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Multi Resonance Finder MRF for Doublezepps

If you are planning a double zepp, you will ask yourself at least the following questions:

- What length must the dipole and feeder have so that the PA "sees" the lowest possible SWR on as many amateur radio bands as possible?
- Which type of cable is best suited for this?
- Which bands cannot be adjusted at all with the tuner and for which there is at least a small glimmer of hope?

The MultiResonanceFinder (MRF) performs millions of arithmetic operations to answer these questions, it consists of various components of the JWD-tools, such as those used in *15_CableCalculator*, *16_SpecialNetworkAnalyser* or *17_DoubletCalculator*.
More information on the theoretical background can be found in the PDFs attached to these tools.

Just like the *DoublezeppCalculator* (DZC), the MRF also determines the input impedances of stretched dipoles in free space on the basis of integrals of antenna theory /5/.
But: in contrast to the DZC, the MRF searches fully automatically for all the dipole-feeder combinations that are resonant on a maximum number of bands, both balanced and unbalanced (OCF) dipoles are investigated.

The new version 2.0 of the MRF takes into account some wishes of OMs who have already worked with one of the previous versions for a long time:

- The frequencies that are not required are no longer excluded by entering a zero (0), but by setting a checkmark. As a result, the standard frequencies once entered are retained.
- In the "Resonances" area, an additional value *SWRshow* must be entered.
  Thus, SWR values can also be displayed in the result rows for frequencies that meet this condition without being resonant but may still be well tunable with an ATU (such as 80m band at ZS6BKW).
  The display of nonsensical resonances is avoided, which contributes to clarity.
- The influence of a "balun for undefined impedances" at the feeder input and a second balun (common-mode choke) at the feeder output can now be recorded in the calculation.
  The common-mode choke is sometimes required for asymmetrically fed dipoles (OCF-dipoles).

Operating instructions

- Enter (depending on local conditions) the minimum (*Min. Length*) and the maximum possible (*Max. Length*) length of the dipole. Within this range, the MRF will look for an optimal span of the dipole.
- With the step you determine the amount by which the length should increase with each new calculation. A small increment provides more accurate SWRs, but increases the computing time.

- The MRF calculates not only symmetrical, but also unbalanced (OCF) dipoles.
  In the *OCF Points* field, you therefore enter a number (1, 2, ...) that determines how many possible feed points should be considered.
  The number 1 means that only symmetrical dipoles are eligible, because they have only a single feeding point, which is 50% of their range.

  An (integer) number greater than 1 includes unsymmetric dipoles in addition to symmetric dipoles, the value 10 means, for example, that 10 variants are examined, which are calculated at 50%, 45%, ... 5% of the span.
  Of course, the higher you choose OCF points, the longer the computing time takes.
  On the other hand, this also increases the chance of finding an optimal feeding point outside the middle.

- Now enter the data of the feeder, i.e. its minimum and maximum length, the step size of the length change as well as the cable data, i.e. impedance *Zw*, shortening factor *VF*, cable attenuation *a(dB/100m)* at a reference frequency (usually 10MHz).
  Starting from this frequency, the attenuation values for the remaining frequencies are interpolated according to the known formula (dependence on the square root of the frequency ratio).

- As you can see, the search for resonance points includes 11 amateur radio bands.
  The corresponding frequencies are already entered by default in the corresponding fields, but can be corrected by you.

- If you are not interested in a band, remove the checkmark, this saves computing time.

- In the field *SWRmax* you enter the SWR that you would just accept as "resonance". Since many PAs only regulate down from an SWR > 2, this value has a particularly important meaning. It is also logical that the MRF will provide fewer resonance points for smaller S*WRmax* values than for larger ones.

- In the *Nmin* field, enter the minimum number of resonance points that a certain combination of dipole and feeder length must provide to be included in the result matrix.
  Nmin you usually choose between 1 and 5.

- The number 1 means that all combinations that are only resonant on a single band are also displayed. However, at the end of the result matrix, many combinations that are useless for multi-band operation also appear.
  On the other hand, combinations with resonances on more than 4 bands are highly interesting. 6 resonances (at *SWRmax* = 2) are rarely to be topped, unless you enlarge *SWRmax*.

- The additional value *SWRshow* must always be larger than *SWRmax* and serves to inform whether other bands could be adjusted using an ATU.

- After clicking on "START", it may take seconds to minutes for the result matrix to appear, depending on the parameter settings.

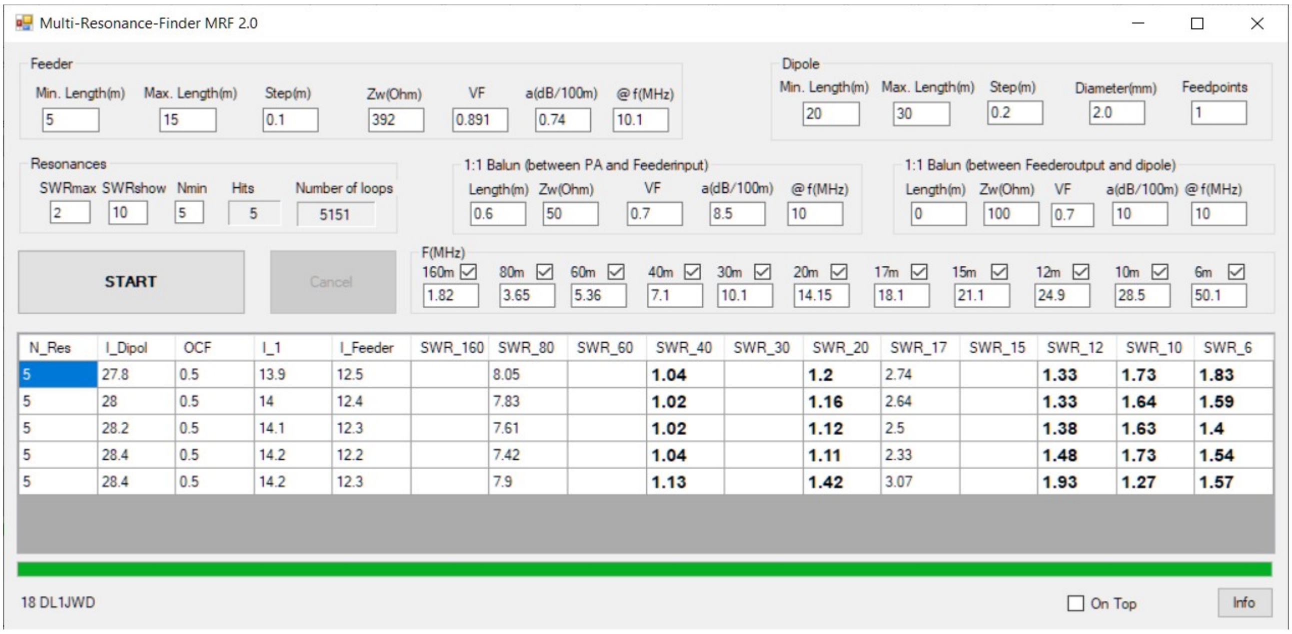
- If you have chosen the distances between minimum and maximum dipole or feeder length too large or have set their length gradations too finely or the memory of your PC is too small, it may happen that the program aborts with an OutOfMemory error.
  A Windows 10 PC with 8GB RAM is ideally suited for the MRF.

Example 1 **The second discovery of the ZS6BKW "miracle antenna"**

With a search of total lengths between 20 and 30m, a feeder made of semi-open tape cable *CQ553* from *Wireman* and a 1:1 balun wound with 0.6m RG316, the MRF leads you purposefully to the so-called "ZS6BKW miracle antenna".

For the 450Ohm Wireman tape cable CQ553 one does not use the inaccurate catalog values (Zw=450Ohm, VF=0.9), but the exact measurement data published in /2/ (Zw=392Ohm, VF=0.89, 0.63dB/100m at 3.5MHz; 0.74dB/100m at 10.1MHz; 1.11dB/100m at 28MHz).

Since it is a symmetrically fed dipole (*Feedpoints* = 1), a second 1:1 balun (common-mode choke) is not required, for its winding length the value 0 must therefore be entered.



N_Res	l_Dipol	OCF	l_1	l_Feeder	SWR_160	SWR_80	SWR_60	SWR_40	SWR_30	SWR_20	SWR_17	SWR_15	SWR_12	SWR_10	SWR_6
5	27.8	0.5	13.9	12.5		8.05		**1.04**		**1.2**	2.74		**1.33**	**1.73**	**1.83**
5	28	0.5	14	12.4		7.83		**1.02**		**1.16**	2.64		**1.33**	**1.64**	**1.59**
5	28.2	0.5	14.1	12.3		7.61		**1.02**		**1.12**	2.5		**1.38**	**1.63**	**1.4**
5	28.4	0.5	14.2	12.2		7.42		**1.04**		**1.11**	2.33		**1.48**	**1.73**	**1.54**
5	28.4	0.5	14.2	12.3		7.9		**1.13**		**1.42**	3.07		**1.93**	**1.27**	**1.57**

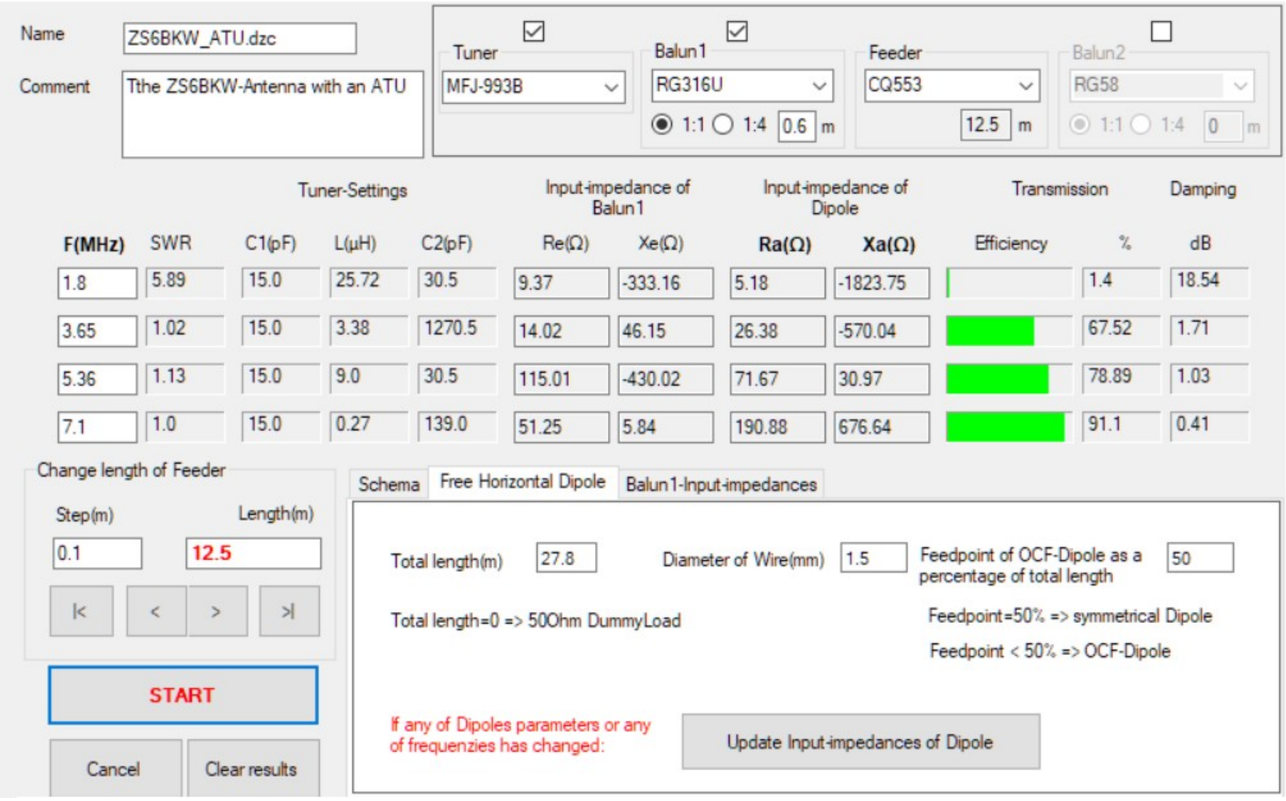
After clicking on "START" it takes only a few seconds until the MRF presents the result list.
One of the best solutions seems to be a ZS6BKW with a 27.8m long dipole and a feeder length of 12.5m.

The 5 resonances of the dipole highlighted by bold type are on the bands 40m (1.04), 20m (1.2), 12m (1.33), 10m (1.73) and 6m (1.83).
The 17m band (2.74) and also the 80m band (8.05) should not pose any problems for most antenna tuners, but then sometimes high adaptation losses are to be expected.

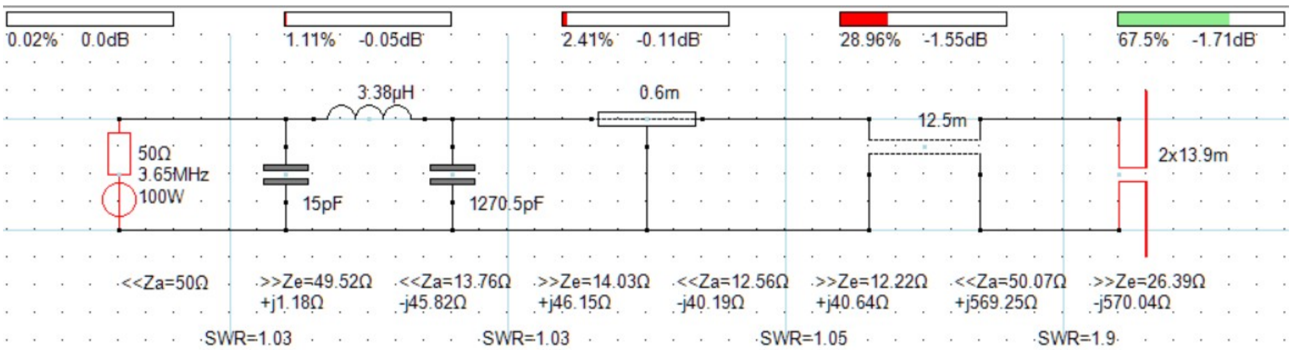
But a reasonable antenna adjustment on the bands 160m, 60m, 30m and 15m becomes impossible (SWR is not displayed because of *SWRshow* = 10).

Loss analysis using DoublezeppCalculator and SpecialNetworkanalyser

Outside the natural resonances, considerable losses can occur in the balun, which in many cases lead to its destruction or unusability of the antenna system.
As *17_DoubletCalculator* confirms, despite ATU on the 80m band only an efficiency of 67% can be achieved:



More precisely the losses can specified with the *16_Special NetworkAnalyser,* e.g. on 80m Band:



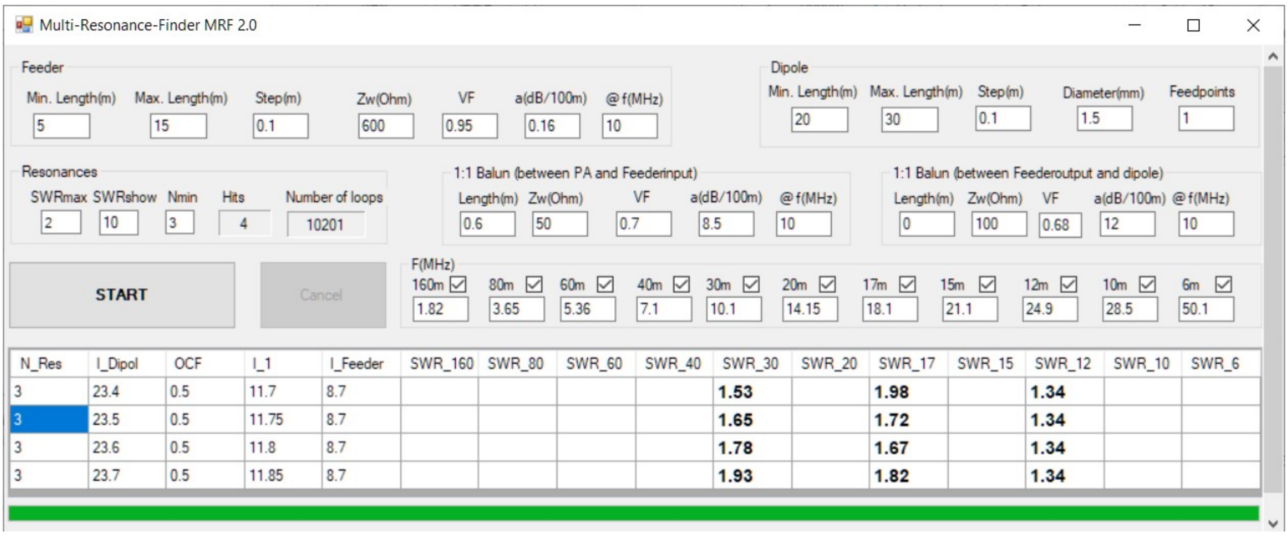
Influence of the feeder cable type

Anyone who is enthusiastic about the ZS6BKW "miracle antenna" will inevitably be tormented by the following question:
Shouldn't a low-loss "real" chicken ladder lead to even better results than the CQ553 semi-open ribbon cable?

The MRF gives a shocking answer: everything is only getting worse!
Despite high-quality chicken ladder (*Zw=600; VF=0.95; a=0.16dB/100m at 10MHz*) as optimum is only a 2x11.75m dipole with 8.7m long feeder and pitiful three resonances (30m, 17m and 12m).

Thus, the MRF confirms an astonishing thesis on a mathematical basis:

The ZS6BKW "miracle antenna" only works well with a semi-open tape cable similar to CQ553!

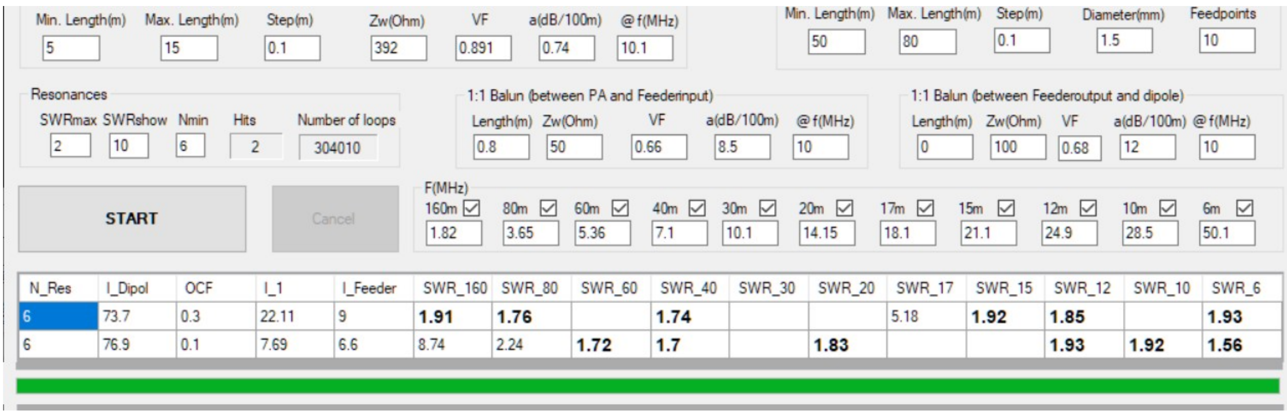


N_Res	l_Dipol	OCF	l_1	l_Feeder	SWR_160	SWR_80	SWR_60	SWR_40	SWR_30	SWR_20	SWR_17	SWR_15	SWR_12	SWR_10	SWR_6
3	23.4	0.5	11.7	8.7					**1.53**		**1.98**		**1.34**		
3	23.5	0.5	11.75	8.7					**1.65**		**1.72**		**1.34**		
3	23.6	0.5	11.8	8.7					**1.78**		**1.67**		**1.34**		
3	23.7	0.5	11.85	8.7					**1.93**		**1.82**		**1.34**		

Example 2 The Long JWD-Doublezepp - "Miracle antenna" also with 160m band

If you have significantly more space than 27m, you will use the MRF to search for a "miracle antenna" that also covers the 160m band.

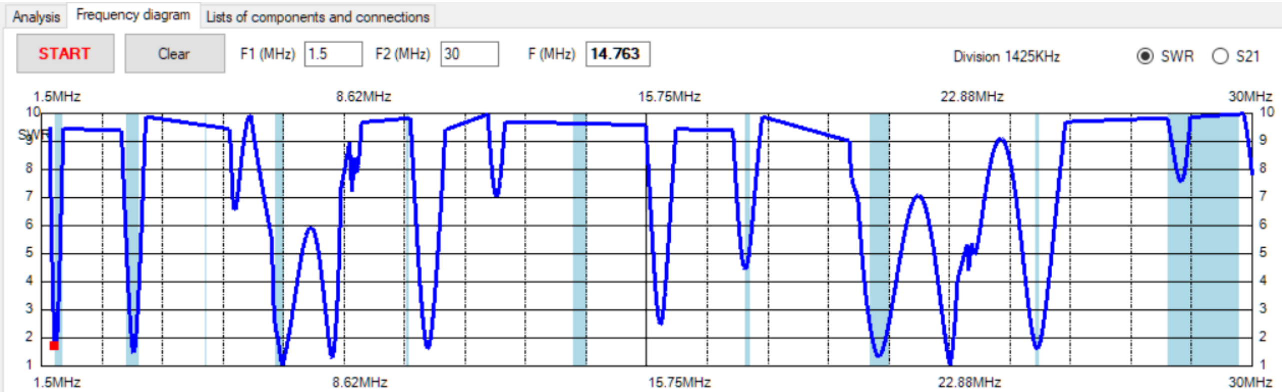
After about 2 minutes, the program spits out an 73.7m OCF dipole, which is fed with 9m CQ553 at 30% of its total length and brings it to a total of 6 resonances!
These can be found on the bands 160m, 80m, 40m, 15m, 12m and 6m.
The 17m band is also within reach, but unfortunately not so good is the 20m band[1].



N_Res	l_Dipol	OCF	l_1	l_Feeder	SWR_160	SWR_80	SWR_60	SWR_40	SWR_30	SWR_20	SWR_17	SWR_15	SWR_12	SWR_10	SWR_6
6	73.7	0.3	22.11	9	**1.91**	**1.76**		**1.74**			5.18	**1.92**	**1.85**		**1.93**
6	76.9	0.1	7.69	6.6	8.74	2.24	**1.72**	**1.7**		**1.83**			**1.93**	**1.92**	**1.56**

The *16_SpecialNetworkAnalyser* as well as practical measurements with a VNA confirm all 6 resonances found for the *Long JWD-Doublezepp*:

1 With a switchable feeder extension of 5m, the 20m band also comes to a SWR < 2.



Literature

[1] W.Doberenz, DL1JWD: "Mit dem Multiresonanz-Finder auf Jagd nach der "Wunderantenne", FUNKAMATEUR 7/20
[2] Th. Sauer, DL9NBJ: "ZS6BKW Antenne – Wunderantenne für 5 Bänder ohne Traps" https://www.dl9nbj.de/zs6bkw-antenne/
[3] U. Neibig, DL4AAE: "Dämpfung und Verkürzungsfaktor von Zweidrahtleitungen", FUNKAMATEUR 11/16
[4] W. Doberenz, DL1JWD:"SWR gut - alles gut?", CQ DL 4/19
[5] K. Kark, "Antennen und Strahlungsfelder", Vieweg Verlag 2004