T2FD - THE FORGOTTEN ANTENNA

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If a survey were taken of all shortwave DXers to find the antennas they use, I suspect the majority would be found using the random wire. Next in popularity would likely be the commercially available sloper antennas and trap dipoles.

However, an antenna's popularity does not necessarily reflect excellent performance. While being simple and inexpensive to erect, the randomwire is susceptible to electrical noise, and presents a wide range of impedances to the receiver, depending on received frequency.

The terminated, tilted, folded dipole (T2FD) is a little known antenna that performs excellently. Compact in size compared to a half-wave dipole (approx. 67 feet long at 60 meters), the T2FD provides signal gain, wide frequency coverage, and exceptionally low noise characteristics.

An early discussion of the T2FD appeared in the June 1949 issue of QST, a popular magazine for radio amateurs. The author of this article continued his examination of the T2FD in the November 1951 QST as well as the February 1953 issue of the same magazine. A more recent article on the T2FD appeared in the May 1984 73 Magazine.

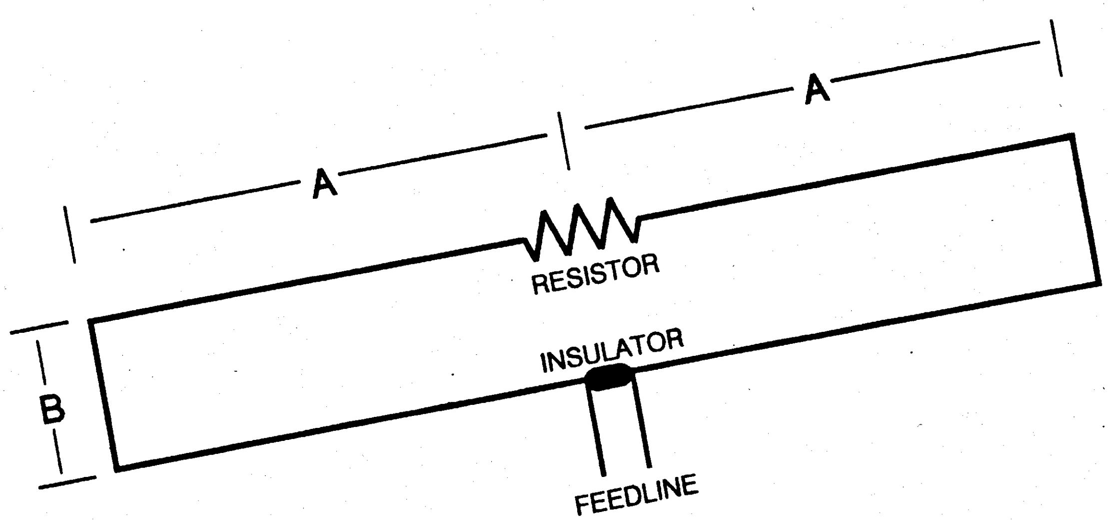
The World Radio Television Handbook for 1988 gave a brief description and diagram of the T2FD, and that year's WRTH Newsletter provided additional construction information. Further details were given in the 1989 WRTH. However, some misleading and incomplete information is given in these WRTH sources, which this article will later clarify.

DESIGN

Some have called the T2FD a "squashed rhombic" antenna. It does bear some design similarities to the non-resonant rhombic, but theoretically it is admittedly inferior. However, the T2FD performs well in a modest amount of space, while a rhombic antenna can be immense–virtually impractical–at all but the highest SWBC bands.

The T2FD is essentially a closed loop design with the element ends folded back and joined by a non-inductive resistor (see figure below). The feed line can be 300 to 600 ohm twinlead or open line.

Because twinlead and open line can be affected by nearby metallic objects (downspouts, metal window frames, etc.), a better feed line is coaxial cable connected to an impedance transformer (balun).



The T2FD has a characteristic 5 or 6 to 1 frequency ratio, which means that it works effectively from its low-end design frequency up to 5 or 6 times that frequency. For instance, the T2FD which I use is designed for optimum performance at 4.9 Mhz, but can operate up to the 25-29 Mhz range. In practice this antenna also works satisfactorily down to the 75 & 90 meter tropical bands, but not as well as a dipole or delta loop designed for 75 or 90 meters.

The formulas for calculating T2FD dimensions are as follows:

1. The length of each leg ("A") from the center is equal to 50,000 divided by the lowest desired operating frequency (in kHz) and then multiplied by 3.28. The answer is in feet.

2. The spacing between radiating wires ("B") is equal to 3000 divided by the lowest desired operating frequency (in kHz) and then multiplied by 3.28. The answer is in feet.

3. The sloping angle for a non-directional pattern should be on the order of 30°, but 20-40° is acceptable.

EXAMPLE: to design a T2FD for the center of the 90 meter band (3300 kHz) and up:

"A" = (50,000 / 3300) x 3.28	"B" = (3000 / 3300) x 3.28
"A" = 49.70 feet	"B" = 2.98 feet

Total length of the antenna would be 99.4 feet (2 x 49.7), and the width would be 2.98 feet ("B").

The total wire used to complete the loop equals 204.76 feet (4 x 49.7) + (2 x 2.98).

PERFORMANCE

The United States Navy conducted extensive transmiting and receiving tests of a single T2FD antenna in the late 1940s at Long Beach, California. They employed a Model TCC Navy 1 Kw transmitter, with a frequency range from 2.0 to 18.0 Mhz. After a year of use on all frequencies, the T2FD was found to be superior to individual antennas on the various bands. The other antennas were removed from the Long Beach site after the tests.

Similar results during the same period were experienced by the Kyushu Electric Communications Bureau of Japan. Their experiments indicated that the terminated, tilted folded dipole was superior to the "zepp" and half-wave dipole types previously used. They noted wideband characteristics, and the T2FD gave a 4 to 8 dB signal increase at their various receiver sites.

My experience has shown the T2FD to be a fine performer when only a single shortwave receiving antenna can be erected, due to its wideband nature. It also has the advantage of electrical noise rejection (to a degree) compared to a random wire or even a dipole.

On the following page is a comparison of a 60 meterband T2FD, a 500 ft. longwire, and a 50 ft. random wire antenna. Tests were conducted at the home of Fred Carlisle, a DXer from rural Yelm, Washington. Nearby his home is a large dairy, whose processing equipment operates day and night and generates some amount of electrical interference. The noise was rarely audible on the T2FD, yet signal strengths were comparable to (or better than) the other antennas in use, on a range of frequencies:

The 500 ft. and 50 ft. antennas were switched in and out of the receiver's high impedance input; the T2FD fed the 50 ohm coax input. The receiver used was a JRC NRD525 with a custom, highly accurate analog S-meter. The meter is calibrated to the industry standard S-units/microvolts scale.

As the results show, the T2FD antenna did not begin to drop off in performance until down in the 120 meterband. This is well below the 60 meterband design frequency of this particular T2FD.

THE TERMINATING RESISTOR

According to the QST articles mentioned, the value of the terminating resistor is rather critical. Its value depends on the feedpoint impedance, and is normally above it. For instance, if 300 ohm feed line is used (or 75 ohm coax into a 4:1 balun) the correct termination value is 390 ohms. For 600 ohm feed line, a 650 ohm value is best. If a 450 ohm feed line is in use, the correct resistor would be in the vicinity of 500 ohms. I have not discovered why the optimum terminating resistance is higher than the feedpoint impedance, nor do I know of a formula for calculating this relationship.

The terminating resistance becomes more critical as the feedpoint impedance is lowered. With lines of lower impedance (including a directly connected 50 ohm coaxial cable), the value is critical within about 5 ohms. (The QST articles did not state an exact recommended value when using a low impedance line.)

The WRTH editions give the erroneous impression that T2FD antennas REQUIRE a 500 ohm resistor and a 10:1 balun transformer, used with 50 ohm coax cable. This is not the case, although these values will work fine if you have the 10:1 balun available (normally hard to come by). A T2FD built with 75 ohm coax (RG-59 or RG-6), a common 4:1 balun, and a 390 ohm terminating resistor is recommended.

FREQ./STN.	T2FD(NW-SE)	50'(N-S)	500'(E-W)
17680 RNZ	S9	S8-S9 w/buzz	S9 w/buzz
17700 RM	S7-S8	S7 w/buzz	S7 w/buzz
17795 RA	S8	S6-S7 w/buzz	S7 w/buzz
15440 RBI	S6-S7	S6 w/loud buzz	S6 w/loud buzz
15435 BSKSA	S7-S8	S7 w/loud buzz	S7 w/loud buzz
15330 RAI	S5-S6	S5 w/loud buzz	S5-S6 w/loud buzz
12085 RD	S8-S9	S8-S9 slight noise	S8-S9 slight noise
11955 RJ	S9+10dB	S9	S9-S9+10dB
11940 RJ	S8	S9	S9
11505 RB	S4-S5	S4 moderate noise	S4-S5 slight noise
9895 RM	S9+10dB	S7	S9
9425 VoG	S6-S7	S5	S6
9375 RT	S8	S6 slight noise	S7 slight noise
7355 WYFR	S8-S9	S6-S7	S7
7335 CHU	S8-S9	S6	S7-S8
7255 VoN	S7-S8 slight noise	S5-S6 mod. noise	S6-S7 slight noise
6165 RN	S9+15dB	S9+10dB	S9
6150 RI	S7-S8	S7	S6
6135.4 RFO	S7-S8	S6 some noise	S6
5030 TBC	S5 slight noise	barely audible	S5 slight noise
5000 WWV	S9+10dB	S9+10dB	S9
4985 R.Bras.Cent.	S5	S5	S6
4915 Anhanguera	S4-S5	S5 noisy	S5 some noise
4885 O. del M.	S6	S6 slight noise	S6 slight noise
4865 L.V. de C.	S6	S6-S7	S5-S6
4765 RM	S7	S7 slight noise	S6-S7
3990 VOA Liberia	S4-S5	S5	S5
3975 BBC	S5	S5	S5
3330 CHU	S5 strong noise	S5 strong noise	S5 strong noise
3385 Rebelde	S5	S5 some noise	S6 some noise
2500 WWV	S6	S6-S7 some noise	S8
1610 TIS stn.	S5	barely audible	S8-S9

The resistor used MUST NOT be a wire-wound type; its inductance would affect performance to a substantial degree. A carbon resistor of 1/2 to 1 watt in size is perfect (for a receive-only T2FD). The WRTH Newsletter in 1988 said that the wire for a T2FD must be made of pure copper between 3mm and 5mm thick. In reality, the exact thickness and type of wire have very little bearing on the T2FDs performance for receiving. Your main consideration will be wire strength, regardless of diameter.

CONSTRUCTION TIPS

A T2FD takes more hardware to construct than a typical dipole. Maintaining a uniform spacing between the parallel wires, as well as sturdiness, are the primary considerations. My first attempt at a T2FD self-destructed when the antenna was hoisted into the air. I underestimated the strain the wires would be under. My current T2FD has been in use for over 1-1/2 years, and was built with 14 gauge stranded, cold-drawn copper wire.

The spacers or spreader bars can be fashioned from 5/8" (minimum) diameter wood dowels, or even acrylic rod if available. Drill appropriate sized holes at each end of the spreader bar for the wire to pass through. The spreaders should be secured to the wires so that they do not slide; one method is to "jumper" each spreader end with a short piece of stiff wire and solder to the antenna wire.

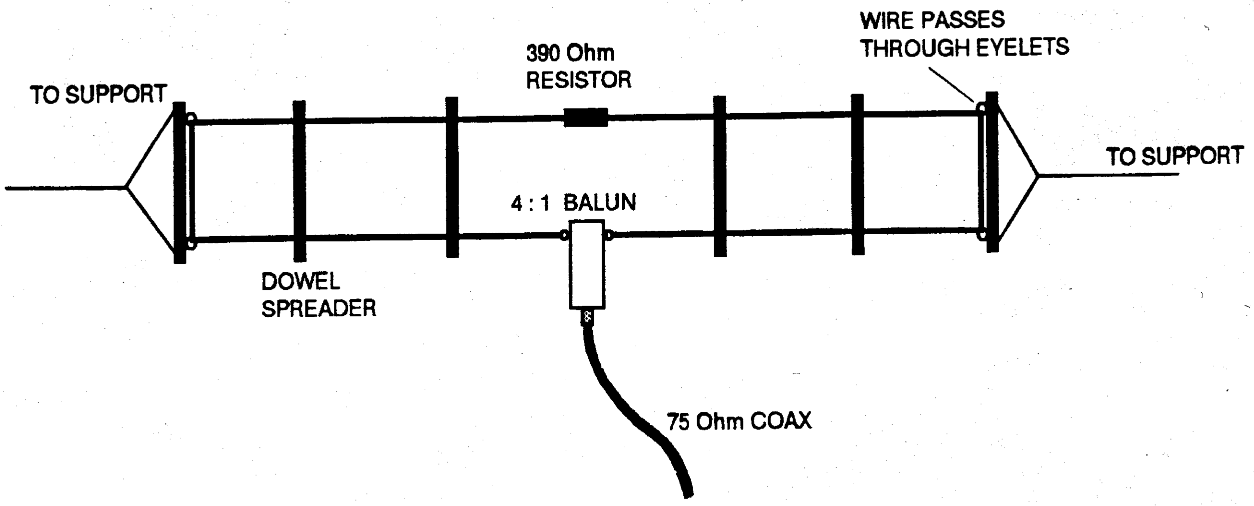
It is essential that you encase the terminating resistor inside a plastic cylinder or other support, and weatherproof the assembly. Be positive that the resistor will not receive the strain from the wires.

I prefer to use eyelet bolts on the end spreader bars for the antenna wire to pass through. An alternative would be some type of rod or strong, small diameter tubing cut to the length of dimension "B". The wire would simply thread through the rod.

Most amateur radio supply stores sell 4:1 baluns that only need a wrap of "Coax Seal" around the connections to be totally waterproof. The type with a coax connector that will accept a PL259 plug is perfect.

The diagram on the following page illustrates this type of construction, using the commonly available 4:1 balun, 390 ohm resistor, and 75 ohm RG-59 coaxial cable:

Typical construction details for T2FD.
Actual dimensions calculated per formulas on page A10.2.



Performance of the Terminated Folded Dipole, C.L. Countryman, QST, November 1951.

More on the T2FD, C.L. Countryman, QST, February 1953.

A Little Gem for QRP, 73 Magazine, May 1984.

World Radio Television Handbook, 1988 & 1989, Billboard Publications.

World Radio Television Handbook Newsletter, 1988.