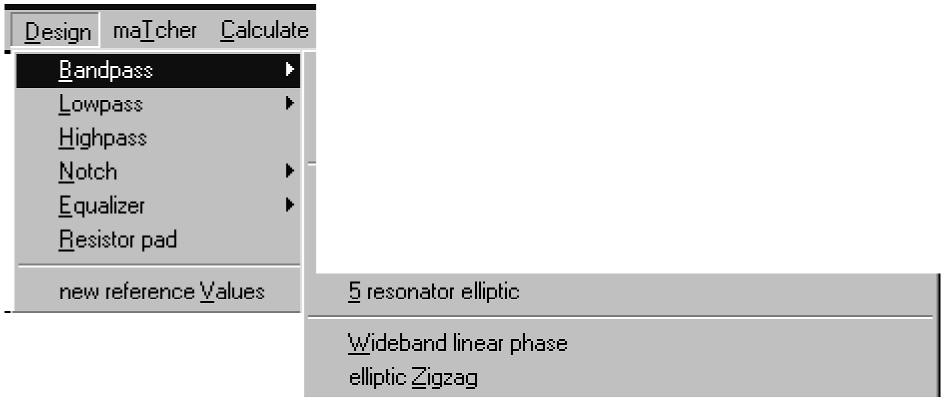

5 resonator elliptic

This is a special circuit that is the basic direct scaled elliptic function bandpass filter with Norton transforms applied so as to generate an additional L-C "resonator" between the two notch sections making 5 resonators per “section”, thus the name. The impedance ratio of each transform is iterated to generate the smallest possible part value spread. Even order networks will have an additional transform on the end section to make its series inductor equal to the average value of all the other inductors.. Because of the iteration, filters with much narrower bandwidth can be built than with the basic direct scaled circuit. All inductors are paralleled with a capacitor in the parallel input configuration reducing the circuit’s sensitivity to stray capacity. This makes it a good circuit to use at high frequency. For an example, see the section on the circuit editor **Equal value** command which can be used to make all of the shunt capacitors equal in value. For further details, see RF Design magazine, December 1992, Page 25.

Wideband Linear phase

This filter is a linear phase or constant delay filter that will exhibit a constant delay across most of its passband. Transient and impulse responses are excellent but, like most linear phase filters, skirt selectivity is rather poor. Only N=2 , N=4 and N=6 networks are implemented.

The design method used for the wideband linear phase bandpass filter is a series of curve fit equations taken from data published for 9 different bandwidths from 10 to 90% for the 2nd order circuit, and only 5 bandwidths for the 4th order version. Bandwidths for the 4th order filter are 18% to 70%. The N=6 version is usable between 7% and 70%.

The designs are only an approximation and should be optimized for delay. For good results, the bandwidths should be kept within the limits mentioned above. Usable designs can been made outside these limits however.

At narrower bandwidths, part values can become unreasonable on the 4th order version. In the example below, Norton transforms are used to modify the values at branches 1,6 and 7.

```
File name = default
Design = Wide band linear phase
order N                        4
arithmetic   Fo.        MHz. 100
Bandwidth               MHz. 25
design Zo.                     50
 Source zo.                    50
 Termination zo.               50
Input config:  S-Ser. P-Par. P
```

```
 0  ┌── Termination ──┐             50 Ohms
    │                 │
 1  │                 L        747.46 nHy.
    │                 │
 2  │                 C        3.6582 pFd.
    │                 │
 3  ├────── C ────────┤        41.916 pFd.
    │                 │
 4  │                 L         201.9 nHy.
    │                 │
 5  │                 C        18.382 pFd.  <-- Norton transform, ratio = .1
    │                 │
 6  ├────── C ────────┤        182.26 pFd.
 7  ├────── L ────────┤        17.516 nHy.
    │                 │
 8  │                 L        57.435 nHy.  <-- Norton transform, ratio = 4.0
    │                 │
 9  ├────── C ────────┤        36.286 pFd.
10  └──── Source ─────┘            50 Ohms
11  Fc = 99.216 MHz.
```

The two transforms results in this circuit:

```
 0  ┌── Termination ──┐             20 Ohms
    │                 │
 1  │                 L        298.98 nHy.
    │                 │
 2  │                 C        9.1455 pFd.
    │                 │
 3  ├────── C ────────┤        104.79 pFd.
    │                 │
 4  │                 L         80.76 nHy.
    │                 │
 5  ├────── C ────────┤        31.422 pFd.  <-- Part added by the transform.
    │                 │
 6  │                 C        14.532 pFd.
    │                 │
 7  ├────── C ────────┤        35.628 pFd.
 8  ├────── L ────────┤        100.81 nHy.
    │                 │
 9  │                 L        114.87 nHy.
    │                 │
10  ├────── L ────────┤        114.87 nHy.  <-- Part added by the transform.
11  ├────── C ────────┤        36.286 pFd.
12  └──── Source ─────┘            50 Ohms
13  Fc = 99.216 MHz.
```

The second transformation was done using a ratio that was less than the inverse of the previous transform ratio (.1) making the load and source impedance unequal. This was done so that the inductor at branch 1 could be reduced in size at the same time the old branches 6 and 7 were fixed. The impedance can be brought back to the desired 50 Ohm value from 20 ohms by using the matcher. This will add a new component to ground at the termination end. The new component will upset the group delay slightly, but the narrower the bandwidth, the less the upset will be and the more the need for it becomes. The optimization module can be used to improve this situation if necessary.

Remember to analyze the final design carefully to make sure that it is the proper bandwidth and center frequency after all these transformations, and especially after delay optimization. The "Scale" feature of the circuit editor is useful for centering a design that is off frequency.

elliptic ZigZag

This option designs the elliptic function Zig-Zag or "coil saving bandpass" filter. Only even order filters are possible (N=2,4,6 etc.).

```
File name = default
 Design = Elliptic Zig-Zag bandpass
 order N                       6
 passband Ripple (0=Butt. dB) 0.05
 Define pass / stop      (dB) 0.05
 required Attenuation    (dB) 60
 arithmetic   Fo.        MHz. 100
 Bandwidth               MHz. 25
 design Zo.                   50
  Source zo.                  50
  Termination zo.             50
 confIg: Standard  Transform  S
 tYpe: 2=double 3=type "C"    2
```

```
  0 ┌─ Termination ─┐          73.1 Ohms
  1 ├───── L ──────┤        28.623 nHy.
  2 ├───── C ──────┤        84.543 pFd.
    │            ┌─┴─┐
  3.│            L   C      104.66 nHy.       13.851 pFd.  Fx = 132.19 MHz.
    │            └─┬─┘
    │              │
  5 │              C        9.9183 pFd.  <-- ratio < 1.0
    │              │
  6.├─── C ─── L ──┤        52.578 pFd.       86.873 nHy.  Fx = 74.469 MHz.
  8 ├───── C ──────┤         65.92 pFd.
    │            ┌─┴─┐
  9.│            L   C      63.034 nHy.       26.587 pFd.  Fx = 122.94 MHz.
    │            └─┬─┘
    │              │
 11 │              C        13.238 pFd.  <-- ratio < 1.0
    │              │
 12.├─── C ─── L ──┤        22.472 pFd.       175.82 nHy.  Fx = 80.069 MHz.
 14 ├───── C ──────┤        49.784 pFd.
    │              │
 15 │              C        8.6332 pFd.  <-- ratio > 1.0
    │              │
 16 │              L         328.6 nHy.
    │              │
 17 └──── Source ──┘            50 Ohms
 18  Fc = 99.216 MHz.
```

The series components have been arranged so that Norton transforms can be inserted to equalize the source and termination impedance without generating any negative capacitors. The arrows (<--) point to the branches that can support these transforms. The new capacitors that will be added will also help in controlling degradation caused by distributed capacity at the junctions of the components in the series branches. The transform at branch 15 must have an impedance ratio greater than 1.0, while the other two must be less then 1.0. Doing this can make a bad part value spread worse though, like in this example! Any series capacitor and notch section could be interchanged (with the circuit editor “move” command) allowing a transform with an inverted ratio. By “moving” the series capacitor at branch 5 so that it is located next to branches 1 and 2, the impedance can be transformed up (rather than down) using an impedance ratio greater then 1. The large inductor at the source end (branch 16) can be reduced by using a lower design impedance. The matcher can be used later to get back to the usual 50 ohm level on either end of the filter with only a little degradation in passband return loss.

The same design is shown below after all of these modifications. The design impedance was reduced to 30 Ohms.

```
  0  ┌─ Termination ─┐          50 Ohms
  1  ├────── C ──────┤      43.761 pFd.  <-,
                     │                      | Matching
  2  │               C      46.303 pFd.  <-'
     │               │
  3  ├────── L ──────┤      83.465 nHy.
     │               │
  4  │               C      7.2154 pFd.  <-- Ratio = 4.5
     │               │                    Note that the order of the cap.
  5  ├────── C ──────┤      8.0907 pFd.   (br 5) and L-C notch (br 6,7) were
     │             ┌─┴─┐                  reversed using the >MOve command.
  6. │             L   C    67.821 nHy.       21.375 pFd.  Fx = 132.19 MHz.
     │             └─┬─┘
  8. ├─── C ── L ────┤      81.139 pFd.       56.294 nHy.  Fx = 74.469 MHz.
 10  ├────── C ──────┤      101.73 pFd.
     │             ┌─┴─┐
 11. │             L   C    40.846 nHy.       41.029 pFd.  Fx = 122.94 MHz.
     │             └─┬─┘
 13  ├────── C ──────┤      1.0484 pFd.
     │               │
 14  │               C      19.381 pFd.  <-- Ratio = .9
     │               │
 15. ├─── C ── L ────┤      31.211 pFd.       126.59 nHy.  Fx = 80.069 MHz.
 17  ├────── C ──────┤      66.683 pFd.
     │               │
 18  │               C      16.833 pFd.  <-- Ratio = 1.2
     │               │
 19  ├────── C ──────┤      1.6067 pFd.
     │               │
 20  │               L      197.16 nHy.
     │               │
 21  ├────── C ──────┤      26.195 pFd.  <-- Matching
 22  └──── Source ───┘          50 Ohms
 23   Fc = 99.216 MHz.
```

The termination impedance was 213.2 Ohms after all of the transforms were applied and before the impedance matching was done.

An additional form of the Zig-zag bandpass filter is provided that has a better overall parts value spread under some conditions than the standard configuration. This form has the disadvantage of a "hot node" at each series connected "notch" section which can cause problems at high frequency. Each series and parallel "notch" section of the standard topology is converted to a dipole equivalent.

This alternate topology is selected on the PARAMETERS menu:
confIg: Standard Transform T

The design shown below using the transformed topology has a parts value spread af about 80:1, the same filter using the standard topology has a spread of about 200:1. This filter is identical to the example shown for the standard form except that the ultimate attenuation is reduced from 60 dB down to 20 dB to make a filter with sharper skirts. With 60 dB ultimate attenuation, the standard topology has a better value spread.

```
File name = XFORMED
Design  Elliptic Zig-Zag bandpass
order N                        6
passband Ripple (0=Butt. dB) 0.05
Define pass / stop      (dB) 0.05
required Attenuation    (dB) 20 <────
arithmetic Fo.          MHz. 100
Bandwidth               MHz. 25
design Zo.                   50
 Source zo.                  50
 Termination zo.             50
confIg: Standard  Transform  T <───
tYpe: 1=sing 2=doub 3="C"    2

 0 ┌─ Termination ─┐            146 Ohms
 1 ├────── L ──────┤         55.816 nHy.
 2 ├────── C ──────┤         39.228 pFd.
   │               ├───┐
 3.│            L  │   │     1010.8 nHy.
   │            │  │   │
 4 │            C  │   C     2.2966 pFd.       9.6188 pFd.
   │            └──┬───┘
 6.├─── L ─┐       │         46.125 nHy.
 7 ├─── C ─┴─ C ───┤         55.607 pFd.       20.995 pFd.
   │               ├───┐
 9.│            L  │   │     676.74 nHy.
   │            │  │   │
10 │            C  │   C     3.3555 pFd.        21.38 pFd.
   │            └──┬───┘
12.├─── L ─┐       │         16.829 nHy.
13 ├─── C ─┴─ C ───┤         183.98 pFd.       16.485 pFd.
   │               │
15 │               C         10.196 pFd.
   │               │
16 │               L         336.44 nHy.
   │               │
17 └──── Source ───┘             50 Ohms 18  Fc = 99.216 MHz.
```