EE-103 VLSI Design
Lab 04

Kaiyuan Zhang

kzhang11@tufts.edu

Tufts UNIVERSITY

SCHOOL OF ENGINEERING

Electrical and Computer Engineering

Outline

- HSPICE parameter optimization

Hspice Optimization

Concept:
The automatic generation of model parameters and component values from a given set of electrical specifications or measured data.

With user-defined optimization program and a known circuit topology. This tool automatically selects the design components and model parameters to meet DC, AC, and transient electrical specifications.

Hspice Optimization Tool

Optimization requires several statements: (4 parts in our lab)

- Set up an optimization model:
  ```
  .model OPT1 OPT
  ```
- Define the parameter to be optimized:
  ```
  .PARAM w_n = OPTrange(400n, 200n, 1000n)
  ```
- Tell the optimization goal:
  ```
  .measure tpd param='tpHL-tpLH' goal=0
  ```
- Sum up in analysis method:
  ```
  .TRAN 1p 20u sweep optimize=OPTrange RESULTS=tpd
  MODEL=OPT1
  ```

Hspice Optimization Example

Syntax: .MODEL ModelName OPT …

```
.model OPT1 OPT
```

Syntax: .PARAM parameter=OPTxxx (init., min, max)

```
.PARAM w_n = OPTrange(400n, 200n, 1000n)
```

Syntax: *.measure <MeasureName> <MeasureClause> GOAL=<GoalValue>*

```
.measure tpHL trig v(in) val='vdd/2' rise=1 targ v(out) val=
'vdd/2' fall=1
.measure tpLH trig v(in) val='vdd/2' fall=2 targ v(out) val=
'vdd/2' rise=2
.measure tpd param='tpHL-tpLH' goal=0
```

Hspice Optimization Example

Syntax: *.Tran <Step> <Period> Sweep Optimize=OPTxxx Results=measure Model=Optmod*

```
.TRAN 10p '2*per' sweep optimize=OPTrange RESULTS=tpd
MODEL=OPT1
```

Hspice Optimization Example

```
.param trf = 4p
.param del = 2u
.param per = 10u
.param pw = 5u

*define analysis voltage
vinput vi gnd pulse 0 vdd del trf trf pw per

.model opt1 opt
.param wp = OPTrange(400n, 200n, 1000n)


.measure tran tphl trig v(vi) val='vdd*0.5' rise=2 targ v(vo) val='vdd*0.5' fall=2
.measure tran tplh trig v(vi) val='vdd*0.5' fall=2 targ v(vo) val='vdd*0.5' rise=2
.measure tran tpd param='tphl-tplh' goal=0

.tran 1p '3*per' sweep optimize=OPTrange RESULTS=tpd MODEL=OPT1

.end
```

Find the opt result

You can find the results in .lis file. You can search the model name for OPT to locate it.

```
***  model name:    0:opt1     ****
***********************************

    names  values   units      names  values   units      names  values
    -----  ------   -----      -----  ------   -----      -----  ------
   level=   1.00              relin=   1.00m           relout=   1.00m
    grad=   1.00u             close=   1.00              cut=   2.00
     max= 600.00k            itropt=  20.00           cendif=   1.00m
  difsiz=   1.00m           parmin= 100.00m

 **warning** (lab06.sp:18) Both nodes of element vgnd are connected t
 **info** (lab06.sp:32) DC voltage reset to initial transient source


*****************************************************************
******  option summary
******
runlvl   = 3         bypass   = 2

    optimization  results

         residual sum of squares     =  1.490661E-03
         norm of the gradient        =   17.1000
         marquardt scaling parameter =  6.250000E-02
         no. of function evaluations =         6
         no. of iterations           =         2

    optimization completed

         parameters < relin=  1.0000E-03 on last iterations

 **** optimized parameters optrange
*                                          %norm-sen        %change

 .param wp = 485.9407n       $  100.0000          7.4044
 ****
```

Additional Info on Hspice Optimization

- https://class.ece.uw.edu/cadta/hspice/chapter_11.pdf

Understanding the Statements Syntax

Several Star-Hspice statements are required for optimization.

- .MODEL modname OPT ...
- .PARAM parameter=OPTxxx (init, min, max)
- A .DC, .AC, or .TRAN analysis statement with MODEL=modname, OPTIMIZE=OPTxxx, and RESULTS=measurename
- .MEASURE measurename ... <GOAL = | < | > val> – note that a space is required on either side of the relational operator =, <, or >

The .PARAM statement lets you specify initial, lower, and upper bound values. The types of .MEASURE statements available for optimization are described in *Chapter 4, Specifying Simulation Output*.

Output statements .PRINT, .PLOT, and .GRAPH must be associated with the analysis statements .DC, .AC, or .TRAN. An analysis statement with the keyword OPTIMIZE is used for optimization only. To generate output for the optimized circuit, another analysis statement (.DC, .AC, or .TRAN) must be specified, along with the output statements. The proper specification order is:

1. Analysis statement with OPTIMIZE
2. .MEASURE statements specifying optimization goals or error functions
3. Ordinary analysis statement
4. Output statements

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Thank you!