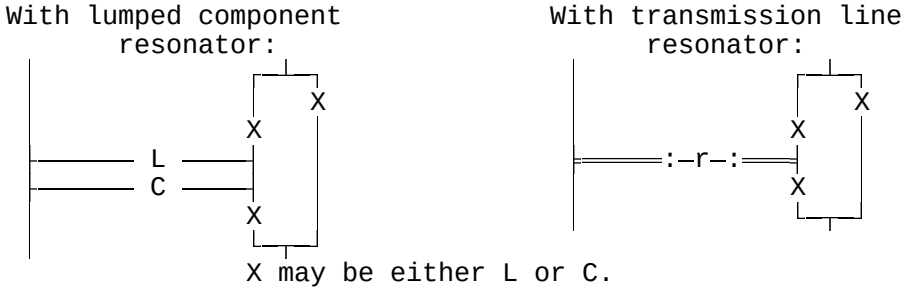
Appendix D
Coupled Triplets

The circuit editor is equipped to convert many conventional transmission zero networks into coupled triplet networks which utilize coupling between alternate "resonators" to produce the zeros. The coupled triplet networks look like this:



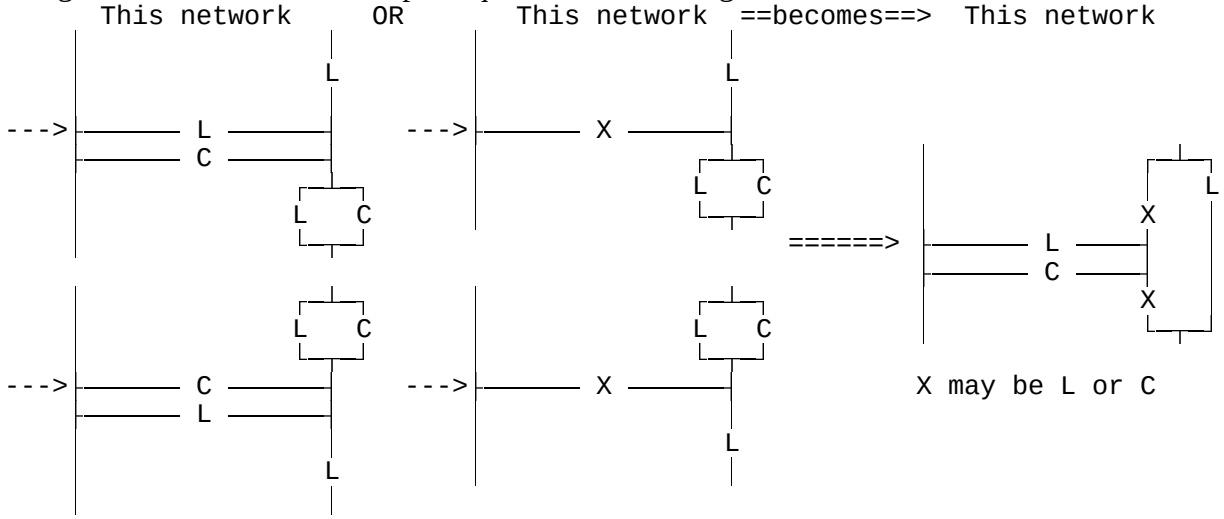
The editor command for the coupled triplet transformation is **[MIS1:] Triplet** followed by the branch number of the single shunt component, a shorted stub "resonator" or the lowest branch number of a shunt L-C "tank resonator" pair.

On networks having a parallel L and C, an impedance transformation can be specified to scale the network impedance from the "triplet" through to the termination. The prompt will look like this after the **Triplet** command is given:

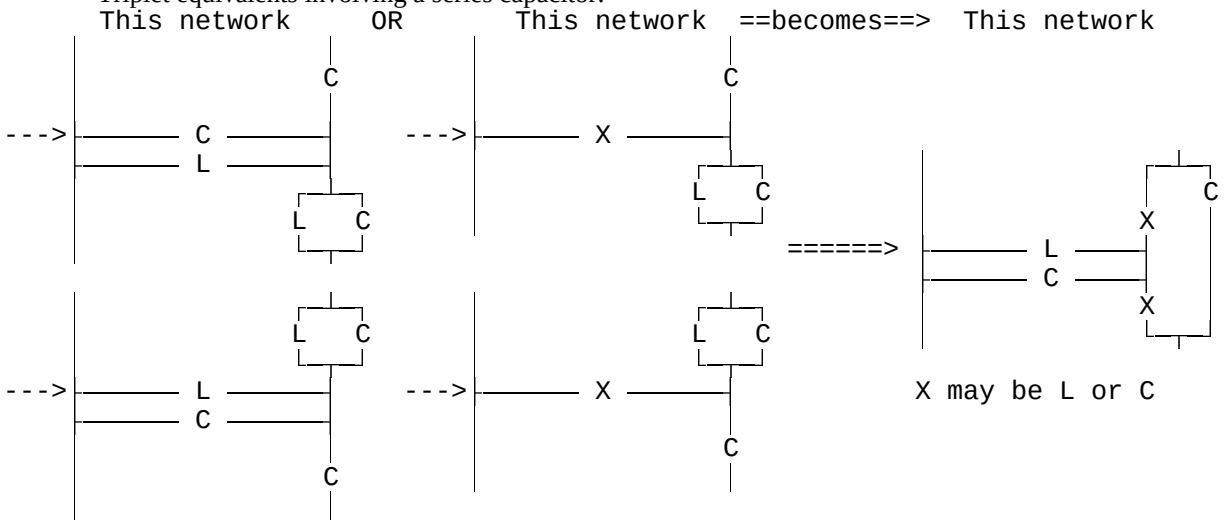
(Cr = 1.0) Impedance ratio at triplet?

The same editor command (Triplet) will allow the values in the shunt "resonator" of the triplet network itself (in "triplet" form) to be forced to any desired value. Some situations will result in negative values however.

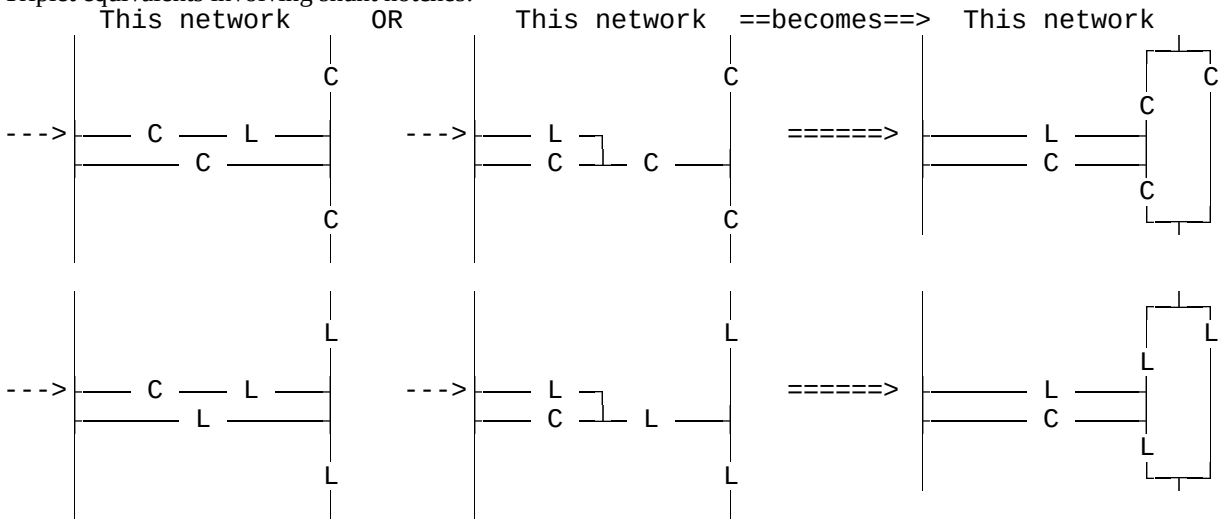
The possible conventional networks that are compatible with the coupled triplet are shown below. In all cases when performing these transformations you must specify the branch number marked by the arrow. Note that this transformation can not be reversed later. It can be undone by using the "oops" command however. Oops will undo the last 10 commands. If you are not comfortable with the transformations that are to follow and would like to be able to back up directly to a point before the Triplet command, you can also use the **Save** command to save the network before the Triplet command is given. You can recall it later using the **Recall** command. Triplet equivalents involving a series inductor:



Triplet equivalents involving a series capacitor:

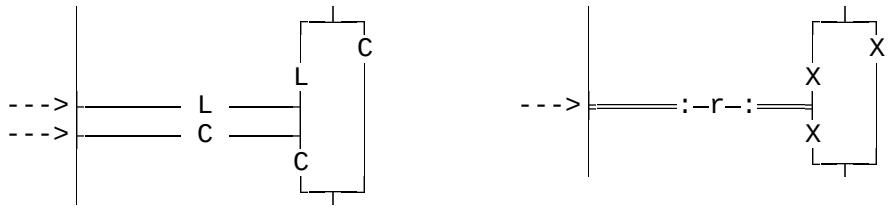


Triplet equivalents involving shunt notches:



Triplet shunt value transform

The two arrows in the L-C triplet network shown below identify the shunt L-C "tank" components. In several cases, one or the other of these two parts will be an open component that can simply be left out of the realization. That is, a huge inductor or a tiny capacitor. In other cases, it is possible to directly specify the value of either of these two parts. The **Triplet** command is also used for this function. Specify the branch number of the part whose value is to be forced. The program will prompt you for the value you want. The other will be adjusted to compensate. The impedance of a transmission line resonator may be forced as well.



*** Example 1 ***

Design = Basic direct scaled bandpass (Using the reference lowpass placer)

```
passband Ripple (0=Butt. dB) 0.05
 arithmetic Fo.          MHz. 1000
 Bandwidth               MHz. 50
 design Zo.                   5
  Source zo.                  50
  Termination zo.             50
 confIg: Ser. Par. Tee Delta  S
 tYpe: 1=sing 2=doub 3=ratio  2
   --- POLE PLACER DATA ---
 Zeros at Infinity = 3
 Finite transmission zero frequencies:
     1.500
 Finite transmission zero sequence: 1
 Placer specification mask:

 Lowpass reference used:
    ├──── R ────┤       1
                L       1.01903
    ├──── C ────┤       1.13056
                ┌─┐
               L   C     1.18953  0.37363  f = 1.5
                └─┘
    ├──── C ────┤       1.13056
                L       1.01903
    ├──── R ────┤       1
```

The resulting bandpass is shown below. Note that the matcher was used to match the 5 Ohm design impedance to 50 Ohms before entering the circuit editor.

```
  0  ┌─ Termination ─┐            50 Ohms
  1  ├──── C ────┤          9.5523 pFd.
                 |
  2              L          16.218 nHy.
                 |
  3              C          1.8326 pFd.
                 |
  4  ├──── C ────┤          719.74 pFd.
  5  ├──── L ────┤        0.035216 nHy.
                ┌─┐
  6.            L   C     0.051282 nHy.       458.53 pFd.  Fx = 1037.9 MHz.
                └─┘
                 |
                ┌─┐
  8.            L   C     0.055277 nHy.       494.25 pFd.  Fx = 962.89 MHz.
                └─┘
                 |
 10  ├──── C ────┤          719.74 pFd.
 11  ├──── L ────┤        0.035216 nHy.
                 |
 12              C          1.8326 pFd.
                 |
 13              L          16.218 nHy.
                 |
 14  ├──── C ────┤          9.5523 pFd.
 15  └─── Source ──┘            50 Ohms
 16   Fc = 999.69 MHz.
```

The first step is to raise the impedance at the series "trap" pair to get better capacitor values.

[NORT:] Xform branch 12
Preset ratio = 1.0000
What ratio ? 50

```
 0  ┌─ Termination ─┐          2500 Ohms
 1  ├──────── C ────┤       0.19105 pFd.
    │               │
 2  │             L │        810.92 nHy.
    │               │
 3  │             C │     0.036653 pFd.
    │               │
 4  ├──────── C ────┤        14.395 pFd.
 5  ├──────── L ────┤        1.7608 nHy.
    │               │
 6. │           ┌─┐ │      2.5641 nHy.       9.1706 pFd.  Fx = 1037.9 MHz.
    │           L C │
    │           └─┘ │
    │               │
 8. │           ┌─┐ │      2.7638 nHy.       9.8849 pFd.  Fx = 962.89 MHz.
    │           L C │
    │           └─┘ │
10  ├──────── C ────┤        14.172 pFd.
11  ├──────── L ────┤        1.7608 nHy.
    │               │
12  │             C │      0.25918 pFd.
    │               │
13  ├──────── C ────┤        1.5735 pFd.
    │               │
14  │             L │        16.218 nHy.
    │               │
15  ├──────── C ────┤        9.5523 pFd.
16  └──── Source ───┘            50 Ohms
17  Fc = 999.69 MHz.
```

Next, prepare the network for a triplet by getting rid of the capacitor at branch 10.

[NORT:] Interchange branches 10,11
[NORT:] Pi-T at branch 12

```
 0  ┌─ Termination ─┐          2500 Ohms
 1  ├──────── C ────┤       0.19105 pFd.
    │               │
 2  │             L │        810.92 nHy.
    │               │
 3  │             C │     0.036653 pFd.
    │               │
 4  ├──────── C ────┤        14.395 pFd.
 5  ├──────── L ────┤        1.7608 nHy.
    │               │
 6. │           ┌─┐ │      2.5641 nHy.       9.1706 pFd.  Fx = 1037.9 MHz.
    │           L C │
    │           └─┘ │
    │               │
 8. │           ┌─┐ │      2.7638 nHy.       9.8849 pFd.  Fx = 962.89 MHz.
    │           L C │
    │           └─┘ │
10  ├──────── L ────┤        1.7608 nHy.
    │               │
11  │             C │        16.766 pFd.
    │               │
12  ├──────── C ────┤        101.79 pFd.
```

```
13 |                  C       1.8614 pFd.
   |                  |
14 |                  L       16.218 nHy.
   |                  |
15 |------- C --------|       9.5523 pFd.
16 |------ Source ----|           50 Ohms
17  Fc = 999.69 MHz.
```

The network between branches 8 and 11 is now ready to be converted to a coupled triplet using the**Triplet** command.

[MIS1:] Triplet at branch 10

```
 0 |- Termination -|          2500 Ohms
 1 |------- C -------|      0.19105 pFd.
   |                 |
 2 |                 L       810.92 nHy.
   |                 |
 3 |                 C     0.036653 pFd.
   |                 |
 4 |------- C -------|       14.395 pFd.
 5 |------- L -------|       1.7608 nHy.
   |                 |
 6.|               L   C     2.5641 nHy.       9.1706 pFd.  Fx = 1037.9 MHz.
   |                 |
 8 |------- L -------|       4.7473 nHy.
   |                 |       Fx = 962.89 MHz.
 9.|                 C       6.2186 pFd.
12 |               L         93.682 nHy.
14 |------- L -------|       2.7989 nHy.
15 |------- C -------|        1e-10 pFd.
13 |                 C       10.547 pFd.
   |                 |
17 |------- C -------|       101.79 pFd.
   |                 |
18 |                 C       1.8614 pFd.
   |                 |
19 |                 L       16.218 nHy.
   |                 |
20 |------- C -------|       9.5523 pFd.
21 |------ Source ----|           50 Ohms
22  Fc = 999.69 MHz.
```

The L-C resonator at branches 14 and 15 must be modified by forcing some lower value inductor at branch 14. As the network is now, the capacitor at branch 15 is an open circuit, which the "LC to stub generator" that will be used next, can't handle. The value of 1 nHy was picked only because it is less than what is there now. This will ensure a reasonable capacitor value at branch 15.

[MIS1:] Triplet at branch 14
(Cr) to abort * What is new value (nHy.) ? 1

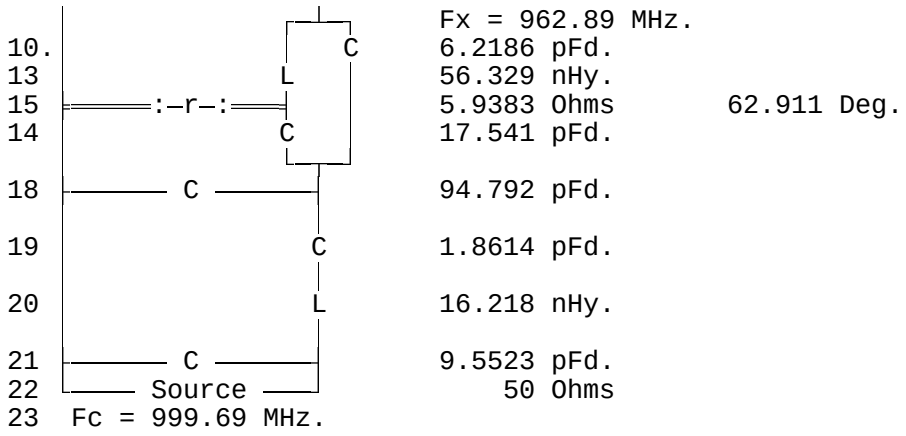
```
 0 ┌─ Termination ─┐          2500 Ohms
 1 ├─────── C ─────┤       0.19105 pFd.
   │               │
 2 │               L        810.92 nHy.
   │               │
 3 │               C      0.036653 pFd.
   │               │
 4 ├─────── C ─────┤        14.395 pFd.
 5 ├─────── L ─────┤        1.7608 nHy.
   │             ┌─┴─┐
 6.│             L   C      2.5641 nHy.       9.1706 pFd.  Fx = 1037.9 MHz.
   │             └─┬─┘
 8 ├─────── L ─────┤        4.9123 nHy.
   │             ┌─┴─┐      Fx = 962.89 MHz.
 9.│             │   C      6.2186 pFd.
12 │             L   │      56.329 nHy.
14 ├─────── L ───┤   │           1 nHy.
15 ├─────── C ───┤   │      11.632 pFd.
13 │             C   │      17.541 pFd.
   │             └─┬─┘
17 ├─────── C ─────┤        94.792 pFd.
   │               │
18 │               C        1.8614 pFd.
   │               │
19 │               L        16.218 nHy.
   │               │
20 ├─────── C ─────┤        9.5523 pFd.
21 └───── Source ──┘            50 Ohms
22  Fc = 999.69 MHz.
```

Next, the L-C resonator will be replaced by a shorted stub resonator. The "LC to stub generator" must first be programmed using the >PS command. Select option "V" on the stub generator menu. The actual replacement of the L-C network by a stub is done using the **Stub** command.

```
Stub   (Select option "V" on the stub generator          │ (4) L/C  0.00   │
                  menu and exit)                         │ (5) L/C  0.00   │
      │ ┌─ L ─┐   │     ││ │             │               │ (6) L/C  0.00   │
     8├─┴─ C ─┴───┤   ────> V╞════:─r─:════╡  90°          │ (7) L/C  0.00   │
                        ││                   ──────────> │ (V)  T  90.00 ° │
                                                         └─────────────────┘
```

[MIS3:] Stub at branch 14

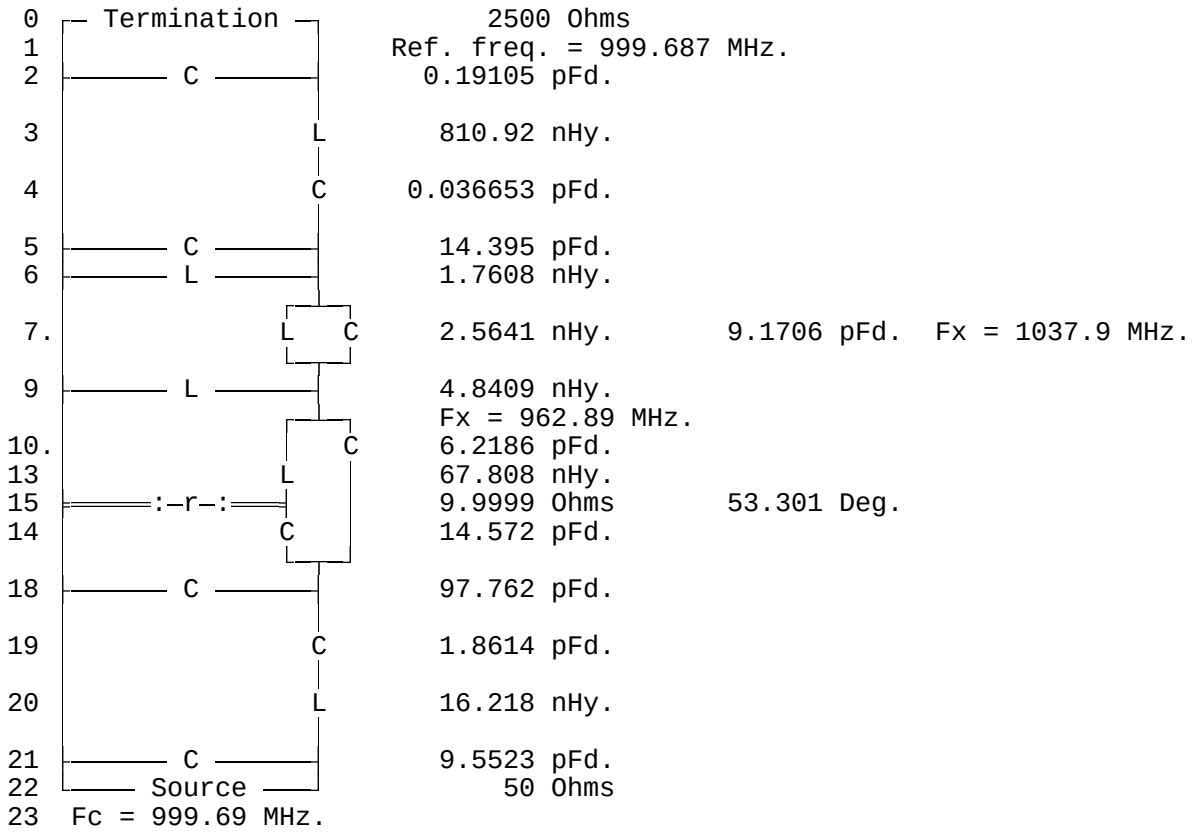
```
 0 ┌─ Termination ─┐          2500 Ohms
 1 │               │     Ref. freq. = 999.687 MHz.
 2 ├─────── C ─────┤       0.19105 pFd.
   │               │
 3 │               L        810.92 nHy.
   │               │
 4 │               C      0.036653 pFd.
   │               │
 5 ├─────── C ─────┤        14.395 pFd.
 6 ├─────── L ─────┤        1.7608 nHy.
   │             ┌─┴─┐
 7.│             L   C      2.5641 nHy.       9.1706 pFd.  Fx = 1037.9 MHz.
   │             └─┬─┘
 9 ├─────── L ─────┤        4.9123 nHy.
```



The final impedance of the stub resonator will be set later. For now we will use the **Triplet** command to preset it to 10 Ohms (which is roughly the impedance of a quarter wave ceramic resonator) to verify that the values are within acceptable range.

[MIS1:] Triplet at branch 15

(Cr) to abort * What is new value (Ohms) ? 10

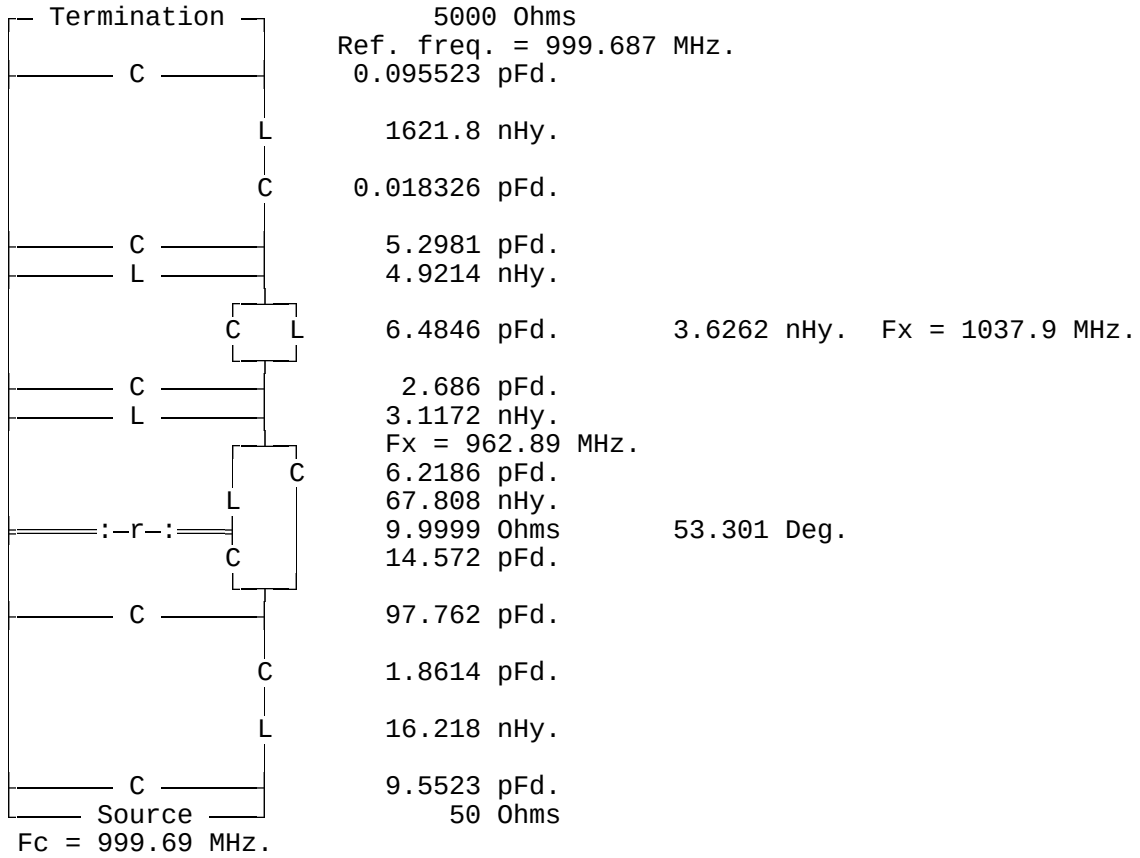


It is advisable to have a capacitor to ground next to the inductor at branch 9 to absorb its distributed capacity and to provide a binding post to connect the adjacent components. A Norton transform at the second series "trap" will generate this capacitor. The ratio can be

any value greater than 1.0 to ensure a positive value.

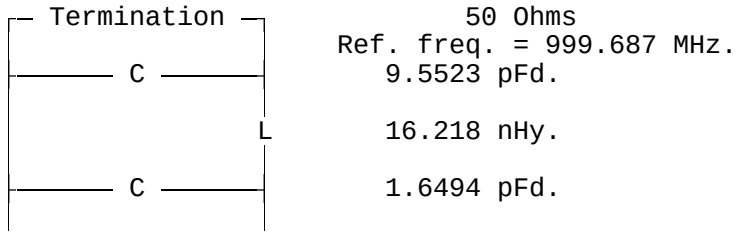
[NORT:] Xform at branch 7

Preset ratio = 1.0000
What ratio ? 2



At this point, we will need to bring the termination impedance back to 50 ohms. To do this, the **Ratio** command will be used to set the "preset ratio" to that of the source to termination. Once this ratio is set, a Norton transform will restore the termination impedance. Note that <Enter> instructs the program to use the "Preset ratio" just established with the **Ratio** command or simply select the [OK] button.

[NORT:] Ratio of branches 23,0
[NORT:] Xform at branch 4
Preset ratio = .005
What ratio ? <Enter> (Use preset ratio)



```
 5  │                C       0.18326 pFd.
    │                │
 6  ├────── C ───────┤        5.1332 pFd.
 7  ├────── L ───────┤        4.9214 nHy.
    │              ┌─┴─┐
 8. │              C   L      6.4846 pFd.       3.6262 nHy.  Fx = 1037.9 MHz.
    │              └─┬─┘
10  ├────── C ───────┤         2.686 pFd.
11  ├────── L ───────┤        3.1172 nHy.
    │              ┌─┴─┐      Fx = 962.89 MHz.
12. │              │   C      6.2186 pFd.
15  │              L   │      67.808 nHy.
17  ╞════:─r─:═════┤   │      9.9999 Ohms       53.301 Deg.
16  │              C   │      14.572 pFd.
    │              └─┬─┘
20  ├────── C ───────┤        97.762 pFd.
    │                │
21  │                C        1.8614 pFd.
    │                │
22  │                L        16.218 nHy.
    │                │
23  ├────── C ───────┤        9.5523 pFd.
24  └──── Source ────┘            50 Ohms
```

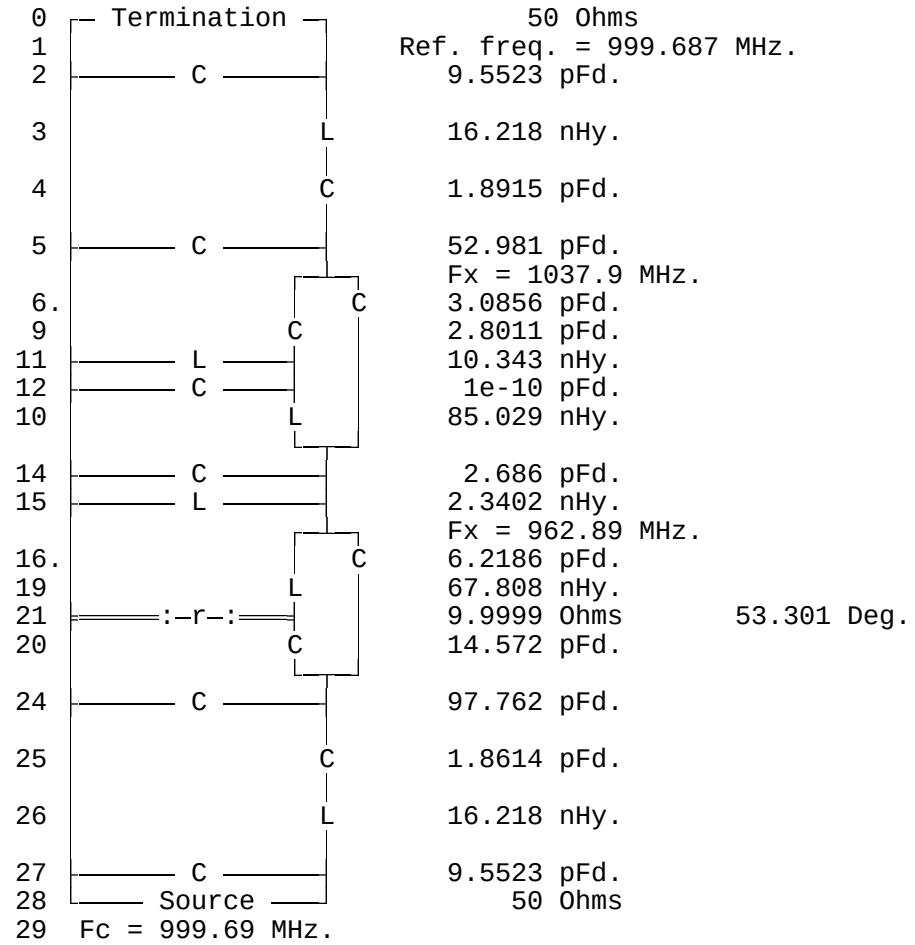
25 Fc = 999.69 MHz.

The Pi configuration next to the second series trap will be converted to a tee to adjust the topology for the last triplet.

[NORT:] Pi-T at branch 5

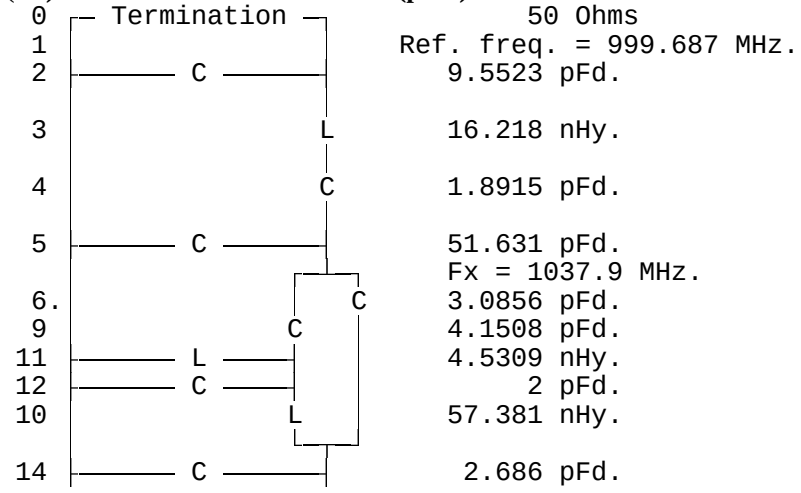
```
 0  ┌─ Termination ─┐             50 Ohms
 1  │                │      Ref. freq. = 999.687 MHz.
 2  ├────── C ───────┤        9.5523 pFd.
    │                │
 3  │                L        16.218 nHy.
    │                │
 4  │                C        1.8915 pFd.
    │                │
 5  ├────── C ───────┤        52.981 pFd.
    │                │
 6  │                C        5.8868 pFd.
    │                │
 7  ├────── L ───────┤        4.9214 nHy.
    │              ┌─┴─┐
 8. │              C   L      6.4846 pFd.       3.6262 nHy.  Fx = 1037.9 MHz.
    │              └─┬─┘
10  ├────── C ───────┤         2.686 pFd.
11  ├────── L ───────┤        3.1172 nHy.
    │              ┌─┴─┐      Fx = 962.89 MHz.
12. │              │   C      6.2186 pFd.
15  │              L   │      67.808 nHy.
17  ╞════:─r─:═════┤   │      9.9999 Ohms       53.301 Deg.
16  │              C   │      14.572 pFd.
    │              └─┬─┘
20  ├────── C ───────┤        97.762 pFd.
    │                │
21  │                C        1.8614 pFd.
    │                │
22  │                L        16.218 nHy.
    │                │
23  ├────── C ───────┤        9.5523 pFd.
24  └──── Source ────┘            50 Ohms
25  Fc = 999.69 MHz.
```

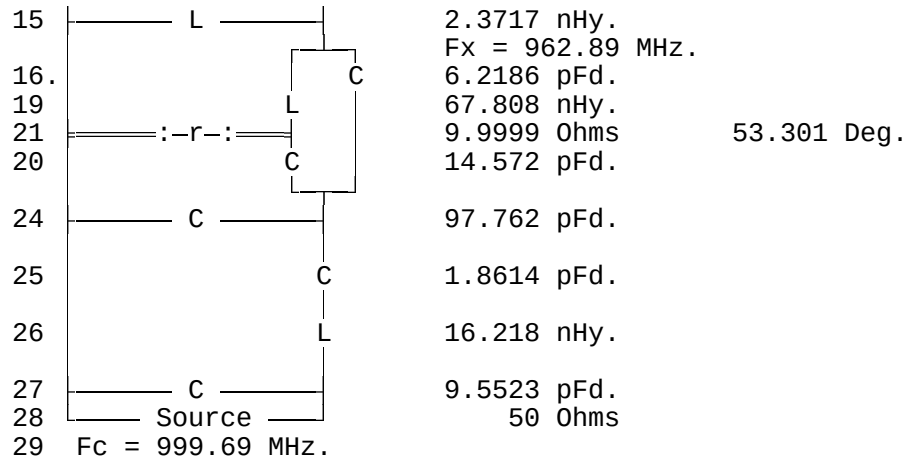
[MIS1:] Triplet at branch 7



As with the first triplet, the open capacitor at branch 12 must be brought up to something realistic. This time we will force it directly to 2 pFd.

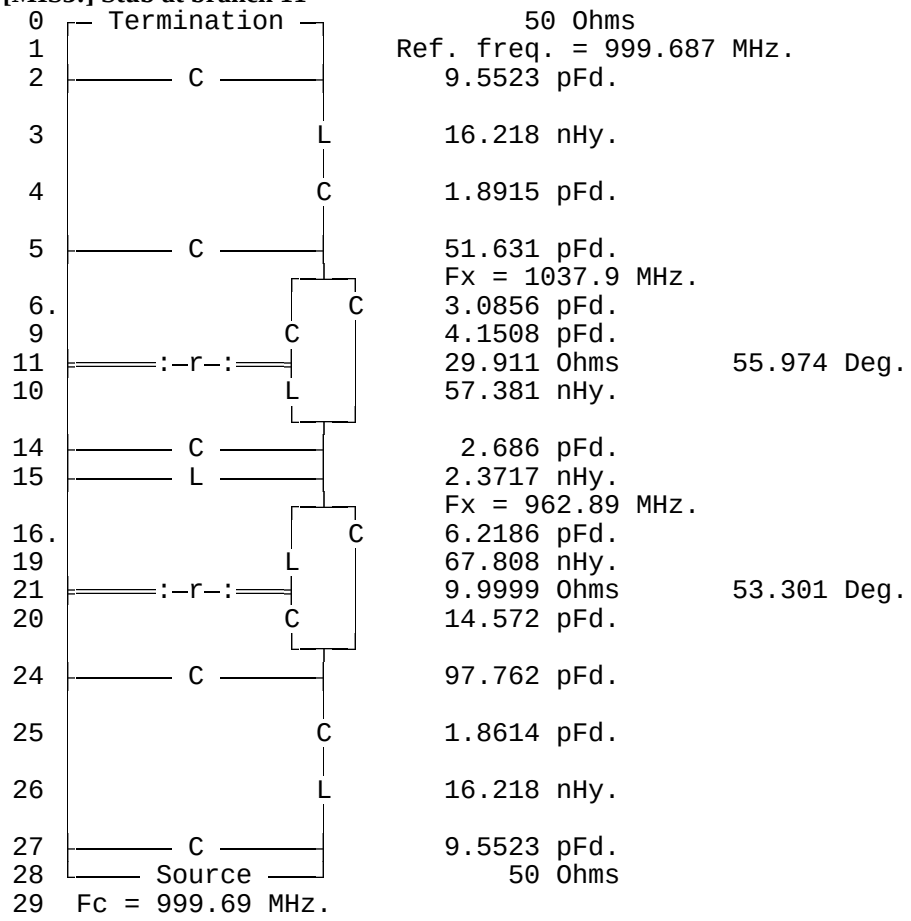
[MIS1] Triplet at branch 12
(Cr) to abort * What is new value (pFd.) ? 2





The "LC to stub generator" will still be programmed from its first use. The L-C resonator can now be converted to a shorted stub using the **Stub** command.

[MIS3:] Stub at branch 11



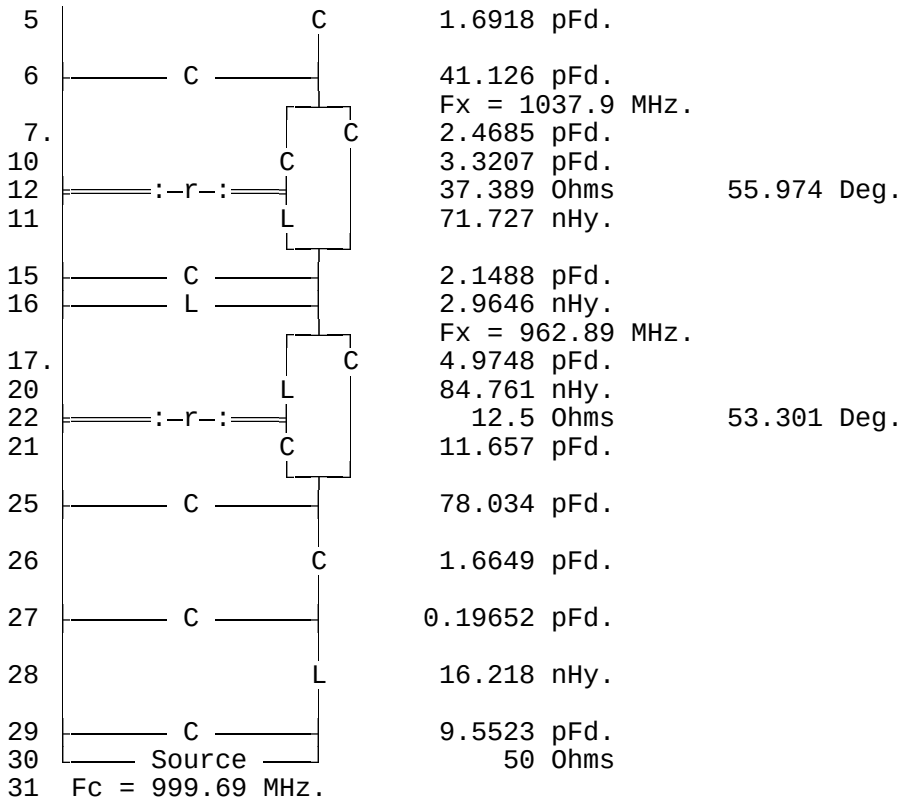
The distributed capacity at the "hot nodes" between branches 3, 4 and branches 25, 26 to ground can be absorbed by shunt capacitors that can be added by transforming the entire triplet network up slightly in impedance and then back down with two Norton transforms, one on either side of the triplet pair. The ratio is picked just high enough to generate capacitors with good values. 1.25 and its reciprocal of .8 will be used.

[NORT:] Xform at branch 25
Preset ratio = .005
What ratio ? 1.25

```
 0  ┌─ Termination ─┐          62.5 Ohms
 1  │               │     Ref. freq. = 999.687 MHz.
 2  ├──────C──────┐ │        7.6418 pFd.
    │             │ │
 3  │             L │        20.273 nHy.
    │             │ │
 4  │             C │        1.5132 pFd.
    │             │ │
 5  ├──────C──────┐ │        41.305 pFd.
    │             │ │        Fx = 1037.9 MHz.
 6. │           ┌─┘ C       2.4685 pFd.
 9  │           C   │        3.3207 pFd.
11  ╞═══:─r─:═══╡   │        37.389 Ohms       55.974 Deg.
10  │           L   │        71.727 nHy.
    │           └─┐ │
14  ├──────C──────┐ │        2.1488 pFd.
15  ├──────L──────┐ │        2.9646 nHy.
    │             │ │        Fx = 962.89 MHz.
16. │           ┌─┘ C       4.9748 pFd.
19  │           L   │        84.761 nHy.
21  ╞═══:─r─:═══╡   │          12.5 Ohms       53.301 Deg.
20  │           C   │        11.657 pFd.
    │           └─┐ │
24  ├──────C──────┐ │        78.034 pFd.
    │             │ │
25  │             C │        1.6649 pFd.
    │             │ │
26  ├──────C──────┐ │       0.19652 pFd.
    │             │ │
27  │             L │        16.218 nHy.
    │             │ │
28  ├──────C──────┐ │        9.5523 pFd.
29  └──── Source ─┘ │            50 Ohms
30   Fc = 999.69 MHz.
```

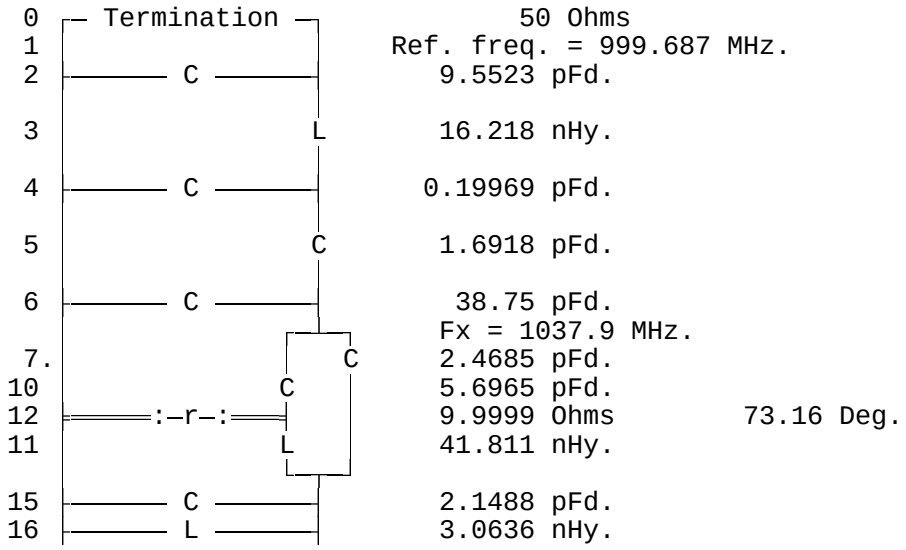
[NORT:] Xform at branch 4
Preset ratio = .005
What ratio ? .8 (.8 is the inverse of 1.25)

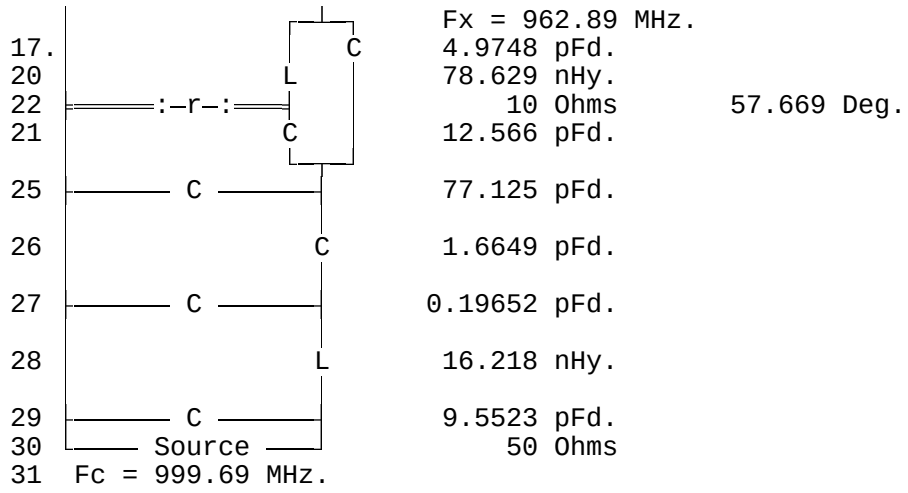
```
 0  ┌─ Termination ─┐            50 Ohms
 1  │               │     Ref. freq. = 999.687 MHz.
 2  ├──────C──────┐ │        9.5523 pFd.
    │             │ │
 3  │             L │        16.218 nHy.
    │             │ │
 4  ├──────C──────┐ │       0.19969 pFd.
    │             │ │
```



As the last step, both resonators will be forced to the assumed 10 Ohms impedance needed for ceramic resonators.

[MIS1:] Triplet 12
(Cr) to abort * What is new value (Ohms) ? 10
[MIS1:] Triplet 22
(Cr) to abort * What is new value (Ohms) ? 10

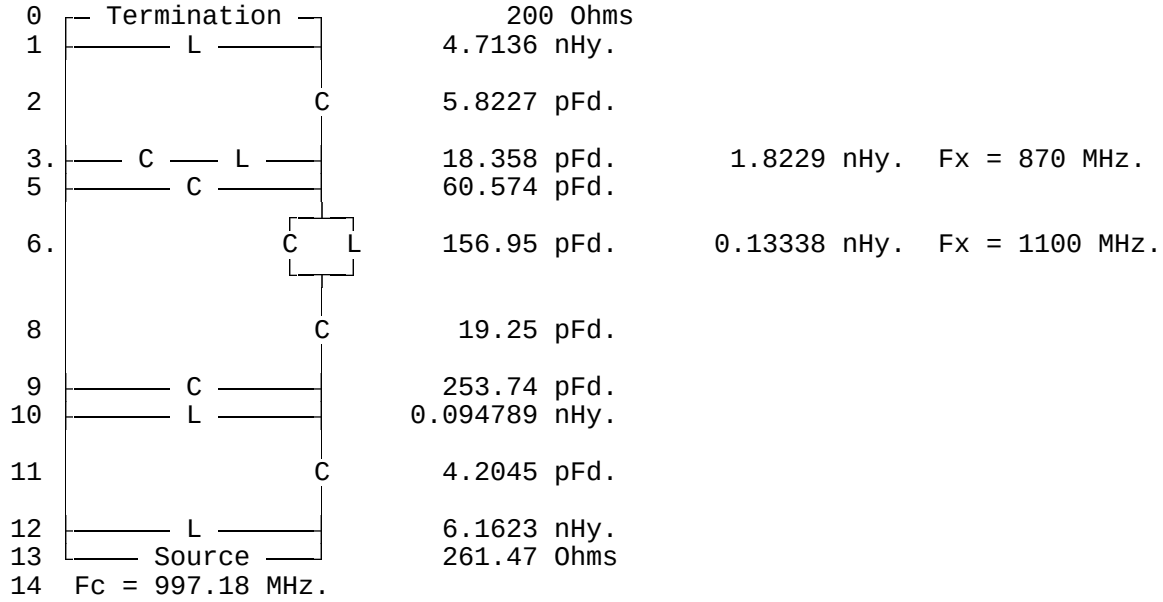




*** Example 2 ***

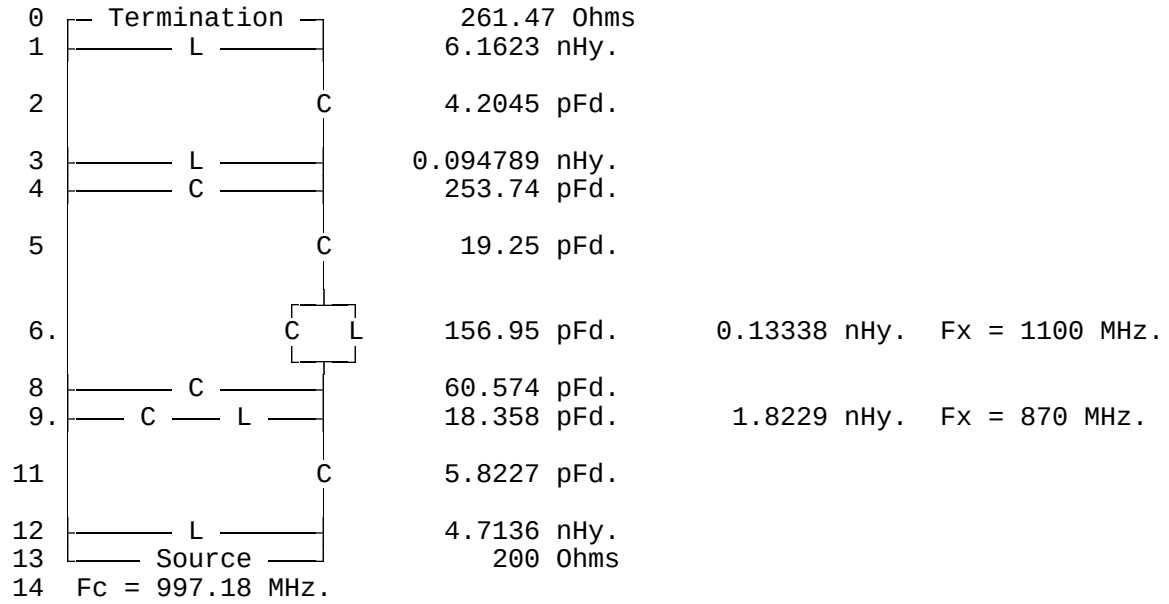
This example will illustrate how a fully pole placed filter can be converted for coupled triplets. It will also illustrate some of the things that might go wrong as you do the transformations.

```
Design = Conventional pole placer
passband Ripple (0=Butt. dB) 0.05
arithmetic Fo.          MHz. 1000
Bandwidth               MHz. 150
design Zo.                   200
tYpe: 1=sing 2=doub 3=ratio  2
  --- POLE PLACER DATA ---
Zeros at zero (Dc.) = 5
Zeros at Infinity = 1
Finite transmission zero frequencies:
  870.000 1100.000
Finite transmission zero sequence: 1 2
Placer specification mask:
```



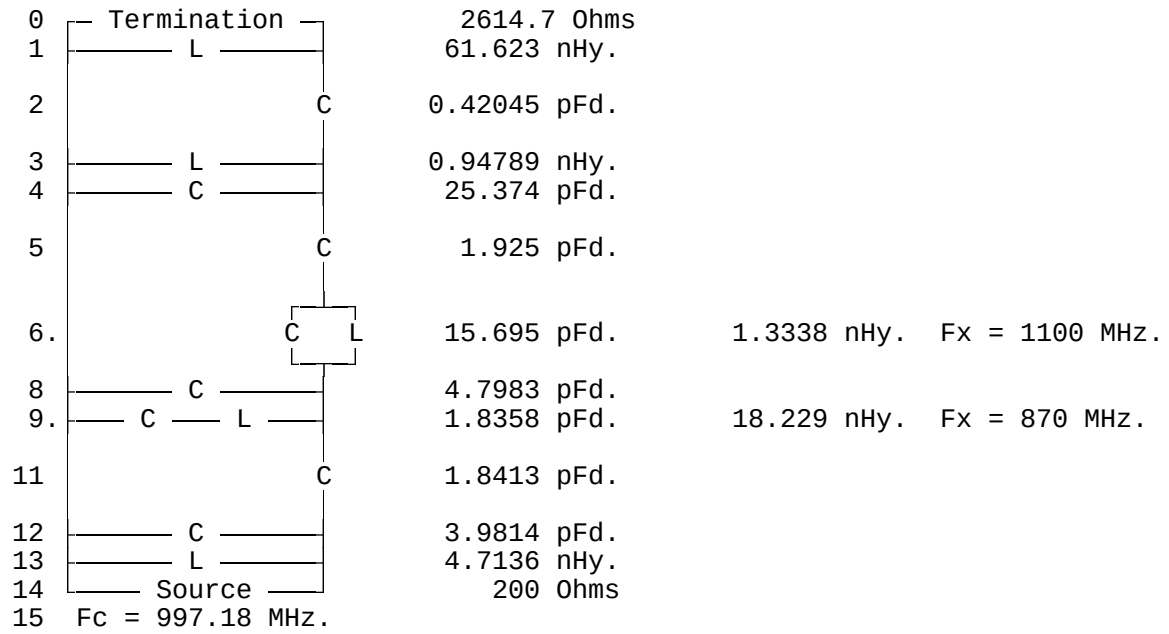
The first step is to reverse the filter end-for-end.

[main:] Reverse



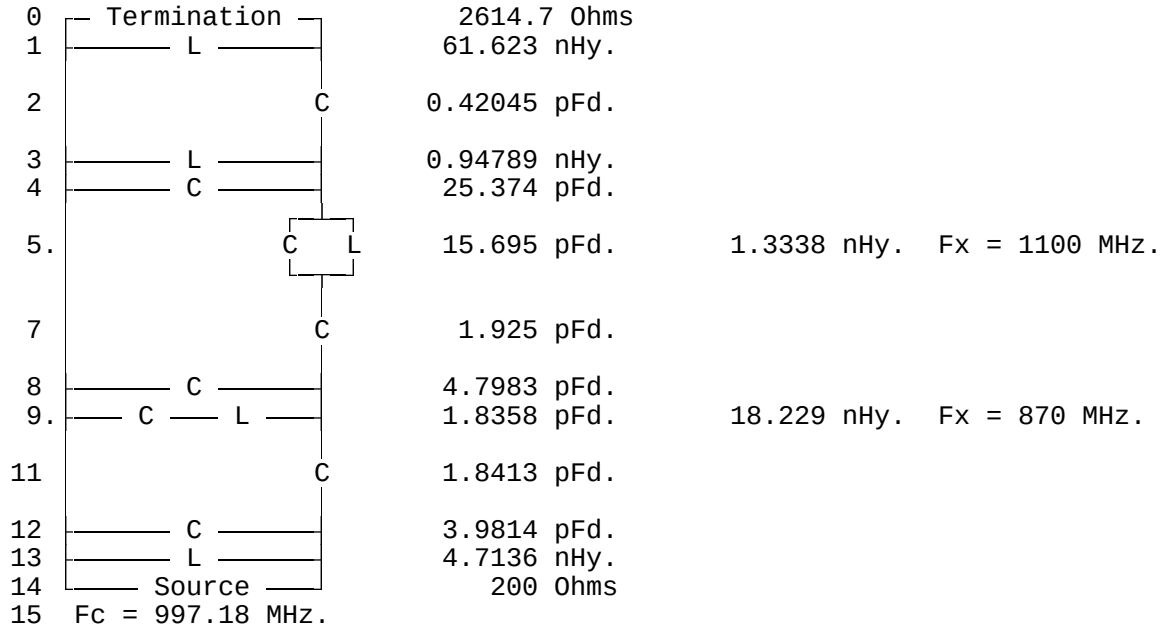
At this point, a capacitor is needed in parallel with the inductor at branch 12. It is also going to be necessary to raise the impedance of the network. A Norton transform at branch 11 will accomplish both requirements. The needed impedance ratio here is guess work since you don't know what part values will be generated by the second triplet that will provide the finite zero above the passband. Let's pick a value of 10.

[NORT:] Xform 11
Preset ratio = 1.00
What ratio ? 10



In order to form a network compatible with a coupled triplet at the shunt notch "trap" at branch 9, the series capacitor at branch 5 must be moved to the other side of the series notch "tank" at branch 6. This will also make the network at branches 2, 3 and 4 ready to accept a triplet for the high side finite zero.

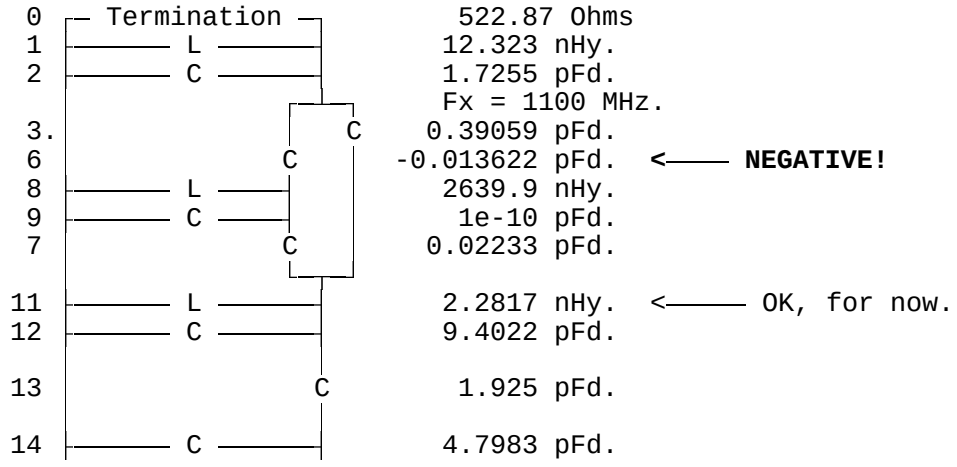
[NORT:] Move branch 5
Position them after what branch number ? 6



Since the impedance ratio of 10 that was used to raise the impedance of the network earlier may not be correct, we will convert the section at branch 2 to a triplet to see what values are generated before generating the triplet at branch 8.

When the triplet command is used at a network having both a parallel L and C, as exist at branches 3 and 4, you have the option to select an impedance ratio that will scale the network from the triplet through to the termination. A ratio of .2 was chosen to bring the termination impedance down.

[MIS1:] Triplet at branch 3
Impedance ratio at triplet ? .2



```
15.├── C ── L ──┤        1.8358 pFd.       18.229 nHy.  Fx = 870 MHz.
                │
17              C        1.8413 pFd.
                │
18 ├──── C ─────┤        3.9814 pFd.
19 ├──── L ─────┤        4.7136 nHy.
20 └─── Source ──┘           200 Ohms
21  Fc = 997.18 MHz.
```

The results indicate that the ratio of 10 picked earlier for the Norton transform at the source end was ok since the values at branches 11 and 12 are reasonable. A different ratio will produce different values. The triplet equivalent itself has a negative value however. The reason for this is usually because the series capacitor at branch 2 (before the triplet command) was too small. This can be gotten around by splitting this capacitor into two caps in series, one capacitor can be larger than the other. The large one will be placed next to the triplet. To do this, back up using the OOps feature, split the series capacitor with one value set to 5 pFd, then interchange the two.

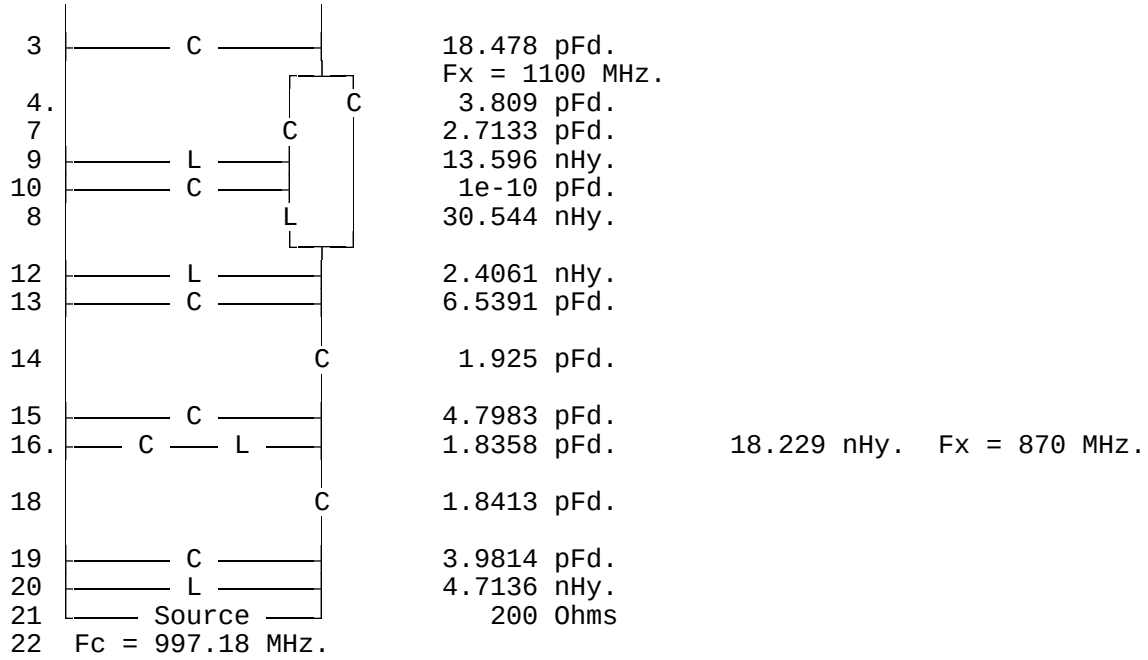
Oops (Mouse right button)
[NORT:] Split branch 2
(Press a mouse button or Cr for both equal)
Value of 1 part (pFd.) ? 5
[NORT:] Interchange branches 2,3

```
 0 ┌─ Termination ─┐         2614.7 Ohms
 1 ├──── L ─────┤        61.623 nHy.
                │
 2              C       0.45905 pFd.
                │
 3              C            5 pFd.
                │
 4 ├──── L ─────┤        0.94789 nHy.
 5 ├──── C ─────┤         25.374 pFd.
                │
 6.            C   L      15.695 pFd.       1.3338 nHy.  Fx = 1100 MHz.
                │
 8              C         1.925 pFd.
                │
 9 ├──── C ─────┤        4.7983 pFd.
10.├── C ── L ──┤        1.8358 pFd.       18.229 nHy.  Fx = 870 MHz.
                │
12              C        1.8413 pFd.
                │
13 ├──── C ─────┤        3.9814 pFd.
14 ├──── L ─────┤        4.7136 nHy.
15 └─── Source ──┘           200 Ohms
16  Fc = 997.18 MHz.
```

Now we can try again to get the triplet.

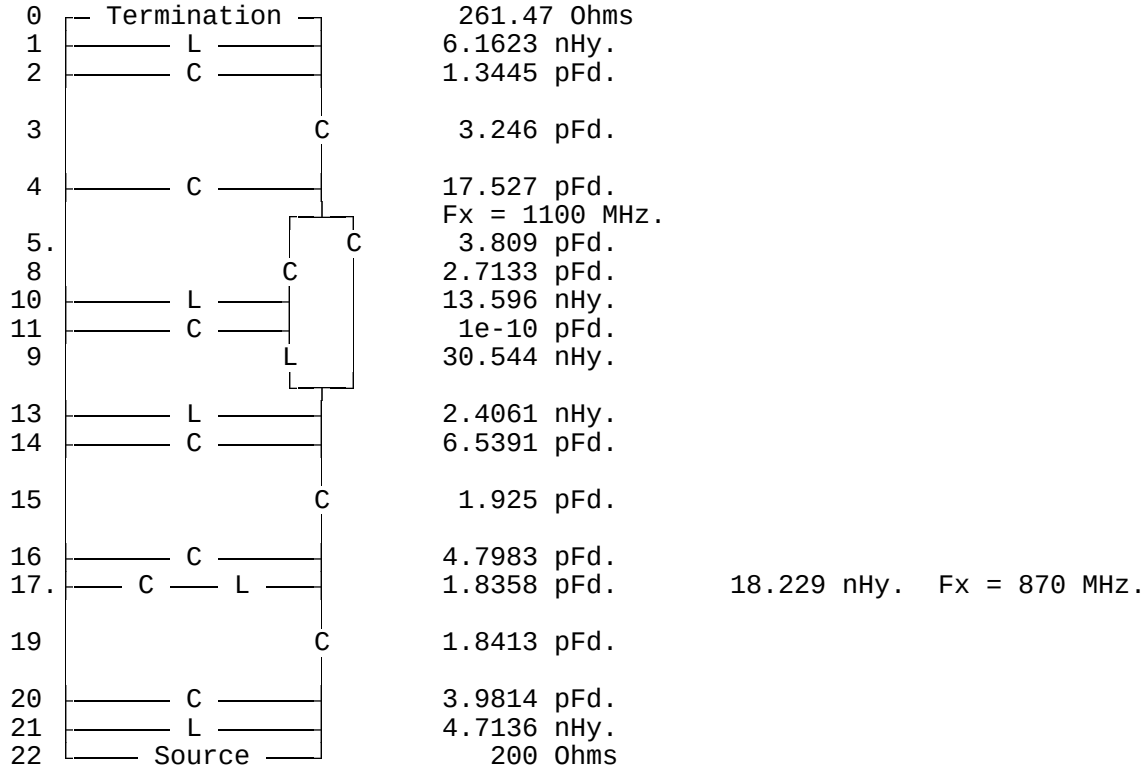
[MIS1:] Triplet at branch 4
(Press a mouse button or Cr = 1.0) Impedance ratio at triplet ? .2

```
 0 ┌─ Termination ─┐         522.94 Ohms
 1 ├──── L ─────┤        12.325 nHy.
                │
 2              C        2.2953 pFd.
```



With the triplet inserted, we can proceed to generate a capacitor in parallel with the inductor at branch 1 by applying a Norton transform at branch 2. A ratio of .5 will return the termination to where it was and generate the needed capacitor.

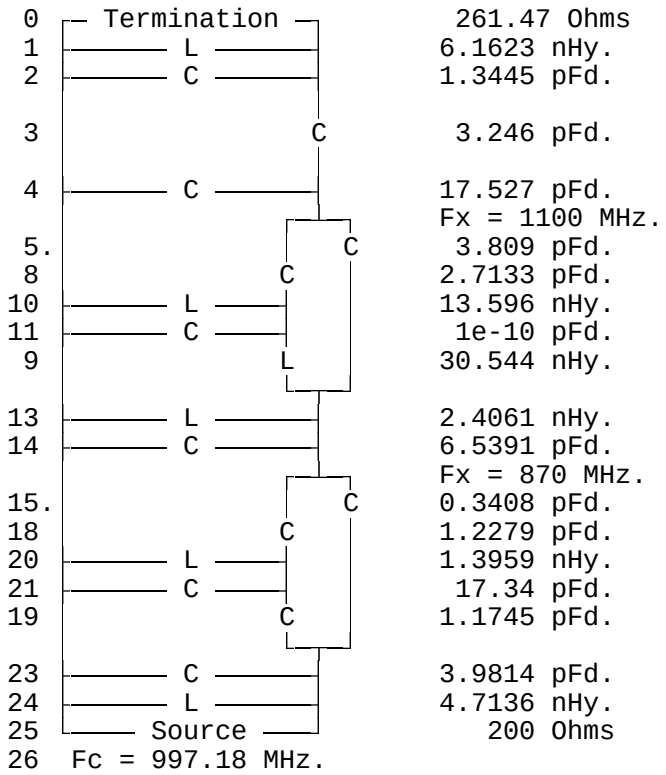
[NORT:] Xform at branch 2
Preset ratio = 1.00
What ratio ? .5



```
23  Fc = 997.18 MHz.
```

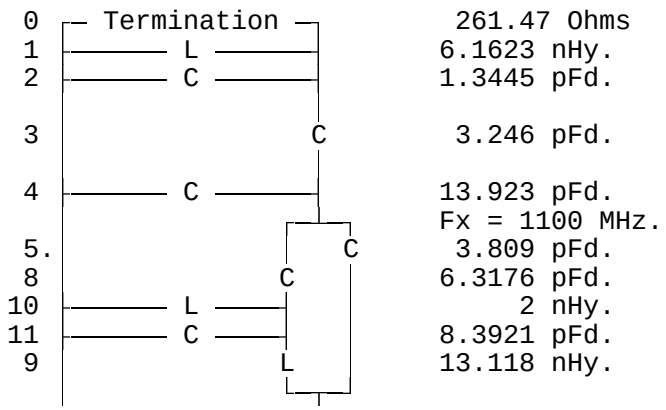
Now, the finite zero generated by the "trap" at branch 16 can be converted to a triplet.

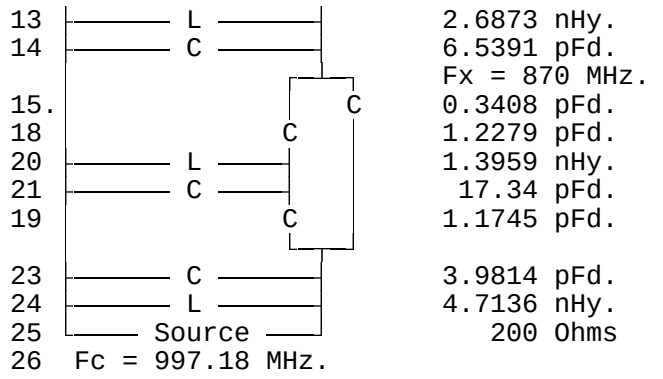
[MIS1:] Triplet at branch 16



Next, we would like to have values at the shunt "resonators" inside the triplets that are within a range that can be converted to shorted stub resonators. The values at branches 20 and 21 are ok as is. We will use the CT command again to make the values at the other triplet reasonable. Let's force 2 nHy. at branch 10.

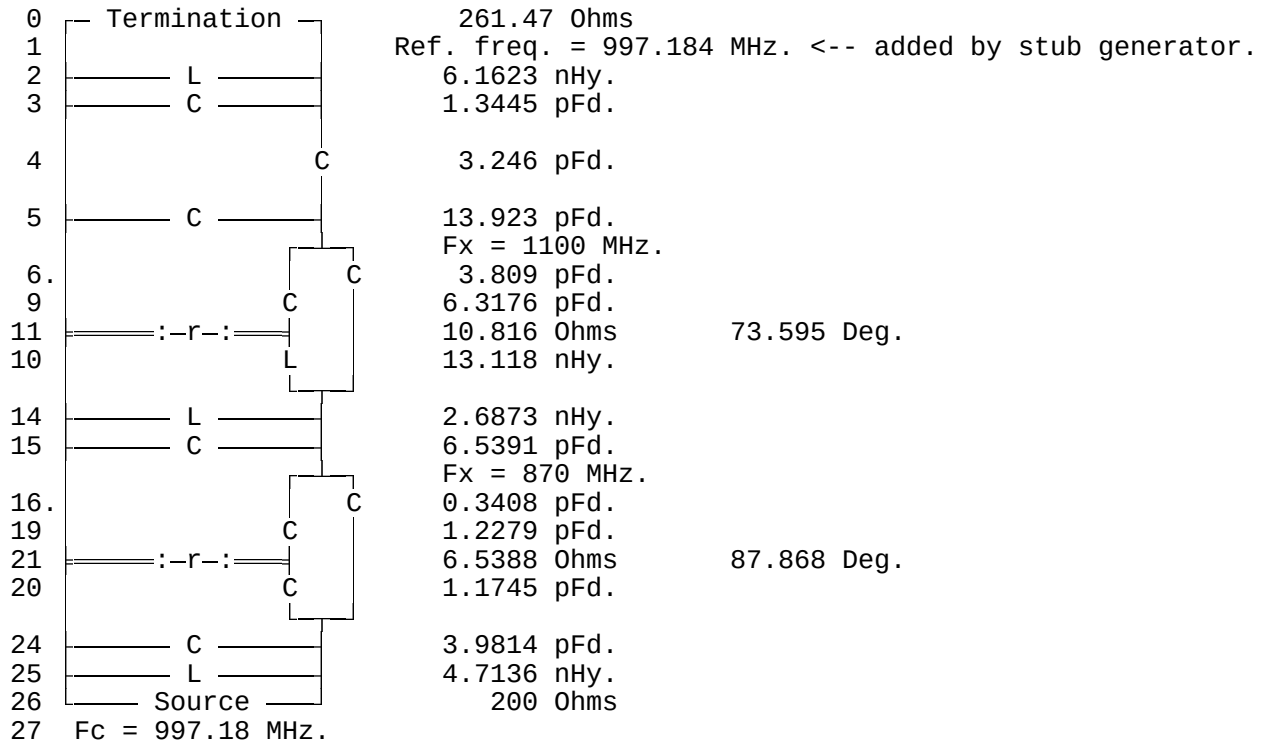
[MIS1:] Triplet at branch 10
(Cr) to abort * What is new value (nHy.) ? 2





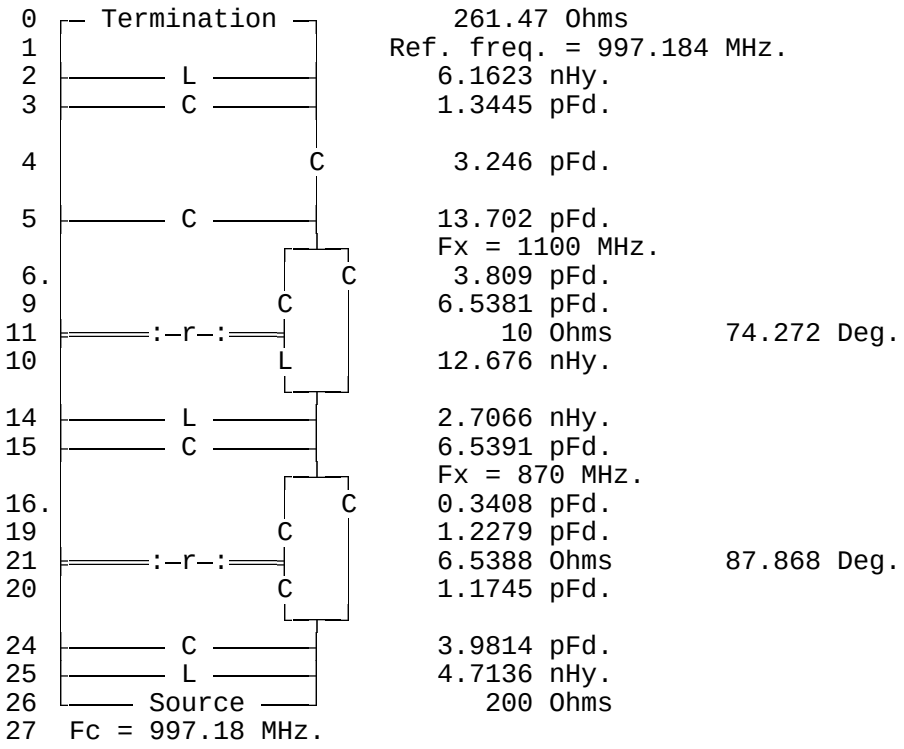
Now we can use the "LC to stub generator" to convert the L-C resonators inside both triplets to shorted stubs. Use the **Prog Stuber** command and choose the "V" option from the stub generator menu. Exit and use the **Stub** command to do the conversion.

[MIS:3] Program stuber (Pick option "V" on the menu)
[MIS3:] Stub at branch 10
[MIS3:] Stub at branch 21 (This was branch 20 before the reference frequency branch was added by the stuber when branch 10 was converted)



If quarter-wave ceramic dielectric resonators are to be used for the resonators, the correct impedance for these can be forced now by using the **Tripet** command again. This example assumes the resonators are 10 Ohms. The actual value will be specified by the manufacturer of the resonators. They are usually between 8 and 12 Ohms.

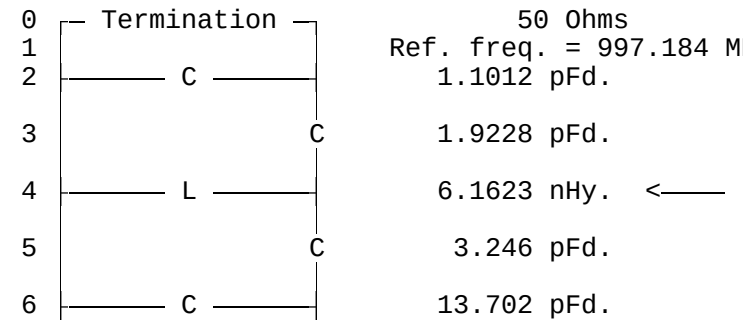
[MIS1:] Triplet at branch 11
(Cr) to abort * What is new value (Ohms) ? 10

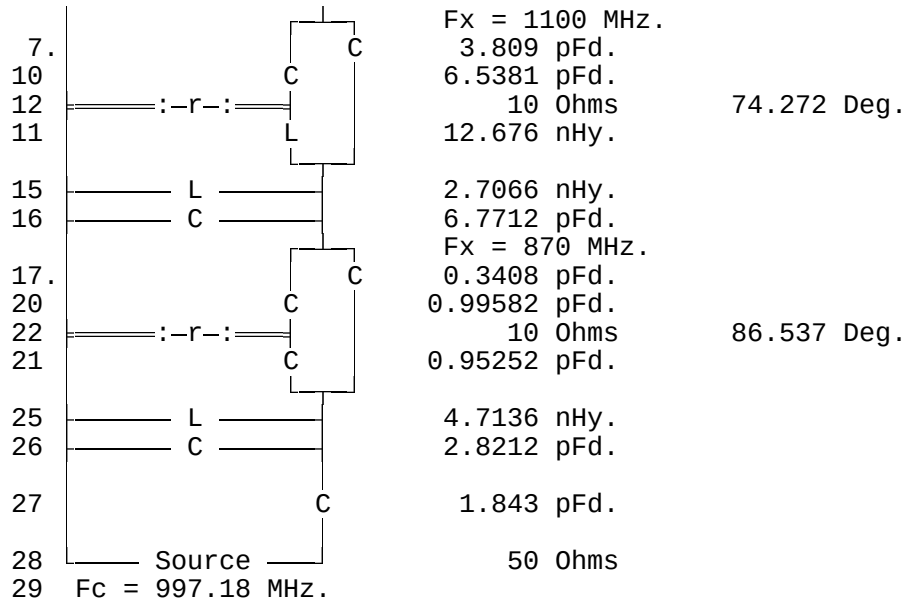


[MIS1:] Triplet at branch 21
(Cr) to abort * What is new value (Ohms) ? 10

The impedance matcher can be used now to match the load and source impedance to 50 Ohms. It is a good idea to save the network using the **Save** command before doing the impedance matching. This is the only way to back up after the filter has been source or load matched.

Two different matching networks were chosen at each end (option A and C). As it happened, the series C matching network if used on the source end (option A) would result in too small of a capacitor value across the termination end inductor. A capacitor of any value desired could be generated across the inductor at branch 4 by applying Norton transforms at branches 5 and 3 to lower the impedance at the inductor. The ratios would have to be N and 1.0 / N to maintain the 50 Ohm termination impedance.





A much better solution would be to recall the network saved before matching was applied and reduce the termination impedance to about 180 Ohms with a Norton transform at branch 3, then try the matching operation again. A series capacitor matching network would then yield acceptable values and fewer parts as well.

Acknowledgment

Special thanks is given to Dr. George Szentirmai, Life Fellow IEEE, for the derivation of the equations associated with the coupled triplet equivalences.

Also thanks to Mr. William B. Lurie for the improved stub resonator substitution calculation procedure used here.