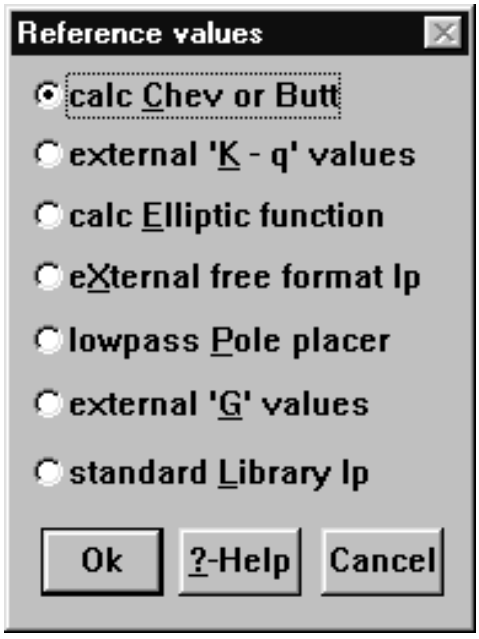
Reference lowpass values

Virtually all of the design modules in the system operate by scaling normalized lowpass reference filters in various ways. The source of these lowpass values can be in several formats. Which format to be used is chosen from a menu that can be found via the "Design" option on the main control menu. It will also come up automatically after a new design is chosen.



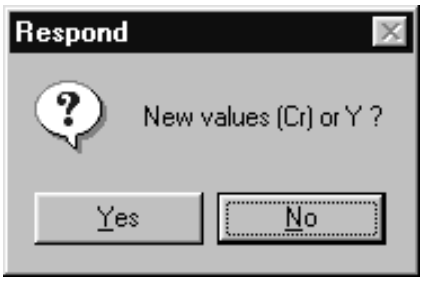
(*) calc. Chev or Butt

Calculate Chebyshev or Butterworth values internally.

Design by external (keyed in) values

In addition to calculating the usual all-pole Chebyshev and Butterworth type of designs, exotic designs can be done by keying in normalized values from tables for responses like predistorted gaussian and Legendre. There are many sources of these values, but the prompts built into the program were set up to match the tables published in The HANDBOOK OF FILTER SYNTHESIS by Anatol I. Zverev published by John Wiley and Sons, Inc. pages 311-379. The computer will take care of all of the details about load and source impedance and the like for any configuration including highpass and notch designs.

Each time a design is calculated (after the first time), a prompt will appear allowing you to key in the values again. This gives you the opportunity to try different normalized values while keeping the same parameters. The prompt will appear at the center of the screen. Just press the <space> bar or the <Enter key to use the values in memory again.



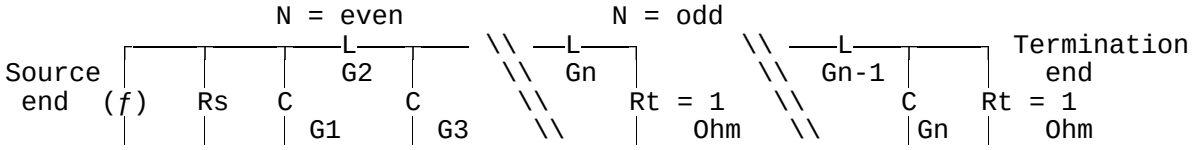
Design by lowpass "G" values

(*) external 'G' values

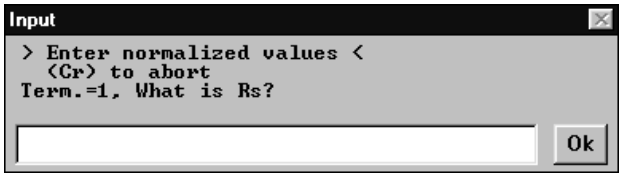
"G" values are the actual element values of a normalized lowpass in Farads and Henrys.

The ratio of source to termination end impedance of a filter is determined by the number of elements and circuit configuration. Normally, with an odd order filter (N=3,5,7 ..) the Rs and Rt will be the same, but with an even order filter, the series end impedance will be lower than the parallel end.

The situation can become confusing when you must predict the impedance at the source end when the normalized Rs is not equal to 1. To simplify this situation, all values entered will be standardized to that required by a lowpass filter having a 1 Ohm termination end impedance, a PARALLEL source end element, and a cutoff frequency of 1 radian / sec. In the event you are doing a singly terminated design, the source Zo will be fixed at infinity. For the usual doubly terminated case, the value of Rs must be input.



Doubly terminated designs



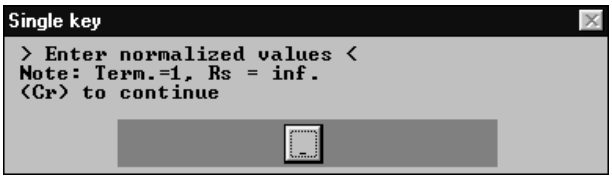

```
(*) tYpe: 1=sing 2=doub 3=ratio  2   <-- On parameters menu.

 > Enter normalized values <
Term.=1, What is Rs? 1.25  <-- You must enter Rs.
```


```
What is G1 ? .1401
What is G2 ? .6554     (These numbers are for a gaussian filter)
What is G3 ? .7349
What is G4 ? 2.6209
```

Singly terminated designs

```
(*) tYpe: 1=sing 2=doub 3=ratio  1   <-- On parameters menu.
 > Enter normalized values <
Term.=1, Rs = inf. <-- Both Rs and the termination Zo are fixed.
```



Simply press the <space> bar or <Enter> key.

```
What is G1 ? . . .
```

By "k" and "q" values

(*) external 'K & q' values

"k and q" values are normalized coupling coefficients and loading factors.

The input prompts are similar to the same as those used for normalized “G” values.

```
 > Enter normalized values <
What is q1? 1
What is qn? 1       (These values are for 3 pole Butterworth response
What is k12 ? .7071    with infinite "Q").
What is k23 ? .7071
```

(*) Elliptic function

Calculate elliptic function values internally.

Free format lowpass values

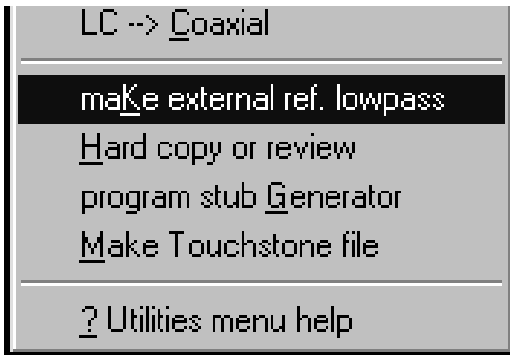
(*) eXternal free format lp

Using this option will allow a disk file containing a normalized lowpass filter to be used as the reference from which a filter is to be scaled. It is most useful in picking a specific normalized lowpass having a desired response from a library of different reference values you use frequently. This reference can have any configuration that represents a working lowpass filter including series or parallel connected

notch sections in any order. It is a standard ".DZN" design file and therefore can be keyed into the system using the “Insert” command of the circuit editor. It can be saved like any other design. An easy method of generating these files from any reference values in memory is provided on the Utilities menu. Because it is to be used as a reference, and will have no "specks", the ".SPK" file generated when you save can just be deleted. In order for the program to accept the file as a reference, it must be normalized to 1 radian / second and 1 ohm Zo. Checks are made to see that the termination Zo is 1 Ohm and that the frequency reference in the file is very close to 1 radian / sec (.159 Hz.). In the event a file specified as a reference does not meet these criteria or is inappropriate for a particular design, a warning message will appear.

Making an external reference lowpass file from "G" or "k and q" tables

The first thing that PCFILT does is to derive a normalized lowpass filter of the "free format" type from any format chosen for the values and hold it in memory. It does this regardless of the source of the



values, even if the values are in the form of loading and coupling coefficients ("k and q" values). The reference lowpass in memory can be converted to the external reference type and recorded to disk by using the <K> option from the utilities menu:

In this example, the values in memory have been saved in a directory called "\NORM" that has been set up as a place to keep a library of reference lowpass filters that are frequently used. The file generated will be \NORM\REF37.DZN and will be a standard design file. You can use any file name that is consistent with your personal cataloging system, but you must NOT use the main file name shown on the main control menu, that would cause the final design to overwrite the new reference lowpass when it is saved. To make sure that this will never happen, an error message is generated if you inadvertently try to use the same name.

Once the values you have keyed in are converted and recorded to disk, they can be used again at some later date by selection the "(*) eXternal free format" reference type and specifying the file name you used to make the file initially. Continuing with the same example, you would input the same file name in the parameters window.

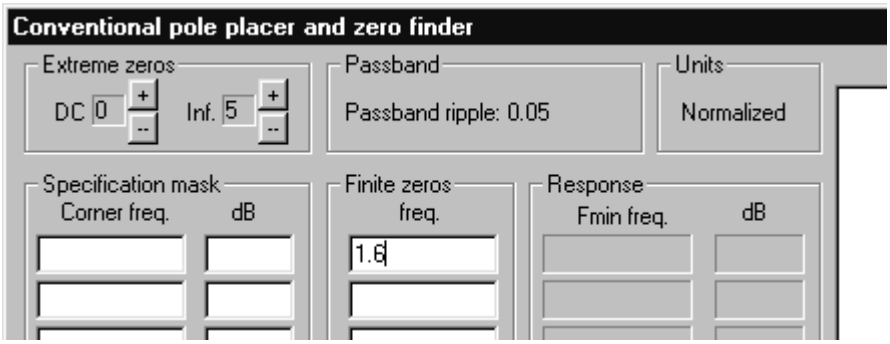
(-) eXternal reference filename

When the design is calculated, this reference filter would be loaded into memory first. The program checks each time the [Calculate] command is used to see that the reference in memory is the same as that shown on the parameters window. If you change the filename, the new reference will be loaded automatically.

(*) reference pole Placer

The program has a lowpass pole placer that can be used to generate free format reference lowpass filters for use in the scaling process which can be saved and used with the "(*) eXternal free format lp" option described above. When using this option, You are asked if you want to rerun the lowpass pole placer each time the design is calculated, just as it does when using external "G" or "k and q" values.

The low pass placer operates in identical fashion to the bandpass placer described in detail in another section of this guidebook. The main difference is that the finite zero frequencies are now normalized and expressed in radians (units normalized to the passband) rather than normal frequency units. When a bandpass filter is scaled from a lowpass having finite zeros, these finite zeros will be generated in pairs, one above the passband and one below. Shown below is the upper left corner of the placer dialog box.

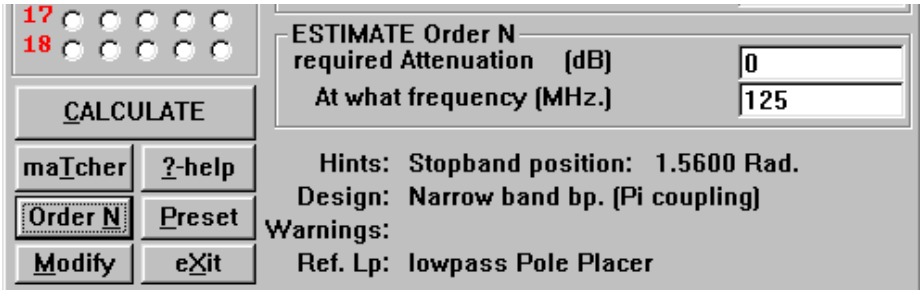


In the case shown above, the two notch sections will fall +-1.6 "half- passbands" on either side of the geometric center frequency of the filter.

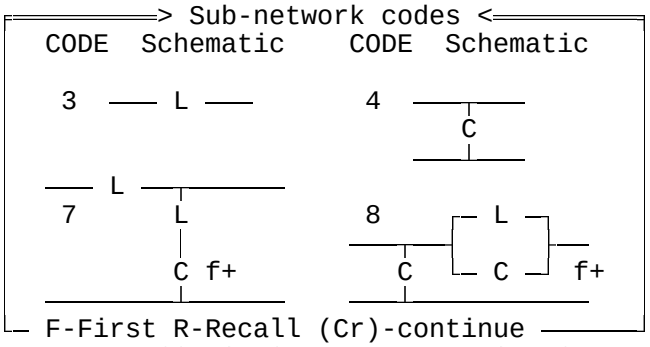
Determining finite zero or corner frequency locations

To determine the normalized frequency of any point down the skirt of a proposed filter in radians, the “Estimate order N" feature of the parameters menu can be used. Any frequency you specify will be displayed in radian frequency relative to the passband specifications you have set up in the parameters window above.

Once the normalized frequencies of your stopbands have been determined, the finite zeros can be keyed in directly, as is shown above, or the automatic placer can be used to determine the extreme zeros.



When a reference filter is synthesized, only the sub-networks that are applicable to lowpass filters are presented. These are codes 3,4,7 and 8.

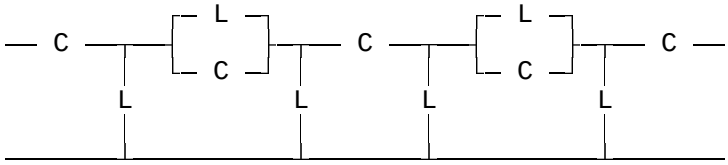


Here, unlike with the bandpass synthesizer, you have two options for the automatic syntheses. The finite zero sub-networks may be put in the middle of the filter, or at the source end. The default is the middle which is usually best for the scaling of bandpass filters.

```
ENTER THE CODES FOR THE FILTER STRUCTURE   (R)-Recall last manual entry.
(Start at the termination end.) Inf. zeros = 6 Finite zeros = 2
        Automatic: Put finite zeros (F)-First (Cr)-in the middle.
```

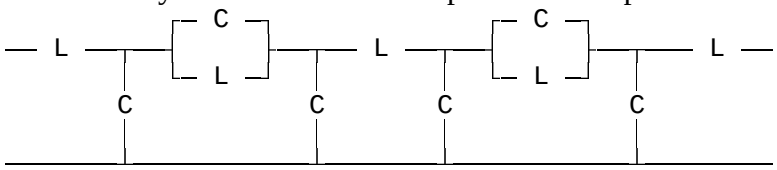
Symmetrical highpass using placer

Suppose we needed a highpass filter having symmetrical topology and element values. The filter must pass all frequencies from 200 MHz. up and should attenuate 160 MHz. with two finite zeros at the same location. We also require 5 Zeros at DC. The required topology must be as shown below:

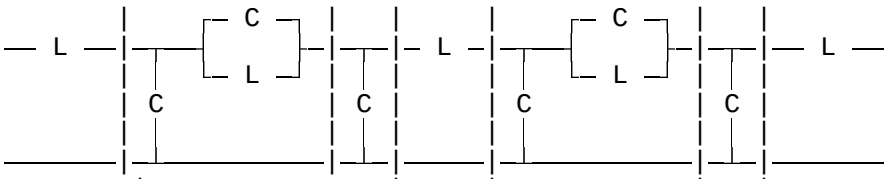


The default topology generated by the placer if you simply pressed the <Enter> key at the prompt would be to put both finite zeros together in the middle of the filter. Since a single series element is required in the center of the filter, the network codes must be specified manually. The filter is being scaled from a normalized lowpass which is the "inverse" of the final highpass. That is, each part must be replaced by one of the opposite type.

The radian location of both finite zeros will be 200 / 160 = 1.25 Radians and the 5 extreme zeros at DC would map to 5 zeros at infinity for the reference lowpass. The lowpass reference required is shown below:

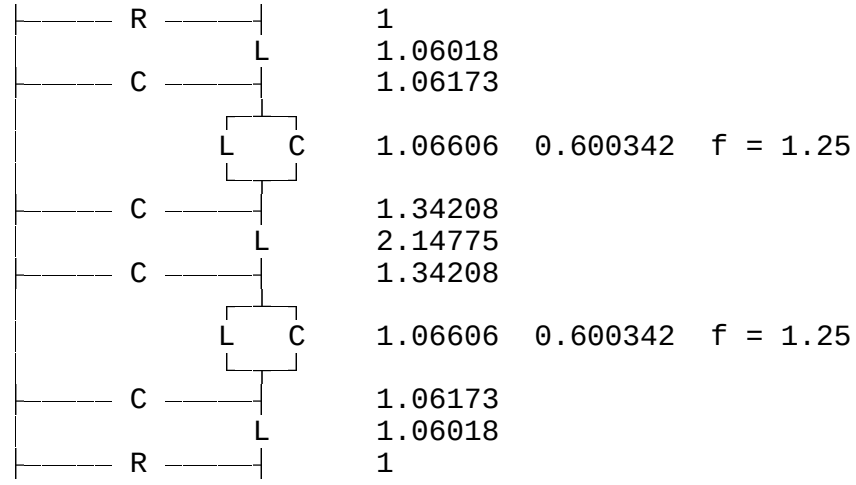


Breaking the network down into its sub-network codes we get:



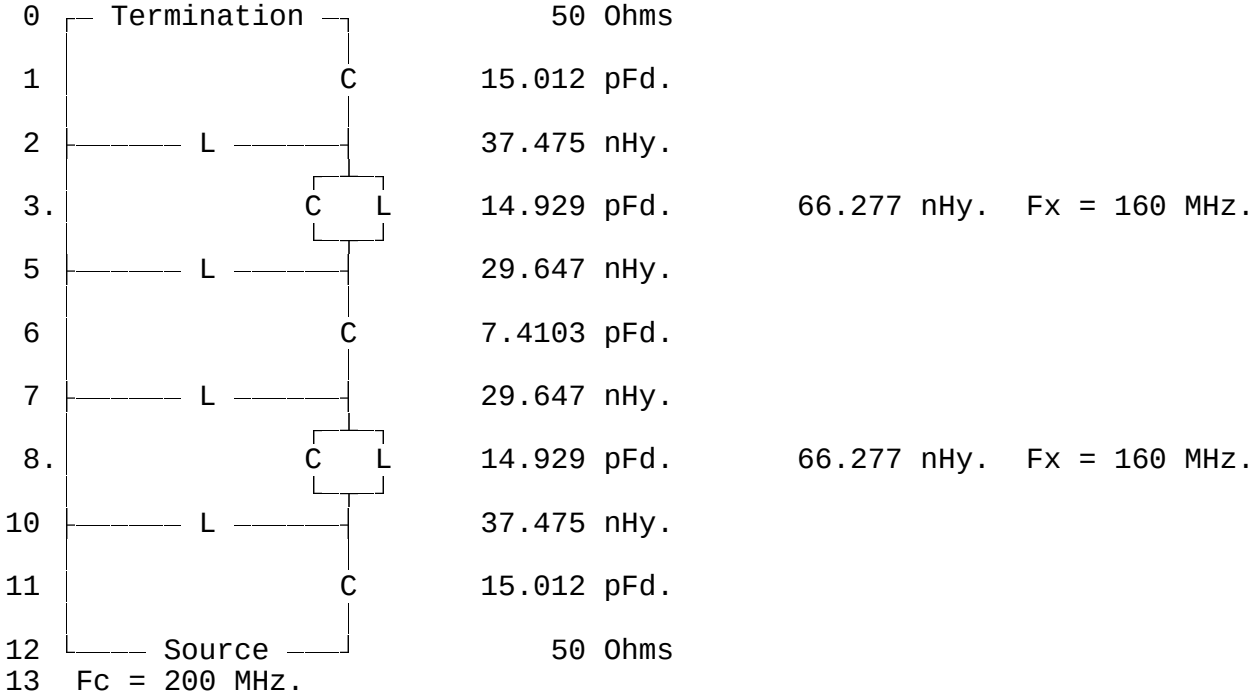

```
|      3   |     8      4 |  3   |      8     | 4 |   3  <--- Codes
```

Enter the Sub-network codes at the prompt:
(Cr = Auto.) > 3,8,4,3,8,4,3 <Enter>
The results are shown below:

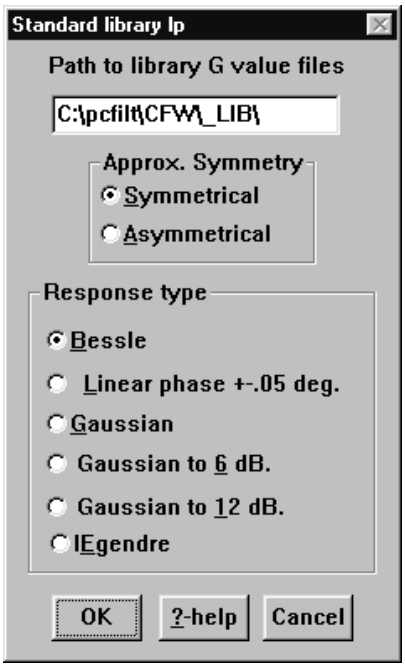



```
Design = Highpass
passband Ripple (0=Butt. dB) 0.05
design Zo.                   50
Cutoff freqency fc.     MHz. 200
confIg: (input)  Ser.  Par.  S
tYpe: 1=sing 2=doub 3=ratio  2
```

The final design looks like this:



(*) standard Library lp



When a standard library response is selected, the menu shown here will appear. This option uses a mechanism that provides quick access to a library of standard normalized lowpass reference filters in the form of "G" values which should be located in the directory "_LIB", just below the working directory. These files can be in the same format as any ".DZN" design file and are identical to the files used by the "eXternal free format lp". This allows the user to generate his own reference files beyond those provided. Normally however, these reference files are extracted from a large file (LIB_REF.DAT) provided to save disk space. If the necessary reference lowpass can't be found in this main library file, the program will look for a separate file with a filename in a predefined format. You can also add your own references to the main reference file.

When PCFILT is initially called, the default directory (your working directory) is stored in memory and used as the default path to the library subdirectory which is assumed to be "_LIB" just below. This default path name will show near the top in the "Standard library lp" dialog box if you have not manually defined some other path. For most users, the path to the library files will be: C:\PCFILT_LIB\

The path may be changed to anything you like using the top option on the "Standard library lp" window, but you won't need to do this unless you want to have an alternate set of library files, a predistorted set for example. The only limitation is that the entire path name must be no longer than the width of the window. You can return to the default path name by deleting the existing path name with the <Delete> or <Backspace> key and pressing the <Enter> key at the prompt rather than entering a path name manually. Once the design file has been saved, the path name showing will be recorded in the ".SPK" specification file along with the design. The next time that file is recalled, the path name you set will be recalled as well.

Two sets of files are provided for each type of response. Both sets were taken from published tables. The Asymmetrical set are useful for lowpass filters and are the most commonly used type. The alternate set were actually converted from "k" and "q" values chosen for as close to symmetrical parts values as possible. This set works best with narrow band bandpass filters.

```
    Approximate symmetry:
(*) * Symmetrical - <S>
(*)   Asymmetrical - <A>
```

Most of these files were generated using the "K" (make reference lowpass) option of the UTILITIES menu of PCFILT. The user can modify or add to them as needed if the correct fine name system is followed for additional files.

Library file name system:

The library filenames are built up from 4 elements, the symmetry code number, followed by the response type name, then the number of poles and finally the extension. A typical standard library file is shown below:

```
   1LPH0510.DZN
   ||||  ||  |└─── Extension: Always ".DZN"
   |└──┘  └──┘└── Number of poles (N)
   |  └ Response type name: "BESS"  = Bessel (Maximally flat delay)
   |                        "LPH05" = Linear phase with ±.05 Deg. error
Symmetry code:              "GAUS"  = Gaussian
   1 = Asymmetric           "GTO6"  = Gaussian to 6 dB.
   2 = Symmetric            "GTO12" = Gaussian to 12 dB.
                            "LEGEN" = Legendre
```

You will find file names just like these just above each corresponding reference lowpass in the file LIB_REF.DAT. The format will be obvious. New reference lowpass can be added right after those provided or left separately in the library directory.