An Introduction to APLAC

Dr. José Ernesto Rayas-Sánchez

1

APLAC Simulator

- APLAC was originally developed at the Technical University of Helsinki, Finland
- It was originally commercialized by APLAC Solutions Corp., Finland
- APLAC was later acquired by AWR and embedded in Microwave Office
- AWR was later acquired by National Instruments (NI)
- NI was recently acquired by Cadence

Dr. J. E. Rayas-Sánchez 2

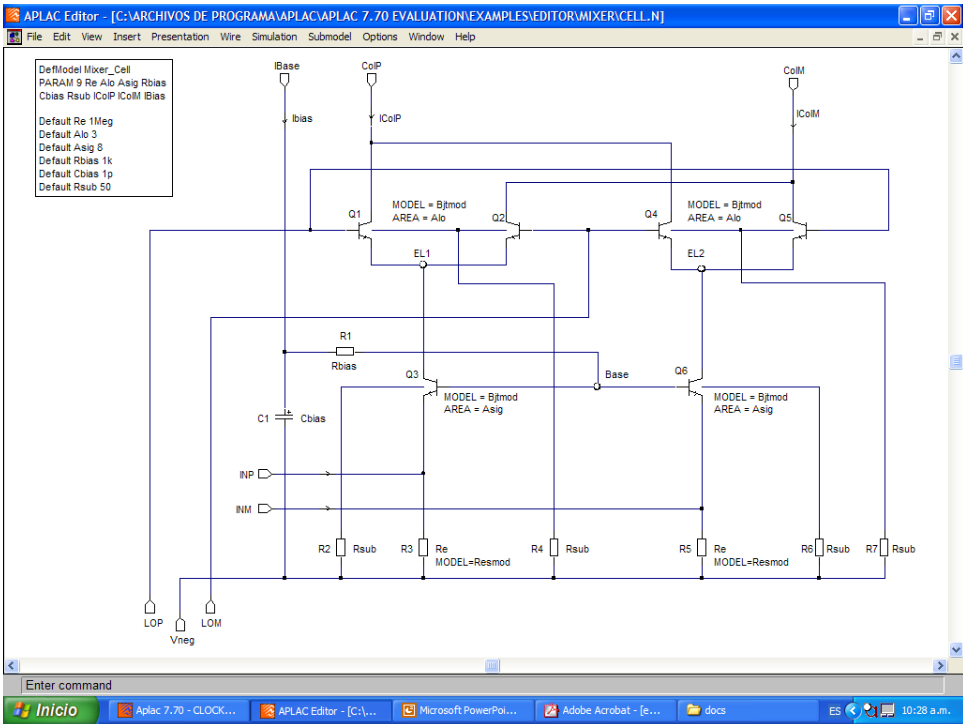
APLAC Simulator (cont.)

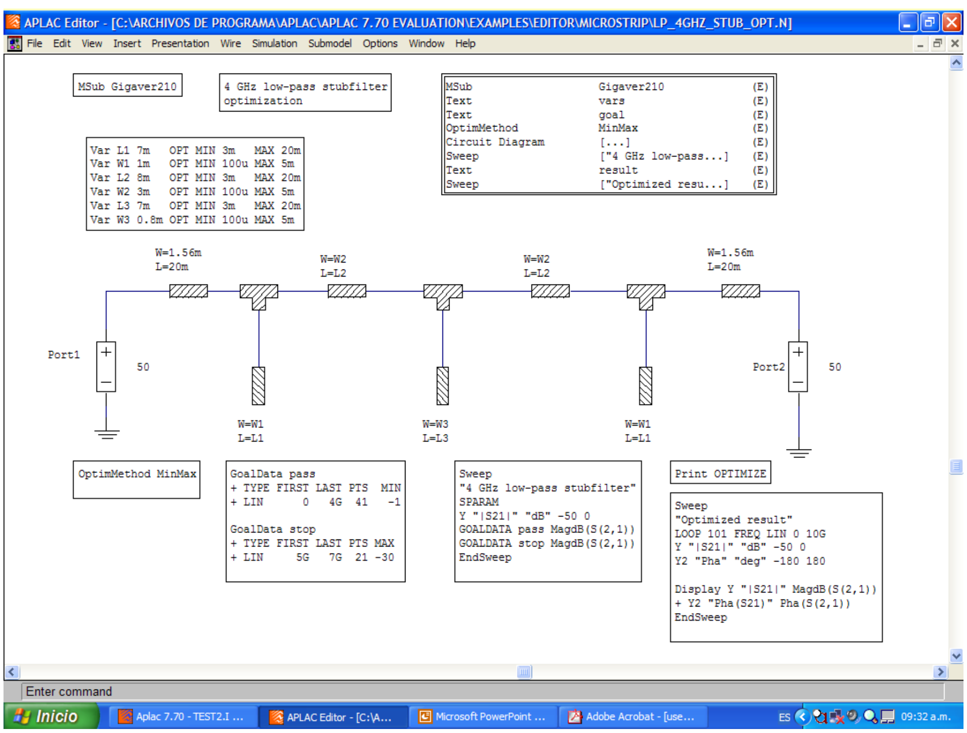
- Original version of APLAC:
  - A comprehensive mixed-mode high frequency circuit-based simulation and optimization system
  - It was able to realized EM-based simulation, optimization and design centering
- Current version of APLAC, restricted to circuit simulation (with emphasis on HB), is embedded in Cadence/AWR Design Environment™/Microwave Office

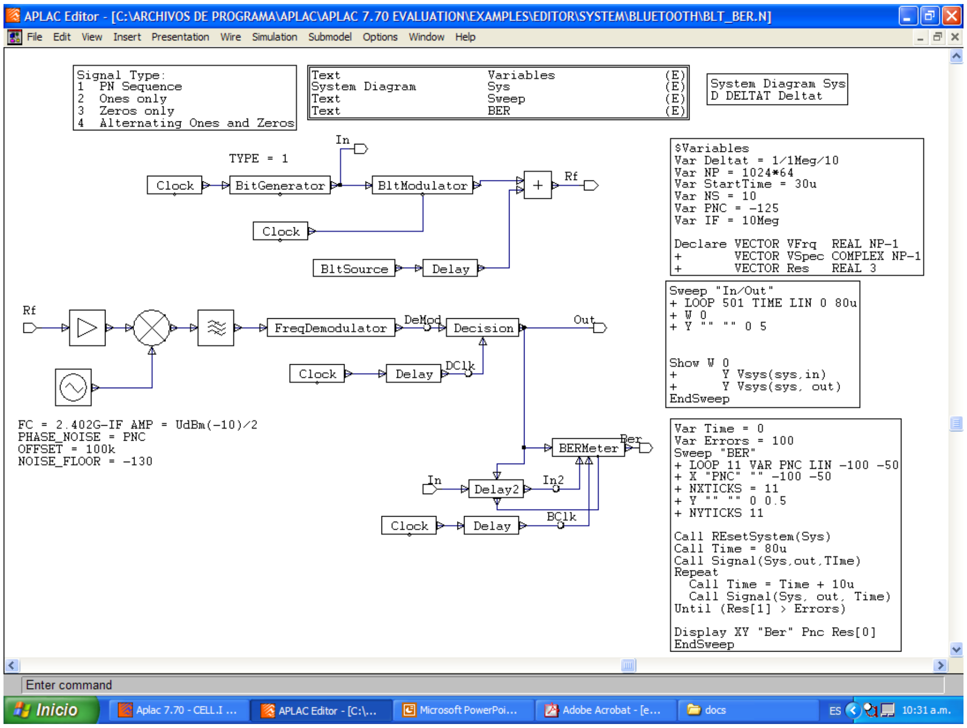
https://www.awr.com/resource-library/microwave-office-aplac-datasheet

APLAC Circuit Analysis Modes

- DC analysis and DC sensitivity
- AC analysis and AC sensitivity
- Transient analysis
- Monte Carlo analysis
- Stability analysis
- Group delay analysis
- S-parameter analysis
- AC Noise analysis
- Harmonic Balance (Single-Multitone, Large Signal)


APLAC Editor - [C:\ARCHIVOS DE PROGRAMA\APLAC\APLAC 7.70 EVALUATION\EXAMPLES\EDITOR\MIXER\CELL.N]
File Edit View Insert Presentation Wire Simulation Submodel Options Window Help
DefModel Mixer_Cell
PARAM 9 Re Alo Asig Rbias
Cbias Rsub IColP IColM IBias
Default Re 1Meg
Default Alo 3
Default Asig 8
Default Rbias 1k
Default Cbias 1p
Default Rsub 50
IBase
ColP
ColM
Ibias
IColP
IColM
Q1
MODEL = Bjtmod
AREA = Alo
Q2
Q4
Q5
EL1
EL2
R1
Rbias
Q3
Base
Q6
MODEL = Bjtmod
AREA = Asig
C1
Cbias
INP
INM
R2
Rsub
R3
Re
MODEL=Resmod
R4
R5
R6
R7
LOP
LOM
Vneg
Enter command
Inicio
Aplac 7.70 - CLOCK...
APLAC Editor - [C:\...
Microsoft PowerPoi...
Adobe Acrobat - [e...
docs
ES
10:28 a.m.


APLAC Editor - [C:\ARCHIVOS DE PROGRAMA\APLAC\APLAC 7.70 EVALUATION\EXAMPLES\EDITOR\MICROSTRIP\LP_4GHZ_STUB_OPT.N]
File Edit View Insert Presentation Wire Simulation Submodel Options Window Help
MSub Gigaver210
4 GHz low-pass stubfilter
optimization
MSub Gigaver210 (E)
Text vars (E)
Text goal (E)
OptimMethod MinMax (E)
Circuit Diagram [...] (E)
Sweep ["4 GHz low-pass...] (E)
Text result (E)
Sweep ["Optimized resu...] (E)
Var L1 7m OPT MIN 3m MAX 20m
Var W1 1m OPT MIN 100u MAX 5m
Var L2 8m OPT MIN 3m MAX 20m
Var W2 3m OPT MIN 100u MAX 5m
Var L3 7m OPT MIN 3m MAX 20m
Var W3 0.8m OPT MIN 100u MAX 5m
W=1.56m
L=20m
W=W2
L=L2
Port1
50
Port2
W=W1
L=L1
W=W3
L=L3
OptimMethod MinMax
GoalData pass
+ TYPE FIRST LAST PTS MIN
+ LIN 0 4G 41 -1
GoalData stop
+ TYPE FIRST LAST PTS MAX
+ LIN 5G 7G 21 -30
Sweep
"4 GHz low-pass stubfilter"
SPARAM
Y "|S21|" "dB" -50 0
GOALDATA pass MagdB(S(2,1))
GOALDATA stop MagdB(S(2,1))
EndSweep
Print OPTIMIZE
Sweep
"Optimized result"
LOOP 101 FREQ LIN 0 10G
Y "|S21|" "dB" -50 0
Y2 "Pha" "deg" -180 180
Display Y "|S21|" MagdB(S(2,1))
+ Y2 "Pha(S21)" Pha(S(2,1))
EndSweep
Enter command
Inicio
Aplac 7.70 - TEST2.I ...
APLAC Editor - [C:\A...
Microsoft PowerPoint ...
Adobe Acrobat - [use...
ES
09:32 a.m.



APLAC Programs

- Aplac Simulator (aplac.exe)
- Aplac Editor (aplaced.exe)

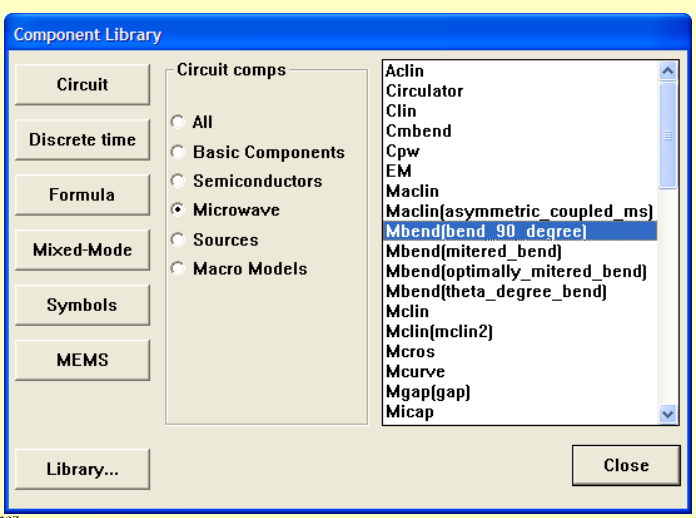
Dr. J. E. Rayas-Sánchez 8

APLAC Editor

- Diagrams
  - Circuit diagrams
  - System diagrams
- Control objects

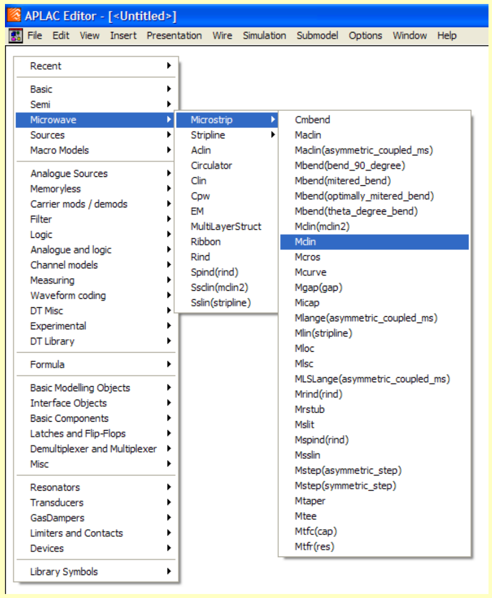
Drawing Schematics

Insert > Component



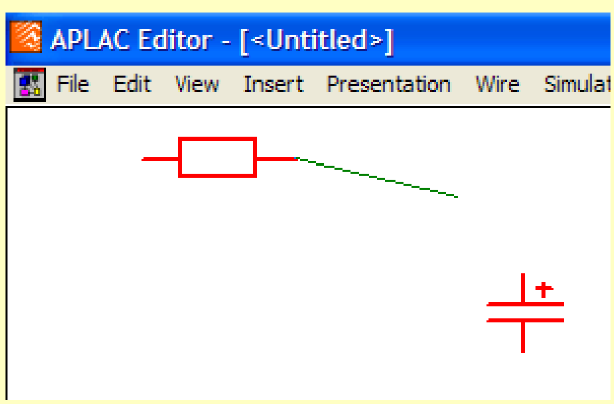
Drawing Schematics (cont.)

Right click:



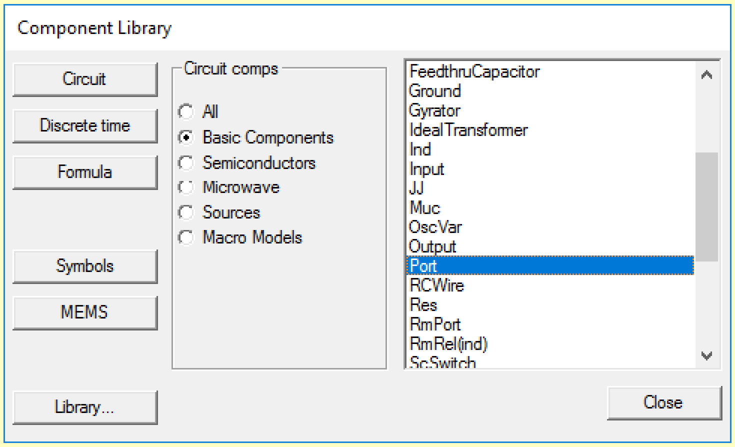
Drawing Schematics (cont.)

Double click: insert wire



Drawing Schematics (cont.)

Inserting ports:



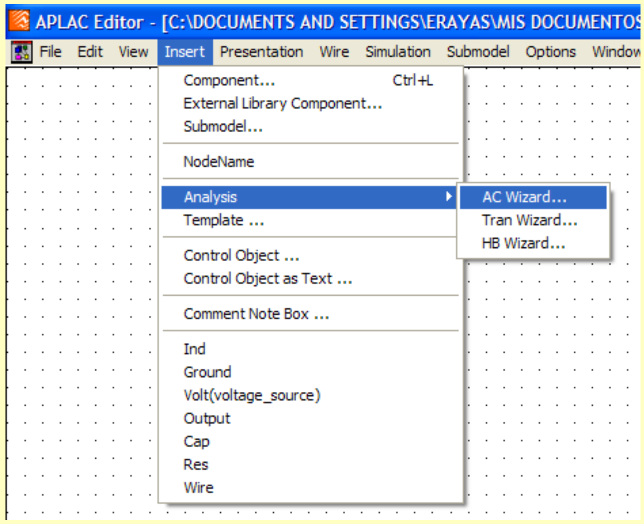
Or… Insert > Port

APLAC Control Objects

- Using Wizards
- Manually
- Using Analysis Templates

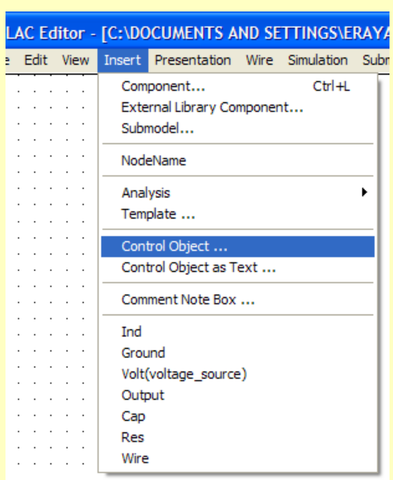
Using Wizards to Setup an Analysis

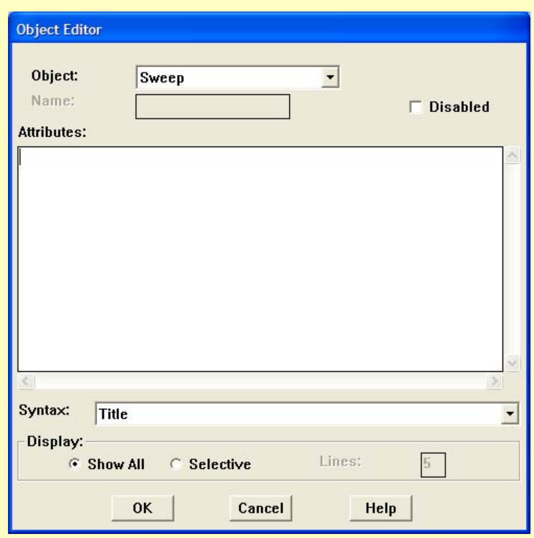
Type of analysis and corresponding sources are easily defined



Dr. J. E. Rayas-Sánchez 15

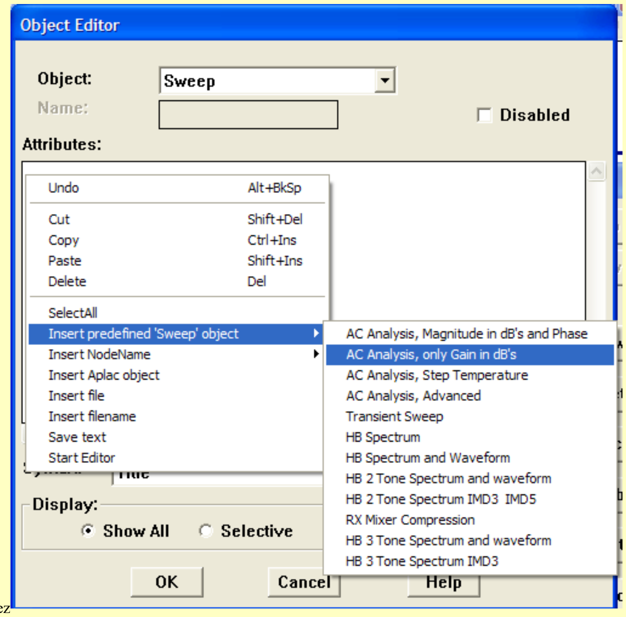
Setting up an Analysis Manually





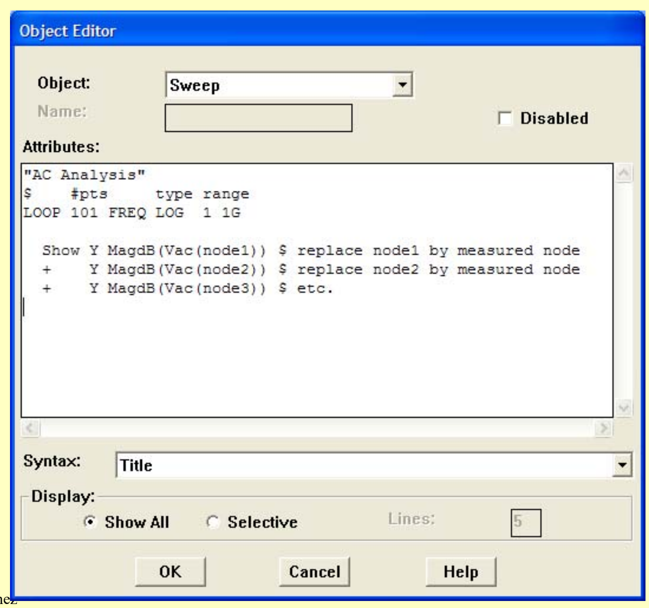
Dr. J. E. Rayas-Sánchez 16

Setting up an Analysis Using Templates



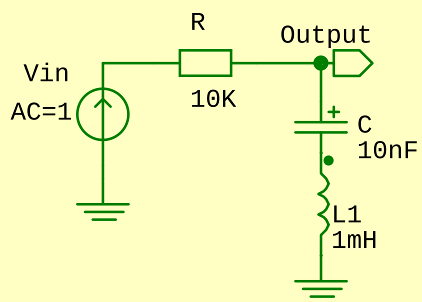
Dr. J. E. Rayas-Sánchez 17

Setting up an Analysis Using Templates (cont.)



Dr. J. E. Rayas-Sánchez 18

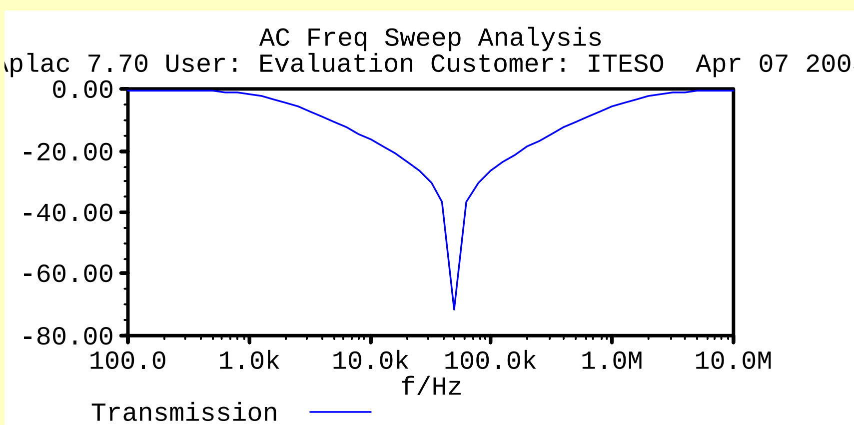
A Simple Example



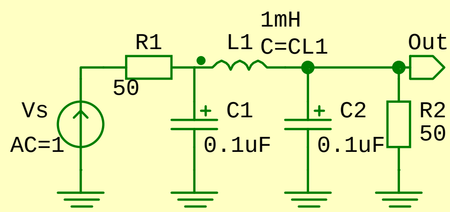
$ --
$ File   : C:\APLAC\PROJECTS\TEST2.I
$ Schema file : C:\APLAC\PROJECTS\TEST2.N
$ Generated with APLAC Editor version 2.7.1
$ Mon Apr 07 09:12:42 2003
$ --

Res R node1 Output
+ 10K
Cap C Output node2
+ 10nF
Volt Vin node1 GND
+ AC=1
Ind L1 node2 GND
+ 1mH
Sweep "AC Freq Sweep Analysis"
+ loop 51 freq log 100Hz 10MEGHz
Display Y “Transmission" MagDB(Vac(output))
EndSweep

A Simple Example (cont.)



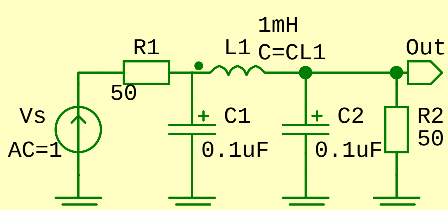
Declaring and Using Variables




```
Declare
VAR = CL1
```

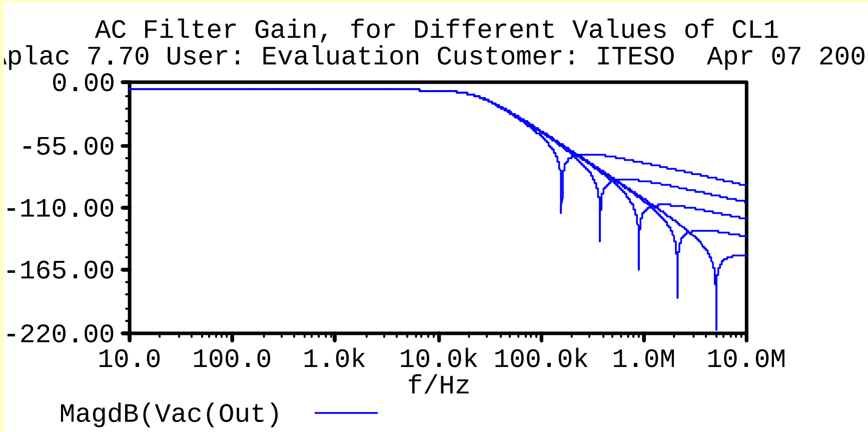
```
Sweep
"AC Filter Gain, for Different Values of CL1"
LOOP 5 VAR CL1 LOG 1p 1n

+ LOOP 10000 FREQ LOG  10Hz 10MEGHz

  Show Y MagdB(Vac(Out))

EndSweep
```


Declaring and Using Variables (cont.)



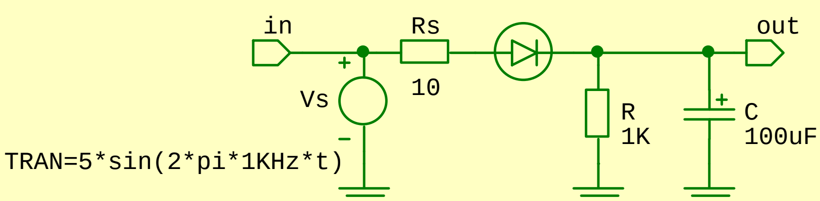

```
Declare VAR = CL1

Res R1 node1 node2
+ 50
Ind L1 node2 Out
+ 1mH
+ C=CL1
Res R2 Out GND
+ 50
Cap C1 node2 GND
+ 0.1uF
Cap C2 Out GND
+ 0.1uF
Volt Vs node1 GND
+ AC=1
Sweep "AC Filter Gain, for Different Values of CL1"
+ LOOP 5 VAR CL1 LOG 1p 1n
+ LOOP 10000 FREQ LOG  10Hz 10MEGHz
  Show Y MagdB(Vac(Out))

EndSweep
```

Declaring and Using Variables (cont.)



Dr. J. E. Rayas-Sánchez 23

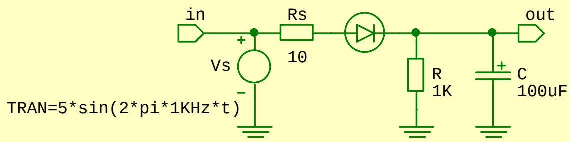
Transient Analysis - Example




```
Sweep
"Transient Analysis, Filtered Half-Wave Rectifier"
LOOP 300 TIME LIN 0 15ms

Show  Y Vtran(in)
+     Y Vtran(out)

EndSweep
```

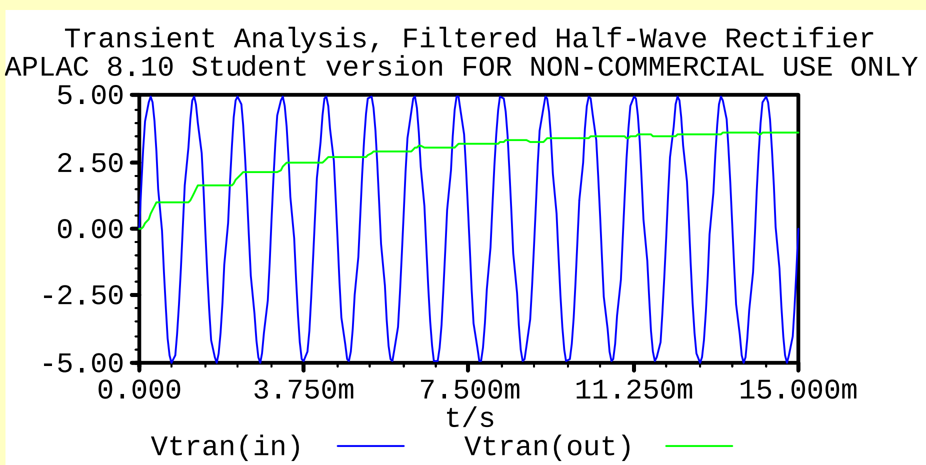
Dr. J. E. Rayas-Sánchez 24

Transient Analysis – Example (cont.)




```
Res R out GND
+ 1K
Diode D1 node1 out

Volt Vs in GND
+ TRAN=5*sin(2*pi*1KHz*t)
Res Rs in node1
+ 10
Cap C out GND
+ 100uF
Sweep "Transient Analysis, Filtered Half-Wave Rectifier"
+ LOOP 300 TIME LIN 0 15ms
Show  Y Vtran(in)
+     Y Vtran(out)

EndSweep
```

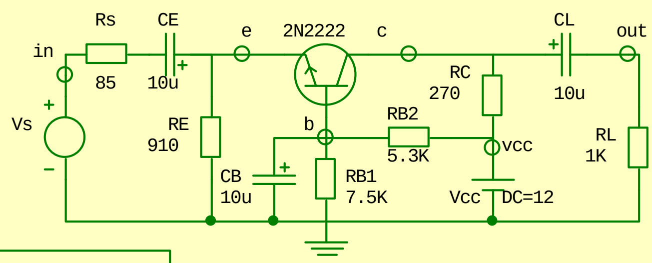

Transient Analysis – Example (cont.)



Combining Several Analysis – Example

```
#define f 1KHz
#define A 1V
```

AC=1
TRAN=A*sin(2*pi*f*t)




```
Sweep
"Common Base Amp - AC Analysis"
LOOP 100 FREQ LOG  10Hz 900MEGHz
WINDOW=0 grid Y "Av" "dB" -40 20
WINDOW=1 grid Y "Zin" "" 0 1K

Show W=0 Y=MagdB(Vac(out))
Show W=1 Y=1/((1-Mag(Vac(node1)))/85)
EndSweep
```

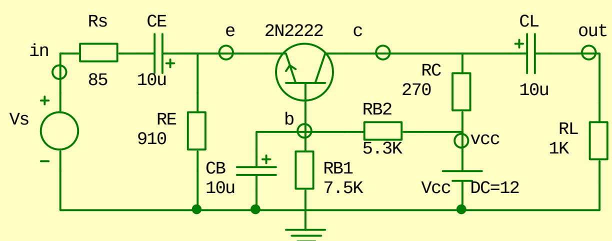
```
Sweep
"Common Base Amplifier"
LOOP 1000 TIME LIN 0 5ms
GRID Y "" "V" -3 3

Show Y=Vtran(in) Y=Vtran(out)
EndSweep
```

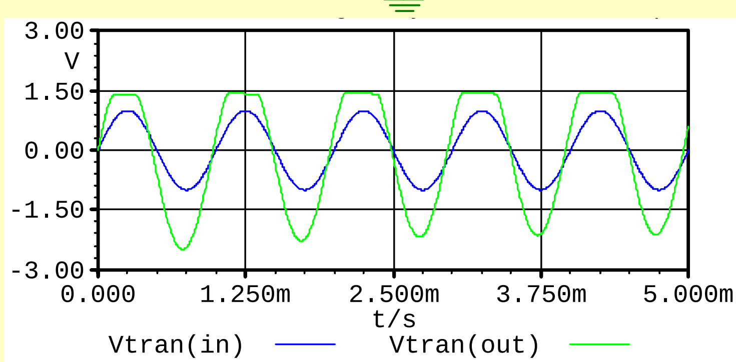
Dr. J. E. Rayas-Sánchez 27

Combining Several Analysis – Example (cont.)

```
#define f 1KHz
#define A 1V
```

AC=1
TRAN=A*sin(2*pi*f*t)



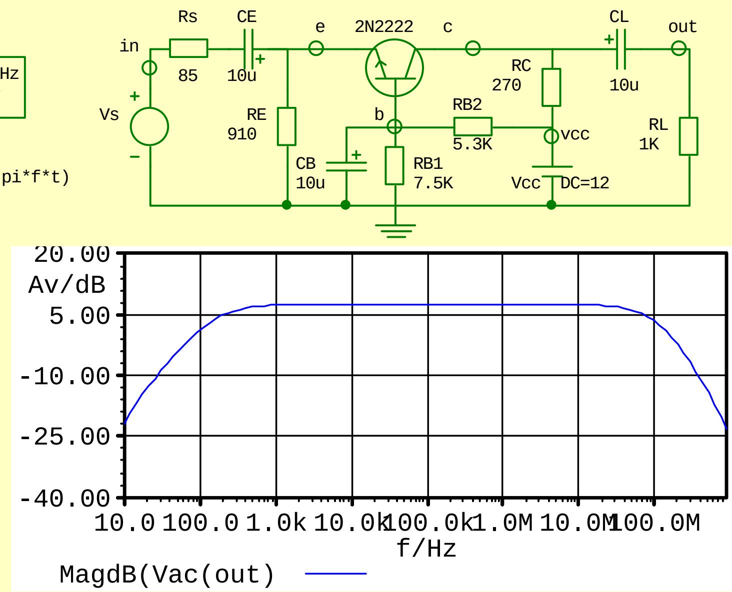


Dr. J. E. Rayas-Sánchez 28

Combining Several Analysis – Example (cont.)

```
#define f 1KHz
#define A 1V
```

AC=1
TRAN=A*sin(2*pi*f*t)



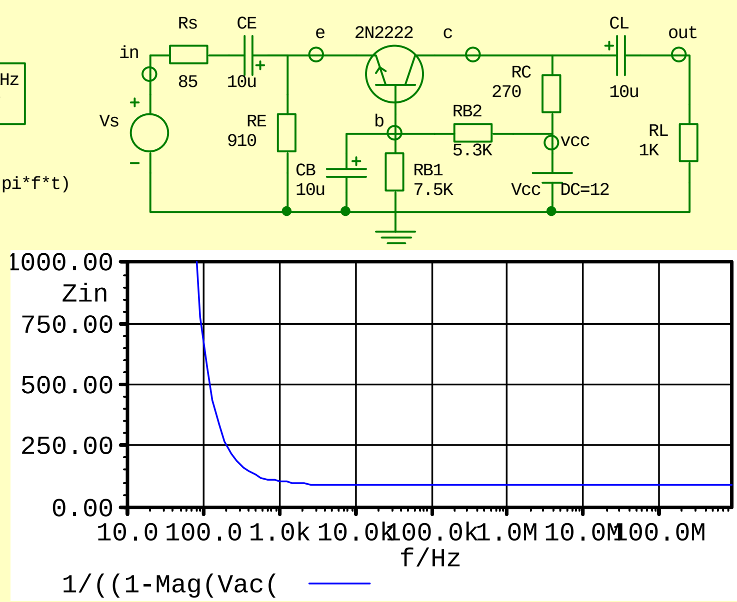
Dr. J. E. Rayas-Sánchez

29

Combining Several Analysis – Example (cont.)

```
#define f 1KHz
#define A 1V
```

AC=1
TRAN=A*sin(2*pi*f*t)



Dr. J. E. Rayas-Sánchez

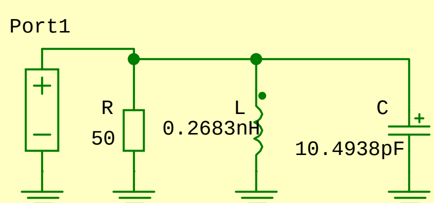
30

S-Parameter Analysis

- S-parameter analysis (and Y-, Z- and H-parameter analysis as well) is based on the AC analysis
- It is a small signal analysis (for linearized circuits)
- The circuit under simulation must be defined as a multiport network
- In Aplac a multiport is defined with the statement DefNPort

Dr. J. E. Rayas-Sánchez 31

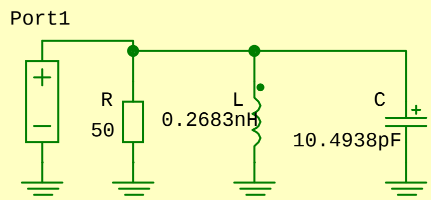
S-Parameter Analysis – Example 1




```
Sweep
"S-Parameters Analysis"
LOOP 1000 FREQ LIN 1GHz 5GHz
WINDOW=0 SMITH $ Use Smith Chart
BIGSCREEN

Show W=0 RI=S(1,1) MARKER=1
+ W=1 Y Mag(S(1,1))


EndSweep
```

Dr. J. E. Rayas-Sánchez 32

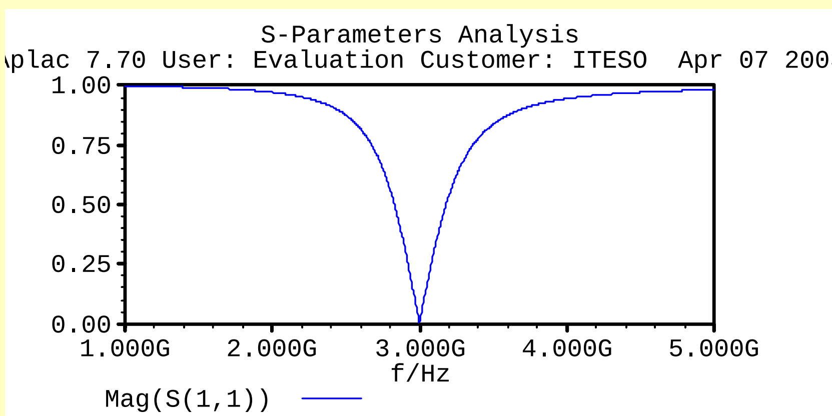
S-Parameter Analysis – Example 1 (cont.)




```
Res R Port10 GND
+ 50
Cap C Port10 GND
+ 10.4938pF
Ind L Port10 GND
+ 0.2683nH
DefNPort nport 1
+ Port10 GND 50
Sweep "S-Parameters Analysis"
+ LOOP 1000 FREQ LIN 1GHz 5GHz
+ WINDOW=0 SMITH $ Use Smith Chart
+ BIGSCREEN
Show W=0 RI=S(1,1) MARKER=1
+ W=1 Y Mag(S(1,1))

EndSweep
```

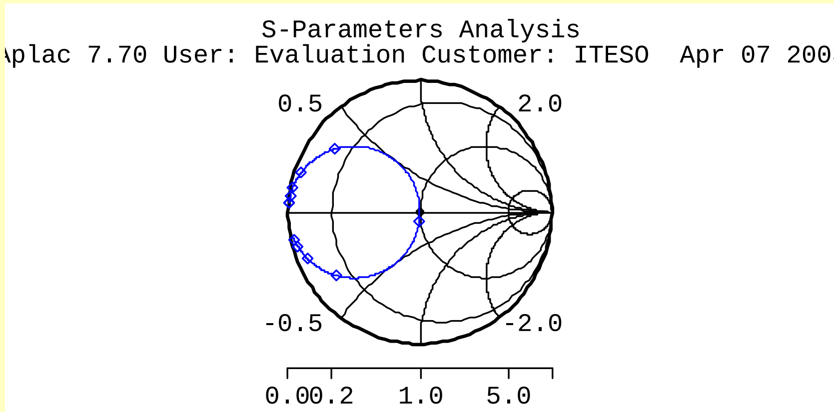
Dr. J. E. Rayas-Sánchez 33

S-Parameter Analysis – Example 1 (cont.)



Dr. J. E. Rayas-Sánchez 34

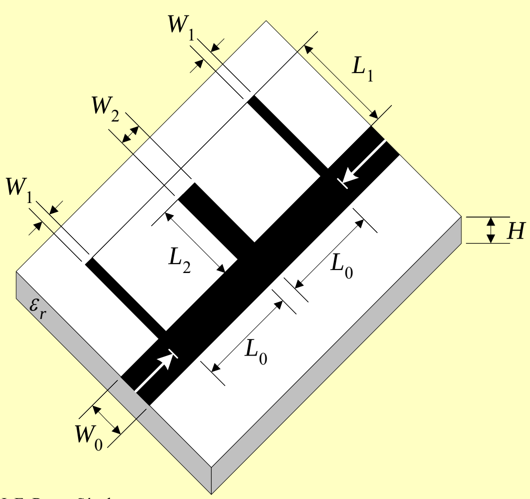
S-Parameter Analysis – Example 1 (cont.)



Dr. J. E. Rayas-Sánchez 35

S-Parameter Analysis – Example 2

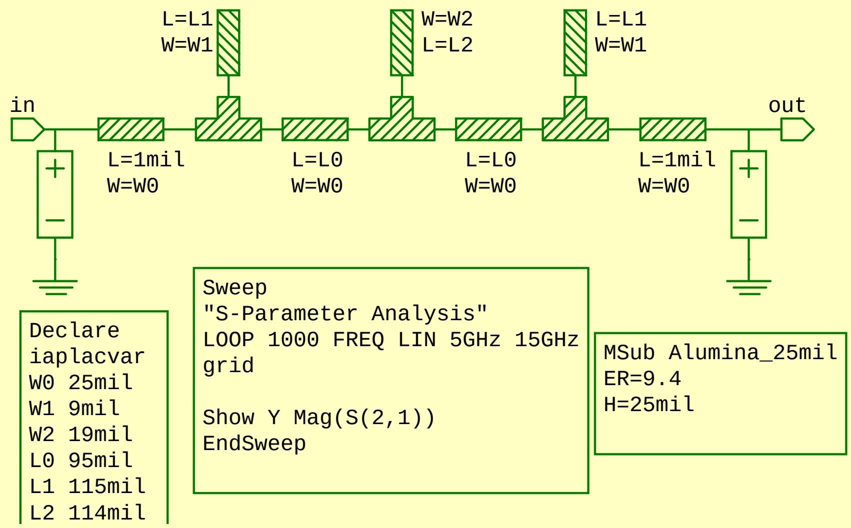
Bandstop Microstrip Filter with Quarter-Wave Open Stubs



H = 25 mil
ε_r = 9.4 (alumina)
W_0 = 25 mil
W_1 = 9 mil
W_2 = 19 mil
L_0 = 95 mil
L_1 = 115 mil
L_2 = 114 mil

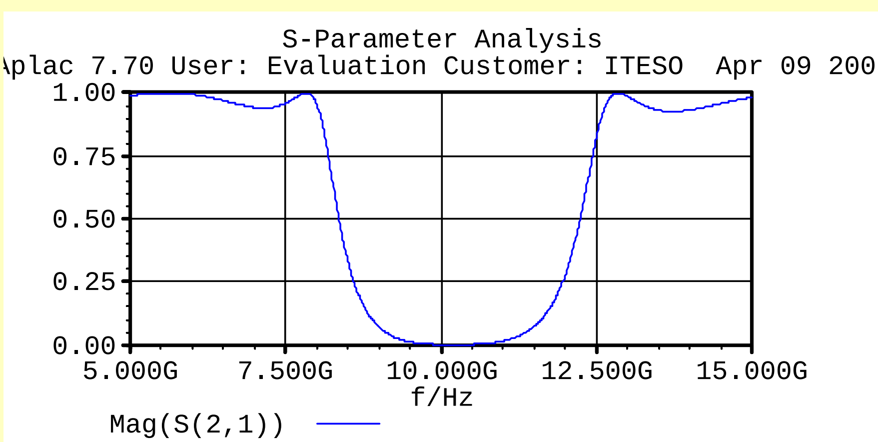
Dr. J. E. Rayas-Sánchez 36

S-Parameter Analysis – Example 2 (cont.)



Dr. J. E. Rayas-Sánchez 37

S-Parameter Analysis – Example 2 (cont.)



Dr. J. E. Rayas-Sánchez 38