Agilent Technologies

Advanced Design System 2011.01

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Sensitivity Analysis

Acknowledgments

About Sensitivity Analysis

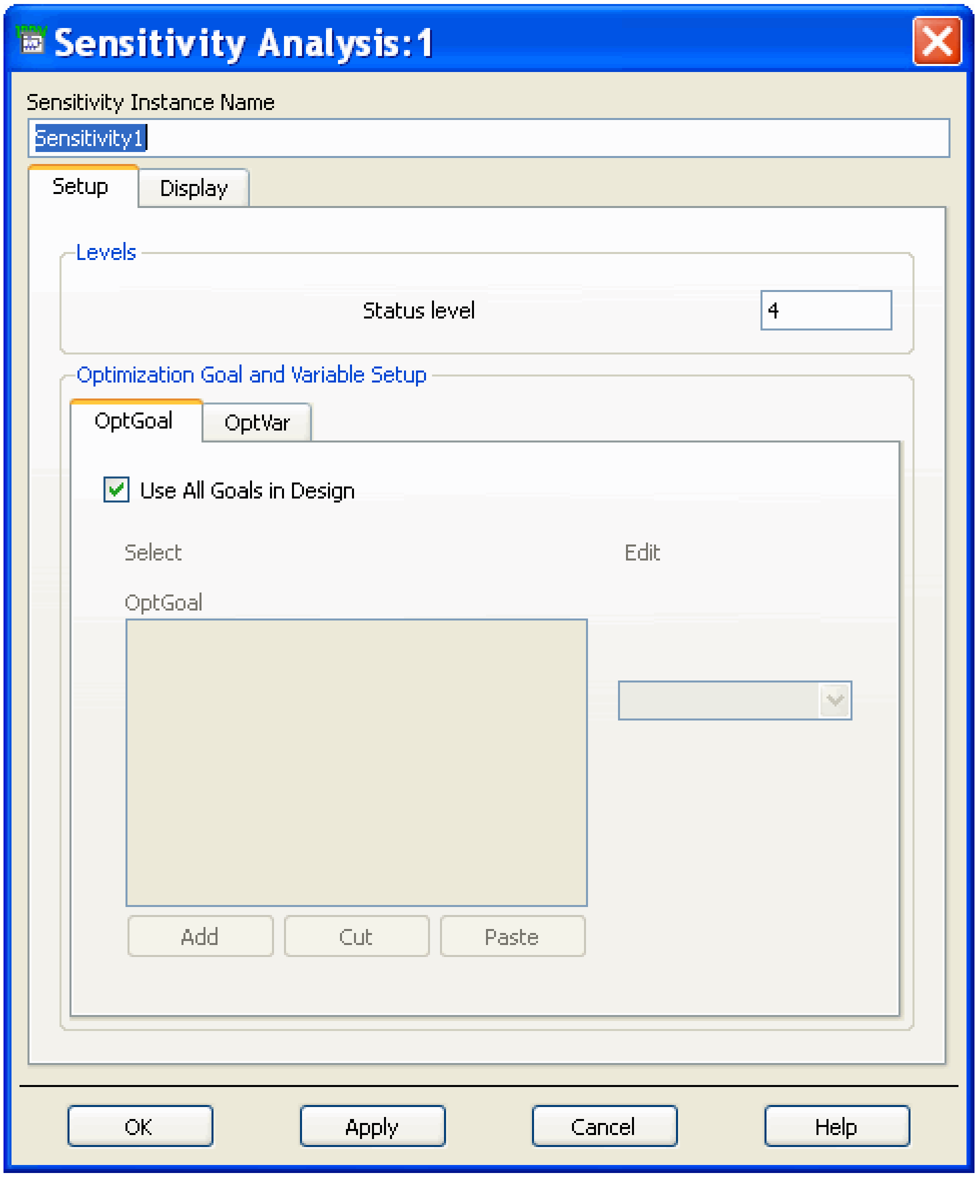
Even though sensitivity is a fundamental element of gradient optimization methods, sensitivity analysis is not a type of optimization.

The prerequisites for sensitivity analysis are the same as for any optimization. You must first have:

- At least one component parameter in your design identified as an optimization variable. You specify details in the Component Parameter dialog box by clicking the **Tune/Opt/Stat/DOE Setup** button. As with any optimization, choose *Enabled*. Choose *Continuous* for Type. The Format field (such as min/max) has no affect with sensitivity analysis. For more information, about specifying component parameters, refer to *Specifying Component Parameters for Optimization* (optstat).
- At least one optimization goal component (*Goal*) placed in the Schematic window. Sensitivity takes into consideration only the goal expression and has no affect on limit line information. For more information, refer to *Setting Optimization Goals* (optstat).

To perform a sensitivity analysis:

1. Place a Sensitivity component in a Schematic window.



Sensitivity analysis comprises a single-point or infinitesimal sensitivity analysis of a design variable. For circuit design, it involves taking partial derivatives of the response with respect to a design variable of interest. It is thought that these numbers can help pinpoint variables that contribute disproportionately to performance variance.

ADS contains other techniques for robust design, including statistical design using both yield analysis and yield optimization. These features are described in *Using Statistical Design* (optstat).

The method used to compute sensitivities is based on finite difference approximation requiring N+1 circuit simulations, where N is the number of optimization variables.

By choosing Sensitivity dialog box > Setup tab > OptVar tab (in the Optimization Goal and Variable Setup box), you can specify a subset of all optimization variables within the design.

Results are sent to the Status window for immediate feedback without the need to open the Data Display window, by choosing Sensitivity dialog box > Setup tab > Levels box >

Status level field and entering a proper annotation level. Sensitivity analysis results are also unconditionally sent to the dataset, and this data can be examined in the Data Display window.

See also *Sensitivity Analysis Example* (sensana).

Sensitivities and Normalized Sensitivities

Sensitivities are approximated as follows:

$$S_{P_i} = \frac{\partial R(P_i)}{\partial P_i} \approx \frac{R\left(P_i^0\right) - R\left(P_i^+\right)}{P_i^0 - P_i^+}$$

where $R(P^0)$ is the response evaluated at the nominal point and $R(P_i^+)$ is the response due to a perturbation in the i^{th} parameter.

Note that in ADS, the response R is actually the expression found in the goal(s) given in the Optim (Nominal Optimization) component performing the sensitivity analysis. Additionally, if a goal contains several simulation points, only the point with the highest sensitivity is reported.

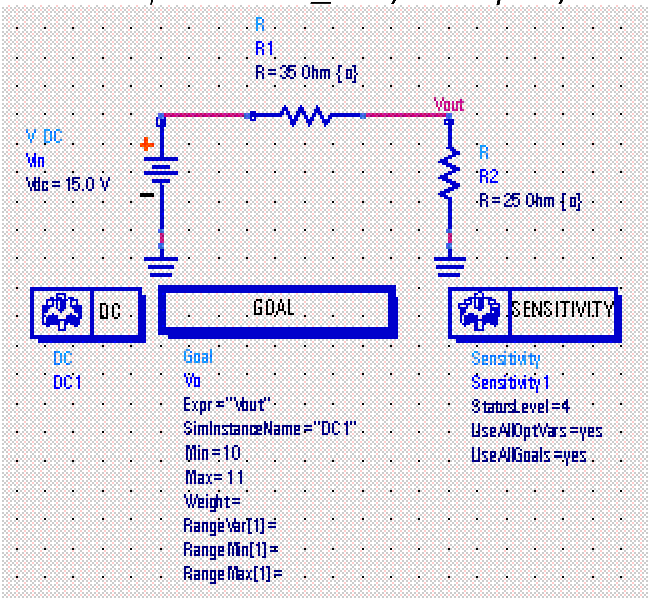
Normalized sensitivities use the approximate gradient (single-point sensitivity) to predict the percentage change in the response due to a 1% change in the design variable. Normalized sensitivity is defined as:

$$S_N - P_i = S_{P_i}\left[\left(P_i^0\right)/(R(pi0))\right] = \left\{\left[R\left(P_i^0\right) - R\left(P_i^+\right)\right]/\left(R\left(P_i^0\right)\right)\right\}/\left\{\left[P_i^0 - P_i^+\right]/\left(P_i^0\right)\right\}$$

The sensitivity information is saved in the dataset using the Goal instance name and also Goal LimitLine name. Normalized sensitivities are saved with the name: norm_ *<goal_instance_name>*.

Sensitivity Analysis Example

The following example illustrates the use of sensitivity analysis. This example can be found in *$HPEESOF_DIR/examples/Tutorial/sensitivity_ex1_wrk*.



The results of this example are shown below.

ANALYTICAL

$$Vo = \frac{Vin * R2}{R1 + R2} = \frac{Vin * R2}{RT}$$

$$S^{Vo}_{R1} = \frac{-Vin * R2}{RT^2} = \Big|_{Vin=15,\ R1=35,\ R2=25} -0.10417$$

$$S^{Vo}_{R2} = \frac{Vin}{RT}\left(1 - \frac{R2}{RT}\right) = \Big|_{Vin=15,\ R1=35,\ R2=25} 0.14583$$

Normalized

$$Sn^{Vo}_{R1} = S^{Vo}_{R1} \frac{R1}{Vo} = \Big|_{Vin=15,\ R1=35,\ R2=25} -0.58333$$

$$Sn^{Vo}_{R2} = S^{Vo}_{R2} \frac{R2}{Vo} = \Big|_{Vin=15,\ R1=35,\ R2=25} 0.58333$$

SIMULATED

sensVariables	Vo	norm_Vo
R1.R	-0.10417	-0.58333
R2.R	0.14583	0.58333