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Agilent Technologies

MBP

Mismatch Modeling in MBP

Application Note

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Mismatch Modeling in MBP

Application Note

This application note introduces the basic components of Model Builder Program's (MBP's) mismatch module. The steps to run the built-in extraction flow and how to configure and plot an IMV graph in MBP are also demonstrated. **Note**: This document was originally released for MBP V2011.1.2 in December 2011.

Introduction

Two devices in design that are the same (e.g., exactly the same property, geometry, etc.) may show different electrical behavior on the Silicon due to mismatch. The main reason for the difference is the local process variance across the wafer. Mismatch affects the yield and reliability of the final products. An accurate mismatch model is therefore, necessary to ensure the robust design of many analog and digital circuits.

MBP supports mismatch modeling and simulation for all major semiconductor devices such as MOSFETs, bipolar transistors, resistors, and capacitors. In this document, we first introduce the data format supported, plot configuration and Monte Carlo (MC) simulation in MBP. Examples of running the built-in extraction flow, and configuring and plotting an IMV graph are also demonstrated. For more information go to www.agilent.com/find/eesof or contact your local Agilent office. The complete list is available at: www.agilent.com/find/contactus.

Data, Plot and MC Simulation

Data Format

For mismatch, MBP supports two kinds of data formats. The first one is based on the actual measurement data, while the other allows you to input the mean and sigma value of the target.

Data Format I

Here is an example of the first data format supported in MBP:

```
miscondition{date=,type=NMOS}
Page (name=vth_gm,target=vth_gm,scale=1.0,p=(L,W))
{vds=0.1,Vgs=1,Vbs=0,icon=1E-7,T=25}
{0.18,2.0}
0.002604200182343308 0.015163779612074824 -0.0016386308204789923
0.0012339958926110839 0.008895426625025848 -0.0048731228537369775
.....
{0.18,10.0}
0.0011114374468496058 0.007055480752867993 -7.450025621094092E-4
4.969414898894353E-4 0.003966458228031433 -0.0024213892738844667
.....
```

The first line of the data file begins with the keyword "miscondition" and contains information like date and device type. The second line defines all page-related information. The information within the round bracket *"( )"* contains Page name, target, scale, and P variable. The information within the brace *"{ }"* declares Page constants, including the bias/current condition and temperature.

The latter part is the data block information. Every curve block always begins with *{L W}*. All data information is then listed behind it. In this example, the data information is the threshold voltage difference *(Δvth_gm)* between two adjacent devices with the same geometry.

Data Format Ⅱ
You can also choose the other format. As an example:

condition{corner = tt,date = oct_20_02}
Datatype{mismatch}
Version{1.0}
type{nmos}
Delimiter{,}
Instance{L, W, T}
Input{vds=0.05, Vgs=1, Vbs=-1,icon=1e-7}
Targets{Ids}
Data{ L, W, T, vds, vgs, vbs, ids}
40, 5, 25, 0.05, 3, 0, 0, 6.448e-4
40, 2, 25, 0.05, 3, 0, 0, 9.836e-4
30, 2, 25, 0.05, 3, 0, 0, 9.6235e-4
20, 2, 25, 0.05, 3, 0, 0, 1.28e-3
20, 1, 25, 0.05, 3, 0, 0, 1.889e-3
20, 0.5, 25, 0.05, 3, 0, 0, 2.448e-3
6, 1, 25, 0.05, 3, 0, 0, 3.4727e-3
10, 0.5, 25, 0.05, 3, 0, 0, 3.503e-3
6, 0.5, 25, 0.05, 3, 0, 0, 4.1108e-3
.....

In this format, the first part of the data file contains general information such as corner type, date, data type, device type, instance, bias condition, and target. The second part of the data file includes the data block information. The first line begins with the keyword "Data" following the variables. All data is then listed from the second line. Note that the last two values in every line correspond to the mean and sigma of the target. For example:

"*40,5,25,0.05,3,0,0,6.448e-4*" means *"L=40um,W=5um, T=25C, Vds=0.05V, Vgs=3V, Vbs=0, ΔIds(mean) =0, ΔIds(sigma)=6.448e-4A*" .

Plot

As shown in Figure 1, the plot shows the value of *σ (ΔVth_gm)* versus *1/sqrt (W*L)*, and the trend slope lines. The simulation point and trend line are plotted in blue and the measurement data and trend line are plotted in purple.

By clicking on the legend *"L, W"* you can disable/enable the geometries to be plotted. Right click on the

plot and check the item "*Fit Line through Origin*" from the popup menu. MBP then forces the trend lines through the origin, as shown in Figure 2.

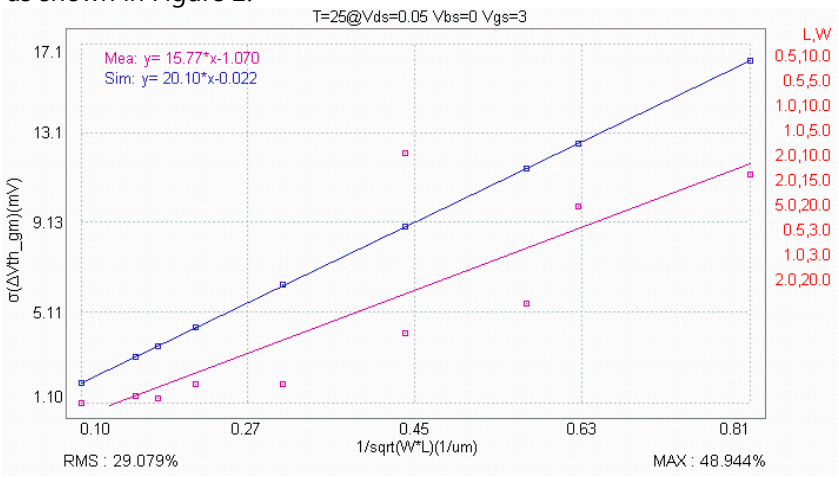

Figure 1. Mismatch plot

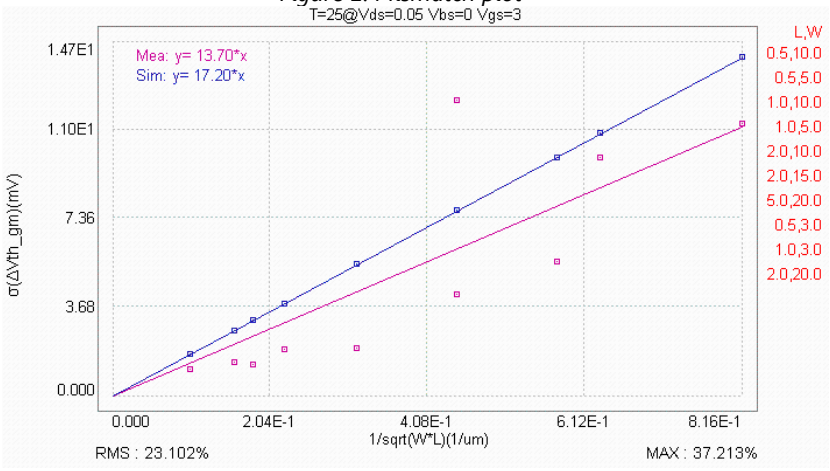

Figure2. Fit Line through Origin

MC Simulation

MBP's internal engine supports Monte Carlo analysis of mismatch models. You can right-click on the plot and select *Set Monte Count*, as shown in Figure 3. Then, set an appropriate number. A large number may lead to a more accurate result, but it can also cause a longer simulation time.

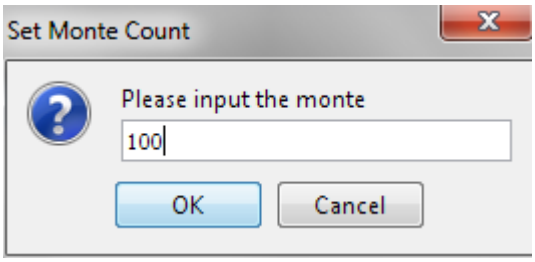

Figure3. Set Monte Count

You have an option to execute a fast MC simulation by choosing *Simulation -> Fast-MC* from the main

menu.

Extraction Flow

We can use a demo to describe the steps required to run a mismatch model extraction through the built-in flow.

Demo Files

The demo folder is *$MBPHOME\demo\Mismatch\mosfet*. Here, *$MBPHOME* is the MBP installation path. There are a total of three files in the folder:

- demo_model: the initial model card.
- param.txt: the parameter list used in the extraction flow.
- mis_data.mea: the demo data.

You can follow the steps below to complete the whole process.

Step1. Set Model Type

First, set the mode type. Choose *Model -> Select Model* from the main menu. In the popup Model Type window, choose *Statistical* as the Project Type. Then choose *mosfet* as the device type, as shown in Figure 4.

Click the *OK* button to close the window.

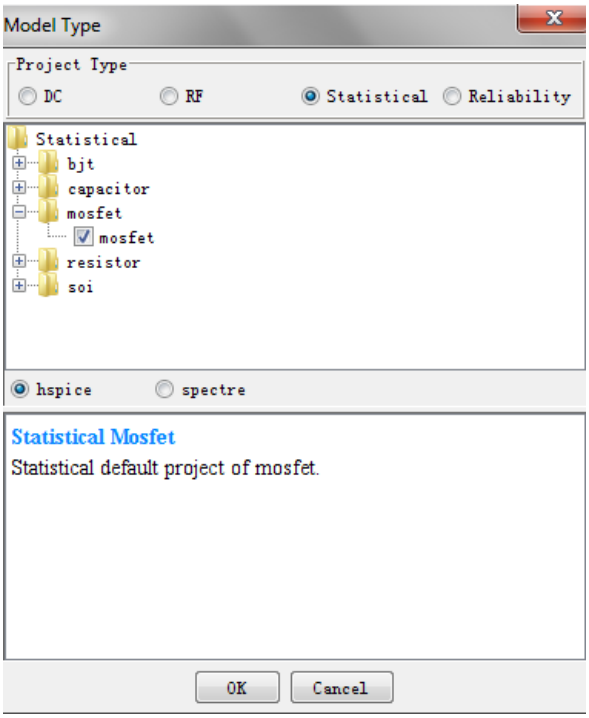

Figure 4. Model type

Step 2. Load Data and Model

Choose *File* -> *Data* -> *Load* from the main menu and load the data file "mis_data.mea," as shown in Figure 5.

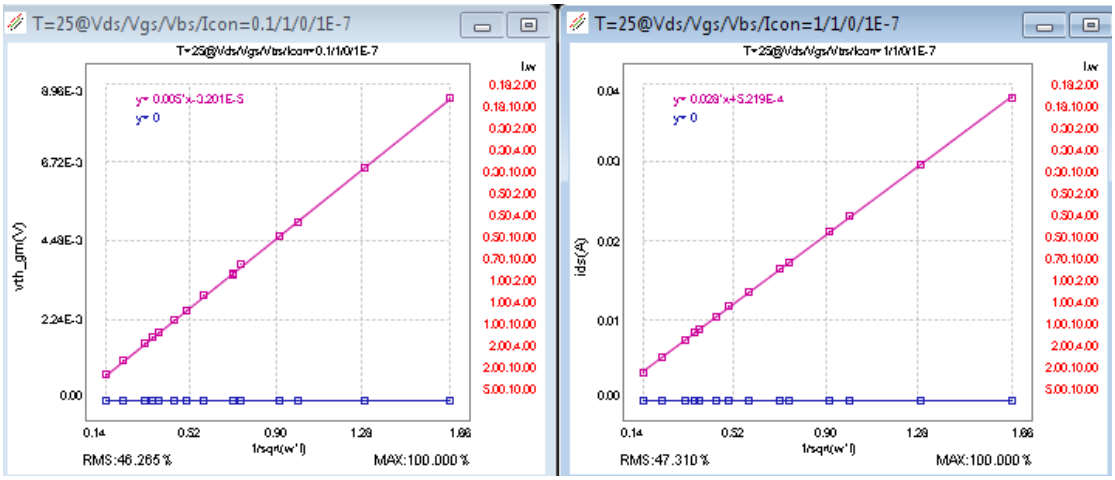

Figure5. Data VS initial model

Then, choose *File* -> *Model* -> *Load* from the main menu and load the model file "model_nmos.l." Here, MBP supports the ability to load the model with or without mismatch information.

Step 3. Extraction Flow

Choose *Extraction* -> *Extraction Flow* from the main menu. The extraction panel is shown in Figure 6.

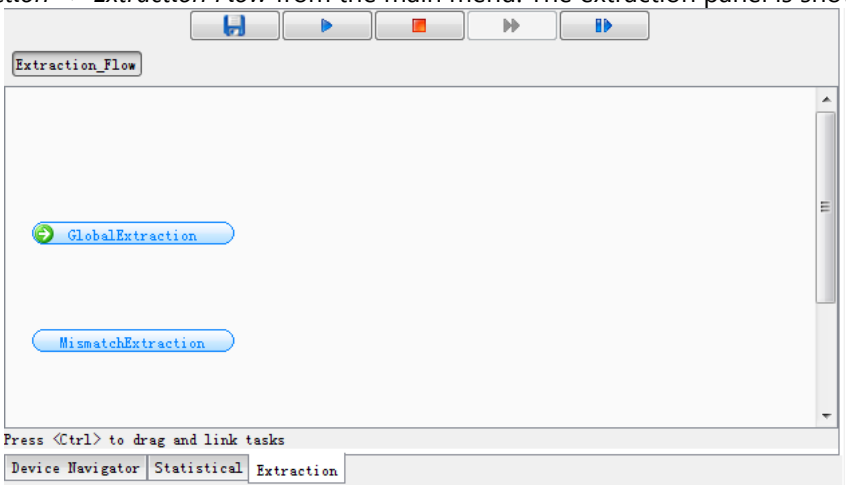

Figure6. Extraction Flow panel

Double click the *Mismatch Extraction* button to expand the flow, as shown in Figure 7

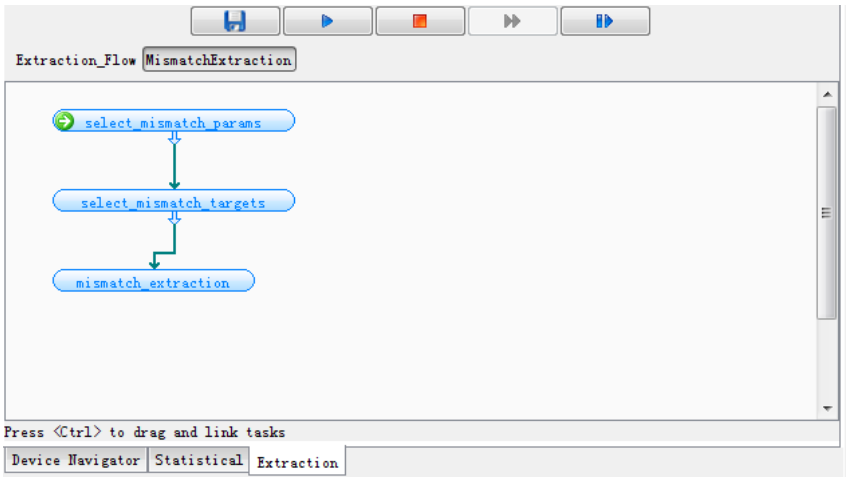

Figure7. Global Extraction flow

There are three steps in the flow: select_mismatch_params, select_mismatch_targets and mismatch_extraction. Click the *run* icon to run the mismatch extraction flow. The *Select Parameters* window pops up as shown in Figure 8

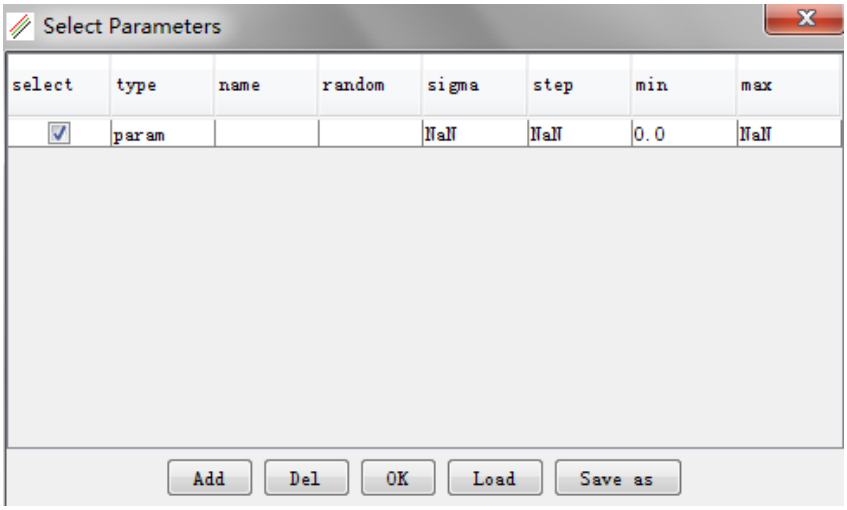

Figure8. Select Parameters window

Click the *Load* button to load the parameter list file "*param.txt.*" The parameters used for mismatch extraction are shown in Figure 9.

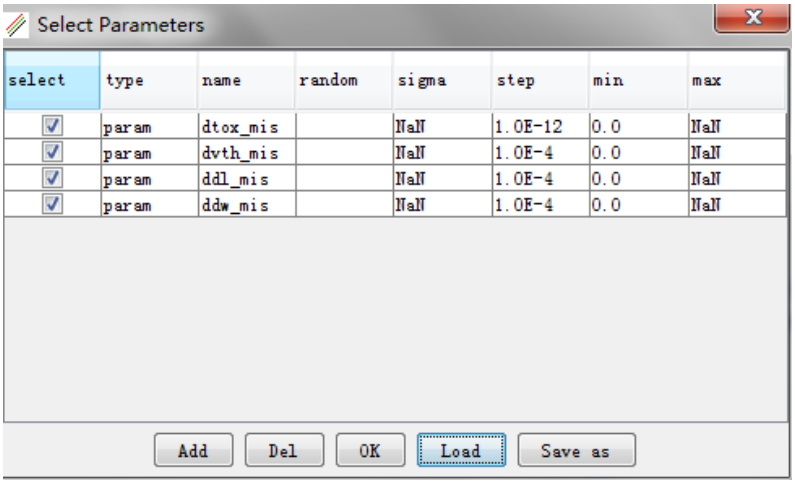

Figure 9. Load Parameter list

Some comments on the column names in the figure above are as follows:

• select: when it is checked, the parameter gets re-extracted. If it is unchecked, then the parameter depends on the sigma value. If the sigma value is given, the final value of the parameter is the sigma value. If sigma value is not given, the current value of the parameter remains as the final one.
• name: mismatch parameter name. When *select* is unchecked, the parameter name can be blank. At the same time, both *random* and *sigma* must have correct values.
• random: random variable name. If in the current model file there is a random variable for the parameter, then put the name of the random variable here. If in the current model file there is no random variable for the parameter, you can either input a new name here, or keep it blank. For the latter case, a new name is created automatically. Note that the names of random variables cannot be repeated.
• sigma: sigma of the mismatch parameter. You can input the value here. The extraction flow then bypasses this parameter and uses the predefined value instead.
• step: the step for BPV calculation. It is used to calculate the sensitivity of the parameter to the target.

Click the *OK* button to continue. The Select Targets window pops up as shown in Figure 10

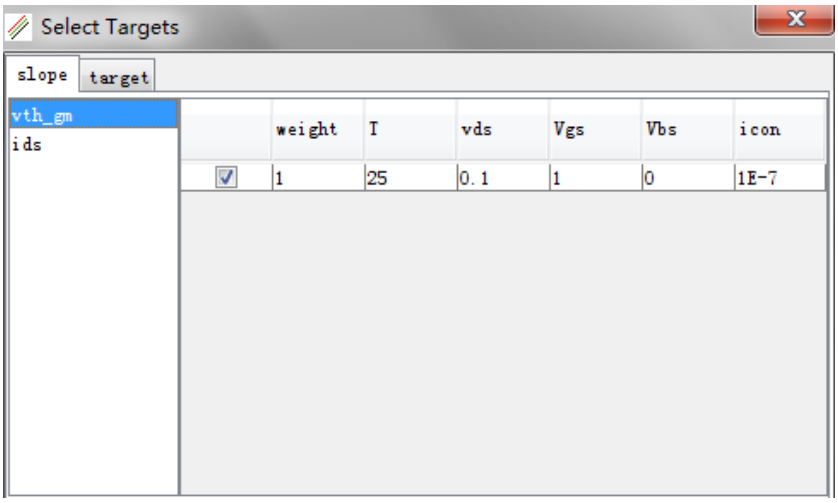

Figure 10. Select targets - slope

In this window, you can select the data group for the following extraction and the corresponding weight.

Click the "*target*" tab in the window as shown in Figure 11.

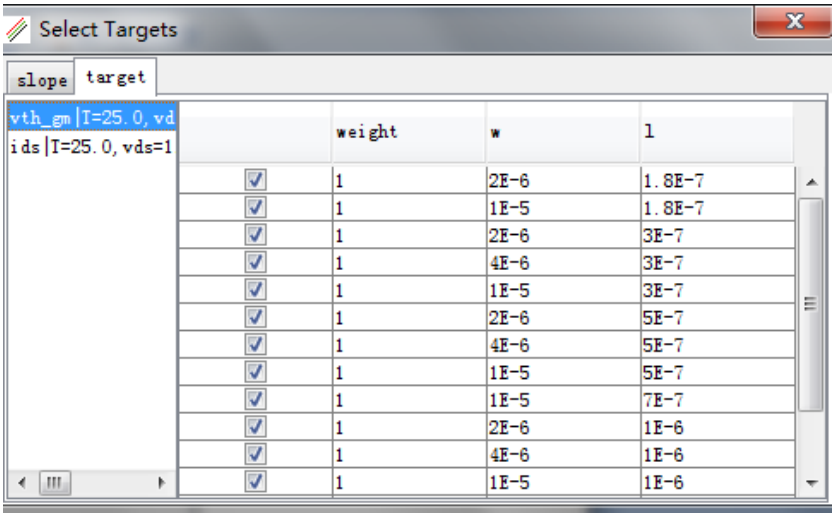

Figure 11. Select targets - target

All the specific targets corresponding to the data group in Figure 10 are listed here. You can also change the weight values, which affects the final value of the slope.

Close the window to continue. In the last step, the *Save* dialog window pops up. Input a file name to save the extracted model file. Then, the following mismatch parameters that have been extracted are found:

```
.param
+s_dtox_mis = 8.320052E-10 s_dvth_mis = 6.310913E-4
s_ddl_mis = 9.80127E-2
+s_ddw_mis = 6.175251E-3
.param
+random5 = agauss(0.0,1.0, 1)
+random6 = agauss(0.0,1.0, 1)
+random7 = agauss(0.0,1.0, 1)
+random8 = agauss(0.0,1.0, 1)
.param
+dtox_mis = '0.0+s_dtox_mis*random5'
+dvth_mis = '0.0+s_dvth_mis*random6'
+ddl_mis = '0.0+s_ddl_mis*random7'
+ddw_mis = '0.0+s_ddw_mis*random8'
```

The fitting result is shown in Figure 12.

You can continue to fine tune the parameters manually. They can also modify some settings and rerun the flow until a satisfying result is obtained.

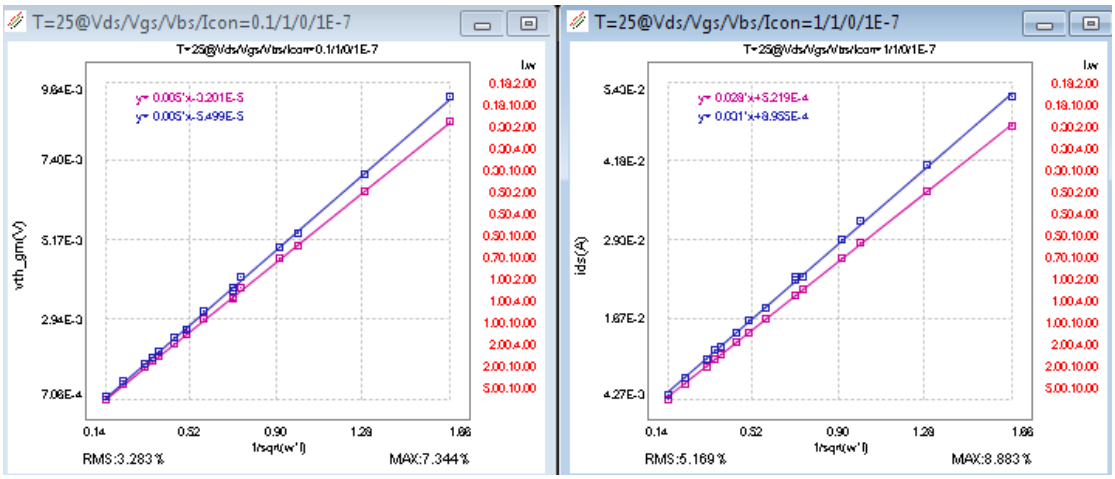

Figure 12. Fitting result

Mismatch IMV

Lastly, we use a demo case to illustrate how to customize mismatch IMV and plot it in MBP. After loading the data and model, choose *Script* -> *Script Project* from the main menu to pop up the MBP Script interface.

In the left "*Project*" tab window, *click default* -> *imv* -> *imv* -> *mismatch* to expand the folder, as shown in Figure 13.

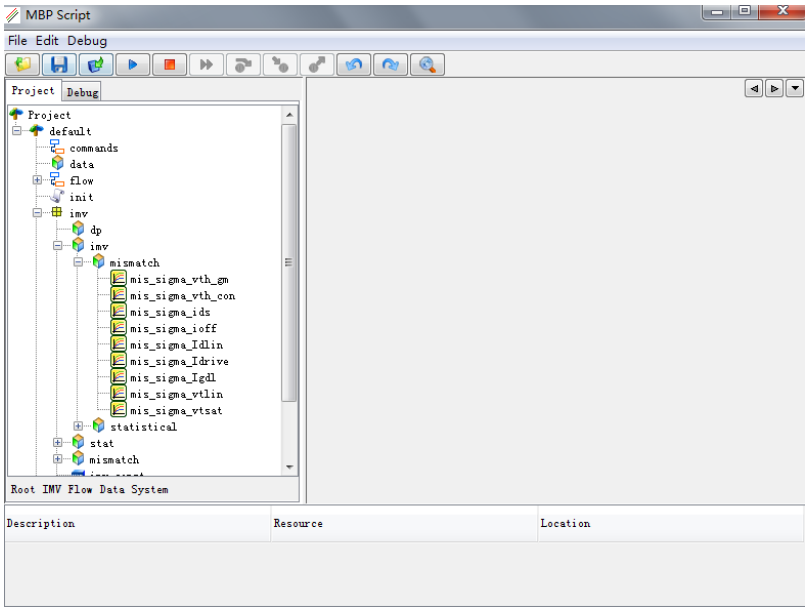

Figure 13. MBP script

Right-click the IMV "mis_sigma_ids" and choose *New* -> *Graph* (Figure 14).

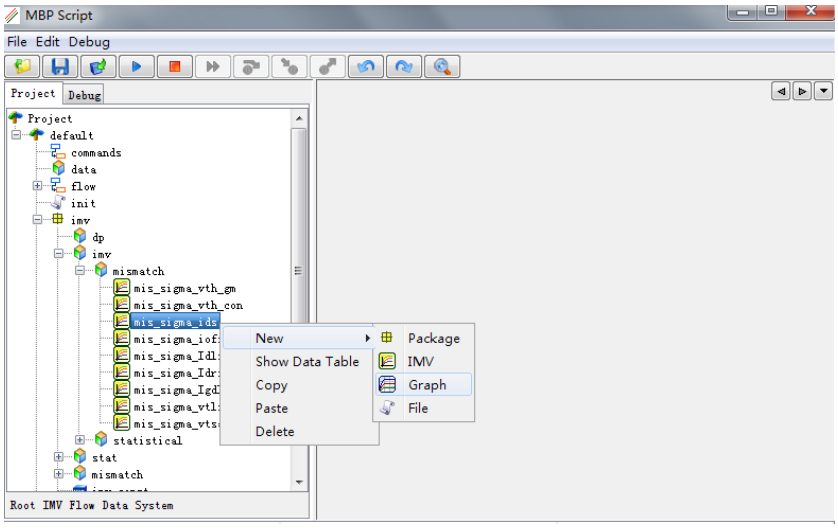

Figure 14. Create new graph

Input "mis_sigma_ids_w_l" as the code name. In the "*GRAPH_PROP*" tab, choose "w" as "Axis[x]," "mis_sigma_ids" as "Axis[x]" and "l" as "Axis[x]," as shown in Figure 15.

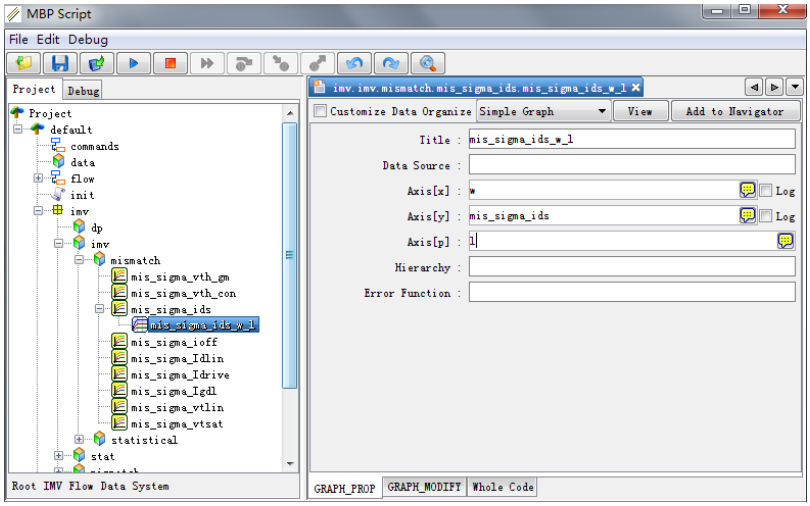

Figure 15. Configure graph

Click the icon to save the current code. In the main menu of MBP, choose *Extraction -> IMV -> IMV Pages* to open the IMV page. Click the icon to refresh. You can then view the customized IMV page (mis_sigma_ids_w_l) as shown in Figure 16.

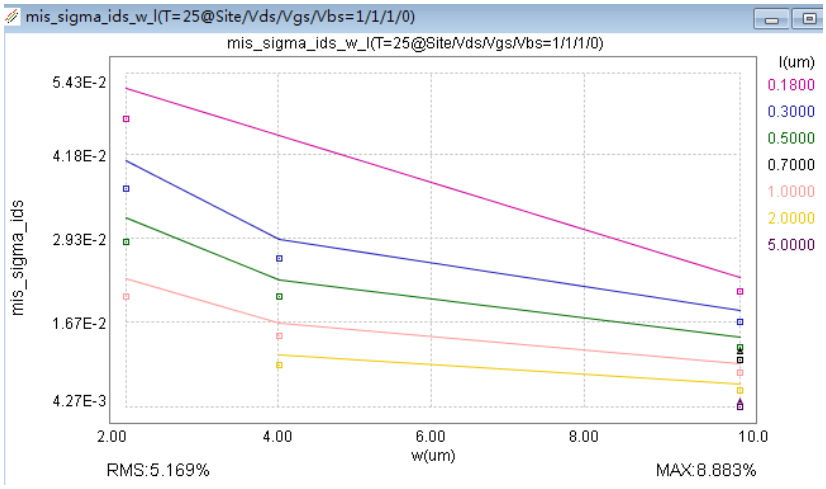

Figure 16. IMV pages