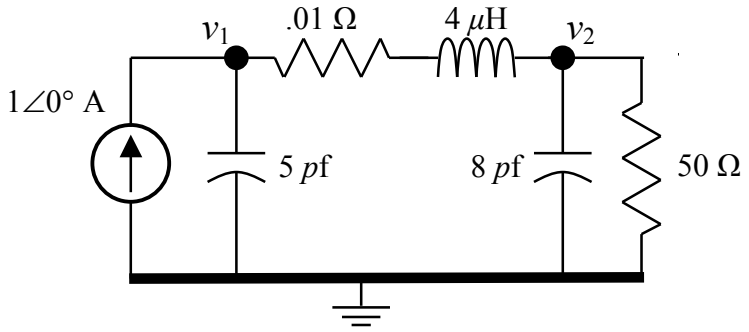
Welcome to AC circuit solver. The executable is AC.exe and AC.txt is the source code.
This program is free. Please use - modify - distribute as you wish.

The procedure to use this program is as follows:

1) Download the files to a directory of your choice.
2) Draw a diagram of the circuit you wish to study.
3) Number the nodes consecutively from 1 to the highest number leaving no gaps. I usually start with the input signal as node 1 and the output as the last node. Ground is node 0.
4) Create a new text file in notepad or another text editor program to enter circuit data.
5) Type in the first line of data defining the output type and frequencies to be modeled.
6) Type in the data for each element. The format is given below in examples.
7) Run the program AC.exe and enter your input file name. The results will appear automatically on the screen in file OP. Close this file when you are finished.

Below is a PI network filter with 4 microhenry inductor that has .01 ohms resistance. The capacitors are 5 picofarads and 8 picofarads. The circuit is driven with a 1 amp current source.



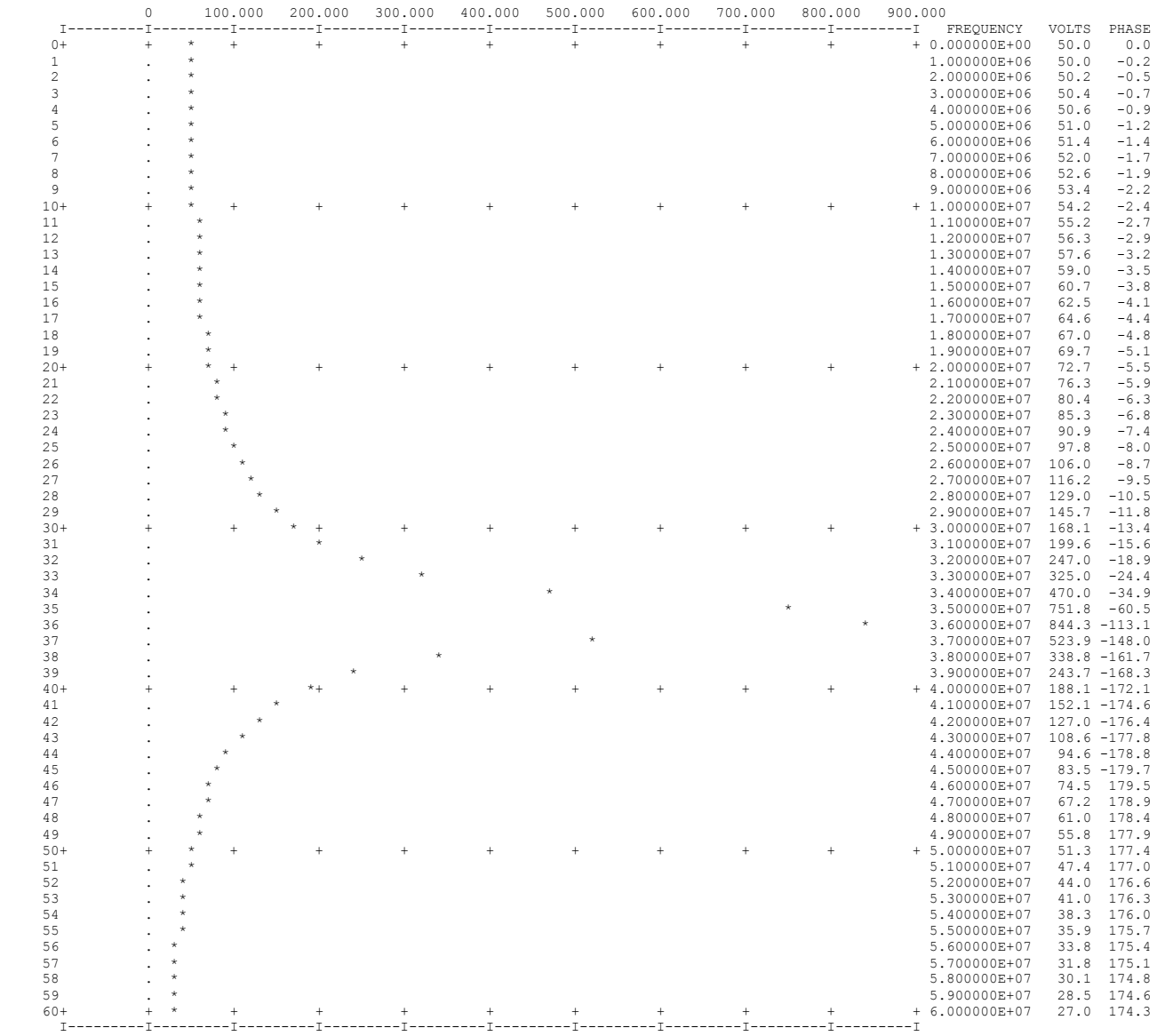
The data below is put in file pi.txt in free field format using spaces or commas between values.

```
* PI network circuit plotted with linear frequency and voltage scales
*
LI 2 60 900. 0E6 60E6
IS 1 0  1.   0.
RL 1 2 .01  4e-6
RC 1 0  0.  5E-12
RC 2 0  0.  8E-12
R  2 0 50.   0.
```

The * are comment lines that can appear anywhere. The * must be in the first column.
LI 2 60 900. 0E6 60E6 is a linear frequency linear voltage plot of node 2 with 60 lines for the graph and maximum scale of 900 volts. The frequency range is 0 to 60 MHz.
IS 1 0 1. 0. is a 1 amp at angle 0° independent current into node 1 from node 0 (gnd).
RL 1 2 .01 4e-6 is a .01 ohm resistance in series with a 4 microhenry inductance.
RC 1 0 0. 5E-12 is a 5 picofarad capacitor with 0 ohms resistance in series with it.
RC 2 0 0. 8E-12 is an 8 picofarad capacitor with 0 ohms resistance in series with it.
R 2 0 50. 0. is a 50 ohm resistor in parallel with the 8 picofarad capacitor.

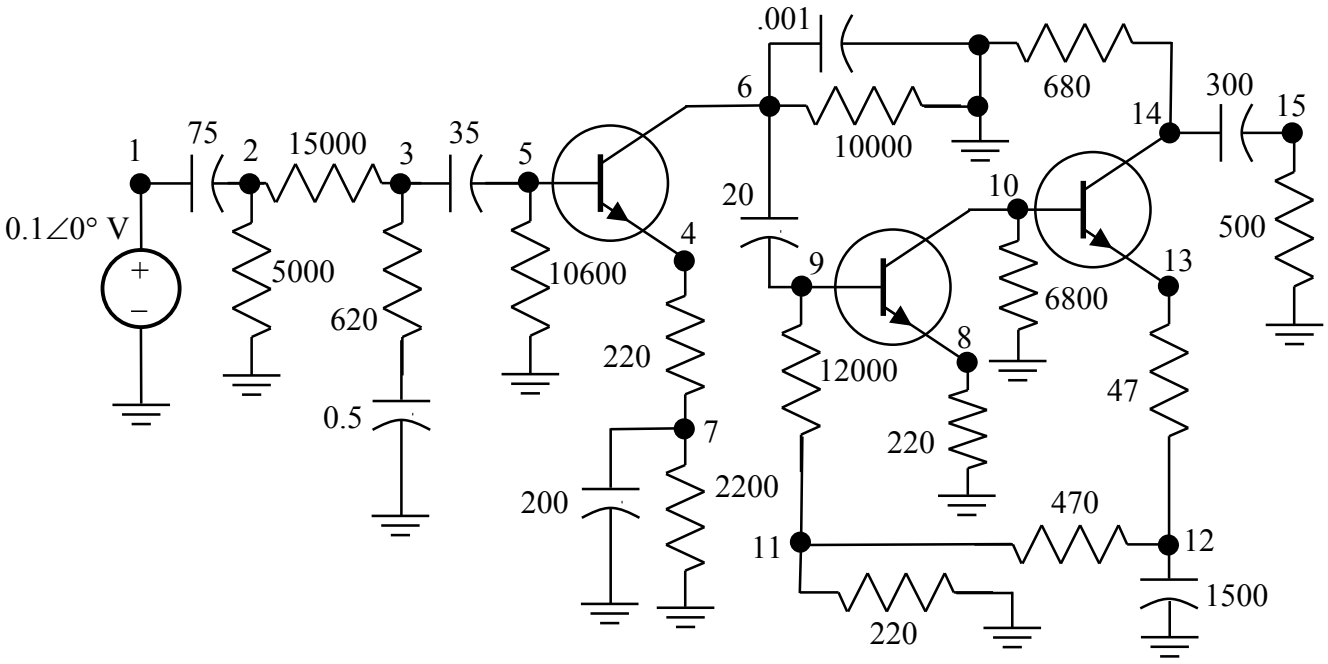
The format of the RLC data is that the node numbers are first and then the resistance always is next and is followed by either the L or C value. Valid descriptors are R, RL, and RC. L and C are not recognized. R is a valid entry and is equivalent to RL with a zero value of inductance. Note that 0 Hz is acceptable if the network is not singular at 0 Hz. This network is not singular at 0 Hz. On the next page is what the output looks like when AC.exe is run and the input file is pi.txt.

```
FILE: pi.txt

* PI network circuit plotted with linear frequency and voltage scales
*
LI 2 60 900. 0E6 60E6  is a linear freq - linear V node 2 60 line graph with max scale = 900 V and freq range from 0 to 60 MHz.
IS 1 0  1.   0.        is a 1 amp at 0 degrees independent current source into node 1 from node 0 (gnd).
RL 1 2 .01  4e-6       is a .01 ohm resistance in series with a 4 microhenry inductance.
RC 1 0  0.  5E-12      is a 5 picofarad capacitor with 0 ohms resistance in series with it.
RC 2 0  0.  8E-12      is an 8 picofarad capacitor with 0 ohms resistance in series with it.
R  2 0 50.   0.        is a 50 ohm resistor in parallel with the 8 picofarad capacitor.
```



FREQUENCY	VOLTS	PHASE
0.000000E+00	50.0	0.0
1.000000E+06	50.0	-0.2
2.000000E+06	50.2	-0.5
3.000000E+06	50.4	-0.7
4.000000E+06	50.6	-0.9
5.000000E+06	51.0	-1.2
6.000000E+06	51.4	-1.4
7.000000E+06	52.0	-1.7
8.000000E+06	52.6	-1.9
9.000000E+06	53.4	-2.2
1.000000E+07	54.2	-2.4
1.100000E+07	55.2	-2.7
1.200000E+07	56.3	-2.9
1.300000E+07	57.6	-3.2
1.400000E+07	59.0	-3.5
1.500000E+07	60.7	-3.8
1.600000E+07	62.5	-4.1
1.700000E+07	64.6	-4.4
1.800000E+07	67.0	-4.8
1.900000E+07	69.7	-5.1
2.000000E+07	72.7	-5.5
2.100000E+07	76.3	-5.9
2.200000E+07	80.4	-6.3
2.300000E+07	85.3	-6.8
2.400000E+07	90.9	-7.4
2.500000E+07	97.8	-8.0
2.600000E+07	106.0	-8.7
2.700000E+07	116.2	-9.5
2.800000E+07	129.0	-10.5
2.900000E+07	145.7	-11.8
3.000000E+07	168.1	-13.4
3.100000E+07	199.6	-15.6
3.200000E+07	247.0	-18.9
3.300000E+07	325.0	-24.4
3.400000E+07	470.0	-34.9
3.500000E+07	751.8	-60.5
3.600000E+07	844.3	-113.1
3.700000E+07	523.9	-148.0
3.800000E+07	338.8	-161.7
3.900000E+07	243.7	-168.3
4.000000E+07	188.1	-172.1
4.100000E+07	152.1	-174.6
4.200000E+07	127.0	-176.4
4.300000E+07	108.6	-177.8
4.400000E+07	94.6	-178.8
4.500000E+07	83.5	-179.7
4.600000E+07	74.5	179.5
4.700000E+07	67.2	178.9
4.800000E+07	61.0	178.4
4.900000E+07	55.8	177.9
5.000000E+07	51.3	177.4
5.100000E+07	47.4	177.0
5.200000E+07	44.0	176.6
5.300000E+07	41.0	176.3
5.400000E+07	38.3	176.0
5.500000E+07	35.9	175.7
5.600000E+07	33.8	175.4
5.700000E+07	31.8	175.1
5.800000E+07	30.1	174.8
5.900000E+07	28.5	174.6
6.000000E+07	27.0	174.3

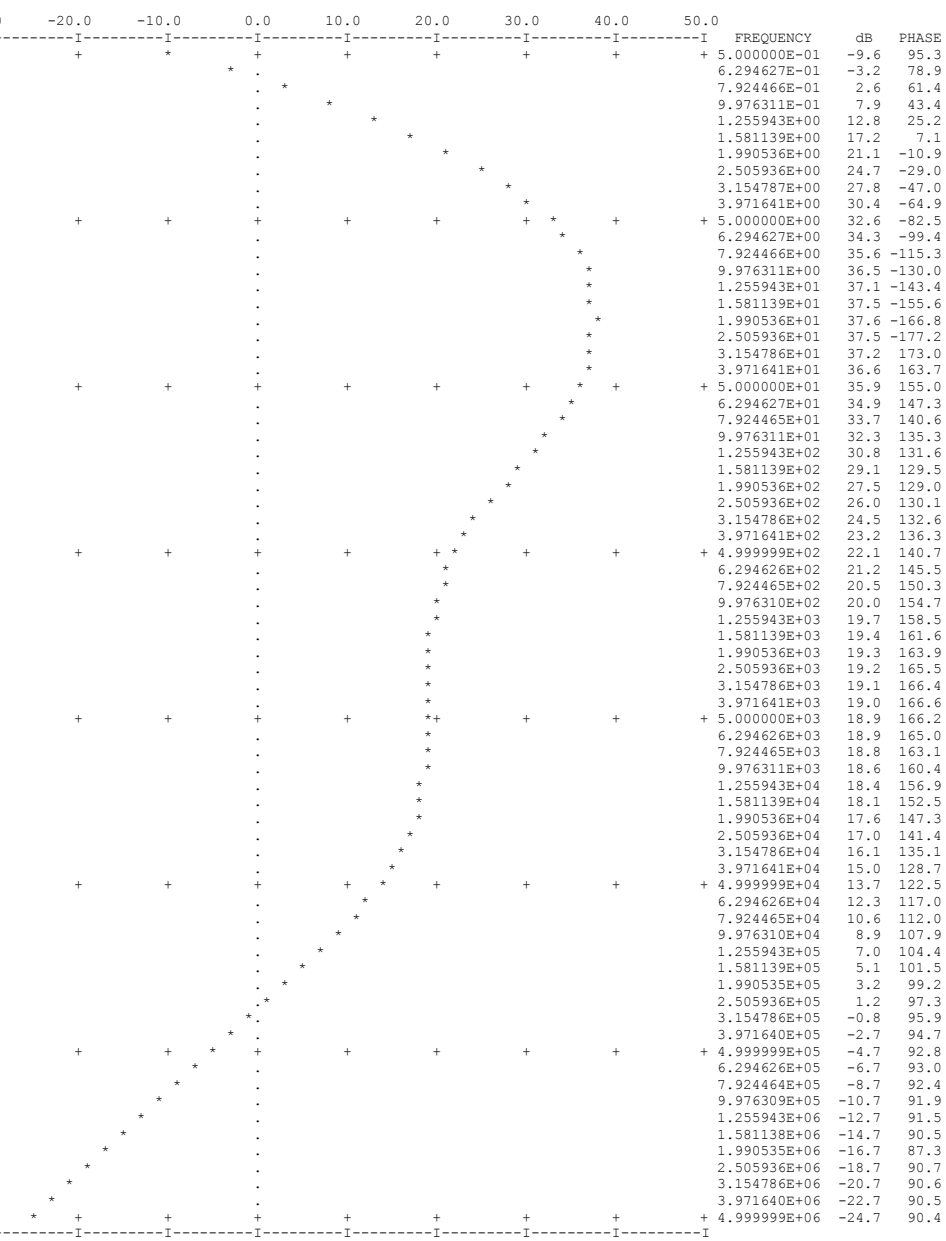
The circuit below is a 3 stage transistor amplifier with a bass frequency boost. All resistors are in ohms and all capacitors in microfarads. The transistors each have current gains of 200.



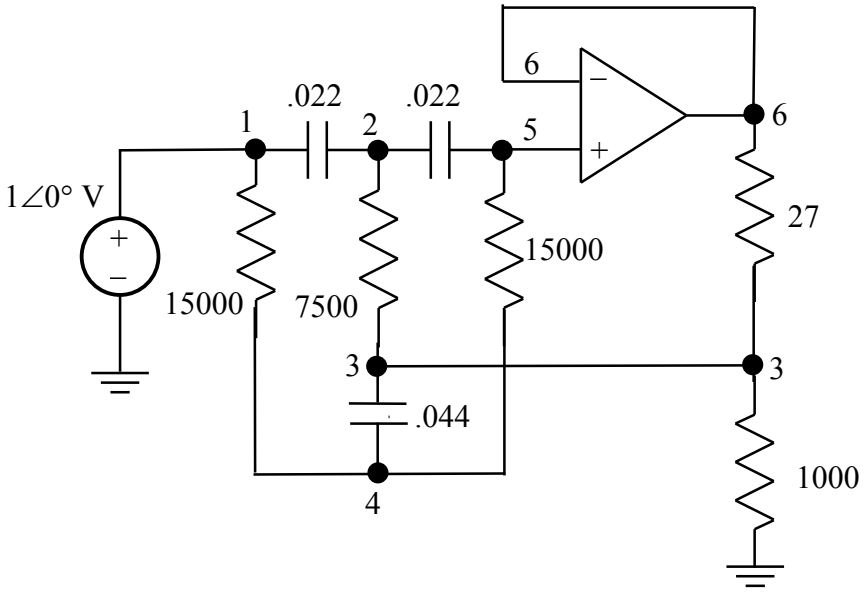

```
* 3 stage transistor amplifier with low frequency boost
*
  BO 15 70   50.0  .5     5000000.   (bode plot of node 15, 70 lines, 50 dB scale, .5 Hz to 5 MHz)
  VS  1  0      0.1          0       (voltage source to node 1, .1 volts at angle 0 degrees)
  RC  1  2        0        75.0E-06
  R   2  3      15000.0      0
  R   2  0      5000.        0
  RC  3  0      620.0       .50E-06
  RC  3  5        0        35.0E-06
  TR  4  5        6        200.     (transistor: emitter, base, collector nodes, hfe=200 current gain)
  R   5  0      10600.       0
  R   4  7      220.0        0
  R   7  0      2200.        0
  RC  7  0        0        200.E-06
  R   6  0      10000.       0
  RC  6  0        0        .001E-06
  RC  6  9        0        20.0E-06
  TR  8  9       10         200.
  R   8  0      220.         0
  R  10  0      6800.        0
  R   9 11      12000.       0
  R  11  0       220.        0
  R  11 12       470.        0
  RC 12  0        0       1500.E-06
  R  12 13       47.         0
  TR 13 10       14         200.
  R  14  0      680.         0
  RC 14 15        0        300.E-06
  R  15  0      500.         0
```

The transistor model assumes one ohm from the base to the emitter. The current through this assumed internal resistance is then amplified as a dependent current source between the collector and emitter. You may add more components around this simple transistor model to construct more elaborate high frequency models and/or to create the correct AC input impedance for your specific problem.

```
FILE: 3trans.txt

* 3 stage transistor amplifier with low frequency boost
*
  BO 15 70  50.0  .5    5000000.  (bode plot of node 15, 70 lines, 50 dB scale, .5 Hz to 5 MHz)
  VS  1  0     0.1        0       (voltage source to node 1, .1 volts at angle 0 degrees)
  RC  1  2       0      75.0E-06  75 uf cap from node 1 to node 2
  R   2  3     15000.0    0       15000 ohm resistor from node 2 to node 3
  R   2  0     5000.      0
  RC  3  0     620.0     .50E-06  series 620 ohm resistor and .5 uf capacitor from node 3 to ground
  RC  3  5       0      35.0E-06
  TR  4  5       6       200.     (transistor: emitter, base, collector nodes, hfe=200 current gain)
  R   5  0     10600.     0
  R   4  7     220.0      0
  R   7  0     2200.      0
  RC  7  0       0      200.E-06
  R   6  0     10000.     0
  RC  6  0       0      .001E-06
  RC  6  9       0      20.0E-06
  TR  8  9      10       200.
  R   8  0     220.       0
  R  10  0     6800.      0
  R   9 11     12000.     0
  R  11  0      220.      0
  R  11 12      470.      0
  RC 12  0       0     1500.E-06
  R  12 13       47.      0
  TR 13 10      14       200.
  R  14  0     680.       0
  RC 14 15       0      300.E-06
  R  15  0     500.       0
```



The circuit below is an operational amplifier configured as a notch filter at ~500 Hz.

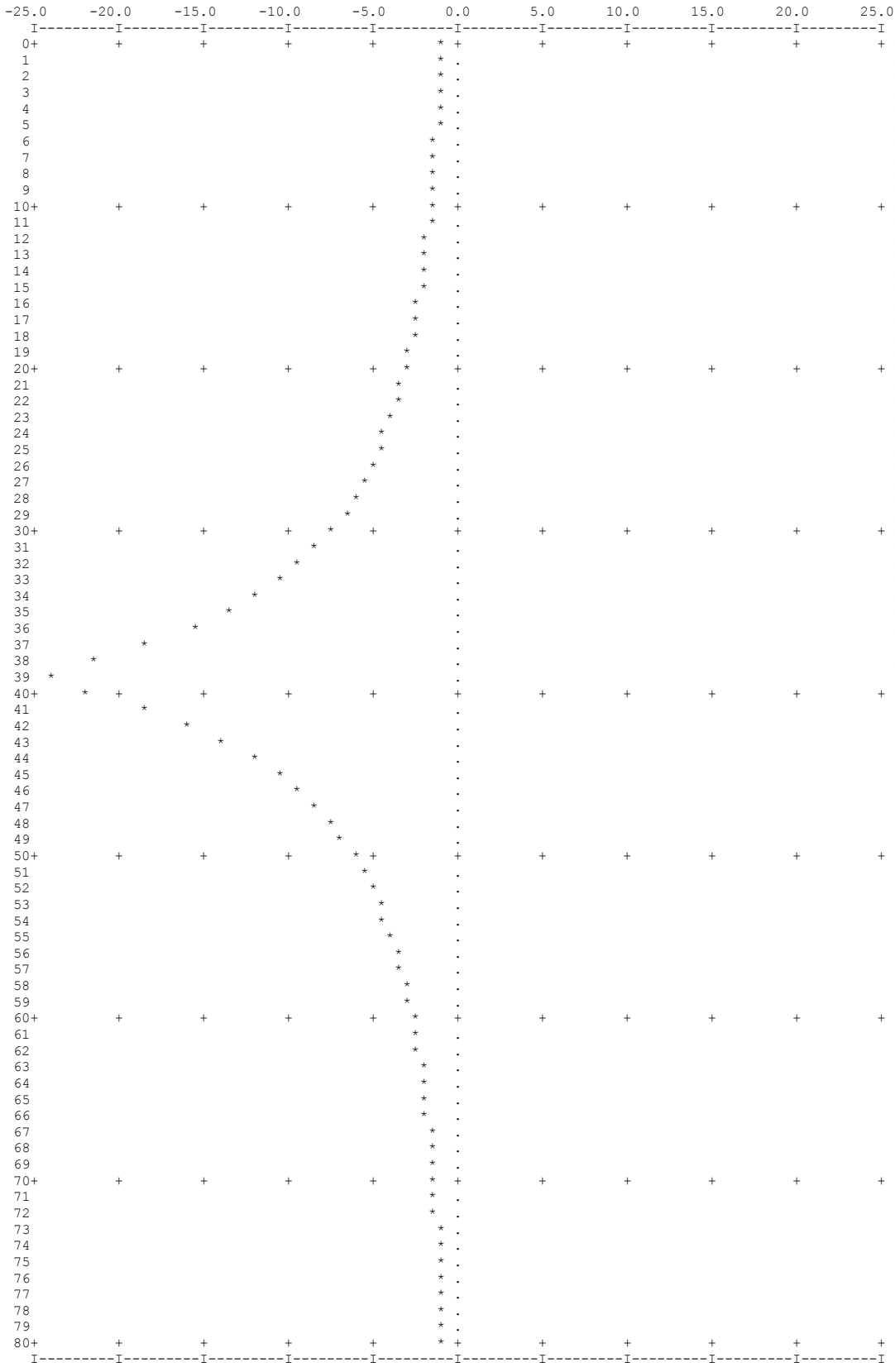



```
* 24 dB notch filter at ~500 Hz
*
  BO   6    80    25     430     540
  VS   1    0       1.         0
  RC   1    2       0       .022E-06
  R    2    3     7500         0
  R    1    4     15000        0
  RC   3    4       0       .044E-06
  RC   2    5       0       .022E-06
  R    4    5     15000        0
  R    3    0      1000        0
  R    3    6      27          0
  OA   5    6       6        100000.
```

The first line of data specifies a bode plot on node 6 with 80 lines of graph and a 25 db scale from a low frequency of 430 Hz to high frequency of 540 Hz. This filter is pretty sharp in its tuning.

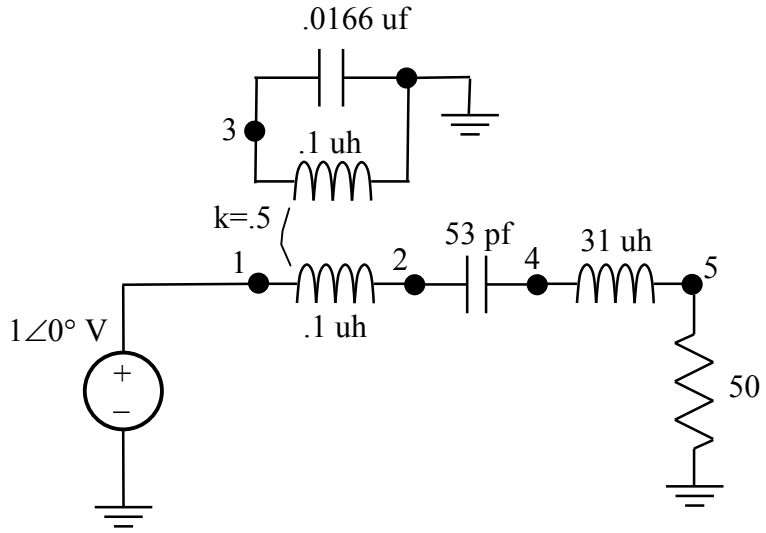
The OA data means operational amplifier. The nodes are + input, - input, output, and the last value of data is the amplifier's open loop gain, which I set to 100000 for this problem.

The output is shown on the next page less the listing of the input data.



FREQUENCY	dB	PHASE
4.300000E+02	-1.0	-24.8
4.312261E+02	-1.0	-25.4
4.324557E+02	-1.1	-26.0
4.336888E+02	-1.1	-26.6
4.349254E+02	-1.2	-27.2
4.361655E+02	-1.2	-27.9
4.374091E+02	-1.3	-28.5
4.386563E+02	-1.4	-29.3
4.399071E+02	-1.4	-30.0
4.411614E+02	-1.5	-30.8
4.424193E+02	-1.6	-31.6
4.436808E+02	-1.7	-32.4
4.449460E+02	-1.8	-33.3
4.462146E+02	-1.9	-34.3
4.474870E+02	-2.1	-35.2
4.487629E+02	-2.2	-36.3
4.500425E+02	-2.4	-37.3
4.513257E+02	-2.5	-38.5
4.526126E+02	-2.7	-39.6
4.539032E+02	-2.9	-40.9
4.551974E+02	-3.1	-42.1
4.564953E+02	-3.4	-43.5
4.577970E+02	-3.6	-44.9
4.591023E+02	-3.9	-46.3
4.604114E+02	-4.3	-47.8
4.617242E+02	-4.7	-49.4
4.630407E+02	-5.1	-51.0
4.643610E+02	-5.6	-52.6
4.656851E+02	-6.1	-54.2
4.670129E+02	-6.7	-55.9
4.683445E+02	-7.5	-57.5
4.696799E+02	-8.3	-59.0
4.710192E+02	-9.3	-60.3
4.723622E+02	-10.4	-61.4
4.737091E+02	-11.8	-61.9
4.750598E+02	-13.5	-61.5
4.764144E+02	-15.6	-59.4
4.777728E+02	-18.3	-53.4
4.791351E+02	-21.6	-38.1
4.805013E+02	-24.1	-3.3
4.818713E+02	-22.1	34.3
4.832453E+02	-18.7	51.9
4.846232E+02	-15.9	58.8
4.860051E+02	-13.8	61.3
4.873908E+02	-12.0	61.9
4.887806E+02	-10.6	61.5
4.901743E+02	-9.4	60.5
4.915719E+02	-8.4	59.2
4.929736E+02	-7.6	57.7
4.943792E+02	-6.8	56.1
4.957889E+02	-6.2	54.5
4.972025E+02	-5.6	52.9
4.986202E+02	-5.2	51.2
5.000420E+02	-4.7	49.6
5.014678E+02	-4.3	48.1
5.028976E+02	-4.0	46.5
5.043316E+02	-3.7	45.1
5.057696E+02	-3.4	43.7
5.072117E+02	-3.2	42.3
5.086580E+02	-2.9	41.0
5.101083E+02	-2.7	39.8
5.115628E+02	-2.5	38.6
5.130215E+02	-2.4	37.5
5.144843E+02	-2.2	36.4
5.159513E+02	-2.1	35.4
5.174224E+02	-2.0	34.4
5.188978E+02	-1.8	33.5
5.203774E+02	-1.7	32.6
5.218611E+02	-1.6	31.7
5.233492E+02	-1.5	30.9
5.248414E+02	-1.5	30.1
5.263380E+02	-1.4	29.4
5.278387E+02	-1.3	28.6
5.293438E+02	-1.2	28.0
5.308531E+02	-1.2	27.3
5.323668E+02	-1.1	26.7
5.338847E+02	-1.1	26.1
5.354070E+02	-1.0	25.5
5.369337E+02	-1.0	24.9
5.384647E+02	-0.9	24.4
5.400000E+02	-0.9	23.9

The circuit below shows how transformer data is set up. A high frequency air wound transformer with a coupling coefficient of only .5 is used. Dual resonances are observed in the output plot.




```
* Resonant transformer with .5 coupling coefficient
*
LO 5 80  1.8    3.5E6     4.5E6
VS 1 0      1.      0
TF 1 2 .1E-6  0
TF 3 0 .1E-6 .5
RC 3 0  0 .0166E-6
RC 2 4  0. 53.E-12
RL 4 5  0. 31.E-6
R  5 0 50.    0.
```

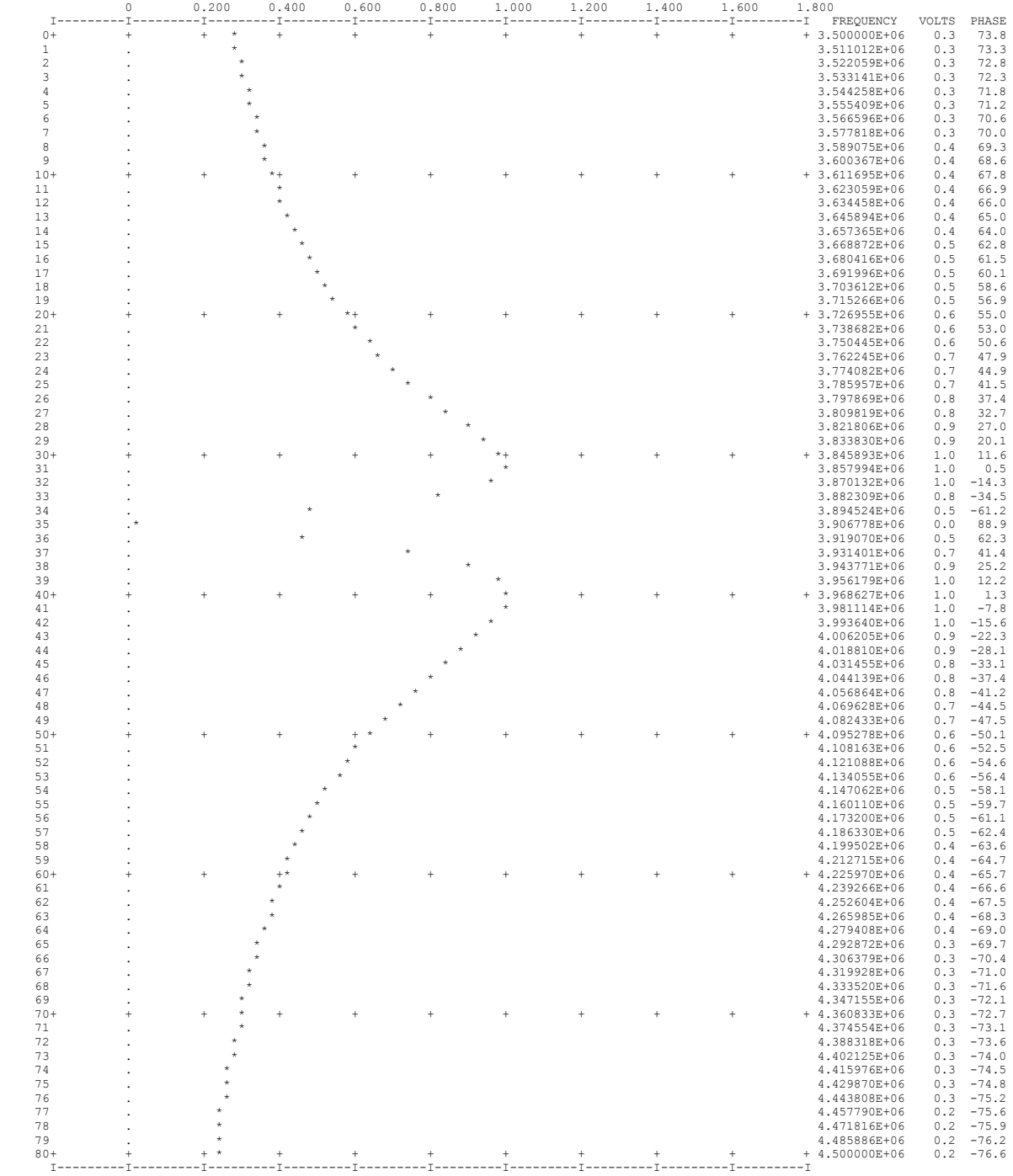
LO specifies a linear plot of voltages versus log frequencies. Node 5 is graphed and the voltage axis maximum is 1.8 volts. The frequencies are varied from 3.5 to 4.5 MHz on a graph of 80 lines.

The two winding transformer requires two lines of data, each starting with the letters TF. The primary winding is on the first transformer from node 1 to node 2 as shown above. The self inductance of this winding is .1 microhenries. The 0 item on the first TF line is not used.

The second TF line specifies the secondary winding from nodes 3 to 0 (ground). The *from* node on each TF line is polarized the same, i.e. the two windings are wound the same direction so that a plus voltage on the *from* node on the first TF record will result in a plus voltage on the second TF *from* node number. The self inductance of the second winding is .1 microhenry as shown above. The last item on the second TF record is the coupling coefficient which is set to .5 in this problem. The program does not allow a larger coupling coefficient than 0.999.

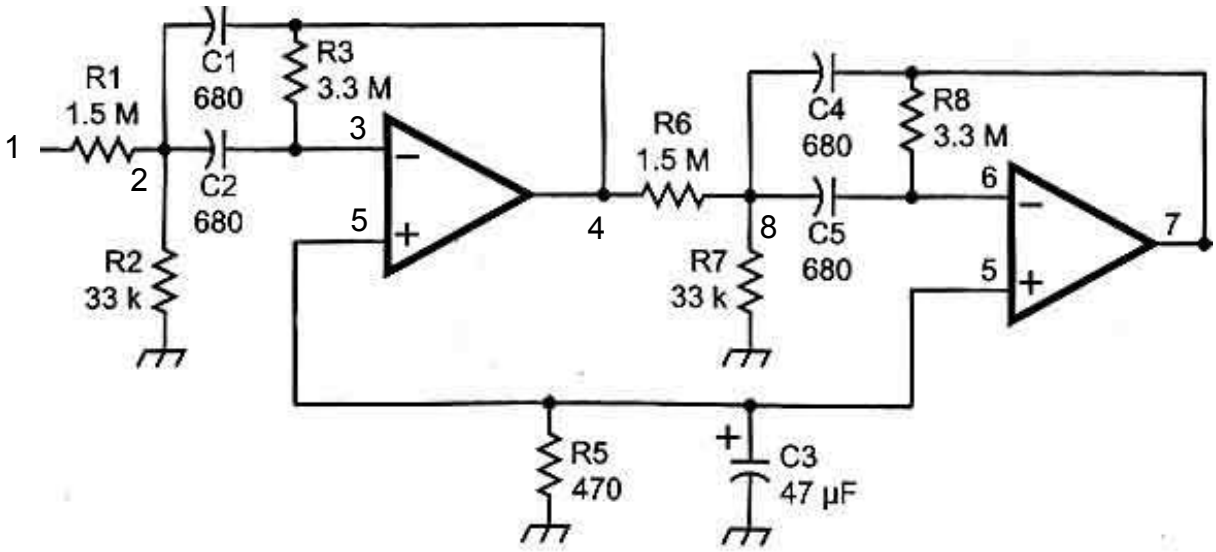
The output report for this circuit is shown on the next page.

```
FILE: xfmr.txt

* Resonant transformer with .5 coupling coefficient
*
LO 5 80  1.8  3.5E6  4.5E6  LO is a log range of freqs and linear graph plot of node 5, 80 lines, 1.8 volts max, from 3.5 to 4.5 MHz
VS 1 0      1.      0       voltage source of 1 volt at angle 0 degrees from ground to node 1
TF 1 2 .1E-6  0             transformer primary winding connected to nodes 1 and 2 with inductance of .1 uH
TF 3 0 .1E-6 .5             transformer secondary winding connected to nodes 3 and ground with inductance of .1 uH and .5 coupling K
RC 3 0   0 .0166E-6         .0166 uf capacitor from node 3 to ground
RC 2 4   0. 53.E-12         53 picofarad capacitor from node 4 to ground
RL 4 5   0. 31.E-6          31 micro Henry  inductor from node 4 to node 5
R  5 0 50.    0.            50 ohm resistor from node 5 to ground
```

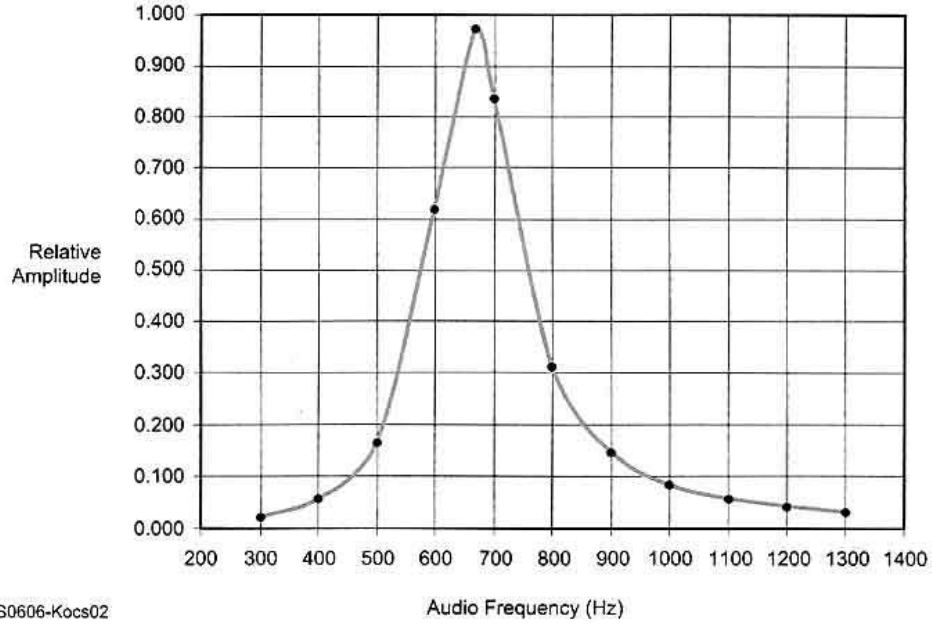


To show what the tabulation output looks like, the PI network problem is rerun below:

```
FILE: pita.txt

* PI network circuit output is tabulation
*
TA 2 6 900. 0E6 60E6   tabular output, 2 is not used, 6 frequency steps, 900 is not used, and frequency
range of 0 MHz to 60 MHz
IS 1 0  1.   0.        is a 1 amp at 0 degrees independent current source into node 1 from node 0 (gnd)
RL 1 2 .01  4e-6       is a .01 ohm resistance in series with a 4 microhenry inductance
RC 1 0  0.  5E-12      is a 5 picofarad capacitor with 0 ohms resistance in series with it
RC 2 0  0.  8E-12      is an 8 picofarad capacitor with 0 ohms resistance in series with it
R  2 0 50.   0.        is a 50 ohm resistor in parallel with the 8 picofarad capacitor
    TABULAR DATA
                                    FREQUENCY=  0.0000000E+00  HERTZ
                                    --------------------------------
      NODE   REL-GAIN-DB   ABS-GAIN-DB   REAL-VOLTAGE      IMAG-VOLTAGE    ABS-VOLTAGE      PHASE
      ----   -----------   -----------   ------------      ------------    -----------      -----
        1     33.982594      0.000000    5.0018391E+01     0.0000000E+00    5.0018391E+01     0.000000
        2     33.980858     -0.001736    5.0008392E+01     0.0000000E+00    5.0008392E+01     0.000000

                                    FREQUENCY=  1.0000000E+07  HERTZ
                                    --------------------------------
      NODE   REL-GAIN-DB   ABS-GAIN-DB   REAL-VOLTAGE      IMAG-VOLTAGE    ABS-VOLTAGE      PHASE
      ----   -----------   -----------   ------------      ------------    -----------      -----
        1     48.840797      0.000000    5.8847038E+01     2.7039005E+02    2.7671964E+02    77.721748
        2     34.686077    -14.154722    5.4189816E+01    -2.2863054E+00    5.4238026E+01    -2.415915

                                    FREQUENCY=  2.0000000E+07  HERTZ
                                    --------------------------------
      NODE   REL-GAIN-DB   ABS-GAIN-DB   REAL-VOLTAGE      IMAG-VOLTAGE    ABS-VOLTAGE      PHASE
      ----   -----------   -----------   ------------      ------------    -----------      -----
        1     57.292606      0.000000    1.0585859E+02     7.2450830E+02    7.3220099E+02    81.687279
        2     37.236092    -20.056515    7.2410995E+01    -6.9654202E+00    7.2745239E+01    -5.494539

                                    FREQUENCY=  3.0000000E+07  HERTZ
                                    --------------------------------
      NODE   REL-GAIN-DB   ABS-GAIN-DB   REAL-VOLTAGE      IMAG-VOLTAGE    ABS-VOLTAGE      PHASE
      ----   -----------   -----------   ------------      ------------    -----------      -----
        1     68.078171      0.000000    5.6508728E+02     2.4707986E+03    2.5345945E+03    77.117653
        2     44.509983    -23.568188    1.6349641E+02    -3.8956451E+01    1.6807344E+02   -13.402026

                                    FREQUENCY=  4.0000000E+07  HERTZ
                                    --------------------------------
      NODE   REL-GAIN-DB   ABS-GAIN-DB   REAL-VOLTAGE      IMAG-VOLTAGE    ABS-VOLTAGE      PHASE
      ----   -----------   -----------   ------------      ------------    -----------      -----
        1     71.565727      0.000000    7.0780121E+02    -3.7201877E+03    3.7869221E+03   -79.227676
        2     45.487934    -26.077791   -1.8633400E+02    -2.5740129E+01    1.8810347E+02  -172.134949

                                    FREQUENCY=  5.0000000E+07  HERTZ
                                    --------------------------------
      NODE   REL-GAIN-DB   ABS-GAIN-DB   REAL-VOLTAGE      IMAG-VOLTAGE    ABS-VOLTAGE      PHASE
      ----   -----------   -----------   ------------      ------------    -----------      -----
        1     62.236832      0.000000    5.2617523E+01    -1.2926533E+03    1.2937238E+03   -87.669060
        2     34.200123    -28.036709   -5.1234997E+01     2.3058090E+00    5.1286858E+01   177.423157

                                    FREQUENCY=  6.0000000E+07  HERTZ
                                    --------------------------------
      NODE   REL-GAIN-DB   ABS-GAIN-DB   REAL-VOLTAGE      IMAG-VOLTAGE    ABS-VOLTAGE      PHASE
      ----   -----------   -----------   ------------      ------------    -----------      -----
        1     58.276707      0.000000    1.4587402E+01    -8.1991071E+02    8.2004047E+02   -88.980728
        2     28.628592    -29.648113   -2.6871052E+01     2.6772292E+00    2.7004091E+01   174.310257
```




```
* Active Audio Filter for CW Reception, QST, June 2006, page 32
*
LI 7 60 1.8 200 1400  plot node 7, 60 lins, 1.8V max scale, 200-1400 Hz
VS 1 0  1.   0.       voltage source on node 1 at 0 degrees (not shown)
R  1 2 1.5e6 0.       R1 is a 1.5 megohm resistor from node 1 to node 2
R  2 0 33000 0.       R2 is a 33 k ohm resistor from node 2 to ground
R  3 4 3.3e6 0.       R3 is a 3.3 megohm resistor from 3 to 4
R  5 0 470.  0.       R5 is a 470 ohm resistor from node 5 to ground
R  4 8 1.5e6 0.       R6 is a 1.5 megohm resistor from node 4 to node 8
R  8 0 33000 0.       R7 is a 33 k ohm resistor from node 8 to ground
R  6 7 3.3e6 0.       R8 is a 3.3 megohm resistor from node 6 to node 7
RC 2 4  0. 680.e-12   C1 is a 680 picofarad capacitor from nodes 2 to 4
RC 2 3  0. 680.e-12   C2 is a 680 picofarad capacitor from nodes 2 to 3
RC 5 0  0. 47.0e-6    C3 is a 47 microfarad cap from node 5 to ground
RC 8 7  0. 680.e-12   C4 is a 680 picofarad capacitor from nodes 8 to 7
RC 8 6  0. 680.e-12   C5 is a 680 picofarad capacitor from nodes 8 to 6
OA 5 3  4  10000.     operational amplifier, + - output nodes, gain=1e4
OA 5 6  7  10000.     operational amplifier, + - output nodes, gain=1e4
```



This is the plot of the output voltage gain of the filter from measured values.

The AC.exe program plot is on the next page.

```
FILE: filter.txt

* Active Audio Filter for CW Reception, QST, June 2006, page 32
*
LI 7 60 1.8 200 1400  plot node 7, 60 lines, 1.8V max scale, 200-1400 Hz
VS 1 0  1.   0.       voltage source on node 1 at 0 degrees (not shown)
R  1 2 1.5e6 0.       R1 is a 1.5 megohm resistor from node 1 to node 2
R  2 0 33000 0.       R2 is a 33 k ohm resistor from node 2 to ground
R  3 4 3.3e6 0.       R3 is a 3.3 megohm resistor from 3 to 4
R  5 0 470.  0.       R5 is a 470 ohm resistor from node 5 to ground
R  4 8 1.5e6 0.       R6 is a 1.5 megohm resistor from node 4 to node 8
R  8 0 33000 0.       R7 is a 33 k ohm resistor from node 8 to ground
R  6 7 3.3e6 0.       R8 is a 3.3 megohm resistor from node 6 to node 7
RC 2 4  0. 680.e-12   C1 is a 680 picofarad capacitor from nodes 2 to 4
RC 2 3  0. 680.e-12   C2 is a 680 picofarad capacitor from nodes 2 to 3
RC 5 0  0. 47.0e-6    C3 is a 47 microfarad cap from node 5 to ground
RC 8 7  0. 680.e-12   C4 is a 680 picofarad capacitor from nodes 8 to 7
RC 8 6  0. 680.e-12   C5 is a 680 picofarad capacitor from nodes 8 to 6
OA 5 3  4  10000.     operational amplifier, + - output nodes, gain=1e4
OA 5 6  7  10000.     operational amplifier, + - output nodes, gain=1e4

             0        0.200     0.400     0.600     0.800     1.000     1.200     1.400     1.600     1.800
    I---------I---------I---------I---------I---------I---------I---------I---------I---------I---------I   FREQUENCY   VOLTS  PHASE
   0+         *         +         +         +         +         +         +         +         +         + 2.000000E+02    0.0  173.1
    1         *                                                                                          2.200000E+02    0.0  172.3
    2         *                                                                                          2.400000E+02    0.0  171.4
    3         *                                                                                          2.600000E+02    0.0  170.5
    4         *                                                                                          2.800000E+02    0.0  169.5
    5         .*                                                                                         3.000000E+02    0.0  168.5
    6         .*                                                                                         3.200000E+02    0.0  167.4
    7         .*                                                                                         3.400000E+02    0.0  166.1
    8         .*                                                                                         3.600000E+02    0.0  164.8
    9         .*                                                                                         3.800000E+02    0.0  163.3
   10+        + *       +         +         +         +         +         +         +         +         + 4.000000E+02    0.0  161.7
   11         . *                                                                                        4.200000E+02    0.0  159.9
   12         . *                                                                                        4.400000E+02    0.0  157.9
   13         .  *                                                                                       4.600000E+02    0.1  155.5
   14         .  *                                                                                       4.800000E+02    0.1  152.9
   15         .   *                                                                                      5.000000E+02    0.1  149.8
   16         .    *                                                                                     5.200000E+02    0.1  146.2
   17         .     *                                                                                    5.400000E+02    0.1  141.8
   18         .      *                                                                                   5.600000E+02    0.2  136.6
   19         .          *                                                                               5.800000E+02    0.2  130.1
   20+        +         +   *     +         +         +         +         +         +         +         + 6.000000E+02    0.3  121.9
   21         .                    *                                                                     6.200000E+02    0.4  111.4
   22         .                          *                                                               6.400000E+02    0.5   97.7
   23         .                                *                                                         6.600000E+02    0.7   79.7
   24         .                                      *                                                   6.800000E+02    0.9   56.1
   25         .                                            *                                             7.000000E+02    1.1   27.1
   26         .                                                  *                                       7.200000E+02    1.2   -4.8
   27         .                                                        *                                 7.400000E+02    1.1  -35.2
   28         .                                                              *                           7.600000E+02    0.9  -60.7
   29         .                                          *                                               7.800000E+02    0.7  -80.6
   30+        +         +         +      *  +         +         +         +         +         +         + 8.000000E+02    0.5  -95.7
   31         .                     *                                                                    8.200000E+02    0.4 -107.1
   32         .                  *                                                                       8.400000E+02    0.3 -116.0
   33         .              *                                                                           8.600000E+02    0.3 -122.9
   34         .           *                                                                              8.800000E+02    0.2 -128.5
   35         .         *                                                                                9.000000E+02    0.2 -133.1
   36         .       *                                                                                  9.200000E+02    0.2 -136.9
   37         .      *                                                                                   9.400000E+02    0.1 -140.1
   38         .     *                                                                                    9.600000E+02    0.1 -142.9
   39         .    *                                                                                     9.800000E+02    0.1 -145.2
   40+        +    *    +         +         +         +         +         +         +         +         + 1.000000E+03    0.1 -147.3
   41         .   *                                                                                      1.020000E+03    0.1 -149.1
   42         .   *                                                                                      1.040000E+03    0.1 -150.7
   43         .  *                                                                                       1.060000E+03    0.1 -152.1
   44         .  *                                                                                       1.080000E+03    0.1 -153.4
   45         .  *                                                                                       1.100000E+03    0.1 -154.6
   46         .  *                                                                                       1.120000E+03    0.1 -155.7
   47         . *                                                                                        1.140000E+03    0.0 -156.6
   48         . *                                                                                        1.160000E+03    0.0 -157.5
   49         . *                                                                                        1.180000E+03    0.0 -158.3
   50+        + *       +         +         +         +         +         +         +         +         + 1.200000E+03    0.0 -159.1
   51         . *                                                                                        1.220000E+03    0.0 -159.8
   52         . *                                                                                        1.240000E+03    0.0 -160.4
   53         . *                                                                                        1.260000E+03    0.0 -161.0
   54         . *                                                                                        1.280000E+03    0.0 -161.6
   55         .*                                                                                         1.300000E+03    0.0 -162.1
   56         .*                                                                                         1.320000E+03    0.0 -162.6
   57         .*                                                                                         1.340000E+03    0.0 -163.0
   58         .*                                                                                         1.360000E+03    0.0 -163.5
   59         .*                                                                                         1.380000E+03    0.0 -163.9
   60+        +*        +         +         +         +         +         +         +         +         + 1.400000E+03    0.0 -164.3
     I---------I---------I---------I---------I---------I---------I---------I---------I---------I---------I
```