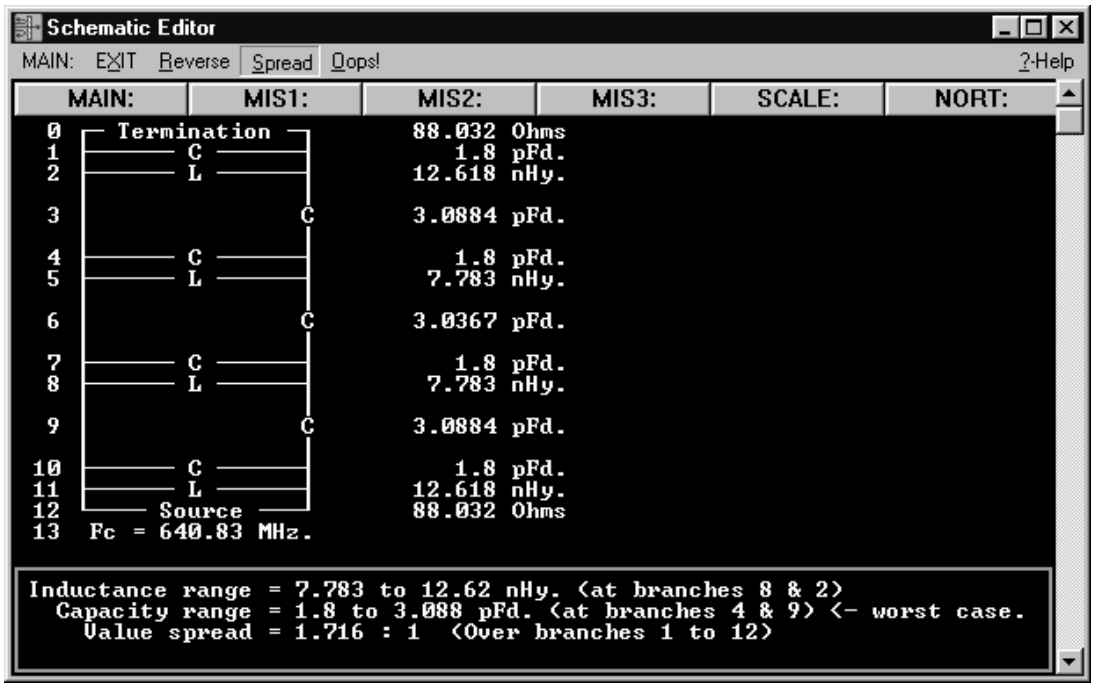
Manual Circuit Edit Module

The circuit editor is primarily intended for the manipulation of designs but is also useful for any occasion where individual network elements must be manually changed or added.

When the edit option is selected from one of the menus in the system that provide for its use, the program will draw the schematic diagram of the design in memory.

Below is the schematic representation of an L-C filter as drawn by the circuit editor



Use the up / down arrow keys, Page, Home and End keys to scroll the schematic up or down. The scroll bar on the right may be used as well. The mouse is used to select one of 6 buttons corresponding to 6 different top menu. Initially the “MAIN:” menu is displayed. One of the options on the MAIN menu is the “Spread” option which displays the extreme values in the current design and the value spread as a ratio of the largest to smallest value in a boxed in area at the bottom of the edit window. This area is used to display all messages while editing.

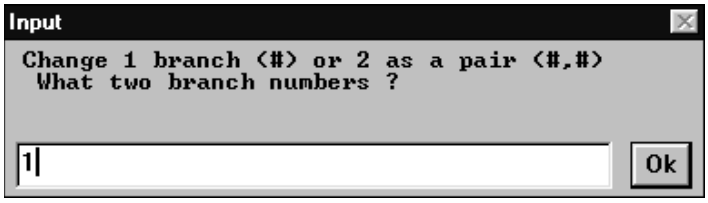
Editing Commands

The circuit editor is a manually driven method of controlling the many functions available within the program. Many of these same functions are also used by the design modules internally. Commands are given by choosing menus and menu options as well as answering some keyboard prompts.

Many of the commands deal with functions requiring branch number information. The command to change the value of a part is a command that requires a branch number. The branch number to specify is the number shown to the left of the part you want to change on the schematic drawing. The change value command is located on the menu selected by pressing the **[MIS1:]** button. To change the value of the shunt capacitor associated with the L/C resonant circuit at the termination end of the node filter shown earlier, you could do this:

Press the **[MIS1:]** button which will bring up this menu at the top of the edit window:

Select the "**Change**" menu option. The editor will now prompt you for the branch number:



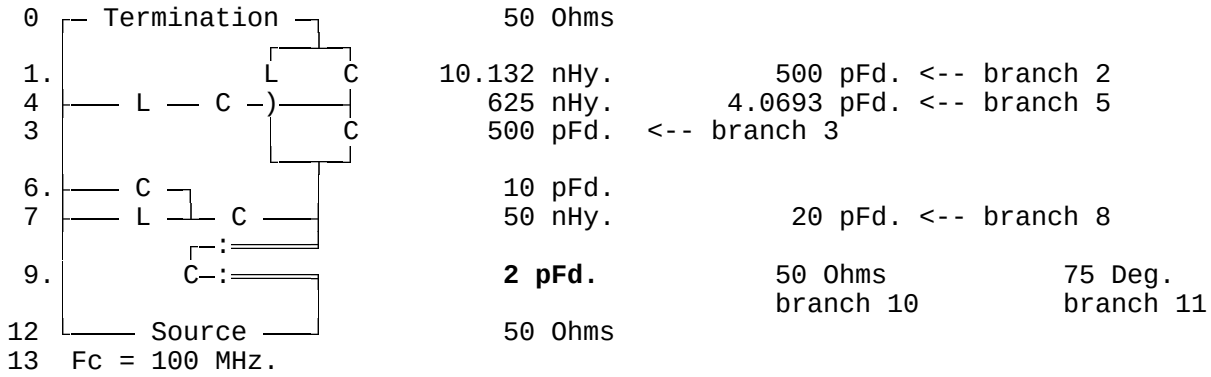
Key in the number just to the left of the capacitor you want to change. The is the "branch number". In this case it's 1.

The next prompt will ask for the value you want to put at branch 1:

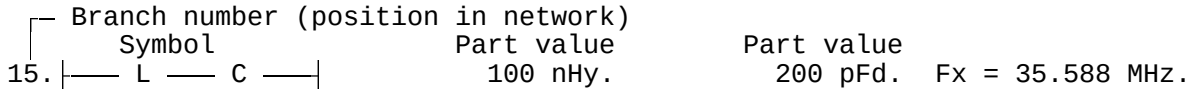
Several other commands require 2 branch numbers. The command to swap or interchange two branches (**Interchange** on the **[NORT:]** menu) is one of these. The prompt for branch numbers allows two branch numbers to be entered separated by a comma (#,#).

More about branch numbers

In the sample node filter shown at the beginning of this section, each individual part has a branch number to the left of it. This is not always the case. Some networks consist of more than one branch. Multiple branches are identified by a period (.) after the first branch number of the network. Only the first branch on each horizontal line can be numbered. Branches not numbered directly simply count up to the right even though in some networks, like the all-pass equalizer in the example below (branches 1 - 5), are not numbered consecutively.



As you edit a network, branch numbers are continuously being adjusted. Records of multiple branches are also up-dated internally. The editor is semi-intelligent with respect to multiple branches, it knows where a multiple branch starts and ends. Multiple branches may usually be specified as a single entity using the first branch number to identify the entire branch. The entire capacitively loaded stub in branches 9,10 and 11 (above) may be specified as branch 9 (the one with the period) when using commands like **Interchange** Branch. You can also specify a single branch within a multiple branch if appropriate. You could use the **Change** command to alter the electrical length of this same stub by specifying branch 11. In general, if you want to do something to an entire multiple branch, specify the first branch number. The program will usually know what you are trying to do.



The source, termination and Fc (branches 12, 0 and 13 respectively, in the example above) are valid branches and may be specified with any command where doing so is logical.

NOTE: Rather than key branch numbers into the program using the prompt AFTER selecting a menu command, the branch numbers may be designated BEFORE selecting the menu command by clicking on the VALUE of the component at that branch with your left mouse button. When you click on the value, it will turn red to confirm your choice. Two different branches may be identified this way. Note the 2 pFd value at branch 9 in the example above.

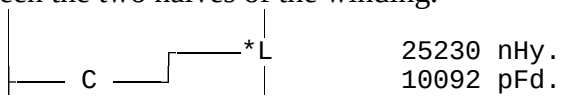
Schematic drawing symbols

The symbols used to represent circuit elements use the IBM extended character set. These characters should be compatible with virtually all computer CRT screens. They are used to provide connecting lines between components. The extended characters are not supported by modern printers however and an alternate set of characters are used when printing. The generic character set schematics are described in the section on design files and interfacing with other software (pages 5-1 to 5-4).

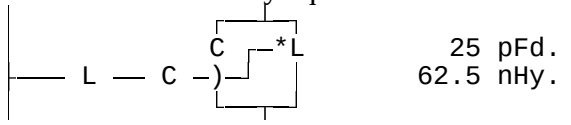
Each of the circuit element symbols is explained below

Termination or load end if the network. It is always the top element and is to be considered a purely resistive impedance.

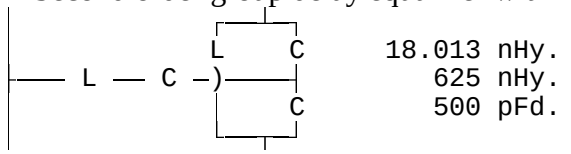
First order group delay equalizer. The symbol –-*L is an inductor center tapped with 100% coupling between the two halves of the winding.



Second order delay equalizer with center tapped inductor (low delay).



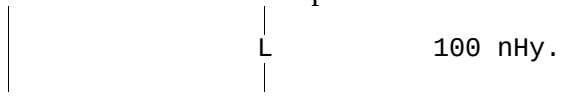
Second order group delay equalizer with high delay. Note the strange branch numbering.



Reference frequency for all transmission lines that follow. It indicates the frequency at which electrical length refers (in degrees). It is really required only for multiplexers having transmission line elements (where two different reference frequencies are needed), otherwise the identification frequency at the bottom of the schematic drawing is used as reference.

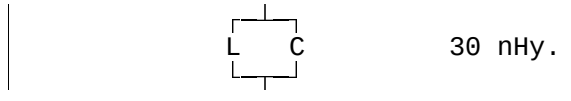
Parallel connected component

Series connected component.

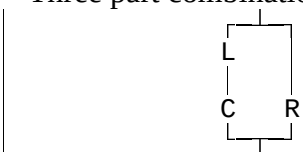


Shunt notch or 2 parts to ground. Fx is resonant frequency if parts are an L/C combination.

Series notch or 2 parallel connected parts in series. Fx is the resonant frequency if the parts are an L/C combination.

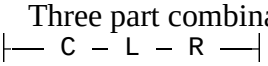


Three part combination in series.



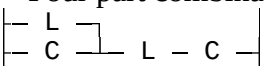
19.	L	30 nHy.	
20	C R	10 pFd.	5.1 Ohms

Three part combination to ground. Usually an amplitude equalizer.



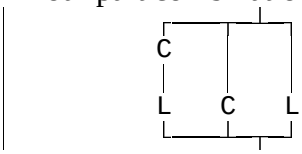
22.	C – L – R	10 pFd.	30 nHy. 220 Ohms

Four part combination in parallel.



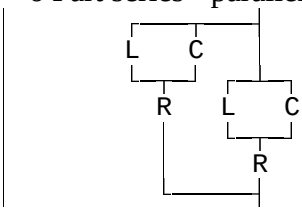
1.	L	25.361 nHy.	
2	C L – C	104.04 pFd.	12.01 nHy. 219.7 pFd.

Four part combination in series.



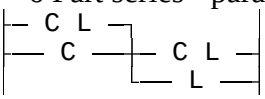
1.	C	10.144 pFd.	
2	L C L	260.1 nHy.	4.8039 pFd. 549.26 nHy.

6 Part series - parallel combination in series.



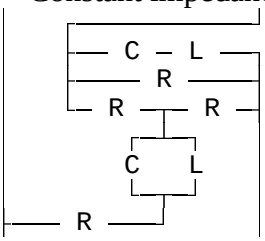
78.	L C	10 nHy.	5.1 pFd.
80	R L C	270 Ohms	4.8039 nHy. 549.26 pFd.
83	R	25 Ohms	

6 Part series - parallel combination in parallel.



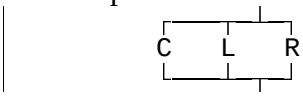
84.	C L	43.884 pFd.	68.02 nHy.
86	C C L	250.09 pFd.	4.2994 pFd. 590.63 nHy.
89	L	103.64 nHy.	

Constant impedance amplitude equalizer.



1.	C – L	362.16 pFd.	16.554 nHy. Fx = 65 MHz.
3	R	3.6995 Ohms	
4	R R	50 Ohms	50 Ohms
6	C L	13.731 pFd.	436.63 nHy. Fx = 65 MHz.
8	R	675.77 Ohms	

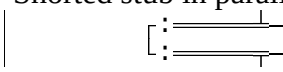
Three part combination in series.



25.	C L R	50 pFd.	220 nHy. 330 Ohms

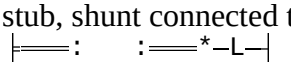
NOTE: double lines (═══) indicate transmission line conductors.
Single lines (———) indicate connecting leads.
Colons (:) indicate the END of a transmission line.
The key to visualizing shunt stub connections from the symbols is to consider the analogy of a railroad track you are standing on. The individual conductors of an open wire line converge in the distance if you were looking into one end just as the individual rails of the train track would converge. ├═══: :═══┤

Shorted stub in parallel with a single component (usually a capacitor) series connected.



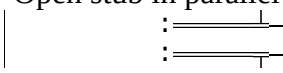
90. 50 Ohms 40 Deg.
91 15 pFd.

Open stub, shunt connected through a single component (usually an inductor).



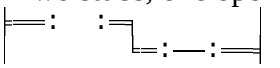
93. 50 Ohms 45 Deg. 20 nHy.

Open stub in parallel with a single component (usually an inductor) series connected.



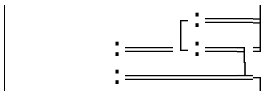
96. 50 Ohms 40 Deg.
97 15 nHy.

Two stubs, one open and one shorted, shunt connected.



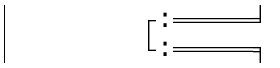
99. 20 Ohms 30 Deg.
101 70 Ohms 30 Deg.

Two stubs, one open and one shorted, series connected.



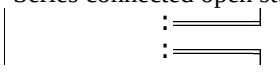
103. 70 Ohms 30 Deg.
105 20 Ohms 30 Deg.

Series connected shorted stub.



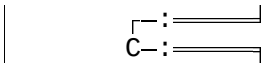
28. 50 Ohms 90 Deg.

Series connected open stub.



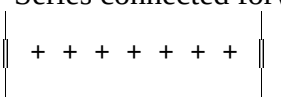
30. 50 Ohms 90 Deg.

Series connected stub, end loaded.



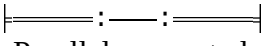
32. 2 pFd. 50 Ohms 45 Deg.

Series connected forward transmission line.



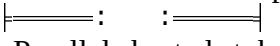
35. 50 Ohms 45 Deg.

Parallel connected shorted stub.



37. 75 Ohms 90 Deg.

Parallel connected open stub.



39. 92 Ohms 45 Deg.

Parallel shorted stub connected by series component.

```
41. ├═══:——:═══*—C—┤          150 Ohms          88 Deg.          0.2 pFd.
```

Parallel connected stub, end loaded.

```
39. ├═══════:—C—:═══════┤          0.2 pFd.          150 Ohms          88 Deg.
```

Test branch which causes analysis to give detailed R +-jX data looking into (not at) the point it marks. See the section on the analysis module for more.

```
44 │   Report ——> —┘   (If not present, Zo is looking into source end)
```

Perfect transformer.

```
45 ├═══════[ N:1 ]═══════┤          2.5 :1 turns
```

Multiplexer side port input. It connects the circuit above it to the point marked with the same common letter that follows. (Common A in this case) or to the source (in which case it will say: -- to Source --->).

```
   │                    │
   └————————>           └——— to Common A ———>
```

Termination of a multiplexer side port. It is assumed to be a pure resistive impedance. It can be thought of as a "dummy load".

```
46 ┌—— port term ——┐          50 Ohms
```

The point where a side port of a multiplexer is connected to another. If it is not present in a multiplexer, the common point is the source.

```
47 │                    │<——— Common A
```

"Stepped impedance" stopband notch consisting of two stubs in series connected parallel to the network.

```
48. │      ╔═: :═╗       │          32.813 Ohms          30 Deg.
50  ├═══:┘       └:═══┤          445.82 Ohms          30 Deg.
```

Series connected stopband notch. This is identical to the Series connected shorted stub that it resembles but is treated as a special case.

```
   │          z┌:═══════┘
28.│           └:═══════┐          50 Ohms          90 Deg.
```

Parallel connected stopband notch. This is identical to the Parallel connected open stub that it resembles but is treated as a special case.

```
39. ├═══════: z :═══════┤          92 Ohms          90 Deg.
```

Source of power to a network. It represents a signal generator having a series connected purely resistive source impedance. The analysis "looks" into this end of the network.

```
48 └——— Source ———┘          50 Ohms
```

Identification frequency of the network. It is used by the frequency scaling functions. It is usually geometric Fo of a bandpass.

```
49  Fc = 86.603 MHz.
```

The editing commands

Each command and its use is described in detail

++++++++++ **[MIS1:] Change**

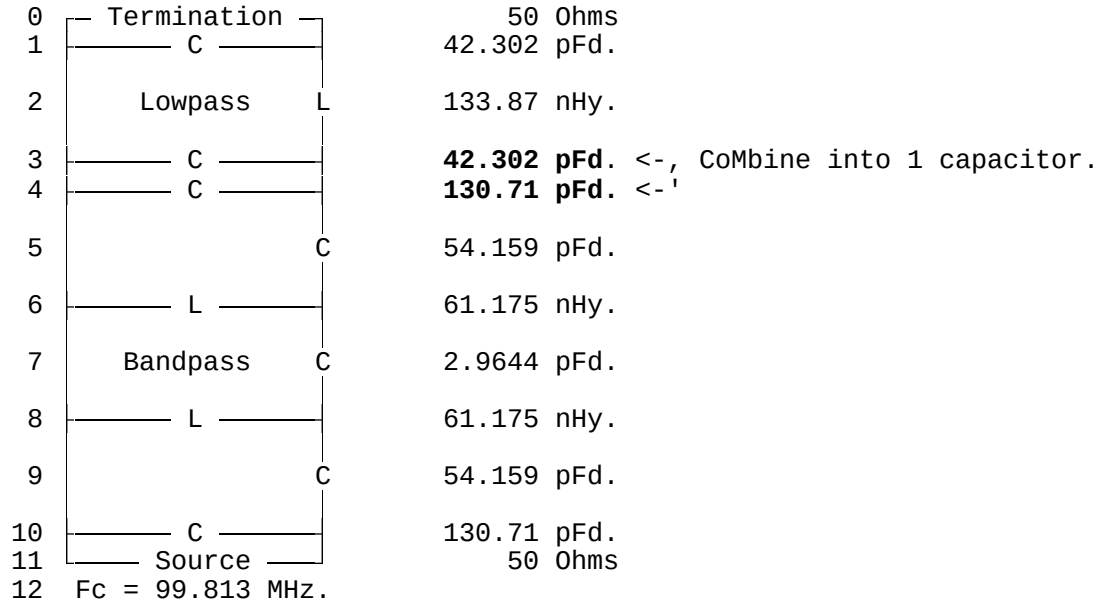
Change the value at any branch number including source, termination or Fo. Individual branches anywhere within multiple branches can be changed. Input a single branch number to change the value at one branch, or two branch numbers (#,#) to change two branches simultaneously.

Change 1 branch (#) or 2 as a pair (#,#)

What two branch numbers (#,#) ?

++++++++++ **[NORT:] combine**

Combine 2 branches. The result is placed at the position of the second branch specified. Parts at the two branches specified must be the same type and connected either parallel or series. It is NOT necessary that the two branches that are to be combined be adjacent branches, only that they be electrically connected. In the combination 2 pole bandpass and 5 pole lowpass filter shown below, it is desirable to combine the two capacitors in branches 3 and 4 into one capacitor:



Combine

Combine first branch -- into --> second branch.

What two branch numbers ? 3,4

```
 0 ┌─ Termination ─┐          50 Ohms
 1 ├──────── C ────────┤      42.302 pFd.
   │                   │
 2 │                   L      133.87 nHy.
   │                   │
 3 ├──────── C ────────┤      173.01 pFd.  <-- 1 Cap. (42.302+130.71 pFd.)
   │                   │
 4 │                   C      54.159 pFd.
   │                   │
 5 ├──────── L ────────┤      61.175 nHy.
   │                   │
 6 │                   C      2.9644 pFd.
   │                   │
 7 ├──────── L ────────┤      61.175 nHy.
   │                   │
 8 │                   C      54.159 pFd.
   │                   │
 9 ├──────── C ────────┤      130.71 pFd.
10 └──────── Source ────┘          50 Ohms
11  Fc = 99.813 MHz
```

++++++++++ **[MIS2:] Copy**

Copy a single branch, or all between two branches.

Copy Branch # for 1 branch.

Copy Branch #,# for 2 or more branches.

Position them After what branch number ?

++++++++++ **[NORT:] Cp**

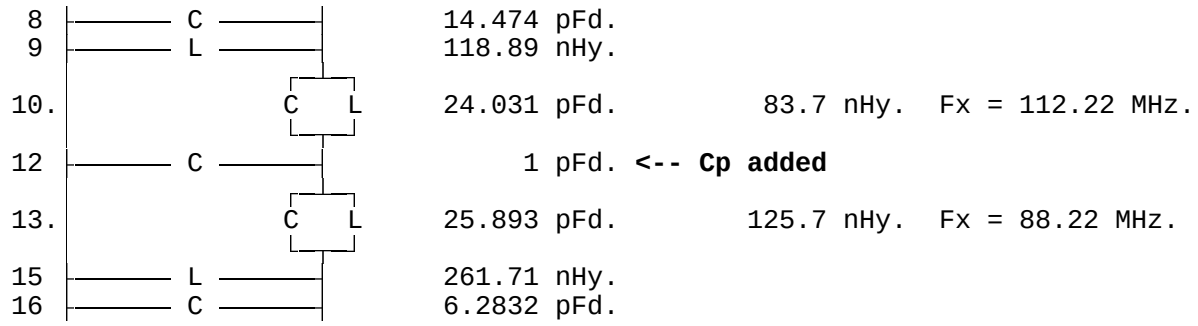
CP - This is used to add, change or delete a capacitor used to absorb the stray capacity at the junction of the two series "notch" traps in the conventional elliptic bandpass filter topology. A detailed example of its use can be found in the section on direct scaled bandpass filters with notch sections.

```
 8 ├──────── C ────────┤      9.1399 pFd.
 9 ├──────── L ────────┤      184.64 nHy.
   │                   │
   │                ┌──┐
10.│                L  C      108.81 nHy.       18.486 pFd.  Fx = 112.22 MHz.
   │                └──┘
   │                   │
   │                ┌──┐
12.│                L  C      138.41 nHy.       23.515 pFd.  Fx = 88.22 MHz.
   │                └──┘
   │                   │
14 ├──────── L ────────┤      219.71 nHy.
15 ├──────── C ────────┤      8.6607 pFd.
```

To add a 1 pFd capacitor to ground to absorb the distributed capacity at the junction of the two series notch sections in the network shown above, use the CP command at branch 10:

CP

(Cr to abort) Cp value (pFd.) ? 1



The CP editor command can be used again, at the same branch number to change the value to something other than 1 pFd if you like. Once the shunt capacitor has been inserted initially, you can also specify the branch number of the parallel capacitor directly. That is, either branch 10 or branch 12 will work identically in this example.

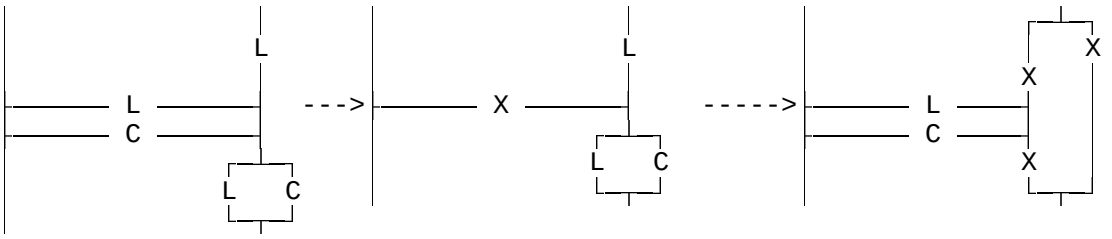
To delete the capacitor from the circuit in the event the results are not satisfactory, you can simply specify a value of zero pFd or just press the <Enter> key in response to the Cp value prompt.

When using this feature on each section of a high order elliptic filter, begin at the source end and work up toward the termination end. You must do this because the transformation scales the impedance level of the rest of the network up to and including the termination impedance. This will change the value of all the parts in that area. The direction of the scaling, up or down, is determined by the order of the series notch sections. This order is automatically reversed depending on the existing ratio of source to termination impedance. This is done to try to reduce the overall impedance ratio of source to termination in a high order filter. To reverse this scaling direction (invert the scaling ratio) in a single "section" manually, delete the existing Cp and interchange the two series notches, then replace the Cp.

++++++++++ **[MIS1:] Triplet**

Triplet

For details see Appendix D



++++++++++ **[MIS1:] Delete**

Delete a single branch, or all between two branches.

Delete # for 1 branch.

Delte #,# for 2 or more branches. (from branch #, to branch #)

Using the bandpass, lowpass combination shown above to illustrate the CM command, let's delete the bandpass section leaving only the lowpass:

```
 0  ┌─ Termination ─┐          50 Ohms
 1  ├──── C ────────┤       42.302 pFd.
    │               │
 2  │    Lowpass  L │       133.87 nHy.
    │               │
 3  ├──── C ────────┤       42.302 pFd.
 4  ├──── C ────────┤       130.71 pFd.
    │               │
 5  │             C │       54.159 pFd.
    │               │
 6  ├──── L ────────┤       61.175 nHy.
    │               │
 7  │  Bandpass   C │       2.9644 pFd.
    │               │
 8  ├──── L ────────┤       61.175 nHy.
    │               │
 9  │             C │       54.159 pFd.
    │               │
10  ├──── C ────────┤       130.71 pFd.
11  └─── Source ────┘          50 Ohms
12   Fc = 99.813 MHz.
```

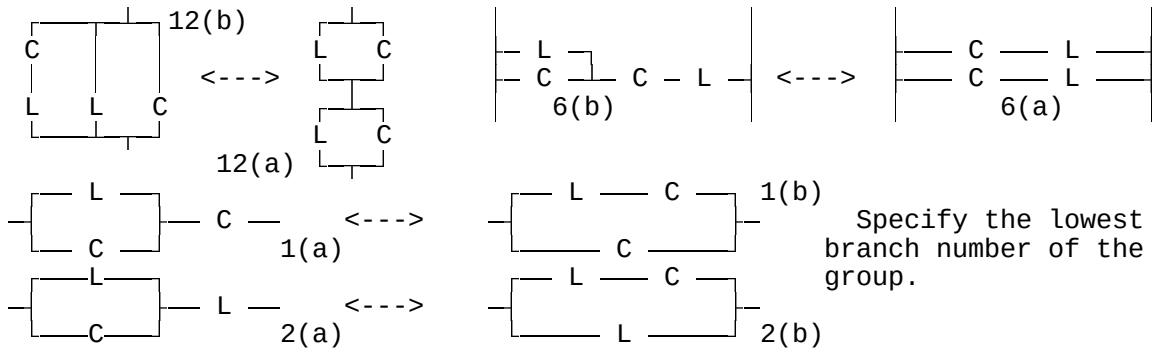
Delete
What two branches? 4,10

```
 0  ┌─ Termination ─┐          50 Ohms
 1  ├──── C ────────┤       42.302 pFd.
    │               │
 2  │    Lowpass  L │       133.87 nHy.
    │               │
 3  ├──── C ────────┤       42.302 pFd.
 4  └─── Source ────┘          50 Ohms
 5   Fc = 99.813 MHz.
```

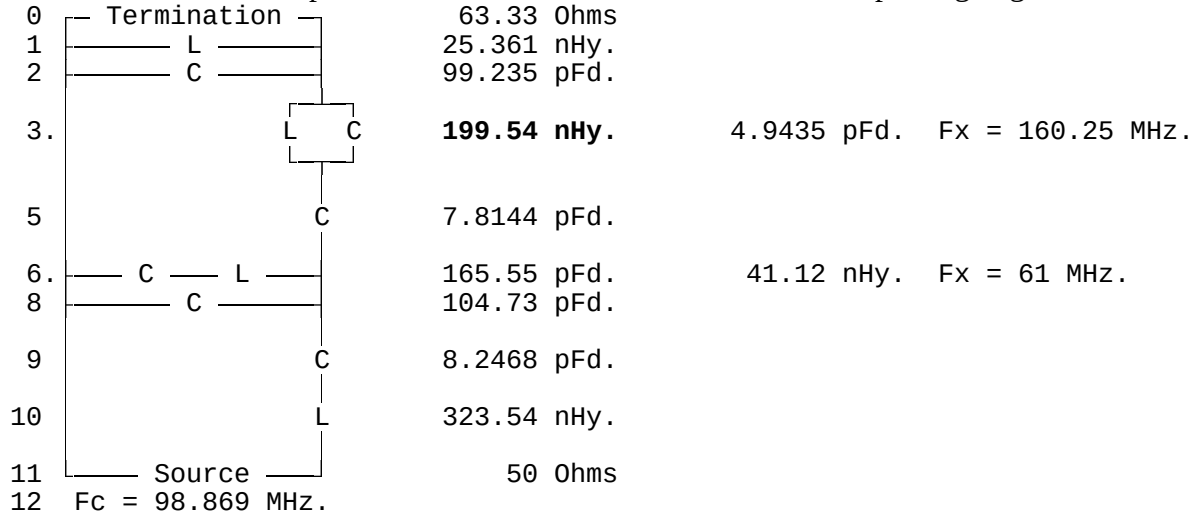
++++++++++ **[NORT:] Dipole**

Dipole

Convert between these pairs of equivalent networks. In Series or Parallel within the network.

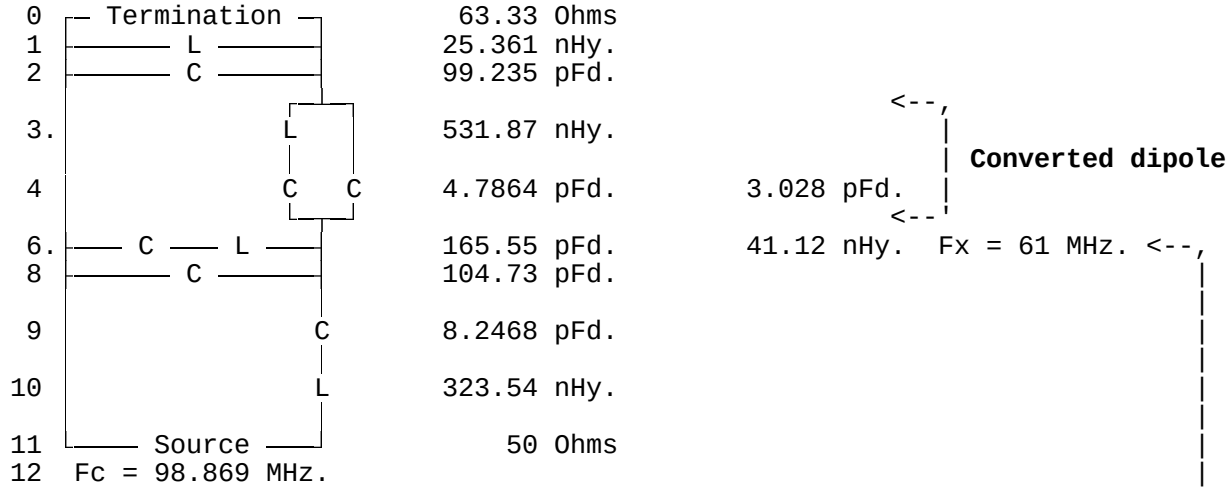


To convert the dipole network at branches 3,4 and 5 in an elliptic zig-zag filter:



Dipole

Branch 3



Note: The dipole at branches 6,7 and 8 may be converted in the same way by pressing the <Enter> key, but with this topology, you have the option to specify the resulting inductor:

Dipole

Branch 6

Preset ratio = 1.0000

(Cr) normal transform, -1 for preset, Inductor value (nHy.) ?

++++++++++ **[MIS2:] Equal value**

Force all Equal Values in a bandpass filter.

It will function on L-C filters having series or parallel resonant sections and on tubular filters. It will also operate with a 5 resonator parallel input elliptic design that does not contain any series resonant, untransformed sections, like the one shown below:

```
 0  ┌─ Termination ─┐            50 Ohms
 1  ├──────── C ────┤         108.05 pFd.
 2  ├──────── L ────┤         28.328 nHy.
    │               │
 3.                 C   L     45.833 pFd.       30.062 nHy.  Fx = 135.59 MHz.
    │               │
 5  ├──────── C ────┤         107.71 pFd.
 6  ├──────── L ────┤         23.754 nHy.
    │               │
 7.                 C   L      85.11 pFd.       55.825 nHy.  Fx = 73.015 MHz.
    │               │
 9  ├──────── C ────┤         90.321 pFd.
10  ├──────── L ────┤          23.68 nHy.
11  └──────Source ──┘            50 Ohms
12   Fc = 99.499 MHz.
```

Equal value

Equal L or C ? C

(Cr) to maintain source Zo -or- Value desired (pFd.) ? 30

```
 0  ┌─ Termination ─┐           178.9 Ohms
 1  ├──────── L ────┤         102.85 nHy.
 2  ├──────── C ────┤             30 pFd. <---
    │               │
 3.                 C   L     13.005 pFd.       105.94 nHy.  Fx = 135.59 MHz.
    │               │
 5  ├──────── L ────┤         83.234 nHy.
 6  ├──────── C ────┤             30 pFd. <---
    │               │
 7.                 C   L     25.754 pFd.       184.49 nHy.  Fx = 73.015 MHz.
    │               │
 9  ├──────── L ────┤         73.028 nHy.
10  ├──────── C ────┤             30 pFd. <---
11  └──────Source ──┘          157.3 Ohms
12   Fc = 99.499 MHz.
```

++++++++++ **[MAIN] EXIT** (Also: Right mouse button)

Exit editor.

<R> to Restore original design, <Enter> to save work.

The original design is automatically saved in a temporary file every time the editor is entered. When exiting, the <R> Restore option will allow you to replace all editing with the original design. This is an abort feature.

++++++++++ **[NORT:] Force**

Force Branch.

Force the value of a capacitor or inductor using Norton transforms in an existing "T" or "Pi" circuit (the "Pi" circuit MAY contain a series notch as with the 5 resonator elliptic filter used to illustrate the **Force** command). This command calculates the turns ratio (k:1) of the "perfect" transformer associated with a Norton transform necessary to yield a specified value at either side of the transform after the combination of

the existing parts and the extra parts generated by the transform itself (see the description of the **Xform** Norton transform command for further information). In the sample transformed direct scaled filter design shown below (initially used to describe the **Xform** command), branches 2, 3 and 5 represent a "Pi" transform. Branches 5, 6 and 7 represent a second transform. Each transform will support one forced value. The capacitor at branch 2 can be forced using branch 3 as the center element. Branch 7 may be forced using branch 6 as the center element. Because branch 5 is common to both transforms, it can be forced using either transform. Note that only 2 of the 3 parallel capacitors can be forced. It would be nice if both the capacitors at branches 2 and 7 in the filter below were 20 pFd. To do this requires 2 steps. One for each transform.

```
  0 ┌─ Termination ─┐            15 Ohms
    │               │
  1 │               L       105.75 nHy.
    │               │
  2 ├──── C ────────┤        19.531 pFd.
    │               │
  3 │               C        4.9727 pFd.
    │               │
  4 ├──── L ────────┤        105.75 nHy.
  5 ├──── C ────────┤        16.576 pFd.
    │               │
  6 │               C       4.9727 pFd. <-- center element of 1st transform.
    │               │
  7 ├──── C ────────┤        19.531 pFd. <-- branch to force.
    │               │
  8 │               L       105.75 nHy.
    │               │
  9 └──── Source ───┘            15 Ohms
 10  Fc = 98.869 MHz.
```

Force branch

(Cr) to abort * Branch # to force
At what branch number ? 7
Value desired at branch #7 (pFd.) ? 20
Branch number of center element ? 6

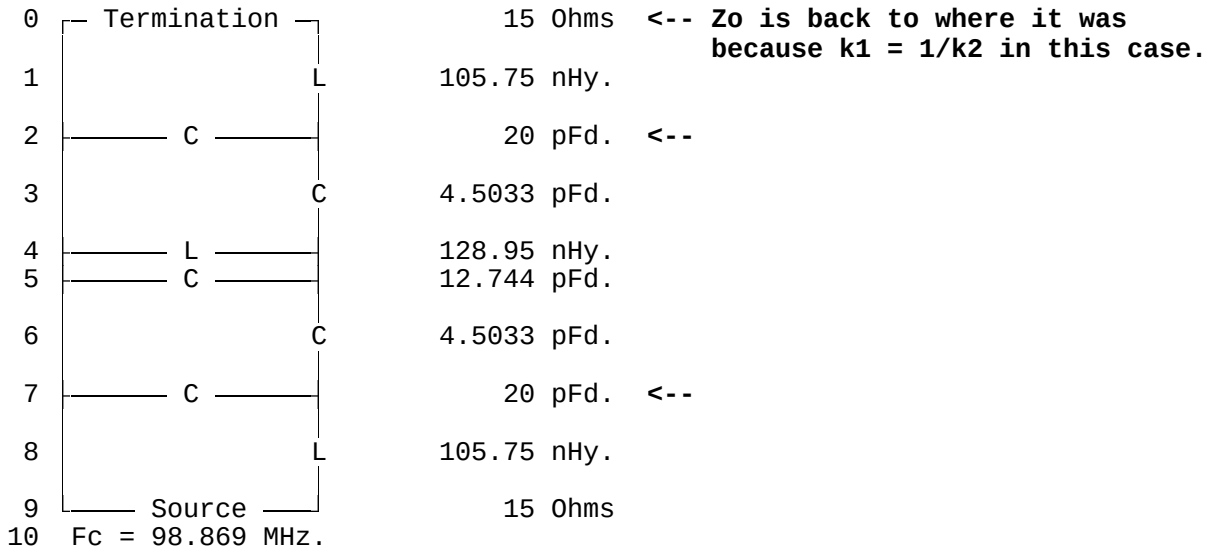
```
  0 ┌─ Termination ─┐          18.29 Ohms  <-- notice Zo scaling.
    │               │
  1 │               L       128.95 nHy.
    │               │
  2 ├──── C ────────┤        16.017 pFd.  <-- branch to force.
    │               │
  3 │               C        4.0782 pFd.  <-- center element of 2nd transform.
    │               │
  4 ├──── L ────────┤        128.95 nHy.
  5 ├──── C ────────┤        13.169 pFd.
    │               │
  6 │               C        4.5033 pFd.
    │               │
  7 ├──── C ────────┤            20 pFd.
    │               │
  8 │               L       105.75 nHy.
    │               │
  9 └──── Source ───┘            15 Ohms
 10  Fc = 98.869 MHz.
```

Force branch

Branch number to force ? 2

Value desired at branch #2 (pFd.) ? 20

(Cr) to abort * Branch number of center element ? 3



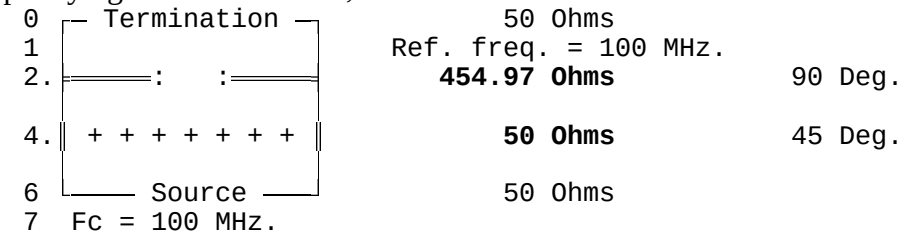
++++++++++ **[all menus] ?-Help**

There is a separate help screen to cover each menu.

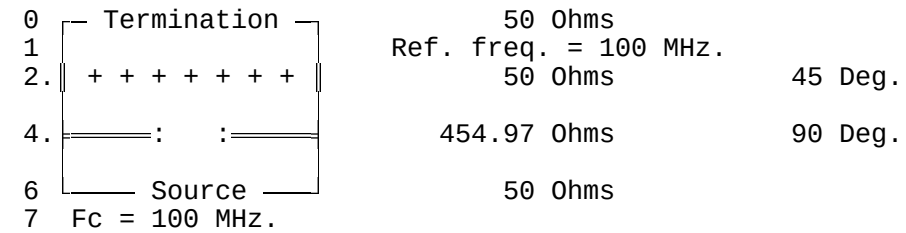
++++++++++ **[NORT:] Interchange**

Interchange two Branches.

This command is used to interchange or swap two individual or multiple branches. A multiple branch is assumed in its entirety if the first branch number is specified (the one followed by the period). The network below contains an open shunt stub and a series transmission line. They can be reversed by specifying branches 2 and 4, like this:



Interchange



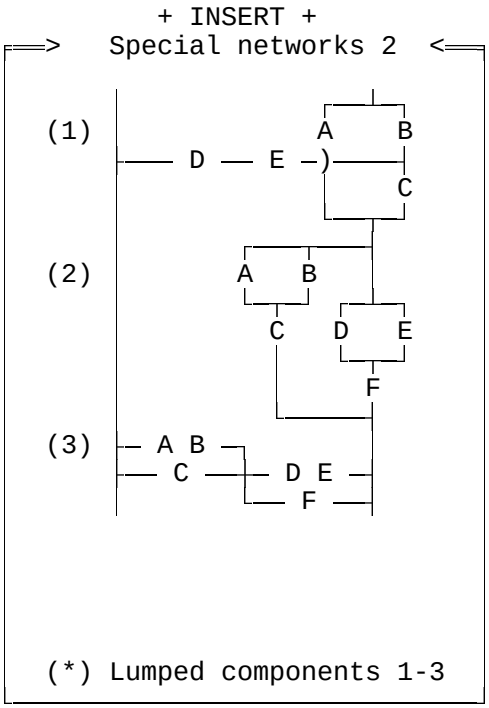
Single branches (other than the first of a multiple branch) may be swapped in the same way. To swap the first branches of two multiple branches, you will have to change each value separately with the **Change** command.

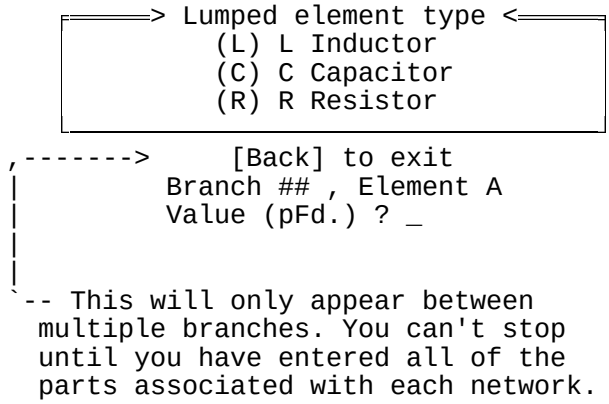
++++++++++ **[MIS1:] Insert**

Insert a new branch AFTER the branch specified.

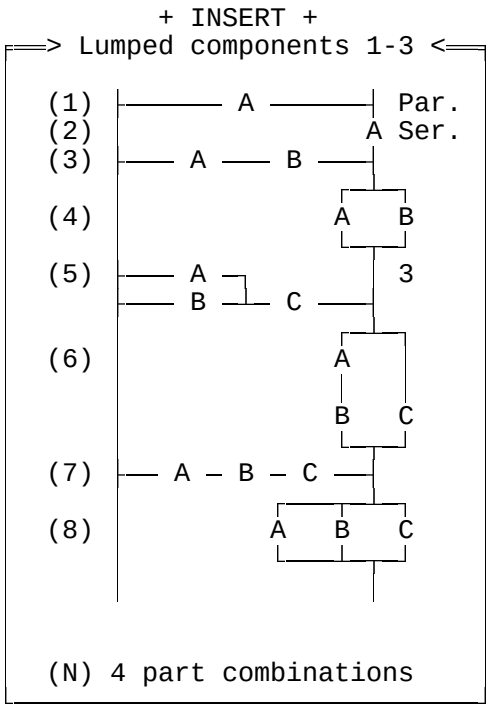
The **Insert** command allows the user to add branches to the network from the keyboard. Each branch is added starting between the one specified and the next one. The type of branch added is selected from one of four menus that will continuously alternate as the <Space> bar is pressed. This is becasue the [Next] button is the default selection on each menu. The first two menus are for adding lumped components, the third and fourth are for transmission line components and special branches used for multiplexers and the like. Simply press the button corresponding to the desired branch type.

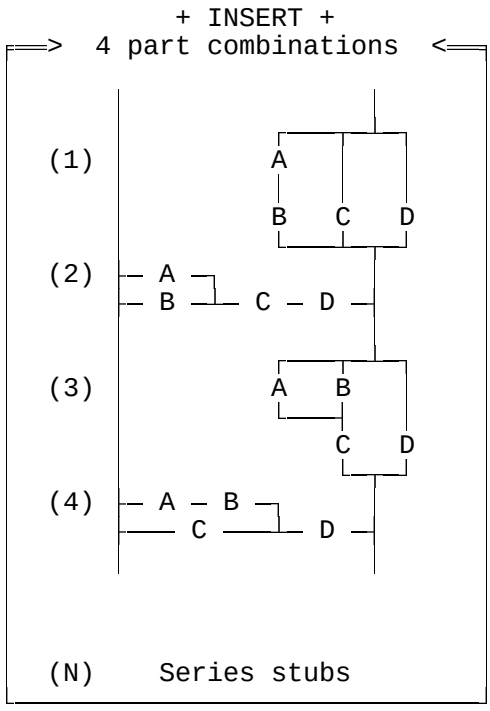
The selection of what type of part to insert at each branch is done by another button menu. Each branch location is labeled A,B,C etc. so that any type part (R, L or C) may be at any location. The A,B,C.. simply represents the order in which they must be entered.

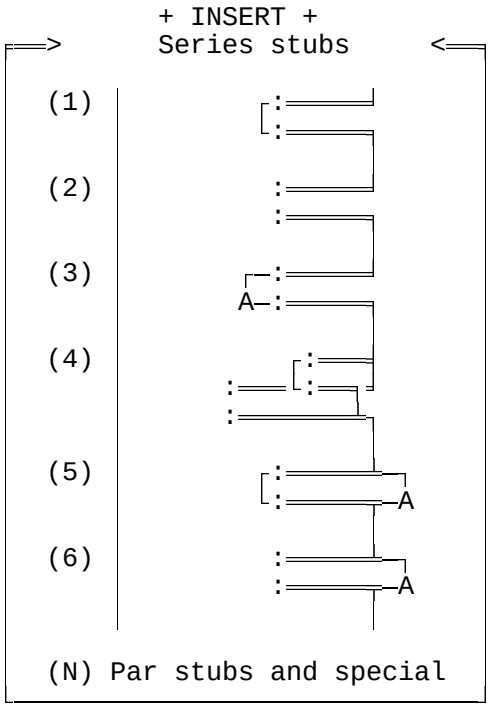


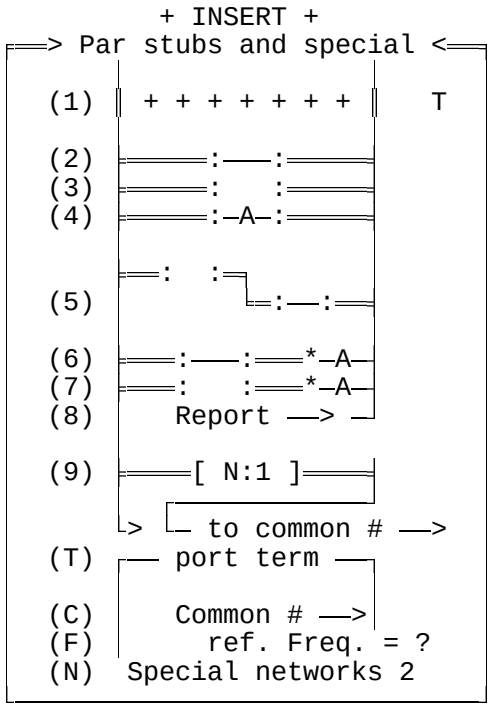


As each addition is made, a running count is kept and displayed of the branch number. Branch numbers are automatically opened to accommodate the newly added parts. When adding multiple branches, you will be prompted for part A, B, C and D. When you are done, simply press the [Back] (‘~’) key and the new circuit will be drawn.









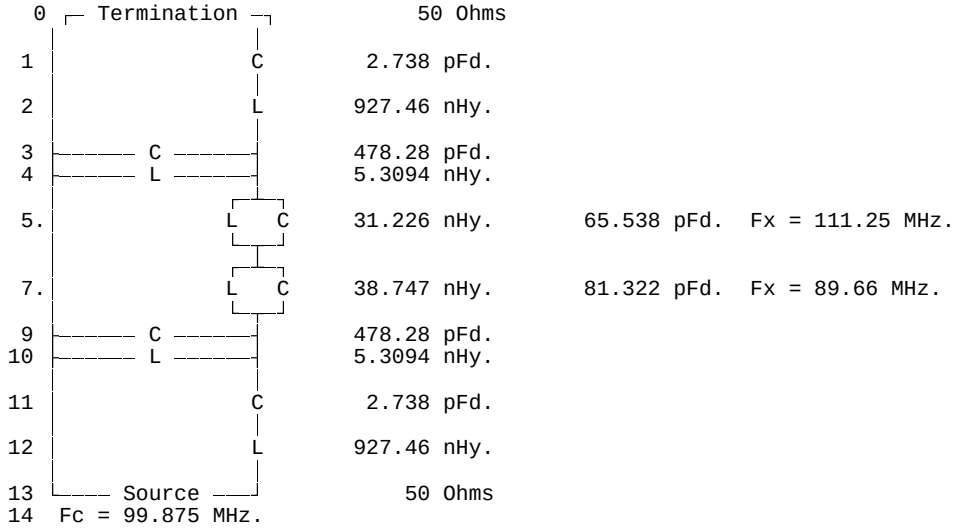
++++++++++ **[NORT:] Iterate**

Iterate 5 resonator elliptic sections.

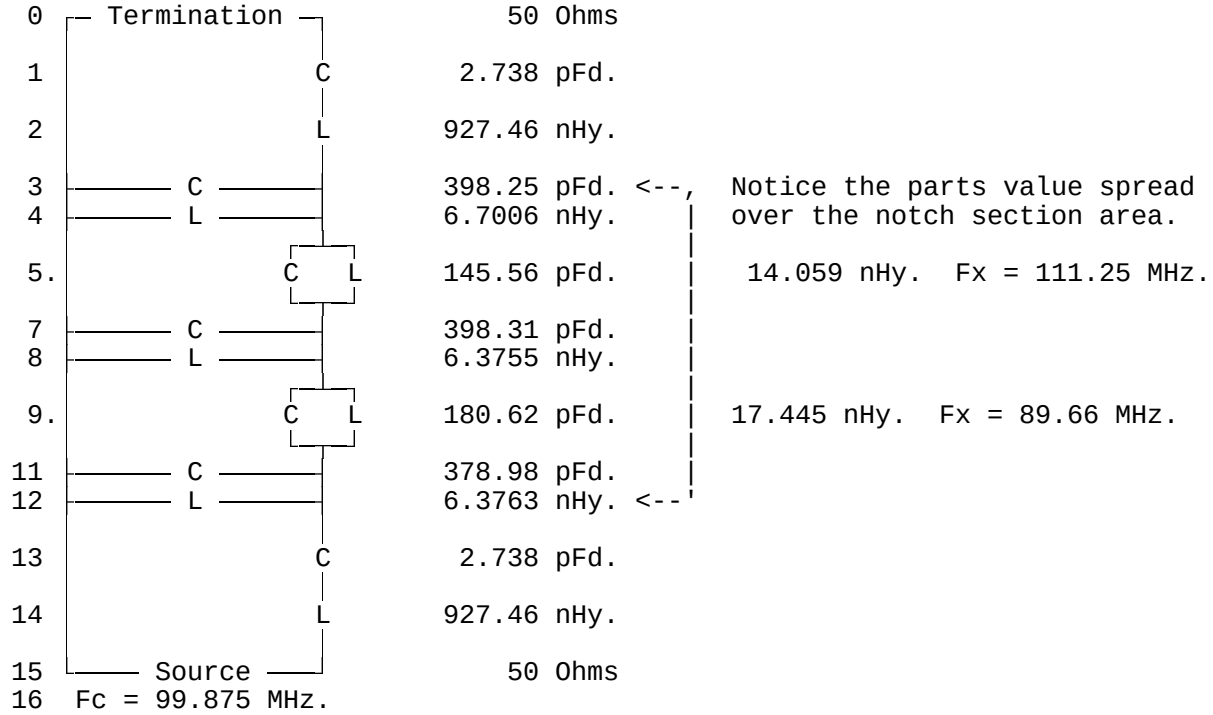
This function can be used anytime 1 or more consecutive series notch bandpass sections exist in a network to reduce the parts value spread in that area. The same function is used by the 5 resonator bandpass

module and it will automatically convert all series notch sections to that configuration. If shunt notch section exist in the network, a warning message will be given. The dual of this type network can be iterated instead.

This feature is best used when the editor is called from within the forced value transformed bandpass module. In that case, the pole sections would be transformed before entering the editor. The example below was generated using the basic direct scaled bandpass module and has no transformations. Only the area of the notches is effected by the IT function.



Give the **Iterate** command:

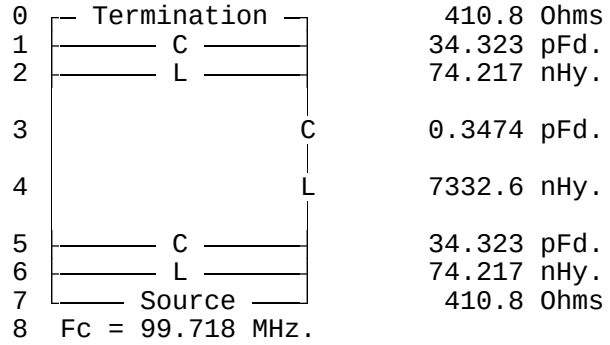


++++++++++ **[MIS2:] J-k inverter**

"J" or "K" inverter

The "J" and "K" inverter function can be used to derive a node or mesh filter from a direct scaled filter. An inverter will transform a network into its "dual" from the section specified up to the termination. The example below is a 15% bandwidth direct scaled filter that we will transform into a combination mesh / node network.

The first step is to invert the parallel section at branches 3 and 4 into a series section. The type of coupling generated (L or C) will be determined by the type of part (L or C) at the lowest branch number in the previous section, branch 5 in this case. Because branch 5 is a capacitor, inverting will generate a capacitor coupling. The choice of "J" or "K" inverter is automatic. Specify the section "tank" you wish to invert by the highest branch number of the two, like this:

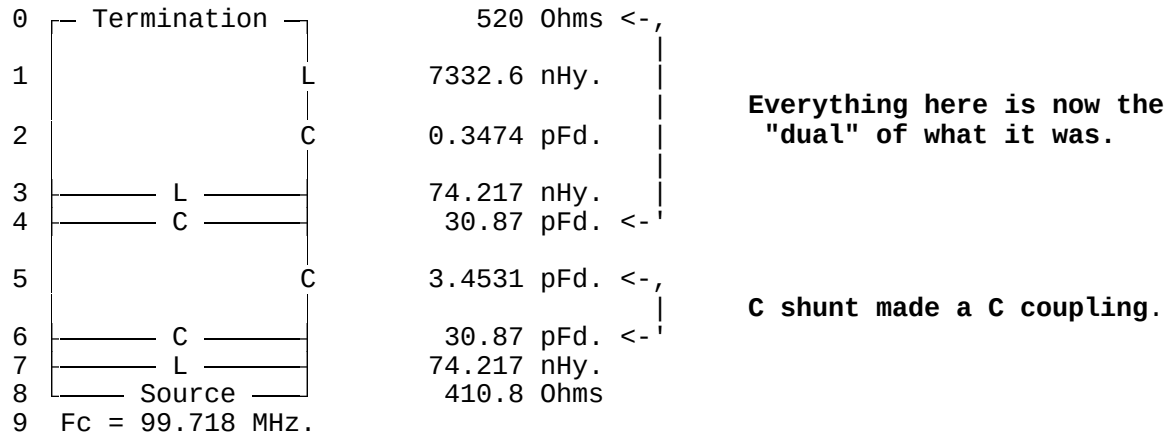


J-k inverter

Specify highest branch number in L/C 'tank' to invert

At what branch number ? 4

What is desired value of inverted 'tank' L (nHy.)? 74.217



Next, we will invert the last section at branches 1 and 2. Note that the part at branch 3 is an inductor. This will generate a series inductor for a coupling. If we want a capacitor coupling, we only need to interchange (IB) branches 3 and 4 to put the capacitor at branch 3. In this case, the program asks for the value of the desired inverted capacitor.

J-k inverter

Specify highest branch number in L/C 'tank' to invert
At what branch number ? 2
What is desired value of inverted 'tank' C (pFd.)? 30

```
 0 ┌─ Termination ─┐          470 Ohms
 1 ├──────── C ────┤           30 pFd.
 2 ├──────── L ────┤       95.151 nHy.
   │               │
 3 │             L │       789.07 nHy.  <-,
   │               │                      |  L shunt made an L coupling.
 4 ├──────── L ────┤       81.922 nHy.  <-'
 5 ├──────── C ────┤        30.87 pFd.
   │               │
 6 │             C │       3.4531 pFd.
   │               │
 7 ├──────── C ────┤        30.87 pFd.
 8 ├──────── L ────┤       74.217 nHy.
 9 └──── Source ───┘        410.8 Ohms
10  Fc = 99.718 MHz.
```

Now we have a classic node filter. The initial design we started with had a parallel connected tank at its source end. If the source end had been series connected, the final inverted design would have been a mesh filter having all series connected sections. If the initial direct scaled filter had more poles (sections) we could have simply skipped one of the sections causing the final design to switch from a node filter to its dual after the skipped section.

We can now proceed to invert the last section again to yield a series connected section that is mutual reactance coupled:

J-k inverter

Specify highest branch number in L/C 'tank' to invert
At what branch number ? 2
What is desired value of inverted 'tank' C (pFd.)? 30

```
 0 ┌─ Termination ─┐          6.748 Ohms
   │               │
 1 │             L │       5.2653 nHy.
   │               │
 2 │             C │           30 pFd.
   │               │
 3 ├──────── L ────┤       89.886 nHy. <-- L coupling remains.
   │               │
 4 │             L │       699.18 nHy.
   │               │
 5 ├──────── L ────┤       81.922 nHy.
 6 ├──────── C ────┤        30.87 pFd.
   │               │
 7 │             C │       3.4531 pFd.
   │               │
 8 ├──────── C ────┤        30.87 pFd.
 9 ├──────── L ────┤       74.217 nHy.
10 └──── Source ───┘        410.8 Ohms
11  Fc = 99.718 MHz.
```

At this point all that is needed is to use a Norton transform with branch 3 as the center element to improve the L/C ratio of the new series section.

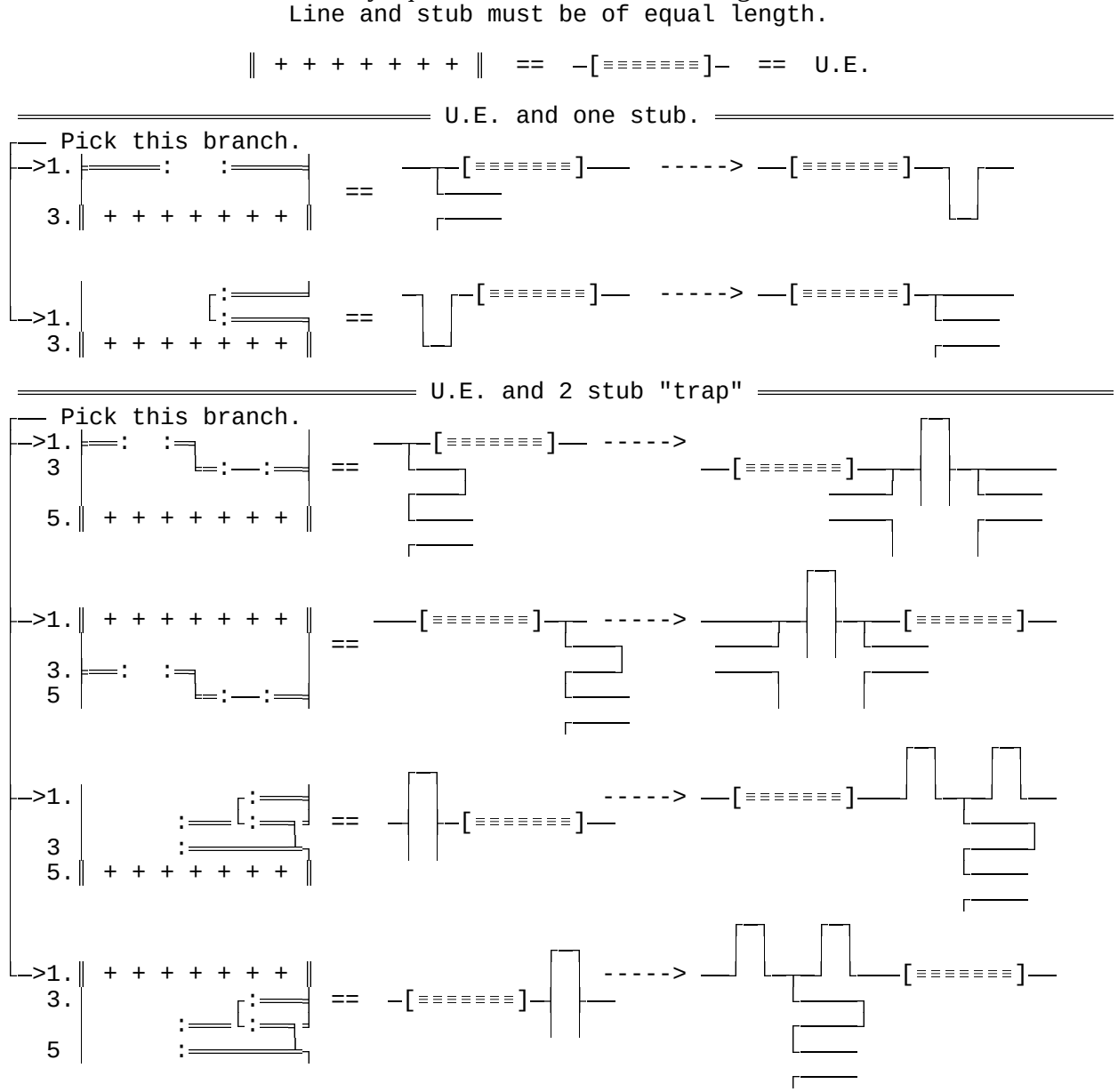
++++++++++ **[MIS3:] Kuroda**

Kuroda Transform

Kuroda and Kuroda-Levy identities utilize a transmission line (Unit Element) to invert a stub of equal electrical length to its dual. This transformation is useful for modifying unrealizable elements in microwave designs. All adjacent stubs generated by the transforms are automatically combined. A detailed example of its use can be found in APPENDIX-B.

Specify the lowest branch number of the stub and Unit Element pair to be transformed. In each case below, specify branch 1.

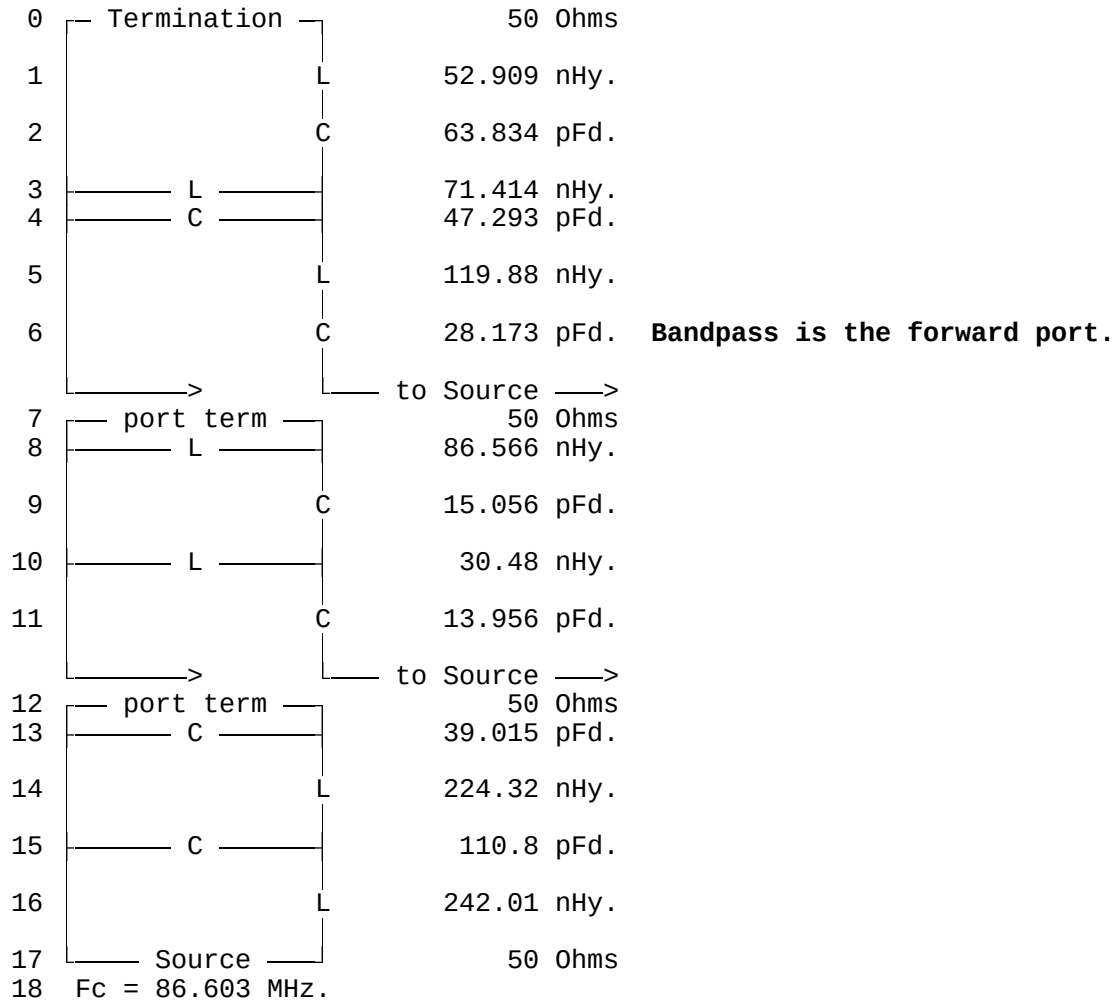
Kuroda and Kuroda-Levy equivalent transforms involving 1 Unit Element.



++++++++++ **[NORT:] Move**

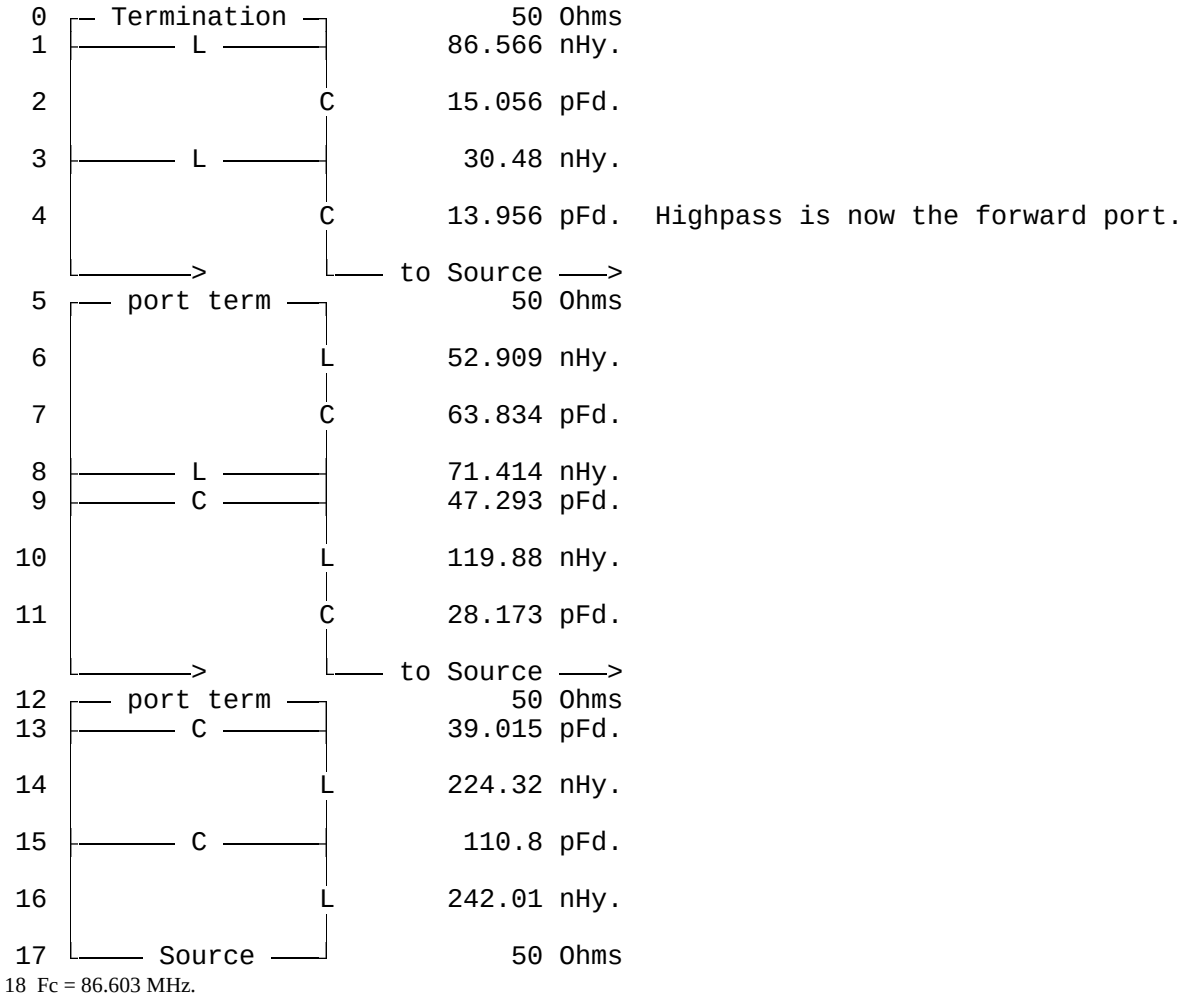
Move a branch, or group of branches as a unit.

The **Move** command can be used anytime it is desired to move one or more single or multiple branches from one place to another in a network. It will also move a selected multiplexer side port to the forward port position for analysis. The example below is a simple contiguous triplexer with its center (bandpass) port in the forward position. Shown below is the procedure for moving the highpass port to the forward position.



Move

Move branches between - low# , High#
What two branch numbers ? 7,11
(Cr) to move the SIDE port to the FORWARD position
Position them After what branch number ? (Cr)



It was not really necessary to specify the second branch number (11) when moving the multiplexer side port in the previous example, the program will find the source end of a side port automatically. The second branch only has to be specified when a series of contiguous branches that the program can't identify as a single entity must be moved at one time. A single multiple branch, like an all-pass equalizer, can me moved as a single entity.

Move

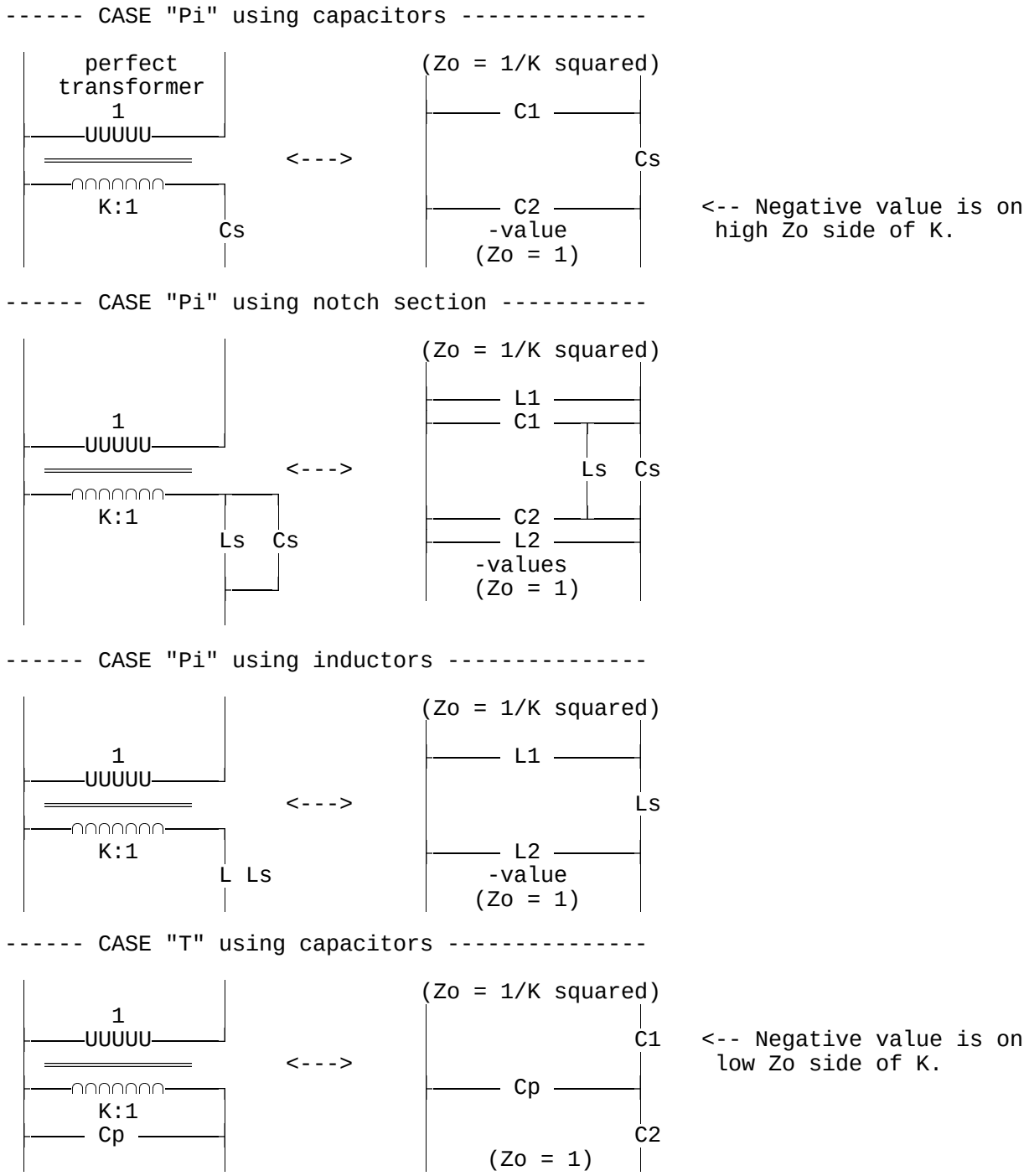
Move branches between - low# , High#
What two branch numbers ? 7 <--- Only branch 7 needed
(Cr) to move the SIDE port to the FORWARD position
Position them After what branch number ? (Cr)

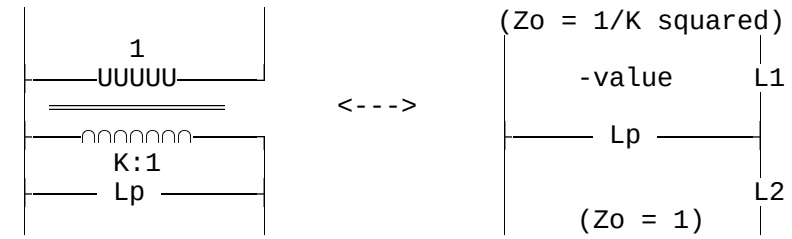
NOTE: An additional command **Rotate**, may be used to rotate the port of the highest branch number to the forward position without specifying any branch numbers at all. This is the quickest method.

++++++++++ [NORT:] Xform

Norton Transform.

The **Xform** command is based on Norton's first and second equivalences which state that the circuits shown below are equivalent. In each "Pi" configuration, the element on the high Zo side of the transformation is an unrealizable negative value. In the "T" configuration case, the negative element appears on the low Zo side.



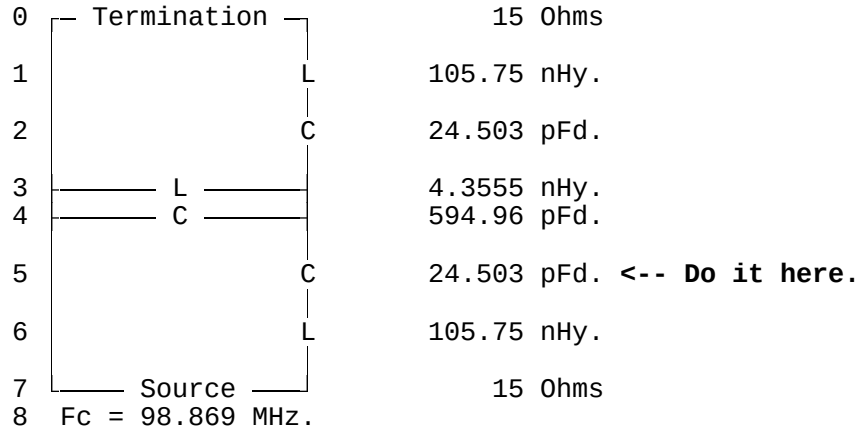


When the **Xform** command is used at the center element of three capacitors or inductors in the "Pi" or "T" configuration (Cs, Ls, Cp or Lp above) The new components generated by the transformation are calculated and automatically combined with any existing adjacent branches. This means the transformation can be repeated until the desire results are achieved. The program is capable of "looking around" other branches to find appropriate branches for combination.

The command can also be used at an isolated capacitor or inductor, where no adjacent branches exist to absorb the new components generated by the transformation. In this case, the new components are simply inserted. The schematic drawing module will display negative values in yellow or brown (if you have a color monitor). The program will also perform the transformation on a series notch (in the "Pi" configuration).

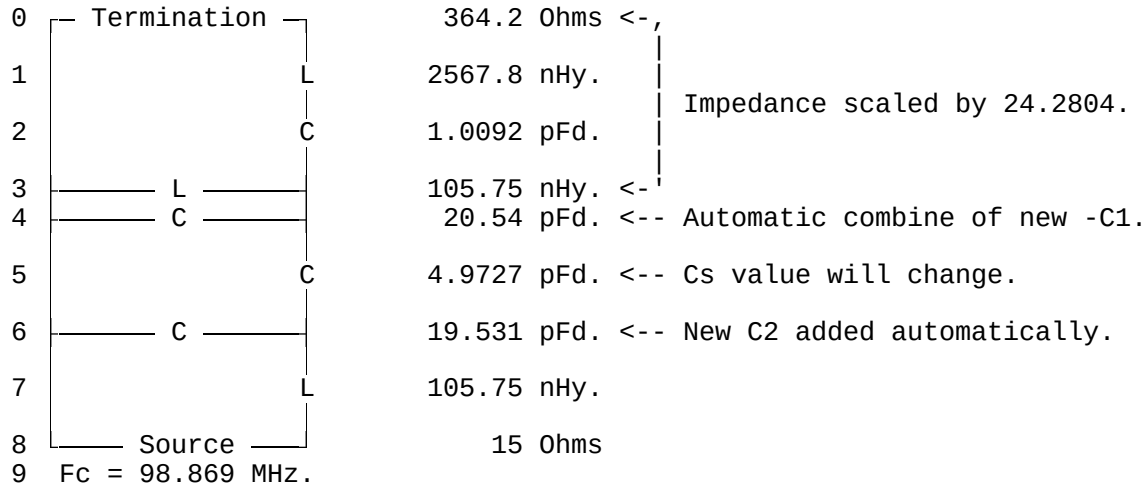
The transformation adds a perfect transformer to the network so that all parts from the transformer up to and including the termination are scaled by the impedance ratio chosen. When doing several transformations to a network, it is necessary to start at the source end and work up toward the termination so that the impedance scaling does not upset your work.

The sample design below is that of a 15% direct scaled bandpass filter that would be difficult to construct because of the extreme values of the parts at branches 3 and 4. To make the inductor at branch 3 equal to the inductor at branch 6 (the value of which was chosen by selecting the design Zo of 15 ohms) a Norton transform can be done at the series capacitor at branch 5. The ratio of 105.75 nHy / 4.3555 nHy is 24.2807, so this is the impedance ratio to specify for the transformation (this ratio may be calculated and set ahead of time by using the **Ratio** command).



Xform

Branch number of center element ? 5
Preset ratio = 1 <-- see the RA command about "Preset"
Impedance ratio (-1 for preset)? 24.2807



A second transformation can now be done using branch 2 as the center element for the transform. The new shunt capacitor at branch 6 can also be forced to a standard value by using the FB command (This example is continued to illustrate that procedure, see the FB command).

++++++++++**[MAIN:] Oops** (Also mouse right button menu)

This command will Undo the last 10 commands in reverse order.

++++++++++ **[MIS3:] -Value**

negative V - replace a part with the opposite type part of the opposite sign.

```
-C ---> +L or -L ---> +C
+L ---> -C or +C ---> -L
```

When using the **Xform** (Norton Transform) command, parts having negative values are sometimes generated. The -V command will replace a negative part with a positive part of the opposite type. This is an act of desperation. It can be done if no other way can be found to eliminate the negative value, but it can be counted on to upset things.

++++++++++ **[MIS3:] Prog stuber**

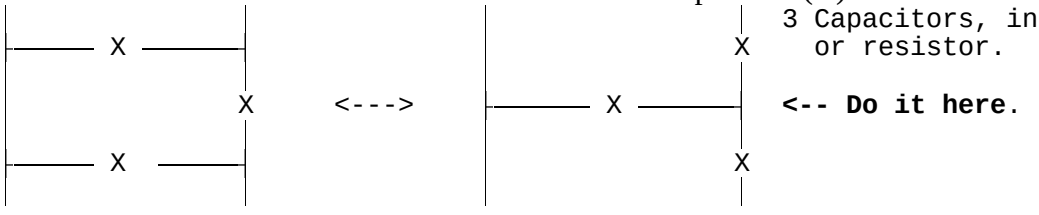
Program Stub generator

In order to use the associated **Stub** command, the stub generator must be programmed for which type of stub is to be generated. This command calls the L-C —> Stub generator menu. This is identical to calling the stub generator from the utilities menu.

++++++++++ **[NORT:] Pi-T**

PT - "Pi" ---> "T" or "T" ---> "Pi"

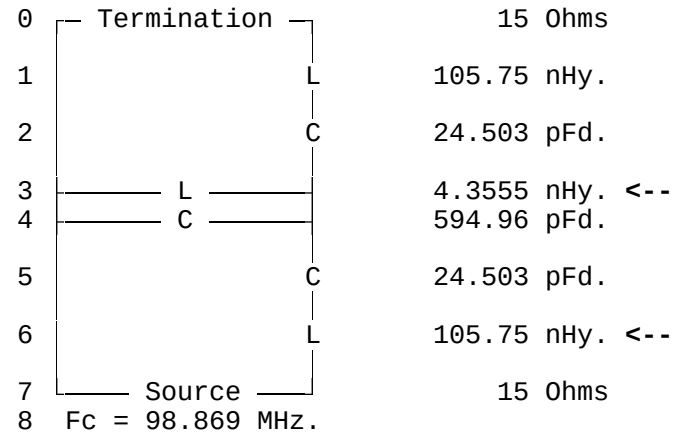
The **Pi-T** command will alternate between the two equivalent circuits shown below. The branch reference is the center branch of the 3. Each of the 3 components (X) must be of the same type.



++++++++++ **[NORT:] Ratio**

Ratio sets the preset Ratio of two branch values.

Several of the other editor commands require that impedance ratio information be supplied. Often this ratio will be that of two component values within the network, such as the value of 2 inductors (see the NT command). The **Ratio** command allows that ratio to be calculated and held for later use. This ratio is called the "preset" ratio. The sample filter shown below is the same design used to illustrate the use of the **Xform** (Norton Transform) command. Here is how the **Ratio** command can be used to set up the needed 24.2807 ratio to transform the inductor at branch 3 to equal the inductor at branch 6.



Ratio

What tw branches? 6,3
ratio preset to 24.2807

The preset is now set to 24.2807 and will remain that value until it is changed by another **Ratio** command or until you exit the editor. If the branch numbers are called in the reverse order (that is branches 3,6) the preset ratio is simply inverted (1/24.2807 = .04118). The preset ratio is initially set to 1.0 when first entering the editor. The branches used could be R, L or C types, but both branches should be of the same type.

The usual way to use the preset ratio is by responding with <Enter> to a ratio prompt in any command that allows its use.

++++++++++ **[MIS1:] Recall**

Recall memory

This command will recall a design file saved earlier with the **Save** command. The design currently in memory is LOST!

++++++++++ **[MAIN:] Reverse**

Reverse network end-for-end ("flip" source-for-termination).

++++++++++ **[MIS2:] Rotate**

Rotate multiplexer ports - See the **Move** command

++++++++++ **[SCALE:]**

Norm. Converts a design to 1 Ohm and 1 radian / sec. frequency.
Un-Norm Will restore a design to the Fo and Zo it was before the **Norm** command was used.
Src-Zo-Impedance. Simple impedance scaling. Specify source Zo.
Term-Zo-Impedance. Simple impedance scaling. Specify termination Zo.
Ratio-Zo-Impedance. Simple impedance scaling. Specify by ratio.
Freq. Simple frequency scaling.
Invert. Used to "invert" a normalized lowpass <--> highpass.
Dual. Will convert a circuit to its "dual".
Bandpass. This will scale: LP->BP, HP->Notch or BP->dual passband.

++++++++++ **[NORT:] Split**

Split branch into two equivalent branches.

Any single capacitor or inductor may be split into two parts of equal value. They may be series or parallel connected.

```
 0 ┌─ Termination ─┐          50 Ohms
 1 ├──────── C ────┤         100 pFd.
 2 └──── Source ───┘          50 Ohms
 3  Fc = 100 MHz.
```

Split
At branch 1
(Cr for both equal) Value of one part (pFd.) ? <Enter>

```
 0 ┌─ Termination ─┐          50 Ohms
 1 ├──────── C ────┤          50 pFd. <-, 2 capacitors of 50 pFd will
 2 ├──────── C ────┤          50 pFd. <-'   combine to equal 100 pFd.
 3 └──── Source ───┘          50 Ohms
 4  Fc = 100 MHz.
```

++++++++++ **[MIS3:] Stub**

Stub

If the L-C —> Stub generator has been properly programmed, (using the **Prog stuber** command) the **Stub** command can be used to substitute a transmission line stub for an L, C or L-C notch section. Most of the stub types can also be converted back to their L-C equivalents.

++++++++++ **[MIS1:] Save**

Save design in file.

This command will save the design im memory to disk so that it may be brought back at any time, even days later. The file generated is NOT considered a "temporary" file. The Saved design can be recovered with the **Recall** command.

++++++++++ **[MAIN:] Spread** (also: Right mouse button - Spread)

Value **Spread** on design (flag negative values).

. The network is surveyed for the extreme inductor and capacitor values over the range of branches specified or over the entire network. The range of each and the branches where the extreme values are located is indicated. This function will also sound a warning if any negative values exist in the network. A typical display is shown below:

```
Inductance range = 78.33 to 78.33 nHy. (at branches 1 & 1)
 Capacity range = 1.768 to 30.29 pFd. (at branches 6 & 2)  <-- worst case.
   Value spread = 17.14 : 1
```

In this example, all the inductors are equal throughout the network.

++++++++ **[MIS1:] L-Cd** Inductor distributed capacity

Insert

This will insert an additional capacitor in parallel with an inductor equal to the distributed capacity so that compensation can be done using the optimization feature or the *Compensate* option. The value inserted is initially set to 0.3 pF until you change it. The WAIRL.EXE program included with PCFILT can be used to estimate the distributed capacity of air-wound inductors.

Compensate

Use this on the branch that will be used to compensate for the inserted distributed capacity. Best by far is using a parallel capacity to absorb the Cd. In the case of an inductor alone, it can be adjusted to compensate to a limited degree. This is done by assuming the distributed capacity is a negative inductor with a reactance value equal to that of the distributed capacity at the geometric Fo of the filter. Select the branch numbers of the element to adjust and of the inserted Cd. The geometric center frequency is requested and defaults to the frequency shown just after the source. In some networks, particularly multiplexers, the frequency will not be correct.

The inserted Cd branch my be deleted using the [MIS1:] delete option directly on the branch of the Cd itself. This will NOT delete the entire multiple branch as it would if you specified the first branch number of the group.