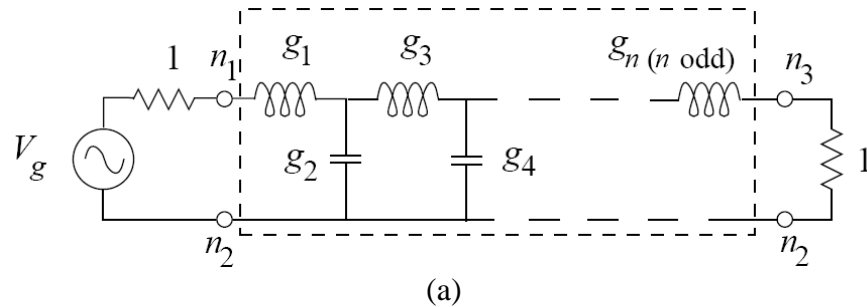# Chebyshev Lumped Lowpass Filter   chebyshevLPF

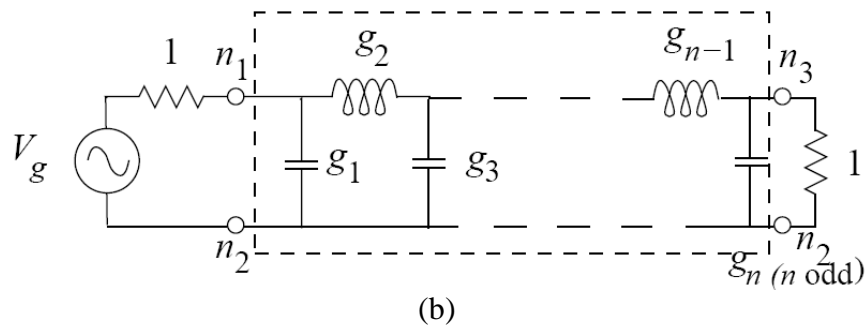TYPE I: (not implemented)

(a)

TYPE II:

(b)

Figure 1: Lowpass filter prototype. The 1 Ohm source and load impedances are scaled by Z_0. The circuit implemented is inside the dashed box.

Form: cheyshevLPF:*(i*nstance name) *n*1 *n*2 *n*3 *(*parameter list)

     *n*1, *n*2 and *n*3 are the element terminals. Terminal *n*2 is the element reference terminal, n1 is the input terminal and n3 is the output terminal.

Parameters:

Parameter	Type	Default Value	Required?
n: Filter Order (must be odd, no limit)	Integer	3	No
f0: Corner Frequency	Double	None	Yes
z0: Characteristic Impedance	Double	None	Yes
ripple: Filter ripple (in dB)	Double	1	No
Ql: inductor Q	Double	10000	No
Qc: capacitor Q	Double	10000	No
Type: Filter Type, Type 1 or Type 2 (only type II)	Integer	2	No

Details:
This is a linear element, comprised of ideal inductors and capacitors. Chebyshev filters of odd order are usually used. If an even order is specified, the element includes a resistor in parallel with the output to control the ripple.

chebyshevLPF:f1 2 0 3 n=21 f0=300e6 z0=50 ftype=1 ripple=1 ql=1000 qc=1000
Here, node 2 is the input, node 0 is the local reference, and node 3 is the output. This is a 21st-order highpass filter with 1 dB of ripple, 50 ohm impedance, and a 300 MHz corner frequency.

Example of Transient Analysis (.TRAN2) Fixed times steps, time-stepping nonlinear analysis.
netlist: chebyshevLPF.net:

```
* Transient chebyshevLPF test
.options verbose

.tran2 tstop=80ns tstep=0.1ns out_steps=1

vsource:1 1 0 vac=1 f=300e6 phase=90
R:Rin 1 2 r=10
chebyshevLPF:f1 2 0 3 n=11 f0=300e6 z0=10 ftype=0 ripple=0.1
R:Ro 3 0 r=10
.options gnuplot
.options plotVT1Preamble="set xlabel 'Time (s)'; set ylabel 'Magnitude (V)"
.out plot term 3 vt plotVT1Preamble in "out.tran.value"

.end
```

The output log file is:
********** fREEDA 1.3 running on Sun Apr 20 14:07:01 2008 **********

```
* Transient chebyshevLPF test
.options verbose

.tran2 tstop=80ns tstep=0.1ns out_steps=1

vsource:1 1 0 vac=1 f=300e6 phase=90
r:rin 1 2 r=10
chebyshevLPF:f1 2 0 3 n=11 f0=300e6 z0=10 ftype=0 ripple=0.1
r:ro 3 0 r=10
.options gnuplot
.options plotvt1preamble="set xlabel 'time (s)'; set ylabel 'magnitude (v)"
.out plot term 3 vt plotvt1preamble in "out.vsource.value"
```

****

 *** Network Dump:

 *** Title:

* Transient chebyshevLPF test

'OPTIONS' table, 22 entries
1:    'itl1'   = 40   (int)
2:    'itl2'   = 20   (int)
3:    'chgtol'   = 1e-14   (double)
4:    'plotvt1preamble'   = 'set xlabel 'time (s)'; set ylabel 'magnitude (v)'   (string)
4:    'verbose'   = 1   (int)
4:    'itl4'   = 10   (int)
4:    'cptime'   = 1e+06   (double)
5:    'itl5'   = 5000 (int)
5:    'defl'   = 0.0001   (double)
7:    'abstol'   = 1e-12   (double)
7:    'defad'   = 0   (double)
11:   'tnom'   = 27   (double)
12:   'vntol'   = 1e-06   (double)
14:   'trtol'   = 7   (double)
16:   'defw'   = 0.0001   (double)
17:   'numdgt'   = 4   (int)
20:   'pivrel'   = 1e-13   (double)
20:   'reltol'   = 0.001   (double)
21:   'gmin'   = 1e-12   (double)
22:   'defas'   = 0   (double)
23:   'gnuplot'   = 1   (int)
27:   'limpts'   = 201   (double)

'OUTPUT' table, 1 entries
16:   'out1'   (output request) =
      type = 0   termination
      type = 1   terminal id(val,type) = (6,1)
      type = 101   operator
      type = 206   string = set xlabel 'time (s)'; set ylabel 'magnitude (v)
      type = 12   filename = out.vsource.value
No expressions
***
No sweeps

 *** Circuit "Main" listing:
vsource:1 - General DC and sinusoidal voltage source
         1
         0

r:rin - Resistor
         1
         2

chebyshevLPF:f1 - 3 terminal Chebyshev Filter
         2
         0
         3

r:ro - Resistor
         3
         0

```
************************************************************************

   *** Starting analysis ...

--------------------------------------------------------------------------
  Matrix size = 13
  Matrix nnz = 36
  equed = 7.66328e-305
  recip_pivot_growth = 0.994658
  1 / Condition number = 0.207838
  info = 0
  ferr = 5.36751e-307
  berr = 1
  No of nonzeros in factor L = 52
  No of nonzeros in factor U = 53
  No of nonzeros in L+U = 92
  L\U MB 0.001 total MB needed 0.004   expansions 0
  Using line search method.
  Nonlinear analysis tolerance (ftol) = 6.12865e-06
  Maximum number of nonlinear iterations per time-point (maxit) = 250
  Using Lee and Lee's quasi-Newton updates.
  --- Starting transient simulation ...

  Number of nonlinear state variables: 0
--------------------------------------------------------------------------
 | Step |  Time (s) |  Residual  |  Recent Max  |    Max     |
--------------------------------------------------------------------------
 |     0 | 0.000000e+00 | 0.000000e+00 | 0.000000e+00  | 0.000000e+00 |
 |     1 | 1.000000e-10 | 0.000000e+00 | 0.000000e+00  | 0.000000e+00 |
 |     2 | 2.000000e-10 | 0.000000e+00 | 0.000000e+00  | 0.000000e+00 |
 |     3 | 3.000000e-10 | 0.000000e+00 | 0.000000e+00  | 0.000000e+00 |
 |     4 | 4.000000e-10 | 0.000000e+00 | 0.000000e+00  | 0.000000e+00 |
 |     5 | 5.000000e-10 | 0.000000e+00 | 0.000000e+00  | 0.000000e+00 |
.
.
.
 |   800 | 8.000000e-08 | 0.000000e+00 | 0.000000e+00  | 0.000000e+00 |
   --- Maximum Residual: 0

--------------------------------------------------------------------------

 Plotting output file: out.vsource.value.


************** fREEDA 1.3 stopping on Sun Apr 20 14:07:03 2008  ***********
```
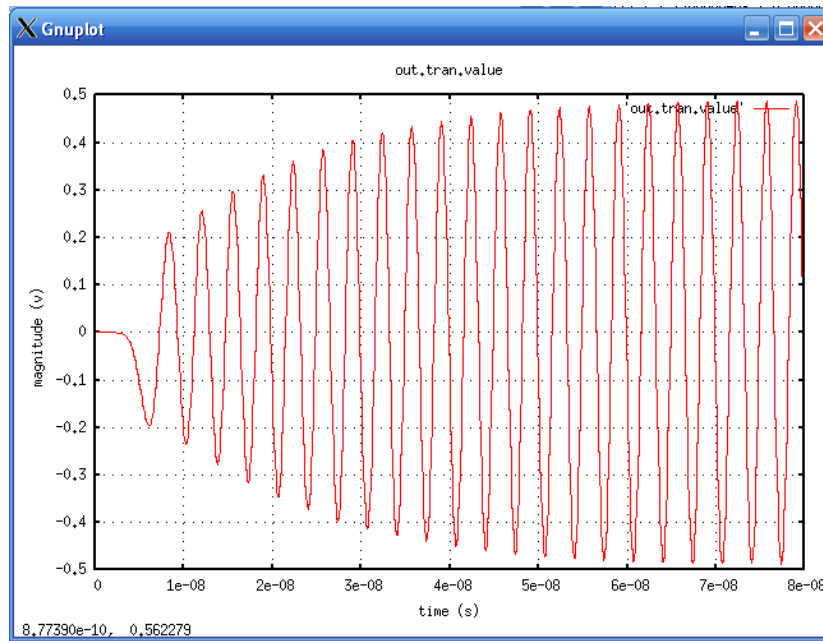
out.tran.value

8.77390e-10, 0.562279

Example of AC analysis
Netlist file: chebyshevLPFAC.net:

* AC Analysis
.ac start = 1e6 stop = 1GHz n_freqs=100
vsource:v1 1 0 vac= 5
resistor:rs1 1 2 r=50
chebyshevLPF:f1 2 0 3 n=21 f0=300e6 z0=50 ripple=1
resistor:rl1 3 0 r=50

vsource:v2 4 0 vac= 5
resistor:rs2 4 5 r=50
chebyshevLPF:f2 5 0 6 n=21 f0=300e6 z0=50 ftype=1 ripple=1
resistor:rl2 6 0 r=50

.options gnuplot
.options plotVF1Preamble="set logscale x; set xlabel 'FREQUENCY (Hz)'; set ylabel 'Magnitude (dB)"
.out plot term 3 vf term 2 vf div mag db plotVF1Preamble in "out.ac1.value"
.out plot term 6 vf term 5 vf div mag db plotVF1Preamble in "out.ac2.value"

.end

Output log file:
********** fREEDA 1.3 running on Sun Apr 20 14:36:04 2008 **********

* AC Analysis
.ac start = 1e6 stop = 1GHz n_freqs=100
* AC Analysis
.ac start = 1e6 stop = 1ghz n_freqs=100
vsource:v1 1 0 vac= 5
resistor:rs1 1 2 r=50
chebyshevLPF:f1 2 0 3 n=21 f0=300e6 z0=50 ripple=1
resistor:rl1 3 0 r=50

.options gnuplot
.options plotvf1preamble="set logscale x; set xlabel 'frequency (hz)'; set ylabel
'magnitude (db)"
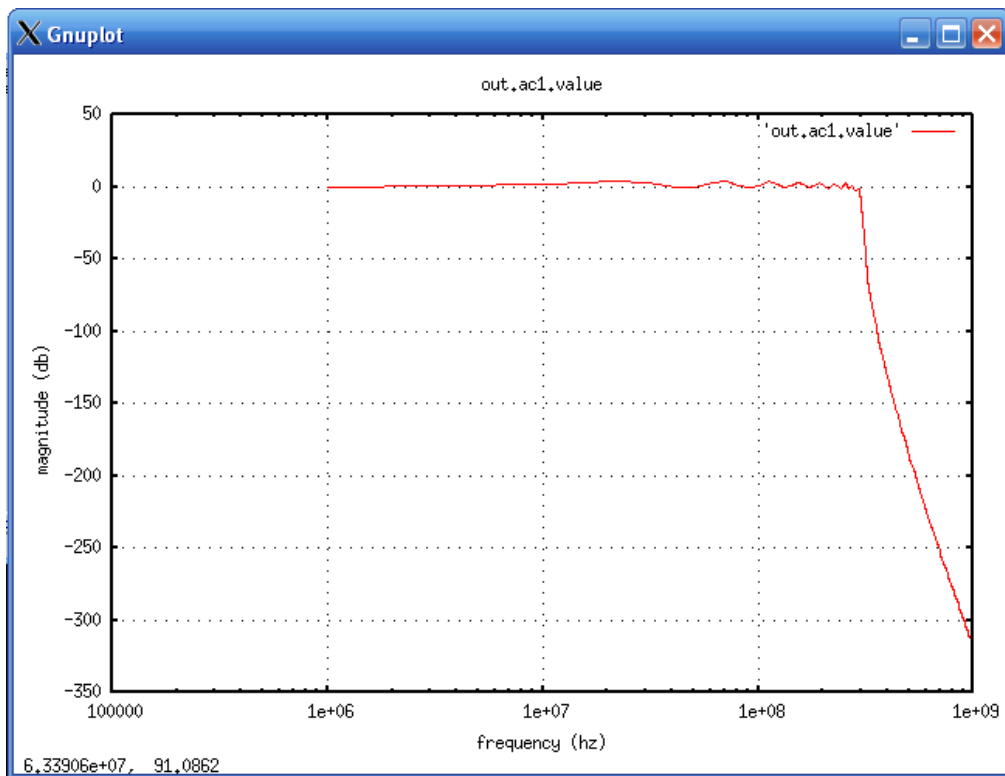.out plot term 3 vf term 2 vf div mag db plotvf1preamble in "out.ac1.value"

.end

   *** Starting analysis ...

   *** AC Analysis ***

   Frequency step = 1.00909e+07 Hz
    --- Writing output vectors ...
 Plotting output file: out.ac1.value.
 Plotting output file: out.ac2.value.

*************** fREEDA 1.3 stopping on Sun Apr 20 14:36:06 2008 ***********

Results are:

Version:
2008.04.21 (2008 April 21)

Credits:

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