OSA90/hope™

A NEW SYSTEM FOR NONLINEAR CIRCUIT OTIMIZATION

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OSA's CAE Product Line

OSA90™

customization oriented optimization shell
statistical analysis and yield optimization
interacts with external simulators

OSA90/hope™

general nonlinear circuit simulation and optimization
analytically unified DC, small-signal and large-signal harmonic balance analysis

HarPE™ Version 1.5

device characterization
single-device circuit simulation and optimization

HarPE™ Version 1.5+S

statistical modeling
Monte Carlo analysis

COM Type of Datapipe™ Connection

similar to SIM, but additionally allows strings to be passed to or returned from the user's program

syntax:

```
char x2[] = "string to be passed to the user's program";
Datapipe:  COM FILE = filename
               N_INPUT = n   INPUT = (x1, x2, ...)
               N_OUTPUT = m  OUTPUT = (y1, char y2[15], ...);
```

the user specifies:

filename	-	the name of user's executable program
n	-	the number of arguments to be passed to the user's program
x2,..	-	labelled string to be passed to the user's program
m	-	the number of arguments that will be returned from the user's program
y2,..	-	labelled strings to be returned from the user's programs

OSA90/hope Input File Overview

Model
...
End

ImportData
...
End

Sweep
...
End

Specification
...
End

MonteCarlo
...
End

Statistics
...
End

OSA90/hope Input File Model/Expression Block

Model

expressions

datapipes

circuit elements

VLABEL ...

VSOURCE ...

PORT ...

CIRCUIT ... (response labels created here)

expressions post-processing responses

End

Example of OSA90/hope Model/Expression Block

```
Model        ! a diode mixer

     SRL  1  0  R=0.01  L=1.8UH;
     RES  1  2  R=10.0;  !  resistance in diode model
     CAP  3  0  C=2.8PF;
     SRL  3  4  R=0.01  L=.1UH;
     SRL  1  5  R=10KOH  L=20UH;

! use built-in nonlinear diode model

     DIODE      2  3  IS: 1.e-14  N: 1  TEMP: 295  VJ: 0.9
                CJ0: 0.001PF;

! define bias source

     VSOURCE 5 0  NAME=BIAS VDC=0.5V;

! define user labels

     Power_LO: -5DBM;
     Power_RF: -20DBM;

! define input (two-tone excitation) and output ports

     PORT 1 0  NAME=in R=1KOH  P=Power_LO  P2=Power_RF;
     PORT 4 0  NAME=out R=1KOH;

     CIRCUIT;
```

Example of OSA90/hope Model/Expression Block

```
! use built-in functions for polar-rectangular transformation;
! after "CIRCUIT" statement the labels MVout and PVout are
! automatically generated by the program

        MP2RI(MVout, PVout, RVout[0:13], IVout[0:13]);

! define more user labels

        IF_freq: 7MHZ;
        T1: 1 / IF_freq;
        Time: 0;
        K: 0;

! use built-in function for frequecy-to-time transformation

        DFT_FT(RVout, IVout, SPECTRAL_FREQ, Time, Vout_T);

End
```

OSA90/hope Symbolic Subcircuit Definition

```
! define a symbolic subcircuit

#define trewmodel (gate, drain, cr1, cr2, cr3, cr4, $) {

SRL  @gi$  gate      R: P_Rg  L: P_Lg;
SRL  @di$  drain     R: P_Rd  L: P_Ld;
SRL  @si$  @ground   R: P_Rs  L: P_Ls;

FETT1    @gi$ @di$ @si$
  L:  gate_L   {NORMAL SIGMA=3.5% CORRELATION=FET[cr2]}
  A:  gate_a   {NORMAL SIGMA=3.5% CORRELATION=FET[cr1]}
  ND: doping {NORMAL SIGMA=7.0% CORRELATION=FET[cr4]}
  W:  gate_W {NORMAL SIGMA=2.0% CORRELATION=FET[cr3]}
  EPSR: Eps    EC:   Ecv     VS:   Vsv
  U0:   U0v   VBI:  biv     D:    diffu
  LAMBDA:  Lamdav    ALPHA: alpha     TAU:   Tauv ;

}

Model

! use the symbolic subcircuit

     trewmodel(@gate1, @drain1, 1, 2, 3, 4, FET1);
     trewmodel(@gate2, @drain2, 5, 6, 7, 8, FET2);

End
```

OSA90/hope Input File Sweep Block

```
Sweep

! small-signal simulation

SP:   FREQ: from 6GHZ to 15GHZ step 0.1GHZ
      VG: -1.8  VD: 6  gain VSWR;

! harmonic balance simulation

HB:   IF_freq: 7MHZ 9MHZ
      FREQ=900MHZ  FREQ2=(FREQ + IF_freq)
      Time: from 0 to T1 N=1000
      Vout_T, Vin_T, Iin_T_mA
      Title="Mixer Analysis At Two Different IF Frequencies";

HB:   IF_freq: 7MHZ 9MHZ
      FREQ=900MHZ  FREQ2=(FREQ + IF_freq)
      K: from 0 to N_SPECTRA step=1
      SPECTRAL_FREQ[K]  MVout[K]  MVin[K]  MIin[K],
      Title="Mixer Analysis: Frequency Spectrum";

End
```

OSA90/hope Input File Specification Block

```
Specification

! small-signal specifications

SP:   FREQ: from 8GHZ to 12GHZ step=1GHZ
      VG: -1.8  VD: 6 gain > 12 gain < 16  VSWR < 2;
SP:   FREQ: 6GHZ  VG: -1.8  VD: 6 gain < 2;
SP:   FREQ: 15GHZ VG: -1.8  VD: 6 gain < 2;

End
```

OSA90/hope Input File MonteCarlo Block

```
MonteCarlo

SP:   N_OUTCOMES=100
      FREQ: from 6GHZ to 15GHZ step 0.1GHZ
      VG: -1.8  VD: 6  gain VSWR;
SP:   FREQ: from 8GHZ to 12GHZ step=1GHZ
      VG: -1.8  VD: 6 gain > 12 gain < 16  VSWR < 2;
SP:   FREQ: 6GHZ  VG: -1.8  VD: 6 gain < 2;
SP:   FREQ: 15GHZ VG: -1.8  VD: 6 gain < 2;

End
```

OSA90/hope Input File Statistics Block

```
Statistics

    Correlation: FET  dimension=12  format=full;

!A1   L1   W1   Nd1   A2   L2   W2   Nd2   A3   L3   W3   Nd3

1.00 0.00 0.00 -0.25 0.80 0.00 0.00 -0.20 0.78 0.00 0.00 -0.10
0.00 1.00 0.00 -0.10 0.00 0.80 0.00 -0.05 0.00 0.78 0.00 -0.05
...
...

End
```

Built-in Device Models

Diode

FET:	Curtice
	Materka
	Statz
	Trew (physics)
	modified Trew (physics)
Bipolar:	Gummel-Poon

Preprogrammed user models

FET:	Curtice
	Ladbrooke (physics)
	Materka
	Plessey
	TOM

Custom designed device models

HarPE™ Version 1.5 and Version 1.5+S

characterize devices

extract parameters: specification- or data-driven

build equivalent circuit models

build physics models

simulate and optimize single device circuits at DC, small-signal and large-signal harmonic balance

statistically model devices

estimate Monte Carlo yield

HarPE™ Measurements

- power spectra
- waveforms
- S-parameters
- DC data
- Cascade Microtech
- MDIF

Modeling and Design

alter built-in models

define your own models

create functions and goals

use formulas and expressions

optimize linear and nonlinear parameters

HarPE™ Displays

built-in responses

- DC I-V curves
- Smith charts, polar plots
- small-signal parameters
- harmonics vs. input power
- harmonics vs. frequency
- spectra and waveforms

user-defined responses

sensitivity displays

arbitrary parameter sweeps

graphics zoom and hardcopies

user-defined colors

HarPE™ Statistics

multi-device parameter extraction

statistical estimation

discrete approximation

graphics

- histograms
- scatter plots
- run charts
- zoom
- hardcopies

consolidated statistical models for both built-in or user-defined models

Monte Carlo yield

OSA90™ Features

state-of-the-art optimizers: ℓ_1, least squares, minimax

variable definition, expressions, vector processing

specification and goal definition

labelled module inputs and outputs

module functional interconnection with pre-, inter- and post-processing

exact or approximate gradient

statistical centering

OSA90™ Graphics

continuous plots, point plots, dot plots and bar plots

parametric plots

multiple plots

histograms, run charts

sensitivity displays

arbitrary parameter sweeps

graphics zoom and hardcopies

user-defined legends

user-defined colors

OSA90/hope™ Features

OSA90, plus

general nonlinear circuit FAST™ simulation and optimization

arbitrary topology

analytically unified simulation: DC and small-signal with large-signal harmonic balance

symbolic subcircuit definition: linear and nonlinear

multitone, multisource excitations

nonlinear sources controlled by arbitrarily placed voltages

user-definable models

comprehensive device library

physics-based optimization