Power Line Noise Hunting

THE PROBLEM:
Here in Schaumburg, Illinois, I'm lucky to live in a community section which has buried utility lines and so my amateur radio high frequency radio "experience" is pretty good. Low noise levels are the normal condition at my QTH. Over the past few years, I've increased my mobile HF operating time and have spent many lunch breaks outside the office area leisurely listening to radio amateurs and/or various short-wave broadcast stations from the car. I've noticed that there is a much higher noise level in the area around my office compared to my home location and have often had to drive away from the office in order to clearly pick up the desired stations over the hash and hum from the above ground lines in this area.

THE ANSWER:
Back in late 1999 or early 2000, I found an article in Worldradio Magazine in which an author described a setup for tracking down the sources of power line noise. His system used a Radio Shack Air Band AM receiver (part number 12-615) with a home made dipole antenna system and allowed him to easily track down and identify the noise sources in his neighborhood. In his article, the author described how to remove the internal ferrite bar antenna and how to hook up a phono-type connector to allow an external antenna to be used on the receiver. The author continued with tips for using the completed system and told of how he had used it to identify several sources of noise in his neighborhood.

THE IMPLEMENTATION:
Following this lead, I picked up one of the Radio Shack air-band receivers and preferring BNC connectors over the phono type, installed a female BNC connector on the top of the radio housing where the previous telescoping whip was mounted. Routing a length of RG-174 miniature cable inside the receiver from the BNC jack to where the telescoping antenna hooked up was quite easy. Removing the ferrite bar antenna allowed for space to mount the BNC jack. Some careful work with an exacto knife enlarged the existing antenna hole to allow the new antenna jack to be mounted. Now the receiver was done and ready to go and I was ready to build the external antenna. *(As an alternative, the connector may be omitted and the RG-58A/U cable directly routed inside the case to the connection point on the receiver's printed circuit board. This would yield a much neater, but slightly less flexible solution.)* For the noise-locator's antenna, the World Radio article mentioned using a wire mounted on

wood support system which seemed difficult to build at that time, so I stopped at this point and thought further about how to make a good dipole for the VHF band. The goal for this antenna system was to be lightweight, stiff, not easily breakable, and cheap!

Finding myself busy with other things, I set aside this project for several months. Meanwhile, I continued my HF mobile lunchtime activities and just drove out of the high noise level area around the office.

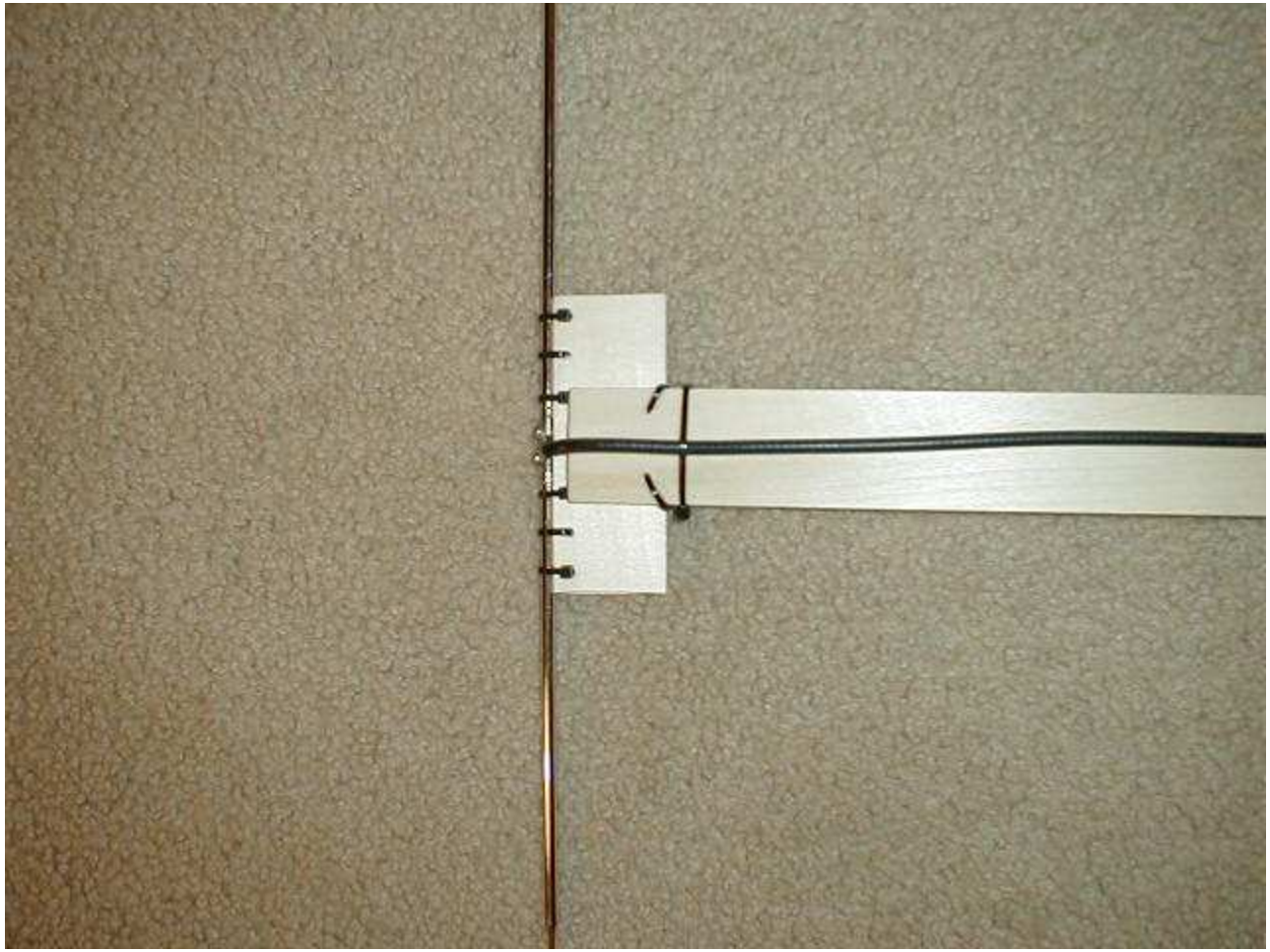
MAKING CHOICES:
Being in the local Radio Shack during lunch helps to remind me of those unfinished projects around the shack and during one such visit, I happened to see their replacement rod antennas for cordless phones. Examining each product type for length and estimated durability revealed a choice which should meet the goals listed above. I selected two of the 28", 5 section antennas (part number 270-1405) which are non-swivel telescoping antennas. This would be just about right when the last element section is left non-extended. This was a good start on the antenna project, but I still needed something lightweight and strong to hold them in the proper dipole orientation and also to provide a handle for the antenna system too.

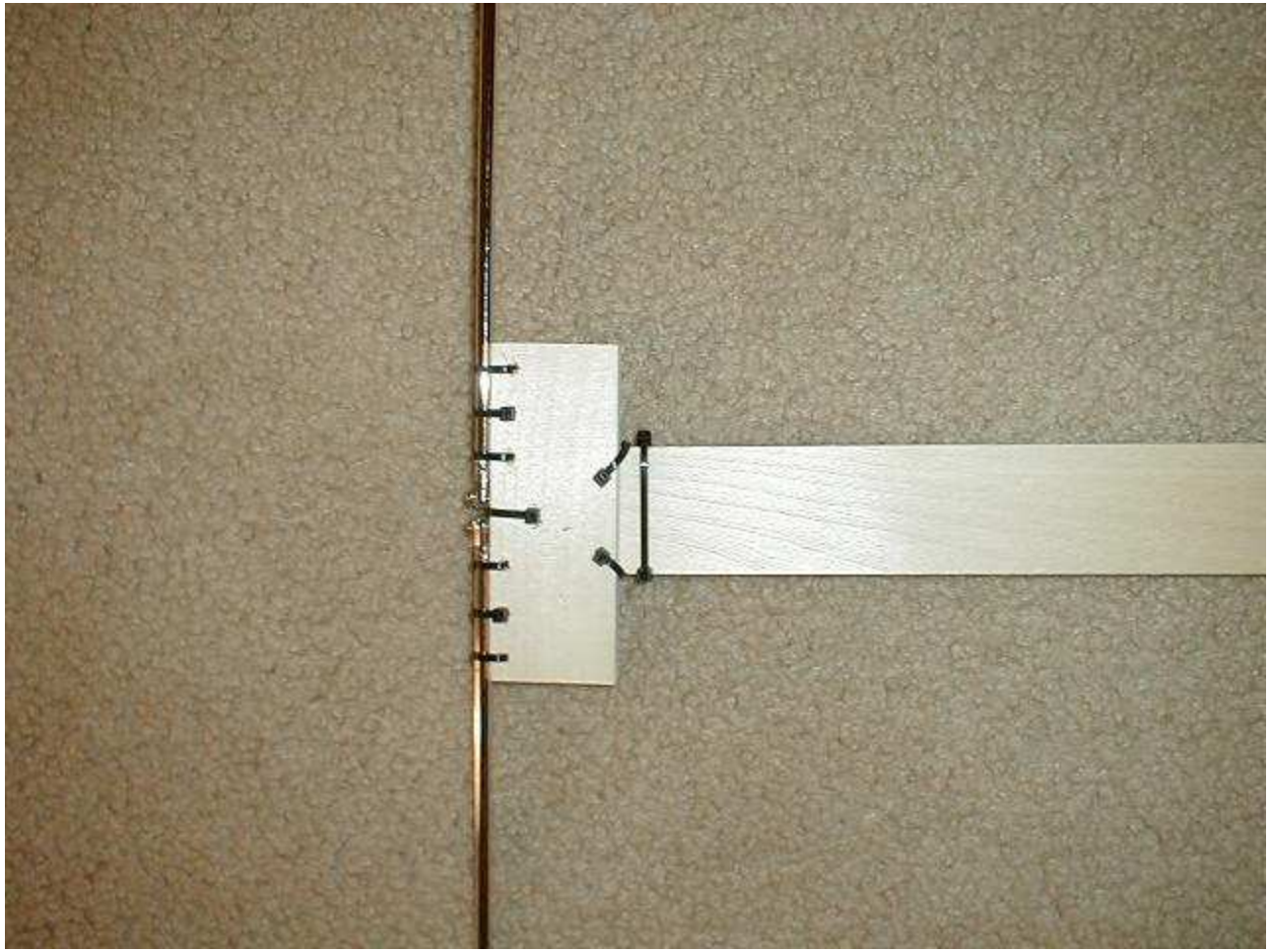
BUILDING IT:
While visiting a local home/wood supplies store, I found some wood which looked like it would fit the need. I selected a 36" length of clear (no knots) Aspen wood which was 1.5" wide and 1/4" thick. Cutting off a 4" length of it, I fabricated the upper piece as shown in the photos below. Seeking to minimize the use of metal fasteners (so as to minimize the antenna's pattern degradation), I elected to use black UV resistant tie-wraps to hold the elements to the wood upper part and also to hold the antenna assembly to the handle wood part. This should be relatively clear from the photos of the completed assembly. I used a scrap BNC to BNC cable made out of RG-58A/U coax and just cut one end off of the cable to yield the length needed. Selecting a length of about 4 - 5 feet should allow the receiver to be separated from the wooden handle/antenna system if needed. When hooked together with the velcro and with the extra cable wrapped around the handle, the system is easily used with one hand.

One area which deserves further explanation is the attachment of the RG-58A/U coax leads to the elements. I did this by first attaching the elements to the upper assembly (tie-wraps) with the elements about 1/4" apart from each other. Selecting a pair of coarse thread (metal) screws from my hardware junk box (guessing at #8 size approx. 1/2" long), I sized up the depth of the hole needed in the wood underneath the elements. Next, I drilled small starter holes in the wood underneath the element's end mounting holes. Preparing the coax leads by separating the center conductor from the shield lead, I formed the leads into loops around the chosen screws and then solder tinned the leads to hold their shape. The chosen screws bite into the inside of the mounting hole for the antenna elements and pass through into the wood for further strength. Placing the coax leads over the antenna mounting ends and installing the screws down and through until seated into the wood completes the assembly of the upper antenna system. (The stack-up is: screw heads, cable leads, element ends, airgap, wood.) I used three tie-wraps to hold each element onto the upper wood section with the elements being placed along the upper edge of the 4" length of wood.

Drilling holes and mounting the upper antenna assembly onto the handle took about 5 more minutes. Three tie wraps were used to hold the 4" length of wood to the main support handle. One was used on each lower edge and one was mounted along the top edge (and passes between the ends of the elements). Next, I secured the cable down the antenna handle (more tie-wraps--hooking them together in pairs to allow reaching around the handle) and wrapped the extra cable around the handle leaving a small length for hooking up to the receiver (securing the wrapped cable with another pair of tie-wraps). Mounting the velcro on the end of the wooden handle and on the back of the receiver allowed the first view of how this would look when completed. (When mounting the velcro on the radio, be sure not to cover the battery cover--you will eventually need to replace the batteries and would not want to have to remove the velcro from the receiver back lower edge to be able to remove the battery door.)

THE OUTCOME:
Here are the photos of my completed system:





PARTS LIST:
The following parts and materials were used in this project:

- Radio Shack AM/FM/VHF-Airband Receiver, RS 12-615 1 each
- Radio Shack Replacement Antenna Rods, RS 270-1405 2 each
- Aspen wood, 36" long, 1/4" thick, 1.5" wide 1 each
- RG-58A/U 48" Cable with one attached BNC connector 1 each
- Black Plastic Tie-Wraps, 4" long, UV resistant 17 each
- Velcro with adhesive back, 1.5" long set -- loops & hooks 2 each
- BNC Jack (similar to RS 278-105 should be OK) 1 each
- Small coaxial cable, 8" (similar to RG-174A/U) 1 each
- Small metal (coarse thread) screws, approx. 1/2" long 2 each

Total estimated cost (buying all components new) is approximately: $45. I used items from my junk box and spent $34 total for the receiver, antenna elements, and the wood.

LUNCHTIME FUN:
Now the system was complete. Turning on the system and scanning around my basement revealed no obvious noise sources. I was eager to try it out in the area of my office. Days passed with no time for this event. Finally, the weather was looking better (over 20 degrees F), the sky clear, and enough time to go out and give it a try. (SAFETY FIRST: When using this system, do not allow the antenna elements or any part of the receiver/antenna system to contact any parts of the power system! Keep a safe distance away from all wires and poles at all times. :o)

I'd identified that the noise levels were higher slightly south of my office (near the intersection of Golf and Roselle Roads) and proceeded to a large parking lot on the northeast corner of the intersection. Safely parking the car and stepping outside, I extended the elements on the antenna (except for the last section which remained retracted), powered up the receiver, and tuned for a clear spot at the lower edge of the AM aircraft band. A buzzing sound came out of the speaker. There was power line noise here!

Stepping a few feet away from the vehicle, I slowly rotated the antenna while holding it up above my head. (This placed the antenna into horizontal polarization.) Looking around, I noticed that the intersection had power lines running down both sides of the streets in all directions. Turning the antenna broadside to the southern street, I found a slight variation in the audio signal levels from the receiver. Catching on that the easiest way to use this was going to be by "tracking nulls", I rotated around again until I found a null in the audio noise level. Walking about 40 feet in the direction of the null, I rotated again and found that I was on a line pointed to/from my noise source! Looking along the line, I saw a power pole about 40 feet in the direction I was headed with a store in the opposite direction. (I was pointing at the fourth pole north along the NE corner of the intersection) This might be it! Continuing closer to the pole, I found that pointing the ends of the dipole at it would yield a noise null and turning the antenna broadside to it would yield a noise peak. Circling the pole along 180 degrees confirmed that this pole was the noise source I'd been searching for. (I would have had to go into a busy street to complete my circle around the pole. SAFETY FIRST!)

But what on the pole was causing the problem? The wires along the top and middle? The transformers mounted part way up? How to tell? If the dipole was directional in the horizontal plane, how about using it in the vertical plane too? Standing about 20 feet from the pole, I slowly pointed one end of the antenna at the pole and swept up and down the length of the pole. I found that the null formed by the antenna pointed to the small rack of transformers mounted part way up the pole. Pointed up at the upper and middle wires resulted in a higher noise level than when the end was pointed at the rack with the transformers mounted on it. The transformers were generating the noise!

Wanting to be sure that this was the right pole, I returned to my vehicle and crossed to the other side of the road opposite to the suspect power pole. Repeating the measurements confirmed that the pole in question was indeed the source of the noise in this area.

Here's a shot of the power pole with the transformers visible:

Looking around the area, I saw many power poles with transformers mounted on them. Perhaps there was another one which was contributing to the noise too? Walking north up the parking lot, I discovered that there seemed to be another source in that direction. Returning to my car, I drove to the next parking lot north and got out again to hunt for noise signals. Sure enough, there was another pole with very similar looking transformers (smaller ones--not the bigger ones commonly used in this area). Repeating the same tests (walk around finding the nulls, and then sweeping up and down the pole with the antenna) confirmed that this pole too was contributing to the high HF noise levels in this area. It's interesting that the transformers looked to be identical to the ones mounted on the other pole, and very different from the other ones used in the area.

Here's a shot of the second pole discovered during this search:

WHAT'S NEXT:
When I get some more time, I'll continue my survey of the areas around this intersection. (Visual searches have not revealed any more of the smaller transformers which were used on the two noise generating poles.) After I get the area surveyed, I'll notify the ComED electrical provider in this area and see if they're interested in responding to this issue.

16-FEB-2001 UPDATE:
I just received the following note (slightly edited as presented below) from Bob WB9PFM with great insight into this local noise issue:

> Gary,
>
> I am not a rated expert in power distribution but I wonder if those "transformers" are really something else. I know that they use pole-top capacitors for power factor correction. There also are switches and controllers integrated in the pole package that switch capacitors as the power factor changes. I went to the

> INTERNET and got this view of a GE capacitor which confirms what I suspected.
>
> http://www.geindustrial.com/industrialsystems/powerquality/catalog/cappole/
>
> I had some connection to utilities in an earlier life where we sold (products) to control capacitors and voltage regulators.
>
> I have a friend who works in engineering at ComEd and if you like I will call him and discuss. Perhaps he has a better "in" than you calling from the outside.
>
> Bob Pautsch - WB9PFM

Looking over the referenced page, I have to agree that this seems to be some form of capacitor bank (and not just smaller transformers :o). It is possible that the function which switches the capacitors in and out may be causing the noise. Perhaps a noisy switch? Either way, after a little more searching on my part, I'll be interested in pursuing this further with the power company.

8-MARCH-2001 UPDATE

I sent the following note to the power company via their web-page feedback link:

> *Submitted via web input on 3-7-01*
> Dear ComEd Engineering Staff Member,
> I've identified a pair of power factor correction systems in Schaumburg which are causing excessive radio frequency interference to local HF and VHF radio communications systems. These two PFC systems are located on the NE corner of Golf and Roselle Roads in Schaumburg and were realized as the sources of this radio interference by using VHF AM radio direction finding equipment with directional antennas. (These systems have been emitting excessive RF energy for some time now and recently have been interfering with FCC licensed communications as far away as the intersection of Roselle & Hwy 90 to the north.) More information on the location techniques used to identify these particular power poles as the interfering source is available at http://www.qsl.net/n8dmt /powerline.html. (Photos of the particular poles are also available at this site. These are the only identified pole mounted PFC systems in this immediate area. As a reference, other PFC systems found in Schaumburg do not emit interfering RF energy as these two systems do.)
>
> Your assistance in reducing the amount of radio frequency interference generated from this pole mounted equipment would be greatly appreciated. (A copy of this request will be forwarded to the Chicago office of the FCC as appropriate.) If you have questions regarding this request, please feel free to call me at 847-xxx-xxxx M-F 8 AM to 4 PM. Thank you.
>
> Gary Mastenbrook
> Schaumburg, IL
> (work email used here)

I also sent a quick note to the FCC and was surprised to receive the following reply:

> From: Callctr3 Callctr3 [mailto:Callctr3@fcc.gov]
> Sent: Thursday, March 08, 2001 12:55 PM
> To: Gary.Mastenbrook
> Subject: Re: RFI from Commonwealth Edison power distribution systems in Schaumburg, Illinois
>
> The FCC does not regulate the power companies, they are under the jurisdiction of the State Public Utility Commission. GCC30

>>> (my work email address) 03/07/01 11:00AM >>>
Dear Reader,
I'm wondering if you might be able to assist in the resolution of a radio frequency interference issue here in Schaumburg, Illinois. Two AC power line distribution power-factor-control pole mounted systems have been identified as sources of broadband RFI which interferes with licensed HF and VHF radio communications over a large area in my community. Power distribution here in Schaumburg is provided by Commonwealth Edison company of Illinois (http://www.ucm.com /homepage/homepage.htm).

I have two questions:

1. Since this interference has been occurring for a long period of time (noticed approximately 1 year ago with gradually increasing RFI levels), I'm wondering if there are standard practices and procedures which power distribution companies must follow in regards to system maintenance and/or measurement of intentional/unintentional interference from their systems?

2. Are there established levels for emitted RFI from power distribution systems and components? (i.e., Is there a legal way to "help" ComEd clean up their act?) What is the process (from the FCC's point of view) to "encourage" this provider to reduce or eliminate this source of RFI to FCC licensed communications services?

As background, I've provided further information on this issue (including specifics of the RDF techniques and field results) on my webpage at: http://www.qsl.net /n8dmt/powerline.html

In reference, I have attached a copy of the web-interface customer feedback/comment note (inserted as text below this email) which was submitted via ComEd's website on 2-7-01. (ComEd does not provide a direct email address for feedback.)

Thank you in advance for your assistance.

Regards,

Gary Mastenbrook

I find it to be pretty amazing that the FCC considers RFI to licensed radio services to be outside of their domain...

MID-MARCH UPDATE:
Great news: a troubleshooting representative of the power company called me and we talked about the problem. This gentleman was not a radio amateur, but seemed to be knowledgeable about the issues of radio interference caused by power systems. He's going to go take a look at the two identified poles and see if there's an obvious problem with them. Following up, a week or so later, I received a call back with information that there is an identified problem with the two poles, and that the parts will need to be ordered and then installed after they arrive.

11-APRIL-2001 UPDATE
I'm able to drive by the area while talking on 10 meters with a weak west coast station on 10-April-2001. I strongly suspect that the parts were installed and poles fixed, but since we had rain recently, wanted to wait for a drier day to retest. The next day (4/11/01), I received a call saying that the parts were put in, and the problem should be gone. "Would I please confirm that it's better?" Given my experience the previous day, I was able to relate that the problem seems to be corrected, although I would like to return to the area again with the test system to see how it looked with that equipment. In summary, at this point the problem seems to be corrected and I can use my HF mobile station near work again! Great news! **A**

BIG THANK YOU TO ComEd!!

Here's my step-by-step process for powerline noise resolution:

- Identify the (exact) source of the problem using appropriate test instrumentation. (Like the receiver/antenna system described above on the page.)
- Contact the appropriate company and inform them of the problem (using terms appropriate to their technology's language--no Q-signals, etc.)
- Offer to show them how you identified the equipment/system causing you interference.
- Hope that they recognize the issue's importance and take approprate action. (Worked in my case! :o)
- If successful in having your issue solved, be sure to write a follow-up thank-you note indicating that the issue has been resolved.
- Enjoy your new radio environment!

Along the way, I've heard about others who are having issues with HF powerline noise in their areas. The ARRL offers a helpful ear to such issues, so please consider sending them an email at: rfi@arrl.org. They may be able to provide assistance or advice appropriate to your specific case.

If you have questions or comments about this page or how you can duplicate this system for use in your neighborhood, please feel free to contact me via email. Thanks for reading this story!

73's

Gary N8DMT

N8DMT HOME