NEC model of the Cobra antenna

This article explores the Cobra Junior linear loaded antenna for 80m to 10m bands.

Introduction

Cobra

The Cobra antenna is a linear loaded dipole described by Ray Cook (W4JOH) in 73 magazine (June 1997), and gets its name from the "S" configuration of the radiator conductors. Two versions were described, this article looks at the Cobra Junior which is 22.25m (72') overall, and promoted as an all band antenna from 3.5MHz to 30 MHz.

A system view

Components of an antenna system interact with each other in a complex way, and it is important to analyse the entire antenna system (radiator, earth, transmission line, balun, ATU etc) to obtain a correct understanding of how the system works overall.

Directivity and **Gain** are important parameters of an antenna.

Directivity is the ratio of the radiation intensity from an antenna, in a given direction, to the radiation intensity averaged over all directions. **Directivity** is mostly related to the geometry of the antenna, and how current is distributed on the conductors.

Gain is an actual or realised quantity which is less than **Directivity** due to **Loss** in the antenna system.

Loss in the antenna system is the conversion of radio frequency energy to heat, eg in the resistance of conductors.

Gain is related to **Directivity** and **Loss** by the formula **Gain**=**Directivity**/**Loss** or **Gain**(dB) =**Directivity**(dB) - **Loss**(dB).

This article focuses on antenna system **Loss** which degrades antenna system **Gain**, reducing **Loss** increases **Gain**.

This analysis does not consider directivity, or polar pattern of the radiator, or degradation of ladder line performance when wet.

Acceptable loss

Real antennas are a compromise between performance and practical limitations or economies of implementation.

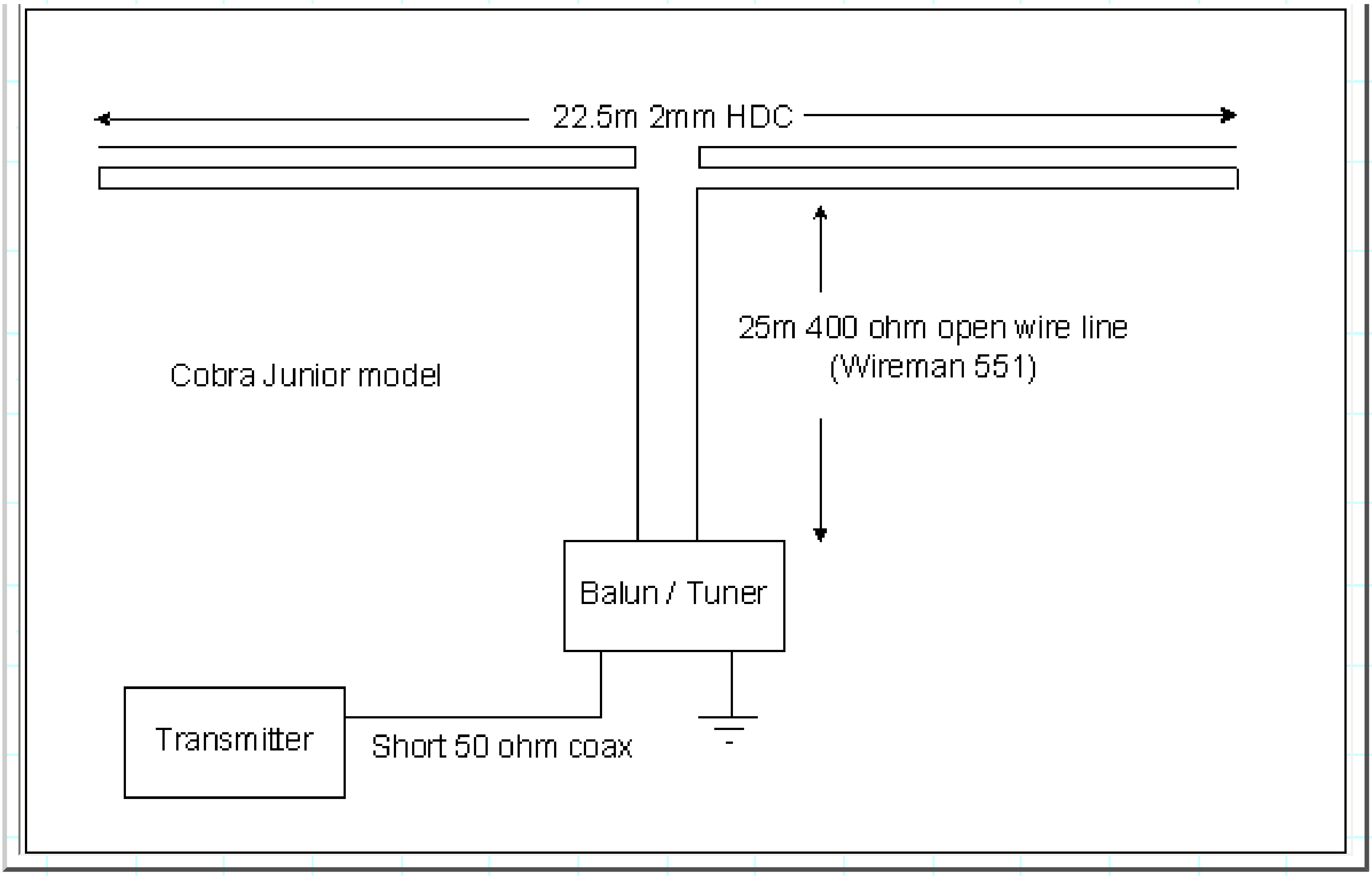
Each implementer must make a judgement of system loss that is acceptable to their compromise solution. Generally, one expects to accept higher losses in a multi-band antenna system as part of the trade-off for frequency coverage. For average situations, it should be possible to implement multi-band HF antennas with not more than 3dB of system loss on any required frequency. For the purpose of this article, 3dB is regarded as the maximum acceptable system loss, that is at least 50% of the transmitter output power is radiated.

Analysis

General

The antenna modelled in this article is a linear loaded dipole with a length overall of 22.25m and is at a height of 10m over average ground (&epsilon=13, σ=0.05). Each leg of the dipole consists of three 2mm HDC conductors of 11.125m length wired in a linear loaded configuration with bridges at the ends as required. The radiator conductors are arranged vertically with a spacing of 100mm. The modelled antenna is fed with 25m of Wireman 551Ladder Line and an ideal 1:1 balun. See Figure 1 for a diagram of the Cobra Junior model configuration.

Figure 1: Cobra Junior configuration modelled



Transmission line losses are modelled using the method and characterisation used by the RF Transmission Line Loss Calculator / Enhanced .

This model also includes a practical L match. The L match used for tuner loss is in general, the most efficient way to transform the load impedance. Using the loss of a practical L-match tends to underestimate the loss in any other tuner configuration.

The NEC model deck is here.

Model comments

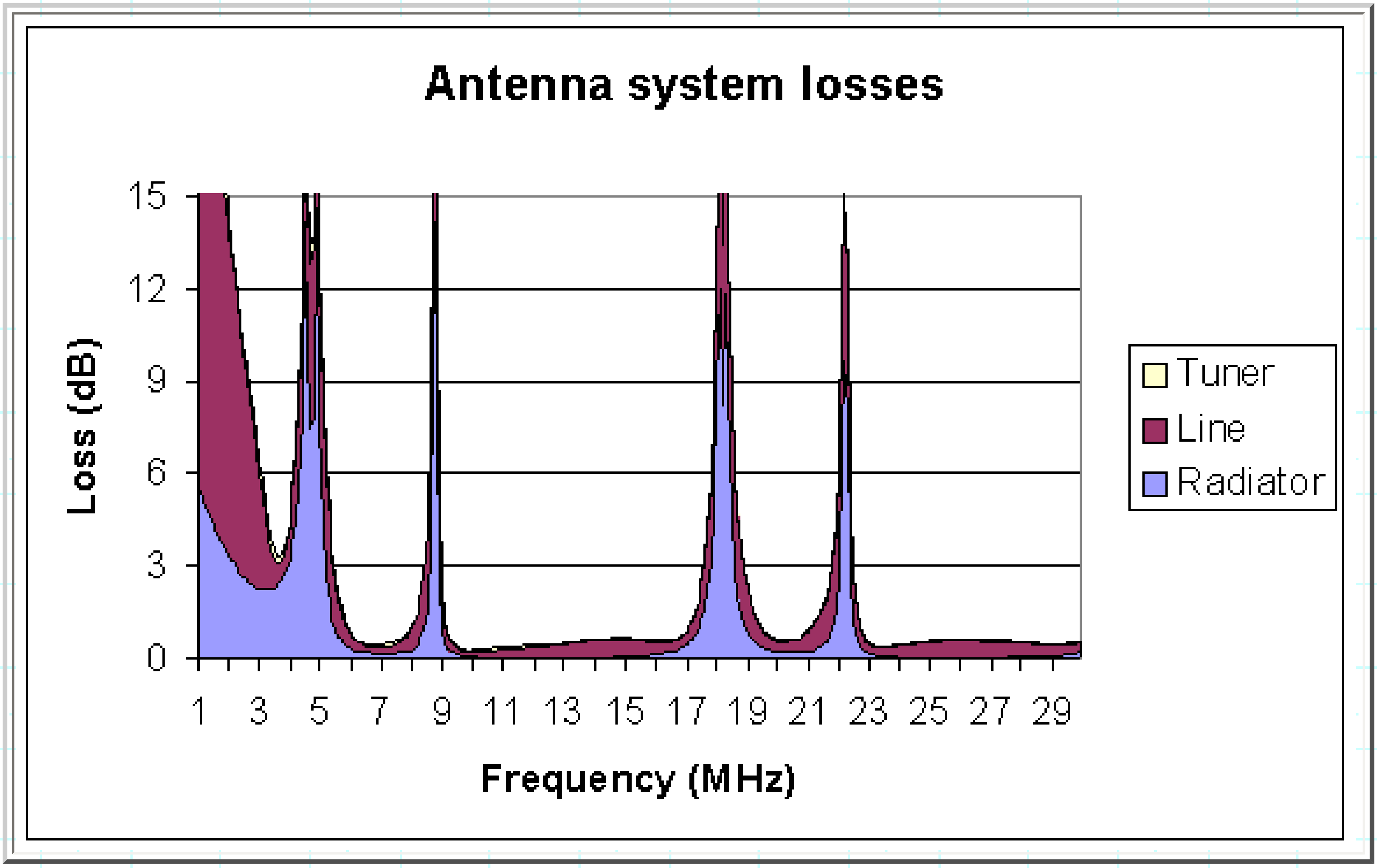
Though the Cobra is described generally with a 4:1 balun, the use of an ideal 1:1 balun in these models may slightly affect tuner losses which are insignificant so the change is immaterial.

At some frequencies in the region of the peaks in radiator loss, model results indicated some numerical instability, however the calculated values approached the maxima smoothly and suggest that the occurrence of the maxima is real even if there may be some issue with the exact magnitude of the peaks. The models were run with nec2dx500.exe which is a double precision NEC2 implementation. Similar results were obtained at some spot frequencies using EZNEC v3.0.58.

Antenna system losses

Figure 1 shows the results of modelling the system losses. The graph shows the principal components of antenna system loss over the frequency range of 1 to 30Mhz.

Fig 1: Cobra Junior antenna system losses



The radiator loss is quite interesting, it is very different to what would be expected from an unloaded centre fed dipole. There are peaks in radiator loss at several frequencies, and the loss in the region of these peaks is very large and would for most purposes be regarded as unacceptable.

An insight into the loss mechanism can be gained by considering that in each incremental length of the combined radiator there are three wires. The contribution of the incremental length to radiation or moment is approximately proportional to the algebraic sum of the currents (haring regard to their phase), whereas the contribution of the incremental length to loss is proportional to the sum of the square of the magnitude of each of the currents. It is this mechanism that gives rise to loss maxima where the sum of the moments over the whole antenna is low compared to the sum of the loss increments.

Though the performance around 3.5MHz might be regarded as acceptable loss for a multi-band antenna, the performance degrades rapidly at higher and lower frequencies. There is a risk that in specific installations, the notch in loss around 3.5MHz above might be displaced sufficiently by environmental factors (environmental detuning) that performance may be substantially worse than the observed 3.5dB or so. A similar issue exists in respect of the 15m band where modelled loss is acceptable, but is adjacent to a region of very high losses and environmental detuning could seriously impact performance. To a lesser extent, the 30m band is adjacent to another loss maximum at around 9MHz. On this model, the antenna cannot claim to cover the 17m band with acceptable loss where system losses are calculated to be around 17dB.

Line losses are moderate above 3.5MHz, but dwarfed by radiator losses at many frequencies. Tuner losses are very low, and insignificant.

Conclusions

- System losses are relatively high, and in some frequency bands are so high as to be unacceptable for most applications.
- The minimum usable frequency is around 3.5MHz, though system loss does not quite meet the acceptable loss criteria.
- System losses are acceptable in HF amateur bands from 40m to 10m with the exception of the 17m band where losses are extremely high. Note that losses in the 80m band and 60m band exceed the the acceptable loss criteria.
- Model losses adjacent to the 80m, 30m and 15m bands are very high, and there is a risk that with environmental detuning, performance in some of those bands might be much worse than indicated by the model.
- This analysis does not support the proposition that the "loss of the extra wire" in linear loading is "essentially negligible" as stated in the ARRL Antenna Handbook (18th ed).

Links

- Cobra Ultralight a commercial implementation of the Cobra and Cobra Junior, but with different conductors and conductor spacing than those modelled in this article.
- Cobra "Senior" antenna system losses graph similar to Figure 1, similar model except length overall is 42.7m, make your own analysis.
- Centre fed dipole (30.5m overall) with 23m of 600 ohm tuned feeders loss graph for comparison with Cobra Junior.

How was it done?

The analysis is based on an NEC model of the radiator. The NEC model of the dipole is available here. NEC2 was called from a custom PERL script that created the Sommerfield ground model and run NEC2 to create a report of feed point impedances from 1MHz to 30MHz in 0.1MHz steps.

A PERL script was written to parse the NEC report, and do the transmission line calculations (impedance transformation, loss, voltage etc) and L-Tuner simulation. The results were written to a tab delimited text file which was loaded into Excel for the final analysis and graphics.

Transmission line parameters come from the Transmission Line Loss Calculator / Transmission Line Loss Calculator Enhanced.

(Note that none of the results depend on approximations based on VSWR.)

Changes

Version	Date	Description
1.01	11/06/2006	Initial.
1.02		
1.03		

V1.01 10/08/06 23:54:34 -0600 .

Use at your own risk, not warranted for any purpose. Do not depend on any results without independent verification.
