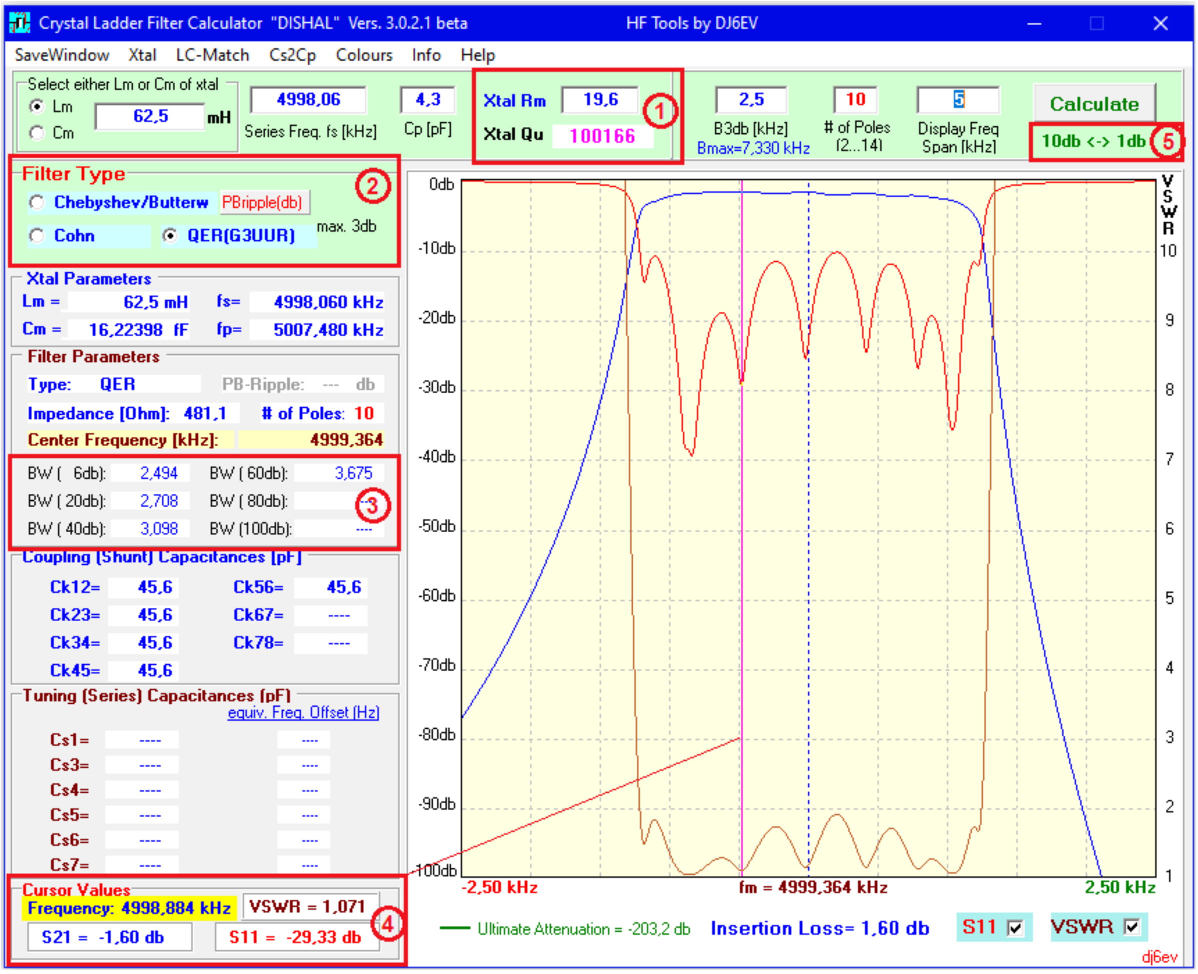
Crystal Ladder Filter Program "Dishal v.3"

This Program was written to provide a simple and convenient way of calculating the necessary component values to construct crystal ladder filters of the Lower-Sideband type. It accepts any number of crystal resonators (poles) from 2 to 14 (4 to 14 for the QER filter).

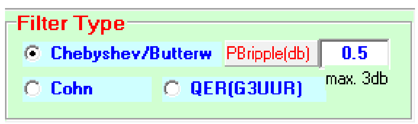
The new version 3.0.2.x has been completely reworked by replacing the comprehensive mathematical frequency response model by a dedicated ladder simulation engine. Hence, the limitation (assuming lossless crystals) of the version 2 is now resolved. This now allows the input of the crystal loss resistance Rm, the display of the response curves of all four filter types and the display of the Return Loss S11 and VSWR if desired. However, this version is still a calculator, not a simulator.

First, a short description of the changes in the new Dishal version 3 compared to last version 2.0.5.2 .The layout changes are shown below, also a list of changes. The graphic display has been enlarged from 400x400 to 500x500 pixels.



[1] The input field for the xtal loss resistance Rm. The resultant xtal quality factor "Xtal Qu" is calculated and shown below the input field.

[2] The new panel to select the filter type. The input field for the passband ripple is only shown if the Chebyshev/Butterworth type is selected:



[3] The real bandwidth values for attenuations from -6db to -100db. The number of displayed bandwidth values depends on the number of filter poles and the displayed frequency span. The reference for the relative attenuations is the filter top ("Insertion Loss"), i.e. for an I.L. of 2db, the level of –60db is therefore measured at the absolute -62db level.
This information allows an easy and accurate calculation of the shape factor of a filter with crystal losses (e.g. 60db/6db ratio, etc.).

[4] An added feature to play around with. The cursor line appears when the mouse pointer is moved into the graphics field. The values of Frequency, Transmission S21, Return Loss S11 and VSWR are shown (the VSWR scaling up to 11 is shown at the right side of the graphic display).

[5] The former "LOG<->Lin" selection has been changed to "10db<->1db" for an expanded LOG scale with 1db/div. The Return Loss S11 curve is only shown on the 10db/div scale.

Also new:

The filter Insertion Loss is shown below the graphics field and two checkboxes to display Return Loss S11 and VSWR

Simulator Netlists

The program still generates the Netlists for the three Simulators GPLA, ARD and LTSpiceIV for all filter types (see appendix).

(Table and Symmetry line)

Both items have been deleted because they relied on the original Dishal procedures which calculated a frequency pair based on a given attenuation. It was based on a lossless filter and also was only available for the Chebyshev/Butterworth filter types.

The configuration file

The program generates a configuration file **Dishal3.cfg** which is not compatible with the configuration files of the Dishal versions 2 (Dishal.cfg) because it now contains two additional settings: the xtal Rm and the filter type setting.

--- End of change info ---

Input fields

Crystal Parameters

You can select either the crystal motional inductance **Lm** or the motional capacitance **Cm**. The other value is then calculated according to the value of the crystal **Series frequency fs**.
Also required is the value of the crystal's holder capacitance **Cp**.

You may notice that there is no input field for the crystal parallel frequency **fp**. This was omitted because the measurement of fp does not yield very reliable results due to it's sensitivity to stray capacitance and termination resistance. Hence, fp is calculated from the above parameters.

Filter Parameters

- 3db-Bandwidth (BW):
The 3db bandwidth can be chosen up to the maximum possible bandwidth. This maximum BW is calculated and now also shown below the input field. If it is exceeded, an error message is generated, showing the maximum possible value. Additionally, a hint message with this information is shown when the mouse pointer is moved into the B3db field.

- Passband ripple:
  A passband ripple of 0db generates a Butterworth response, any value from >0 to 3db generates a Chebychev response. Now moved into the filter selection panel. Passband ripple is not applicable for Cohn and QER.

- Frequency Span: can be freely chosen between >0 and 400kHz for the graphic display.

The **"Calculate"** button or the <**RETURN**> key can be used to calculate and update the results after any change of inputs.

Any invalid or missing input will generate an error message.

Result fields

Xtal parameters

Here, the motional inductance Lm and capacitance Cm of the crystal is shown besides the respective series and parallel resonance frequencies fs and fp. The holder capacitance Cp is not shown here but can be read off the input field. The calculated motional Cm or Lm is displayed with a resolution of at least 6 decimal places. This has nothing to do with the actual accuracy but allows the representation of the exact crystal series frequency if these data are to be used in a simulation program.

Filter parameters

The following parameters are shown in the upper part of this area:

the Filter type (Butterworth / Chebychev, Cohn, QER),
the Passband ripple (only for Butterworth/Chebyshev),
the Source / Load Impedance, (appears in red colour when the Impedance is >3000 Ohm)
the number of xtals,
and the resultant Center frequency
Also, the resultant real bandwidth values are shown for:
-6db, -20db, -40db, -60db, -80db, and -100db

Coupling (Shunt) capacitances

These are the calculated values for the coupling capacitors to achieve the design bandwidth. The subscripts ("Ck12", "Ck23", etc.) describe their position between the respective xtals.

Note: The value for a respective Ck appears in red colour if Ck is smaller than 10pF.

Tuning (Series) capacitances

These are the capacitors in series with the xtals to tune them to the common mesh frequency of the filter. Their subscripts ("Cs1", "Cs3", etc.) also describe their connection to the respective xtals.

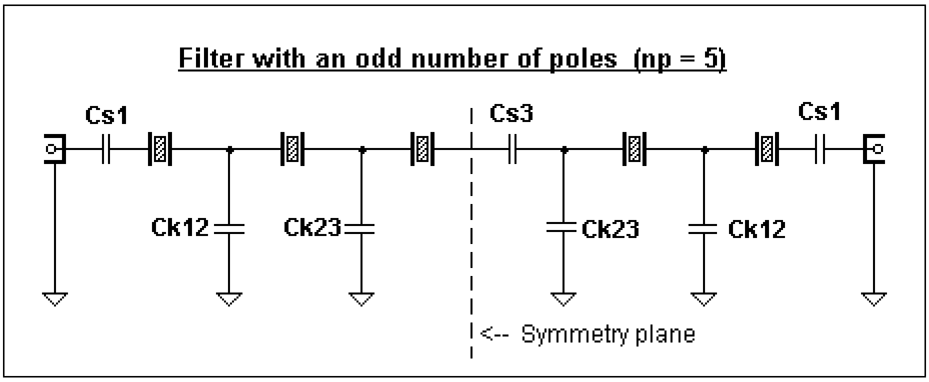
Besides the capacitance values, the individual (always positive) frequency offsets of fs caused by the tuning capacitances are shown. If crystals with the respective frequency offsets can be supplied then the tuning capacitors can be omitted. The "reference frequency" for these offsets is always the frequency of xtal #2 (and xtal #n-1) in the filter – the only ones without a tuning (series) capacitance.

→ For more details see the part: "Mesh Frequency" (Appendix)

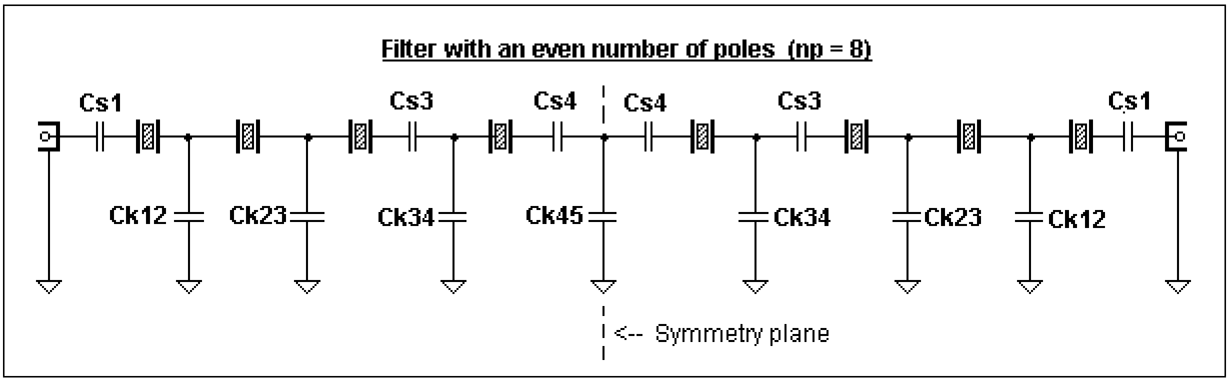
You will notice that only **half** of the necessary coupling and tuning capacitances are listed.

This is sufficient because the topology of all four filter types covered by the program is always symmetrical. Therefore, the coupling capacitance Ck_1,2 is identical with Ck_n-1,n, and so forth.

The following pictures of filters with odd and even numbers of poles illustrate this property.



Position of the coupling capacitors (Ck) and the tuning capacitors (Cs) in typical filter configurations.



A table with the complete filter schematics for all numbers of poles from 2 to 14 is provided at the end of the appendix for a comprehensive information regarding the assignment of the coupling and series capacitances.

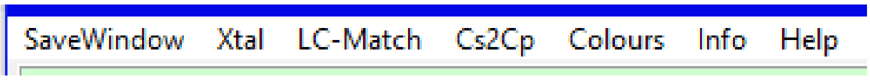
The Graphic Display

The graphic display field shows the resultant filter response curve. The filter curve is always centered on the calculated center frequency "fm". Based on the selected frequency span of up to 400kHz, the respective plus and minus frequency offsets are also displayed. The response curve can also be displayed with an expanded log scale of 1db/div by hitting the **10db<->1db** button below the "**Calculate**" button in the Input bar.

The ultimate attenuation value is shown below the graphics field and will also appear as a green line if it is within the display range of 0 -100db

New: The Insertion Loss of the displayed filter, the Return Loss S11 and VSWR (if checked) are shown as well below the graphis field.

The Menu bar



SaveWindow

A click on this label generates a bitmap picture of the whole program window and saves it in the program folder as "Filter.bmp". To indicate that the picture is generated, the graphic display changes its colour for a fraction of a second. (A copy of this bitmap is also available in the Windows clipboard). All calculated data - including the value of the mesh frequency - and the response curve are contained in the picture and can be used for further evaluation. If several different pictures are required, one has to either rename the file (recommended) or to move it into another folder because any new picture is overwriting the existing one without warning.

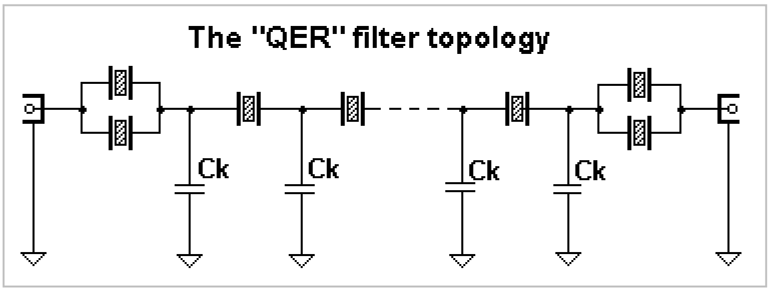
Cohn, Now moved from the Menu bar to the filter selection panel

Filter designs using the "minimum-loss" coupling method publicized by Seymour Cohn [7] have become quite popular – especially for CW filters – despite their known deficiencies like uncontrollable passband ripple and relatively high group delay distortion. The advantages are the simple design, using equal values for the resonators and the coupling capacitors, together with relatively steep filter slopes.

This program also applies the Dishal method, i.e., the effects of the crystal parallel capacitance Cp are accurately taken into account. Hence, it delivers equally exact calculation results for the coupling and termination values.

QER(G3UUR), Now moved from the Menu bar to the filter selection panel

G3UUR developed a new variant of the Cohn type filter which combines the simplicity of the equal coupling values for Ck with a dramatic reduction of the passband ripple and group delay distortion. As an example - the PB ripple of an 8-pole QER filter is just ~0.3db as compared with the extremely high ripple of 5 to 6db of the equivalent Cohn structure. This "Quasi-Equi-Ripple" property (QER) is achieved by replacing the series end capacitances with a second xtal in parallel to each series end xtal as shown in the diagram. Also, the coupling coefficients and termination impedances are somewhat different as compared with a Cohn filter. The additional xtals do not change the effective number of poles of the filter.



A comprehensive information about this filter type can be found in the ARRL-Handbook 2010 [9] and in QRP Quarterly [10]. A simulation, which compares the passband response of an 8-pole Cohn filter with the response.of the QER structure, can be seen in the appendix.

Of course, the program also applies the Dishal equations for a correct calculation of the values for the coupling capacitances and termination impedances.

Xtal

Opens a drop-down menu, containing two programs for the easy calculation of the crystal parameters, and a third one for crystal tuning:

3db-Method
This one is based on the values measured with a passive test set, using a precision signal generator and detector or a network analyzer. It assumes that the "3-db" method is used. A detailed description about this measurement method and how to construct such a very useful setup and it's application can be found on the web page of K8IQY under the title "Precision VXO" :

http://www.k8iqy.com/testequipment/pvxo/pvxopage.htm

This is just one example of the many available articles about crystal parameter measurements.

Note:
The 3db-method program expects the direct voltage ratio "Uout/Uin [%]" or the attenuation in "db" as an input to calculate the loss resistance Rm. If Rm is determined directly by substitution as decribed by K8IQY, then its value can be placed directly into the "Rm" field if the checkbox is activated (see appendix).

G3UUR-Method
This is probably the most popular method, using an oscillator circuit with a switchable capacitor in series with the crystal which allows the calculation of the basic xtal motional inductance and capacitance. Its description can be found in many publications and on the Internet.

The updated program is not anymore using the simplified equations which lead to relatively high errors in the calculation of the xtal parameters. It now applies the accurate equations which take the influence of the Colpitts voltage divider capacitances (normally 470pF each) correctly into account. This yields results with better accuracy for the parameters.

However, it is possible to return to the simplified calculation method for compatibility by setting the values for the voltage divider capacitances in the program to "0" (zero).

Although the xtal loss resistance cannot be measured directly with this method, the oscillator amplitude level can be used as a good measure of the xtal quality factor and the resulting activity. This allows the sorting of the xtals according to their relative quality factors and to weed out bad xtals. Only a diode detector at the oscillator output stage and a high-resistance volmeter (DVM) are necessary for these comparative measurements.

Xtal Tuning
This program allows the calculation of individual series tuning capacitances to achieve equal mesh frequencies when the available xtals cannot be matched for identical series resonances. Its application with a calculated example is shown in the appendix.

Please note that this procedure is only available for the Chebyshev/Butterworth filter types, because it is especially tailored to their topology (frequency deviation info of the series caps). It is therefore deactivated for the Cohn and QER filter types.

Table → Deleted

LC-Match

Selecting "LC-Match" opens a separate program window to calculate the values for an appropriate LC matching network to match the filter to the external source and load impedances. This may be a better choice for specific cases rather than the transformer method. Both possible versions for this network – the Low-Pass and the High-Pass topology and their values are shown. The calculation assumes resistive impedances and also requires that R1 is always smaller than R2. Otherwise, an error message is displayed. If the difference of the filter and external impedances is equal or smaller than 1:1.02 (→ return loss 40db), then the message "No matching network necessary" appears.

Note: When this program ist called, it will automatically take the frequency and termination values from the main program and calculate the resulting values for the LC networks. Of course, any other input values can be chosen for calculations after start-up.

Cs2Cp

This subprogram can be used to transform the termination series capacitance Cs1 into its parallel equivalent. The termination impedance is also changed accordingly. At startup, the calculated values for frequency, impedance and Cs1 are taken from the main program but can be freely changed for a general application of the program. This menu item is deactivated for the QER filter type to avoid an unnecessary error message (no series capacitance).

Colours

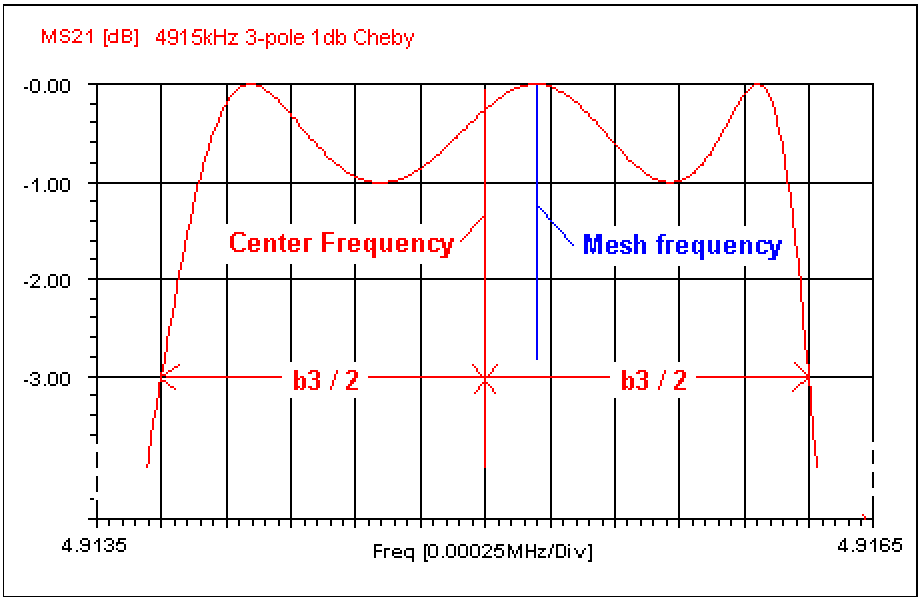
This add-on menu allows you to change the colours of the graphic display components. All colours can be reset to the standard settings by "Default".

Appendix

The filter "Mesh" and Center frequency

In normal bandpass filters of the mesh (ladder) type, the filter center frequency and the mesh frequency are identical. This is **not** the case with the ladder bandpass filters using crystals.
(Thanks to Jack Hardcastle, G3JIR, who pointed this discrepancy out)

The reason for this is, once again, the inevitable parallel (holder) capacitance Cp which causes not only an asymmetry in the stopband but also in the passband. Thus, because the center frequency is defined as the median between the 3db points, the mesh frequency is always slightly higher in a lower-sideband ladder filter (in the upper-sideband topology it is always lower). The following picture of a 3-pole Chebychev filter illustrates this effect – here, the mesh frequency is 195Hz higher than the center frequency.



The mesh frequency is shown as a hint message whenever the mouse pointer is moved over either the "Center frequency" number in the Filter Parameter field or over the same number below the graphic display.

Note: If a picture is taken with "SaveWindow", the mesh frequency is shown below the graphic diagram.

The values of the tuning C's provided by the program ensure equal frequencies of all meshes.
Only, if any additional tuning of individual crystals is desired the following info might be helpful:

1) The filter mesh frequency is always defined by the second mesh in the filter (and the second last which is identical), being the highest frequency because the crystal is connected in series with the smallest coupling capacitances on both sides. All other meshes are then tuned to this reference mesh frequency with additional series tuning caps.

2) The application of the Xtal Tuning program in the "Xtal" menu for an individual tuning of xtal mesh frequencies is described in detail on the following pages.

Crystal Tuning with the "Xtal Tuning" program

It is always recommended to select crystals with identical series resonance frequencies (and, of course, identical motional inductances) for a ladder filter. This makes the design of filters with the Dishal program extremely easy and yields results which provide the best fit to the theoretical response. The variation of the xtal frequencies should not exceed ± 2% of the desired bandwidth. A spread of up to ± 5% is only acceptable if larger ripple values can be tolerated.

However, there may be cases where only crystals with a wider frequency spread are available. Within certain limits, those crystals can be individually "tuned" with series capacitances which differ from the calculated values for the ideal case. For this purpose, the respective equivalent offset frequencies are shown in the Dishal program besides the values of the series (tuning) capacitances Cs_x.

The xtal tuning program is very easy to use because the necessary frequency offset information is already provided by the Dishal program. The resulting filter passband curve may slightly deviate from the ideal one. This can be a small increase of the passband ripple, sometimes together with minor changes of bandwidth and center frequency. However, these effects are still negligible compared to the errors introduced by actual component tolerances and crystal losses. An explanation of the various reasons for this behaviour is beyond the scope of this description.

The tuning method is explained with a typical example.

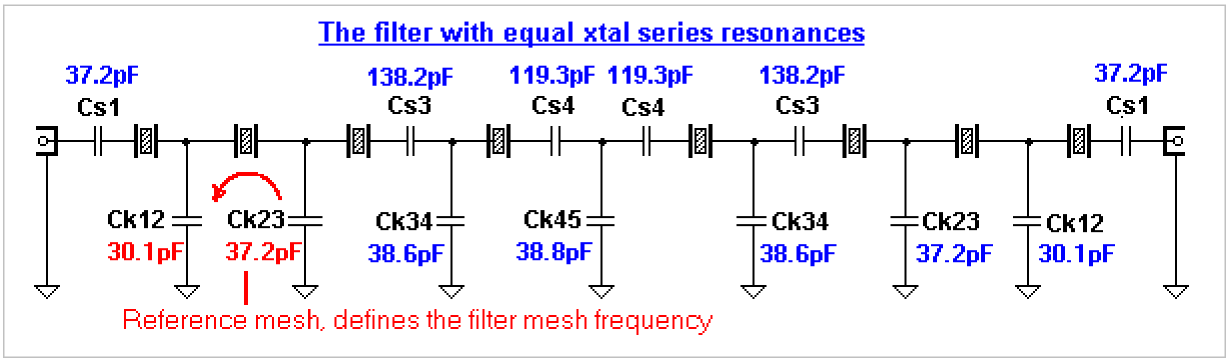
Let's assume 8 crystals with the following arbitrary series frequencies (kHz):

#1: 4999.670, #2: 4999.895, #3: 5000.010, #4: 5000.120, #5: 5000.235, #6: 5000.320,
#7: 5000.485, #8: 5000.680. (this is an unusually large total spread of 1010Hz)

We will construct an 8-pole filter with a 3db bandwidth of 2.5kHz and a ripple value of 0.5db, using the above crystals.

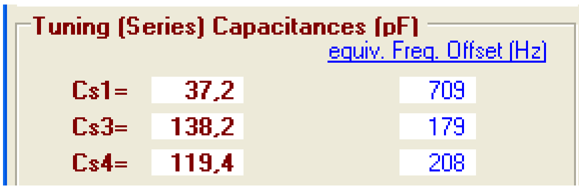
The first step is to select a crystal from the list which lies somewhere in the middle of the frequency distribution. Therefore, we take crystal #4 (5000.120kHz) for the reference mesh #2 which also defines the nominal series frequency **fs** for the Dishal program.

Now, we will first calculate the filter assuming identical crystals with the selected series resonance of 5000.120 kHz. Typical values for the motional inductance Lm = 70mH and a holder capacitance of Cp = 3.7pF are used. The Dishal program will yield the following result:



The meshes #2 and #7 are the only ones without a series capacitance. They define the mesh frequency of the filter which is the highest due to the smallest coupling capacitances connected to them. Consequently, their frequency offset is Zero by definition and is not listed. All other crystals must be tuned to this mesh frequency by their series capacitances Cs1...Cs4.

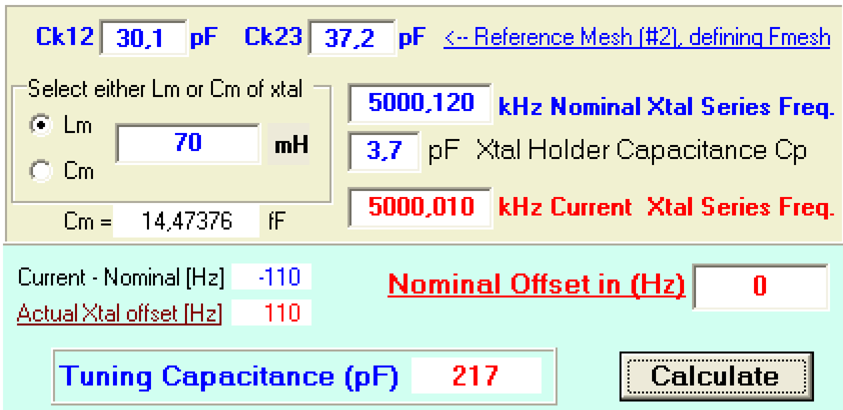
The program provides us with the values of the coupling capacitors which define the filter properties and are also important for the calculation of the necessary tuning capacitors. The values for Cs1 to Cs4 in the above picture are of no interest because we must change them anyway due to the different crystal frequencies. However, in the list below, the corresponding frequency offsets are shown as well. These are needed for the tuning process.



The values in the "equiv. Freq. Offset" fields are now used for the tuning procedure with the "Xtal Tuning" program.
The values of the coupling (shunt) capacitors as shown above will not be altered.

We can now activate the "Xtal Tuning" program in the Menu drop-down list. For user convenience, all necessary initial parameters are automatically imported from the main Dishal program at startup. The only fields which should be changed in the tuning process are "Current Xtal Series Freq." and "Nominal Offset".

Since crystal #4 is used for mesh #2, we select the crystal #3 (5000.010kHz) for the mesh on the other side of the filter (mesh n-1 = #7). We know that this mesh is also defined with a nominal offset of Zero. We put the values for the frequency ('Current Xtal Series Freq.') and the 'Nominal Offset' into the Xtal-Tuning program and get the following result:

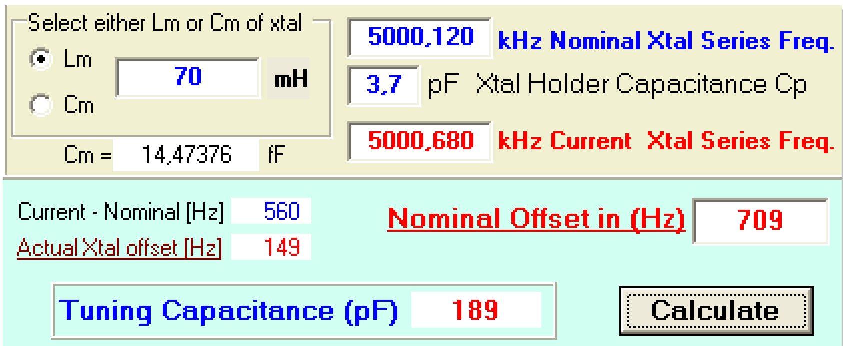


← Coupling values of mesh #2, taken from the Dishal program
← This frequency is used as the basic series freq. "**fs**" in the Dishal program for the calculation of the coupling (and basic series) capacitances.

← The respective offset freq. as calculated and shown in the list for the series (tuning) Csx. **Special case here: Zero**

The mesh #7 requires a series capacitance of 217pF.

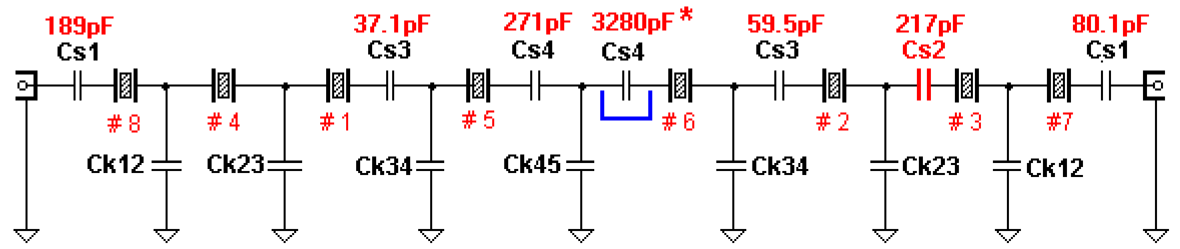
We proceed further by looking at the end meshes (#1 and #8) which require the largest offset. It is obvious that we choose the crystals with the highest positive deviation from the nominal frequency of 5000.120kHz. These are the crystals #7 and #8 (5000.485 and 5000.680kHz). The required offset for the end meshes is 709 Hz. We put the numbers into the program and get:



Because the crystal has already an offset of 560Hz, an additional tuning of only 149Hz is required. The value of the calculated series-C is therefore **189 pF**.

For the crystal with 5000.485kHz at the opposite end of the filter, the program yields **80.1 pF** to achieve the same nominal offset.

We can now calculate the rest of the necessary tuning capacitances which produces this filter *:



Filter with unequal xtal frequencies, using individual tuning C's

The xtal numbers refer to the list in the text * < Can be replaced by a short

This is just one example of how to proceed with crystals having different series frequencies. The degree of freedom is limited by the fact that the crystals can only be pulled upwards in frequency by capacitors. Therefore, it can happen in the process that the starting values lead to a situation where the inherent crystal offset is already larger than required by any of the filter meshes. In this case, we have to repeat the whole process with a higher crystal frequency as the starting value.

However, any recalculation can be performed in a very short time frame with the two programs.

The crystals should not be shifted excessively in frequency. The crystal quality factor Qu is reduced with an increasing offset, i.e. decreasing value of the series capacitance. Hence, a warning is given by the program when the capacitance value goes below 10pF.

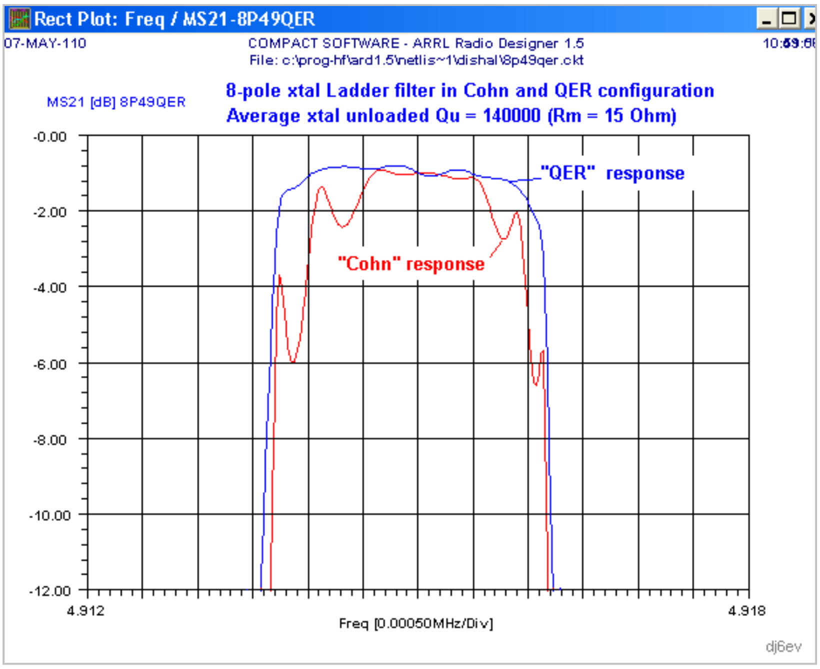
Of course, there are other proven tools available for the calculation and tuning of individual filter meshes. Wes Hayward, W7ZOI has written such a tool to calculate the necessary values with the program "FineTune" which comes with the book "EMRFD" [5] as part of "LADPAC2002" or its older counterpart "MeshTune" (DOS) which was supplied with the book "RF Design" [6]. Because the approach is very different from the method used here, it is recommended that you read the respective introductions carefully.

Somebody with a fearless mind wanting to construct nearly ideal filters by tuning each individual mesh should read the article by J. Makhinson, N6NWP [8] which describes the basics and the necessary steps in detail. However, it should be noted that N6NWP is also using crystals with more or less identical parameters as a starting point. His "fine-tuning" is performed to compensate for all tolerances to achieve such excellent filter responses as shown in his article. This is quite time consuming and requires numerous accurate measurements as well.

* The filter could also be designed without any tuning capacitors if we had a set of crystal pairs with the frequency offsets as calculated by the Dishal program. However, the crystals must still have more or less identical values for Lm / Cm (max. ± 2%). In this example, the required crystal frequencies would be:

2x 5000.120kHz for the meshes 2 and 7(n-1) (as the reference frequency **fs**)
2x 5000.829kHz for the meshes 1 and 8 (+ 709 Hz)
2x 5000.299kHz for the meshes 3 and 6 (+ 179 Hz)
2x 5000.328kHz for the meshes 4 and 5 (+ 208 Hz)
Even here, we get some deviations from the ideal passband, but they are extremely small.

Quasi-Equiripple (QER) – Filter vs. Cohn-Filter



The picture shows the response curves of an 8-pole 2,5kHz wide ladder filter with lossy xtals for the classic Cohn configuration in comparison with the QER filter which uses a slightly different topology.

The extreme ripple of more than 5db and the narrow resonance peaks make the 8-pole Cohn filter practically useless for SSB operation. The QER filter, however, shows a ripple value of less than 0.5db and an even smaller insertion loss.

Some practical hints

Of course, actual filters exhibit an insertion loss and rounding of the passband edges due to the losses in the crystals (loss resistance Rm) and, to a minor degree, losses in the capacitances. This leads to a slightly smaller 3db-bandwidth than calculated (the filter response curve now shown with the new version 3 reflects this very accurately). However, this effect is normally quite small with a sufficiently high Qu of the xtals compared to the deviations caused by component tolerances. An example: a 4915kHz 8-pole filter was designed for a 2.4 kHz bandwidth at 3db, and showed a real bandwidth of 2.36 kHz. At 6db down, the difference was even less (<20Hz). If you need a guaranteed minimum bandwidth then you should simply use the desired 5- or 6db bandwidth of a filter as the design (3db) bandwidth.

The display of the actual 6db-Bandwidth in Version 3 helps to determine any adjustments.

And there is also the influence of stray capacitances of the filter board in the order of 1.5 to 2pF, which must be subtracted from the calculated coupling capacitances.

It is always very helpful to transfer the calculated data into a good simulation program. Thus, one can freely change individual component values, introduce controlled deviations from the ideal capacitance values or crystal parameters and termination resistances.
The automatic generation of netlists for three simulators, including LTSpice is provided

New Calculator for the 3db Method

The 3db calculator as implemented in the older Dishal programs has been extended to allow the input of not only the voltage ratio "Uout/Uin[%]" but also the direct input of the attenuation in "db".

The user can chose between these two inputs by selecting one of them with the corresponding RadioButton.

Furthermore, a CheckBox has been implemented besides the Loss Resistance field to input the crystal loss resistance Rm directly if this value has been found by a substitution measurement. The RadioButtons are blanked out when the box is checked, thus preventing any input of attenuation. All values are recalculated and the result fields are updated. The pictures show both input modes:

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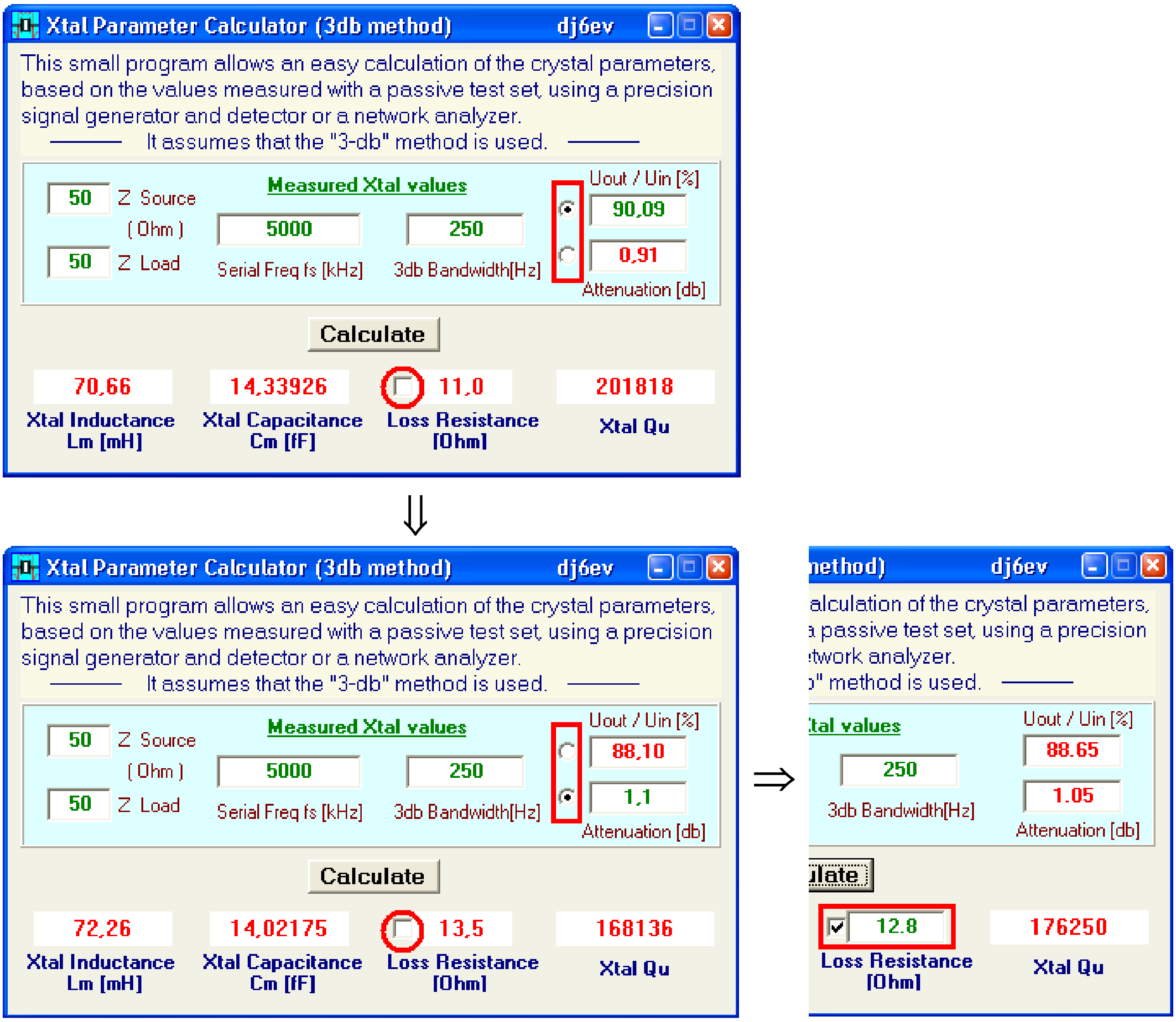


The texts in all active input fields always appear in **green** color, the result fields are **red**. Hence, changing the input method changes the colors of the affected fields accordingly

Automatic generation of Netlists for GPLA- , ARD- and LTSpice Simulators

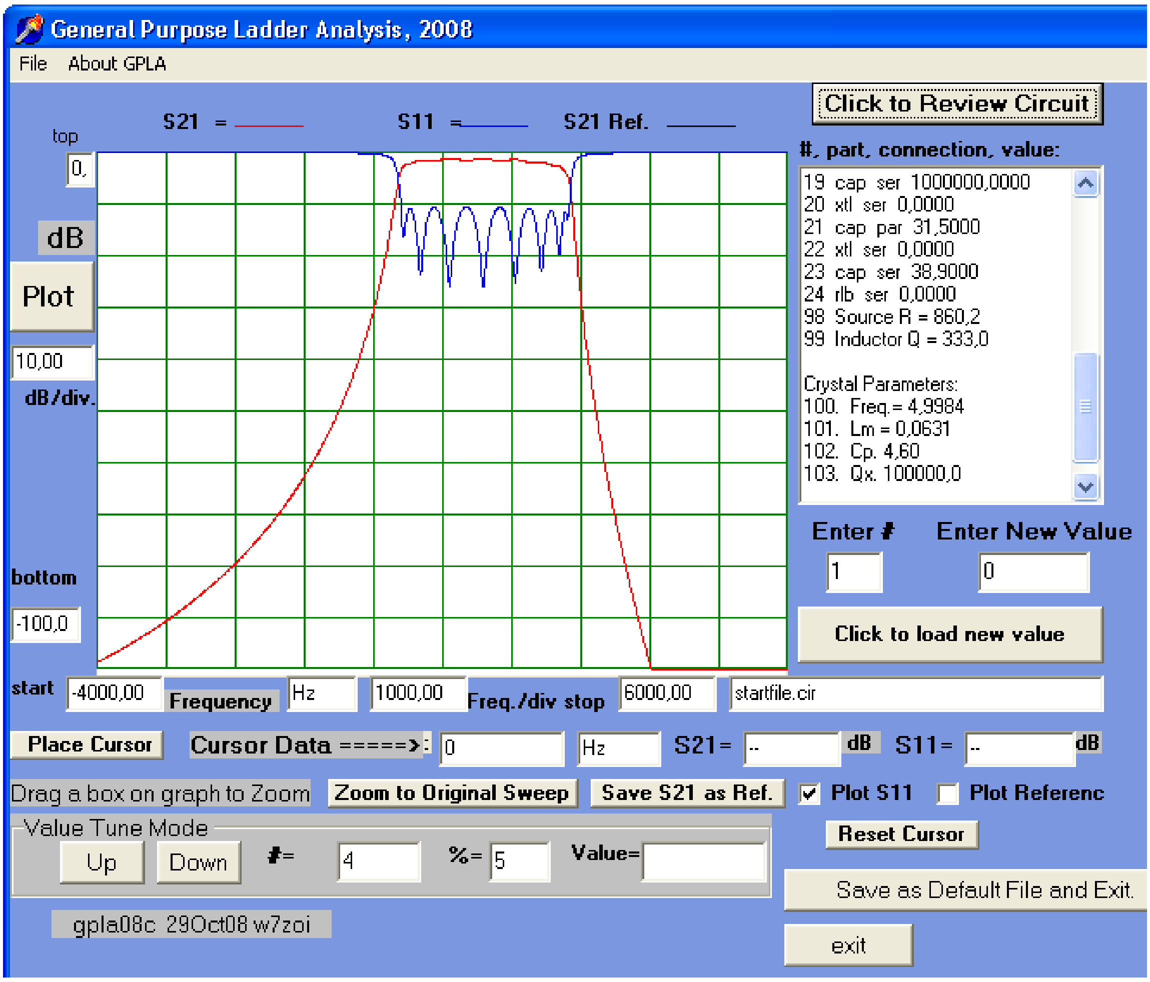
The version 3.0.2.x generates netlists automatically in the background each time a calculation is performed. The lists are generated for three simulators, the ARRL Radio Designer (ARD), the GPLA program by W7ZOI (part of the LADPAC package) and the popular LTSpice simulator. For this purpose, three folders are generated at the first start of the Dishal program:

"GPLA_Files", "ARD_Files" and "SPICE_files"

Starting with Vers. 3.0.2.3, the Xtal Qu for all lists is transferred from the calculated filter model in the program. Of course, Qu can be changed in the simulation to any other value.

GPLA Netlist: (*)

The netlist is saved in "GPLA_Files", always as "Startfile.cir". The program **gpla08.exe** (must be located in this folder) automatically loads this file at the start. The curve can be shown using the **"Plot"** command.



The component values can now be changed as desired using the edit field on the right side. However, GPLA does not allow individual parameters for the xtals (they are always assumed to be identical). The list can be saved using any desired name with the "File / Save As" command.

The subprograms **"Cohn"** and **"QER(G3UUR)"** generate netlists as well. Because GPLA does not accept the special QER topology (no parallel xtals allowed), a trick was used with two xtals in series for the inner meshes. This leads to halving the coupling cap values and doubling the termination impedance to display the correct frequency response. Thus, the values in the Dishal QER program window are the correct ones to be used for an actual design.

(*) GPLA is a part of the software package "LADPAC2008", which can be found on the CD of the "EMRFD" book **[5]**. It can also be downloaded from the Internet for owners of the EMRFD book.
The download link: https://w7zoi.net/emerrata.html

ARD Netlist

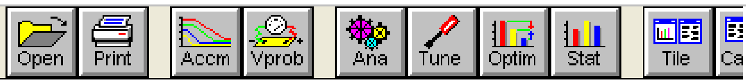
The ARRL simulator accepts comments which allows the implementation of meaningful headers and additional information. The list is saved in the folder "ARD_Lists" with a name reflecting the filter type, a 3-digit number for the filter frequency (resolution 0.1MHz) and the number of poles. The filter types are shown as follows: 'T' →Chebychev, 'B' →Butterworth, 'C' →Cohn, and 'Q' →QER.

An example: "T049_p8.ckt" is a ~4.9MHz Chebychev filter with 8 poles.

The old DOS "8.3" restriction (max. name length=8) limits the information contained in the file names.

In addition to that file, a copy is generated in the Windows "Clipboard", which allows a very convenient transfer into the ARD via the "File / New", "Edit / Paste" commands.

An example for such an automatically generated list is shown here:




```
;**********************************************
;*** 8 pole Chebychev Filter; b3=2.5kHz ***
;**********************************************

imp: 860.2oh    ;filter termination
Ck12: 31.5pF
Ck23: 38.9pF
Ck34: 40.3pF
Ck45: 40.6pF

Cs1: 38.9pF
Cs2: 999999pF   ;for tuning only
Cs3: 144.4pF
Cs4: 124.7pF

blk             ;default Xtal Q =100000
srx 10 20 r=19.8oh L=63.1mH C=16.06771fF
cap 10 20 c=4.6pF
xtal: 2por 10 20      ;fs= 4998.37kHz
end
```

```
blk
TRF  100 120 r1=50 r2=imp
xtal 120 130            ;---1
cap  130 140 c=Cs1
cap  140   0 c=Ck12
xtal 140 150            ;---2
cap  150 160 c=Cs2
cap  160   0 c=Ck23
xtal 160 170            ;---3
cap  170 180 c=Cs3
cap  180   0 c=Ck34
xtal 180 190            ;---4
cap  190 200 c=Cs4
cap  200   0 c=Ck45
xtal 200 210            ;---5
cap  210 220 c=Cs4
cap  220   0 c=Ck34
xtal 220 230            ;---6
cap  230 240 c=Cs3
cap  240   0 c=Ck23
xtal 240 250            ;---7
cap  250 260 c=Cs2
cap  260   0 c=Ck12
xtal 260 270            ;---8
cap  270 280 c=Cs1
TRF  280 300 r1=imp r2=50
Tchby8p: 2por 100 300
end

freq
Step 4.995MHz 5.005MHz  20Hz
end
```

After the analysis any desired graphics display can be created with the Report Editor. Of course, all parameters (including indidvidual xtals) can be freely changed. The circuit and report files should be saved with a different name.

The netlists for the ARD can also be genrated for all four filter types of the Dishal program, including the subprogram **"QER(G3UUR)"**.

LTSpice Netlist

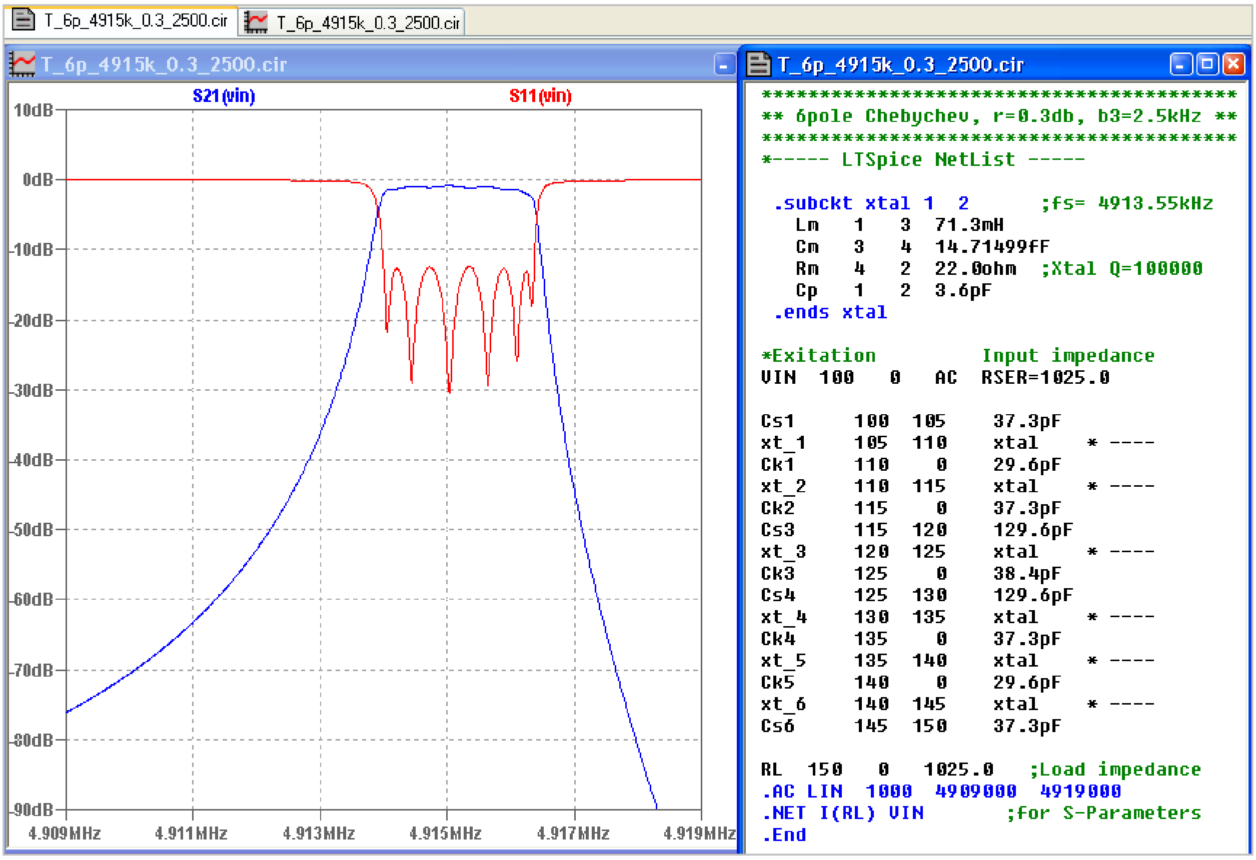
The LTSpice-IV simulator is a freeware program from Linear Technology which has become very popular within the amateur community. The netlists for all four filter types, generated as .CIR files by the Dishal program, are saved in the "SPICE_files" folder with an information about filter type, number of poles, approximate center frequency in kHz, (passband ripple for Chebychev /Butterworth in db) and filter bandwith in Hz. The filter type is again defined by the following leading letters:

'T' →Chebychev, 'B' →Butterworth, 'C' →Cohn, and 'Q' →QER.

Example: T_10p_4999k_0.3_2500.cir

→ 10 pole Chebychev with fm~4999kHz, 0.3db PB ripple and a design BW of 2500Hz.

The .cir files can be directly loaded into LTSpiceIV via the "File / Open" command and simulated. The file type in the "Open" menu window must be set to "Netlists"). The netlist structure has been selected for an easy display of S-parameters S11, S21, (S12, S22).



Please note:

The simulators **gpla08** , **ARD** and **LTSpice** are <u>not</u> a part of the Dishal package.

Acknowledgement

My special thanks go to Jack Hardcastle, G3JIR, for the many productive discussions and exchange of ideas over the past years regarding this interesting topic. He also motivated me to overcome my laziness and transfer my age-old DOS program into this Windows version, and to add various tools to it during the recent months. His work laid the fundamentals for the algorithms which led to the current program versions.

I also like to thank Dr. Dave Gordon-Smith, G3UUR, for many valuable tips regarding the improved version of the oscillator method and my Dishal implementation of his QER filter model.

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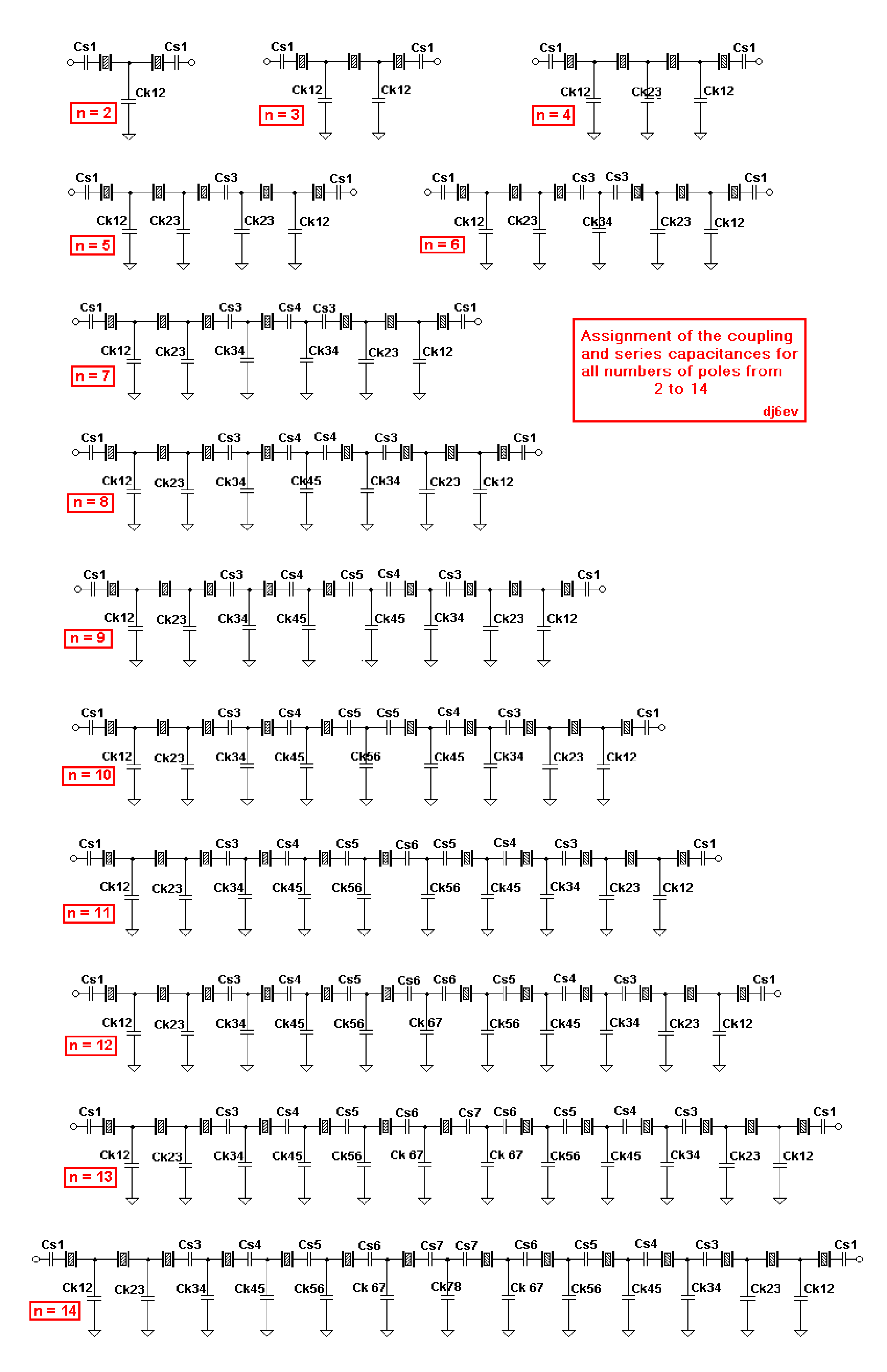
November 2007 (revised January 2009)
Revised May 2010
Revised Jan 2024 for the new version 3


n = 2
n = 3
n = 4
n = 5
n = 6
n = 7
Assignment of the coupling and series capacitances for all numbers of poles from 2 to 14
dj6ev
n = 8
n = 9
n = 10
n = 11
n = 12
n = 13
n = 14