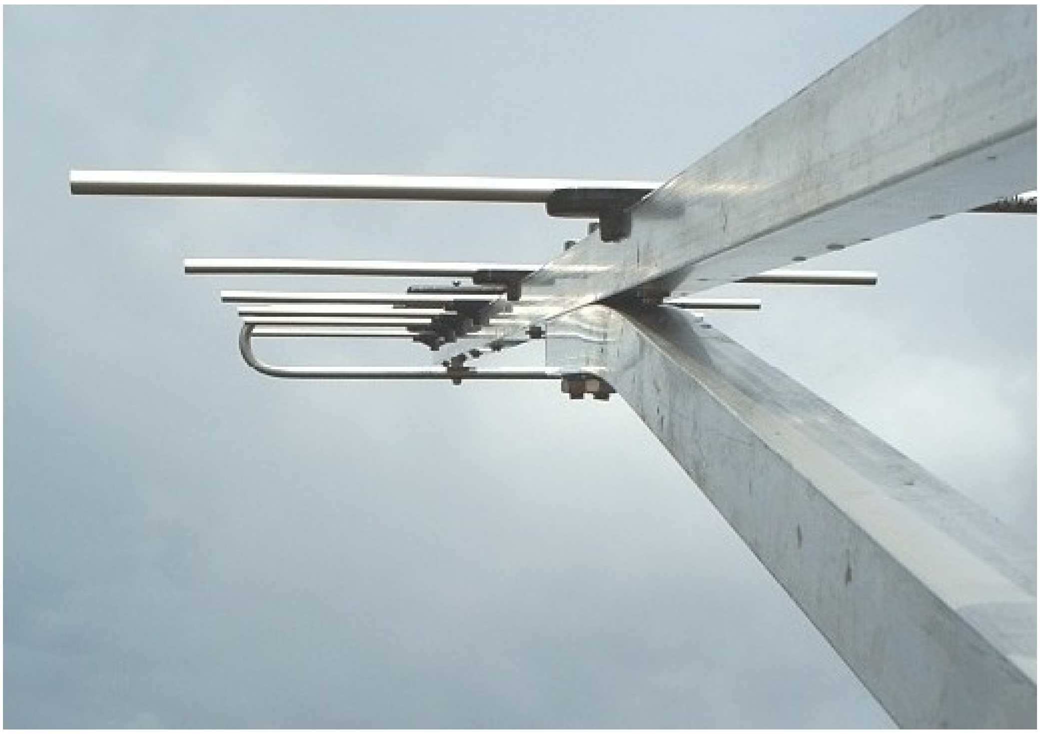
Manual to

DB7YBN's

Yagi Element Configuration Tool



Ref. Vers. 1.51

Written by Hartmut Klüver, DG7YBN on

2017-02-09

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1 Basics

Applying the right BC to a Yagi will ensure getting the most out of its patterns characteristic. Yagis that are carefully designed for certain properties must be built with exact element lengths to take full advantage of these properties. Otherwise you will either loose gain or, more important in my view, add antenna temperature when building with imperfectly compensated boom and insulator influence. It is the F/B and F/R ratios, which will suffer with highest numbers on most designs otherwise.

History

From a simple MS Excel sheet that added BC numbers for On-Boom mounted elements this project grew to a large Visual Basic for Applications powered file. Little by little I added other BCs, automated read-in of NEC files and a data base structure including export to a CSV file.

This project started in 2012, when I released vers. 1.0.1 as 'Elements on Boom Calculator' - often referred to as 'BC Excel'. Since v. 1.24 I have renamed it to 'DG7YBN Yagi Element Configuration Tool' because today it holds much more features that a mere Boom Correction. Such as management of element positions on the boom with editable offset to boom ends or giving the elements centre position.

Meticulous Accuracy?

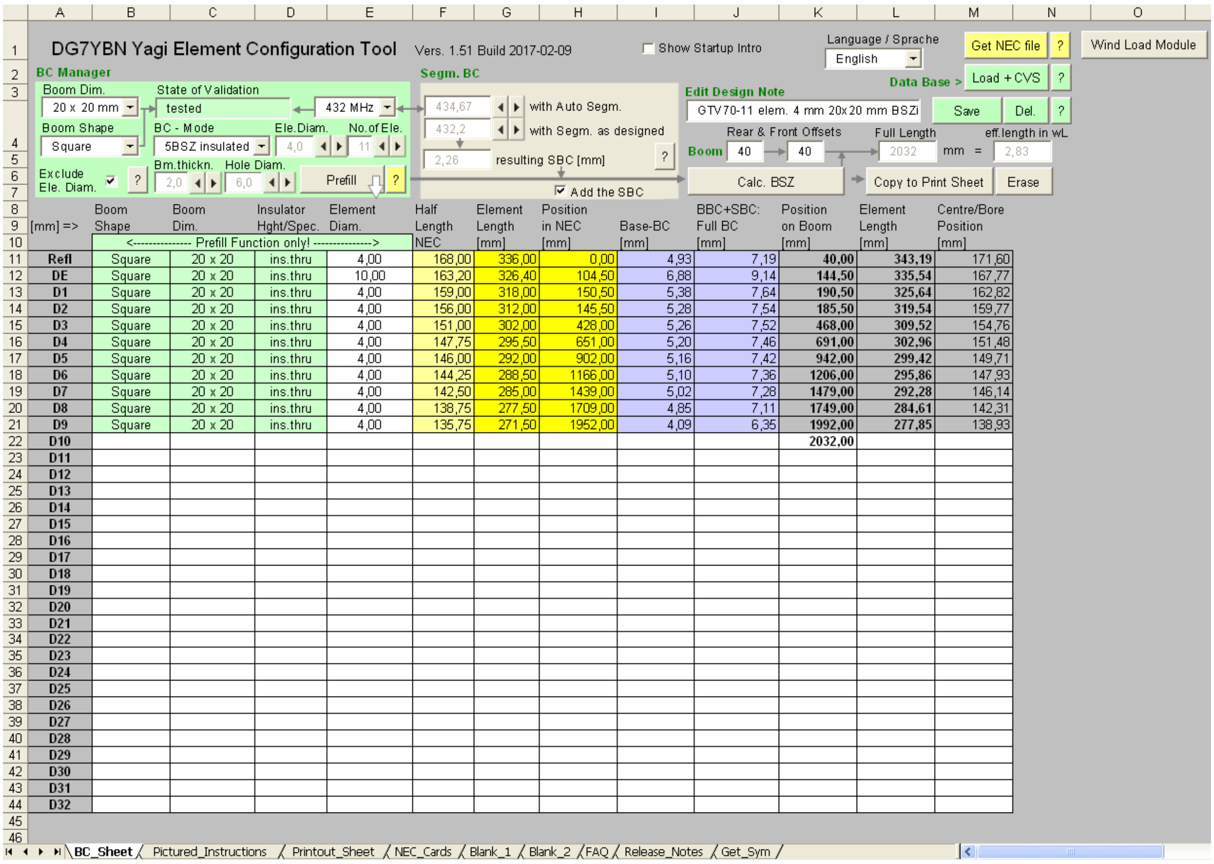
The Yagi Element Configuration Tool uses and produces numbers to two decimal places. You may ask how to produces these in the real world? My answer is, well you are not expected to necessarily, but note that every process or preliminary result is rounded in the input and calculation chain that finally puts out the to be cut element length. All these ‘rounding derivations’ will sum up. Sticking to two decimal numbers keeps up a lot more of accuracy down to the final number. And keeping to two decimal places does no harm. So I keep it accurate on high level. Until it is up to the final step, which is to cut the element.

Those who are well equipped with measurement tools and like to build for UHF are well advised to use or buy a calliper gauge of sufficient size and make plenty of use of it. Or stick to very conventional or wide band designs like the DL6WU series. I have been active building, measuring and plotting or consulting on number of highly developed 432 MHz Yagis for some years now. Among the Yagis handled where some of the most advanced designs present such as the EF7015, EF7017 and EF7023 by YU7EF, a 23 ele. LFA by G0KSC and my GTV 70-19. A delta of +/- 0.5 mm on the length of a number of elements makes a difference on most modern 70 cm designs if you want top performance and the right VSWR.

There are voices that mind that neither the last few 10^{th} of dB in gain, nor a few dB in F/B or some Kelvin in Antenna Temperature would be of significant importance. But I say, now, when we have to cut elements off a long rod anyway, why not do it with the best of care for the right length and get the most from your self built antenna?

1.1 The BC Sheet

The BC_Sheet is the main sheet of the tool. It contains all the functions for BC computation and the necessary adjustments to this.



[mm] =>	Boom Shape	Boom Dim.	Insulator Hght/Spec.	Element Diam.	Half Length NEC	Element Length [mm]	Position in NEC [mm]	Base-BC [mm]	BBC+SBC: Full BC [mm]	Position on Boom [mm]	Element Length [mm]	Centre/Bore Position [mm]
	<-------------- Prefill Function only! -------------->											
Refl	Square	20 x 20	ins.thru	4,00	168,00	336,00	0,00	4,93	7,19	40,00	343,19	171,60
DE	Square	20 x 20	ins.thru	10,00	163,20	326,40	104,50	6,88	9,14	144,50	335,54	167,77
D1	Square	20 x 20	ins.thru	4,00	159,00	318,00	150,50	5,38	7,64	190,50	325,64	162,82
D2	Square	20 x 20	ins.thru	4,00	156,00	312,00	145,50	5,28	7,54	185,50	319,54	159,77
D3	Square	20 x 20	ins.thru	4,00	151,00	302,00	428,00	5,26	7,52	468,00	309,52	154,76
D4	Square	20 x 20	ins.thru	4,00	147,75	295,50	651,00	5,20	7,46	691,00	302,96	151,48
D5	Square	20 x 20	ins.thru	4,00	146,00	292,00	902,00	5,16	7,42	942,00	299,42	149,71
D6	Square	20 x 20	ins.thru	4,00	144,25	288,50	1166,00	5,10	7,36	1206,00	295,86	147,93
D7	Square	20 x 20	ins.thru	4,00	142,50	285,00	1439,00	5,02	7,28	1479,00	292,28	146,14
D8	Square	20 x 20	ins.thru	4,00	138,75	277,50	1709,00	4,85	7,11	1749,00	284,61	142,31
D9	Square	20 x 20	ins.thru	4,00	135,75	271,50	1952,00	4,09	6,35	1992,00	277,85	138,93
D10										2032,00		
D11												
D12												
D13												
D14												
D15												
D16												
D17												
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D27												
D28												
D29												
D30												
D31												
D32												

The ‘BC_Sheet’ is organised in a header and a workspace section.

• Header: from left to right BC Manager, green field; Segm.-BC, light grey field; other and Data Base management & NEC import on left side

Workspace: from left to right :

• Prefill Area : (green // white) as first four columns: - holding Boom Parameter and Elem. Diameter

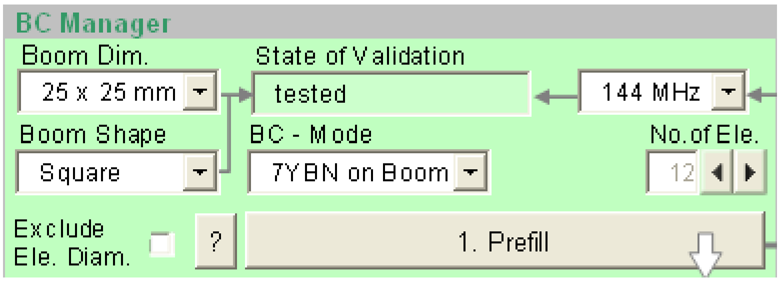
• Geometry section : (yellow) - holding elem. lengths and positions on boom

• Output BC : (light blue) computed BC as Base-BC without SBC and Base-BC with added SBC

• Output Boom Position and corrected elem. length (grey) : Position on boom, corrected element length using the BBC + SBC and element centre position

• Prefill Section

The Prefill section can effectively be used with the ‘BC Manager’s selection options. ‘No. of Ele.’ on the right is Number of Elements a to be entered design contains. The Prefill Function will fill in rows up to the given number of elements. In this example we see a 12 element Yagi, thus ‘No. of Ele.’ is adjusted to ‘12’ and Prefill fills in rows [Refl, DE, D1 to D10] with chosen boom cross section dimensions, form (square / round) and, in case of DG7YBN On-Boom-BC, the height of the standard insulators the BC was derived with.



[mm] =>	Boom Shape	Boom Dim.	Insulator Height	Element Diam.
	<-------------- Prefill Function only! -------------->			
Refl	Square	25 x 25	1,70	8,00
DE	Square	25 x 25	1,70	10,00
D1	Square	25 x 25	1,70	8,00
D2	Square	25 x 25	1,70	8,00
D3	Square	25 x 25	1,70	8,00
D4	Square	25 x 25	1,70	8,00
D5	Square	25 x 25	1,70	8,00
D6	Square	25 x 25	1,70	8,00
D7	Square	25 x 25	1,70	8,00
D8	Square	25 x 25	1,70	8,00
D9	Square	25 x 25	1,70	8,00
D10	Square	25 x 25	1,70	8,00
D11				
D12				
D13				
D14				
D15				

The BC sheet will only compute up to the last coloured line or row. Go back to the full screenshot image of the BC_sheet and find all three sections to be coloured to the line holding the numbers of D10 = element #12.

• Geometry Section

The Geometry section is where you enter element lengths and positions on boom as in the NEC file or from given table or measured Yagi. Note: Position starts with ZERO = 0 for the Refl.

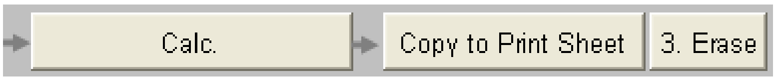
Half Length NEC	Element Length [mm]	Position in NEC [mm]
504,00	1008,00	0,00
476,00	952,00	243,00
474,00	948,00	428,00
470,50	941,00	780,00
459,00	918,00	1323,00
451,00	902,00	1968,00
445,50	891,00	2719,00
440,00	880,00	3542,00
434,50	869,00	4394,00
432,00	864,00	5284,00
428,50	857,00	6239,00
417,00	834,00	6874,00

When entering numbers from a NEC table by hand one commonly needs to double numbers as usually the wire ends are given symmetrically around the boom running down the x-axis.

In this sheet the columns ‘Half Length in NEC’ and ‘Element Length [mm]’ are corresponding in a way that whatever number is entered first – the other is complete automatically. Use it for either convenient fill in from a NEC model table or as ‘helping hand’ when entering numbers form a given design into a NEC geometry table.

• Output BC Section

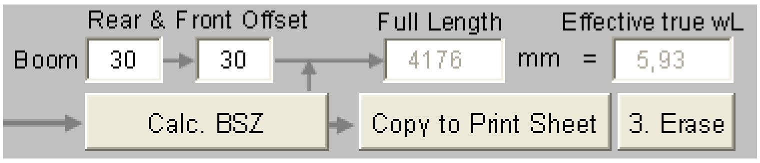
Clicking Button ‘Calc.’ will fill the rows of this section with computed BC (Base-BC), added Segmentation-BC (BBC+SBC) = Full BC, Element Position on Boom with rear and front Offsets per ‘Boom Section’ and Centre Position on Elements.



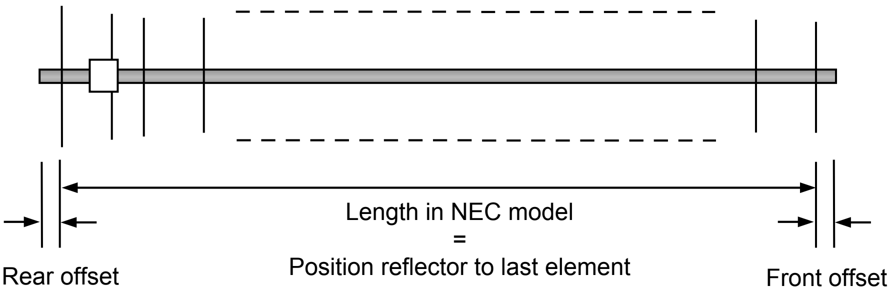
Button ‘Copy to Print Sheet’ puts all data to the Print Sheet. Button ‘Erase’ clears this section of computed numbers.

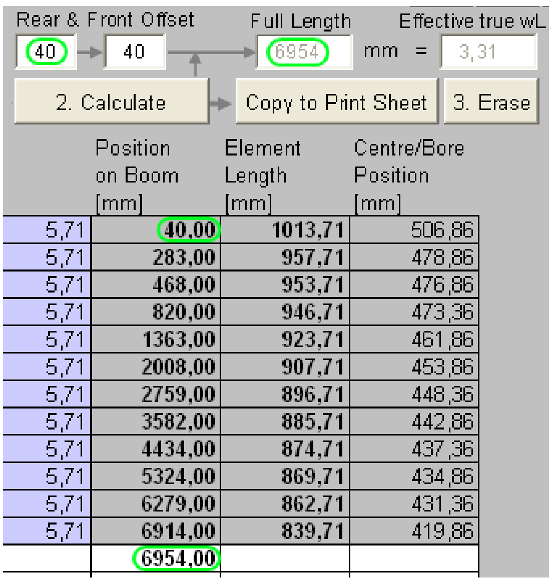
Base-BC [mm]	BBC+SBC: Full BC [mm]	Position on Boom [mm]	Element Length [mm]	Centre/Bore Position [mm]

• Boom Numbers



Enter Offsets to rear and front end of boom to your like. Find full length displayed in millimetres and wave length according chosen band.





	Position on Boom [mm]	Element Length [mm]	Centre/Bore Position [mm]
5,71	40,00	1013,71	506,86
5,71	283,00	957,71	478,86
5,71	468,00	953,71	476,86
5,71	820,00	946,71	473,36
5,71	1363,00	923,71	461,86
5,71	2008,00	907,71	453,86
5,71	2759,00	896,71	448,36
5,71	3582,00	885,71	442,86
5,71	4434,00	874,71	437,36
5,71	5324,00	869,71	434,86
5,71	6279,00	862,71	431,36
5,71	6914,00	839,71	419,86
	6954,00		

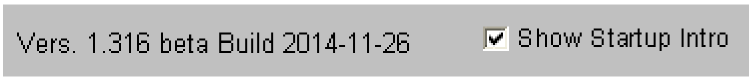
Enter boom tube end offsets on rear and front end of the to be built Yagi.
To edit these textboxes click into them with your mouse and type in a new number.

To process new entries the ‘2. Calculate’ button must be clicked.

Find the first wire = reflector and complete set of elements shifted from position = 0 to the rear boom end offset. Find the boom length for building below last element position and in textbox ‘Full Length’.

For analysts the Yagi Element Configuration Tool also the shows the effective length, as the electrical length without the rear and front offsets expressed in wave lengths (wL). The Tool uses c = 299.792.458 m/s for computing the wave length.

1.2 Stop showing the Intro

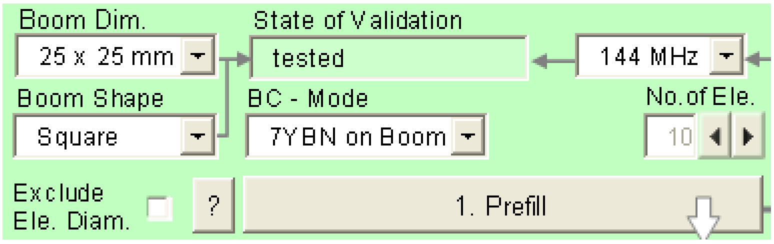


The Yagi Element Configuration Tool shows 3 pop-up Messages during the start up procedure. Please read then carefully, but once you have done that you might want to start your sessions without having to wait for these messages to pass.

Just unhook the ‘Show Startup Intro’ option and set an end to this procedure for next start up, provided you save your copy of this tool.

2 BC Modes

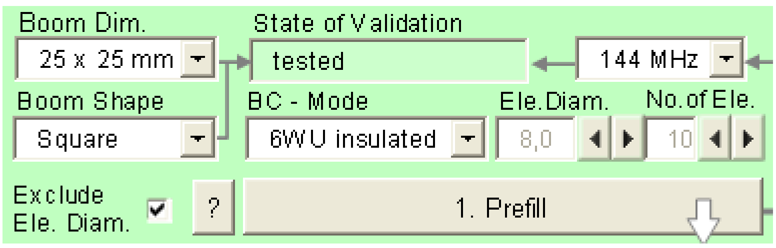
2.1 DG7YBN On-Boom with standard insulators



A BC for use with standard plastic insulators made from furnace black Polyamide (PA 6) plus using a long shafted screw M3 all through the boom to keep element and insulator in place. Best results are yielded using pre defined element diameters of 8 mm (2 m band) respectively 6 mm (70 cm band). With these configurtions I have done extensive testing and verification (s. Dubus Technik X). It will work for minor diameter derivations like from 8 to 6 mm with very little offset too.
Not checking the ‘Exclude Ele. Diam’ box means that the prefill function will overwrite whatever diameters for elements an imported or filled in model geometry had brought with it to the 8 / 6 mm standard depending on band chosen.

The element diameter is not a parameter in the DG7YBN On-Boom BC. Hence the numbers given, filled in or imported in this row have a documentation purpose only. BC numbers applied are gained from antenna measuring. Due to varying heights of the proposed insulators for different boom dimensions no formula can be set up here.

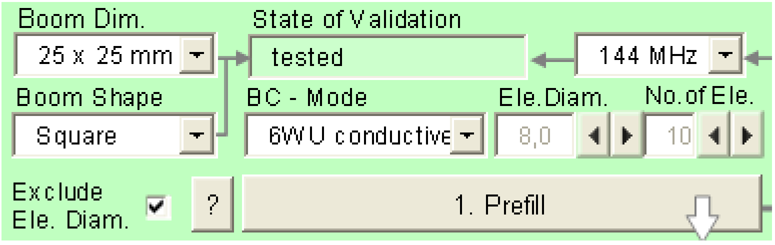
2.2 DL6WU insulated through boom



This Mode uses the well known formula published by DL6WU / G3SEK for length correction of elements mounted insulated through boom. Note that no difference is made out between round and square boom shape with the DL6WU /G3SEK formula for insulated through boom.

The element diameter is not a parameter in the DL6WU / G3SEK formula. Hence the numbers given, filled in or imported in this row have a documentation purpose only.

2.3 DL6WU conductive through boom

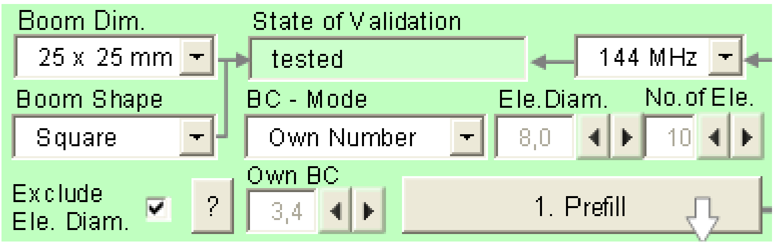


This Mode uses the well known formula published by DL6WU / G3SEK for length correction of elements mounted conductive through boom.

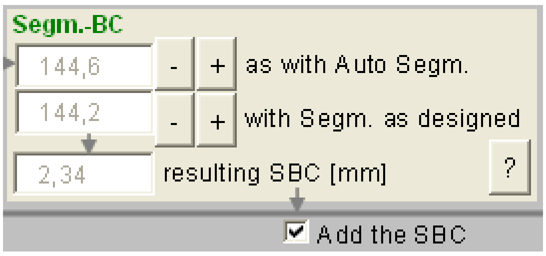
Note (i) that no difference is made out between round and square boom shape with the DL6WU /G3SEK formula for insulated through boom; (ii) the difference between the 'insulated' and 'conductive' fastening correction is a fixed factor 2 for all frequencies and boom dimensions.

The element diameter is not a parameter in the DL6WU / G3SEK formula. Hence the numbers given, filled in or imported in this row have a documentation purpose only.

2.4 Own BC number



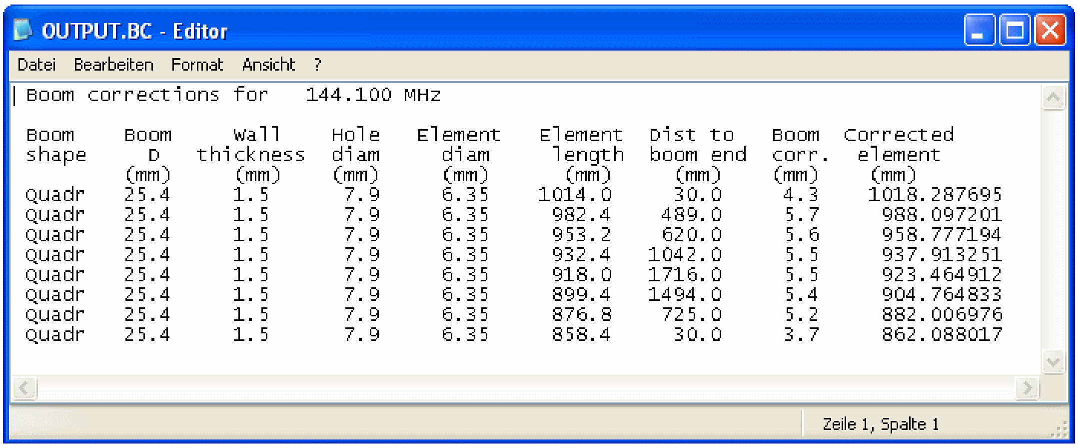
In this mode you may enter whatever Boom Correction you want as own number to suit not included building styles, experiments or while yourself testing for an new BC. Or simply to use this tool with DJ9BV, I0JXX or other BC. The number you adjust in the 'Own BC' textbox and the element length are added. The SBC can be added as an option, depending on hooking the 'Add SBC' option.



Example: Own BC is 3.4 mm, SBC is 2.34 mm, may the elem. length be 980.0 mm.
This will result in 980.0 + 3.40 + 2.34 = 985.34 mm of corrected elem. length.

The element diameter for computing corrected element lengths is not a parameter to this BC mode. There is one sole BC number applied on the complete set of elements which must be assumed to have same or 'not to far astray' diameters. Use Prefill to fill in identical numbers for all elements or edit as suitable for own purpose and documentation.

2.5 SM5BSZ BC.exe insulated through boom


OUTPUT.BC - Editor

Datei Bearbeiten Format Ansicht ?

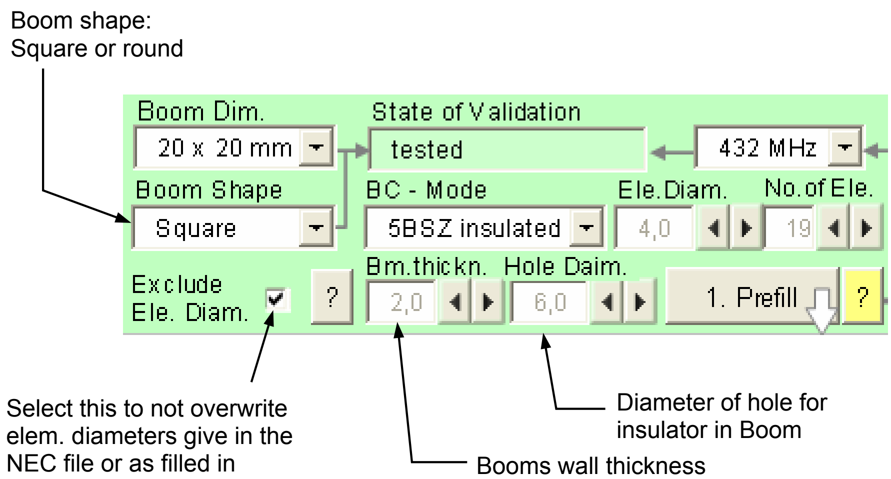
Boom corrections for 144.100 MHz

Boom shape	Boom D (mm)	Wall thickness (mm)	Hole diam (mm)	Element diam (mm)	Element length (mm)	Dist to boom end (mm)	Boom corr. (mm)	Corrected element (mm)
Quadr	25.4	1.5	7.9	6.35	1014.0	30.0	4.3	1018.287695
Quadr	25.4	1.5	7.9	6.35	982.4	489.0	5.7	988.097201
Quadr	25.4	1.5	7.9	6.35	953.2	620.0	5.6	958.777194
Quadr	25.4	1.5	7.9	6.35	932.4	1042.0	5.5	937.913251
Quadr	25.4	1.5	7.9	6.35	918.0	1716.0	5.5	923.464912
Quadr	25.4	1.5	7.9	6.35	899.4	1494.0	5.4	904.764833
Quadr	25.4	1.5	7.9	6.35	876.8	725.0	5.2	882.006976
Quadr	25.4	1.5	7.9	6.35	858.4	30.0	3.7	862.088017

Zeile 1, Spalte 1

Screenshot of the original SM5BSZ Fortran based BC.exe.

BC.exe uses frequency, booms shape (round / square), booms outer dimensions, booms wall thickness, diameter of hole in boom to fit insulators, element diameter & length and distance of elem. position to *nearest* boom end as parameters.

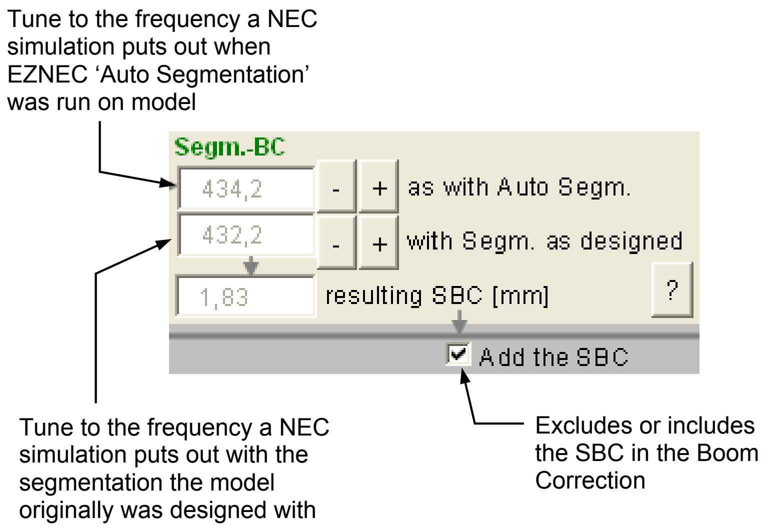


With SM5BSZ BC mode the element diameter of **each** individual element row is read and used to produce the individual BC. In contrast to other BC in BC.exe the element diameter is an integral parameter. In this BC Mode it is possible to use different element diameters for each row as long as they fit same hole diameter and min./max. numbers at frequency and boom dimension.

3 Other

3.1 Segmentation BC

The Segmentation BC (SBC) is an additional length correction that works on the frequency derivation, that NEC computed SWR and Return Losses show, when the models wire segmentation is changed.



Find Base-BC and 'Full BC' as Base-BC + SBC in the table

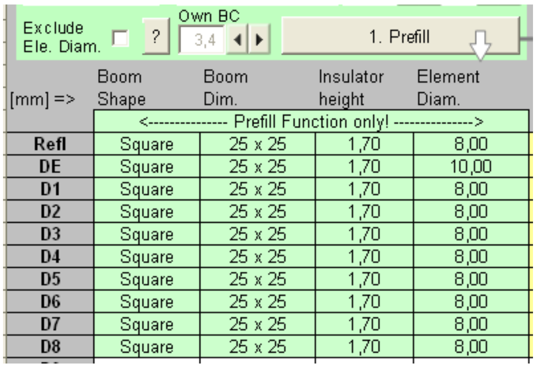
Element Length [mm]	Position in NEC [mm]	Base-BC [mm]	BBC+SBC: Full BC [mm]
335,00	0,00	4,65	6,45
315,00	104,50	6,66	8,46
316,30	153,00	5,34	7,14
313,00	246,00	5,37	7,17
303,00	428,00	5,28	7,08

Example: A highly segmented 144 MHz Yagi design models simulation shows best RL at 144.3 MHz. A simulation of same design model using EZNEC 'Auto Segmentation' function at 144.1 MHz on that model shows best RL shifts up to 144.7 MHz

SBC = delta freq. * Factor = 0.4 MHz * 5.85 mm/MHz = 2.3 mm

For factors used per band see appendix.

3.2 Prefill Function



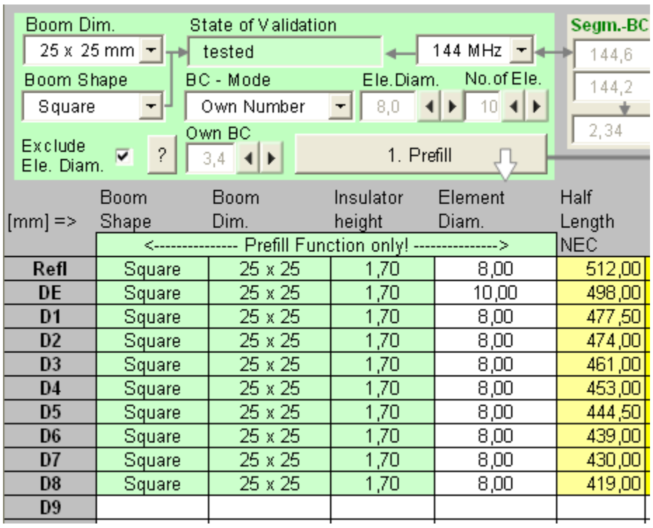
[mm] =>	Boom Shape	Boom Dim.	Insulator height	Element Diam.
	<-------------- Prefill Function only! -------------->			
Refl	Square	25 x 25	1,70	8,00
DE	Square	25 x 25	1,70	10,00
D1	Square	25 x 25	1,70	8,00
D2	Square	25 x 25	1,70	8,00
D3	Square	25 x 25	1,70	8,00
D4	Square	25 x 25	1,70	8,00
D5	Square	25 x 25	1,70	8,00
D6	Square	25 x 25	1,70	8,00
D7	Square	25 x 25	1,70	8,00
D8	Square	25 x 25	1,70	8,00

With using the 'Prefill' function the number of rows as defined as 'No. of Ele.' is automatically filled in with

- Boom Shape
- Boom Dimension
- Insulator height (if on-boom-BC mode is selected)
- Element Diameter (if not excluded, s. § Exclude Element Diameter from Prefill)

3.3 Exclude Element Diameter from Prefill

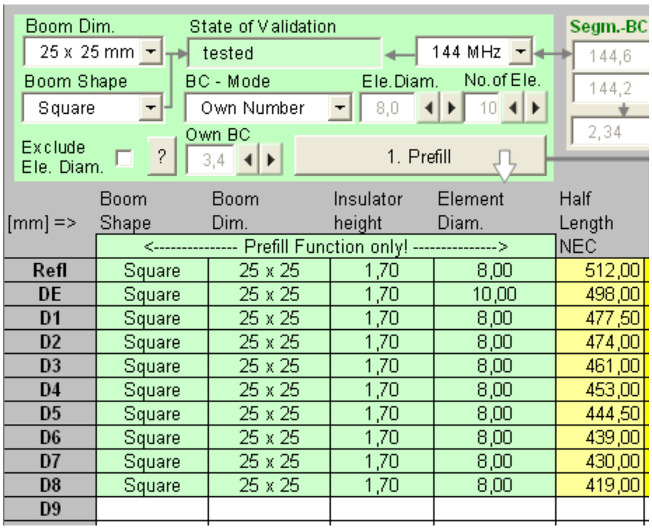
With parameter Element Diameter excluded* from Prefill the column 'Element Diam.' shows a **white** background colour -as a sign that only the green field, columns 'Boom Shape', Boom Dim.' and 'Insulator Height' are subject to be filled in with numbers taken from the green field above.



[mm] =>	Boom Shape	Boom Dim.	Insulator height	Element Diam.	Half Length
	<-------------- Prefill Function only! -------------->				NEC
Refl	Square	25 x 25	1,70	8,00	512,00
DE	Square	25 x 25	1,70	10,00	498,00
D1	Square	25 x 25	1,70	8,00	477,50
D2	Square	25 x 25	1,70	8,00	474,00
D3	Square	25 x 25	1,70	8,00	461,00
D4	Square	25 x 25	1,70	8,00	453,00
D5	Square	25 x 25	1,70	8,00	444,50
D6	Square	25 x 25	1,70	8,00	439,00
D7	Square	25 x 25	1,70	8,00	430,00
D8	Square	25 x 25	1,70	8,00	419,00
D9					

*) to understand the meaning of this it might take a little excurse to the history of this MS Excel: The first version enclosed the DG7YBN On-Boom BC mode only. Which I though to put out very correct numbers for the element diameters I had set it up with. Hence I programmed the prefill function in a way that it would overwrite any suggested other element diameters except for 8 mm on 144 MHz and 6 mm on 432 MHz.

With parameter Element Diameter included in Prefill the column ‘Element Diam.’ shows a **green** background colour - as a sign that it is included in Prefill now.



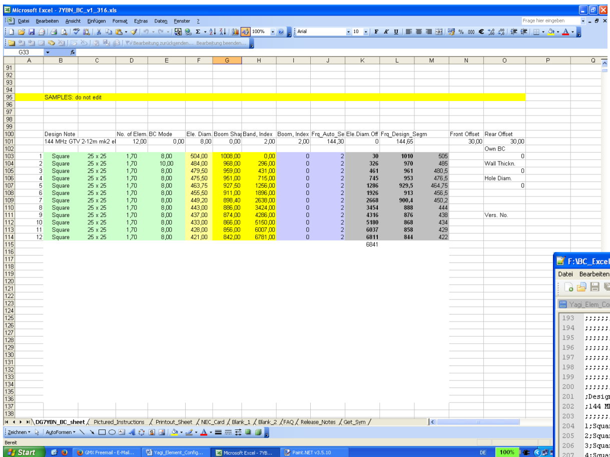
[mm] =>	Boom Shape	Boom Dim.	Insulator height	Element Diam.	Half Length
	<-------------- Prefill Function only! -------------->				NEC
Refl	Square	25 x 25	1,70	8,00	512,00
DE	Square	25 x 25	1,70	10,00	498,00
D1	Square	25 x 25	1,70	8,00	477,50
D2	Square	25 x 25	1,70	8,00	474,00
D3	Square	25 x 25	1,70	8,00	461,00
D4	Square	25 x 25	1,70	8,00	453,00
D5	Square	25 x 25	1,70	8,00	444,50
D6	Square	25 x 25	1,70	8,00	439,00
D7	Square	25 x 25	1,70	8,00	430,00
D8	Square	25 x 25	1,70	8,00	419,00
D9					

4 Data Base Management

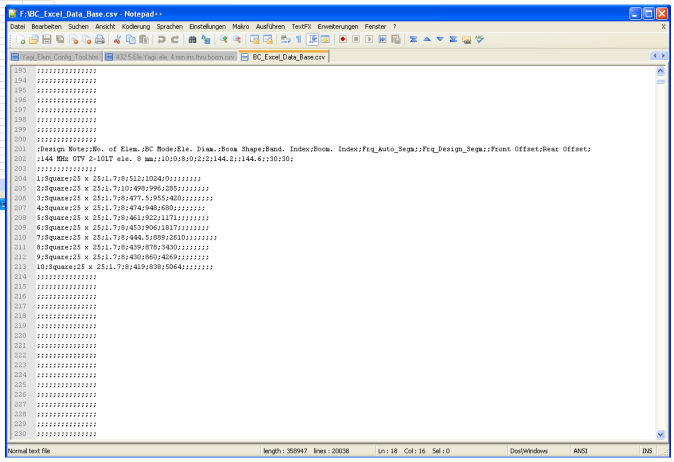
4.1 Intro

Getting an antenna design with all the coordinates for elements and positions into the workspace is laborious. Therefore the Yagi Element Configuration Tool was fitted a data base system.

1. Internal data base: on ‘BC_sheet’ starting from row 100 and with any 100 rows offset reaching the next of the 200 sample data spaces starting row.



2. External data base: the Excel tool can produce and read a CSV file in its data base format. Single designs or a complete copy of an internal data base can be stored and read into the MS Excel Tool for archival, migration or exchange between users.

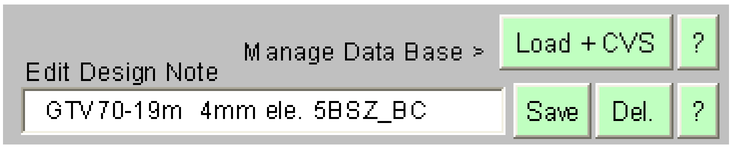


4.2 Internal Data Base

The ‘on sheet’ internal data base of this MS Excel tool holds storage place for 200 design samples.

A number of functions embedded in the tool helps you to manage your ‘on sheet’ samples, save, delete or recall a chosen design into the workspace cells.

The Data Base Management section holds three buttons and the ‘Edit Design Note’ textbox. Click into the textbox and edit the name of the actual design in workspace to your like. The max. length of the Design Note is 39 characters. This ‘Design Note’ will be used to name the data set of this design in the data base for your own identification when scanning the data base for later recalling of a design.



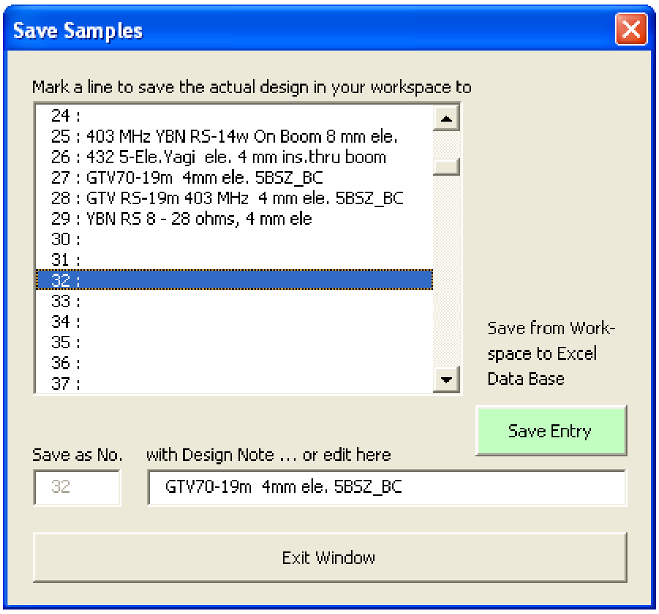
• Button ‘**Load + CSV**‘ is for loading a design data set form internal data base (held in lower lines of this worksheet starting with line 100. Further to export / import a single data set or the complete internal data base to / from an external CSV file.

• Button ‘**Save**’ enables adding the actual design held in workspace to the internal data base.

> **Attention: Saving to the internal data base adheres SAVING this MS Excel before shutting the tool, since all new entries are a mere edit of the worksheet as in any standard MS Excel sheet action!**

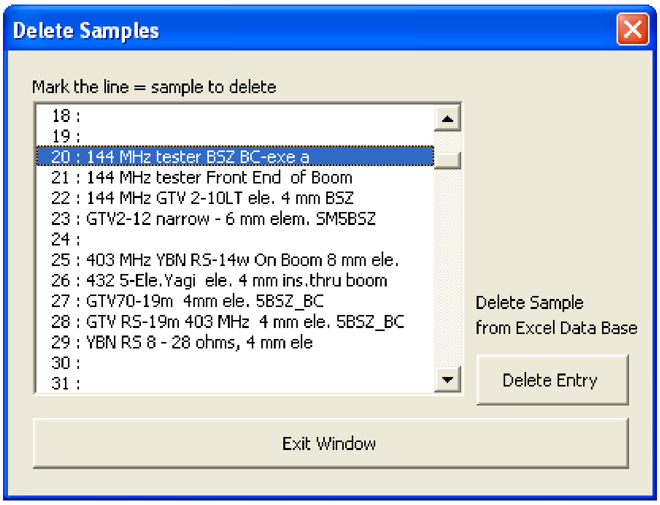
• Button ‘**Delete**’ enables deleting a selected data set form the internal data base.

4.3 Save Samples



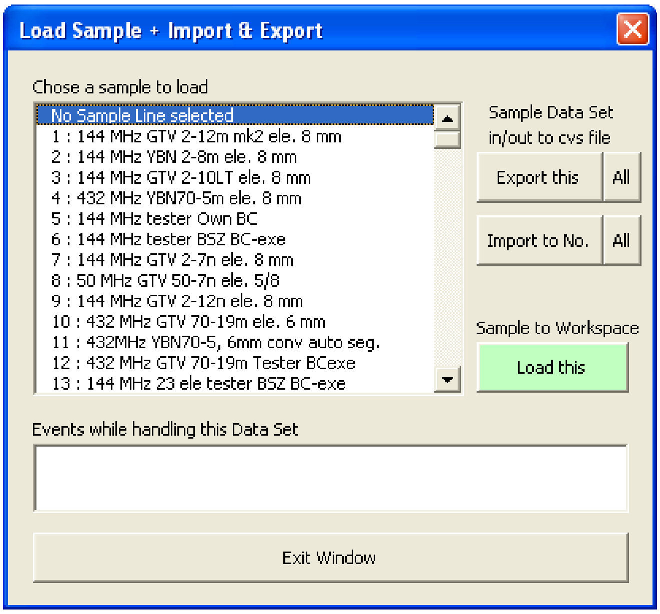
Scroll the data base, mark a free line #, make final edits to the samples name and click ‘Save Entry’ to save a new design. In case the space is not empty you will be asked whether to really save or exit.

4.4 Delete Samples



Scroll the data base, mark the to be deleted design and click the ‘Delete Entry’ button. You will be asked whether to really delete or exit before the command is executed.

4.5 Load Samples



Scroll the data base, identify the design to be loaded into the workspace area and mark it. Upon clicking the ‘Load this’ button you will be asked whether to really load this sample or exit when the workspace is not empty.

4.6 Behind the scenes

What happens when a sample design is being saved to the internal data base?

The complete content of the workspace Excel Cells from row 11 to 44 plus ‘header information’ containing Design Note, No. of Elements, BC mode, SBC frequencies etc. is copied to the lower part of the worksheet. This according the number chosen for the entry x 100. Example: Data Set 18 is to be found starting with row 1800.

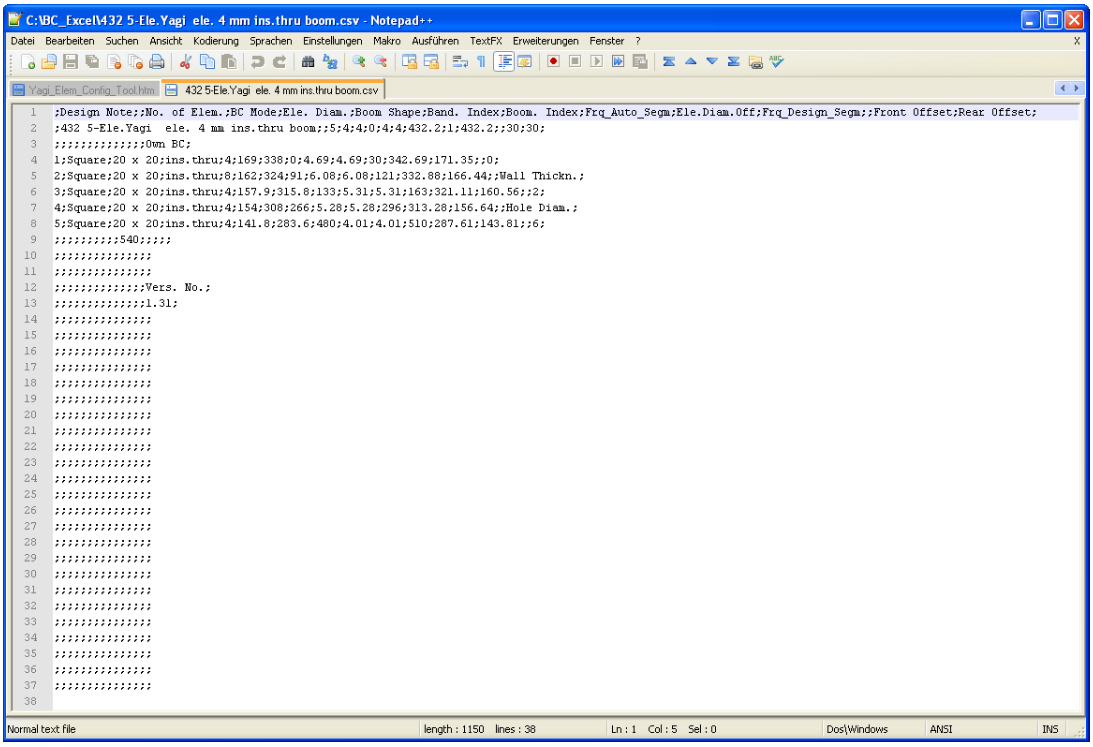
What happens when a sample design is being loaded from the internal data base?

The complete content of the data space marked with the chosen number for the entry x 100 is copied from the lower part of the worksheet into the workspace Excel Cells from row 11 to 44 plus sorting ‘header information’ to replace last Design Note, adjust No. of Elements, BC mode, SBC frequencies etc.

4.7 About CSV file & Export / Import

What is a CSV file? Comma-separated values = CSV is a common file format standard used to store and / or exchange simply structured data. Often the semicolon is used instead of the comma. So do I in this application.

A CSV file can be viewed and edited with any editor as its content is plain text. The delimiting tag between data base entries is detected by the VBA code and by interpretation of order of listed next data field the program assigns the right cell on the Excel Sheet at import.



```
;Design Note;;No. of Elem.;BC Mode;Ele. Diam.;Boom Shape;Band. Index;Boom. Index;Frq_Auto_Segm;Ele.Diam.Off;Frq_Design_Segm;;Front Offset;Rear Offset;
;432 5-Ele.Yagi  ele. 4 mm ins.thru boom;;5;4;4;0;4;4;432.2;1;432.2;;30;30;
;;;;;;;;;;;;;;Own BC;
1;Square;20 x 20;ins.thru;4;169;338;0;4.69;4.69;30;342.69;171.35;;0;
2;Square;20 x 20;ins.thru;8;162;324;91;6.08;6.08;121;332.88;166.44;;Wall Thickn.;
3;Square;20 x 20;ins.thru;4;157.9;315.8;133;5.31;5.31;163;321.11;160.56;;2;
4;Square;20 x 20;ins.thru;4;154;308;266;5.28;5.28;296;313.28;156.64;;Hole Diam.;
5;Square;20 x 20;ins.thru;4;141.8;283.6;480;4.01;4.01;510;287.61;143.81;;6;
;;;;;;;;;;540;;;;;
;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;Vers. No.;
;;;;;;;;;;;;;;1.31;
;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;
;;;;;;;;;;;;;;;
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```
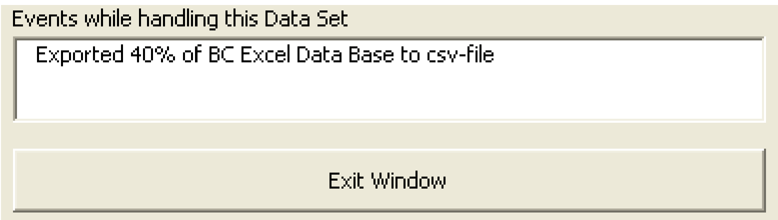

Sample single design CSV file generated with the 'Yagi Element Configuration Tool'

The CSV file system enables sharing designs and computed sets with other users without sending the complete MS Excel Workbook, data archival storing and last not least migration of data sets to newer or future versions of the 'Yagi Element Configuration Tool'.

Using the 'Export' > 'All' function enables to produce a complete copy of all present data sets in a convent way. Though writing and reading up to 200 data sets form / to CSV takes up to about 30 s. Progress in processing the started task is shown in percent

Either button click will open the standard windows 'Save as' window, in which you can sort path and name of the CSV file in the common MS Windows style.



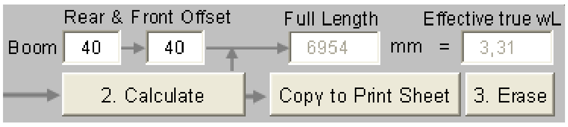
On completion of the task, the program will show ‘Data Base successfully imported / exported’ in its ‘Events’ textbox.

4.8 Acknowledgments

Note: The CSV file handlings core code is programmed by Christos Samaras
See: http://www.myengineeringworld.net

5 Printout Sheet

Clicking the ‘Copy to Print Sheet’ will copy the content of the workspace into a printer friendly sheet, competed with a header space that holds all other parameters plus design description.



Design Note:
GTV70-19m 4 mm elem. 5BZS BC

Created with DG7YBN BC Tool
Vers. 1,31

Boom Dim.: 20 x 20 mm
Boom Shape: Square
BC Mode: 5BSZ insulated

f-auto: 434,2 MHz
f-des: 432,2 MHz

Len. mech.: 4176 mm
Len. electr.: 5,96 wL

Hole Diam.: 6 mm
Boom Wall Thickn.: 2 mm

[mm] =>	Boom Shape	Boom Dim.	Insulator height	Element Diam.	Half Length NEC	Element Length [mm]	Position in NEC [mm]	Base-BC [mm]	BBC+SBC: Full BC [mm]	Position on Boom [mm]	Element Length [mm]	Bore Position [mm]
	<--------------- Prefill Function only! --------------->											
Refl	Square	20 x 20	ins.thru	4	167,5	335	0	4,65	6,45	30	341,45	170,73
DE	Square	20 x 20	ins.thru	10	157,5	315	104,5	6,66	8,46	134,5	323,46	161,73
D1	Square	20 x 20	ins.thru	4	158,15	316,3	153	5,34	7,14	183	323,44	161,72
D2	Square	20 x 20	ins.thru	4	156,5	313	246	5,37	7,17	276	320,17	160,09
D3	Square	20 x 20	ins.thru	4	151,5	303	428	5,28	7,08	458	310,08	155,04
D4	Square	20 x 20	ins.thru	4	148,75	297,5	641	5,22	7,02	671	304,52	152,26
D5	Square	20 x 20	ins.thru	4	147	294	888	5,19	6,99	918	300,99	150,50
D6	Square	20 x 20	ins.thru	4	145,75	291,5	1152	5,16	6,96	1182	298,46	149,23
D7	Square	20 x 20	ins.thru	4	143,75	287,5	1425,5	5,11	6,91	1455,5	294,41	147,21
D8	Square	20 x 20	ins.thru	4	142	284	1707	5,06	6,86	1737	290,86	145,43
D9	Square	20 x 20	ins.thru	4	141,25	282,5	1992	5,04	6,84	2022	289,34	144,67
D10	Square	20 x 20	ins.thru	4	140,25	280,5	2270,5	5,01	6,81	2300,5	287,31	143,66
D11	Square	20 x 20	ins.thru	4	139,75	279,5	2545	4,99	6,79	2575	286,29	143,15
D12	Square	20 x 20	ins.thru	4	139,5	279	2818	4,98	6,78	2848	285,78	142,89
D13	Square	20 x 20	ins.thru	4	138,5	277	3080	4,94	6,74	3110	283,74	141,87
D14	Square	20 x 20	ins.thru	4	138,5	277	3344	4,93	6,73	3374	283,73	141,87
D15	Square	20 x 20	ins.thru	4	137,25	274,5	3608	4,87	6,67	3638	281,17	140,59
D16	Square	20 x 20	ins.thru	4	135,5	271	3883	4,74	6,54	3913	277,54	138,77
D17	Square	20 x 20	ins.thru	4	134	268	4116	3,82	5,62	4146	273,62	136,81
	End of boom = >									4176		

Note: Always use the ‘Printout Sheet’ for printing. Due to the attached internal data base the workspace sheet hold up to 20000 lines ... on which you would probably not like to waste paper, ink and time on.

6 Import of NEC files

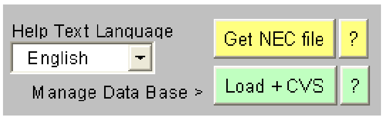
6.1 General Notes

The Yagi Configuration Tool can import antenna models from a NEC file that has the format as described in the original NEC manual from the Lawrence Livermore Laboratories. The Tool can convert a NEC file that has the antenna wire coordinates coded in ‘Symbols’ as Arie Voors’s 4nec2 uses them whenever the Optimiser is run.

Since it is likely that the NEC files data need to be conditioned for use in the Tools workspace on the BC_Sheet any import of NEC files has to be done in two steps

1. Swap to the ‘NEC Card’ sheet of the Excel workbook and click the ‘Import a NEC file’ button. This will open the standard file dialog object window of the MS Windows system32 API. In which a path and **.nec** file can be selected. Then check your import on needed orientation of coordinates, check if any coordinates are packed in symbols and eliminate complex drivers. Now you design in ready to be copied into the main BC workspace.

2. Swap to the ‘BC_Sheet’ and use the ‘Get NEC file’ button to cast the conditioned NEC import into the workspace.



For a clean import the .nec file that serves as source must be completely conform to the definitions used in the NEC manual, see § NEC Card Excursion.

Possible source programs of .nec files

The Yagi Element Configuration Tool is extensively tested with files generated by 4nec2. Whereas files originating from MMANA or EZNEC V 5+ do not work out. EZNEC uses a binary coded file data system. However to get an EZNEC made design into the Yagi Element Configuration Tool it can be opened and saved using 4nec2 to derive a compatible .nec file.

Where to find the .nec file of the wanted design?

4nec2 holds antenna design files in the following folder

C:\progams\4nec2\models

6.2 NEC Card Sheet

NEC Import Workbench

Erase all | Import a NEC file | ? | ?

Swap x - y | Swap y - z | ? | Trace z | Remove Offset in z

Status	
done	Import
done	found GW Cards?
is clean	holds Symbols?
10	No. of Wires

Remove Symbols | Check if clean

NEC Cards									
GW			End 1 in x	End 1 in y	End 1 in z	End 2 in x	End 2 in y	End 2 in z	Ele. Radius
GS			Scaling Fact.		Comments				
FR					Freq.				
	Wire No.	No. of Segm.	Pos.on Boom	Half Ele. Lgt.					
CE									
GW	1	27	0	-0,097	0	0	0,097	0	0,002
GW	2	27	0,07600001	-0,0875	0	0,07600001	0,0875	0	0,0025
GW	3	26	0,098	-0,0785	0	0,098	0,0785	0	0,002
GW	4	26	0,154	-0,0775	0	0,154	0,0775	0	0,002
GW	5	25	0,239	-0,0745	0	0,239	0,0745	0	0,002
GW	6	25	0,357	-0,0725	0	0,357	0,0725	0	0,002
GW	7	24	0,481	-0,0715	0	0,481	0,0715	0	0,002
GW	8	24	0,615	-0,07	0	0,615	0,07	0	0,002
GW	9	24	0,758	-0,0665	0	0,758	0,0665	0	0,002
GW	10	23	0,89	-0,065	0	0,89	0,065	0	0,002
GE	0								
LD	5	1	0	0	2,50E+07	0			
LD	5	2	0	0	2,50E+07	0			
LD	5	3	0	0	2,50E+07	0			
LD	5	4	0	0	2,50E+07	0			
LD	5	5	0	0	2,50E+07	0			
LD	5	6	0	0	2,50E+07	0			
LD	5	7	0	0	2,50E+07	0			
LD	5	8	0	0	2,50E+07	0			
LD	5	9	0	0	2,50E+07	0			
LD	5	10	0	0	2,50E+07	0			
LD	5	11	0	0	2,50E+07	0			
LD	5	12	0	0	2,50E+07	0			
LD	5	13	0	0	2,50E+07	0			
EX	6	1	14	0	1	0			
GN	-1								
FR	0	1	0	0	840	0			

The Info box shows whether the model hols 'Symbols' and state of import from .nec file.
In case it does not show a clear & corresponding 'No. of Wires' the import did not work out.

done	Import
done	finding GW Lines
is clean	holds Symbols?
8	No. of Wires

If it does, follow the checklist below to dress the data for moving them to the workspace on the 'BC_Sheet':

• Check if the Yagi models orientation is with boom in x-axis:

If so, we find the element positions in column 'End 1 in x'. If not, swap orientation by mirroring the coordinates by using the 'Swap x-y' and / or 'Swap y-z' buttons.

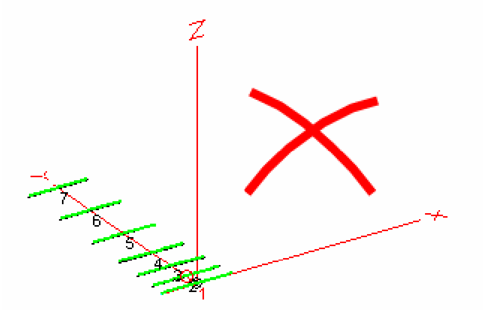
• Check if the model holds on offset in z-axis after (1) is achieved.

Usually this is 'height' for simulations over ground. Both columns 'End1 in z' and 'End2 in z' shall show '0', If not, use button 'Remove Offset in z', enter to be shifted distance to zero and submit. The 'Trace z' function searches for entries with one or both wires ends having offset to z = 0 and marks those with red background colour.

• Check if the model holds a complex structure for Driver (Loop or bent Dipole)

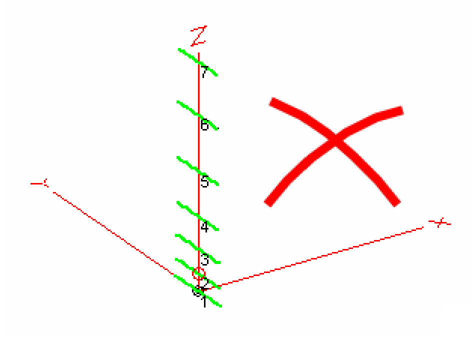
The BC computation is built around a standard Yagi with a single wire (Straight Dipole) as Driver. For LFA Loops use one of the two wires rectangular to the boom only. For bent Dipoles use the span width only, but with boom position as middle section.
This is an all VBA programmed MX Excel, but still an Excel sheet. You can delete multiple Driver wires by hand. Just delete as many complete 'GW' rows as needed to leave a single GW row for the Driver remaining. Enter span width or suitable number in there.

6.3 Axis orientation of NEC model



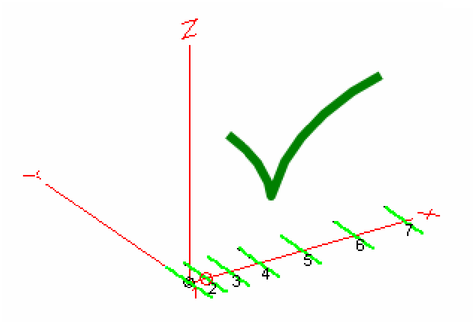
• Boom is on or parallel to Y axis, not suitable for computing in BC Sheet.

Use 'Swap x – y' function here.



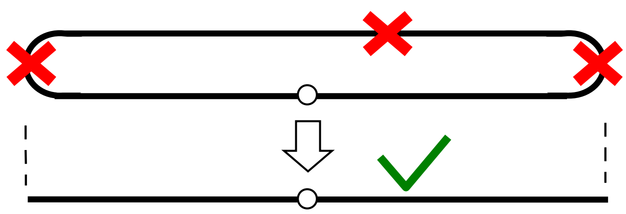
• Boom is on or parallel to Z axis, not suitable for computing in BC Sheet.

Use 'Swap y – z' function and followed by 'Swap x – y' here



• Boom on or parallel to X axis is fine for computing in BC Sheet

6.4 Remove Folded Dipoles from NEC Card Sheet

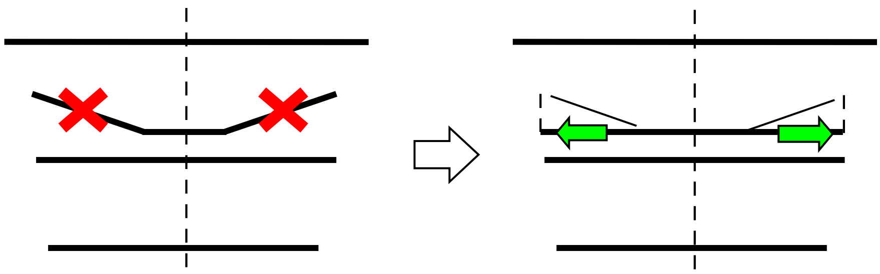


Remove all rows holding GW Cards that form the arced ends and upper arm of the folded dipole. Then prolong the fed wire to the original span width of the ex-Folded Dipole, measured on outer ends.

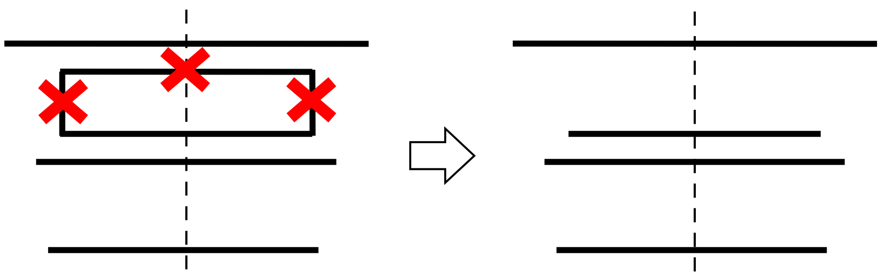
6.5 Remove bent DEs and LFA Loops from NEC Card Sheet

The Yagi Element Configuration Tool can only process straight single wires, like standard elements and straight split drivers. Complex drivers have to be reduced to a single wire.

Example (1) Bent DE : the “GW” card lines holding the bent arms must be deleted as entire rows on the MS Excel sheet. The straight mid section must be prolonged to the original span width of the bent DE. Thus the BC to be applied to the bent DE can be produced as if it still would be present in its complex structure.



Example (2) LFA Loop : the “GW” lines holding the side arms and one of the parallel long wires must be deleted as entire rows on the MS Excel sheet. With just one wire or “GW” card line left the BC to be applied to the LFA Loop can be produced as if it still would be present in its complex structure.



6.6 Remove Offset to Z axis

End 1 in z	End 2 in x	End 2 in y	End 2 in z
Freq.			
16	0	-0,182	16
0	0,1215	-0,1702	0
16	0,181	-0,1685	16
16	0,306	-0,1655	16
16	0,516	-0,16125	16
16	0,7615	-0,15775	16
16	1,019	-0,1555	16
16	1,246	-0,1505	16

This coordinated for reflector wire ends and all of the directing elements wires show an offset of 16 mm in height. This might be due to a simulation model that includes the offset between element and driven element planes on a real build.

Using the 'Trace z' function will Automatically highlight these rows In orange background colour.

End 1 in z	End 2 in x	End 2 in y	End 2 in z
Freq.			
16	0	-0,182	16
0	0,1215	-0,1702	0
16	0,181	-0,1685	16
16	0,306	-0,1655	16
16	0,516	-0,16125	16
16	0,7615	-0,15775	16
16	1,019	-0,1555	16
16	1,246	-0,1505	16

Clicking the button 'Remove Offset in z' brings up this little popup form here. Please enter the Offset that shall be removed. Attention, in here the decimal separator is sensitive.

Select 'Ok' to proceed. All GW Cards that are not on z = 0 will have the entered distance subtracted from the coordinates of their wire ends in z direction.

6.7 NEC Card Excursion

On the left side of the 'NEC_Card' sheet you find the tags used in NEC Cards convention to give those lines a meaning. The NEC Manual refers to these as 'Program Control Cards'

NEC Card notations

The most common and relevant NEC Cards

NEC Tag	**Description**	**Official name**
CM	Design description	Comment Cards
GW	Geometry coordinates of end points of wires	Wire Specification Cards
LD	holds the loss of the chosen material; Lossless models do not hold LD lines	Loading Cards
EX	Specifies where the source is (feed point)	Excitation Cards
FR	Frequency in MHz	Frequency Card
GS	Scaling factor	Scale dimensions

Scaling factors - other units then meters

The NEC Card notation uses meters as baseline measure.

However some models are designed with different measures, like in inch or millimetres. If so, we find a line holding the scaling factor. The Yagi Element Configuration Tool uses millimetres strictly, when moving the model imported to the 'NEC_Card' sheet, care is taken of a possible scaling factor and the geometry is processed to millimetres when cast into the workspace on 'BC_Sheet'.

Example of applied scaling factor

GS = scaling structure dimensions
example: from ft to meters : GS 0 0 0.3048
NEC itself calculates in meters only

Find ore read in the source of the given above small details, which is the

NEC-2 Manual, Part III: User's Guide*

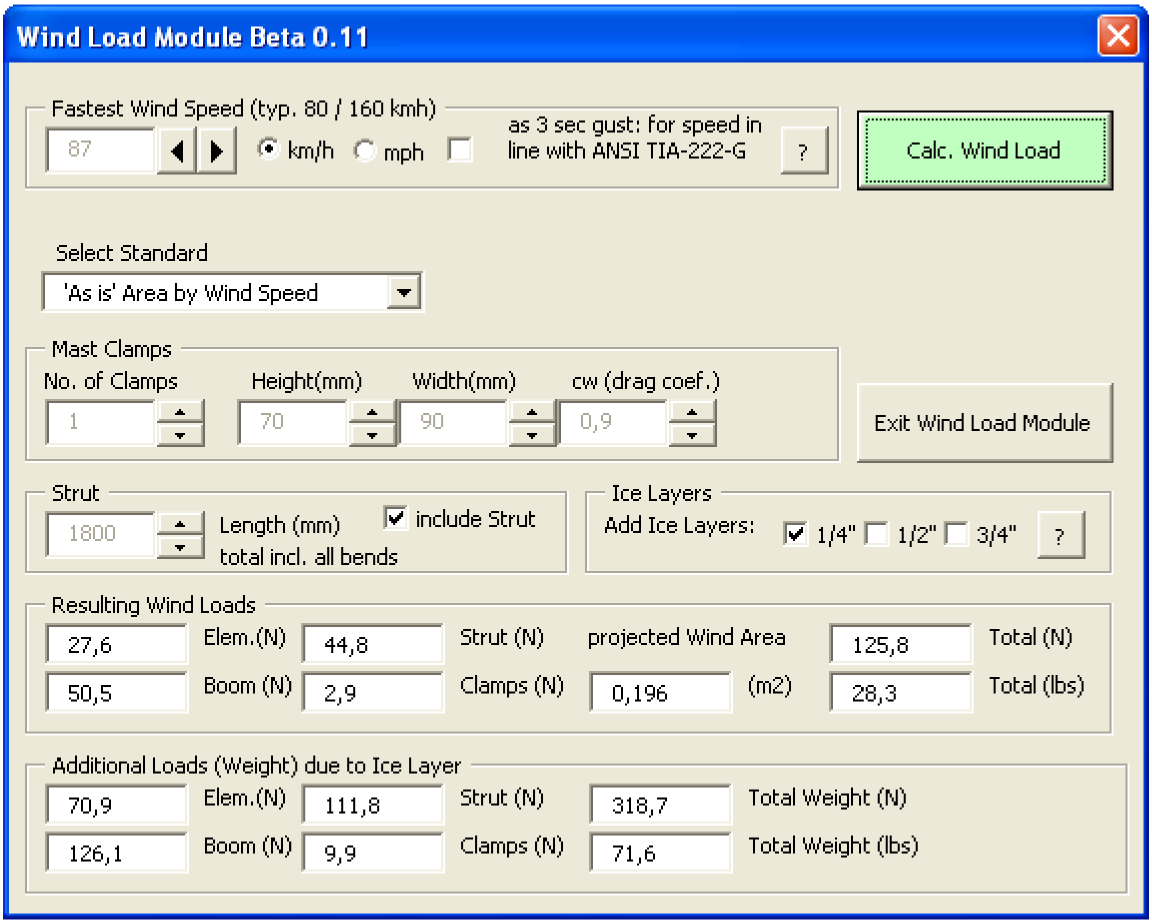
*) Burke, G. J., Poggio, A. J., Lawrence Livermore Laboratory: Numeric Electromagnetics Code (NEC) – Method of Monents, Part III: Users's Guide, UCID – 18834, Jan. 1981

See 'section III, Program Input', pg. 14ff

7 Wind Load Module

Read carefully please!

The version 1.51 Wind Load Module is a BETA version. Results are not fully tested. Do not use the computed wind loads for official structural analysis without checking against suitable references.

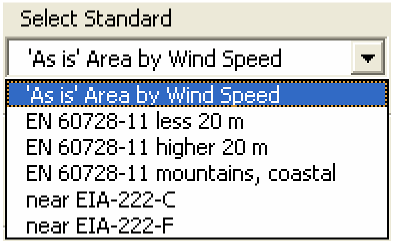


7.1 Motivation & General Thought

I was in need of wind load numbers for own Yagi-Uda designs and while studying basic formulas for wind load calculation it came to me that the Yagi Element Configuration MS Excel already holds all the needs boom and element geometry data for summing up the projected area and choosing drag coefficient by shape of boom.

7.2 Standards and general formulas

● Common Formula / Open for all Input

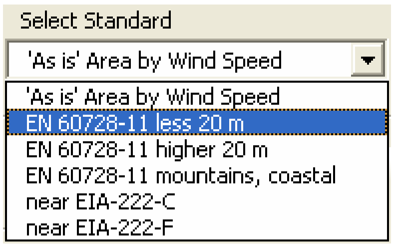


For "***'As is' Area by Wind Speed***" the common formulas are used

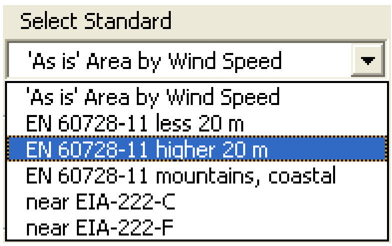
$$F = cd \cdot area \cdot DynPressure$$

$$DynPressure = 0.5 \cdot DensityAir \cdot windSpeed^2$$

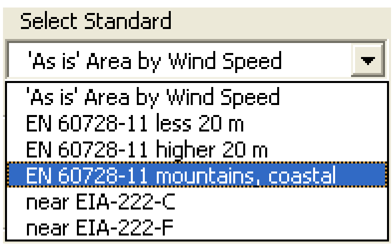
● **European Standards**



For "***EN 60728-11 less 20 m***" meaning antenna height below 20 m a fixed Dynamic Pressure of 800 N/m² is used. So wind speed edit is frozen for this option



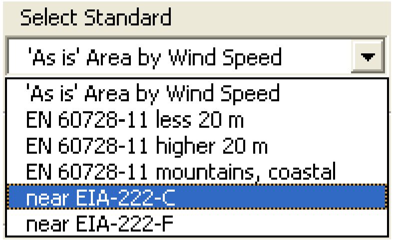
For "***EN 60728-11 higher 20 m***" a fixed Dynamic Pressure of 1,100 N/m² is used. So wind speed edit is frozen for this option



For "***EN 60728-11 mountains, coastal***" a fixed Dynamic Pressure of 1,250 N/m² is used. So wind speed edit is frozen for this option

● US Standards

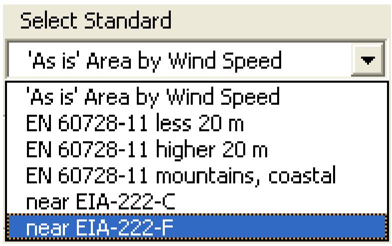
Actually the following EIA-222 standards are used for structural analysis, the quest *IF* an exposed structure withstands a certain wind force. It may however be welcome to compute a Yagi antennas wind load at same settings.



For "***near EIA-222-C***" a set of three fixed wind speeds are used according chosen Exposure Category to compute the dynamic pressure

$$F = cd \cdot area \cdot dyn\_pressure$$

With 3 defined wind speed zones:
Exposure Category **A** sets wind speed to: 86.6 mph
Exposure Category **B** sets wind speed to: 100.0 mph
Exposure Category **C** sets wind speed to: 111.8 mph



For "***near EIA-222-F***" a wind speed according landscape wind speed zone maps shall be selected. This standard uses a "***3 sec gust***" instead of fastest mile throughout. So any entered fastest mile wind speed is computed in to a referring gust speed. See next page for details.

$$F = cd \cdot area \cdot dyn\_pressure \cdot Kz \cdot Gh$$

With Exposure Coefficient $Kz = [z/33]^{(2/7)}$ wherein z = height above average ground to midpoint of item … the Yagi as "*Height Ant.* (m)"

and Gust Response Factor $Gh = 0.65 + 0.60/(h/33)^{(1/7)}$

7.3 Computing the Dynamic Pressure

● Wind Speed

The module uses wind speed in m/sec throughout. For this it is checked which option is chosen and the "raw" entered number is multiplied with an adequate factor as shown:

If entered in km/h then

$$wind\_speed\_mps = wind\_speed\_raw \cdot 1000/3600$$

If entered in miles/h ("***fastest mile***" in ANSI/TIA standards terminology) then

$$wind\_speed\_mps = wind\_speed\_raw \cdot 1.609 \cdot 1000/3600$$

If the module shall use "***3 sec gust***" instead of fastest mile

$$wind\_speed\_mps = 0.00006 \cdot wind\_speed\_mps^2 + 1.0444 \cdot wind\_speed\_mps + 4.8055$$

which is a function gained from the TIA-222-G specs table that holds fastest mile and corresponding 3 second gust numbers.

● Constants used

Density of Air = 1.293 kg/m³ at 0°C and 1 bar

● **Dynamic Pressure**

$$Dyn\_pressure = 0.5 \cdot Density\_Air \cdot wind\_speed\_mps^2$$

7.4 Computing the Projected Areas

Projected Area (Ap) means largest face side of structure multiplied by drag coefficients of the individual patches according their shape.

● Elements

The module skims through the rows of the active set in the workspace and sums up actual element lengths including Boom Correction “BBC+SBC = Full BC” and the actual diameter of each. Drag coefficient used is “*cd = 1.2*”

$$Ap\_element = length\_elem \cdot diameter\_elem \cdot cd\_elem$$

All non empty rows are being summed up to a total projected element area then

● Boom

Reading the booms geometry and shape from the active set in the workspace of the “*BC_sheet*” and using “*cd = 2.0*” for Square Booms, “*cd = 1.2*” for Round Booms. Front and rear offset of boom are included. Area boom is total length of boom by height (square shape) or diameter (round shape) of boom.

$$Ap\_boom = boom\_length \cdot boom\_height \cdot cd\_boom$$

● Strut

This uses same geometry specs for the strut as the boom is made of. Area strut is length of strut by height or diameter of boom.

$$Ap\_strut = area\_strut \cdot cd\_clamps$$

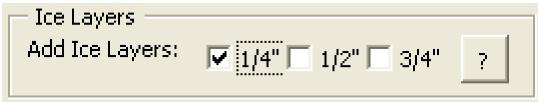
● Mast Clamp

With *cd* being the drag coefficient of the mast clamps base plate only. The “*cd_clamps*” can be edited. Useful numbers are from 0.9 to 1.2. <u>Small details like screws and fastening brackets are not included</u>. Hence to be on the safe side one could opt for an additional clamp, one more that actually installed.

$$Ap\_mast\_clamps = no\_of\_clamps \cdot area\_clamps \cdot cd\_clamps$$

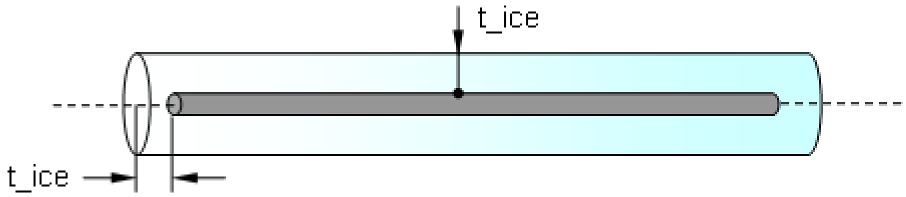
7.5 Adding Ice Layers

This option enables adding layers of ice all around the antenna including mast clamps and strut. Just as real ice would.



● Opting ice layers adds chosen thickness all around elements, boom, strut and mast clamps.

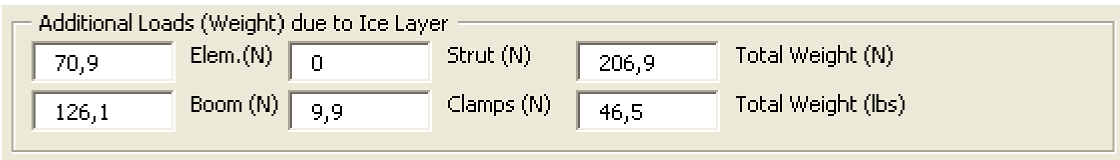
Example: An element of diameter x will be coated with ice all around



$$Diameter\_iced = Diameter + 2 \cdot t\_ice$$

$$Length\_iced = Length + 2 \cdot t\_ice$$

● The ice layer imposes severe additional weight as down facing load adding stress to the mere wind load of the antenna. Which consequently should be taken into account for structural analysis of mast pole or tower



● Constants used

Density of ice = 918 kg/m³ = 918000 N/m³

8 Platforms

The ‘Yagi Element Configuration Tool’ is tested on the following systems

• MS Excel 2003 on MS Windows XP Professional
• MS Excel 2007 on MS Windows XP Professional
• MS Excel 2010 on MS Windows 7 Professional

It should do fine with any ‘non Pro-version’ of MS Windows XP and MS Windows 7 too.

Sorry, due to the implementation of those handy file systems objects (fso) to open, load or safe CSV and NEC files the following elder versions of MS Windows are not suitable to run this application on:

• MS Windows 95 + 98
• MS Windows 2000
• MS Excel from the 97 MS Office … are not supported.

64 Bit?

A 64 bit Operating System like win7 Professional itself is no problem, but a 64 bit MS Excel still is, due to the definition of 64 bit data words and calls to API DLLs. This can be solved, a part of this is done already. But up to today I do not have a 64 bit MS Excel installation to test with.

9 Disclaimer

The Yagi Element Configuration Tool is an MS Excel with several thousand lines of Visual Basic for Applications (VBA in vers. VB 6.0) code running in the background. As this is not compiled runtime code it can easily be manipulated and seriously harm your computer or do harm to files on it.

Using this file is no own risk. No guarantee is given whatsoever.
Use only downloads / files from known & save source.

Hartmut Klüver, 2017-02-09

10 Appendix

10.1 Numbers and constants used

Frequencies used per band selected

Band	Freq. used for BC calculation [MHz]	
50 MHz	50.10	
70 MHz	70.10	
144 MHz	144.20	
222 MHz	222.10	
432 MHz	432.20	
403 MHz	403.00	

SBC Gradient used per band selected

Band	Gradient used for SBC [mm/MHz]	
50 MHz	16.50	
70 MHz	12.50	
144 MHz	5.850	
222 MHz	2.8751	
432 MHz	0.9149	
403 MHz	1.0200	

Speed of Light

c = 299.792.458 m/s

BC Formulas

For DL6WU/G3SEK the original formulas are in operation

For SM5BSZ BC.exe the complete Fortran coded original in the extended to correct scaling of frequency version as per VE7BQH and SM5BSZ is rebuilt in Visual Basic and may be used on courtesy of SM5BSZ