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Layout Dependent Effect Setup Usage

Layout Dependent Effect

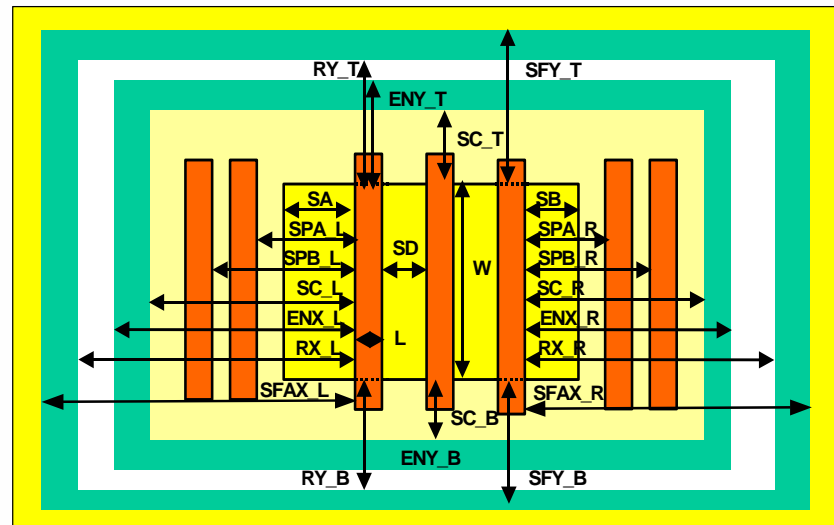
● Concept

- Define layout dependent effect (LDE) parameters by layer boundary and calculate effective parameters in pre-layout stage

● Method

- New adjustable parameters based on layout geometry are added into device CDF for layout dependent effect calculation
- User preset function is provided for customer's pre-defined values
- Utility is provided to allow user to specify those parameters by selected instance.

New CDF Parameters



* 20 new CDF parameters are introduced:

- (a) PSE: SPA_L, SPA_R, SPB_L, SPB_R
- (b) WPE: SC_L, SC_R, SC_T, SC_B
- (c) BE: ENX_L, ENX_R, ENY_T, ENY_B, RX_L, RX_R, RY_T, RY_B
- (d) OSE: SFAX_L, SFAX_R, SFY_T, SFY_B

Legend:
 OD
 PO
 WELL
 CESL

WPE parameters

Add SC_L, SC_R, SC_T, SC_B CDF parameters

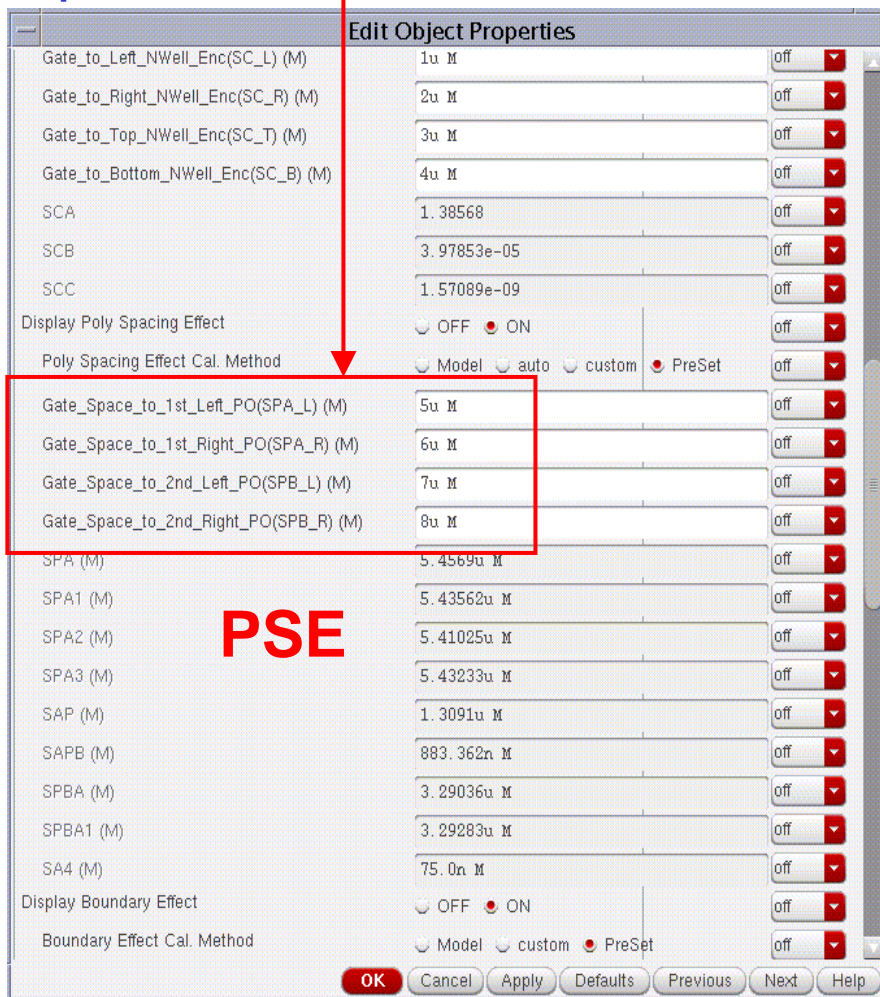
	New layout related input in CDF	layout dependent effect instance parameters
PSE	SPA_L, SPA_R, SPB_L, SPB_R	SPA, SPA1, SPA2, SPA3, SAP, SA4, SPBA, SPBA1, SAPB
WPE	SC_L, SC_R, SC_T, SC_B	SCA, SCB, SCC
BE (D-CESL)	ENX_L, ENX_R, ENY_T, ENY_B, RX_L, RX_R, RY_T, RY_B	ENX, ENX1, ENY, ENY1, ENY2, REX, REY
OSE	SFAX_L, SFAX_R, SFY_T, SFY_B	SODX, SODX1, SODX2, SA5, SA6, SODY

Calculate effective SCA, SCB, SCC

Ex : $SCA_{eff} = f(W, L, NF, SD, SC_L, SC_R, SC_T, SC_B)$

PSE parameters

Add SPA_L, SPA_R, SPB_L, SPB_R CDF parameters



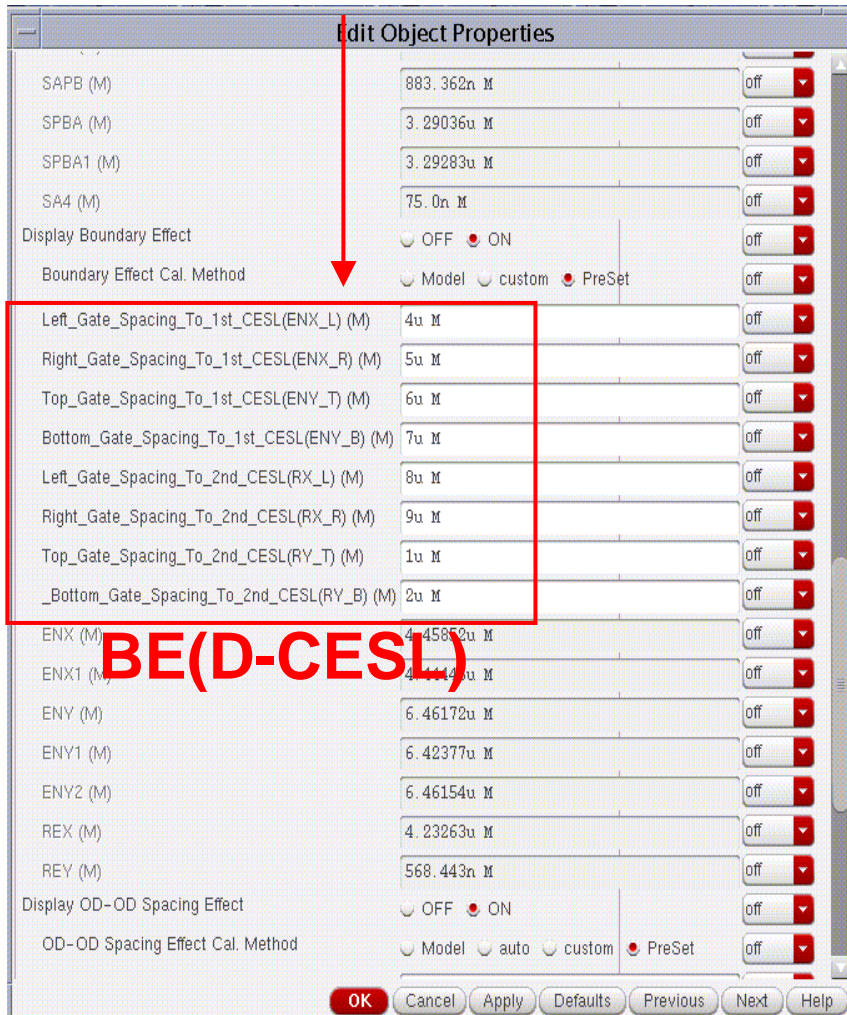
PSE

	New layout related input in CDF	layout dependent effect instance parameters
PSE	SPA_L, SPA_R, SPB_L, SPB_R	SPA, SPA1, SPA2, SPA3, SAP, SA4, SPBA, SPBA1, SAPB
WPE	SC_L, SC_R, SC_T, SC_B	SCA, SCB, SCC
BE (D-CESL)	ENX_L, ENX_R, ENY_T, ENY_B, RX_L, RX_R, RY_T, RY_B	ENX, ENX1, ENY, ENY1, ENY2, REX, REY
OSE	SFAX_L, SFAX_R, SFY_T, SFY_B	SODX, SODX1, SODX2, SA5, SA6, SODY

- PSE (Poly Spacing Effect) parameters are adjustable in CDF for callback calculation

Boundary Effect parameters

Add ENX_L, ENX_R, ENY_T, ENY_B,
RX_L, RX_R, RY_T, RY_B CDF parameters



BE(D-CESL)

	New layout related input in CDF	layout dependent effect instance parameters
PSE	SPA_L, SPA_R, SPB_L, SPB_R	SPA, SPA1, SPA2, SPA3, SAP, SA4, SPBA, SPBA1, SAPB
WPE	SC_L, SC_R, SC_T, SC_B	SCA, SCB, SCC
BE (D-CESL)	ENX_L, ENX_R, ENY_T, ENY_B, RX_L, RX_R, RY_T, RY_B	ENX, ENX1, ENY, ENY1, ENY2, REX, REY
OSE	SPAX_L, SPAX_R, SPY_T, SPY_B	SODX, SODX1, SODX2, SA5, SA6, SODY

- BE (D-CESL Effect) parameters are adjustable in CDF for callback calculation

OSE parameters

Add SFAX_L, SFAX_R, SFY_T, SFY_B CDF parameters

OSE

	New layout related input in CDF	layout dependent effect instance parameters
PSE	SPA_L, SPA_R, SPB_L, SPB_R	SPA, SPA1, SPA2, SPA3, SAP, SA4, SPBA, SPBA1, SAPB
WPE	SC_L, SC_R, SC_T, SC_B	SCA, SCB, SCC
BE (D-CESL)	ENX_L, ENX_R, ENY_T, ENY_B, RX_L, RX_R, RY_T, RY_B	ENX, ENX1, ENY, ENY1, ENY2, REX, REY
OSE	SFAX_L, SFAX_R, SFY_T, SFY_B	SODX, SODX1, SODX2, SA5, SA6, SODY

- OSE (OD Spacing Effect) parameters are adjustable in CDF for callback calculation

Preset Option

Edit Object Properties

Display S/D Parameters ☒ OFF ☐ ON off ▼

Display LOD Effect ☒ OFF ☐ ON off ▼

pre-set-Option **Preset1** **Preset** off ▼

Display Well Proximity Effect ☐ OFF ☒ ON off ▼

Well Proximity Effect Cal. Method ☐ Model ☐ auto ☐ custom ☒ PreSet off ▼

Gate_to_Left_NWell_Enc(SC_L) (M) 1u M off ▼

Gate_to_Right_NWell_Enc(SC_R) (M) 2u M off ▼

Gate_to_Top_NWell_Enc(SC_T) (M) 3u M off ▼

Gate_to_Bottom_NWell_Enc(SC_B) (M) 4u M off ▼

SCA 1.38568 off ▼

SCB 3.97853e-05 off ▼

SCC 1.57089e-09 off ▼

Display Poly Spacing Effect ☐ OFF ☒ ON off ▼

Poly Spacing Effect Cal. Method ☐ Model ☐ auto ☐ custom ☒ PreSet off ▼

Gate_Space_to_1st_Left_PO(SPA_L) (M) 5u M off ▼

Gate_Space_to_1st_Right_PO(SPA_R) (M) 6u M off ▼

Gate_Space_to_2nd_Left_PO(SPB_L) (M) 7u M off ▼

Gate_Space_to_2nd_Right_PO(SPB_R) (M) 8u M off ▼

SPA (M) 5.4569u M off ▼

SPA1 (M) 5.43562u M off ▼

SPA2 (M) 5.41025u M off ▼

SPA3 (M) 5.43233u M off ▼

SAP (M) 1.3091u M off ▼

SAPB (M) 883.362n M off ▼

OK Cancel Apply Defaults Previous Next Help

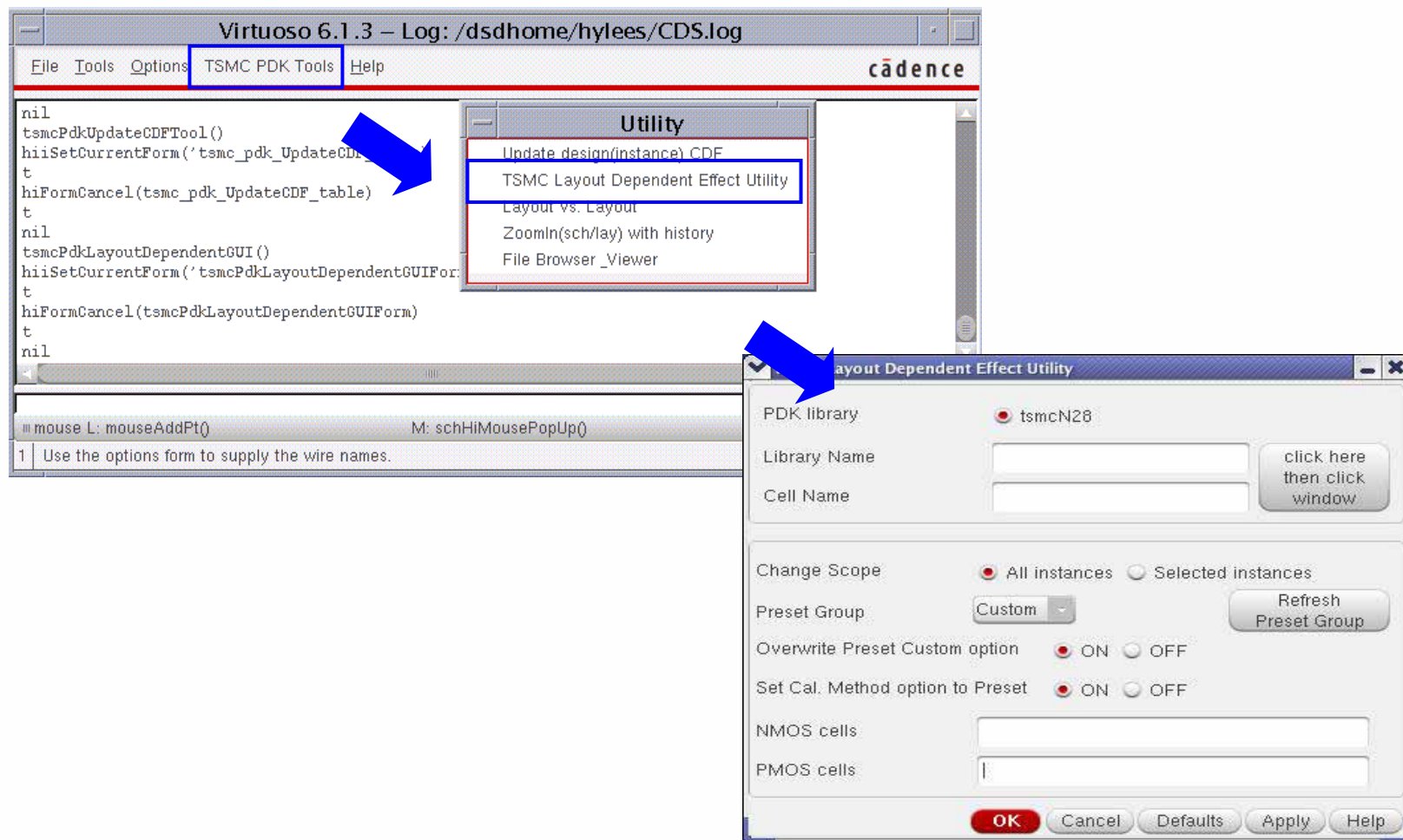
- Preset function is provided for customer's pre-defined parameters
- TSMC utility is provided for user selecting different groups of preset.

I ./.skill/TSMC_LayoutEffect	IW TSMC_LayoutEffectTable
<pre> [Preset1] <NMOS> <wpe> SC_L = 1u SC_R = 2u SC_T = 3u SC_B = 4u </wpe> <pse> SPA_L = 5u SPA_R = 6u SPB_L = 7u SPB_R = 8u </pse> <ose> SFAX_L = 9u SFAX_R = 1u SFY_T = 2u SFY_B = 3u </ose> <ces1> ENX_L = 4u ENX_R = 5u ENY_T = 6u ENY_B = 7u RX_L = 8u RX_R = 9u RY_T = 1u RY_B = 2u </ces1> </NMOS> <PMOS> <wpe> SC_L = 1u SC_R = 2u SC_T = 3u SC_B = 4u </wpe> <pse> SPA_L = 5u SPA_R = 6u SPB_L = 7u SPB_R = 8u </pse> </pre>	<pre> [Preset2] <NMOS> SA = 140n SB = 140n </Tod> <wpe> SC_L = 1u SC_R = 1u SC_T = 1u SC_B = 1u </wpe> <pse> SPA_L = 0.17u SPA_R = 0.17u SPB_L = 4u SPB_R = 4u </pse> <ose> SFAX_L = 0.24u SFAX_R = 0.24u SFY_T = 0.88u SFY_B = 0.88u </ose> <ces1> ENX_L = 4u ENX_R = 5u ENY_T = 6u ENY_B = 7u RX_L = 8u RX_R = 9u RY_T = 1u RY_B = 2u </ces1> </NMOS> <PMOS> SA = 110n SB = 110n </Tod> <wpe> SC_L = 1u SC_R = 1u SC_T = 1u SC_B = 1u </wpe> <pse> SPA_L = 0.14u SPA_R = 0.14u SPB_L = 4u SPB_R = 4u </pse> </pre>

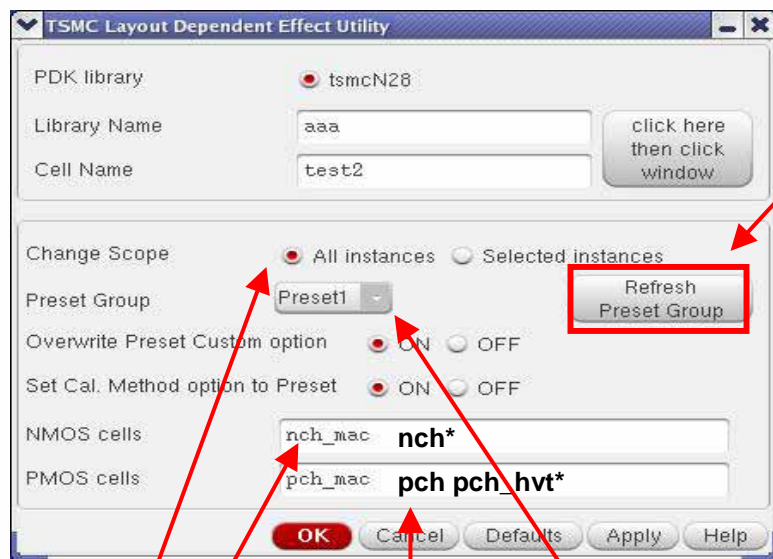
Preset1 table

Preset2 table

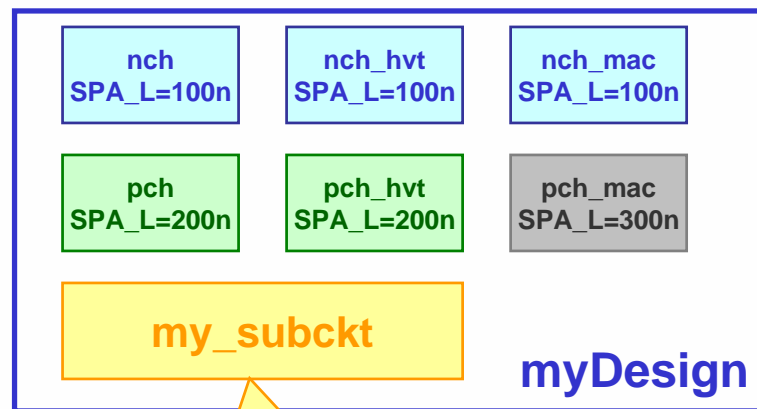
TSMC PDK Tools-Layout Dependent Effect Utility



Specification of Layout Dependent Effect Utility



Press the button to refresh your preset group



Support wildcard and cell list (separated by space)

SPA_L=100n will be applied to "All instances" & "nch*" in cell "myDesign". Which include nch, nch_hvt, nch_mac and my_subckt/nch

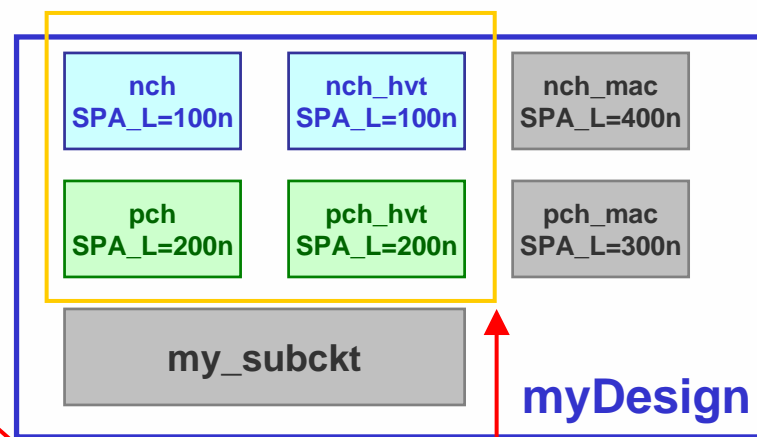
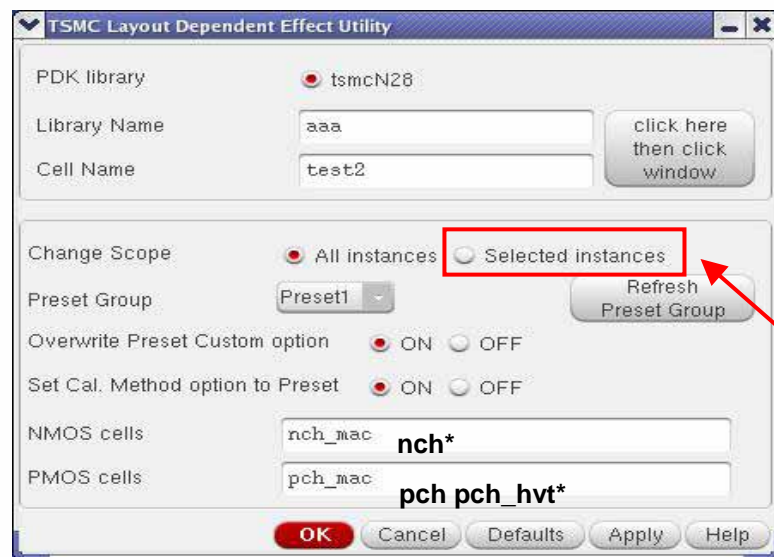
SPA_L=200n will be applied to "All instances" & (pch || pch_hvt) in cell "myDesign". Which include pch, pch_hvt and my_subckt/pch.

```
Control File
<Preset 1>
NMOS
SPA_L = 100n
SPA_R = xxx
...
PMOS
SPA_L = 200n
SPA_R = xxx
...
<Preset 2>
...
```

The utility also support hierarchical instances (for more than one level).

**** The utility can only affect those instances with write permission.**

Specification of Layout Dependent Effect Utility (Cont.)



Only apply the change to those instances that selected by mouse.

SPA_L=100n will be applied to "Selected instances" && "nch*" in cell "myDesign". Which include nch, nch_hvt

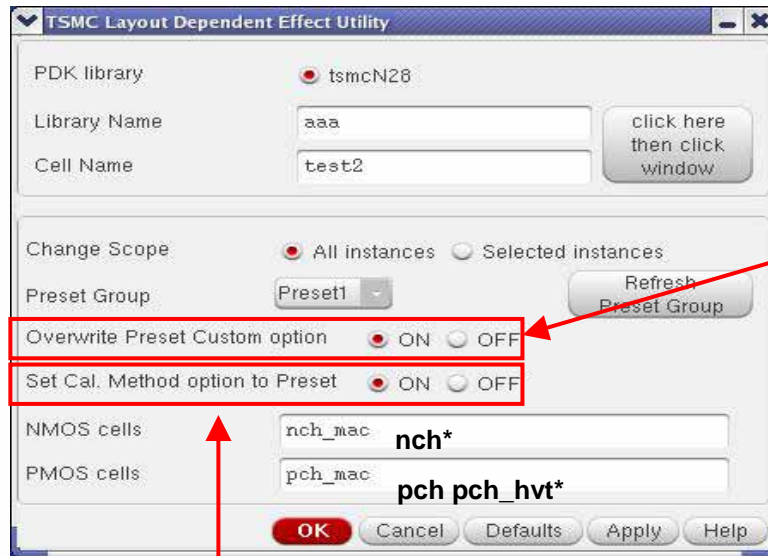
SPA_L=200n will be applied to "Selected instances" && (pch || pch_hvt) in cell "myDesign". Which include pch, pch_hvt .

Control File

```
<Preset 1>
NMOS
  SPA_L = 100n
  SPA_R = xxx
...
PMOS
  SPA_L = 200n
  SPA_R = xxx
...
<Preset 2>
...
```

The control file is put at the skill directory named "TSMC_LayoutEffectTable". Hint, there are no limit for preset group.

Specification of Layout Dependent Effect Utility (Cont.)

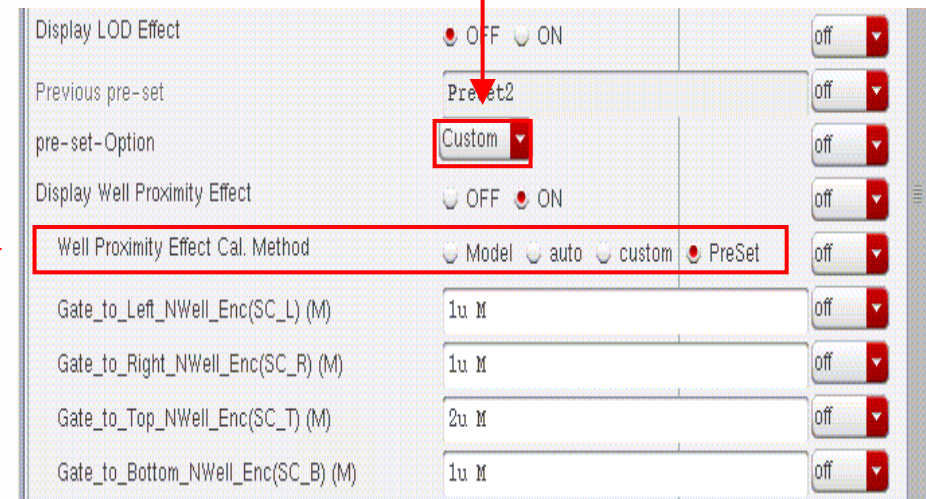


Enable to overwrite the preset option when the original preset option of a instance is "Custom"

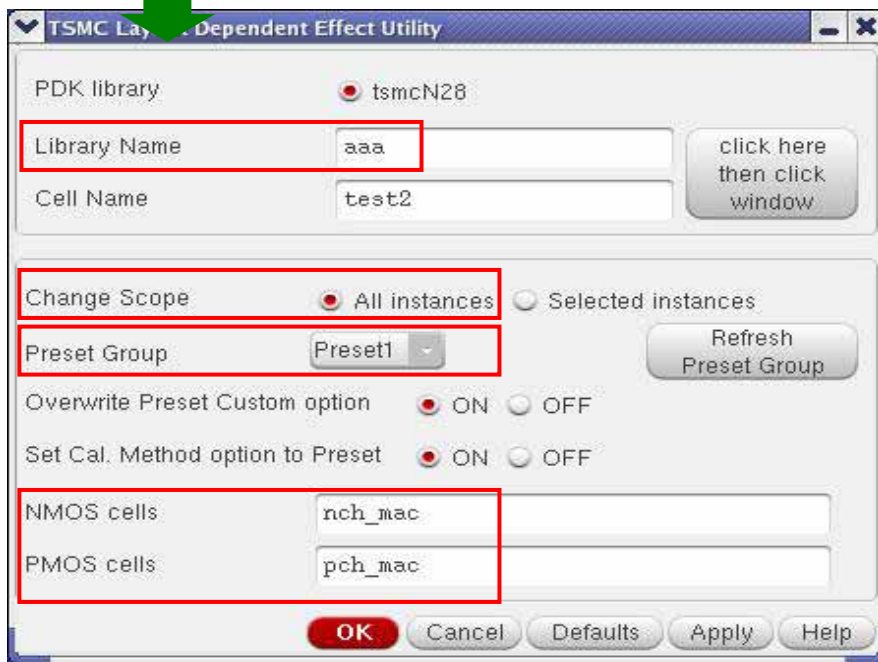
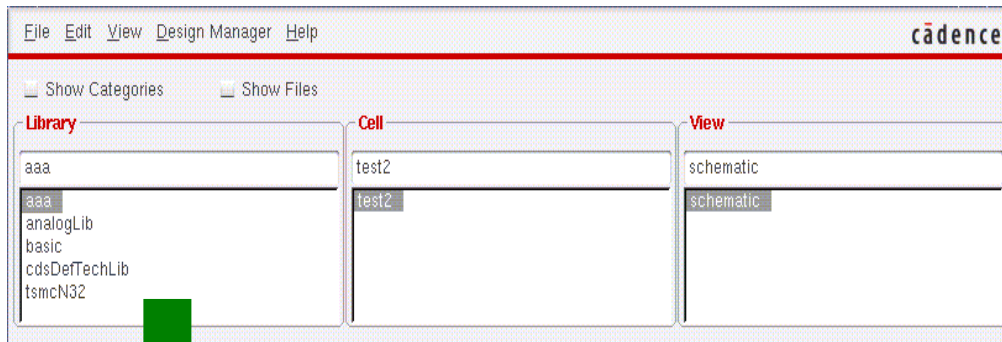
For example, When you turn off this option, This utility will not change the following instance since Its preset option is "Custom"

Enable to reset "Cal. Method option" to Preset

For example, When you turn on this option, This utility will change all Cal. Method CDF options to "Preset".

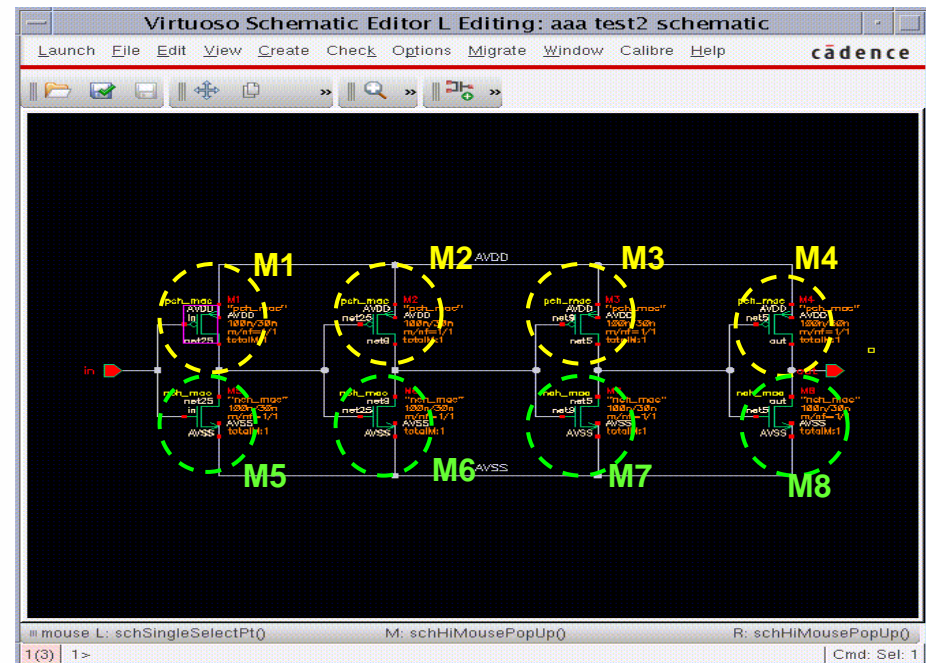


Example 1: Setting LDE parameters of driver by “All instances”



NMOS LDE parameters set to “Preset1”
(M1~M4)

PMOS LDE parameters set to “Preset1”
(M5~M8)



Example 1: Setting LDE parameters of driver by "All instances" (Cont.)

Virtuoso Schematic Editor L Editing: aaa test2 schematic

Launch File Edit View Create Check Options Migrate Window Calibre Help cadence

CDF of M4

Edit Object Properties

Value	Display	
pch_mac	off	
0.85V standard VT PMOS transistor	off	
30n M	off	
100n M	off	
100n M	off	
1	off	
1	off	
1	off	
<input checked="" type="checkbox"/> OFF <input type="checkbox"/> ON	off	
<input type="checkbox"/> OFF <input type="checkbox"/> ON	off	
<input type="checkbox"/> OFF <input type="checkbox"/> ON	off	
Preset1	off	
<input type="radio"/> Model <input type="radio"/> auto <input type="radio"/> custom <input checked="" type="radio"/> PreSet	off	
Gate_to_Left_NWell_Enc(SC_L) (M)	1u M	off
Gate_to_Right_NWell_Enc(SC_R) (M)	2u M	off
Gate_to_Top_NWell_Enc(SC_T) (M)	3u M	off
Gate_to_Bottom_NWell_Enc(SC_B) (M)	4u M	off
SCA	1.38568	off
SCB	3.97853e-05	off
SCC	1.57089e-09	off
<input checked="" type="checkbox"/> OFF <input type="checkbox"/> ON	off	

pre-set-Option
Display Well Proximity Effect
Well Proximity Effect Cal. Method

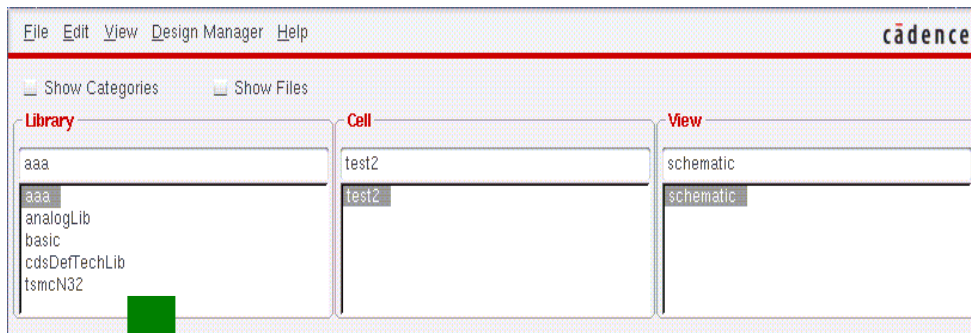
SCA = 1.38568
SCB = 3.97853e-05
SCC = 1.57089e-09

```

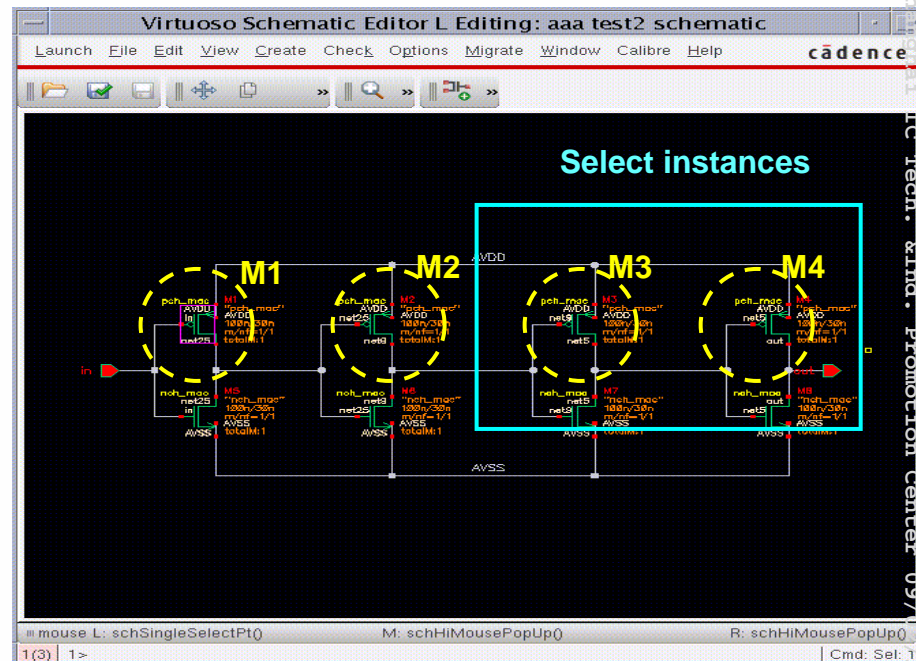
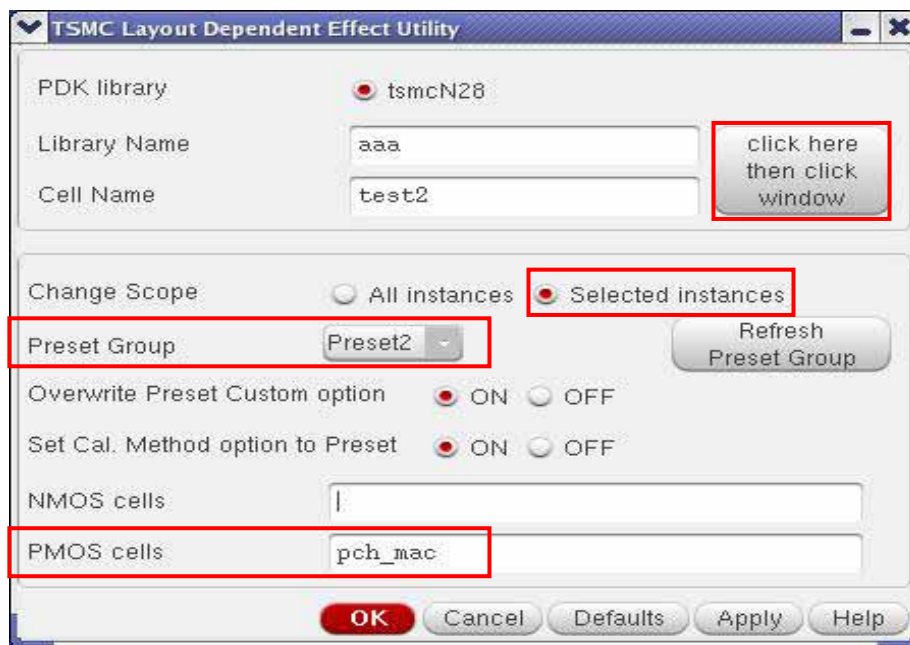
I ./skill/TSMC_LayoutEffect
[Preset1]
<NMOS>
  <wpe>
    SC_L = 1u
    SC_R = 2u
    SC_T = 3u
    SC_B = 4u
  </wpe>
  <pse>
    SPA_L = 5u
    SPA_R = 6u
    SPB_L = 7u
    SPB_R = 8u
  </pse>
  <ose>
    SFAX_L = 9u
    SFAX_R = 1u
    SFY_T = 2u
    SFY_B = 3u
  </ose>
  <ces1>
    ENX_L = 4u
    ENX_R = 5u
    ENY_T = 6u
    ENY_B = 7u
    RX_L = 8u
    RX_R = 9u
    RY_T = 1u
    RY_B = 2u
  </ces1>
</NMOS>
<PMOS>
  <wpe>
    SC_L = 1u
    SC_R = 2u
    SC_T = 3u
    SC_B = 4u
  </wpe>
  <pse>
    SPA_L = 5u
    SPA_R = 6u
    SPB_L = 7u
    SPB_R = 8u
  </pse>
  
```

OK Cancel Apply Defaults Previous Next Help

Example 2: Setting LDE parameters of driver by “Select instances”



PMOS LDE parameters set to “Preset2”
(M3~M4)



Example 2: Setting LDE parameters of driver by "Select instances" (Cont.)

CDF of M3/M4

Object Properties

pre-set-Option

Display Well Proximity Effect

Well Proximity Effect Cal. Method

Gate_to_Left_NWell_Enc(SC_L) (M)	1u M
Gate_to_Right_NWell_Enc(SC_R) (M)	1u M
Gate_to_Top_NWell_Enc(SC_T) (M)	1u M
Gate_to_Bottom_NWell_Enc(SC_B) (M)	1u M
SCA	3.75993
SCB	0.000139359
SCC	4.98519e-09

Display Poly Spacing Effect

Code:

```
[Preset2]
<NMOS>
<lod>
  SA = 140n
  SB = 140n
</lod>
<wpe>
  SC_L = 1u
  SC_R = 1u
  SC_T = 1u
  SC_B = 1u
</wpe>
<pse>
  SPA_L = 0.17u
  SPA_R = 0.17u
  SPB_L = 4u
  SPB_R = 4u
</pse>
<ose>
  SFAX_L = 0.24u
  SFAX_R = 0.24u
  SFY_T = 0.88u
  SFY_B = 0.88u
</ose>
<ces1>
  ENX_L = 4u
  ENX_R = 5u
  ENY_T = 6u
  ENY_B = 7u
  RX_L = 8u
  RX_R = 9u
  RY_T = 1u
  RY_B = 2u
</ces1>
</NMOS>
<PMOS>
<lod>
  SA = 110n
  SB = 110n
</lod>
<wpe>
  SC_L = 1u
  SC_R = 1u
  SC_T = 1u
  SC_B = 1u
</wpe>
<pse>
  SPA_L = 0.14u
  SPA_R = 0.14u
  SPB_L = 4u
  SPB_R = 4u
</pse>
```

SCA = 3.75993
SCB = 0.000139359
SCC = 4.98519e-09

Example 3: Record the history of modification

Step1:TSMC preset LDE table of "Preset2"

Step2:Modify SC_T=1u => 2u

```

IW TSMC_LayoutEffectTable
[Preset2]
<NMOS>
<Tod>
  SA = 140n
  SB = 140n
</Tod>
<wpe>
  SC_L = 1u
  SC_R = 1u
  SC_T = 1u
  SC_B = 1u
</wpe>
<pse>
  SPA_L = 0.17u
  SPA_R = 0.17u
  SPB_L = 4u
  SPB_R = 4u
</pse>
<ose>
  SFAX_L = 0.24u
  SFAX_R = 0.24u
  SFY_T = 0.88u
  SFY_B = 0.88u
</ose>
<ces1>
  ENX_L = 4u
  ENX_R = 5u
  ENY_T = 6u
  ENY_B = 7u
  RX_L = 8u
  RX_R = 9u
  RY_T = 1u
  RY_B = 2u
</ces1>
</NMOS>
<PMOS>
<Tod>
  SA = 110n
  SB = 110n
</Tod>
<wpe>
  SC_L = 1u
  SC_R = 1u
  SC_T = 1u
  SC_B = 1u
</wpe>
<pse>
  SPA_L = 0.14u
  SPA_R = 0.14u
  SPB_L = 4u
  SPB_R = 4u
  
```

Step1

Parameter	Value	Display
Model name	pcn_mac	off
description	0.85V standard VT PMOS transistor	off
Length(M)	30n M	off
Finger_width(M)	100n M	off
Width(M)	100n M	off
Number of Fingers	1	off
Multiplier	1	off
Hard_constrain	<input checked="" type="checkbox"/>	off
Display Simulation Flag	<input type="radio"/> OFF <input type="radio"/> ON	off
Display S/D Parameters	<input type="radio"/> OFF <input type="radio"/> ON	off
Display LOD Effect	<input type="radio"/> OFF <input type="radio"/> ON	off
pre-set-Option	Preset2	off
Display Well Proximity Effect	<input type="radio"/> OFF <input checked="" type="radio"/> ON	off
Well Proximity Effect Cal. Method	<input type="radio"/> Model <input type="radio"/> auto <input type="radio"/> custom <input checked="" type="radio"/> PreSet	off
Gate_to_Left_NWell_Enc(SC_L) (M)	1u M	off
Gate_to_Right_NWell_Enc(SC_R) (M)	1u M	off
Gate_to_Top_NWell_Enc(SC_T) (M)	1u M	off
Gate_to_Bottom_NWell_Enc(SC_B) (M)	1u M	off
SCA	3.75993	off
SCB	0.000139359	off
SCC	4.98519e-09	off
Display Poly Spacing Effect	<input type="radio"/> OFF <input type="radio"/> ON	off

Step2

Parameter	Value	Display
Model name	pcn_mac	off
description	0.85V standard VT PMOS transistor	off
Length(M)	30n M	off
Finger_width(M)	100n M	off
Width(M)	100n M	off
Number of Fingers	1	off
Multiplier	1	off
Hard_constrain	<input checked="" type="checkbox"/>	off
Display Simulation Flag	<input type="radio"/> OFF <input type="radio"/> ON	off
Display S/D Parameters	<input type="radio"/> OFF <input type="radio"/> ON	off
Display LOD Effect	<input type="radio"/> OFF <input type="radio"/> ON	off
Previous pre-set	Preset2	off
pre-set-Option	Custom	off
Display Well Proximity Effect	<input type="radio"/> OFF <input checked="" type="radio"/> ON	off
Well Proximity Effect Cal. Method	<input type="radio"/> Model <input type="radio"/> auto <input type="radio"/> custom <input checked="" type="radio"/> PreSet	off
Gate_to_Left_NWell_Enc(SC_L) (M)	1u M	off
Gate_to_Right_NWell_Enc(SC_R) (M)	1u M	off
Gate_to_Top_NWell_Enc(SC_T) (M)	2u M	off
Gate_to_Bottom_NWell_Enc(SC_B) (M)	1u M	off
SCA	3.08893	off
SCB	0.000109464	off
SCC	4.06348e-09	off
Display Poly Spacing Effect	<input type="radio"/> OFF <input type="radio"/> ON	off

● Users still can change LDE parameters
For example of "SC_T"

● User modify "SC_T to 2um"

● Get new effective WPE parameters
SCA =3.08893
SCB =0.000109464
SCC =4.06348e-09

Example 3: Record the history of modification tsmc (Cont.)

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Step3: CDF shows **pre-set-Option** has been modified by custom

Step4: CDF records original LDE parameters from “Preset2”

CDF Parameter	Value	Display
Model name	pch_mac	off
description	0.85V standard VT PMOS transistor	off
Length(M)	30n M	off
Finger_width(M)	100n M	off
Width(M)	100n M	off
Number of Fingers	1	off
Multiplier	1	off
total_m	1	off
Hard_constraint	<input checked="" type="checkbox"/>	off
Display Simulation Flag	<input type="radio"/> OFF <input type="radio"/> ON	off
Display S/D Parameters	<input type="radio"/> OFF <input type="radio"/> ON	off
Display LOD Effect	<input type="radio"/> OFF <input type="radio"/> ON	off
pre-set-Option	Preset2	off
Display Well Proximity Effect	<input type="radio"/> OFF <input checked="" type="radio"/> ON	off
Well Proximity Effect Cal. Method	<input type="radio"/> Model <input type="radio"/> auto <input type="radio"/> custom <input checked="" type="radio"/> PreSet	off
Gate_to_Left_NWell_Enc(SC_L) (M)	1u M	off
Gate_to_Right_NWell_Enc(SC_R) (M)	1u M	off
Gate_to_Top_NWell_Enc(SC_T) (M)	1u M	off
Gate_to_Bottom_NWell_Enc(SC_B) (M)	1u M	off
SCA	3.75993	off
SCB	0.000139359	off
SCC	4.98519e-09	off
Display Poly Spacing Effect	<input type="radio"/> OFF <input type="radio"/> ON	off

Step3-4



CDF Parameter	Value	Display
Model name	pch_mac	off
description	0.85V standard VT PMOS transistor	off
Length(M)	30n M	off
Finger_width(M)	100n M	off
Width(M)	100n M	off
Number of Fingers	1	off
Multiplier	1	off
total_m	1	off
Hard_constraint	<input checked="" type="checkbox"/>	off
Display Simulation Flag	<input type="radio"/> OFF <input type="radio"/> ON	off
Display S/D Parameters	<input type="radio"/> OFF <input type="radio"/> ON	off
Display LOD Effect	<input type="radio"/> OFF <input type="radio"/> ON	off
Previous pre-set	Preset2	off
pre-set-Option	Custom	off
Display Well Proximity Effect	<input type="radio"/> OFF <input checked="" type="radio"/> ON	off
Well Proximity Effect Cal. Method	<input type="radio"/> Model <input type="radio"/> auto <input type="radio"/> custom <input checked="" type="radio"/> PreSet	off
Gate_to_Left_NWell_Enc(SC_L) (M)	1u M	off
Gate_to_Right_NWell_Enc(SC_R) (M)	1u M	off
Gate_to_Top_NWell_Enc(SC_T) (M)	2u M	off
Gate_to_Bottom_NWell_Enc(SC_B) (M)	1u M	off
SCA	3.08893	off
SCB	0.000109464	off
SCC	4.06348e-09	off
Display Poly Spacing Effect	<input checked="" type="radio"/> OFF <input type="radio"/> ON	off

Now CDF shows “Custom” modify

Record the previous “pre-set” table from **Preset2**