PARAMETERIZATION THROUGH GEOMETRY CAPTURE

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Drafted by John Bandler for Niels Fache
August 24, 1998

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BC-98-6-V

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Background

we address the critical issue of parameterization of geometrical structures for the purpose of layout-based design, in particular automated EM optimization using HP HFSS

advances in computer hardware and software make EM optimization feasible through HP HFSS Designer, though still very CPU intensive for moderate size design problems

as algorithms and computers become faster we expect wider use of EM optimization in the future

Introduction

Geometry Capture facilitates user-parameterization, through graphical means, of arbitrary 2D and 3D geometrical structures

this makes it possible to optimize the shape and dimensions of geometrical objects

HP HFSS Designer performs optimization through automatically adjusting the user-defined parameters

Geometry Capture permits the implementation of explicit numerical bounds and implicit geometrical constraints

as the optimization process proceeds, revised structures must be automatically generated

each structure must be physically meaningful and should follow the designer's intention w.r.t. allowable modifications and possible limits

we leave the parameterization process to the user

Geometry Capture

a technical breakthrough for parameterization of arbitrary structures for EM optimization

a user-friendly tool to establish the mapping between the designable parameter values and the geometrical layout coordinates

automatic translation of the values of user-defined designable parameters to the layout description in terms of absolute coordinates

automatic translation of each new set of parameter values before invoking HP HFSS during optimization without the need of any schematic interruption

parameterizable parameters

- geometrical parameters
- dielectric layer parameters
- metallization parameters

Assigning Optimization Parameters

the choice of designable (optimization) parameters should be left to the designer

designers know best what changes to the object are desired and allowable

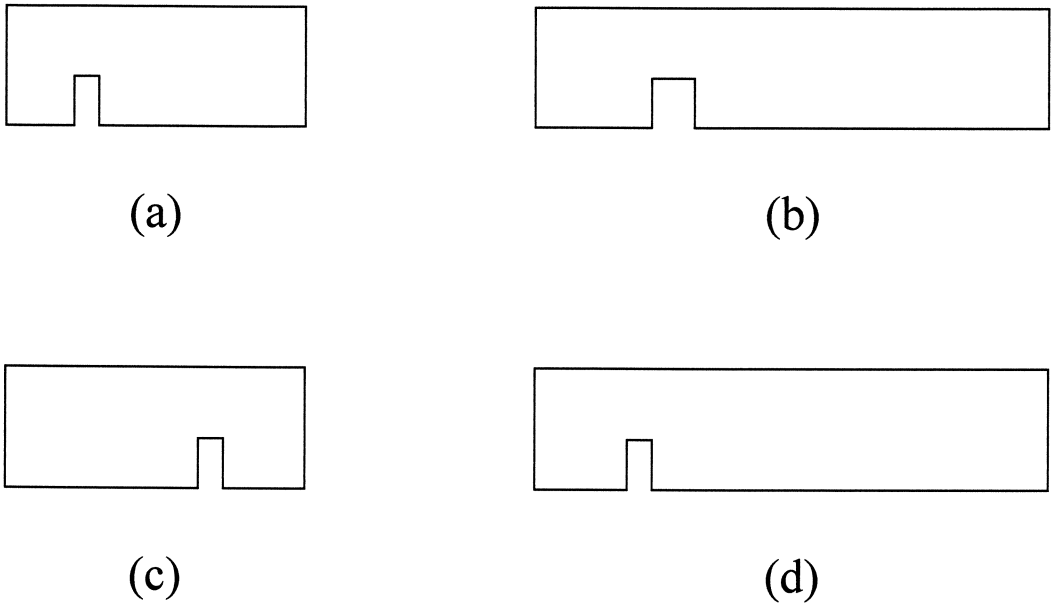
the process is intuitive and depends on experience, but some rules should be to followed

- select as few optimization parameters as possible
- the optimization parameters must be consistent
- understand the evolution of the designable object

the parameter values, as seen by the optimizer, are intermediate to the process of generating actual layouts

parameter transformations such as scaling or normalization can be used to link the optimization parameters with the actual layout design parameters

Various Object Evolutions



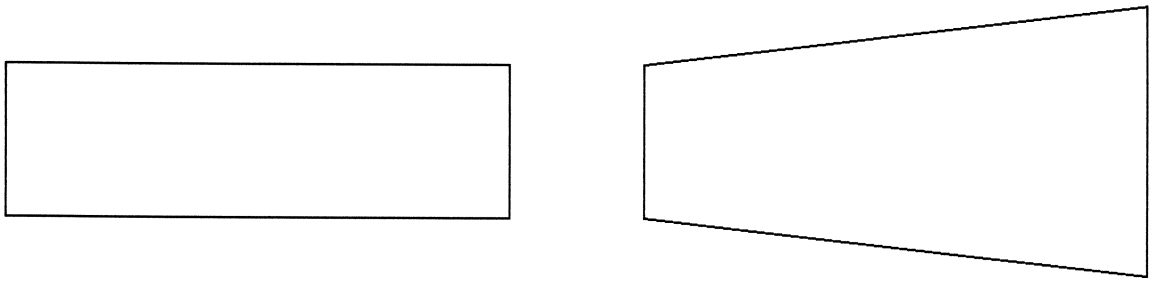
(a) initial geometry

(b) proportional expansion of the whole structure along the x axis

(c) only the location of the slit in the fixed line is allowed to change

(d) only the segment to the right of the slit is allowed to expand

Evolution of a Rectangle to a Tapered Line



one parameter controls the length of the right edge in a symmetric manner

Steps Example

we consider an element called “steps”, which has both dependent and independent parameters

there is “nominal” project called “steps_0” and two perturbed or incremental projects called “steps_1” and “steps_2”

there are many different ways of formulating parameterization in this example: only one such way is illustrated here

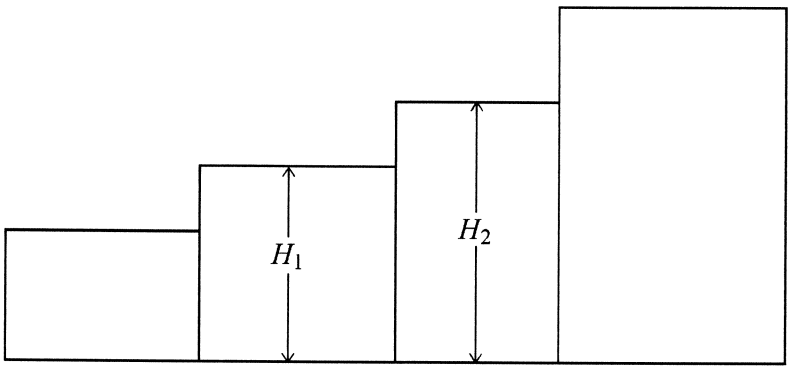
steps_1 varies an independent parameter H_1

steps_2 varies an independent parameter L_2

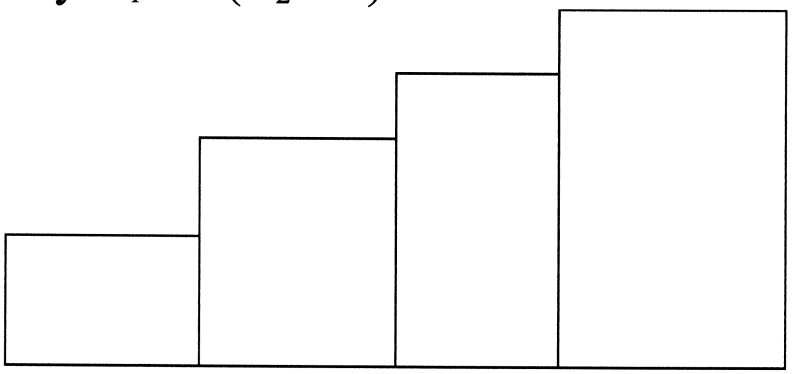
there are two dependent parameters H_2 and L_1

Dependent Parameter H_2

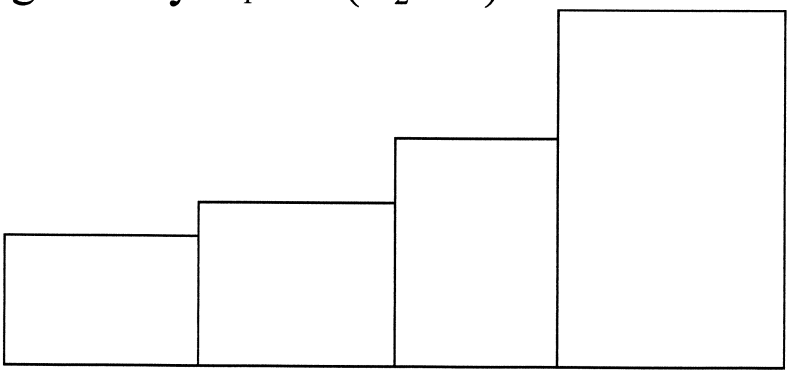
consider an independent optimization parameter H_1



initial geometry $H_1 = 6$ ($H_2 = 8$)



incremental geometry $H_1 = 7$ ($H_2 = 9$)

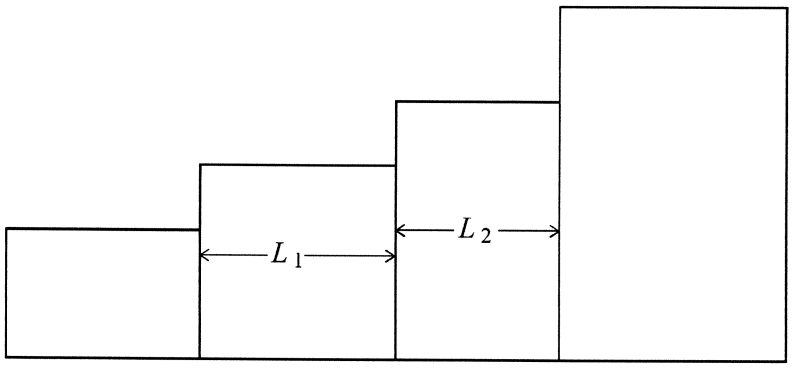


possible outcome $H_1 = 5$ ($H_2 = 7$)

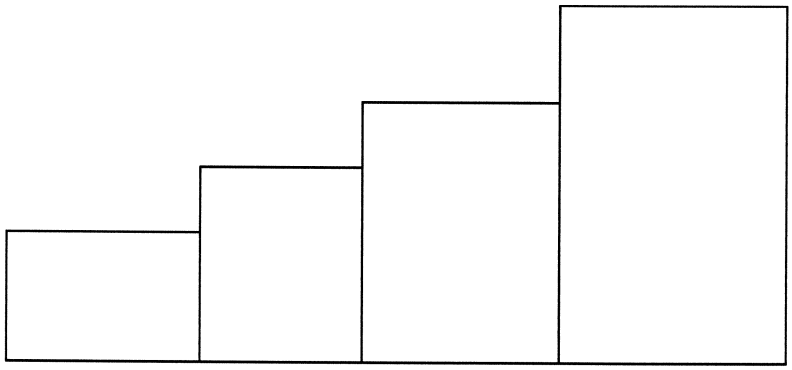
here $4 < H_1 < 9$, $6 < H_2 < 11$, $H_2 = H_1 + 2$

Dependent Parameter L_1

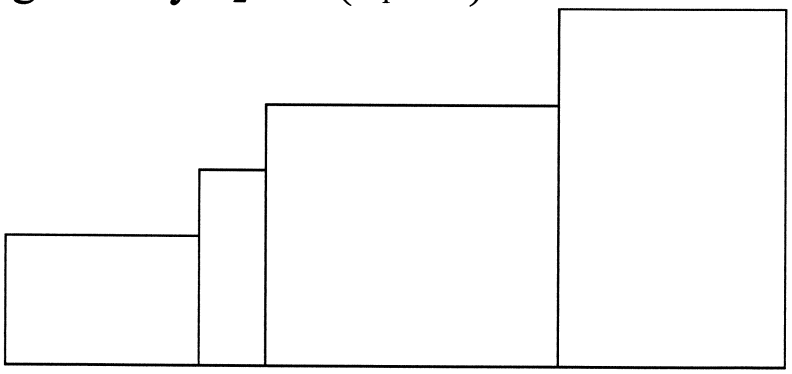
consider an independent optimization parameter L_2



initial geometry $L_2 = 5$ ($L_1 = 6$)



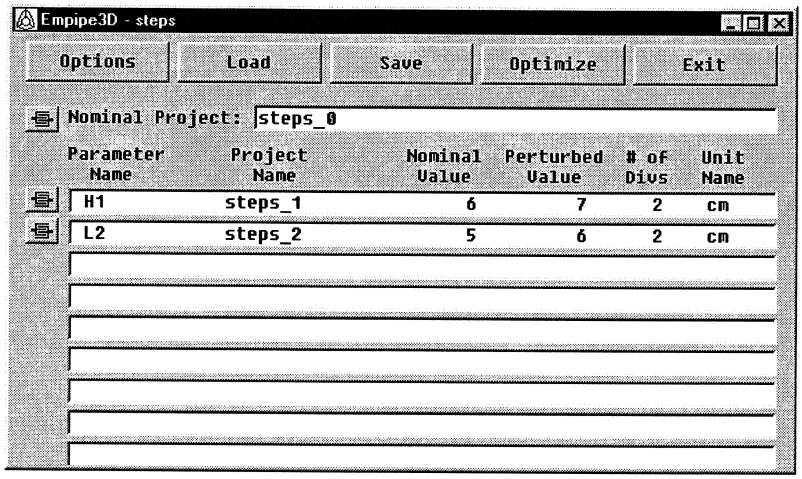
incremental geometry $L_2 = 6$ ($L_1 = 5$)



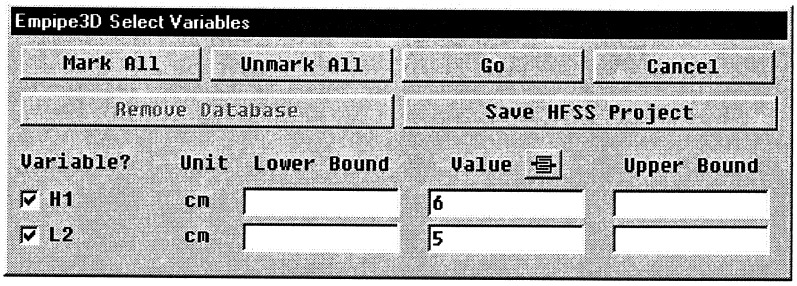
possible outcome $L_2 = 9$ ($L_1 = 2$)

here $0 < L_1 < 11$, $0 < L_2 < 11$, $L_1 + L_2 = 11$

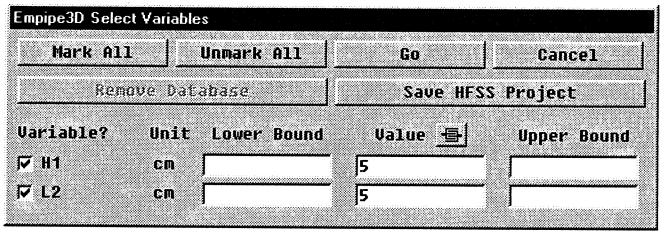
Geometry Capture Form Editor for Steps Example



Window for Selecting Optimization Parameters and Bounds for Steps Example

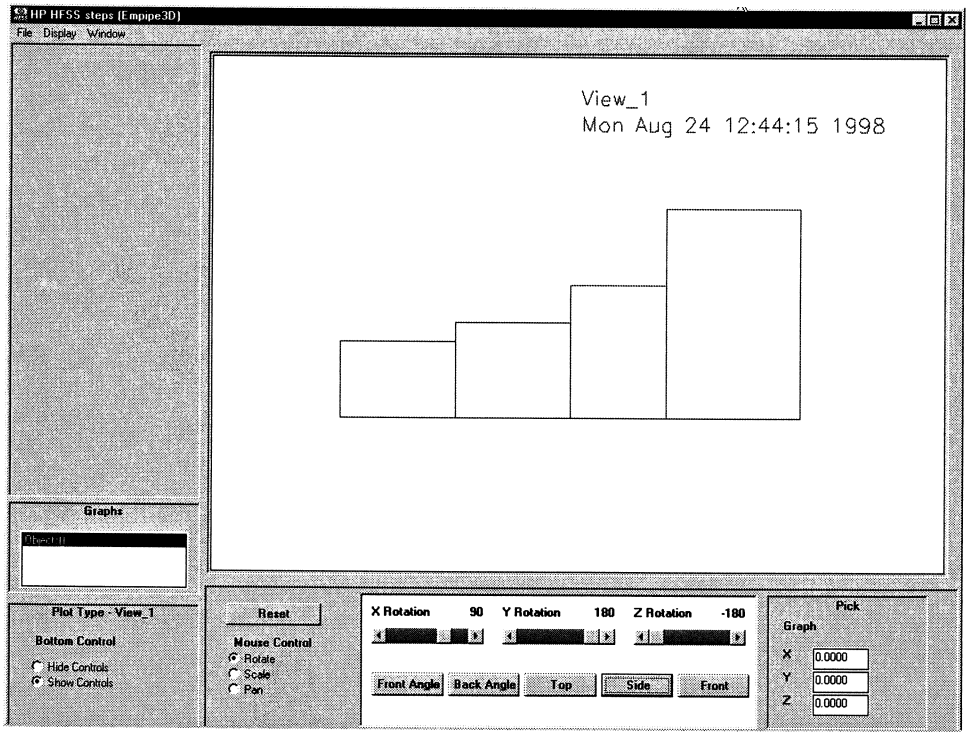


Window Showing Possible Outcome $H_1 = 5$

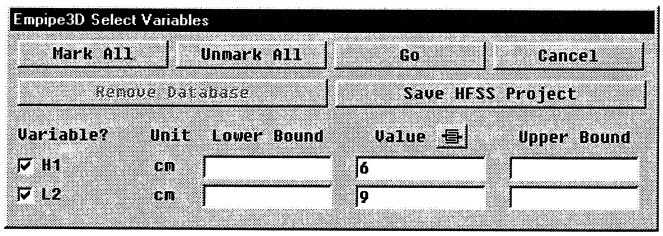


Corresponding Solid Model

notice that $H_2 = H_1 + 2 = 7$

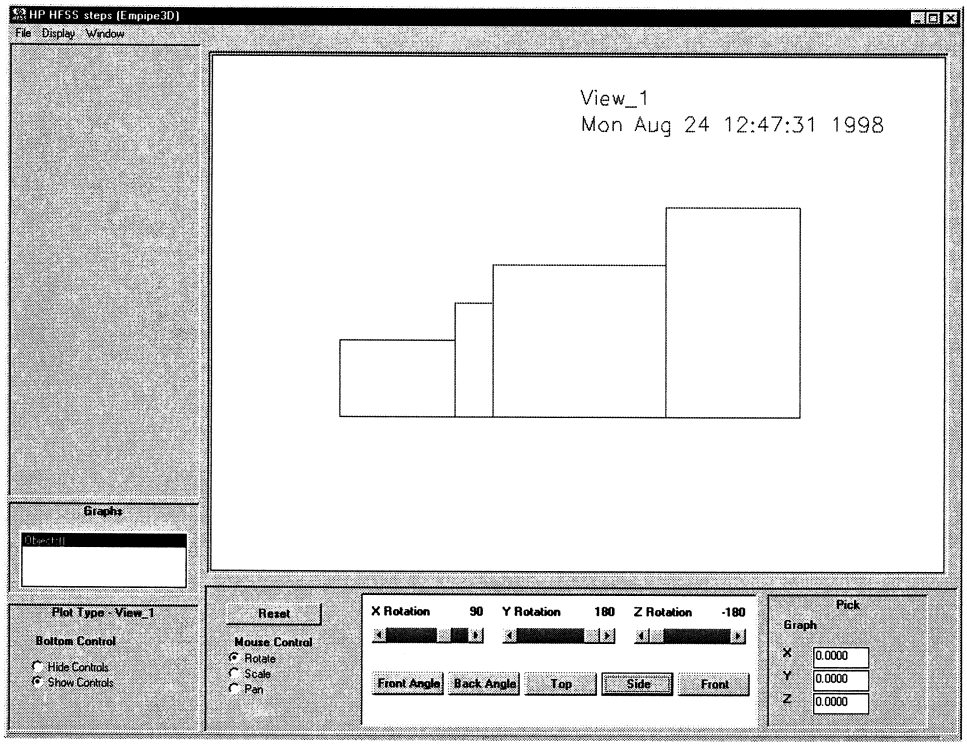


Window Showing Possible Outcome $L_2 = 9$



Corresponding Solid Model

notice that the overall length remains constant with value 11



Discretization of Optimization Parameters

parameter discretization is desirable to take advantage of techniques that facilitate efficiency

- utilization of a data base of already simulated structures
- efficient response interpolation and modeling
- efficient gradient evaluation, handling of tolerances, efficient model evaluation in Monte Carlo analysis and yield-driven design

Conclusions

we presented the concept of parameterization of arbitrary geometrical structures for automated layout-based design using HP HFSS

certain assumptions keep the technique simple and manageable

parameterized structures can be saved and reused