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More on Sag in Wire Antennas

A Computer Program to Calculate Wire Sag

When I read the March 2014 *QST* "Technical Correspondence" column, I thought you might like a program I wrote many years ago. Before retiring, I was a land surveyor. For about the last 20 years I worked for a large engineering firm as head of the surveying operations nationwide. We did transmission line engineering for large utility companies.

I wrote the "Sag Utilities" program so my survey crews could reduce the field measurements to design values, to compare with drawings or technical specs while in the field, so that errors would not force return trips. What we normally measured was the amount of sag, line temperature, span and support elevation data.

This simple program allowed us to take that data and determine the tension for a given temperature and ground or obstruction clearance for other factors. The program is available for download on the ARRL *QST* In Depth web page.[1] The program is also available for download at: **www.mediafire.com/download/0bc80x0i95bo7ps/SagUtil.exe**.

The *Sag_Utilities.zip* file on the *QST* In Depth web page includes a sample data file that you can load by using the FILE > OPEN pull down menu, and selecting the *testdata.sag* file.

You will probably only use the Catenary and Fit Sag options until you play with the program for a while. Figure 1 is a screenshot of the input data and calculations for the example given for the nomograph from the original January 1966 *QST* article, and the March 2014 "Technical Correspondence" column. Note that the CATENARY button has been pressed, and the appropriate data typed into the spaces for TENSION, WIRE WEIGHT/FT, CHANGE HEIGHT (the difference in height from one end of the wire to the other) and SPAN. Hit the CALCULATE button to find your results, displayed above the wire on the program screen.

A tip: the CATENARY CONSTANT field assumes the tension for a 1-pound-per-foot wire. Just multiply the catenary constant by the wire weight per foot to get the horizontally applied tension.

There are many other things we can do with this program. Assume you hang a dipole with 10 pounds of unsupported coax at midspan (using the same data for the other parameters). Divide the weight of the coax by the length of the span between supports; 10 lb / 420 ft = 0.0238 lb/ft. So, we will add 0.0238 lb/ft to the wire weight of 0.011 lb/ft, for a total weight of 0.0348 lb/ft, and plug that in as the weight/ft. The sag value goes to about 15.37 feet. The catenaries will not be correct but the sag point will be close. A screenshot of this example is included as *Fig_2.jpg* in the *Sag_Utilities.zip* file on the *QST* In Depth web page.

Suppose you want to limit sag to 7 feet. If you hit the FIT SAG button it will take you to a new screen, where you can fill in the 7 in the SAG box and hit CALCULATE. The catenary constant is now 3151.17. (This screenshot is included as *Fig_3.jpg* in the zip file.) To find the new tension required for the 7-foot sag, remember the tip from earlier — multiply the 3151 catenary constant times the 0.0348 lb/ft wire weight. This will give you a result of about 110 lb of tension required. One other note: in my program the variable TENSION is the horizontal tension, close enough for nearly level spans, but that would need to be adjusted for the

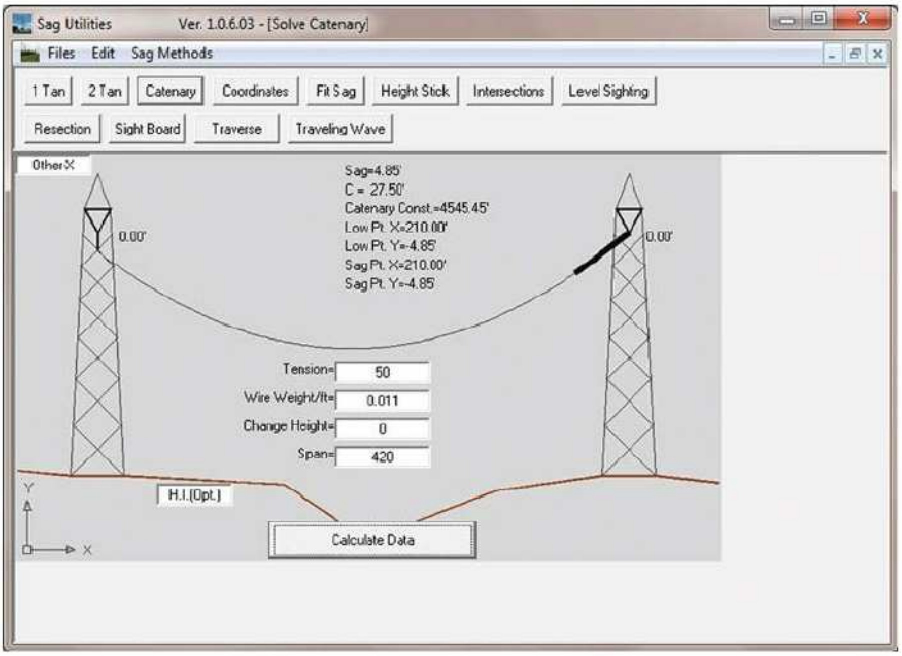

Figure 1 — This screenshot from Ron Watson's *Sag Utilities* computer program shows the calculation for the example used in the March 2014 *QST* "Technical Correspondence" column. The CATENARY button was pressed, the appropriate numbers entered in the spaces below the sagging wire, and then the CALCULATE DATA button was pressed. The results are displayed above the sagging wire. Screenshots from other examples discussed in the text are part of the *Sag Utilities.zip* file available for download from the *QST* In Depth web page. See Note 1.

[1]Notes appear on page 71.

cosine of the angle (horizontal span/cos angle from ground to guy point) for very inclined spans such as guy wires.

Instead of antennas, I find sag calculations to be more useful as guying or temporary guying indicators, such as calculating a pull tension for temporary guying that will not allow more than an inch or two of stretch on a back stay when increasing the side load by "tramming" antennas or equipment or bringing permanent guys to final tension. A tension gauge is also helpful for this, if one is available.

There is a useful calculator online that helps with the length. Go to **www.spaceage control.com/calccabl.htm?F=50&a=420 &q=.011&g=32.18503937&Submit+But ton=Calculate**.

Using this calculator with the data from the original example, a change of tension from 50 to 400 pounds increases the wire length by about 2 inches, so you can see that temporary guying does not need real tight tensioning if you can allow the tower to move an inch or so with side load (wire only, no rope).

If you are using 3⁄16 inch EHS guy cable at a 70-foot high attachment point on a tower, and a guy anchor point 56 feet from the base of the tower (level ground assumed), then if you pull the temporary back stay with a 40-pound horizontal force, you will wind up with about 1 foot of sag in the guy cable, with approximately 66 pounds total tension (about 48 pounds of vertical tension) and a wire length of about 89.7 feet. Since the straight line distance of 89.7 feet = 70 feet high by 56.09 feet offset, it follows that a high tension on the opposite side of the tower will only move about 0.09 feet (about 1⅛ inches). Don't use this with rope! Even non-stretch rope has creep in it and may stress the tower. The angle of the guy from the ground is about 53° so the inline tension would be about 66 lb (40 lb/cos(53°)). (*Fig_4.jpg* is a screenshot of this calculation, included in the zip file.)

To get the approximate tension on a guy wire, say 400 lb in line with the guy with the same dimensions above, put 240 pounds of horizontal tension and pull up the slack until you have about 0.16 foot (1.92 inches) of sag.

I hope you find this information and my program to be useful. — *73, Ron Watson, AA4RW, 156 Charles Cir SE, Cleveland, TN, 37323*; **aa4rw@arrl.net**

Another Program for Calculating Antenna Wire Sag

I am writing about the "Technical Correspondence" letter in the March 2014 issue of *QST* about predicting sag in wire antennas. I am very interested in this subject, and I worked on it a few years ago to offer to the community a solution that is simple to use.

For this purpose I added a *Chain* function to my *Galva* program. This solution includes computations for non-horizontal (extremities not at the same height) wire antennas, and the possibility to reflect a load/mass somewhere along the antenna (to simulate a feed line).

I wrote an article about that in the February 2012 issue of Radio Amateurs of France IARU Society (L'association Réseau des Émetteurs Français) publication *Radio REF Revue*. You can download my article and my *Galva* software from my website at: **www.f5bu.fr/wp/?page_id=13**. *Galva* may be used in French, English, German, and Spanish, and the help is also available in Russian.

Galva is a command interpreter, including graphic commands. It was first built to draw scales for galvanometers, potentiometers, with linear, logarithmic, and others scales, including manual scales. These are easy to draw with the program. Over time, many other possibilities have been added.

The *Chain* function can be confusing, so I have included some examples, which I hope will make it much simpler to use. Even if the code is a bit more complicated, only a few parameters have to be entered/changed.

To give you an idea of what is possible, you can download a zip file with some sample data files from the *QST* In Depth web page. Look for the *F5BU_Galva.zip* file.[2]

GalvChain_A_en.pdf is a pdf print of the *GalvChain_A_en.dat* code example (=*GalvChain_A.dat* with translated commentary).

GalvChain_W1DQ.pdf illustrates the example used in the March 2014 "Technical Correspondence" column.

My conventions are that the wire antenna is suspended between point 1 and point 2. The coordinates of point 1 are $X1 = 0$ and $Y1 = 0$. $X2$ is the abscissa of the second point (arrival). $DH2$ is the vertical distance between the anchor points 1 and 2. D is the straight line distance between the two anchor points. L is the antenna length and a is the coefficient of the equation of the chain (catenary or wire antenna).

The departure angle is aD, also noted as *Theta_1*; *Theta_2* is the arrival angle. T is the tension on the antenna, TV the vertical component and TH the horizontal component, k is the linear weight of the wire antenna (weight per unit length), *FlècheV* is the vertical sag. The sag is defined as the maximum vertical distance between the antenna wire and the straight line connecting the fixing points. $X0$ is a parameter in the real equation, which corresponds to the horizontal distance between point 1 and the lowest point (this is not of interest with horizontal antennas). XF is the horizontal distance between point 1 and the maximum sag point (this is the same as $X0$ with horizontal antennas).

I distinguish the tension on the wire and its horizontal and vertical components. The a coefficient is equal to TH / k, and TH may be some value different from T, which is usually the practical known value (see *GalvChain_A*). So with the *GalvChain_W1DQ.dat* file example, using $a = 4545.45$ ($= 50/0.011$) gives $TH = 50$, $T1 = T2 = 50.05$ (horizontal antenna) and $FlècheV = \text{Sag} = 4{,}852$. Using $a = 4541$ gives $TH = 49.95$, $T1 = T2 = 50$ and Sag = 4.856. Other example files supplied with *Galva* allow us to select the antenna length or the departure angle.

GalvChain_LC.pdf is a pdf print of the *GalvChain_LC.dat* example file with a load (mass) at 35% of the wire length (this may also be expressed as absolute value: %LC1 = 35).

Many pdf files are available in the downloadable *Galva_200a-4L1.zip* file. These files may be seen without installing the program. Of course, to be able to write your own .dat files with *Galva*, you need to learn a little bit about the program, but using just the sag examples is very easy.

Installation is fairly standard: run the *setup.exe* file, start the *Galva.exe* file, choose your language, open a file and have a look at the help (F1), try some changes in an example file, and have some fun experimenting. — *73, Jean-Paul Gendner, F5BU, 182 route de Mittelhausbergen, Strasbourg, 67200 France*; **f5bu@orange.fr**

NVIS Myth Follow-Up

In the "Technical Correspondence" column in the January 2015 issue of *QST*, we ran a letter from George Kidder, PhD, W3HBM, under the heading "The NVIS Myth — A Modeling Study." That letter brought several quick replies.

Several correspondents made some valid points about the NVIS operating strategy. Lloyd Bankson Roach, K3QNT, Western PA Section 2 District Emergency Coordinator, wrote to say, "While mostly accurate, he failed to mention that the NVIS method is a lot more than efficient or inefficient antennas. Near Vertical Incident Skywave methods were exhaustively researched by the German Wehrmacht, and Clarence Beverage, during World War II. In addition, LtCol David Fiedler, USMC did extensive work during the Vietnam War in 1968 on the efficacy of NVIS, especially in jungle and combat conditions. In the late 1990s we owed a great deal to the substantial practical testing performed over 8 years by Patricia Gibbons, WA6UBE (SK), on behalf of the California Department of Emergency Management.

"All of these authors made it abundantly clear that NVIS was a combination of antenna height, frequency, and power level. In order to create and maintain a successful NVIS circuit, all three must be maximized. Knowledge of propagation is every bit as important as antenna construction.

"The use of NVIS, especially during combat conditions demand a certain amount of stealth to avoid jamming, which often requires very low and inefficient antenna height. With this in mind, Dr Kidder's assertions about loss is irrelevant. I am personally acquainted with using NVIS methodology in US Navy amphibious beach operations and can tell you from personal experience, you do what works when you need it. This is why it is so effective during domestic emergencies. It can be easily and effectively deployed with minimal gear."

Paul Gibb, KB1TOR, also wrote with a few thoughts. "Thanks for your article in *QST*, which I found very interesting. Isn't NVIS and the use of low dipole antennas also about improving signal to noise ratio by eliminating/reducing received signals from distant sources? I am very interested in NVIS, because I have been involved with a project to equip a number of municipalities for NVIS operations when repeaters fail and terrain makes VHF simplex communications impossible. I am always looking for anything we can do to make short-range HF emergency communications practical and effective."

George Kidder, W3HBM, offered further comments as well. "Thanks for your interest. I did not mention the receiving situation, and you are right that receiving should be considered. On receive, it is the ratio between desired signal and QRM plus noise that is important, and an improvement of (say) 6 dB in high-angle signals as the result of raising a very low antenna would have the same effect as a decrease of 6 dB in the reception of QRM from afar. Only the S meter would know the difference. This assumes that both antennas have the same noise pickup from whatever source. I suspect that in many cases, local noise would be higher on a low antenna just because of the proximity of noise sources. This would be an interesting but very much longer study. With modern receivers, which can have instant selection of an independent receive antenna, or (with a sub-receiver) have diversity reception with two antennas, one could probably have the best of both worlds by transmitting on the high antenna and receiving on the low one. Of course, the choice of mode will also be important — dare I suggest CW as one answer?

"My 'Technical Correspondence' letter was intended as a quick look at one aspect of the NVIS operating strategy. Much has been written about choice of frequencies, operating modes and other considerations. I was not trying to duplicate (or dispel) that information. My letter focused solely on one aspect that I think is widely misunderstood — the belief that the closer to the ground that you put the antenna, the better it will be for transmitting signals over a local communications range, from ground zero out to a few hundred miles.

"I gave an example for a 75/80 meter dipole antenna. Perhaps I should have also mentioned the 40 meter band and even other bands for NVIS operation. I might also have given a more general 'rule of thumb' for antenna height, such as putting the dipole antenna between 0.1 and 0.25 wavelengths above ground."

Your editor also researched other articles about the NVIS operating strategy. There have been a number of *QST* and *QEX* articles published over the years.

Dean Straw, N6BV, wrote "What's the Deal About 'NVIS'?" in the December 2005 issue of *QST*. That article is an excellent tutorial, and it covers many aspects the operating strategy. Dean also cites a January 1995 *QST* article by Ed Farmer, AA6ZM, calling it "one of the best articles I've seen on NVIS operation." Recent editions of *The ARRL Antenna Book*, including the current 22nd edition, have an expanded version of Dean's article. This is excellent reading for those who want to understand more about the NVIS operating strategy.

Well-known antenna expert L. B. Cebik, W4RNL (SK), wrote about NVIS antennas in several of his "Antenna Options" columns for *QEX*. In the Jan/Feb 2007 issue of *QEX*, he expanded on Dean's *QST* article, and offered several alternatives to the basic dipole. In that column he also called attention to the ground model limitations of the *MININEC* program compared to the "high accuracy" ground of *EZNEC*, with a reference to another *QST* article — "*MININEC*: The Other Edge of the Sword" by Roy Lewallen, W7EL, in the February 1991 issue of *QST*.

In describing his reasons for writing this article for *QEX*, L. B. said, "The second purpose is to put to rest a certain persistent myth about NVIS dipoles, namely, that a super low height provides a gain advantage."

Please note that no one has suggested that a very low dipole will not work. No one has suggested that there is no such thing as NVIS propagation or operating strategy. The main point of Dr Kidder's letter was that if you are able to put your NVIS 80 meter dipole 50 or 60 feet in the air, do it. Of course if you are not able to put it higher than 10 or 15 feet it will still work, but your transmitted (and received) signals won't generally be as strong as they would be with the higher antenna. — *73, Larry Wolfgang, WR1B, Senior Assistant Technical Editor*; **lwolfgang@arrl.org**

Notes

[1]Ron Watson's *Sag Utilities* computer program is available for download from the ARRL *QST* In Depth web page. Go to **www.arrl.org/qst-in-depth** and look for the file *Sag_Utilities.zip*.

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