# OSA90/hope™
## Version 1.1 Technical Brief

### INTRODUCTION

**OSA90/hope™ - Optimization Shell Assembly/ harmonic optimization personal environment offers** simulation, modeling, statistical analysis, nominal and yield optimization capabilities for general linear and nonlinear circuits. It features Datapipe™ which allows you to interactively integrate in-house CAD programs into a custom-designed framework. It provides the advantage of merging the unique and long-standing technologies of *Optimization Systems Associates* with your own expertise. Acquiring OSA90 is the most cost-effective way to invigorate your CAD/CAE capabilities.

### CREATIVE CIRCUIT SIMULATION

OSA90 can simulate linear and nonlinear circuits of general n-port topology with an arbitrary number of nonlinear devices. It can perform DC, small-signal AC, large-signal harmonic balance and two-tone spectral analyses. Multiple DC bias sources and AC excitations can be specified.

The DC, small-signal and large-signal analyses in OSA90 are analytically unified with a consistent circuit description. Small-signal equivalent circuit parameters are automatically derived from nonlinear device models when needed. To represent the nonlinear devices, you can draw upon the built-in library of HarPE™-compatible models, or create your own models using nonlinear controlled sources. Symbolic linear and nonlinear subcircuits can be used to simplify complex circuit descriptions.

The built-in responses available include DC and AC voltages and currents at all ports, and small-signal S-parameters. For two-ports, insertion loss, stability factor and maximum available gain are calculated. Also, user-defined responses can be easily created. You can define frequency sweep, power sweep and arbitrary multi-parameter sweeps. The responses can be plotted graphically, displayed numerically and exported as data files. You can use OSA90 to analyze DC characteristics, harmonic distortion, compression, intercept points and intermodulation products, and to design amplifiers, filters, mixers, frequency multipliers, etc.

### EXPRESSION COMPOSITION

In the input file, you can define labels to represent constants and optimization variables. You can also compose expressions as arbitrary combinations of constants, variables, labels, algebraic operations and standard mathematical functions. You can use expressions to link variables, introduce formulas, describe model equations, postprocess responses and create user-defined functions. A number of useful mathematical transformations, e.g., DFT, are available as built-in functions. Conditional expressions (nested IF ELSE structures) are supported.

You can define arrays (vectors) of variables and vector expressions. Include files can be used to import data and share common formulas among different files. Text macros allow you to personalize keywords, functions and styles, or to introduce the syntax of other programs.

### DATAPIPE TECHNOLOGY

External programs can be functionally connected to OSA90 through Datapipe. Datapipe utilizes UNIX interprocess pipes for high-speed data connections to external *executable* programs. It is especially suitable for incorporating sensitive in-house software since you do not need to reveal the source code.

Datapipes are defined in the input file. You specify a set of inputs from OSA90 to the external program and a set of outputs to be returned. OSA90 starts the child programs in separate processes, and communicates with them in a manner similar to subroutine calls. The inputs to a child can include variables, expressions, and even outputs from other children. The outputs from a child can be labelled, postprocessed, displayed and optimized. For a complex problem, the simulation can be distributed across OSA90 and several children.

Datapipes can contribute to circuit simulation on different levels. For instance, an external device field simulator can accept physical parameters from OSA90 and return responses and/or equivalent circuit parameters to OSA90 for further processing.

Child programs can directly supply error functions and gradients for optimization. This can provide a distinct advantage if the gradients can be accurately and efficiently computed within the child programs.

You can use OSA90 as an optimization shell to drive your in-house simulators via Datapipe. This can add OSA90's friendly user interface, graphics, expression parser, optimization and statistical capabilities to your own software. You can even link separate programs through OSA90 to design a functionally integrated and easily expandable system as your own CAE "total solution".

## POWERFUL OPTIMIZERS

OSA90 features powerful gradient-based optimizers with proven track records for $\ell_1$, $\ell_2$ and minimax optimization. Optimization variables can include circuit parameters, bias voltages, input power levels, inputs to Datapipe child programs and abstract variables. The functions to be optimized can be built-in and user-defined circuit responses, Datapipe outputs and abstract error functions. You can define upper, lower and equality specifications. You can also assign weighting factors.

The $\ell_1$ optimizer is uniquely robust in solving data fitting and circuit modeling problems. Minimax optimization is most suitable for design applications (filters, amplifiers, etc.). For nonlinear circuits, the gradients are computed using FAST™ sensitivities. Generally, the gradients are generated internally, but OSA90 can take advantage of gradients supplied by external simulators via Datapipe. OSA's optimizers offers unrivalled accuracy and efficiency.

The sensitivity display is another significant feature. It can assist you in selecting the most crucial parameters as optimization variables while fixing as constants those that have lesser influence on the functions to be optimized.

## YIELD SIMULATION AND OPTIMIZATION

OSA90 features statistical Monte Carlo analysis and yield optimization. User-identified parameters can be subject to uniform, normal, exponential and lognormal distributions with absolute or relative tolerances. Hierarchical and correlated distributions are also supported. According to a user-specified number of outcomes, the Monte Carlo analysis option estimates the yield and displays various statistical diagrams, including histograms, run charts and parameter sweeps.

OSA90 employs a sophisticated one-sided $\ell_1$ design centering algorithm to optimize the simulated yield. An advanced quadratic approximation scheme is available to reduce the computer time required for complex, large-scale yield optimization.

## ELEGANT USER INTERFACE

OSA90's user interface is elegant and friendly. It is menu-driven, offers on-line help messages and an on-line User's Manual. An integrated full screen editor facilitates the editing and parsing of input files. The syntax is logical and intuitive, and menu options are self-explanatory.

The polished graphical displays in OSA90 features user-selectable forms, formats and colors, zooming and graphics printing. The program can operate in interactive, macro, silent and background modes.

## ELEMENT LIBRARY

OSA90's nonlinear element library includes built-in and user-definable device models for FETs, bipolar transistors and diodes. Nonlinear voltage controlled current and charge sources with arbitrary controlling voltages allow you to create models with arbitrary topology and model equations.

The nonlinear library is designed to accommodate a wide variety of applications. The built-in models include the Curtice and Ettenberg FET model, the Raytheon (Statz *et al.*) FET model, the Materka and Kacprzak FET model, the Khatibzadeh and Trew physics-based FET model, and the Gummel and Poon bipolar transistor model. These models have been coded for optimal efficiency and compatibility. The user-definable models offer you the flexibility from customizing existing models to creating totally unique models. OSA90 allows you to create, test, verify, modify and optimize circuit models easily.

The linear element library includes a number of typical components, such as resistors, capacitors, inductors, transmission lines and controlled sources. You can also import arbitrary linear subcircuits described by their S/Y/Z matrices through data files and/or Datapipes.

## WARRANTY

As a user of OSA90, you can rely on the expedient and professional support from our technical experts, including authors of the program.

With your acquisition of OSA90 you are entitled to a standard 90 day warranty. An option of extended maintenance and free software upgrades is also available.

## CONSULTING SERVICES

Consulting and customization services are offered by *Optimization Systems Associates*. Such services may include implementing specific features and models in your copy of OSA90, or creating software solutions to your specifications.

## PLATFORMS AND AVAILABILITY

OSA90 is available on Hewlett-Packard, Apollo and Sun workstations. For further information please call or write.

Optimization Systems Associates Inc.
P.O. Box 8083, Dundas, Ontario
Canada L9H 5E7

Tel 416 628 8228 Fax 416 628 8225

# OSA90/hope™
## Version 2.0 Technical Brief

### INTRODUCTION

**OSA90/hope™** is a general CAD software system offering simulation, modeling, statistical analysis, and nominal and yield optimization for linear and nonlinear analog circuits. It has an open architecture allowing you to integrate external programs into its design optimization framework.

### BUILT-IN CIRCUIT SIMULATION

**Hope** simulates linear and nonlinear circuits of general n-port topology. Multiple nonlinear devices and sources, both DC and AC, are allowed. Built-in simulators handle DC, small-signal AC, large-signal harmonic balance and two-tone spectral analyses.

**Hope**'s DC, small-signal and large-signal simulations are analytically unified through a consistent circuit description. Small-signal circuits, when needed, are automatically derived from nonlinear models.

The available built-in responses include DC and AC voltages and currents at all external ports, as well as voltages at designated nodes. Small-signal analysis produces S parameters. For 2-ports, **hope** calculates insertion loss, stability factor and maximum available gain. The simulation ranges can be defined through frequency, power, or arbitrary multi-parameter sweeps.

### EXPRESSION COMPOSITION

**Hope** supports expression composition directly in the input file. You can define constants, variables, vectors and matrices. You define expressions using typical algebraic operations and mathematical functions. In this way you link variables, describe model equations, postprocess responses and create user-defined functions. Your expressions can even include implicit calculations such as solving a set of linear equations. All variables, vectors or matrices defined by you in the input file become available for simulation, optimization and display.

In addition to all standard mathematical functions, useful transformations, e.g., the Discrete Fourier Transform, are available for creating expressions. Conditional expressions (nested IF ELSE structures) are supported as well.

### DATAPIPE™ TECHNOLOGY

**Hope** is equipped with several Datapipe protocols ready to connect external programs through UNIX interprocess pipes. This facilitates high-speed data connections to external *executable* programs. It is especially suitable for sensitive software since you do not need to reveal the source code.

Datapipes are flexibly defined in the input file. You specify a set of inputs from **hope** to the external program and define outputs to be returned. **Hope** starts the external programs in separate processes, and communicates with them in a manner similar to subroutine calls.

You can add **hope**'s friendly user interface, graphics, expression parser, optimization and statistical features to your own software. You can link several separate programs through **hope** to design a functionally integrated system as your own "total CAE solution".

### DRIVE SPICE AND em™ THROUGH DATAPIPE

**Hope** is supplied with Datapipe-ready interfaces to an optimization-structured version of the popular circuit simulator SPICE and to the electromagnetic simulator **em** from Sonnet Software, Inc. This augments the built-in simulation capabilities of **hope** by, for example, time-domain and noise calculations of SPICE and by full-wave three-dimensional analysis of **em**. It provides you with design optimization features for these programs. You can, for example, perform direct field-level design of microstrip structures under circuit-level nonlinear analysis.

The interfaces can be modified to suit your particular needs, or can be used as templates for connections to other software systems you may be interested in.

### POWERFUL OPTIMIZERS

**Hope** features powerful and robust gradient-based optimizers: $\ell_1$, $\ell_2$, minimax, quasi-Newton, conjugate gradient, as well as non-gradient simplex and random optimizers. These optimizers offer unrivalled accuracy and efficiency. Optimization variables can include circuit parameters, bias voltages, input power levels, inputs to Datapipe external programs and abstract variables. You can optimize built-in and user-defined circuit responses, Datapipe outputs and abstract error functions. You can define upper, lower and equality specifications. You can also assign weighting factors.

**Hope**'s optimizers have proven track records in circuit optimization. Minimax optimization is most suitable for design applications (filters, amplifiers, etc.). The $\ell_1$ optimizer is uniquely robust in solving data fitting and circuit modeling problems. For nonlinear circuits, the gradients are computed using accurate FAST™ adjoint sensitivities.

## SENSITIVITY ANALYSIS

The extremely useful feature of sensitivity analysis can assist you, via easy-to-understand graphical display, in selecting the most crucial parameters for optimization.

## FLEXIBLE ELEMENT LIBRARY

The linear element library includes a comprehensive set of microstrip components, including typical discontinuities, and a number of lumped elements such as resistors, capacitors, inductors and controlled sources. You can also import arbitrary linear subcircuits described by their S/Y/Z matrices through data files and/or Datapipes.

**Hope**'s nonlinear element library includes built-in and user-definable device models for FETs, bipolar transistors and diodes. All built-in library models are fully compatible with those in HarPE™ - a CAD parameter extraction software system from OSA.

The built-in nonlinear models include: the Curtice and Ettenberg FET, the Statz FET, the Materka and Kacprzak FET, the Khatibzadeh and Trew physics-based FET, the physics-based KTL (Trew/Ladbrooke) FET, and the Gummel and Poon bipolar transistor, and semiconductor diode. These models have been coded for optimal efficiency and compatibility.

The user-definable models offer you flexibility from customizing existing models to creating totally unique models. Expressions for a number of other models have been pre-programmed for immediate inclusion in your input files and are supplied with **hope**. They comprise expressions for TriQuint's Own Model (TOM) and the Plessey model.

**Hope**'s unique nonlinear voltage controlled current and charge sources with arbitrary controlling voltages allow you to create models with arbitrary topology and model equations. In this way you can create, test, verify, modify and optimize your device models easily, efficiently and accurately.

## YIELD SIMULATION AND OPTIMIZATION

First-pass design success can be greatly improved by **hope**'s features of statistical Monte Carlo analysis and yield optimization. User-identified parameters can be subject to uniform, normal, exponential and lognormal distributions with absolute or relative tolerances. Hierarchical, correlated and non-standard distributions are also supported. Monte Carlo analysis estimates the yield and displays various diagrams, including histograms, run charts and parameter sweeps.

**Hope** employs a sophisticated one-sided $\ell_1$ design centering algorithm to optimize the simulated yield. An advanced quadratic approximation scheme is available to reduce the computer time required for complex, large-scale yield optimization.

## ELEGANT USER INTERFACE

**Hope**'s user interface is elegant and friendly. It is menu-driven, offers on-line help messages and an on-line User's Manual. An integrated full screen editor facilitates the editing and parsing of input files. The syntax is logical and intuitive, and menu options are self-explanatory.

The polished graphical display in **hope** features user-selectable forms, formats and colors, zooming and graphics printing. Rectangular, polar and Smith Chart plots are supported. User-definable views give you all the flexibility you need for documenting your results.

**Hope**'s macro features allow you to automate typical operations, introduce personalized keywords, functions and styles, or to accommodate the syntax of other programs.

The program can operate in interactive, macro, silent and background modes.

## WARRANTY

With your acquisition of **hope** you are entitled to a 90 day limited warranty. A software support option which includes software upgrades is also available.

As a user of **hope**, you can rely on professional and timely support from our technical experts, including authors of the program.

## OTHER PRODUCTS FROM OSA

HarPE™ is a well established software system for single device simulation and optimization with particular emphasis on parameter extraction and statistical device modeling.

*Optimization Systems Associates Inc.* has been developing state-of-the-art CAE software and technologies since 1983.

*Optimization Systems Associates Inc.* offers consulting and customization services. Such services may include implementing specific features and models in your copy of **hope**, or creating software solutions to your specifications.

## PLATFORMS AND AVAILABILITY

**Hope** is available on Hewlett-Packard, Apollo and Sun workstations. For further information contact

*Optimization Systems Associates Inc.*
P.O. Box 8083, Dundas, Ontario
Canada L9H 5E7

Tel 416 628 8228 Fax 416 628 8225

# OSA90/hope™
## Version 2.5 Technical Brief

### INTRODUCTION

**OSA90/hope™** is a general CAD software system offering simulation, modeling, statistical analysis, and nominal and yield optimization for linear and nonlinear analog circuits. Its open architecture allows you to create fully optimizable interconnections of components, subcircuits, simulators and mathematical functions.

### BUILT-IN CIRCUIT SIMULATION

**Hope** simulates linear and nonlinear circuits of general n-port topology. Multiple nonlinear devices and sources, both DC and AC, are allowed. Built-in simulators handle DC, small-signal AC, large-signal harmonic balance and two-tone spectral analyses. You can use **hope** for oscillator analysis and design.

**Hope**'s DC, small-signal and large-signal simulations are analytically unified through a consistent circuit description. Small-signal circuits, when needed, are automatically derived from nonlinear models.

Available built-in responses include DC and AC voltages, currents and output powers at all external ports, voltages at designated nodes and currents in designated branches. Small-signal analysis produces S, Y and Z parameters, and group delay. For 2-ports, **hope** calculates insertion loss, stability factor and maximum available gain. The simulation ranges can be defined through frequency, power, or arbitrary multi-parameter sweeps.

### EXPRESSION COMPOSITION

**Hope** supports expression composition directly in the input file. You can define constants, variables, vectors and matrices. You define expressions using typical algebraic operations and mathematical functions. In this way you link variables, describe model equations, postprocess responses and create user-defined functions. Your expressions can even include implicit calculations such as solving a set of linear equations. All variables, vectors or matrices defined by you in the input file become available for simulation, optimization and display.

In addition to all standard mathematical functions, useful transformations, e.g., the Discrete Fourier Transform, and interpolation routines, e.g. 1D and 2D cubic splines, are available for creating expressions. Conditional expressions (nested IF ELSE structures) are also supported.

### DATAPIPE™ TECHNOLOGY

**Hope** is equipped with several Datapipe protocols ready to connect external programs through UNIX interprocess pipes. This facilitates high-speed data connections to external *executable* programs, even across networks. It is especially suitable for sensitive software since you do not need to reveal the source code.

Datapipes are flexibly defined in the input file. You specify a set of inputs from **hope** to the external program and define outputs to be returned. **Hope** starts the external programs in separate processes, and communicates with them in a manner similar to subroutine calls. You can invoke **hope** itself through Datapipe to create a simulation/optimization hierarchy of virtually unlimited depth.

You can add **hope**'s friendly user interface, graphics, expression parser, optimization and statistical features to your own software. You can link several separate programs through **hope** to design a functionally integrated system as your own "total CAE solution".

### DRIVE SPICE AND *em*™ THROUGH DATAPIPE

**Hope** is supplied with Datapipe-ready interfaces to an optimization-structured version of the popular circuit simulator SPICE and to the electromagnetic simulator ***em*** from Sonnet Software, Inc. An extensive library of parametrized microstrip components makes ***em*** readily available for design optimization. Refer to the **Empipe™ Technical Brief** for complete details.

The interfaces can be modified to suit your particular needs, or can be used as templates for connections to other software systems you may be interested in.

### POWERFUL OPTIMIZERS

**Hope** features powerful and robust gradient-based optimizers: $\ell_1$, $\ell_2$, Huber, minimax, quasi-Newton, conjugate gradient, as well as non-gradient simplex and random optimizers. These optimizers offer unrivalled accuracy and efficiency. Optimization variables can include circuit parameters, bias voltages, input power levels, inputs to Datapipe external programs and abstract variables. You can optimize built-in and user-defined circuit responses, Datapipe outputs and abstract error functions. You can define upper, lower and equality specifications. You can also assign weighting factors.

## ELEMENT LIBRARY

The linear element library includes a comprehensive set of microstrip components, including typical discontinuities, and a number of lumped elements such as resistors, capacitors, inductors and controlled sources. You can also import arbitrary linear subcircuits described by their S/Y/Z matrices through data files, arrays and/or Datapipes.

**Hope**'s nonlinear element library includes built-in and user-definable device models for FETs, bipolar transistors and diodes. All built-in library models are fully compatible with those in HarPE™ - a CAD parameter extraction software system from OSA.

The built-in nonlinear models include: the Curtice FET (both symmetrical and asymmetrical), the Statz FET, the Materka and Kacprzak FET, the Khatibzadeh and Trew physics-based FET, the physics-based KTL (Trew/Ladbrooke) FET, and the Gummel and Poon bipolar transistor, and semiconductor diode. These models have been coded for optimal efficiency.

## FLEXIBLE MODELING

One of **hope's** most widely acclaimed features is its modeling flexibility. Linear subcircuits can be created and reused. Unlike conventional simulators, you can define parameterized elements and use them just like library elements.

**Hope**'s unique nonlinear voltage controlled current and charge sources with arbitrary controlling voltages allow you to create models with arbitrary topology and model equations. In this way you can create, test, verify, modify and optimize your device models easily, efficiently and accurately. Expressions for a number of device models, including TriQuint's Own Model (TOM) and the Plessey model, have been pre-programmed for immediate inclusion in your input files, and are supplied with **hope**. All such models are suitable for both DC and AC simulations.

## YIELD SIMULATION AND OPTIMIZATION

First-pass design success can be greatly improved by **hope**'s features of statistical Monte Carlo analysis and yield optimization. User-identified parameters can be subject to uniform, normal, exponential and lognormal distributions with absolute or relative tolerances. Hierarchical, correlated and non-standard distributions are also supported. Monte Carlo analysis estimates the yield and displays various diagrams, including histograms, run charts and parameter sweeps.

**Hope** employs a sophisticated one-sided $\ell_1$ design centering algorithm to optimize the simulated yield. An advanced quadratic approximation scheme is available to reduce the computer time required for complex, large-scale yield optimization.

## ELEGANT USER INTERFACE

**Hope**'s user interface is elegant and friendly. It is menu-driven, offers on-line help messages and an on-line User's Manual. An integrated full screen editor facilitates the editing and parsing of input files. The syntax is logical and intuitive, and menu options are self-explanatory.

The polished graphical display in **hope** features user-selectable forms, formats and colors, zooming and graphics printing. Rectangular, polar and Smith Chart plots are supported. User-definable views give you all the flexibility you need for documenting your results. Documentation tools include a report generator and HPGL graphical output.

**Hope**'s macro features allow you to automate typical operations, introduce personalized keywords, functions and styles, or to accommodate the syntax of other programs. The program can operate in interactive, macro, silent and background modes, or can be invoked through Datapipe.

## WARRANTY

With your acquisition of **hope** you are entitled to a 90 day limited warranty. A software support option which includes software upgrades is also available.

As a user of **hope**, you can rely on professional and timely support from our technical experts, including authors of the program.

## OTHER PRODUCTS FROM OSA

HarPE™ is a well established software system for single device simulation and optimization with particular emphasis on parameter extraction and statistical device modeling. Empipe™ interfaces OSA90/hope with ***em*** from Sonnet Software, Inc. It is an add-on module to OSA90/hope.

*Optimization Systems Associates Inc.* offers consulting and customization services. Such services may include implementing specific features and models in your copy of **hope**, or creating software solutions to your specifications.

## PLATFORMS AND AVAILABILITY

**Hope** runs under X windows on Hewlett-Packard, and Sun workstations. For further information contact

*Optimization Systems Associates Inc.*
P.O. Box 8083, Dundas, Ontario
Canada L9H 5E7

Before Oct. 4/93 Tel 416 628 8228 Fax 416 628 8225
After Oct. 4/93 Tel 905 628 8228 Fax 905 628 8225

# OSA90/hope™
## Version 3.0 Technical Brief

### INTRODUCTION

**OSA90/hope™** is a general CAD software system offering simulation, modeling, statistical analysis, nominal and yield optimization, and data visualization for linear and nonlinear analog circuits. Its open architecture allows you to create fully optimizable interconnections of components, subcircuits, simulators and mathematical functions.

### CIRCUIT SIMULATION

**OSA90** simulates linear and nonlinear circuits of general n-port topology. Multiple nonlinear devices and sources, both DC and AC, are allowed. Built-in simulators handle DC, small-signal AC, large-signal harmonic balance and two-tone spectral analyses. **OSA90** supports oscillator analysis and design.

The DC, small-signal and large-signal simulations are analytically unified through a consistent circuit description. Small-signal circuits, when needed, are automatically derived from nonlinear models.

Available built-in responses include DC and AC voltages, currents and output powers at all external ports, voltages at designated nodes and currents in designated branches. Small-signal analysis produces *S*, *Y* and *Z* parameters, and group delay. For 2-ports, **OSA90** calculates insertion loss, stability factor and maximum available gain. Frequency, power and arbitrary multi-parameter sweeps can be defined for simulation.

### EXPRESSION COMPOSITION

**OSA90** supports expression composition directly in the input file. You can define constants, variables, vectors and matrices. You define expressions using typical algebraic operations and a rich set of built-in mathematical functions, including array operations. You can define interdependent variables, describe model equations, postprocess responses and create user-defined functions. All user-defined variables and functions can be used for optimization.

Even complicated operations such as solving a set of linear equations, finding eigenvalues, the Discrete Fourier Transform, cubic spline interpolation, and estimating data statistics are available as built-in functions. Conditional expressions (IF ELSE structures) are also supported.

### DATAPIPE™ TECHNOLOGY

**OSA90** is equipped with several Datapipe protocols for connecting external programs through UNIX interprocess pipes. This facilitates high-speed data connections to external *executable* programs, even across networks. It is especially suitable for sensitive software since you do not need to reveal the source code.

Datapipes are flexibly defined in the input file. You specify a set of inputs from **OSA90** to the external program and define outputs to be returned. **OSA90** starts the external programs in separate processes, and communicates with them in a manner similar to subroutine calls. You can invoke **OSA90** itself through Datapipe to create a simulation/optimization hierarchy of virtually unlimited depth.

You can enhance your own software with **OSA90**'s friendly user interface, graphics, expression parser, optimization and statistical features. You can link several separate programs through **OSA90** to design a functionally integrated system as your own "total CAE solution".

### DRIVE SPICE AND *em*™ THROUGH DATAPIPE

Specialized Datapipe interfaces are available for the popular analog circuit simulator SPICE and the electromagnetic simulator ***em*** from Sonnet Software, Inc. An extensive library of parameterized microstrip components and user-parameterized arbitrary structures allow you to employ ***em*** in design optimization. Refer to the **Empipe™ Technical Brief** for complete details.

The interfaces can be modified to suit your particular needs, or can be used as templates for connections to other software systems you may be interested in.

### POWERFUL OPTIMIZERS

**OSA90** features powerful and robust gradient-based optimizers: $\ell_1$, $\ell_2$, Huber, minimax, quasi-Newton, conjugate gradient, as well as non-gradient simplex and random optimizers. These optimizers offer unrivalled accuracy and efficiency.

Optimization variables can include circuit parameters, bias voltages, input power levels, inputs to Datapipe external programs and abstract variables. You can optimize built-in and user-defined circuit responses, Datapipe outputs and abstract error functions. You can define upper, lower and equality specifications. You can also assign weighting factors.

## ELEMENT LIBRARY

The linear element library includes the typical lumped elements, a comprehensive set of microstrip components and controlled sources. You can also import linear subcircuit *S*, *Y* and *Z* matrices through data files, arrays and Datapipes.

The nonlinear device model library includes built-in and user-definable models for diodes, FETs, bipolar transistors and HEMTs, including the Curtice FET (both symmetrical and asymmetrical), the Statz FET, the Materka and Kacprzak FET, the Khatibzadeh and Trew physics-based FET, the physics-based KTL (Trew/Ladbrooke) FET, the Gummel and Poon bipolar model, and HEMT models (HOBD, DP, Curtice) provided by Golio (Motorola).

## FLEXIBLE MODELING

One of **OSA90**'s most widely acclaimed features is its modeling flexibility. Linear subcircuits, *with user-definable parameters*, can be created and reused.

Nonlinear controlled current and charge sources with arbitrary controlling voltages/currents allow you to create models with unrestricted topology and model equations. A number of models, including TriQuint's Own Model (TOM) and the Plessey model, are supplied. **OSA90** has been widely used to create, test, verify and optimize new and/or proprietary models, such as HEMT models, temperature-dependent HBT models, and CNN-based models.

## YIELD SIMULATION AND OPTIMIZATION

**OSA90**'s statistical Monte Carlo analysis and yield optimization features can help you to greatly improve first-pass design success. Parameters can be subject to uniform, normal, exponential and lognormal distributions with absolute or relative tolerances. Hierarchical, correlated and sample distributions are supported. Monte Carlo analysis estimates the yield and displays histograms, run charts, scattering diagrams, parameter sweeps and yield sensitivities.

**OSA90** employs sophisticated one-sided $\ell_1$ and one-sided Huber design centering algorithms for yield optimization. Advanced quadratic approximation is an integrated option to reduce the computer time required for large-scale yield optimization.

## 3D VISUALIZATION

Responses and functions can be plotted versus any two variables as 3D surfaces and contours. The 3D images can be zoomed, rotated, smoothed and colored. It is a great visual aid for revealing and illustrating function-variable dependence, clarifying design strategy and verifying optimization solutions.

## SPACE MAPPING

Space Mapping™ is a fundamental new theory exclusive to **OSA90** for linking "coarse" and "fine" models, such as empirical and EM models. Coarse models are used for fast optimization, and the optimal solution is mapped to the fine model space. When applied to direct EM optimization, the results can be astounding!

## USER INTERFACE

**OSA90** operates through a polished and friendly user interface in the industry-standard X-Windows environment. It is menu-driven, features an integrated full screen editor and offers on-line help and an on-line User's Manual. The syntax and menus are logical and intuitive.

Graphical views can be created to customize the displays. For documentation, **OSA90** can generate report, HPGL and PostScript files.

You can define macros to automate repetitive operations, and customize keywords and styles. You can run **OSA90** in macro and background modes.

## WARRANTY AND SUPPORT

With your acquisition of **OSA90** you are entitled to a 90 day limited warranty. A software support option which includes software upgrades is also available.

As a user of **OSA90**, you can rely on professional and timely support from our technical experts, including authors of the program.

## OTHER PRODUCTS FROM OSA

HarPE™ is the world's best commercial software system for device parameter extraction, simulation, optimization and statistical modeling.

*Optimization Systems Associates Inc.* offers consulting and customization services, to create software solutions to your specific needs.

## PLATFORMS AND AVAILABILITY

**OSA90** runs under X-Windows on Hewlett-Packard, and Sun workstations. For further information contact

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Canada L9H 5E7

Tel 905 628 8228
Fax 905 628 8225

# OSA90/hope™
## Version 3.1 Technical Brief

### INTRODUCTION

**OSA90/hope™** is a general CAD software system offering simulation, modeling, statistical analysis, nominal and yield optimization, and data visualization for linear and nonlinear analog circuits. Its open architecture allows you to create fully optimizable interconnections of components, subcircuits, simulators and mathematical functions.

### CIRCUIT SIMULATION

**OSA90** simulates linear and nonlinear circuits of general n-port topology. Multiple nonlinear devices and sources, both DC and AC, are allowed. Built-in simulators handle DC, small-signal AC, large-signal harmonic balance and two-tone spectral analyses. **OSA90** supports oscillator analysis and design.

The DC, small-signal and large-signal simulations are analytically unified through a consistent circuit description. Small-signal circuits, when needed, are automatically derived from nonlinear models.

Available built-in responses include DC and AC voltages, currents and output powers at all external ports, voltages at designated nodes and currents in designated branches. Small-signal analysis produces *S*, *Y* and *Z* parameters, and group delay. For 2-ports, **OSA90** calculates insertion loss, stability factor and maximum available gain. Frequency, power and arbitrary multi-parameter sweeps can be defined for simulation.

### EXPRESSION COMPOSITION

**OSA90** supports expression composition directly in the input file. You can define constants, variables, vectors and matrices. You define expressions using typical algebraic operations and a rich set of built-in mathematical functions, including array operations. You can define interdependent variables, describe model equations, postprocess responses and create user-defined functions. All user-defined variables and functions can be used for optimization.

Even complicated operations such as solving a set of linear equations, finding eigenvalues, the Discrete Fourier Transform, cubic spline interpolation, piecewise linear interpolation, and estimating data statistics are available as built-in functions. Conditional expressions (IF ELSE structures) are also supported.

### DATAPIPE™ TECHNOLOGY

**OSA90** is equipped with several Datapipe protocols for connecting external programs through UNIX interprocess pipes. This facilitates high-speed data connections to external *executable* programs, even across networks.

Datapipes are flexibly defined in the input file. You specify a set of inputs from **OSA90** to the external program and define outputs to be returned. **OSA90** starts the external programs in separate processes, and communicates with them in a manner similar to subroutine calls. You can invoke **OSA90** itself through Datapipe to create a simulation/optimization hierarchy of virtually unlimited depth.

You can enhance your own software with **OSA90**'s friendly user interface, graphics, expression parser, optimization and statistical features. You can link several separate programs through **OSA90** to form a functionally integrated CAE system.

### DRIVE *em*™ AND SPICE THROUGH DATAPIPE

Specialized Datapipe interfaces are available for the electromagnetic simulator ***em*** from Sonnet Software, Inc. and the popular analog circuit simulator SPICE. **Empipe™** drives the field solver ***em*** for automated electromagnetic optimization, featuring our exclusive Geometry Capture™ technology for optimizing user-defined arbitrary planar structures. Any structures that you can simulate using ***em*** you can now optimize using **Empipe**.

The interfaces can be modified to suit your particular needs, or can be used as templates for connections to other software systems you may be interested in.

### POWERFUL OPTIMIZERS

**OSA90** features powerful and robust gradient-based optimizers: $\ell_1$, $\ell_2$, Huber, minimax, quasi-Newton, conjugate gradient, as well as non-gradient simplex and random optimizers. These optimizers offer unrivalled accuracy and efficiency.

Optimization variables can include circuit parameters, bias voltages, input power levels, inputs to Datapipe external programs and abstract variables. You can optimize built-in and user-defined circuit responses, Datapipe outputs and abstract error functions.

Upper, lower and equality specifications can be defined using a convenient graphical editor right on the screen display of the response of interest.

## ELEMENT LIBRARY

The linear element library includes the typical lumped elements, a comprehensive set of microstrip components and controlled sources. You can import linear subcircuits defined by *S, Y* and *Z* matrices, or calculated on-line by external simulators through Datapipe. *S*-parameter data files in the Touchstone® format can be directly included.

The nonlinear device model library includes built-in and user-definable models for diodes, FETs, bipolar transistors, HEMTs and HBTs, including the Curtice FET (both symmetrical and asymmetrical), the Statz FET, the Materka and Kacprzak FET, the Khatibzadeh and Trew physics-based FET, the physics-based KTL (Trew/Ladbrooke) FET, the Gummel and Poon bipolar model, and HEMT models (HOBD, DP, Curtice) provided by Golio (Motorola).

## FLEXIBLE MODELING

One of **OSA90**'s most widely acclaimed features is its modeling flexibility. Linear subcircuits, *with user-definable parameters*, can be created and reused.

Nonlinear controlled current and charge sources with arbitrary controlling voltages/currents allow you to create models with unrestricted topology and model equations. A number of models, including TriQuint's Own Model (TOM) and the Plessey model, are supplied. **OSA90** has been widely used to create, test, verify and optimize new and/or proprietary models, such as HEMT models, temperature-dependent HBT models, and CNN-based models.

## YIELD SIMULATION AND OPTIMIZATION

**OSA90**'s statistical Monte Carlo analysis and yield optimization features can help you to greatly improve first-pass design success. You can define uniform, normal, exponential and lognormal distributions with absolute or relative tolerances. Hierarchical, correlated and sample distributions are supported. Monte Carlo analysis estimates the yield and displays histograms, run charts, scattering diagrams, parameter sweeps and yield sensitivities.

**OSA90** employs sophisticated one-sided $\ell_1$ and one-sided Huber design centering algorithms for yield optimization. Advanced quadratic approximation is an integrated option to reduce the computer time required for large-scale yield optimization.

## 3D VISUALIZATION

Responses and functions can be plotted versus any two variables as 3D surfaces and contours. The 3D images can be zoomed, rotated, smoothed and colored. It is a great visual aid for revealing and illustrating function-variable dependence, clarifying design strategy and verifying optimization solutions.

## SPACE MAPPING™

Space Mapping is a fundamental new theory exclusive to **OSA90** for linking "coarse" and "fine" models, such as empirical and EM models. Coarse models are used for fast optimization, and the optimal solution is mapped to the fine model space. When applied to direct EM optimization, the results can be astounding!

## USER INTERFACE

**OSA90** operates through a polished and friendly user interface in the X-Windows environment. It is menu-driven, features an integrated full screen editor and offers on-line help and an on-line User's Manual. The syntax and menus are logical and intuitive.

Graphical views can be created to customize the displays. For documentation, **OSA90** can generate report, HPGL and PostScript files.

You can define macros to automate repetitive operations, and customize keywords and styles. You can run **OSA90** in macro and background modes.

## WARRANTY AND SUPPORT

With your acquisition of **OSA90** you are entitled to a 90 day limited warranty. A software support option which includes software upgrades is also available.

As a user of **OSA90**, you can rely on professional and timely support from our technical experts, including authors of the program.

## OTHER PRODUCTS FROM OSA

**HarPE™** is the world's best commercial software system for device parameter extraction, simulation, optimization and statistical modeling.

**Empipe™** is the world's only software system directly driving Sonnet Software's ***em*** for fully automated electromagnetic optimization, featuring Geometry Capture for user-defined arbitrary planar structures.

## PLATFORMS AND AVAILABILITY

**OSA90** runs under X-Windows on Hewlett-Packard, Sun and DEC workstations. For further information contact

*Optimization Systems Associates Inc.*
P.O. Box 8083, Dundas, Ontario
Canada L9H 5E7

Tel 905 628 8228
Fax 905 628 8225

# OSA90/hope™
## Version 4.0 Technical Brief

### INTRODUCTION

**OSA90/hope™** is a general CAD software system offering simulation, modeling, statistical analysis, nominal and yield optimization, and data visualization for linear and nonlinear analog circuits. Its open architecture allows you to create fully optimizable interconnections of components, subcircuits, simulators and mathematical functions.

### CIRCUIT SIMULATION

**OSA90** simulates linear and nonlinear circuits of general n-port topology. Multiple nonlinear devices and sources, both DC and AC, are allowed. Built-in simulators handle DC, small-signal AC, large-signal harmonic balance and two-tone spectral analyses. **OSA90** supports oscillator analysis and design.

The DC, small-signal and large-signal simulations are analytically unified through a consistent circuit description. Small-signal circuits, when needed, are automatically derived from nonlinear models.

Available built-in responses include DC and AC voltages, currents and output powers at all external ports, voltages at designated nodes and currents in designated branches. Small-signal analysis produces *S, Y* and *Z* parameters, and group delay. For 2-ports, **OSA90** calculates insertion loss, stability factor and maximum available gain. Frequency, power and arbitrary multi-parameter sweeps can be defined for simulation.

### EXPRESSION COMPOSITION

**OSA90** supports expression composition directly in the input file. You can define constants, variables, vectors and matrices. You can create user-defined functions and postprocess responses using typical algebraic operations and a rich set of built-in mathematical functions. The built-in functions include operations such as solving linear equations, finding eigenvalues, the Discrete Fourier Transform, cubic spline interpolation, piecewise linear interpolation and estimating data statistics. Conditional expressions are also supported. All user-defined variables and functions can be used for optimization.

### DATAPIPE™ TECHNOLOGY

**OSA90** is equipped with several Datapipe protocols for connecting external programs through interprocess pipes. This facilitates high-speed data connections to external *executable* programs, even across networks. Datapipes are flexibly defined in the input file. You specify a set of inputs from **OSA90** to the external program and define outputs to be returned. **OSA90** starts the external programs in separate processes, and communicates with them in a manner similar to subroutine calls.

You can enhance your own software with **OSA90**'s friendly user interface, graphics, expression parser, optimization and statistical features. You can link several separate programs through **OSA90** to form a functionally integrated CAE system.

Specialized Datapipe-based interfaces exist for a number of applications, including the popular analog circuit simulator SPICE and several electromagnetic simulators (for example, Fritz Arndt's library of fast and accurate waveguide building blocks).

### POWERFUL OPTIMIZERS

**OSA90** features powerful and robust gradient-based optimizers: $\ell_1$, $\ell_2$, Huber, minimax, quasi-Newton, conjugate gradient, as well as non-gradient simplex, random and simulated annealing optimizers. These optimizers offer unrivalled accuracy and efficiency.

Optimization variables can include circuit parameters, bias voltages, input power levels, inputs to Datapipe external programs and abstract variables. You can optimize built-in and user-defined circuit responses, Datapipe outputs and abstract error functions. You can invoke **OSA90** itself through Datapipe to create a simulation/optimization hierarchy of virtually unlimited depth.

### SPACE MAPPING™ OPTIMIZATION

Space Mapping is a rapidly developing fundamental new theory for engineering design optimization. Exclusive to **OSA90**, it links "coarse" and "fine" models and is particularly useful in bringing design with CPU intensive simulators into a practical time frame. Coarse models, such as built-in **OSA90** empirical models, are used for fast optimization, and the optimal solution is mapped to the fine model space. When applied to direct EM optimization, the results can be astounding!

An automated algorithm for SM (Aggressive Space Mapping™) is implemented using a two-level Datapipe architecture: a generic layer of iterations creates and updates the mapping, while the parameter extraction phase aligns the specific models. You are given access to interactively control the accuracy and uniqueness of the parameter extraction process.

## ELEMENT LIBRARY

The linear element library includes typical lumped elements, a comprehensive set of microstrip components and controlled sources. You can import linear subcircuits defined by *S, Y* and *Z* matrices, or calculated on-line by external simulators through Datapipe. *S*-parameter data files in the Touchstone® format can be directly included.

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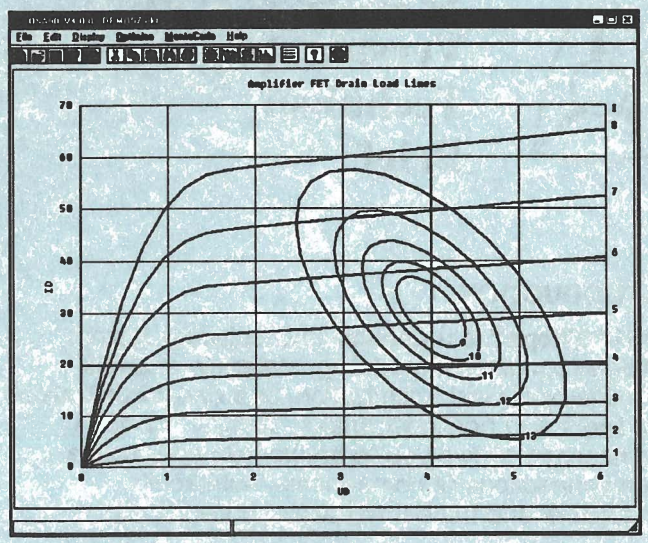
**OSA90**'s statistical Monte Carlo analysis and yield optimization features can help you to greatly improve first-pass design success. You can define uniform, normal, exponential and lognormal distributions with absolute or relative tolerances. Hierarchical, correlated and sample distributions are supported. Monte Carlo analysis estimates the yield and displays histograms, run charts, scattering diagrams, parameter sweeps and yield sensitivities.

**OSA90** employs sophisticated one-sided $\ell_1$ and one-sided Huber design centering algorithms for yield optimization. Advanced quadratic approximation is an integrated option to reduce the computer time required for large-scale yield optimization.

## 3D VISUALIZATION AND GRAPHICAL VIEWS

Responses and functions can be plotted versus any two variables as 3D surfaces and contours. The 3D images can be zoomed, rotated, smoothed and colored. It is a great visual aid for revealing and illustrating function-variable dependence, clarifying design strategy and verifying optimization solutions.

Customized displays can be created using Xsweep, Parametric, Waveform, Smith Chart and Polar Plot graphical views.




## OTHER PRODUCTS FROM OSA

**HarPE**™ is a well established software system for device parameter extraction, simulation, optimization and statistical modeling.

OSA's family of electromagnetic optimization products helps engineers to get the most out of electromagnetic simulators by employing **OSA90** optimizers. **Empipe**™ and ***empath***™ are specifically designed to interact with Sonnet Software's ***em***™. **Empipe3D**™ drives Ansoft HFSS and HP HFSS. **Empipe** and **Empipe3D** are available directly from OSA. ***empath*** is distributed by Sonnet Software, Inc., as part of its integrated EM CAD suite.

## PLATFORMS AND SUPPORT

**OSA90** runs on PC platforms under Windows 95® and Windows NT®, and on UNIX workstations: Sun, Hewlett-Packard and DEC under X-Windows. **OSA90** comes with a 90 day limited warranty. A software support option which includes software upgrades is available. For further information contact

*Optimization Systems Associates Inc.*
P.O. Box 8083, Dundas, Ontario
Canada L9H 5E7

Tel 905 628 8228
Fax 905 628 8225
Email osa@osacad.com
URL http://www.osacad.com