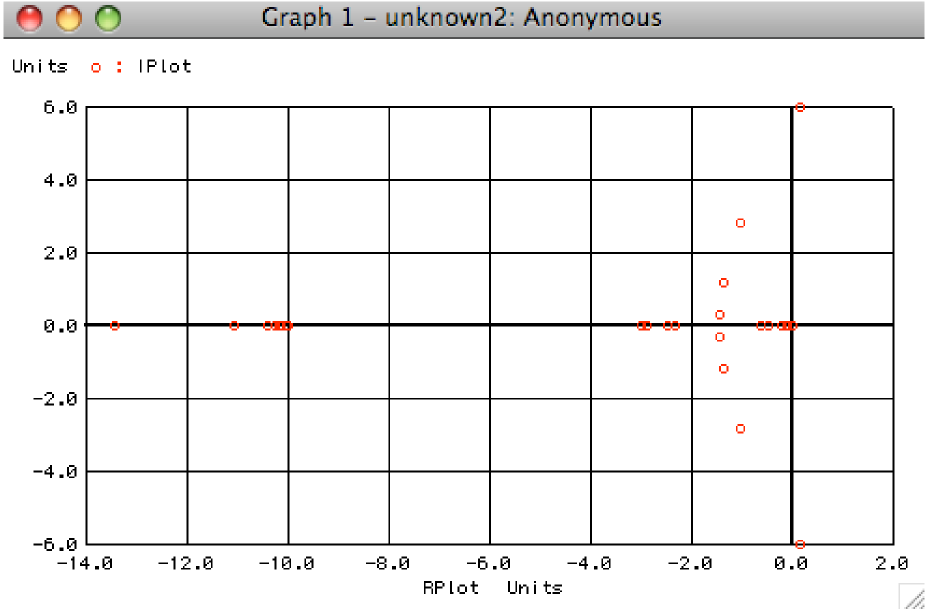
====================RootLocus========================

SPICE PROVIDES A POLE/ZERO EXTRACTION FEATURE. THIS FEATURE CAN BE CROSS CHECKED TO A ROOT LOCUS PLOT OF AN ANALOG SYSTEM IN NEGATIVE FEEDBACK.



```
RootLocus
*
*  VIN      V00      R0     V0      R1      V1        R2     V2
*    _____     __/\  /\  /\_    __/\  /\  /\_    __/\  /\  /\___
*   _|_   |   _|_  \/  \/  |   _|_  \/  \/  |   _|_  \/  \/  |  |
*  /   \  |_ /   \     ____|_ /   \     ____|_ /   \     ____|  |
* |EGN0 |   |EGain|  _|_     |EGN0 |  _|_     |EGN1 |  _|_      |
* |     |  _|     |  ___ C0 _|     |  ___C1  _|     |  ___      |
*  \___/  |  \___/   _|_      \___/   _|_   |  \___/   _|_      |
*   _|_   |   _|_    ///       _|_    ///  _|_  _|_    ///      |
*   ///   |   ///              ///         ///  ///             |
*         |_____________________________________________________|
*
*  P1 = .1/(s+.1)  s is in jw (2PI*F) format
*  P2 =  3/(s+3)
*  P3 =  10/(s+10)
*
*  Transfer_V00->V2 = 3/((s+.1)*(s+.3)*(s+10)
*  Root Locus needs this format   K*(s+z0)(s+z1)../(s+p0)(s+p1)
*  K_4_rootlocus  =  3*Egain

VIN       VIN    0      1.00    AC     1
EGain     V00    0      VIN     V2     1

R0        V00    V0     1.0
C0        V0     0      10.0
EGN0      VEG0   0      V0     0      1
R1        VEG0   V1     1.0
C1        V1     0      .33
EGN1      VEG1   0      V1     0      1
R2        VEG1   V2     1.0
C2        V2     0      0.1


.control
pz                  vin    0      v2     0       vol     pol
setplot             new
set NameList =     ( RPlot IPlot   )
```

```
compose             GVals values   (-1)  0 .5 .6 .8 1 1.5 2.2
settype current     GVals
let NoOfG =         length(GVals)
begin
unset               interrupt

* ===========Loop_K_Gain============
set thisName =    $NameList[1]
let RPlot =       0*vector(40)
set thisName =    $NameList[2]
let IPlot =       0*vector(40)

let k =           1
while             ( k <= NoOfG )
let gainn =       10^GVals[k-1]
alter             egain      gain  = $&gainn
let K_4RL =       3*gainn
print             K_4RL
pz                vin    0     v2     0      vol     pol
print             pz.pole(1)
let pr =          real(pz.pole(1))
let pi =          imag(pz.pole(1))
let               unknown.RPlot[unknown.k-1] = pr
let               unknown.IPlot[unknown.k-1] = pi
echo             "Preal =  $&pr Pimag =  $&pi   "


let  offset =     10
print             pz.pole(2)
let pr =          real(pz.pole(2))
let pi =          imag(pz.pole(2))
let               unknown.RPlot[offset + unknown.k-1] = pr
let               unknown.IPlot[offset + unknown.k-1] = pi
echo             "Preal =  $&pr Pimag =  $&pi   "


let               offset = 20
print             pz.pole(3)
let pr =          real(pz.pole(3))
let pi =          imag(pz.pole(3))
let               unknown.RPlot[offset + unknown.k-1] = pr
let               unknown.IPlot[offset + unknown.k-1] = pi
echo             "Preal =  $&pr Pimag =  $&pi   "

destroy
let k =           k + 1

if                ($?interrupt)
goto              bail
endif
endwhile

settype           notype IPlot
settype           notype RPlot
setscale          GVals
set               pensize = 1
plot              IPlot vs RPlot pointplot

label             bail
echo             "Done."
end
.endc

.end
```

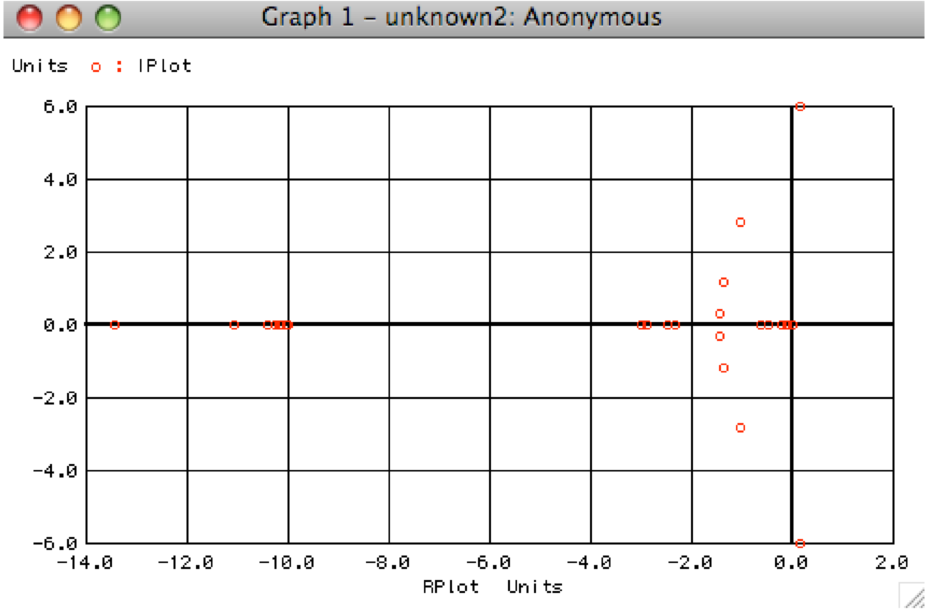
==============End==================

```
Circuit: RootLocus*

k_4rl = 3.000000e-01
```

```
pz.pole(1) = -1.00044e+01,0.000000e+00
pz.pole(2) = -3.01542e+00,0.000000e+00
pz.pole(3) = -1.10494e-01,0.000000e+00
k_4rl = 3.000000e+00
pz.pole(1) = -1.00435e+01,0.000000e+00
pz.pole(2) = -2.87711e+00,0.000000e+00
pz.pole(3) = -2.09738e-01,0.000000e+00
k_4rl = 9.486833e+00
pz.pole(1) = -1.01344e+01,0.000000e+00
pz.pole(2) = -2.49756e+00,0.000000e+00
pz.pole(3) = -4.98312e-01,0.000000e+00
k_4rl = 1.194322e+01
pz.pole(1) = -1.01679e+01,0.000000e+00
pz.pole(2) = -2.32353e+00,0.000000e+00
pz.pole(3) = -6.38897e-01,0.000000e+00
k_4rl = 1.892872e+01
pz.pole(1) = -1.02603e+01,0.000000e+00
pz.pole(2) = -1.43501e+00,3.155547e-01
pz.pole(3) = -1.43501e+00,-3.15555e-01
k_4rl = 3.000000e+01
pz.pole(1) = -1.03993e+01,0.000000e+00
pz.pole(2) = -1.36551e+00,1.157896e+00
pz.pole(3) = -1.36551e+00,-1.15790e+00
k_4rl = 9.486833e+01
pz.pole(1) = -1.10834e+01,0.000000e+00
pz.pole(2) = -1.02345e+00,2.805694e+00
pz.pole(3) = -1.02345e+00,-2.80569e+00
k_4rl = 4.754680e+02
pz.pole(1) = -1.34516e+01,0.000000e+00
pz.pole(2) = 1.606726e-01,5.991900e+00
pz.pole(3) = 1.606726e-01,-5.99190e+00
Done.
```

It is nice to see that the pole zero feature of spice can be sanity checked against a typical root locus plot for an Op Amp. The plot below is done in a point plot format which make it easier to pole value to a K value.



Two details need to be watched out for. First the poles do not come out in frequency format. Second, the transfer function of the H(s) needs

to be in this format..

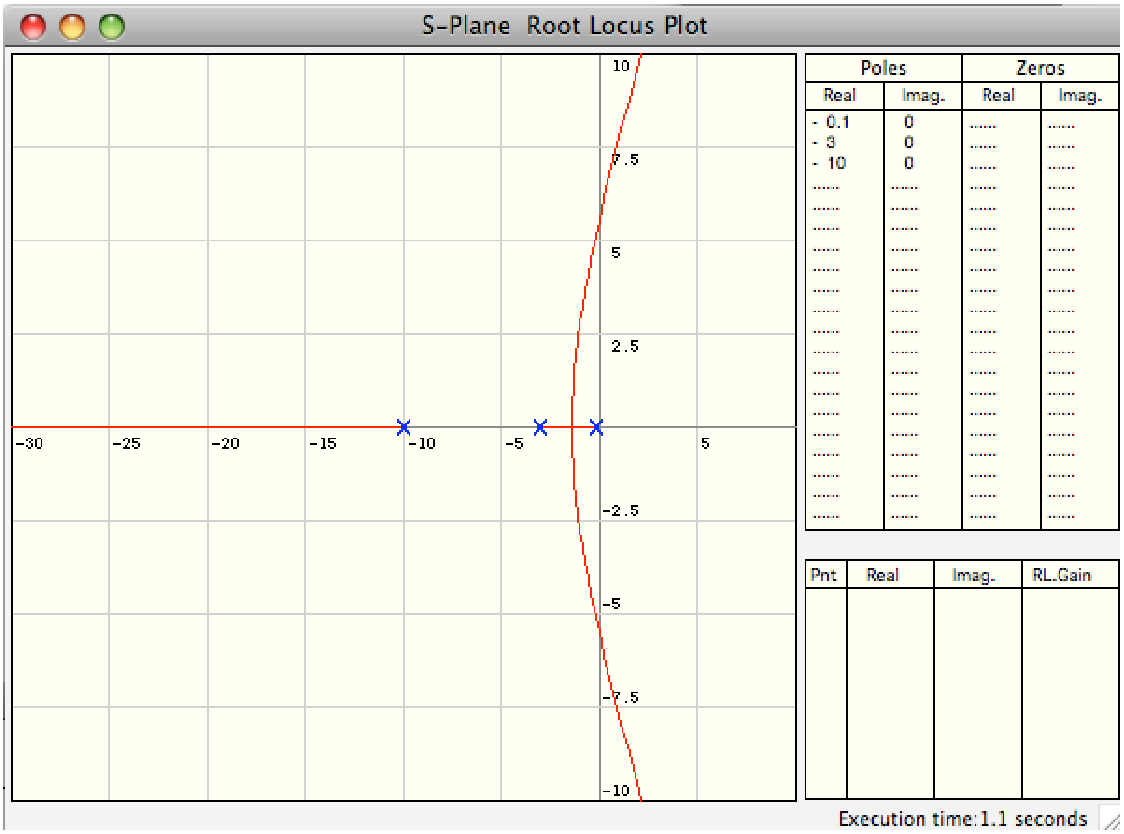
K_4_rootlocus*(s+z0)(s+z1)../(s+p0)(s+p1)

In the circuit below the low pass filters have constant terms that need to be taken account of.

```
*
*  VIN      V00      R0     V0      R1      V1        R2     V2
*    _____     __/\  /\  /\_    __/\  /\  /\_    __/\  /\  /\___
*   _|_   |   _|_  \/  \/  |   _|_  \/  \/  |   _|_  \/  \/  |  |
*  /   \  |_ /   \     ____|_ /   \     ____|_ /   \     ____|  |
* |EGN0 |   |EGain|  _|_     |EGN0 |  _|_     |EGN1 |  _|_      |
* |     |  _|     |  ___ C0 _|     |  ___C1  _|     |  ___      |
*  \___/  |  \___/   _|_      \___/   _|_   |  \___/   _|_      |
*   _|_   |   _|_    ///       _|_    ///  _|_  _|_    ///      |
*   ///   |   ///              ///         ///  ///             |
*         |_____________________________________________________|
*
*  P1 = .1/(s+.1)  s is in jw (2PI*F) format
*  P2 =  3/(s+3)
*  P3 =  10/(s+10)
*
*  Transfer_V00->V2 = 3/((s+.1)*(s+.3)*(s+10)
*  Root Locus needs this format   K*(s+z0)(s+z1)../(s+p0)(s+p1)
*  K_4_rootlocus = 3*Egain
```

The exact same root locus can be run off a mac or PC using a program from the following site.

http://uk.geocities.com/a.a.robinson@btinternet.com/

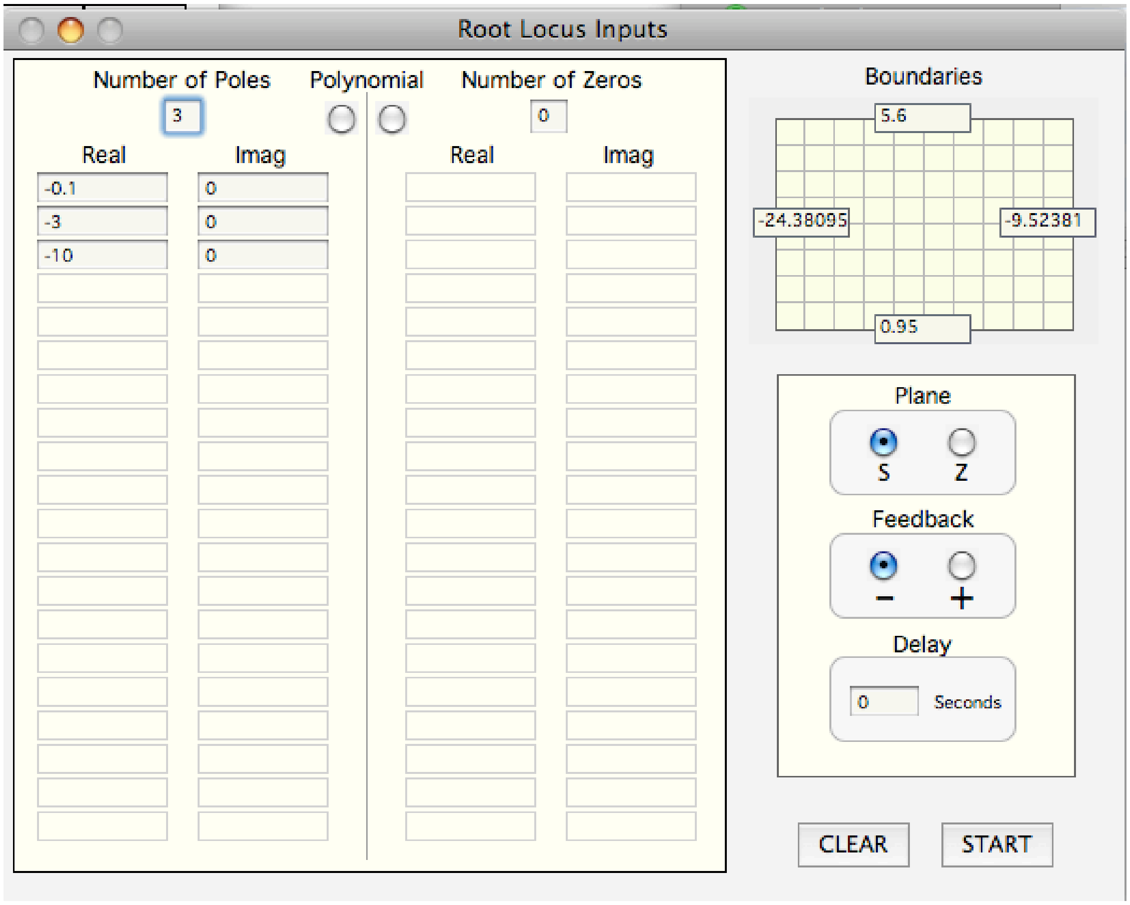


S-Plane Root Locus Plot

Poles		Zeros	
Real	Imag.	Real	Imag.
- 0.1	0	......	......
- 3	0	......	......
- 10	0	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......

Pnt	Real	Imag.	RL.Gain

Execution time:1.1 seconds



Root Locus Inputs

Number of Poles: 3

Polynomial ○ ○

Number of Zeros: 0

Real	Imag
-0.1	0
-3	0
-10	0

Real	Imag

Boundaries: 5.6, -24.38095, -9.52381, 0.95

Plane: ● S ○ Z

Feedback: ● − ○ +

Delay: 0 Seconds