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Terminated Tilted Folded Dipole Shortwave Antenna

If you are a news junkie, and prefer getting your news directly from the source via shortwave radio, an antenna with excellent broadband performance is shown in Figure I, (which is available in larger size jpeg, PostScript, PDF, or xfig, formats.) The T2FD antenna is recommended for use in metropolitan areas, and the performance characteristics do not degrade in close proximity to metal objects, (like rain gutters,) foliage, etc.

The antenna has omnidirectional gain characteristics and the performance is commensurate with a dipole, but has better man-made noise performance, and extremely wide bandwidth, (typically, 5:1.)

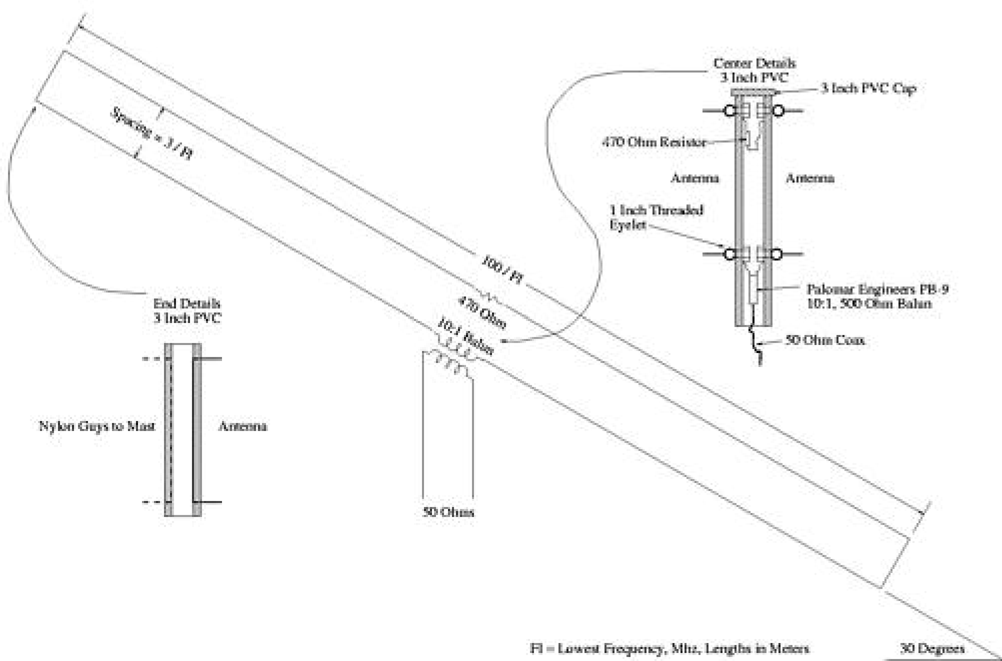

Figure I. Terminated Tilted Folded Dipole Shortwave Antenna

My own construction has a length of 48.25 feet, (limited by available space,) a width of 16.99 inches, and a tilt of 25.8 degrees, giving a lower frequency cutoff of 6.95 MHz. The antenna assembly is elevated 6 feet above the ground. The antenna has quite acceptable reception performance over the complete range of 5.0 MHz. to 30

MHz., (and is tilted directly over a 2 story house with of rain gutters on both stories-running inches from one-and is surrounded by foliage.)

Both masts, (not shown,) were constructed from 3 inch PVC pipe, (as were both ends and center containers of the antenna,) one anchored to a second story chimney, the other to a fence post at ground level, (elevating the antenna 2 feet above the top of the fence, and 2 feet above the top of the chimney.) I used 25 pound test nylon for the guys at each end of the antenna for 50 pound safety shear failure, (in case weather brings the antenna down, the nylon will shear, preventing damage to the fence, chimney, and masts.) PVC glue was used to seal the center container against weather. Four standard 1 inch OD threaded eyelets were used for antenna wire attachments to the center container, with retaining nuts on the inside of the container-the antenna wire fastened directly to the eyelets, and a separate wire soldered to each antenna wire which connected to the resistor and balun mounted internally in the center container. The center container was supported by a two member vertical triangulated bracket made from 1.5 inch PVC pipe, and secured to the side of the house with two door hinges to permit lateral movement in strong weather. All hardware is readily available at a hardware store, and no special tools are required.

A note about the balun: there are two types of baluns for matching a high impedance antenna, like the T2FD, to low impedance coax; transformer, (technically, a balun, balanced-to-unbalanced, which has a primary and secondary winding that are isolated,) and, auto-transformer, (technically, an unun, unbalanced-to-unbalanced, with a single winding that is tapped to provide the low impedance.) For a T2FD antenna, a balun is necessary, (and NOT an unun.) The noise performance of the balun is superior to the unun, since common mode noise, (for example, radiating from the high current magnetics driving a local television/computer CRT,) will tend to cancel since they are common to both legs of the T2FD.

Additionally, it is advisable to insert a common mode choke in the lead in coax cable near the receiver-a common mode choke can be made by winding five to ten turns of the coax cable through a two inch toroid, (I use Amidon Associates T-200-2.) This attenuates common mode signals/noise picked up by the coax lead in. Also, its a good idea to use a common mode choke in the receiver power cord-made the same way; run about five to ten turns of the line cord through a two inch toroid.

It is probably not practical to ground the coax lead in of a T2FD at the antenna, (this is the best way, and the coax should drop straight down to a grounding rod, the shield grounded, and then proceed on to the receiver, which is NOT grounded.) If the antenna is not grounded, then the coax shield should be grounded near the receiver, (i.e., the receiver ground should be connected to a ground rod-or as a less desirable alternative to the third/green wire of the power outlet.) The coax should not be grounded at both ends, (i.e., both at the antenna and the receiver.) For more details of good engineering practices for short wave antenna lead in, see EWE Shortwave Antenna.

At the single ground point, (e.g., at the antenna or receiver,) it is always a good idea to install a lightning arrestor. I use the gas-discharge type.

Performance

The antenna's performance was evaluated in an A-B comparison, (using a Drake R8, dipole cut for 9.545 MHz., broadside to Swiss Radio International from Northern

California, W2AU Grove double to single ended balun.) Both antennas produced the same S unit response, (about S 9,) without preamplification. The RF gain was adjusted to S 1 on the dipole, and the antennas switched. The T2FD produced a S 1 reading.

The receiver was tuned to a quiet location in the 9 MHz. band near 9.545 MHz., and the noise floor measured for both antennas, which were identical at 1.5 S units, (with preamplification.)

The impedance of the T2FD antenna was measured, (through a connection of 5 feet of RG58 using a Palomar noise bridge,) at 0.25 MHz. intervals between 7 MHz. and 25 MHz., and found to exhibit an SWR of 1.5:1 over the range.

The antenna's performance was then evaluated using the A-B comparison against the dipole at 1 MHz. intervals between 5 MHz. and 30 MHz., for both signal gain, and noise floor, and found to be as-good-or-better than the dipole in both S/N ratio and gain.

Historical

I have used the antenna since early 1990. It appeared in the "1989 Edition World Radio TV Handbook", (also called the WRTH,) Volume 43, 1989, Andrew G. Sennitt, Editor, Glenn Heffernan, Publisher, Billboard A.G., pp 566-567, "Equipment Test Bench Section," by Jonathan Marks and Willem Bos.

Since anyone's chances of finding the reference is slim, the section is shamelessly plagiarized:

> ### THE T2FD ANTENNA
>
> In the 1988 WRTH we examined various active and passive antennas. One of the reference antennas was a Terminated Tilted Folded Dipole. This is a traditional favorite in the maritime services, but hardly ever seen in books and periodicals designed for the shortwave broadcast listener. As promised, here are the plans on how to construct one.
>
> The diagram [the diagram in the original article is not the same as Figure I, above] explains the antenna's appearance. The advantage of the design is that you can choose which section of the HF band you want to cover by changing the dimensions. The formula is simple. The length of the antenna (in meters) is 100 divided by the desired lowest frequency in MHz. The distance between the two parallel wires is 3 divided by the frequency in MHz. The bandwidth of the antenna is about 1:5. This means that a a 20 metre antenna will give coverage between 5 and 25 MHz. In practice it will work between 3 and 30 MHz, but you may find performance dropping off slightly at either end of the range. The distance between the parallel wires should then be 60 centimeters.
>
> The angle at which the antenna slopes should be about 30 degrees. Slight variation (between 20 and 40 degrees) are allowed but not outside these limits. In theory the antenna reception pattern consists of various sidelobes without a main direction. You can therefore regard it as omnidirectional. Although a tuned dipole should give better gain than a

T2FD, our experience indicates there is not much difference. Remember though that the T2FD outperforms the dipole when the receiver is tuned outside the limited frequency range of the tuned dipole.

MATCHING

The T2FD has an impedance of 500 Ohms over it entire length. Because that is quite high, there is little influence on performance from trees or roofing. Insulation should provide no problems. But because 50 Ohm antenna cable is used for the downlead, the 10:1 balun transformer is essential. You could construct it yourself, but it is not something for the beginner. We used one made by the Kurt Fritzel company of Neuhofen in West Germany, but there are plenty on the market. The transformer is mounted exactly in the middle of the lower antenna wire.

In the middle of the upper antenna wire is a resistor. For receive only purposes, a 470 Ohm 1 watt resistor is ideal. This is the standard value close to 500 Ohms. Don't just break the antenna wire in two and solder the resistor in between. The first breath of wind and the resistor will snap in two. So take a piece of plastic piping. Put in two holes and two metal bolts. In Europe, the size M4 is about right. Solder the wires to either side, and the resistor between the bolts. Then fill the pipe with some protective material (e.g. candle wax) to make it weatherproof. DO NOT use two 1000 Ohm resistors in parallel to obtain exactly 500 Ohms. The antenna works better when this terminating resistor is slightly below 500 Ohms.

CONSTRUCTION

Standard 50 Ohm coaxial cable should be easy to find. Note that although the length is not important, you should not allow the lead-in coax to run parallel with the antenna wire in close proximity. Let the coax drop a few metres away from the antenna before turning towards the receiver.

We used 5/8 inch plastic piping to spread the antenna wires apart. Do-It-Yourself stores have this type of piping in plentiful supply. On the outside two plastic supports three holes are bored at either end (see diagram [the diagram in the original article is not the same as Figure I, above]). The inner two are used to support the antenna wire so that it cannot shift. The outer hole is used for the insulating nylon chord (3 mm thickness is sufficient).

The wire you use for the antenna must be made of pure copper and between 3 and 5 mm thick. If this proves impossible to find, three cord household cable is also a solution. Wind the three cords together at the ends so that each core is used in parallel. The disadvantage with this cable is that it is liable to stretch. After a few weeks the antenna may start to sag. If this is the case, tighten the nylon supporting cord. Usually this is enough to solve the problem.

We said in the WRTH 88 that we did not know of any commercially available T2FD antennas. We were corrected by several readers who sent us advertisements from North American magazines for the T2FD "construction kit". We were surprised to see price tags of US$200 and

> upwards. Bearing in mind the components are not expensive, a trip to a DIY store and a good amateur radio outlet should solve the problem for about a fifth of that price. The balun transformer should be obtainable from amateur radio outlets. In case of difficulty try Kurt Fritzel, Siemensstrasse 2, D-6708 Neuhofen/Pfalz, Federal Republic of Germany. Tel: (49) 62 63 52 044. Palomar Engineers market a 9:1 balun transformer which is not far off the ideal matching. The PB-9 transformer costs US$23.95 excluding shipping. Further information from Palomar Engineers, P.O. Box 455, Escondido, California, 92025 USA.

July, 2003 addendum: apparently, the original information on the T2FD antenna was described by Commander G.L. Countryman, W3HH, [QST, June 1949, pp. 54-55]. These antennas where used by the US Navy listening posts in the Pacific. **Glenn Swanson, KB1GW**, mentions in KB1GW's Collection of Beverage Antenna Information:

> An early discussion of the T2FD appeared in the June 1949 issue of QST. The author of that article followed up on the T2FD in the November 1951 issue of QST, and in the February 1953 issue of QST. A more recent article on the T2FD appeared in the May 1984 issue of 73 Magazine.

T2FD - The Forgotten Antenna has additional historical information on tests run by the US Navy in the late 1940's.

T2FD Links

Modeling the T2FD
T2FD, The Forgotten Antenna -- antenna special on hard-core-dx.com
UMB T2FD Antenna Receiving Balun from Wellbrook Communications
RF Systems T2FD
HF Aerials
ttfd2-pt1

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