes into the "Pipe B" dimension specified in Table A, ensuring that there is at least 3 inches of space between one side of the pipes and the first wire notch, but no more than 2 inches of space between the other side of the pipes and the nearest wire notch. A power miter saw can cut all four pipes quickly and easily, if used for this step. If using a manual cutting tool, de-burr pipe debris from the cut edges with 150 grade sandpaper prior to any gluing attempts.

2) After cutting the four “Pipe B” pipes, cut four “Pipe A” pipes, according to the dimension listed in Table A for your chosen loop. If using a manual cutting tool, again de-burr any pipe debris on the cut edges with 150 grade sandpaper, as in the previous step.
3) Take the PVC cross fitting, and make a “dry run” prior to gluing (as explained on Page 5), to ensure that all four “Pipe A” pipes will insert easily into the fitting, and come close to bottoming out in the recessed slot. De-burr the ends of the pipes as necessary, to ensure smooth insertion in the cross fitting. Clean the ends of the pipes, then apply PVC glue with a brush to one of the cross fitting’s open slots, and also to the end of one of the “Pipe A” pipes. Insert this end as deeply as possible into the PVC cross fitting’s glued slot, twisting it as necessary to “bottom out” the pipe in the recessed slot. Use rags to clean up any excess glue. Then following the above procedure, glue the other three “Pipe A” pipes into the PVC cross fitting, ensuring that all of them “bottom out” in the slots. This completes the construction of the loop’s vertical frame.
4) Take two “elbow” PVC fittings, and two “tee” PVC fittings, and make a “dry run” (preparation for gluing) with the sides of the four “Pipe B” pipes having the most space between the notches and the end of the pipes. When making the dry run with the “tee” fittings, insert the “Pipe B” end into the **center slot**, not into either of the end slots of the fitting. De-burr the ends of the pipes with 150 grade sandpaper as necessary, to ensure smooth insertion in the fittings. Clean up any debris in the PVC fittings or around the pipe ends, prior to gluing.
5) Observing the photo at the above right, note that all the precut wire notches on the “Pipe B” sections must be facing directly **toward the outside of the loop**, for proper assembly. When gluing to the center slot of the “tee” fittings, these notches must be facing directly **towards one end** of the “tee” fitting, as shown. When gluing to the “elbow” fittings, these notches must be facing **directly opposite the open end** of the elbow fittings, as shown. Before gluing these “Pipe B” sections to the PVC fittings, practice as necessary to know exactly where to position these coil notches, within 3 seconds of inserting the glued pipe into the “tee” and “elbow” fitting slots.
6) Taking one of the “Pipe B” sections, apply a thin coat of PVC glue to the end of the pipe having the most space between the wire notches and the pipe’s edge. Then promptly take a PVC “elbow” fitting, and apply glue to one of the slots. Insert the pipe’s glued edge into the “elbow” fitting’s glued slot, bottoming it out, and **twist the pipe to ensure that the wire notches face directly opposite the “elbow” fitting’s open end.** Clean up excess glue as necessary. Repeat the above steps to glue another “Pipe B” section into another “elbow” fitting, so that two “Pipe B” sections will be glued to “elbow” fittings, both with the wire notches facing directly opposite the “elbow” fitting’s open end.
7) Taking one of the remaining two “Pipe B” sections, apply a thin coat of PVC glue to the end of the pipe having the most space between the wire notches and the pipe’s edge. Then promptly take a PVC “tee” fitting, and apply glue to **the center slot** of the fitting. Insert the pipe’s glued edge into the glued center slot of the “tee” fitting, bottoming it out, and **twist the pipe to ensure that the wire notches face directly towards one of the ends of the “tee” fitting.** Clean up excess glue as necessary. Repeat the above steps to glue another “Pipe B” section into another “tee” fitting, so that two “Pipe B” sections will be glued to “tee” fittings, both with the wire notches facing directly towards one end of the “tee” fittings.
8) Again observing the photo at the above right, note that when the “Pipe B” sections with the “tee” fittings are glued into the “Pipe A” frame pipes, the wire notches **must face toward the outside of the loop**, and that there is only **one correct side** of the “tee” fitting to glue to the “Pipe A” frame pipe (the one opposite the wire notches). Note also that all of these “Pipe B” wire notch pipes **must be glued at a 90 degree angle,** relative to the plane of the “Pipe A” frame pipes.
   In the same way, observing the photo, note that when the “Pipe B” sections with the “elbow” fittings are glued into the “Pipe A” frame pipes, both of these “Pipe B” wire notch pipes **must also be glued at a 90 degree angle,** relative to the plane of the “Pipe A” frame pipes. Practice making these angular glue jobs before the actual glue-up, which will require the longer frame pipes to be “bottomed out” in the PVC fittings, and the shorter wire notch pipes to be rotated to a 90 degree angle within 5 seconds. Know exactly what you plan to do, before reaching for glue.

9) Without using any glue, insert the open end of an "elbow" fitting (attached to a wire notch "Pipe B" side) onto the edge of one of the "Pipe A" frame pipes, and rotate the "Pipe B" wire notch pipe to an exact 90 degree angle, relative to the plane of the "Pipe A" frame pipes. This will act as a guide for making an accurate 90 degree angle glue-up in the next step.
10) Apply glue to the **correct** opening slot (the one farthest away from the wire notches) of the "tee" fitting attached to one of the "Pipe B" wire notch pipes, and also apply glue to the edge of the "Pipe A" frame pipe directly opposite the 90 degree guide, prepared in the last step. Insert the end of the "Pipe A" frame pipe into the glued "tee" fitting, forcing it in to completely bottom out the pipe, and **rotate the "Pipe B" wire notch pipe so that it is a 90 degree angle, following the guide prepared in the last step.** Use rags to clean up as necessary.
11) Remove the unglued "Pipe B" wire notch pipe that was used as a 90 degree angle guide in the last step. Using the wire notch pipe that was glued in the last step as a 90 degree angle guide (assuming it was correctly glued at 90 degrees :>), apply glue to the open slot of the "elbow" fitting attached to the wire notch pipe, and also to the end of the "Pipe A" frame pipe directly opposite the 90 degree guide, glued in the last step. Insert the end of the "Pipe A" frame pipe into the glued "elbow" fitting, forcing it in to completely bottom out the pipe, and **rotate the "Pipe B" wire notch pipe so that it is at a 90 degree angle, following the guide glued in the last step.** Use rags to clean up as necessary.
12) Repeat steps 9, 10 and 11 to attach the remaining two "Pipe B" wire notch pipes to the remaining two "Pipe A" frame pipes. Follow instructions closely, and use rags to clean up any excess glue. This completes the assembly of the PVC loop frame, which should be left **outdoors** to vent off glue fumes for at least 24 hours.




Winding the Coil on the PVC Frame The wire size and length recommendations in Table A have been tested in actual PVC loops, and should be followed for best results. In any case, wire should be stranded, insulated, single conductor, and of a size close to the wire recommended in Table A.

1) Using the wire size specified in Table A for your chosen loop, cut 25 feet more than the Table A length specified for your chosen loop. This should compensate for minor loop frame construction differences. When cutting long lengths of wire for loop construction, it is helpful to lay the wire out flat on the ground—both for measurement, and to avoid tangled messes when winding a coil.
2) Choosing one of the wire notch pipes attached to a "tee" fitting, bend and insert one end of the cut wire length into the wire notch **closest to the "tee" fitting.** and twist and push it up through the wire notch pipe until it comes out of the free end of the pipe (needle nose pliers may help in pulling it through the pipe). Pull about 6" of this wire past the end of the pipe, then use strong strapping tape to secure this wire on the pipe side opposite the wire notches (see photo). Note: this will be the "capacitor pipe," in the final loop.
3) Start to wind your loop coil (in either direction) by pulling the wire, and inserting it into the wire notch pipe slot **closest to the PVC fitting,** on the next frame pipe. Use moderate force to pull out any slack in the wire (further tightening will come later), and push the wire into the notch as deeply as possible. Continue in this manner to proceed to the next frame pipes, always pulling up the slack as you insert the loop wire into the wire slots, and keeping the coil moderately tight and symmetrical

(winding the coil from the bottom to the top of the wire notch pipes). Note: it is normal for the coil to appear quite ugly and disorderly when first wound on the PVC frame.

4) When you have wound the correct number of turns according to the instructions in Table A for your chosen loop, you will end up at the same wire notch pipe (with a "tee" fitiing) that has the other wire end taped in place. Stop at this pipe, temporarily tape off the coil you have wound, and insert the free end of the wire into the last remaining slot on the same wire notch pipe (It may be helpful to cut off any excess wire at this point—you will only need about 12 inches more wire than where the pre-wound coil reaches the last wire notch slot). After inserting the free end of the coil wire into the last wire notch slot, push it upwards until it comes out of the end of the wire notch pipe (like the other end of the wire, which is taped in place). Then remove the tape temporarily securing your recently wound coil, and pull up all slack in the coil by working it through the last coil notch slot (while pulling on the free end of the wire, which now comes out of the pipe end). Finally, tape this free end in the same position as the other coil end, on the side of the pipe opposite the winding notches (secure both ends together, as shown in the photo).
5) Starting from one end of the taped coil, start pulling out the slack in the coil turns, moving from pipe to pipe. Smooth out any bends or kinks in the wire, and push the wire back into the wire notches after pulling out any slack. Continue pulling out the slack in this way until you reach the other end of the coil (where it enters the pipe through the wire slot), and pull up this slack through the wire notch pipe. Temporarily remove the tape securing the coil end to the pipe, pull out all slack in the wire, and re-tape the coil end.
6) Repeat step 5 multiple times (in both winding directions, clockwise and counterclockwise) to pull out as much slack as possible in the coil wire, until the coil is as symmetrical as possible. On loops with many turns, this step may need to be repeated as many as 10 times, for best results. (Note: **minor** bowing of the frame pipes may occur on loops with many turns as the slack is pulled out tightly, but this will not affect the loop's performance). If the ends of a frame pipe bend toward an adjacent pipe, simply grasp the coil wire and slide the frame pipe back into a straight position.
7) When satisfied that your loop coil is as symmetrical as possible, use silicon rubber sealant to seal the wire notch slots **where the ends of the coil enter the pipe.** Use a generous amount to completely cover the two slots, and lock in the symmetry of the coil you have just wound. In a similar manner, use a generous amount of silicon rubber sealant **inside the open end** of the wire notch pipe (where the two wires exit the pipe), to lock in the position of the two end wires. Ensure that **no sealant is applied to the outside edge** of the pipe—in the waterproofing system, a PVC fitting will cover these surfaces. Allow 24 hours for the rubber sealant to cure, before proceeding.




Final Electrical Assembly For those builders wishing to connect the recommended "N50P" variable cap from Crystal Radio Supply and waterproof their loop, final instructions follow. If you wish to connect a different variable cap and are not concerned about waterproofing, ensure that the leads to your variable cap **are as short as possible,** and that you use a plastic tuning knob on your variable cap to minimize hand capacitance.

1) Remove the tape securing the two coil ends to the wire notch pipe. Measuring from the end of the pipe, cut these two coil wire end leads to a length of 4½ ". Strip off ¾" of insulation from one wire end, and ½" of insulation from the other wire end. Twist the stranded wires at the end of each lead together tightly, so they can be securely connected to the variable capacitor.

2) Take a 1.5" PVC "coupler" fitting and the PVC "slip bushing" fitting that you purchased earlier (with one side having a 1.5" diameter, and the other side having the diameter of your loop frame). Use PVC glue to insert the 1.5" side of this "slip bushing" to one side of the 1.5" coupler, pushing the "slip bushing" into the "coupler" until it bottoms out.
3) Thread the two loop wire ends through the smaller-diameter opening in this bushing-coupler assembly until they come out the opposite end (see photo). Then twist the bushing-coupler assembly firmly onto the end of the wire notch pipe, until it reaches its maximum depth (Note: glue is not necessary, and is avoided to enable replacement of the variable cap should it become necessary in the future).
4) Take the 381 pf variable cap from Crystal Radio Supply, and make sure the rotor plates are fully meshed inside the stator plates, to avoid damage during assembly. Pre-tin the loop wire end with ½" of insulation stripped, and solder it to one of the two variable cap terminals at the back of the variable cap (the side opposite the tuning shaft).
5) Attach the other loop wire end to the variable capacitor chassis with an 6-32 x 3/8" screw, a #6 lockwasher, and two 6-32 nuts. Used the threaded screw hole on the side of the variable cap chassis which is opposite the side having the terminal chosen in step 4. Wrap the end of the loop wire securely around the screw with nuts on both sides of the lead wire end, so that it will lock in place when the screw is tightened. Then securely tighten the screw. (Note: Do **not** attempt to solder the wire lead directly to the chassis of the variable cap. This will usually create a poor connection, subject to breakage when the variable cap is inserted in the PVC coupler fitting)
6) Attach a plastic knob to the tuning shaft of the loop's variable cap.Using a portable radio with a signal strength LED or bar graph (Tecsun R9012, Eton E100 or similar), tune in a weak station near the lower end of the band, and place the radio within 3 inches of the loop wire. Check the operation of your new loop by tuning its variable cap slowly clockwise, until the signal from the weak station becomes MUCH stronger. Even if the loop is in a horizontal position on a work table, it should be able to greatly boost the signal from any weak station, once the loop is tuned to the radio's frequency. Ensure proper loop operation before proceeding.
7) While observing the two connecting wires on the back of the variable cap, gently insert the variable cap into the PVC coupler fitting with a slight twisting motion, so that the slack in the wire leads will be taken up inside the coupler. Bend the four terminal leads on the bottom of the variable cap just enough so that the variable cap will lock in place inside the coupler, with the back of the variable cap bottoming out inside the coupler. After this step, use the portable radio to again check the variable cap operation, to ensure that both connecting leads are still connected, and operating properly. If not, remove the variable cab from the coupler fitting and check the leads. Most often at this point, if a problem exists, the wire terminal on the bottom of the variable cap has shorted to the chassis of the variable cap. Use diagonal cutters to remove a section of this terminal so that it will not short, and reinsert it into the coupler fitting. Check normal operation.
8) When the variable cap is fully inserted into the coupler fitting, locked in place with its bottom terminals, in a straight orientation relative to the frame pipe and operating normally, secure the variable cap in this position by carefully applying silicone rubber sealant around three front edges of the variable cap— the left, right and bottom (see photo). Use only enough sealant to bond these edges to the **inside** of the coupler fitting, and ensure that no sealant touches the variable cap's rotor or stator plates. Leave the top edge of the variable cap without sealant, so that the approximate tuning position may be observed (this will not affect waterproofing, in a vertical loop). Let the sealant cure for 24 hours. (This completes the assembly and waterproofing of your PVC Loop.)

<u>Operation and Performance</u> When mounted in a vertical position on an insulating stand, your new PVC Loop should provide a very strong DX signal boost when its loop coil is broadside to the DX (i.e. the loop frame pointing at the DX station), whenever a radio tuned to its frequency is held within a few inches of the loop. Depending upon the size of PVC Loop you have constructed, the DX signal boost will range from very significant (18" size) to overwhelming (9' size).

If you have constructed a loop larger than 4’ square, you will notice that the frequency range of your loop (as constructed) will not cover the entire AM band. The solution to this situation is to use capacitive switching (or wire jumper shorting) schemes, which are beyond the scope of this initial article and will be covered in a dedicated Monster PVC Loop article at a later date. Also in a separate article, the indoor use of 3’ and 4’ PVC Loops connected to communications receivers will be discussed.




PVC Support Bases The ideal structure to support your new PVC Loop is a PVC support base, constructed of identical material (of the same diameter). It is lightweight, waterproof, insulating, strong—and cheap. It makes an excellent first PVC project, as you learn the tricks of cutting and gluing before building your loop. A simple support base is shown in the photo at left, along with the more specialized altazimuth tilting base and heavy-duty monster loop base.

To construct the simple PVC base, glue a short stub of pipe (about 5”) into one side of a “cross” fitting. Glue a 3’ pipe section into the opposite side of the “cross” fitting. Cut two more 3’ pipe sections and glue them into the other two openings in the “cross” fitting. Cut two sections of pipe 33” long, and glue each one into the center opening of two “tee” fittings. This will be the “center assembly.” Cut four 2’ sections of pipe, and glue them into the other openings in the “tee” fittings. These will be the “side legs.” Glue two “elbow” fittings to the other end of the two 33” side leg pipes, **ensuring that the elbow fittings are perpendicular to the 2’ ground level pipes.** Finally glue the two side leg assemblies to the center assembly, ensuring that the **short stub is pointing upward.** This simple base will be suitable for supporting PVC Loops 4’ (and smaller) on flat ground in good weather, and may be downsized for indoor usage. Larger loops should use stronger outdoor support bases, designed to survive the toughest of local weather conditions (a special article will follow).




Collapsible-Frame, Longwave and Tabletop PVC Loops Three popular variants of the basic PVC Loop design are a collapsible-frame model which can be easily transported for DXpeditions and travel, a Longwave model which can tune from 148-374 kHz, and a tabletop model for outdoor park usage. All can be easily made, once you have experience in building the standard PVC Loop-- and all will be covered in detail, in future dedicated articles.

The collapsible-frame model has DXing performance identical to the fixed-frame models, but only two of the “Pipe A” frame pipes are glued to the center cross fitting, and only two of the “Pipe B” wire

notch pipes are glued to the “Pipe A” frame pipes. The others are unglued, which allows for easy disassembly for transport. The coil is wound the same way as in fixed-frame models, but silicone rubber sealant is applied to all the wire notch pipes on all windings, completely locking in coil symmetry indefinitely—whether or not the frame is disassembled.

The Longwave model has the size and sensitivity to dig out weak signals in the lower LW spectrum, with decent nulling ability. It has been successfully built by Steve Ratzlaff as a first-time project, as well as by the author (who is quite intrigued by its strong beacon reception).

The tabletop AM model has four short PVC legs attached to the loop frame, which enables a DXer to place it comfortably on a desktop or picnic table, for casual listening sessions.

Conclusion The author tested three collapsible-frame PVC Loops (3’, 4’ and 5.5’ per side) during summer DXpeditions to Grayland, Washington, and found their performance extremely effective. The signals of typically weak DU (South Pacific) stations were boosted to the point of sounding like locals, when Ultralight radios were inductively coupled to the loops. Several MP3’s of these DU receptions have been posted on Dxer.Ca and the Ultralightdx Yahoo site, and include very strong recordings of 1116-4BC, 648-NZ Rhema, 675-3YA, 738-R.Tahiti and 567-2YA.

It is the author’s sincere hope that this passive loop experimentation will provide some new DXing excitement for those hobbyists who desire more weak-signal success, both at home, and during travel. If you seem to have hit a “brick wall” during your DXing sessions, why not build one of these very inexpensive loops, and enjoy a new burst of hobby enthusiasm? For the cost of the smallest commercial loop models, you can have a monster PVC Loop that will smash down your “brick wall” with exciting new loggings, and give you profound new optimism during the upcoming DX season.

73 and Best Wishes to All,

Gary DeBock

(The author wishes to express appreciation for the detailed assistance of John Bryant in the preparation of this article, and for the contribution of Steve Ratzlaff in testing the Longwave variant PVC Loop.)