# Some Comments on Laport

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In 1954 I purchased "Radio Antenna Engineering", by Edmund Laport,. I still have this book although my copy shows it's age having been carried over most of the world and soaked in seawater on occasion. I've always found the book to be very helpful and it's been one of my standard references for antennas. Recently I mentioned this book to Paul Kiciak, N2PK, during a discussion of short loaded vertical antennas. Paul wondered if Laport was really correct with regard to the current distributions shown for short verticals. His questions made me realize that I had accepted the information in the book rather uncritically for the past 56 years. While I understood what his sources were I had not checked the material (in particular the discussion in chapter 1 on low frequency antennas) using NEC modeling to see if it agreed with Laport.

That's easy to remedy! The following is a short (very short!) study comparing some NEC results to some of the graphs in chapter 1 of Laport. I focused on figures 1.1 and 1.2 which I've used frequently for preliminary designs of short loaded verticals.

## Caveats!

The graphs in Laport are based on mathematical approximations using the assumption of sinusoidal current distribution on the antenna. While not strictly true on real antennas the sinusoidal approximation has been shown to be very good in most situations, especially for antennas where the height (H) is less than λ/2. When modeling with NEC the wires are divided into segments and the currents are given at the center of each segment and assumed constant along a given segment. There is a limit on how short the segments can be, typically 0.001 λ. In this discussion the modeling frequency is 1.83 MHz where 0.001 λ≈ 6". I used segment lengths of 1' for this modeling. For antennas <50° high (≈λ/8), only a limited number of segments can be used. The result is that the current data points will be a bit sparse. There is also the problem that simple sources are placed at the center of a segment so, for example, putting a source in the bottom segment of the vertical means that the source is actually some small distance up from the base. I could have fixed that by using split sources but I didn't think that worth the trouble. Loads are also placed at the center of a segment. There is also the long standing concern for the accuracy of the current distribution around a junction of several wires, especially when sharp angles are involved. If a load or source is placed close to the junction that further complicates things. Generally it's wise to treat what NEC shows at these points with some caution. NEC is a truly wonderful program but it has limitations which must be kept in mind.

It's well known that due to the diameter of the conductor a wire will be electrically a few percent longer than it is physically. Laport does not take that into account. His heights (H) are the physical height in degrees. NEC on the other hand does take this into account. Laport assumes the top loading is in the form of a disc but for modeling I have used a number of radial wires for the top hat. These effects will introduce small differences. The result is that neither NEC nor Laport can be expected to be exact.

Laport Figure 1.1

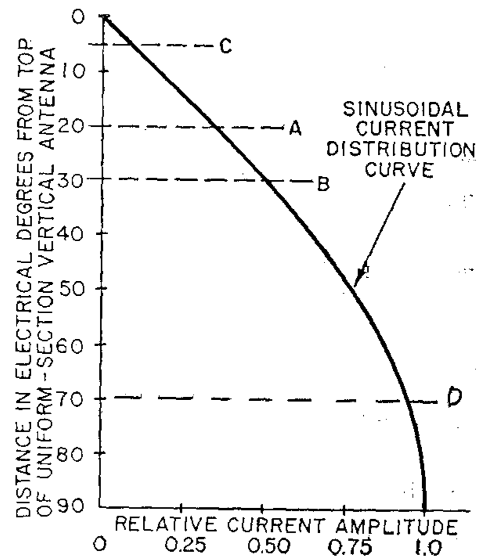


FIG. 1.1. Relative current distributions on electrically short vertical radiators.

Figure 1, Figure 1.1 from Laport showing the current distributions on verticals of different heights.

Figure 1 can be used in two ways: to show the current distribution on a unloaded short vertical (<90°), i.e. the current distribution above lines A-D for different heights or to show the current distribution on a short loaded antenna, i.e. the distributions below lines A-D. The distributions below a given line assume that enough top-loading has been used to resonate the antenna at the operating frequency.

I modeled both these cases with EZNEC pro using the NEC4D engine. For simplicity I used perfect ground and lossless conductors. All the conductors are #12 wire.

Figure 1 shows the current on the vertical is zero at the top and increases as the sin() as you proceed down towards the base and if the antenna is very short the current distribution is essentially linear. Figure 2 compares the modeled current distribution with H = 60° to a sine function. As can be seen, the agreement between NEC and Laport is very good.

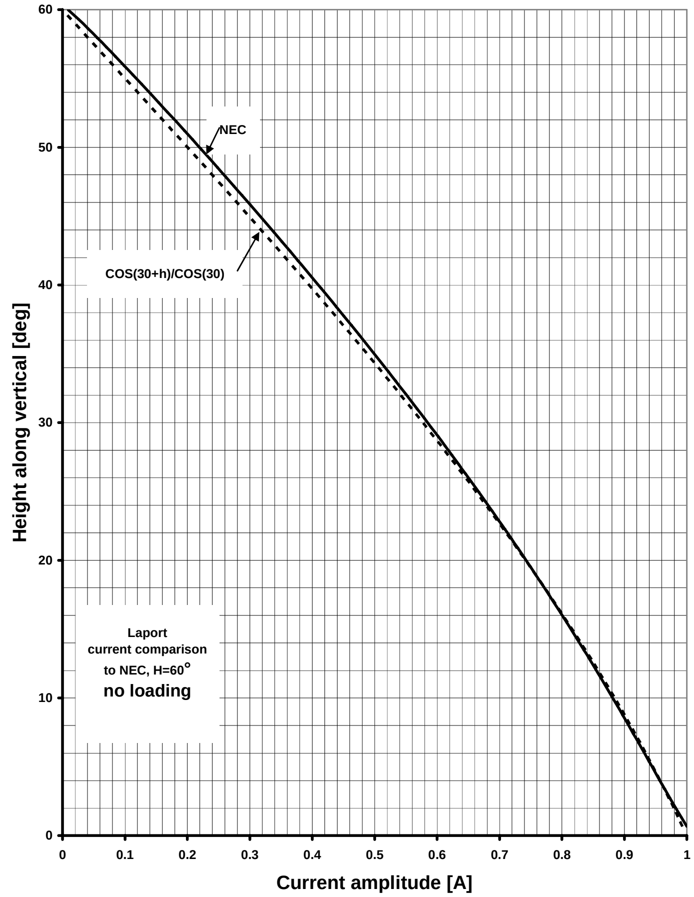


Figure 2 - Comparison of NEC modeling results to
Laport predictions for an H=60° unloaded vertical.

Another possibility would be to chop of the top of the antenna and replace it with a capacitive disc or several horizontal radial wires long enough to resonate the antenna, i.e. $Z_{in} = R_{in} \pm j0$ at the base. The NEC model I used is shown in figure 3.

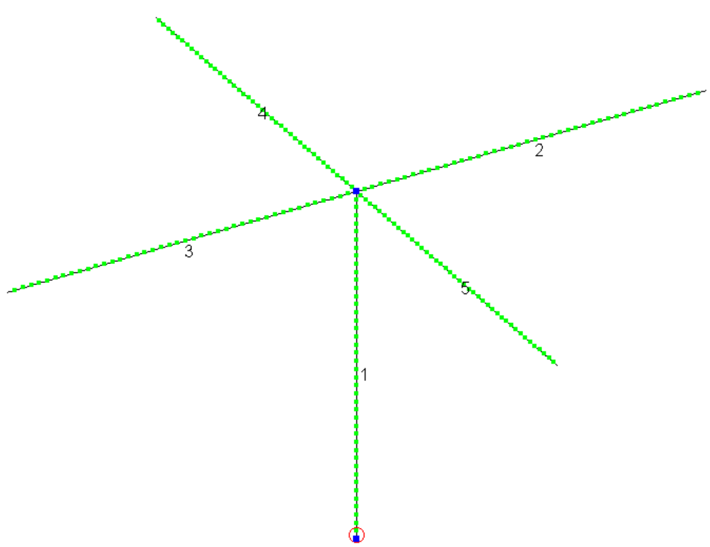


Figure 3 – NEC model for a short (H=30°) top-loaded vertical

Figure 4 compares the current distribution on this model to a cos(h) distribution for H = 30° with two types of top loading to resonate: four radial wires only and a combination of radial wires and an inductor placed right under the top hat. Over most of the vertical we see good agreement between Laport and NEC. However, at the top of the antenna there is a small difference. As we'll see in the next section, this small difference in current distribution doesn't seem to have much effect on the NEC radiation resistance ($R_r$) values compared to Laport's calculation. In any case Laport's profile is a good approximation.

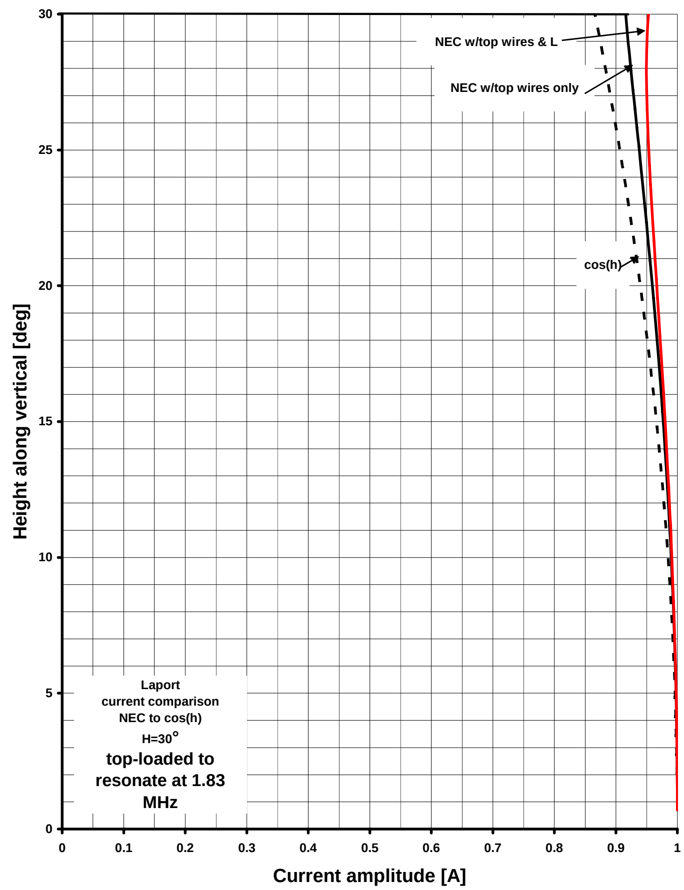


Figure 4 – Comparison between NEC and Laport for H=30° with two forms of top loading: 42' radials wires alone and 20' radial wires with an inductor at the top of the vertical wire.

Laport's figure 1.1 gives a reasonable idea of what to expect for current distribution on at least some types of short verticals.

<u>Laport figure 1.2</u>

In chapter 1 Laport gives a simple approximation for calculating the radiation resistance (Rr) of short verticals. He states that this expression is valid for H < 30° but it seems to work well up to H = 50° at least. The expression he uses is:

$$R_r = 0.01215\,A^2$$

*Where*

$$A = \frac{H}{2}\left(\frac{I_{top}}{I_{base}} + 1\right)$$

H is in degrees. I inserted this expression into EXCEL and generated the graph shown in figure 5 which reproduces Laport's figure 1.2.

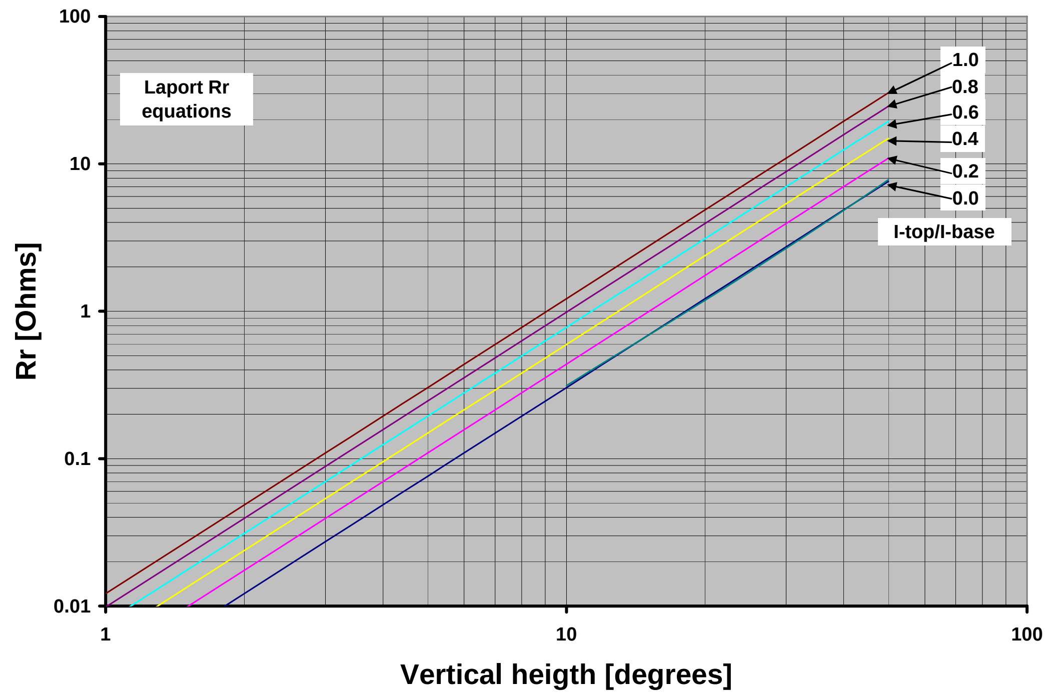


Figure 5 – Radiation resistance, at the base, for short loaded verticals.

To check Laport I modeled several top-loaded verticals with different heights and $I_{top}/I_{base}$ ratios and compared the $R_r$ values between NEC and Laport. Here's what I got:

Table 1

| height [degrees] | NEC It/Ib=0 Rr | Laport It/Ib=0 Rr | NEC It/Ib=0.8 Rr | Laport It/Ib=0.8 Rr |
|---|---|---|---|---|
| 10 | 0.31 | 0.30 | 0.94 | 0.98 |
| 20 | 1.19 | 1.22 | 3.57 | 3.94 |
| 30 | 2.67 | 2.73 | 8.05 | 8.86 |
| 40 | 4.83 | 4.86 | 14.45 | 15.75 |
| 50 | 7.79 | 7.59 | 23.08 | 24.60 |

As can be seen, the agreement is pretty good. More than adequate for an initial design.

Laport's expression relates $R_r$ to the Ampere-degree area of the current distribution (i.e. the integral of the current over H in degrees). In the ARRL Antenna Compendium, Volume 1, 1985, pp. 108-115, Bruce Brown, W6TWW (sk), wrote an article entitled "Optimum Design of Short Coil-Loaded High-Frequency Mobile Antennas. What Bruce did was to extend Laport's concept of "Ampere-degree area" to verticals without top loading but with the coil inserted part way up the vertical. There has been some discussion on his treatment of the current distribution across the loading coil. The current profile across the coil is not constant as he assumes but decreases somewhat from bottom to top. The magnitude of difference in current amplitude between the ends of the loading coil is however, a matter of some dispute but I still feel Bruce's work has considerable merit.

## Conclusion

I think Laport's work agrees well with NEC and has the advantage that for a given antenna height you can get a very good idea of the current distribution and the radiation resistance by inspection with only a few minutes of effort. That's a great starting point for the design of a short antenna where the next step is to NEC modeling.