THE ILA
[Ionic Liquid Antenna]
A VIABLE ANTENNA FOR AMATEUR RADIO

By: John P. Callaghan KB1JGK

ELECTROMAGNETIC WAVES SURROUND US

Some start at the sun, others start deep in space, some originate from various combinations of minerals in the earth and from those intentionally manufactured for communications or medical reasons. Of course, there have been reports in the past of unintentional electromagnetic signals being randomly transmitted through poorly designed devices that use some or all of today's technology.

Yes, we are totally surrounded by these electro-magnetic waves and in most cases this magnetic flux cannot be detected until it arrives at the visible light spectrum. The aurora borealis, which sometimes is seen following a major surface incident on the sun, is a prime example of visible electro-magnetic waves. Until now, detection of specific radio waves amongst all of the noise has been the work of tuning circuits within the receiver itself. Our discussion today will encompass the reduction of background noise so that purposely-transmitted radio emissions are more easily decipherable by a modern receiver. The medium by which this is accomplished could be considered a radical based departure from what is currently considered the norm.

CONVENTIONAL ANTENNAS—THINKING OUT OF THE BOX

To date, most antennas have been manufactured using metal products and are somewhat related to the desired wavelength. Well, if we follow the laws of physics we would see that the optimum reception and transmission would be with a wire cut to a specific frequency and that it's thickness would be related to the bandwidth. Many years ago we started to make concessions to these laws by actually using emitters (transmitting antenna) and receivers (antennas used for reception) at one-tenth, one-quarter, one-half, five-eighths, and three-quarters and of course the full wavelength. Boy, did we find out some things! All of these antennas had some drawbacks when compared to a full-wave model. To make these shorter antennas work properly, an L-C circuit (antenna tuner) had to be designed to match the antenna or the antenna-plus-feedline to the transmitter or receiver.

RESTRICTIONS ABOUND

As the population increased in a given area, the room to place an antenna started to disappear. Regulations were passed to limit antennas and related structures citing community concerns from aesthetics to safety. The community also took on a new look. No longer was the criteria just the state, county or municipal rules. The new "community" started to consist of "neighborhood

associations," "condominium associations," and other such organizations, all with an eye to their own agenda. Yes, these folks wanted "sameness" in an area. Individuality of minority users suddenly disappeared. Stealth antenna's came into being. Some were placed in attics; others were under the siding in a home; some were hidden in window frames and a myriad of other ways.

The most important of these (to our discussion today) was the PVC pipe "flagpole" to which a flag was attached. A "normal" antenna was hidden within the flagpole. Orientation, instead of being vertical (90 degrees perpendicular to the earth's surface at that point) or horizontal (parallel to the earth's surface) was now at a 45-degree angle. The assembly had some drawbacks of it's own. It was a bit harder to tune due to the PVC covering, and sometimes, after a heavy storm, water would get into the pipe and it would have to be drained, or did it? Signals still came through once it was tuned, but it appeared some of the background noise started to drop.

ENTER STAGE RIGHT—THE IONIC LIQUID ANTENNA

David Hatch N9ZRT, a Lutheran Minister, Amateur Radio operator and antenna experiment enthusiast started work on what would be called the Ionic Liquid Antenna. Recently, David Hatch N9ZRT was asked*: "What was the mechanism of your leading to experimentation to development of the ILA?"*

His reply was very interesting: *"That would have been the sheer intrigue of reading the creative counterpoise and antenna possibilities laid out by SGC in their various publications. They wrote and showed ideas that turned me into a mad scientist. Anything and everything became an antenna. And, in learning of the sea as a counterpoise, by dropping a bare wire into it, the idea became reversed in my head. Turn seawater [saltwater] into an antenna. There you have it, and the credit goes to Pierre Goral of SGC!"*

Simultaneously and unknown to each other, various experimenters throughout the United States and elsewhere were also working on the same idea. This bit of information is taken in part from the ILA website.

OTHER HAMS HAVE TRIED THIS BEFORE

An unknown station: During the early spring of 2001, N9ZRT received a phone call from a ham that reported that he had experimented with a saltwater antenna several years back, doing demonstrations to a ham club on 2 meters as well as at the Argonne National Laboratory. We seek out his call, as it was lost in a paper shuffle. From the best of our recollections, he said he had not written an article on his experiment. If you are aware of whom this is, please contact N9ZRT.

VE3UGW: On July 7th, 2001 VE3UGW telephoned N9ZRT explaining that he had done experiments with a liquid antenna as well. VE3UGW built a saltwater antenna by filling a piece of hose with a saturated salt solution back in 1995. An

article about VE3UGW's work appeared in the September 1995 RAC News Bulletin, apparently a reprint from "The Racoon Times" from Iroquois Ontario, Canada.

He writes of his experience: "My tinkering with saltwater was a result of imagination run wild. It started with watching a column of water form on my car's windshield. As I sped up the column elongated, as I slowed down it shortened. At the same time my son was doing a school project on conductivity using regular water and salt water.

It occurred to me that if salt water would conduct an electric current why not RF?

My prototype was a 2m ¼-wave ground plane with coat hanger ground radials and a 20 inch length of plastic tubing for the radiator. I made a super-saturated solution of salt water and poured the solution into the tubing. At the bottom of the tubing I had an ordinary brass faucet fitting that one would use for an outdoor garden hose. I soldered the center lead of the feedline to the faucet fitting and the shield to the coat hanger radials. By opening the faucet, I could adjust the amount of salt water in the tubing to attain a SWR match and next thing you know I was keying up the local repeaters.

My next step was to try it out on HF. Much to my wife's chagrin, I cut up one section of garden hose and suspended it between two tall pine trees on our property. Using the same faucet and a few lengths of ground wire for ground radials, I tuned up on 20m and made several contacts, the furthest being about 700 kilometers. I did find that 30 watts seemed to be the threshold. If I kept the power below thirty watts the SWR remained stable. Once I exceeded thirty watts the SWR increased proportionately with the power applied. I don't know if the solution began to boil or if there were other factors involved, but it didn't like high power.

That was the extent of my experiment. I know it works and the contact I made at a regatta in Sault Ste. Marie was baffled by the description of my antenna but that's what ham radio is all about."

Since the initial introduction of this new approach to signal transmission and reception several improvements to the basic idea have taken place. The first recorded communications between U.S. amateurs took place as reported in the *QST* issue of March 22, 2001.

First QSO reported between ionic fluid antennas: The Live-Wire Group has recorded the first liquid antenna-to-liquid antenna contact on Saint Patrick's Day, March 17--and that's no blarney! The Live-Wire Group currently is experimenting with the liquid antenna concept. Participating in the 17-meter SSB contact were WH2AAT in Orange Park, Florida, and N9ZRT in Green Bay, Wisconsin. Both stations were using 10-foot tall by two-inch wide "columns of ionic fluid" (in this

case, concentrated saltwater). Also participating in the QSO was W8ZU in Glen Rock, Pennsylvania, who was using a conventional antenna. Members of the Live-Wire Group have been experimenting with the Ionic Fluid Antennas (IFA) for more than six months, and they report excellent results on the antenna's performance. In most cases the liquid antennas are operated in the vertical position. The RF is fed into the base of the antenna through several three-inch long copper probes that are exposed to the conductive liquid. Live-Wire members continue to experiment with this antenna concept in various forms including liquid dipoles and "pumpable-to-resonant-length" verticals.

KB1JGK's BACKGROUND INTEREST IN LIQUID CONDUCTORS

My initial thrust on using saltwater as a conductor came about in the late 1960's while studying the electro-chemical system in the human body. After all, cannot we be compared loosely with plastic bag (skin) filled with an electrolyte (blood) that keeps the different systems working efficiently and allows the orderly transfer of electric energy (no matter how infinitesimal) throughout the human body? Are we not transmitters and receptors?

PERFECTING THE ILA'S PROBE

From N9ZRT's first "spider-leg" type probe to the designs by others, probe development has gone through many evolutionary stages. The first probes that I utilized seemed to have one problem in common, they all leaked. The early examples, illustrated below, show some of the reasons this took place. But, at the same time, never let it be forgotten that most of these experimenters did it part time, as a Ham activity and their work professions very seldom gave them the time, training or energy to finalize a design that was waterproof. Even as these designs evolved problems continued to occur.

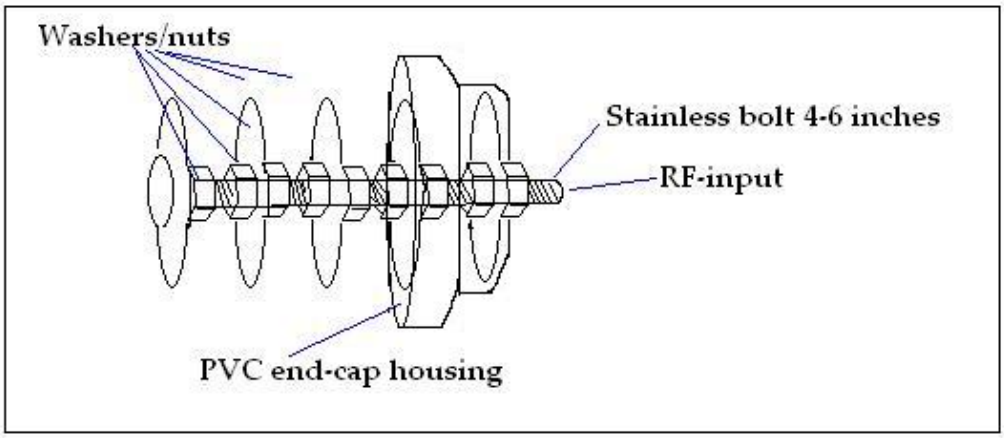


Fig. 1: IFA "Spaced-Washer Probe" Concept

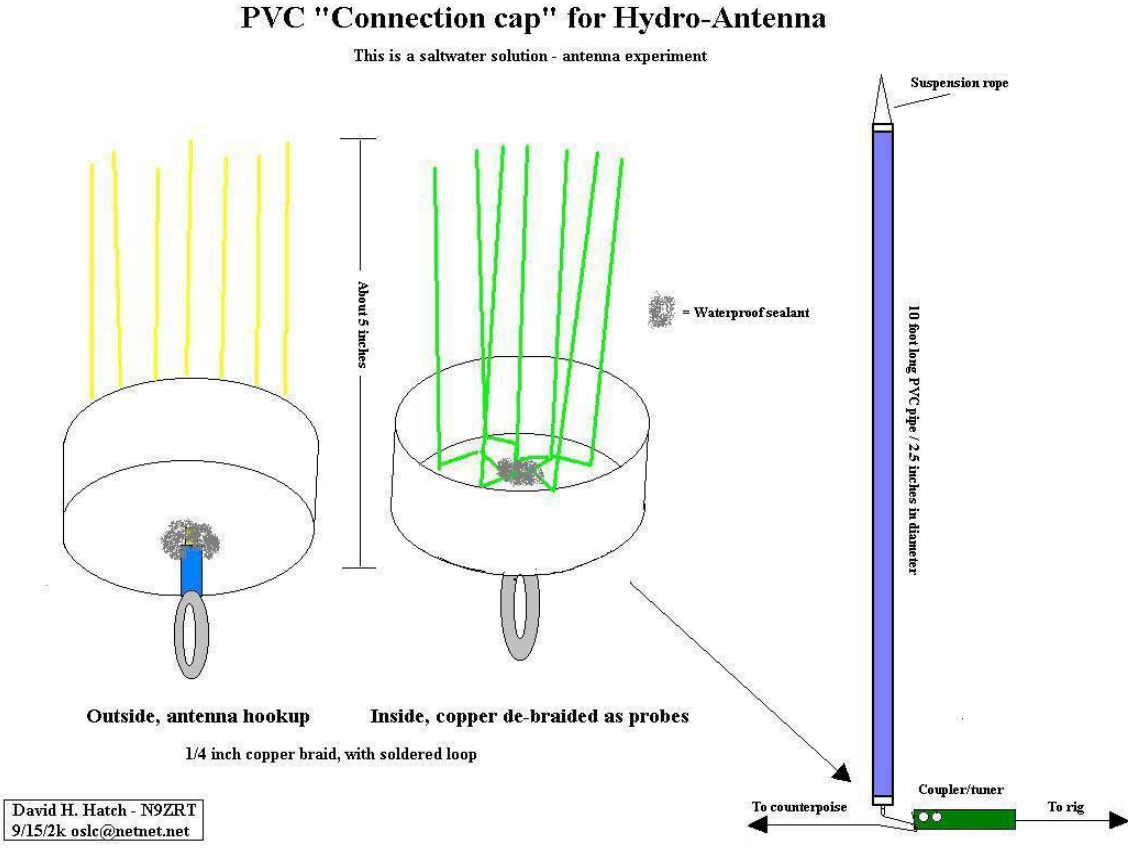


Fig. 2: Spider Connection Cap for ILA – David Hatch, N9ZRT, designer

The illustrated changes by John P Callaghan, KB1JGK (see **Fig. 3**) demonstrate a new look and an easier method of connection to the transmission line. It is an extension of the work first started by David Hatch, N9ZRT, and the major changes it incorporates is a more orderly electrode to protect it from the Salt (NaCl) embedded in the water medium (H2O). A coating of LRB and ATV is applied to the electrode for this protection. (LRB maintains permanent flexibility of 600% to 1,150% elongation. Measured with adjustable durometer readings from Shore A 35-65).

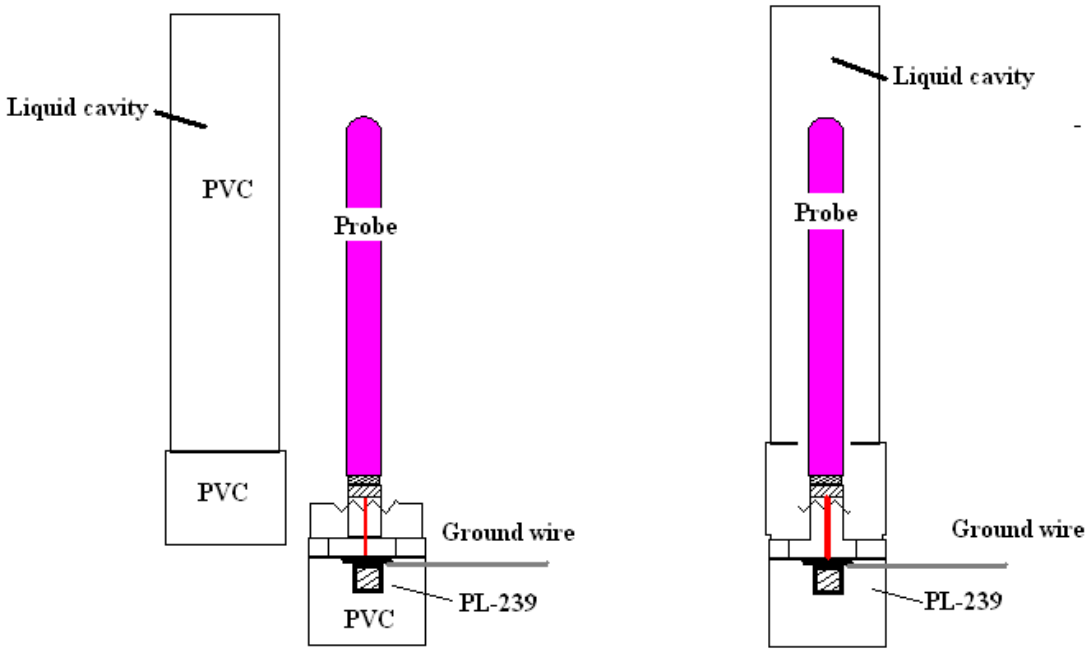


Fig. 3: ILA probe as designed by John P Callaghan, KB1JGK 9/2003

The first recorded contact using this probe imbedded into an ILA was on 18,076 kHz from 1454-1457Z on 10/22/2003 with the MFJ-9017 CW transceiver at 3 watts emitted power. The signals received at OK1DX in the Czech Republic with a report of 559.

WHY PVC?

Price, in my mind, is the overriding factor. The use of PVC piping actually enhances the belief that more is better and adds a new factor: a properly structured antenna need not be the normal calculated length. Lets look at each of these factors independently and discuss the learned effects:

Initial testing has shown that wider is better. That is, a 3” diameter ILA PVC is a much better listener than both the 2” model as well as smaller units. As a matter of fact, the greater the volume of electrolyte, the better the unit seems to work.

So far, to the best of my knowledge, tests have only been run on up to 4" diameter PVC.

The length of the column need not be cut to a specific frequency using standard equations. Mike Martel N1HXF has stated in an article (in part): *"The primary problem is that PVC tubing has a significant velocity factor which causes RF to slow down. This means that an antenna encased in PVC will normally need to have its physical length reduced by about 19%."* Mr. Martel was discussing the effects of velocity at 2 Meters. Testing done at various frequencies indicate that the velocity factor changes with frequency shift. Calculations should be performed for each instance. Here is where a good antenna analyzer comes into play.

THE THEORY BEHIND IT ALL

So how does it all work? The saltwater mixture is at saturation 1176-1179 SG and yields a salinity of approximately 21% at 70 degrees F. It is at this point that you must assume that the mixture now contains an equal amount of salinity throughout its entire structure. The molecules of salt, now almost invisible to the naked eye are there waiting for an electromagnetic wave to strike them either directly or indirectly. Also at this point realization must take place that this antenna placed in a vertical plane and suspended from the earth by a full one-quarter wavelength is now emitting isotropic radiation (well, as close as one can get to this theoretical point). It also has the ability to receive from a full 360-degree circumference on all planes. That is, not only are the signals being received from the horizontal plane but also from the top and bottom as well. The optimum HF frequencies for this antenna initially appear to be 10, 15 and 17 Meters although contacts have been made on 20 and 40 Meters as well. For continued discussion purposes, we shall assume that the frequency chosen is for 18,155 kHz. The initial length chosen will be 12.93 feet (one-quarter wave) X 78% (velocity factor), and the resultant optimum length comes out to be 10 feet 2 inches plus hardware. Schedule 40 PVC (White) has been chosen for the project based on its chemical structure and inherent strength. As well as results that can be obtained using a good quality Antenna Tuner, the ILA can be brought into a closer SWR by increasing or decreasing the height of the electrolyte (saltwater) in the vessel.

Let's take a look at the mechanics of how the signal actually moves either within or without of the medium. The RF is introduced into the saltwater mixture through the exciter (or "probe;" see the figures above). Initially the RF strikes the molecules closest to it and a pool ball effect takes causing the signal to constantly bounce off all the molecules in the vessel until it passes through the PVC into the atmosphere to be detected by the distant receiving apparatus. An illustration of the Pool Ball Effect is located below in **Fig. 4**. (Credit David Hatch, 12-20-02).

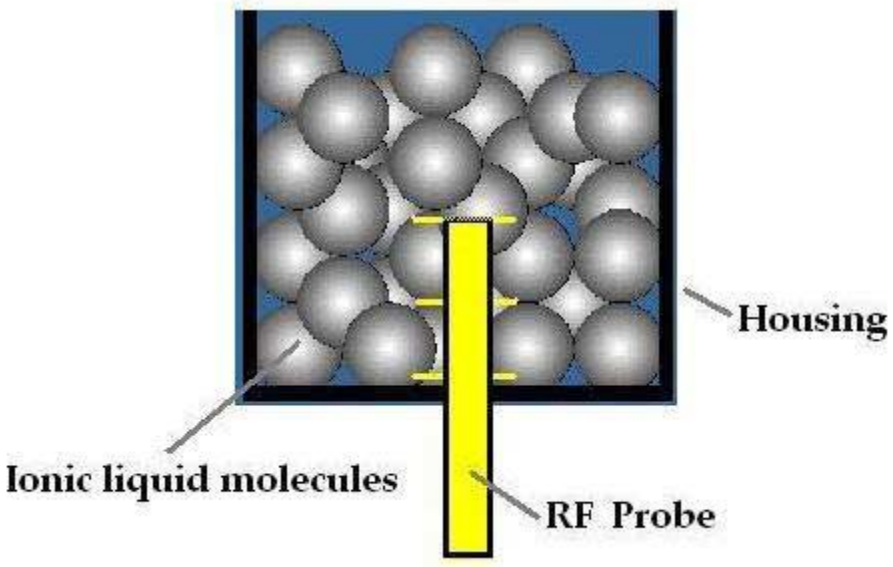
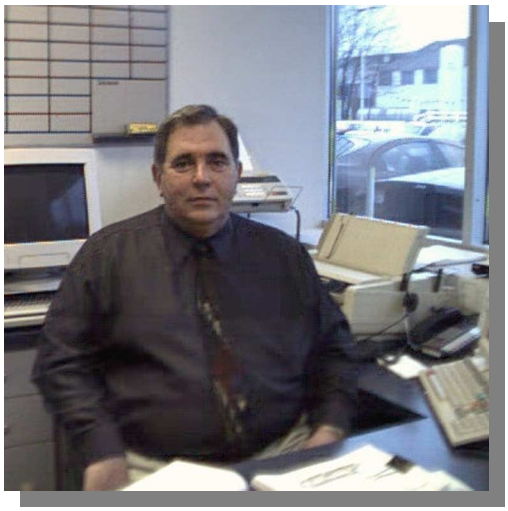


Fig. 5: Pool Ball Effect 1-20-02

CONCLUSION

To put this explanation in more scientific terms, this ILA can be described as follows: *"Multi-step electro-magnetic energy transfer process utilizing a NaCl-H2O mixture with a suggested specific gravity not less than 1172. Unit transfer efficiency gained from suspended Ionic Liquid molecules interacting to move the signal in an isotropic pattern with respect to the ILA. On receive the transfer of the electro-magnetic energy is buffered and directed towards the probe which in this case becomes the signal capture point for further movement to the detector circuits."*

I believe the ILA also holds promise for use in the lower power spectrum of Amateur Radio where conventional antennas just aren't feasible. Additional work is being completed at this time with a saltwater filtering system for use with a conventional antenna to help lower noise levels before going to the receiver. Most transmitting tests have been run at 35 watts or less. **–30-**



BRIEF BIOGRAPHY OF AUTHOR

John P Callaghan, KB1JGK

Back in the early 1950's while attending a technical high school in Bloomfield, NJ USA, I got the HAM radio operator bug and concurrently soloed my first airplane. The more electronic theory I learned in the classroom, the more hooked I became.

Completed school, then off to the USCG, Radioman School in Groton, Connecticut, University Courses, advanced Pilot Training, obtained my first HAM ticket and more.

Soon the children started to come along and HAM radio was put aside as I took graduate courses ending in degrees and working as hard as I could. I traveled extensively during my career and am proud to say I was a team member on many cutting edge technologies including visual digital communications, satellite based digital automatic location systems, Ion generators for health care uses (never approved by the FDA) multiplexing over coaxial lines and standardization of ground potential in the health care delivery system.

Finally retirement came and I was able to take up HAM radio again, step back into a laboratory environment (mine) and start developing. Each morning when I arise I find challenging things await me.

My passion comes with making antennas smaller so that everyone has the opportunity of getting on the air regardless of restrictions where they live.

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