Spiderbeam Aerial-51 Model 404-UL Antenna

How good is it?

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I was recently in discussion with a friend, who shall remain anonymous, about antennas suitable for portable (SOTA, GMA, POTA, WFF) use. My colleague happened to mention having used a Spiderbeam Aerial-51 Model 404-UL Antenna (hereafter as A-51), an OCFD type, with some success while operating SOTA portable.

I was intrigued by his comments, since he mentioned that, in addition to the antenna being usable on the 40, 20, 15 and 10-meter bands - which is the more usual combination of usable bands for such an antenna - he was also able to use it on the 17 and 12-meter bands, which usually result in very high VSWR with OCFD antennas.

In their information sheet for this antenna, Spiderbeam describe it as follows:

> *The Model 404-UL is constructed using ultra-light, yet strong components. All hardware is stainless steel. The Kevlar re-enforced multi-strand wire has 1.6mm outer diameter, very low wind load and weighs only 65gr., yet it still maintains a breaking strength of 60kg. The special lightweight coax used has low loss for its size, yet weighs only 185gr., making it ideal for portable use with any of the Spiderbeam telescoping fiberglass poles.*

The information sheet displays a diagram of the antenna, reproduced here:

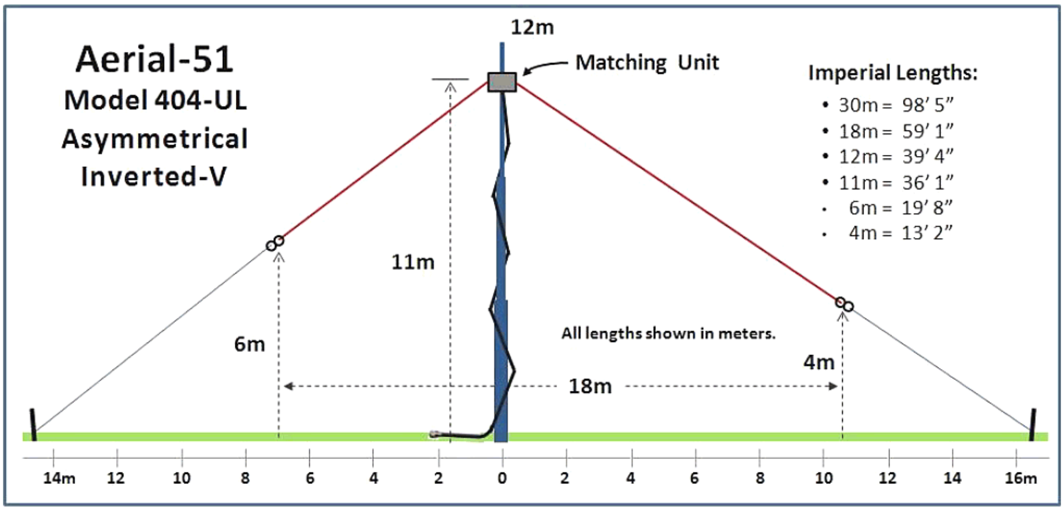

Fig. 1 - Diagram of the A-51 antenna

The A-51 antenna is configured as an asymmetric inverted-vee dipole, with apex at 11 meters AGL and legs at between 35° and 38° from the horizontal, complete with 12m of RG-174 A/U coaxial cable and a matching unit. From the diagram, it is possible to measure each "leg" of the antenna, which shows that the two legs form 40% and 60% of the total length of the antenna, here colored red.

The same antenna can be modelled using a NEC2-based antenna modeller, as for instance here:

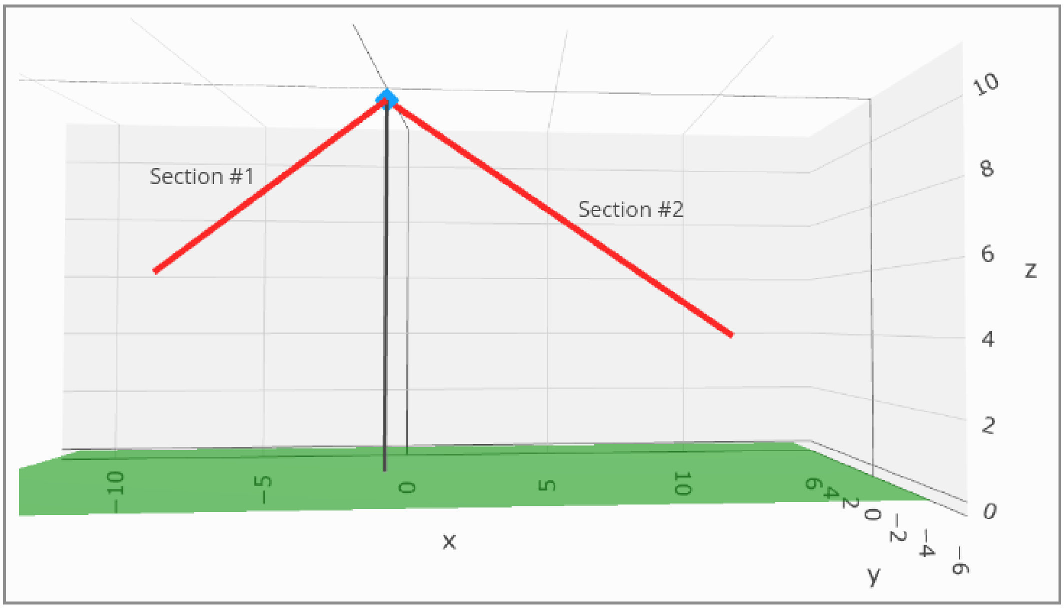

Fig. 2 - NEC2-generated model of the same antenna

The Spiderbeam info document also shows how the antenna performs on various amateur radio HF bands, with VSWR charts:

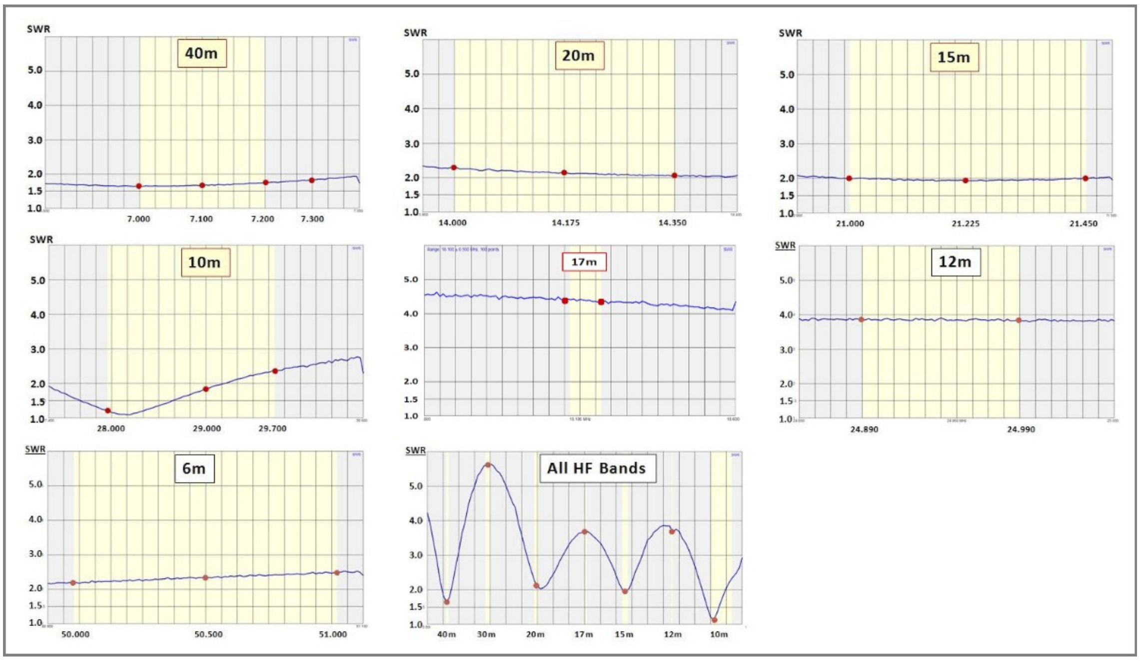

Fig. 3 - A-51 antenna - VSWR charts for various amateur radio bands

From the charts in Fig. 3, we are able to extract the following VSWR values at selected frequencies:

Table 1 - A-51 antenna - VSWR values at selected frequencies, published by Spiderbeam

Band, meters	40	30	20	17	15	12	10	6
Frequency, MHz	7.1	10.1	14.2	18.1	21.2	24.9	28.5	50.2
VSWR	1.7	5.7	2.2	4.4	2.0	3.8	1.4	2.4

The NEC2 model can also display the following VSWR chart, covering the HF bands:

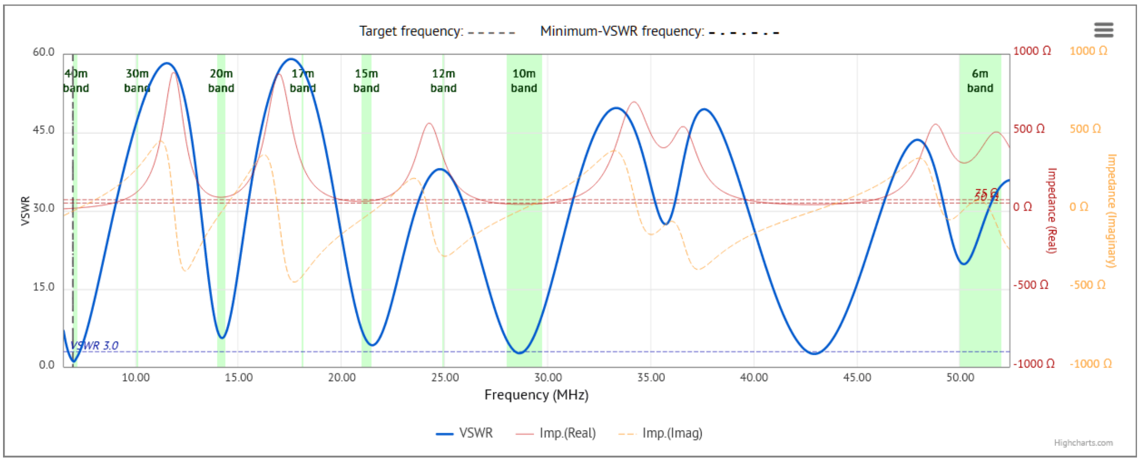

Fig. 4 - NEC2-modelled antenna VSWR chart

from which, by using a zoom function in the chart, we can also extract the following VSWR values at selected frequencies:

Table 2 - NEC2-modelled antenna - VSWR values at selected frequencies

Band, meters	40	30	20	17	15	12	10	6
Frequency, MHz	7.1	10.1	14.2	18.1	21.2	24.9	28.5	50.2
VSWR	1.6	***47.3***	5.6	***57.0***	5.0	***38.0***	2.7	***20.0***

Here we see the expected very high VSWR values for the 30, 17 and 12-meter bands - the 6-meter band, which can also occasionally be used with an OCFD type antenna, also shows high VSWR here. These numbers are calculated by NEC2 using standard physics and math.

First impressions

By comparing the numbers in Tables 1 and 2, we notice large differences between the VSWR values for the 30, 17 and 12-meter bands (the so-called WARC bands) for the A-51 antenna and the modelled antenna. VSWR values for the other bands in the two tables also show some differences, but not so extreme as with the WARC bands.

How can this be so? Are the VSWR values as published by Spiderbeam themselves at fault, or inaccurate? This turns out not to be the case, since reviews of the antenna give results broadly in agreement (within 1 or 2dB) with those from Spiderbeam - one such review is given by Gil F4WBY on Youtube at https://www.youtube.com/watch?v=nfi7dM0slKc . His review gives the following VSWR values:

Table 3 - A-51 antenna - VSWR values at selected frequencies, from F4WBY review

Band, meters	40	30	20	17	15	12	10	6
Frequency, MHz	7.1	10.1	14.2	18.1	21.2	24.9	28.5	50.2
VSWR	2.3	4.9	1.8	3.7	2.0	3.6	1.4	2.4

Let's look now at the discrepancies between the published/reviewed results for the A-51 antenna and the results from the NEC2 model - it will soon become clear where and how those discrepancies arise.

How / Why?

The first point which needs to be made is that the NEC2-modelled antenna gives VSWR values ***at the antenna feed-point***, whereas the published/reviewed VSWR values are measured ***at the transmitter***.

Several studies and sources - both online and in publications from the ARRL - show that differences in VSWR values at an antenna feed-point, compared with those at the transmitter, can be largely attributed to losses incurred within feed-lines, especially in lossy coaxial cables. Generally speaking, the greater the feed-line loss at a particular frequency, the greater the difference between VSWR values at feed-point and transmitter.

These differences follow a mathematical rule relating the two VSWR values: the reflection coefficient Γ_{TRX} at the transmitter is related to the VSWR at the transmitter S_{TRX} as:

$$|\Gamma_{TRX}| = VSWR_{TRX} - 1 \;/\; VSWR_{TRX} + 1 \qquad (1)$$

If for example the VSWR at the transmitter is 3:1, then the reflection coefficient $|\Gamma_{TRX}|$ will be 0.5.

The calculated value of the reflection coefficient at the transmitter can be converted to a corresponding value at the antenna feed-point by reversing the effect of the losses in the feed-line:

$$|\Gamma_{ANT}| = |\Gamma_{TRX}| \;/\; \exp(-2 * L_{DB} \;/\; 8.6858) \qquad (2)$$

where the factor 8.6858 converts dB loss to Nepers.

Using the example above, where the VSWR at the transmitter is 3:1, and the reflection coefficient $|\Gamma_{TRX}|$ is 0.5, if the transmitter is then connected to the antenna with a feed-line with a matched loss of 1.0 dB, Equation 2 tells us that the corresponding $VSWR_{ANT}$ at the antenna is equal to 4.4:1 .

A chart of some typical values of $VSWR_{TRX}$ plotted against $VSWR_{ANT}$ resulting from various different values of feed-line losses can be found online, originating in some editions of the ARRL Radio Handbook - a copy of such a chart is presented here.

The chart is used as follows: for a particular $VSWR_{TRX}$ value, find a loss curve which gives the closest fit to the calculated $VSWR_{ANT}$ value.

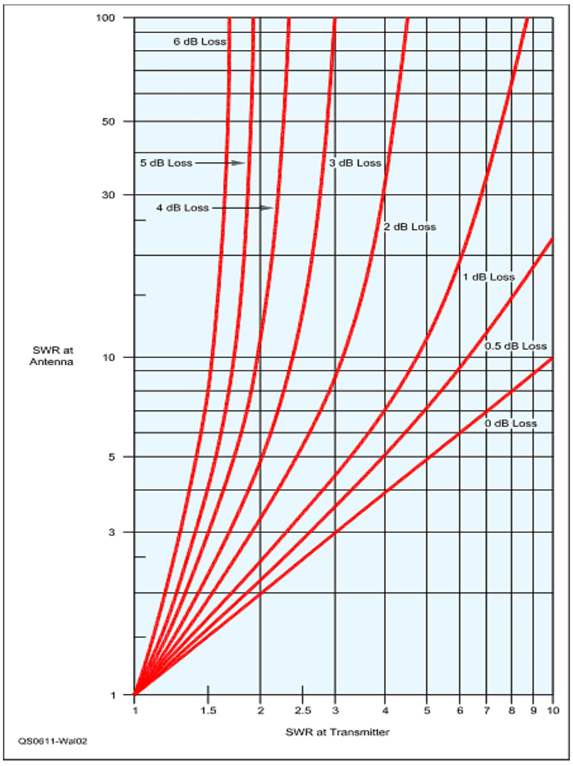

Fig. 5 - VSWR at transmitter / antenna

A similar chart can be calculated for a larger range of values of line-loss, to provide greater accuracy in estimating a $VSWR_{ANT}$ value corresponding to a particular $VSWR_{TRX}$ value, as presented here. This particular chart has a zoom function allowing more precise estimations of VSWR values at transmitter and antenna.

This figure also shows several points corresponding to the VSWR values as derived from the Spiderbeam VSWR charts at particular frequencies.

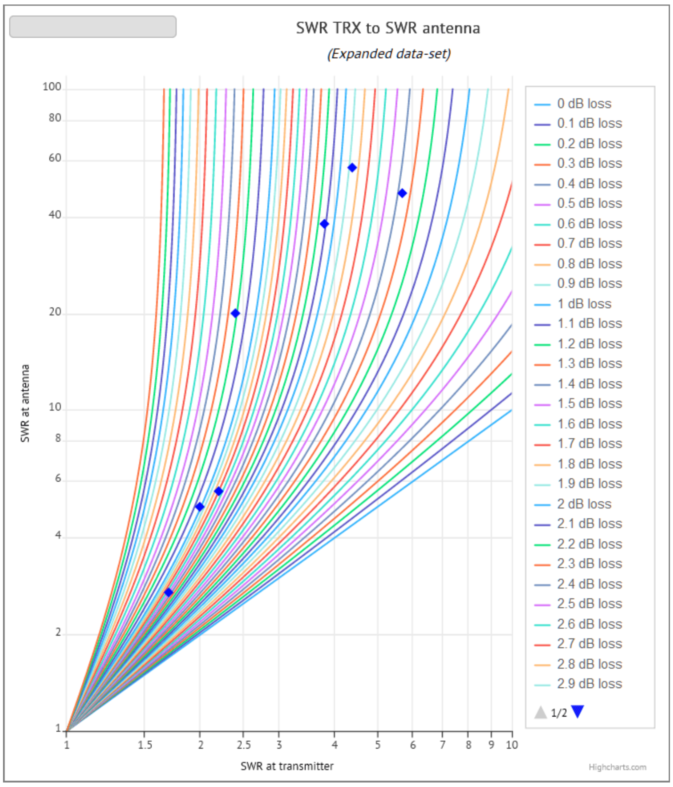

Fig. 6 - VSWR at transmitter / antenna, extended

Using the curves in this extended chart, we can arrive at the following estimations of feed-line loss for the A-51 antenna by comparing $VSWR_{TRX}$ values to $VSWR_{ANT}$ values:

Table 4 - Results

Frequency, MHz	$VSWR_{TRX}$	$VSWR_{ANT}$	Total loss derived from chart	Loss from 12m of RG-174 A/U	Other losses[1]	Power out from 100W input[2]	% loss
7.1	1.7	1.6	-	-	-	-	-
10.1	5.7	47.3	1.37 dB	0.81 dB	0.56 dB	73W	27%
14.2	2.2	5.6	2.7 dB	0.92 dB	1.78 dB	54W	46%
18.1	4.4	57.0	1.87 dB	1.00 dB	0.87 dB	65W	35%
21.2	2.0	5.0	3.0 dB	1.05 dB	1.95 dB	50W	50%
24.9	3.8	38.0	2.12 dB	1.12 dB	1.00 dB	61W	39%
28.5	1.4	2.8	4.55 dB	1.17 dB	3.38 dB	35W	65%
50.2	2.4	20.0	3.42 dB	1.46 dB	1.96 dB	46W	54%

where values for the 40-meter band could not be ascertained from the charts.

Notes:

1: Other losses are calculated by substracting the expected losses from the coaxial cable (from published data for the cable type) from the total losses derived from the chart.

2: Power out from 100W output is derived from converting the total loss in dB (column 4) to power loss in watts.

Conclusions

These results show clearly that the A-51 (Spiderbeam Aerial-51 Model 404-UL) antenna achieves its' "remarkable" published VSWR values by being lossy, both from the RG-174 A/U coaxial cable supplied with the antenna (which is not an especially efficient cable type), as well as from the sealed matching unit which is permanently attached to both the coaxial cable and to the two antenna "legs".

The sealed matching unit has been opened by Gil F4WBY, as seen in his video linked to above: the unit looks like this inside:

Fig. 7 - Inside the A-51 antenna matching unit

where the two toroid cores providing matching and common-mode current suppression are immersed in a solid potting compound, making any attempt at repairs decidedly difficult.

Some small residual losses may also be attributed to the plastic strain-relief sleeves attached to the matching unit body where the coaxial cable and antenna wires emerge from the unit.

Is it a good antenna?

As a rough estimate, between 1/3 to over 1/2 of the signal supplied to the antenna at the transmitter is lost, on most bands. This isn't quite as bad as it may sound since, when operating portable with such an antenna, a great deal depends on the surroundings (trees, buildings, ground type) to influence how well a signal may "get out."

It's well-known that, when operating portable from a remote location, and especially from a hill- or mountain-top, the actual power output from the setup can be as low as just a few watts and still be very effective in bringing in the contacts, and often with good signal reports. The higher VSWR values on the WARC bands would require an antenna tuner.

So the Spiderbeam Aerial-51 Model 404-UL antenna can be an effective antenna when operating portable, although some may question the fact that the coaxial cable and the antenna wires are permanently attached to the unit - if they break off for any reason, the antenna would be rendered practically unusable.