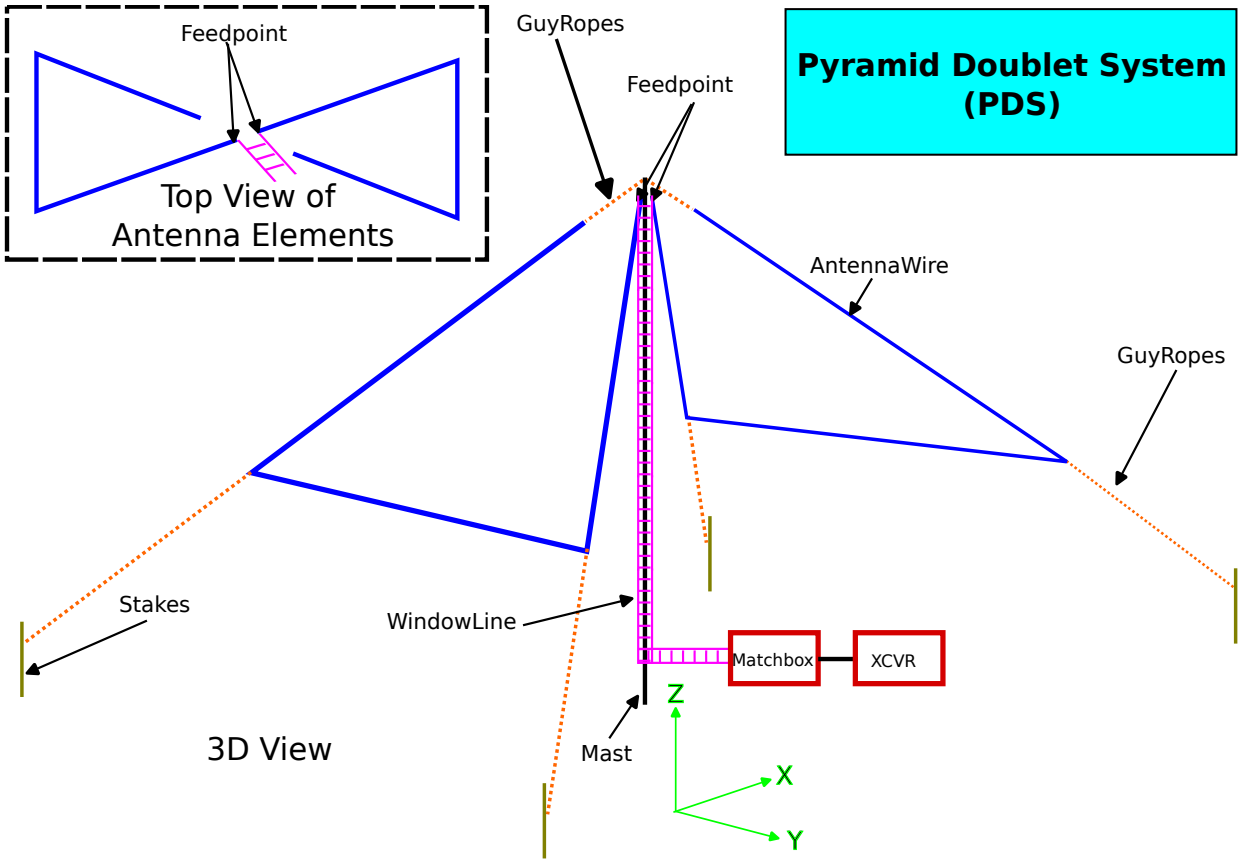
The Pyramid Doublet System



Why “Pyramid Doublet System”?

Pyramid: the antenna portion looks like a pyramid (kind of...)

Doublet: non-Resonant dipole with parallel feedline

System: this is not just about the antenna; it is the entire system that makes it work

Quotes To Consider

From the *ARRL Antenna Book 24th Edition*

> Is Resonance Required?
> An antenna need not be resonant in order to be an effective radiator. There is in fact nothing magic about having a resonant antenna, provided of course that you can devise some efficient means to feed the antenna. Many

> amateurs use non-resonant (even random-length) antennas fed with open-wire transmission lines and antenna tuners. They radiate signals just as well as those using coaxial cable and resonant antennas and as a bonus can usually be used on multiple frequency bands. It is important to consider an antenna and its feed line as a system in which all losses should be kept to a minimum.

Putting it more succinctly, from https://kv5r.com/ham-radio/2018-projects/80-meter-doublet/:

> "And NO, an antenna does NOT need to be resonant to be efficient. Unless you feed it with coax."

Evolution of the Pyramid Doublet System (PDS)

The PDS is a combination of antenna system designs. Nothing in this system is a pure "invention" of mine. As my knowledge of antenna systems and my awareness of various designs grew, I came up with this antenna system to meet a specific set of criteria.

Every antenna system is a compromise. There is no such thing as a "best" antenna system. There are many "best" antenna systems. Each one is "best" for a specific set of criteria. And, of course, every antenna system is limited by the laws that govern electronics, EMF, propagation, etc.

The following sections discuss the various designs that I considered and which became building blocks for the PDS. I include a brief description of each with references. Many others have already documented these systems, so there is no need for me to repeat what they have already documented.

At the end of this document, I have listed several references that I found helpful. These have all contributed to my journey in developing the PDS.

Remember, I'm not saying my PDS is the "best" antenna system. I think it is a really good system and encourage you to take a look at it and see if this concept is something that would work for you in your environment and in pursuit of your goals.

All-band Vs. Multi-band Antennas

I'd like to make a distinction between 2 terms that are frequently confused with each other. These terms are:
multi-band
all-band

Multi-band simply means "multiple bands"; an antenna that works on more than one band.

All-band means the antenna works on **all** bands (within a specified range).

For example, a ***10-40M multi-band antenna*** can work on 10,15,20 & 40M. This design takes advantage of the harmonic relationships of multiple bands. However, it does not work on non-harmonic bands such as 12, 17 & 30M (unless you add complicated and lossy gadgets like traps).

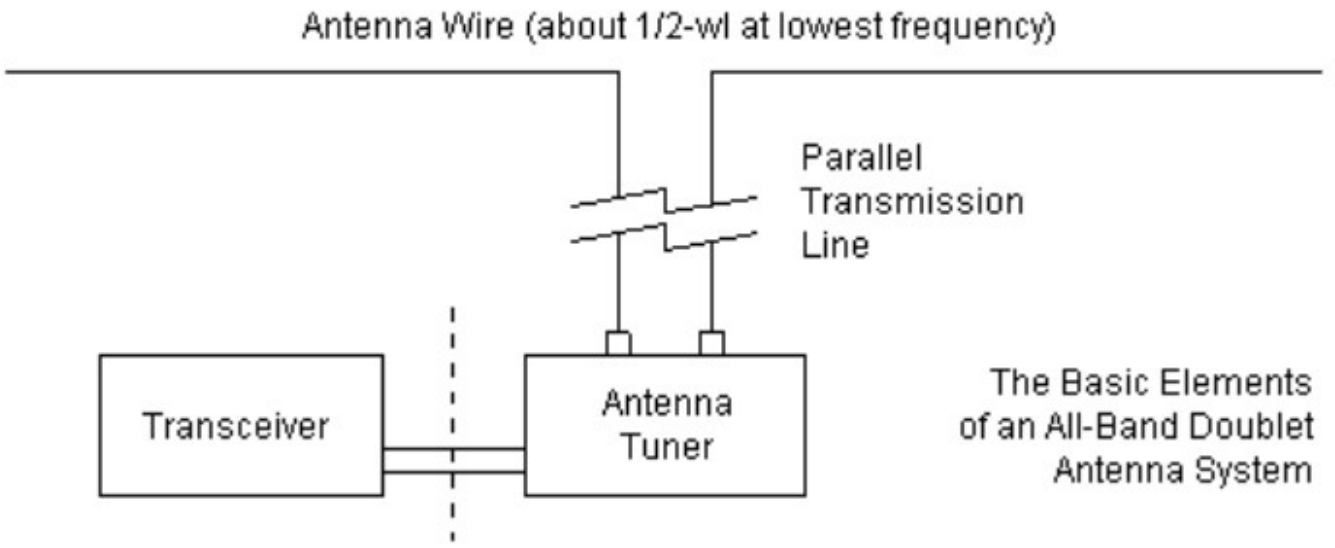
A ***10-40M all-band antenna*** works on **all** bands from 10 to 40M (10, 12, 15, 17, 20, 30 * 40M).

So, be cautious about this terminology. For example, someone might mention they have an "all-band" antenna that covers 10-80M. What they might actually be saying is that it works on 10/15/20/40/80M. This is a multi-band antenna and doesn't work well (if at all) on 12/17/30/60M.

The rest of this document describes all-band antennas that I considered in my journey. I wanted **all** the bands (within a specified range), not just some of the bands.

All Band Doublet System

From All-Band Doublet - L. B. Cebik - W4RNL



The Basic Elements of an All-Band Doublet Antenna System

Characteristics

Antenna: non-Resonant dipole. Exact length is not important.
Feedline: parallel feedline (PFL)
Matchbox(tuner): required

Advantages

> All band coverage in a single antenna system
(the lowest covered band is based on the length of the antenna)
> Not limited to only harmonic bands
> Far less power loss than coaxial feedline (CFL)

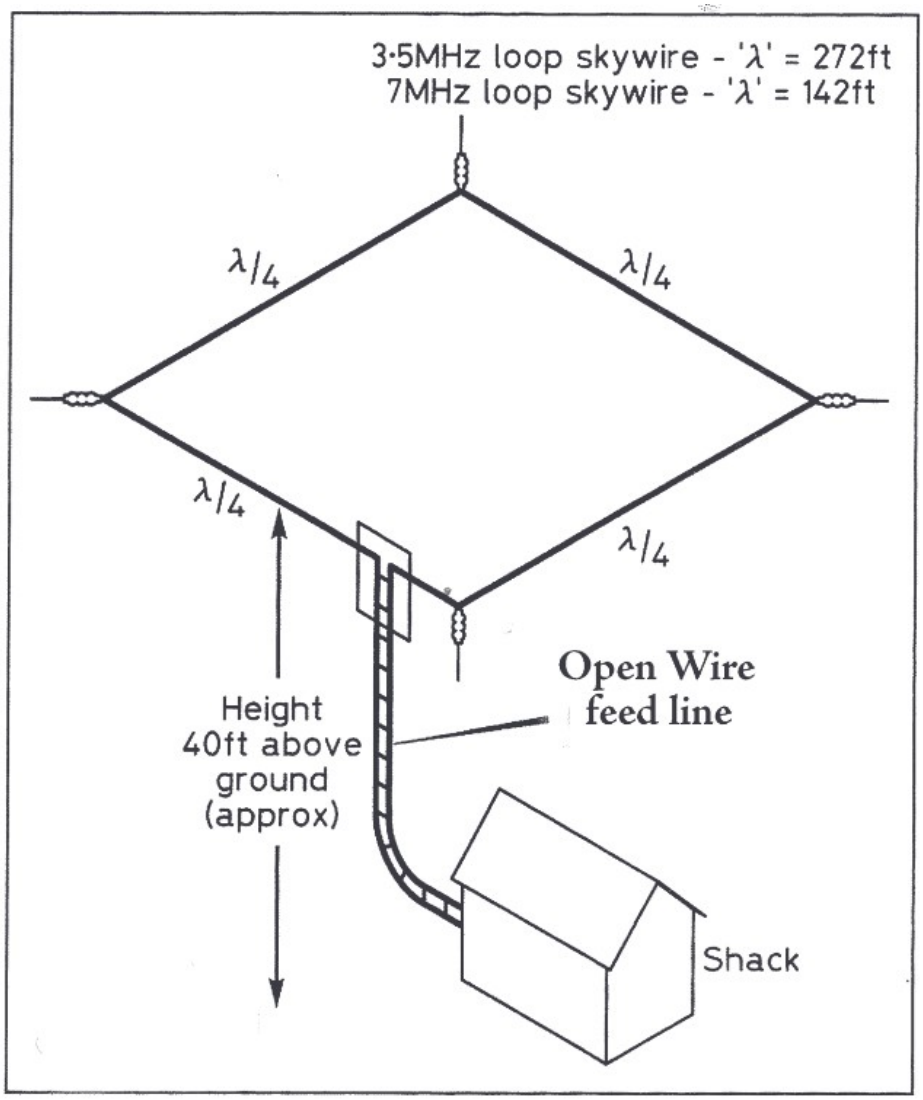
Disadvantages

> The higher the frequency, the more lobes and nulls producing gain in some directions and loss in other directions.
Note: this is the same disadvantage for multi-band antennas.
> Feedline routing is more particular for PFLs than for CFLs.

Notes

> The usual impacts of antenna height apply. e.g., For example, if the antenna is 40' AGL, your 80M and 40M coverages are going to be more NVIS than DX.

All Band Sky Loop



Having been convinced of the advantages of the all band doublet antenna system, I came across the sky loop.

This system incorporates many of the advantages of the doublet but the length is a full wavelength (on the lowest band you want to operate on). There are versions of this that use CFL instead of PFL, but I was committed to using PFL to reduce power loss as much as possible.

The illustration above does not show a matchbox but it is definitely required (assume the matchbox is inside the shack).

This system is what I use at my home QTH. You can see some pictures of this on my qrz.com page (look up KØCKR).

I have been very pleased with this system and have no plans to change it. For my home QTH environment and operating criteria this is my “best” antenna.

Decreasing the Footprint

My wife (KØLTH) and I decided to do some camping and combine our Ham radio activities with our camping trips. Obviously, my beloved sky loop system wasn't going to work for that situation. So, I wanted to see how I could best meet these criteria:

> reduce the footprint of the antenna system
> make the system as easy to put up and take down as possible
> use the same equipment I have at home out in the field (with the exception of the antenna, feedline and power supply)

Using the same equipment reduces my learning curve and keeps things simpler for me. Instead of buying a duplicate transceiver, matchbox, etc. for camping, I mounted my home QTH equipment in a "box". When I go camping, all I have to do is disconnect the feedlines and power supply and carry the box out to the camper (it only weighs 26 pounds). You can see pictures of this on my qrz.com page.
I call it my "shack-in-the-box".

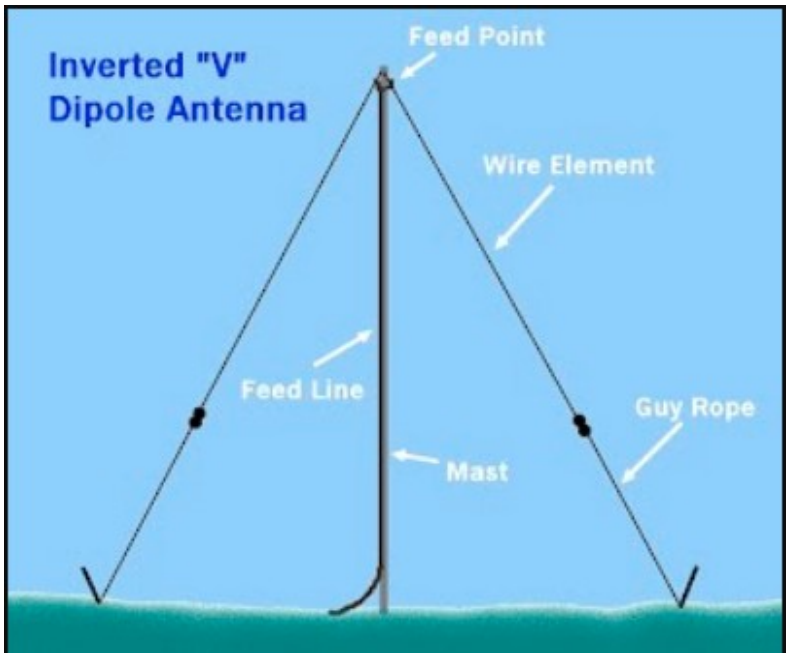
I reviewed multiple references on how to decrease the antenna system footprint. I ended up rejecting the option of using loading coils. Coils introduce too much power loss and inefficiency into the system. I wanted to retain, if possible, the full wire length for the lowest band I wanted to operate on. Nothing beats a full 1/2 wavelength antenna for all around efficiency. Of course using a full 1/2 wavelength wire is never going to get as compact as a system with coils. But, the higher efficiency compared to a "coiled" system was important enough to me to stick to this approach.

I found some ideas for decreasing the footprint in this article:
Making a Dipole Fit the Space Available
This discusses various techniques such as inverted V's, U-shaped and zig-zag antennas.

Yes, bending or zig-zagging a doublet is going to have some impact on radiation pattern and efficiency. However, I concluded that it is the best option for the most efficient, reduced footprint antenna.

Additional research led me to consider a "bow tie" (aka butterfly) configuration. This is yet another way to "bend" a dipole into a smaller footprint. Here is an article on that:

What happens if...You Bend the Ends Into Triangles?



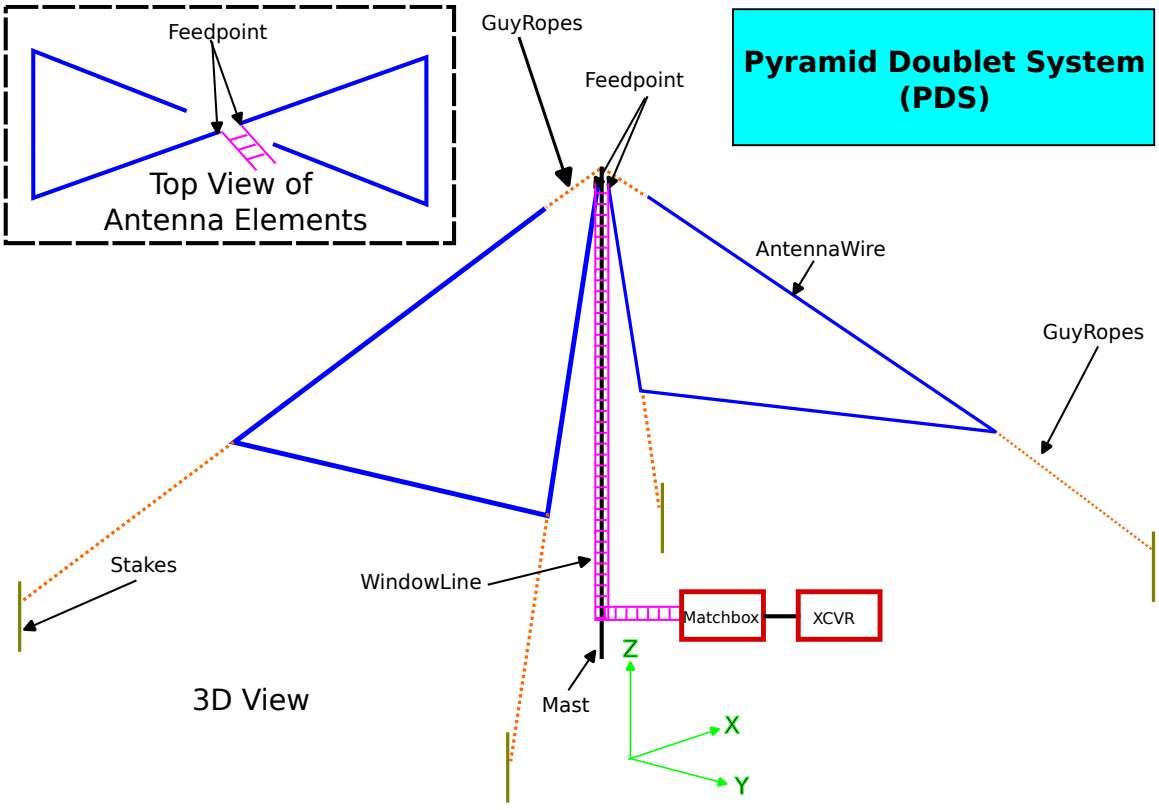
Then my mind went back to the inverted dipole concept. This is a single mast with the antenna wires oriented down toward the ground with guy wires extending to the ground.

There are many Hams that use this configuration for field days utilizing a telescoping mast.

I wondered if I could combine “inverted” and “bowtie” into a single design. This led me to the PDS.

The Pyramid Doublet System (PDS)

This section describes the PDS in more detail.

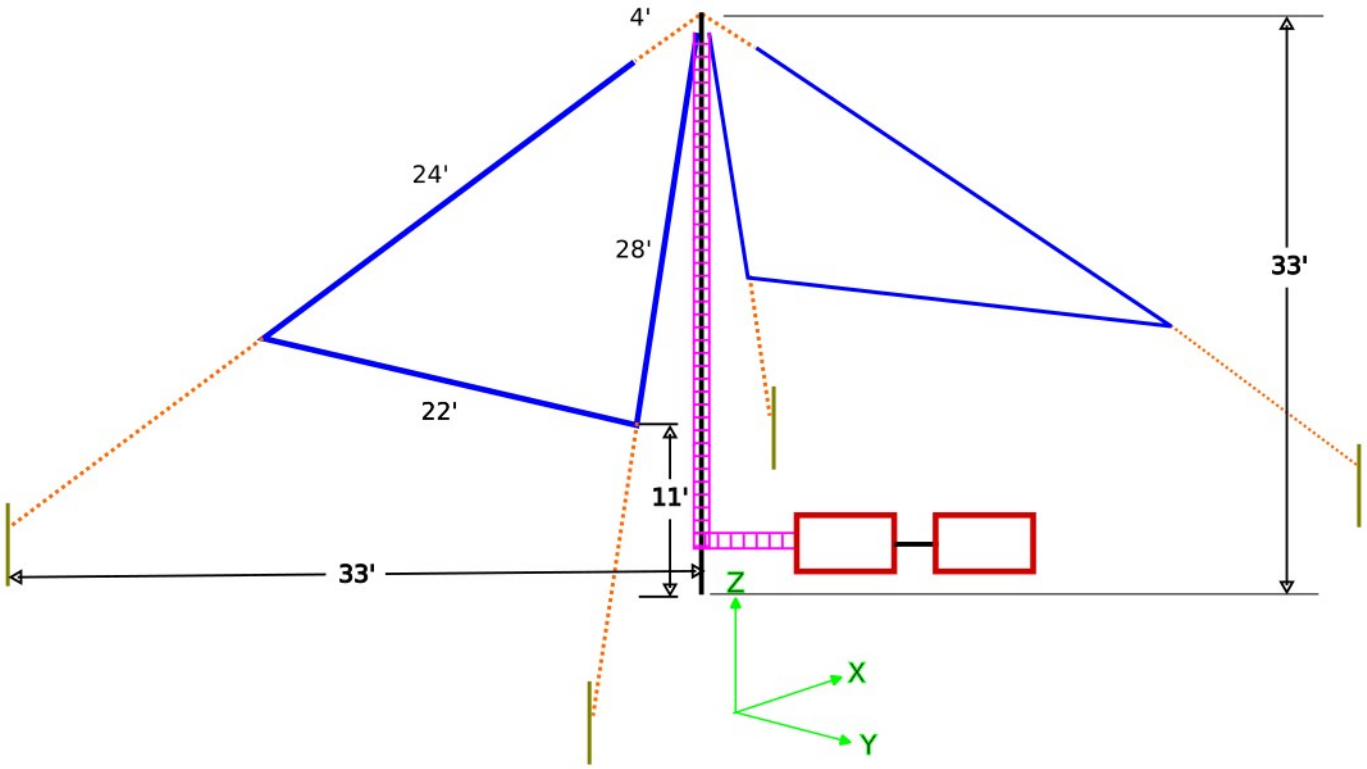


The antenna portion, is ~1/2 wavelength for 80M. It consists of two wires (¼ wavelength elements) bent into a triangular shape and sloped downward. This produces a smaller footprint than a straight 80M dipole or an inverted V.
The distance from the center mast to each stake is 33', making the overall footprint a diameter of 66'.
The center mast is 33' high and the lower, horizontal elements are 12' above ground level (AGL).
An insulator is attached to each lower vertex of the triangle and guy rope is extended to stakes in the earth.
The top, termination end of each wire element has an insulator and guy rope extending to the top of the mast to complete the "triangle".

The 4 guy wires are much more stable than an inverted V.

The doublet is directly connected to a window line (no balun) which feeds into a balanced line matchbox (MFJ-974HB). This is a true all-band antenna allowing for tuning on **all** bands from 80-6M, including non-harmonic bands.

Here is an illustration showing dimensions:



Note that there is nothing "magical" about these dimensions. I started with 33' high because that was the length of my telescoping mast. I then picked a spot to drive a

stake by eyeball and went from there. Perhaps, someone with more math and computer modeling skills can improve on those dimensions from an antenna efficiency perspective.

Since this configuration is a new design concept (at least I was not able to find anything), I had no idea now well this was going to work. However, based on my understanding at the time I was optimistic enough to go ahead and spend the time building it.

First Field Trial With the PDS

Our first camping trip, field trial was on June 15-17, 2022 .

Environment

My goal for this design was to have an effective antenna to take camping. (There are some variations on this design that I will discuss later that may be suitable for a more permanent installation).

We took the camper, PDS and Shack-in-the-Box (SITB) out to Pike National Forest (Colorado) at 10,000’ elevation. The SITB includes an ICOM 7100 running 100W and is powered by the camper battery. The results were very gratifying.

We came back from that trip with a list of improvements to make on both the PDS and for camping in general.

Here are few pics from that trip.

It’s difficult to see all the wires. But, if you compare the picture to the diagram you can pick out most of the features. The guys are ½” wide, orange straps, for visibility so I don’t trip on them.

Here is Laurie (KØLTH) operating under the awning on a beautiful mountain day. We can also move the SITB inside if the weather is not cooperating.

Contacts and Apparent Directivity

Laurie (KØLTH) does most all of the actual radio work. She made a lot of really good contacts including her first contacts with Australia, Moscow and Hawaii. She also completed her first POTA activation.

Since we were camping, we did other things beside radio (hiking, napping, reading, cooking, sleeping, etc.).
We estimate that Laurie spent about 10 hours total on the radio over the 3 days.

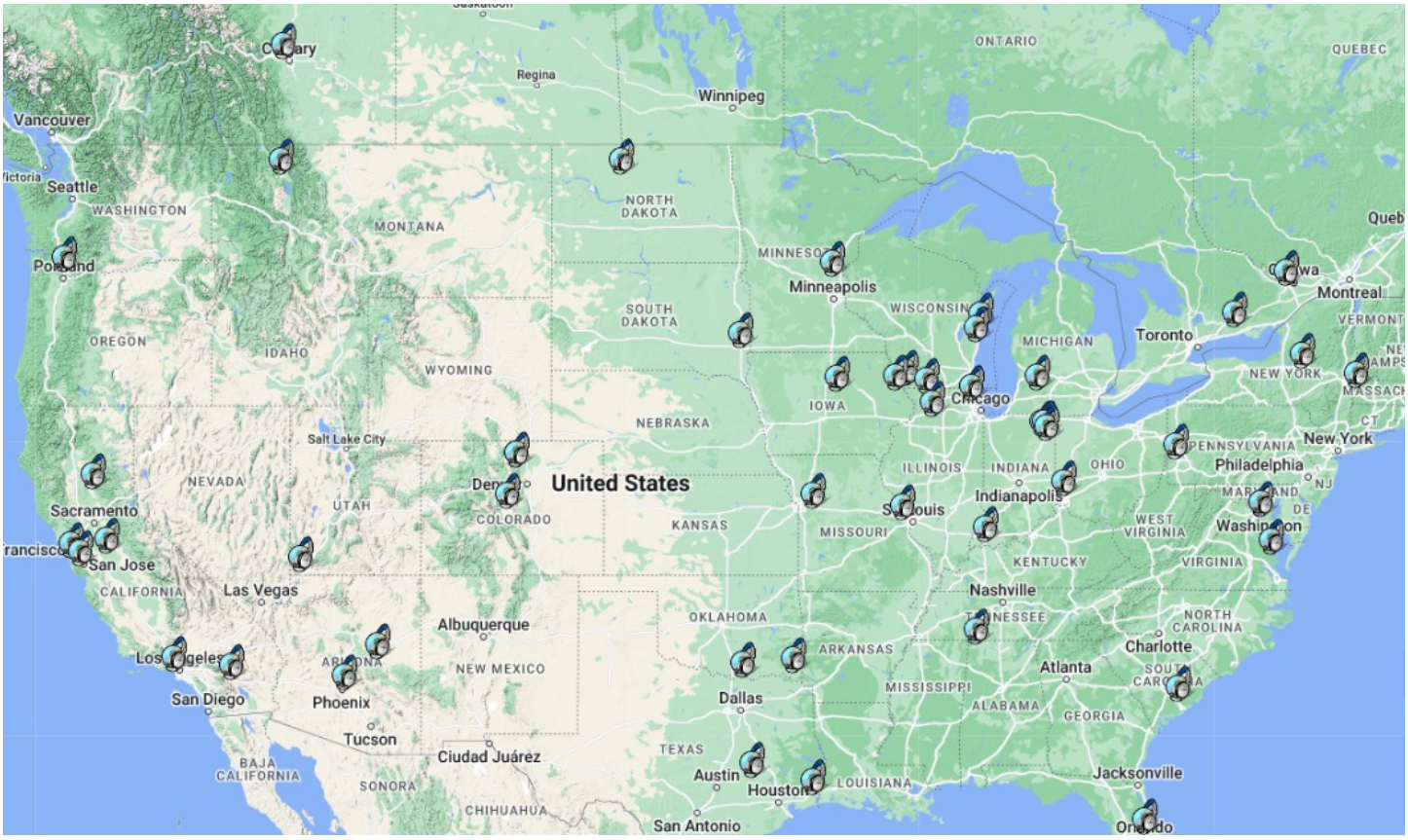
On this trip, almost all of the activity was on 20M. In future trips, we will expand our focus to include other bands. We predict that 40M & 80M will be more NVIS-related activity.

The radiation pattern of the PDS is of special interest. Understanding where the lobes and nulls are will be helpful when we set up the PDS.
Reviewing the contacts Laurie made, the pattern seemed to be fairly omnidirectional.
Note that the results can be skewed by:
> population density

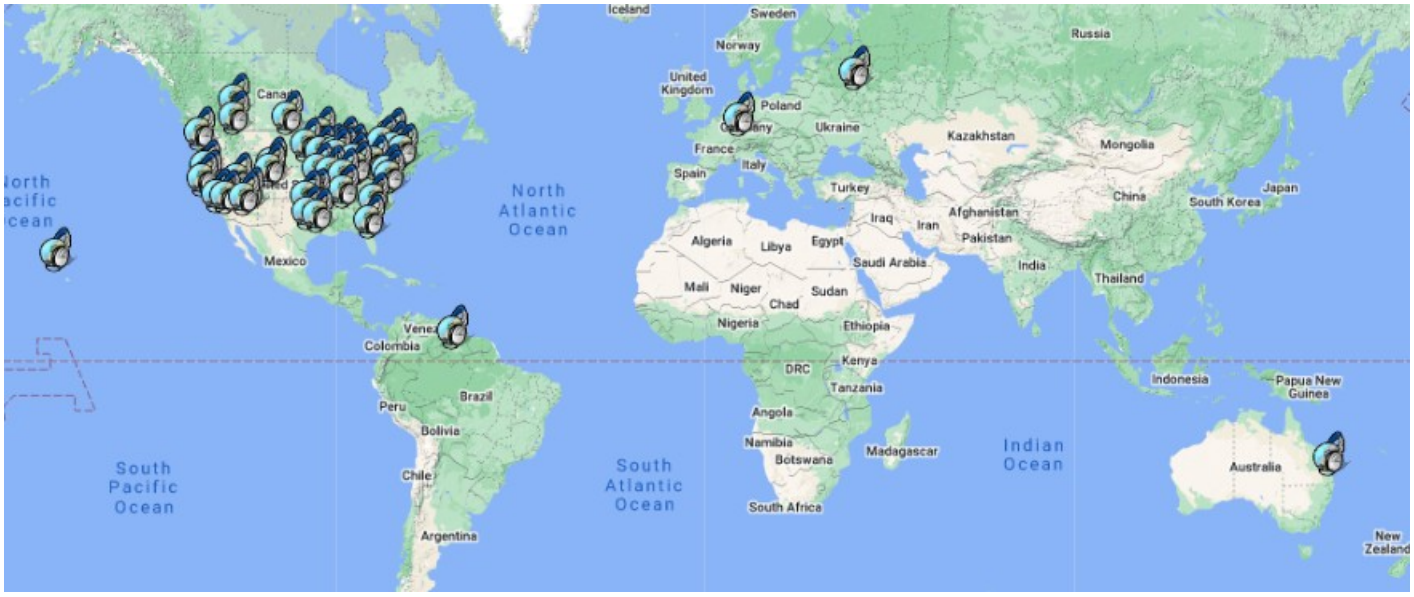
> propagation conditions including:
  - solar activity
  - time of day

As we spend more time using the PDS, the long term, accumulated results will be more revealing.

Here is a map showing the US contacts made on that first camping trip (our location is in central Colorado):



This shows the worldwide contacts made:



We considered this a **very** successful first test of the PDS!

Second Field Trial With the PDS

We took another camping trip on July 12-14, 2022. Here are some results and notes on the PDS for that trip.

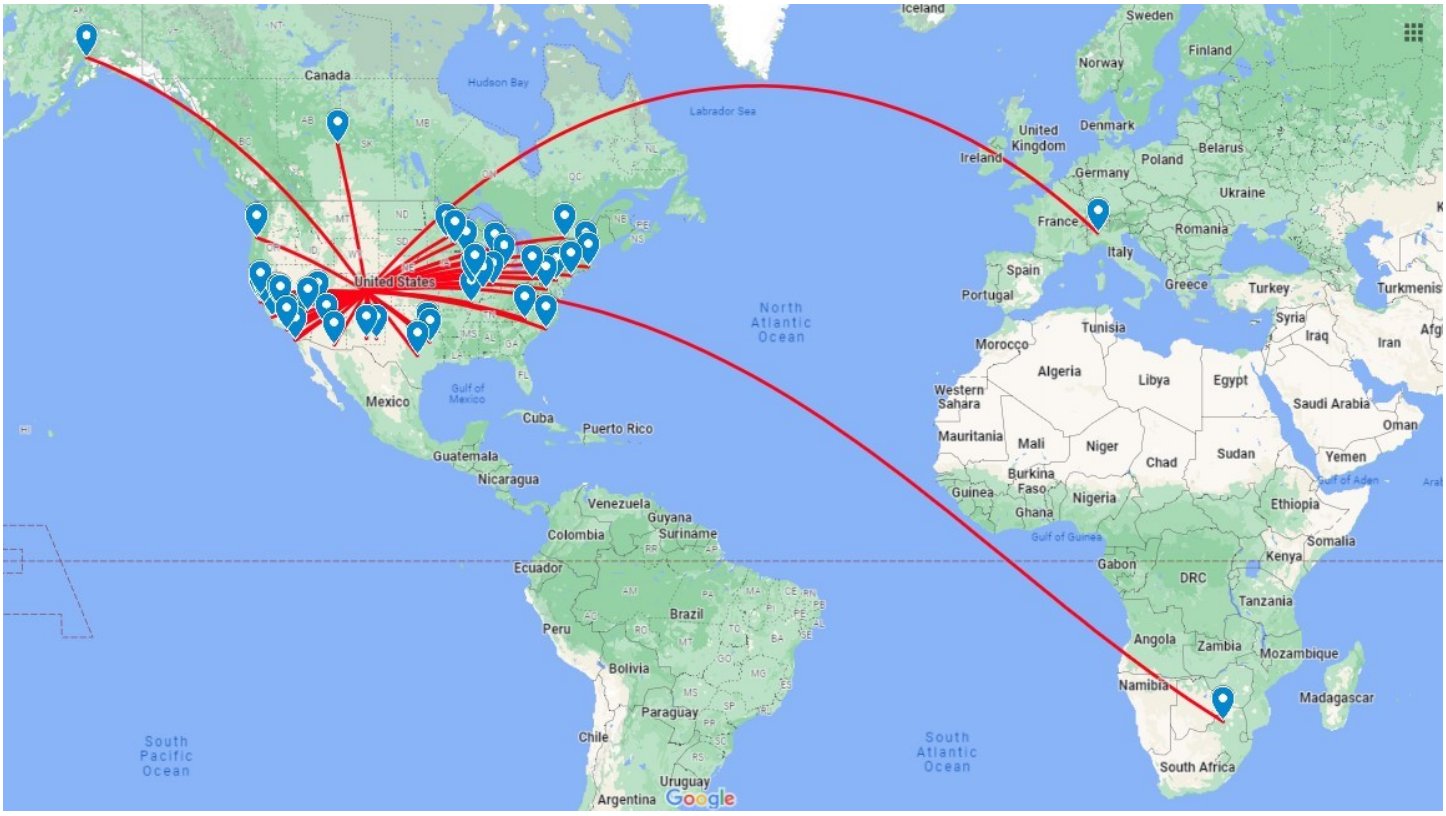
Environment

Our camping environment was similar to our first trip. We were at 9,600’ elevation in San Isabel National Forest (Colorado).

Band conditions were not as good as the previous trip. However, Laurie had a few “firsts” including contacts made to South Africa and Alaska.

Contacts and Apparent Directivity

Here’s a map showing the locations of the contacts made.



We also ran several reverse beacon tests. Here are the results:

Once again, there seems to be a fairly omnidirectional pattern. However, east-west seems to be more strongly favored. This could be due to the locations of the stations in higher population locations.

Radiation Pattern of the PDS

Computer modeling of radiation patterns can be helpful. I personally think that too much emphasis is given to computer modeling as it cannot really model real-world operating conditions (yet). However, it is a useful tool.

Since the PDS is a unique concept, I was only able to find one model that was somewhat similar to the PDS design.

The Broadband Butterfly Terminated Dipole Antenna (BBTD) has a “bow tie” or “butterfly” configuration that is similar to the PDS from a top-down view. Click here for details. Scroll down further in the article and you’ll find an “inverted” variation that looks similar to the PDS in shape. There are radiation patterns modeled for this design. I would think that the PDS radiation patterns will be similar to these.

The BBTD is not a doublet. It uses a balun, termination resistor and coax for the feedline.
I still believe that a non-resonant antenna wire fed with parallel feedline into a tuner in the shack is a more efficient and flexible design. I’m sticking with that until I can find proof otherwise.

Here are some EZNEC Pro 2+ radiation patterns:

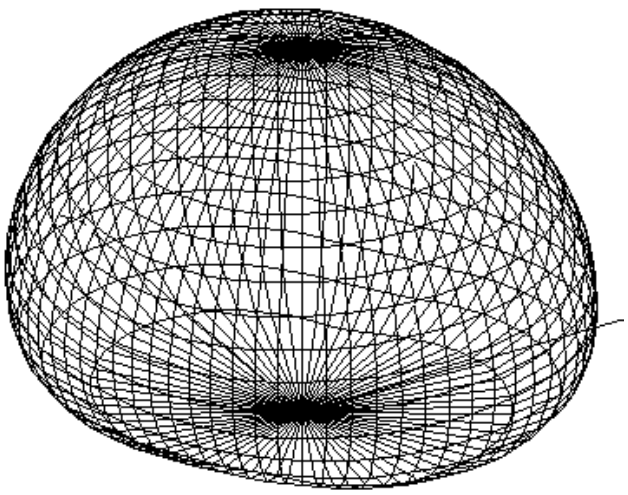


Figure 2: 80M

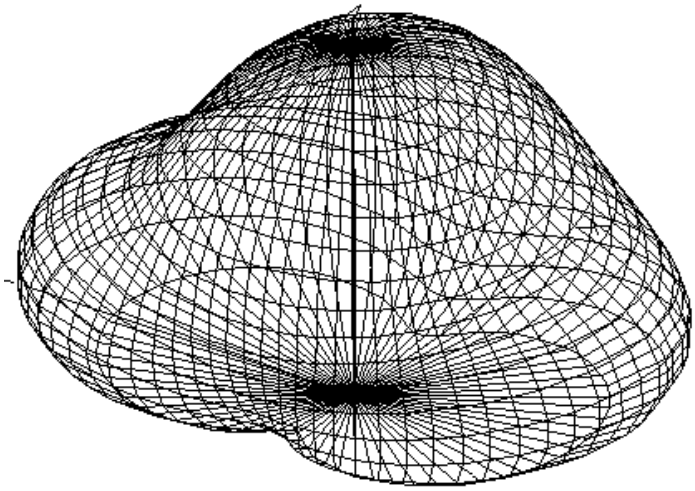


Figure 1: 40M

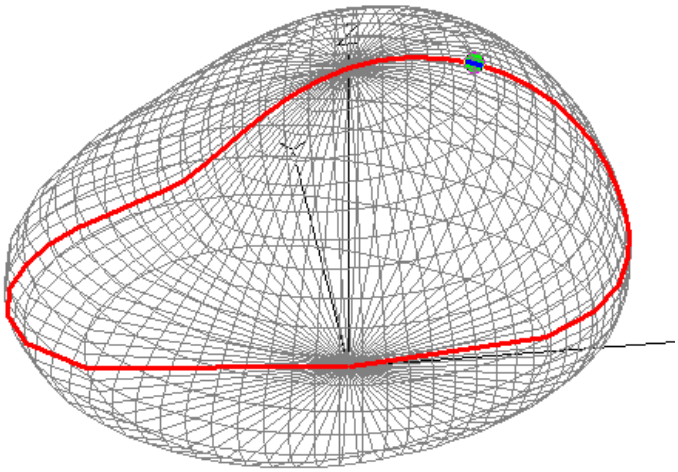


Figure 4: 20M

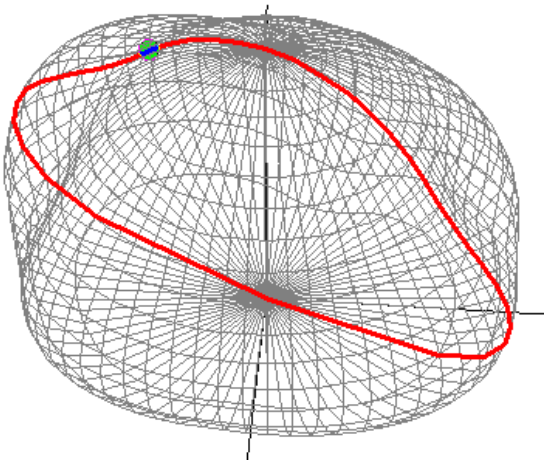


Figure 3: 15M

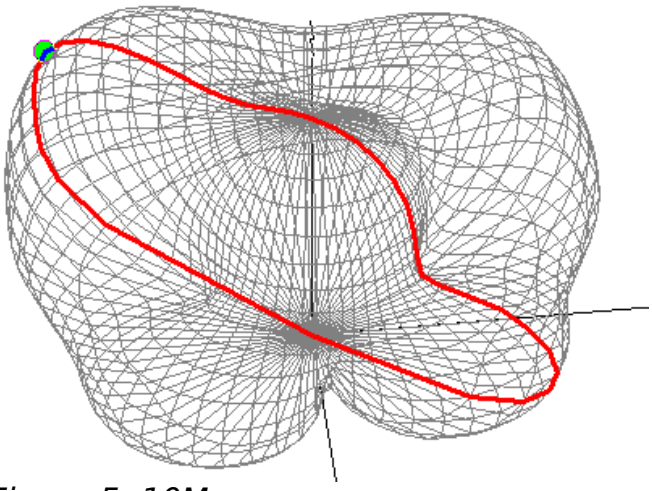


Figure 5: 10M

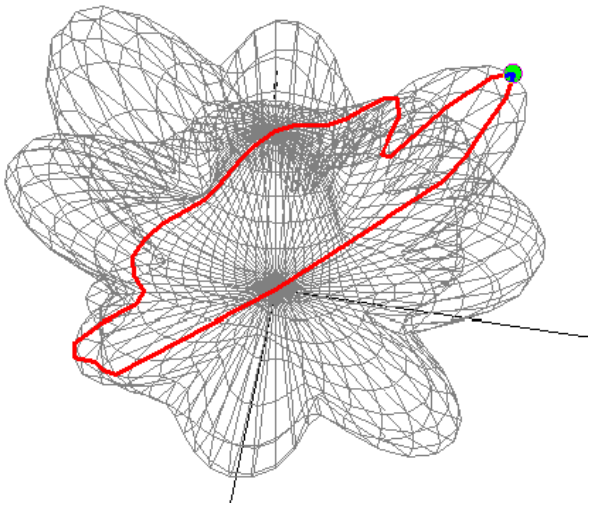


Figure 6: 6M

I'm pretty new to EZNEC, so I'm may not be doing this right.

I don't understand how a symmetrical antenna can produce such asymetrical results on some of the bands.

Take it for what it's worth.

PDS Variations

Since the PDS has been so successful, I began to think about variations that others might be able to use for a more permanent, home QTH installation.

Some people may not have the real estate for a full ½ wavelength doublet. The smaller footprint of the PDS might just be the ticket for them.

And, a single, all-band antenna in a smaller footprint configuration is certainly very appealing.

T-Post Corners

Instead of using stakes in the ground, one could use T-posts. The guy ropes can be tied higher up off the ground reducing the tripping hazard. The posts can also be painted white or orange for improved visibility.

PVC Mast Corners

If you want to raise and flatten out the “bow-tie”, you could drive T-posts at the 4 corners and then slide a piece of PVC over them to provide a higher point to attach the guy ropes to. The height of the PVC could be 6’, 8’ or even 10’. If this is sturdy enough you would not have any guy wire to trip over, just 4 PVC corner posts.

This will change the radiation pattern, but only experimentation will tell if it is an improvement or not. It would certainly get more of the antenna wire higher above the ground.

This would allow you to put the stakes in at equally space intervals. As you tighten up the guy ropes it should pull equally on all the horizontal wires and lines.

The down side is that it makes the antenna more visible. However, it might actually look better depending on your aesthetics tastes.

One might try using a heavy fishing line for these lines and see if they are less visible and if they hold up to use.

Will This Work for Your Environment?

Of course, your environment can be leveraged to design your particular setup. Consider using already existing elements such as trees, buildings and other structures, etc. Use your imagination!

I would love to see some others try this design at the home QTH’s and send me results.

If you're putting this on a more permanent basis, you'll likely need to add a 2nd set of guy wires half way up in order to stand up in high winds.

Some Final Thoughts

All Hams know that every antenna is a compromise antenna. We have to pick and choose which compromises are best for us in our environments.

For this design for our camping trips, I'm good with this antenna being being mainly NVIS on 40/80M. We have used this successfully to check into regional nets on these bands.

The 60° angle (on 2/3 of the elements) makes it closer to a vertical antenna which means height above ground does not impact it as much as it would a horizontal antenna and should provide lower take off angles on the higher bands for DX. It would be great to really understand the radiation patterns of this antenna on the various bands. However, time and experience will tell how it really performs.

The presence of the camper certainly impacts the antenna system. However, this is a conscious compromise. The camper provides a good mounting platform for the telescoping mast and makes it easy to put up and take down. The mast stays attached to the camper all the time.
I would really like to see someone try this design at the home QTH with nothing under the antenna to impact it.

Subsequent Learnings

Since developing the PDS, I have run across several designs that appear to be similar to the PDS. The reader may be interested in looking into these. There are some interesting notes about bowtie/butterfly designs that are helpful.

Broadband Butterfly

Here is a link to this design.

Broadband Butterfly Terminated Dipole (BBTD)

Here is a link to this design.

Scroll down further on this page and you will see an inverted, or pyramid, design that looks similar to the PDS.

However, this is coax-fed and uses a termination resistor both of which contribute to power loss.

This is also a much larger footprint than I wanted to consider for portable, camping scenarios.

References

A Dozen Ways to See and Love Your Feeders - Cebik

KV5R.COM Ladder Line

KK4OBI Bent Dipoles - What happens if...You Bend the Ends Into Triangles?

KV5R.COM 80-Meter Doublet

Skywire Loop Antenna