

7 Inch Diameter “Affordable” FSL Antenna

Combining Maximum MW Performance with Minimal Expense

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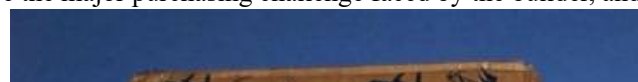


Introduction Most AM-DXers have become aware of a strange ferrite-based portable antenna-- the subject of intense speculation experimentation throughout the year. After the publication of Graham Maynard’s introductory article in the March edition of Med. Wave News, distinctive new Ferrite Sleeve Loop antennas have suddenly appeared on the DXing scene, offering hobbyists the unique option of high gain performance from an extremely compact size. While the DXing performance of these new FSL antennas can indeed be astonishing, the construction cost of full-sized models can be equally breathtaking—resulting in an official nickname of the “Financial Sinkhole Loop.”

Although the cost of multiple ferrite bars will never be cheap, the author was determined to design a moderately-sized FSL which would deliver maximum DXing performance at a reasonable cost. The performance benefits of this new antenna are superb, and it would be very regrettable if access to the breakthrough design was limited because of its excessive cost. While the terms “reasonable” and “affordable” are of course open to interpretation, at the time of its design (August 2011) the 7” FSL antenna described in this article could be constructed at a material cost of under \$150 (U.S. dollars). Although the unpredictable eBay sellers of Russian surplus ferrite may well erode the author’s original objective of reasonable assembly cost, it is sincerely hoped that this article will provide sufficient motivation for many new DXers to construct their own high-performance FSL antenna in an economic manner, and personally experience the astonishing benefits that this new antenna design has to offer. Although this 7” FSL is of modest size and cost, it has been tested repeatedly against a full-sized 4’ PVC box loop, with superior performance results.

Project Overview FSL antenna construction is likely to be quite different from any other antenna project undertaken by a hobbyist due to the twin challenges of ferrite sleeve symmetry and bump resistance. Significant weight from the collection of ferrite rods must be supported on a shock-absorbing, resilient frame—the importance of which will increase if your FSL is to be taken out in remote locations for portable DXing. The ultimate tragedy would be for a hobbyist to spend serious \$\$ to purchase multiple ferrite rods, only to have many of them shatter out in the field after an unplanned “drop test” due to an unsuitably rigid frame. For this reason the development of a strong but resilient frame was a top priority in this project, and its careful duplication is recommended unless your FSL antenna’s mission will be limited to shack usage in secure, indoor locations.

The task of obtaining the large collection of ferrite rods is likely to be the major purchasing challenge faced by the builder, and unless a diligent search is made for an economic option the cost of so many rods can easily reach astronomical levels. To economize most



This ferrite sleeve loop antenna is designed to be inductively coupled to any portable radio with a loopstick, and no radio modifications are necessary to receive the antenna's high gain DXing boost. Although FSL's are typically used to dramatically boost Ultralight radio's weak signal sensitivity, they may also be used with medium and full-sized AM-DXing portables like the ICF-S5 and RF-2200, providing the same high gain inductive coupling boost (and a quantum leap in these classic portables' weak signal reception effectiveness).

G) A 6 1/4" diameter rubber plumbing coupler (Fernco Inc. Part #1004-44, 4" concrete to 4" concrete)

- H) A 36" long section of 1 1/8" Inner Diameter pipe insulation, 3/4" thick
 - I) Three heavy-duty (175 pound test) 18" long plastic tie wraps
 - J) A 2" long section of 3/32" shrink tubing
 - K) Johnson and Johnson waterproof medical tape (either 1", 2" or 3" wide sizes)
 - L) Scotch brand "Extreme" strapping tape
 - M) PVC pipe assembly glue, with brush inside can (Oatey Rain-R-Shine #30891 blue glue recommended)
 - N) An Oatey 4" x 4" closet spacer foam package
- Miscellaneous: 6-32 x 3/8" screw, two 6-32 nuts, 6-32 lock washer, 12" of 5/8" I.D. rubber air hose, a variable capacitor control knob (for 1/4 inch shaft, Crystal Radio Supply knob #3 recommended), two "Duro" .07 oz (2 gram) Super Glue packets

Step-By-Step Construction

1) Cut the PVC pipe into a single 8" section, two 4" sections, and four 2 1/2" sections. Suggestions on cutting and gluing PVC pipe contained in the PVC Loop article (posted at <http://www.am-dx.com/ThePVCLoopOverallArticle.pdf>). After reading the gluing suggestions in the article, glue a PVC "Tee" fit one end of the 8" long PVC pipe section, ensuring that the pipe is glued to the center opening of the PVC fitting (see photo below) that it is bottomed out in the fitting.

2) Insert the unglued end of the 8" long PVC pipe section through the inner hole of the 7" Funnoodle section until it is flush with the opposite end of the Funnoodle. Stand this assembly on the flush edge (see photo at right).

3) Wrap several strips of J & J waterproof tape around the Funnoodle outer surface in equally spaced circular strips, adhesive side out. Overlap each tape strip so that it will be tightly secured around the Funnoodle surface. This spaced taping pattern should only be done for a 5" long section of the Funnoodle, starting from the bottom edge (flush to the table—see photo at right).



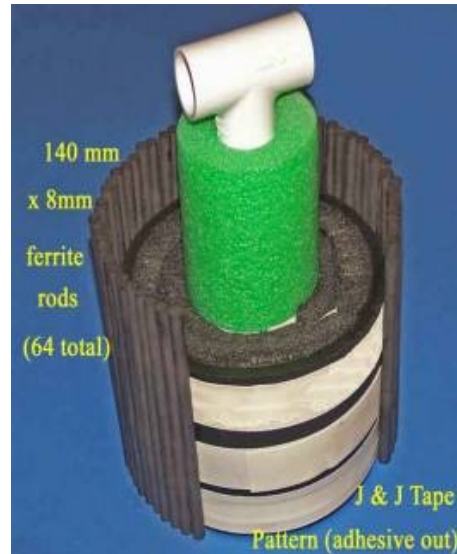
4) Take the pipe insulation, and separate it at the factory-precut line for a length of 24". Cut six 4" long sections of the pipe insulation (with even, perpendicular cuts). Trim each of the factory-cut edges of these 4" sections at an angle, so that each individual piece will make a close fit with the next one, when wrapped around the Funnoodle section (see photo at lower left below). Attach the first pipe insulation piece tightly around the taped Funnoodle section (see photo above). Tightly place another pipe insulation section against this first layer then a short piece (1 1/2" wide) of pipe insulation to complete the first layer (see photo lower left below). Wrap another spaced pattern of J & J waterproof tape around this first layer (adhesive side out). Begin the second pipe insulation layer by overlapping one of the first layer mating edges with a standard long piece of pipe insulation. Three standard sections should complete the second layer of pipe insulation, which together with the first layer should fit snugly within the rubber plumbing coupler, as shown in the photo at right



below.



5) Carefully insert the inner core material inside the rubber plumbing coupler at the edge working it inside inch by inch (see photo at right). Remove the inner PVC pipe, if necessary. When finished, the inner core material should be flush with the outer edge of the rubber plumbing coupler, and provide a snug but resilient fit. Reinsert the PVC pipe (if removed previously) ensuring that the assembly's flush side is completely flat, allowing it to stand vertically.



6) Stand the inner core and rubber plumbing coupler assembly vertically on the flush end, as shown at left. Remove the metal hose clamps from the rubber plumbing coupler, if not done previously. To fill up the slight horizontal slot on the plumbing coupler after removal of the clamps, some 1/2" J & J tape or a folded length of tape (adhesive side out) may be used until the tape is level with the main rubber surface of the plumbing coupler.

Tightly wrap a pattern of J & J waterproof tape horizontally around the plumbing coupler (adhesive side out), using overlapping edges to secure the tape strip (see photo at left). Make sure that each J tape strip is wound tightly, so that the strips do not slide up and down on the rubber plumbing coupler.

Whether 1", 2" or 3" J & J tape is used for this pattern, the tape pattern should extend throughout the 4" height of the rubber plumbing coupler, as shown in the photo at left.

Note: It is common for the Russian surplus ferrite rods to have minor bends and angles, but when lining up the ferrite rods in a cylindrical sleeve, try to ensure that each rod has maximum contact with the J & J tape, and that the ferrite rod angles do not create a major gap with the adjacent ferrite rod. Ferrite rods with severe bends (typically quite rare) should not be installed in the antenna.

7) Take the first 140 mm x 8 mm ferrite rod, and stand it vertically against the J & J tape pattern, flush with the bottom of the plumbing coupler (see photo above). Press the ferrite rod into place on the adhesive tape. In the same way, carefully install the next ferrite rod closely adjacent to the first one, and continue this tight pattern until as many rods as possible are installed vertically, flush with the bottom of the plumbing coupler. When finishing up the last few rods in the sleeve, ensure that they also are vertical, and that the last rod will make a tight fit with the first one (using the rods' minor bend angles to your advantage, if necessary). Because of differences in the ferrite rods or rubber plumbing coupler, the completed sleeve may contain anywhere from 63 rods up to 68 rods.

8) With the assembly still standing on the flush edge, install another pattern of J & J tape tightly around the completed ferrite sleeve's lower 4 inches, adhesive side out. Use this tape pattern to attach a single layer of the Oatey 4" x 4" foam spacer material, cut to fit the exact circumference of the ferrite sleeve. When completed and laid flat, the assembly should resemble the photo at right.

9) With the assembly laid flat as in the photo at right, insert a scrap piece (12" or longer) of 3/4" PVC pipe in one side of the PVC "Tee" fitting at the far edge of the inner core PVC pipe. Then rotate this "Tee" fitting until the end of the scrap piece of 3/4" PVC pipe lays on the table, to the upper right of the antenna assembly. In the same way, insert another scrap piece (12" or longer) of 3/4" PVC pipe in one side of a remaining PVC "Tee" fitting, and lay this scrap pipe in front of the antenna assembly, parallel and lined up with the scrap PVC pipe in back of the antenna assembly (refer to photo on next page).



Note: PVC gluing operations should always be conducted outdoors (because of strong PVC glue fumes). It is also advisable to practice PVC gluing operations with scrap PVC pipe and fittings, prior to completing the PVC frame assembly in the following steps. In each of the following steps, read over all assembly instructions thoroughly before starting each step, and know exactly what you need to do to complete the step before applying glue. Be ready to line up the scrap pieces within 5 seconds (before the glue dries), according to the instructions. Always have some wet newspaper towels available for PVC glue cleanup, prior to starting each frame assembly step.

10) Working outdoors, ensure that the parts in the above photo are laid on a flat surface.

table in the same orientation, with PVC glue and cleanup material nearby. Grasp the far edge of the FSL assembly with one hand and push in the Funnoodle core material around the PVC pipe with the other hand, to provide about 3/4 inch of PVC pipe for gluing purposes (as shown by the photo above). While this section of PVC pipe is still exposed, quickly brush on PVC glue throughout its length, and also apply glue to the center opening of the "Tee" fitting that will mate with (see photo above). Using one hand on each side of the frame assembly, push the center opening of the "Tee" fitting onto the exposed section of PVC pipe until it bottoms out, and within 5 seconds of mating these pieces (while continuing to push in the "Tee" fitting to maintain the bottomed-out position) rotate the scrap PVC pipe section in front so that it exactly lines up with the scrap PVC pipe section in the back of the assembly (refer to the photo at right). Maintaining the pushing pressure on the frame assembly, hold the two scrap pipes in this lined-up position for at least 15 seconds before releasing the pressure (this will allow time for the PVC glue to dry).

11) Remove the scrap pieces of pipe from the PVC "Tee" fittings, and glue the two 4" long PVC pipes in their place (in one end of each of the two "Tee" fittings), making sure that the pipe sections are bottomed out in the "Tee" fittings, and that both 4" pipes are facing in the same direction (like the scrap pieces in the photo at right).

12) Rotate the assembly on the work table so that the 4" pipes are visible on the left and right side of the ferrite sleeve (see photo at left). Roll the ferrite sleeve slightly closer, so that the 4" leg pipes are pointing directly at your eyes. Take the two scrap pieces of PVC pipe and insert them (without glue) in one end of each of the two remaining "Tee" fittings. Have PVC glue and cleanup material ready, before proceeding with the following steps.

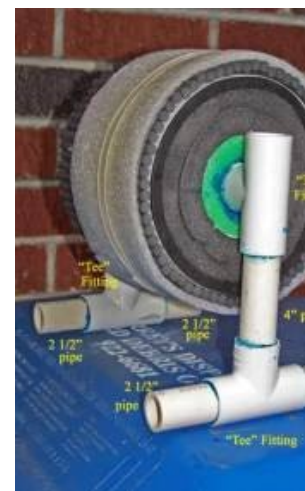


13) (Refer to photo at left) Apply PVC glue to end of the left side 4" pipe, and to the center opening of one of the "Tee" fittings. With the scrap PVC pipe facing upward, push the center opening of the "Tee" fitting onto the end of the 4" pipe so that it bottoms out in the fitting, ensuring (within 5 seconds of mating these pieces) that the scrap PVC pipe is exactly parallel to the left (flush) side of the ferrite sleeve assembly (see photo at left).

14) (Refer to the last photo on the previous page) Apply PVC glue to the end of the right side 4" and to the center opening of the remaining "Tee" fitting. With the scrap PVC pipe facing upward (as in the photo), push the center opening of the "Tee" fitting onto the end of the 4" pipe so that it bottoms out in the fitting, ensuring (within 5 seconds of mating these pieces) that the scrap PVC pipe is exactly parallel to the other scrap pipe, and the right side of the ferrite sleeve assembly (see the photo on the previous page).

15) Remove the scrap PVC pipes from the two "Tee" fittings, and glue two 2 1/2" PVC pipes in the end openings of both "Tee" fittings. Ensure that all four short pipes bottom out in the end openings of the "Tee" fittings, and use cleanup material to remove any excess glue. This completes the assembly of the FSL antenna's basic PVC frame (see photo at right). Keep the assembly outdoors for several hours, to allow sufficient time for the PVC glue fumes to vent out.

16) Bring the assembly indoors, and stand the PVC frame upright on the two "legs." Ensure that the single layer of Oatey foam spacer material is wrapped tightly around the ferrite sleeve, with no gap at the ends (this foam material can be unwrapped and stretched slightly, if necessary, to fill any minor gap between the ends).



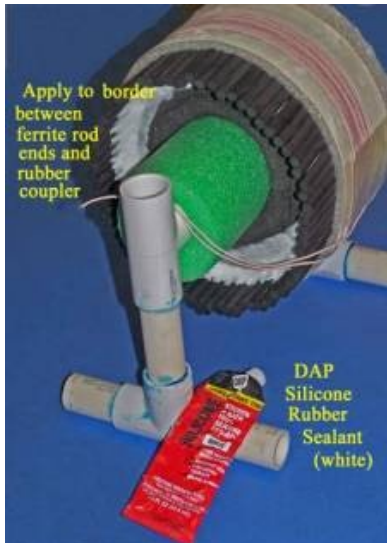
17) Using either 1", 2" or 3" Johnson & Johnson waterproof tape, tightly wrap a turn of tape over the foam material directly above the exact center of the ferrite rods, with the adhesive side out (if you are using the 1" wide tape, use two overlapping turns of tape, for a total width of 1 3/4"). It is important that this tape is wrapped tightly, to secure the ferrite sleeve in a tight cylindrical pattern.



18) Refer to the photo at left. Using a scrap piece of waterproof tape, temporarily tape the end of the 660/46 Litz wire length to the top surface of the Funnoodle material. Leaving 10" of wire to be used for one of the variable capacitor leads, start the first turn of the Litz wire coil 2" from the right edge of the ferrite rods, as shown in the photo.

rods (ensuring that there are no kinks or gaps), as shown in the photo at left. Tightly wind 18 turns of Litz wire in a neat pattern around the waterproof tape, rotating the ferrite sleeve assembly if necessary to maintain wire tension. When the 18-turn coil is finished it should be positioned roughly above the center of the ferrite rods, as shown in the photo above.

19) Refer to the photo at right. When 18 full turns of Litz wire have been wound, extend the final turn three inches past the start of the first turn. Secure the coil with a horizontal strip of Scotch "Extreme" tape, then turn the Litz wire back over the coil to return along the other end (see photo). Secure this last turn with another strip of "Extreme" tape, cutting the wire 10" long.

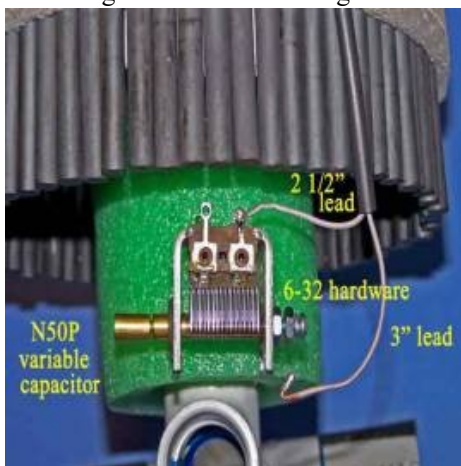


20) (Optional) For maximum antenna survivability in rough DXpedition environments a silicone rubber sealant may be added on the sides of the ferrite sleeve, where the ferrite rod meet the rubber plumbing coupler (see photo at left). This will provide additional protection for the ferrite rods, and enable the FSL to survive sharp horizontal bumps to the PVC frame (the inner core material will already protect the antenna from sharp vertical bumps). This should be done outdoors, prior to installation of the variable capacitor. Have some cleanup material ready and allow sufficient time for the silicone sealant to cure before proceeding to the next step.

21) Refer to the photo at right. Take the 2" long section of shrink tubing, and run the two Litz wire ends through it. Push the shrink tubing along the Litz wires until it touches the edge of the Scotch "Extreme" tape surface. In this position, the shrink tubing will protect the Litz wires from the sharp edges of the ferrite rods (in the sleeve assembly) during future operation.



22) Rotate the ferrite sleeve assembly until the Litz wire's starting (and end) point is at the top, as shown in the photo at right. Ensure that the shrink tubing is still pushed as far as possible up to the Extreme tape edge, then using sharp diagonal cutters (so that the Litz wire insulation does not unravel), cut the lengths of the two Litz wires to 2 1/2" and 3" past the edge of the shrink tubing.



23) Temporarily bend the Litz wire ends away from the antenna assembly to avoid solder drips and scorch marks. Pre-tin the ends of both Litz wires with a hot soldering iron, so that at least 1/2" at the end of both wires is covered with solder in a straight pattern. It is essential that enough heat is used to thoroughly melt solder around all the individual strands in the end sections of these large-diameter Litz wire leads for best results.

24) Refer to the photo at left. Position the variable capacitor in the position shown, at the top of the Fun noodle's outer edge. After making a secure connection solder the 2 1/2" Litz lead to the terminal shown, ensuring that there are no shorts to the variable cap frame. Prepare the end of the 3" Litz wire lead as shown, so that it will fit securely between 6-32 nuts when the screw is tightened in a clockwise pattern.

25) Install (in this order) a 6-32 lock washer and two 6-32 nuts on the 6-32 x 3/8" screw as shown in the photo at left. Install the screw in the variable cap frame by turning it clockwise in the position shown, leaving enough space between the nuts for attaching the prepared end of the 3" Litz wire. Finally, pull this prepared Litz wire end down over the 6-32 screw shaft in the space between the nuts, and ensure that the wire will make a solid connection when the screw is tightened (use needle nose pliers if necessary, to crimp the lead tightly against the screw shaft). Finally, tighten the screw securely against the variable cap frame, ensuring that the Litz wire lead is permanently secured.

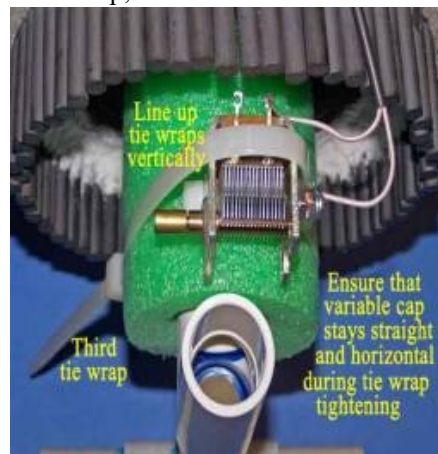
26) Refer to photo at right for the following step. Take two of the 18" plastic tie wraps and pass the end of one tie wrap through the eye of the other, as shown (so that the plastic teeth engage). Place this pair of tie wraps under the variable cap frame as shown, and while holding the right side tie wrap eye up against the variable cap frame, push the left side tie wrap eye flush up against the left side of the variable cap frame, so that the two tie wrap eyes make a tight fit against the variable cap.



After this has been done, temporarily remove the tie wrap assembly and neatly cut off the two excess lengths of tie wrap material. Then place the short tie wrap assembly back under the variable cap frame.



27) Refer to the photo below for the following step. Take the remaining 18" tie wrap and insert its end up through the right side tie wrap eye (as shown in the photo) for a length of 11", passing the tip in between the Litz wires and over the top of the variable cap, as shown.



28) Refer to the photo below for the following step. Wrap the 18" tie wrap around the Funnoodle surface and pass its tip through its eye, ensuring that the tie wrap is lined up vertically with the short tie wrap assembly under the variable cap frame, with both of these items 1/4" from inner edge of the variable cap frame. Ensure that the outer edge of the variable cap frame is flush with the edge of the Funnoodle edge, and that the variable cap stays in a horizontal position when the tie wrap is tightened. Tighten the tie wrap slowly, making sure the variable cap's horizontal and vertical alignment is straight (reposition the variable cap if necessary during tightening, since it can be easily moved along the

Funnoodle surface when the tie wrap is still relatively loose). Check the two pictures at right and below to ensure that your front and side alignment stays correct, and continue to slowly tighten the tie wrap until the variable cap is held securely in place.

29) After the variable cap is secured tightly against the Funnoodle surface, turn the shaft of the variable cap through a complete rotation cycle to ensure that there are no obstructions to prevent free rotation during operation. When the plates are fully open the variable cap plates may temporarily brush up against the Funnoodle surface, but this will not affect the antenna's operation (shallow sections of the Funnoodle surface can be easily removed with sandpaper, if necessary). After ensuring that the variable cap is perfectly aligned and operates smoothly, bend down the remaining variable cap upper terminal (next to the one soldered with Litz wire) over the plastic tie wrap to lock the variable cap in place. Finally, cut off the excess wrap length.



30) Refer to the photo at right for the following step. Install the variable cap control knob on the variable cap shaft and tighten the setscrew securely, ensuring that the knob rotates freely. Cut four 1 3/4" lengths of 5/8" I.D. rubber air hose, ensuring that the cut lines are neatly vertical. Take scissors and cut each of these 1 3/4" long sections in a straight

line lengthwise, trimming away any loose rubber pieces along the edges. Then use the Duro Super Glue packets to glue these four 1 3/4" long rubber air hose lengths to the PVC frame legs as shown, ensuring that no glue runs down the sides or bottom of the rubber hose sections. These short air hose sections will be used as rubber leg grips, providing superior protection for the FSL when the antenna is used on slippery or wet surfaces. This completes construction of the 7" FSL antenna.



Testing and Operation This antenna is designed to provide a high-gain inductive coupling boost to all portable radios having a loopstick, and unlike other similar-sized antennas, it will provide a very substantial signal boost even to full-sized portables like the ICF-S5W and RF-2200. As designed, it will provide this inductive coupling boost on all frequencies from 490-1710 kHz, with signal gain approximately equal to that of a full-sized 4' air-core box loop. Because of the lower noise pickup of the ferrite sleeve, however, it will typically outperform the 4' box loop in the signal-to-noise ratio of weak DX signals. All four 7" FSL test models here were compared with such a 4' box loop, and found superior in weak-signal daytime DX reception (MP3's are available on request).

- 1) In a location free from RF noise, place the FSL antenna in a secure position on a flat surface, away from metal tables and other electrical conductors.
- 2) Position your portable radio about 4" in front of the FSL coil for the initial test.
- 3) Tune in a weak signal (the weaker the better) at the low end of the AM band on your portable radio. It is important that the signal is just above the noise level, to demonstrate the effectiveness of the antenna.
- 4) SLOWLY tune the FSL antenna's variable cap until the antenna's resonant frequency matches that of the portable radio. Looking at the variable cap plates can give you a rough idea of the FSL's tuned frequency, with its plates about half open on a center-band (100 kHz) frequency. The FSL's tuning sharpness is much greater than that of a typical air-core loop, and best results are obtained only when the FSL's variable cap is carefully zeroed in on the correct frequency. When zeroed in on the weak station's frequency, the FSL should give a VERY great inductive coupling boost.
- 5) After the correct frequency is matched, slowly vary the portable radio's distance from the FSL coil to determine the distance for the best inductive coupling boost. This is also a fairly sharp adjustment, which will provide excellent results when optimized.
- 6) FSL performance can be increased by placing the antenna on a non-conducting stand up off of a table, such as on a PVC-frame base for DXpedition or shack usage. Information on such PVC bases and a protective "rain hood" PVC assembly may be obtained from the author.

Conclusion This 7" FSL antenna project will introduce you to an astonishing antenna, hopefully providing you with a major boost to your hobby excitement and satisfaction. Good luck in your construction, and in reaping in the DX upon completion!

73 and Best Wishes,
Gary DeBock