New model equations in BSIMSOIv3.1

If SoiMod=0 (default), the model equation is identical to BSIMPD equation.

If SoiMod=1 (unified model for PD&FD) or SoiMod=2 (ideal FD), the following equations (FD module) are added on top of BSIMPD.

$$V_{bs0} = \frac{C_{Si}}{C_{Si} + C_{BOX}} \times \left(phi - \frac{qN_{ch}}{2\varepsilon_{Si}} \times T_{Si}^{2} + V_{nonideal} + \Delta V_{DIBL} \right) + \eta_e \frac{C_{BOX}}{C_{Si} + C_{BOX}} \times (V_{es} - V_{FBb})$$

where $C_{Si} = \dfrac{\varepsilon_{Si}}{T_{Si}}, C_{BOX} = \dfrac{\varepsilon_{OX}}{T_{BOX}}, C_{OX} = \dfrac{\varepsilon_{OX}}{T_{OX}}$

$$\Delta V_{DIBL} = D_{vbd0} \left(exp \left(- D_{vbd1} \frac{L_{eff}}{2l} \right) + 2exp \left(- D_{vbd1} \frac{L_{eff}}{l} \right) \right) \times (V_{bi} - 2\Phi_B)$$

$$\eta_e = K_{1b} - K_{2b} \times \left(exp \left(- D_{k2b} \frac{L_{eff}}{2l} \right) + 2exp \left(- D_{k2b} \frac{L_{eff}}{l} \right) \right)$$

$$phi = phi_{ON} - \frac{C_{OX}}{C_{OX} + \left(C_{Si}^{-1} + C_{BOX}^{-1} \right)^{-1}} \times N_{OFF,FD}V_t \times ln\left(1 + exp\left(\frac{V_{th,FD} - V_{gs\_eff} - V_{OFF,FD}}{N_{OFF,FD}V_t} \right) \right)$$

$$phi_{ON} = 2\Phi_B + V_t \, ln\left(1 + \frac{V_{gsteff,FD}\left(V_{gsteff,FD} + 2K1\sqrt{2\Phi_B} \right)}{MoinFD \times K1 \times V_t^2} \right),$$

$$V_{gsteff,FD} = N_{OFF,FD}V_t \times ln\left(1 + exp\left(\frac{V_{gs\_eff} - V_{th,FD} - V_{OFF,FD}}{N_{OFF,FD}V_t} \right) \right)$$

Here Nch is the channel doping concentration. V_{FBb} is the backgate flatband voltage. $V_{th,FD}$ is the threshold voltage at $V_{bs}=V_{bs0}(phi=2\Phi_B)$. V_t is thermal voltage. K1 is the body effect coefficient.

If SoiMod=1, the lower bound of V_{bs} (SPICE solution) is set to V_{bs0}. If SoiMod=2, V_{bs} is pinned at V_{bs0}. Notice that there is body node and body leakage/charge calculation in SoiMod=2.

The zero field body potential that will determine the transistor threshold voltage, V_{bsmos}, is then calculated by

$$V_{bsmos} = V_{bs} - \frac{C_{Si}}{2qN_{ch}T_{Si}} \left(V_{bs0}(T_{OX} \circledR \yen) - V_{bs}\right)^2 \quad \text{if } V_{bs} \pounds V_{bs0}(T_{OX} \circledR \yen)$$
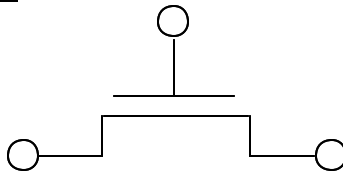
$$= V_{bs} \quad \text{else}$$

The subsequent clamping of V_{bsmos} will use the same equation that utilized in BSIMPD. Please download the BSIMPD manual at (www-device.eecs.Berkeley.edu/~bsimsoi).
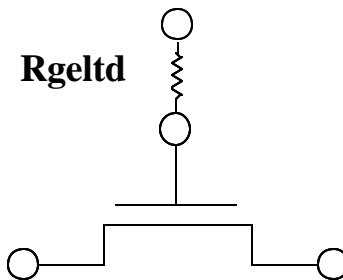
RF Model in BSIMSOIv3.1

BSIMSOI3.1 provides the gate resistance model for devices used in RF application. Four options for modeling gate electrode resistance (bias independent) and intrinsic-input resistance (Rii, bias-dependent) are provided.

Model Option and Schematic:
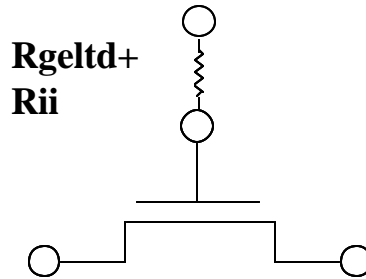
RgateMod = 0 (zero-resistance):

RgateMod = 1 (constant-resistance):

In this case, only the electrode gate resistance (bias-independent) is generated by adding an internal gate node. Rgeltd is given by

$$Rgeltd = \frac{RSHG \cdot \left(XGW + \dfrac{W_{eff}}{3 \cdot NGCON \cdot NSEG}\right)}{NGCON \cdot (L_{drawn} - XGL)}$$
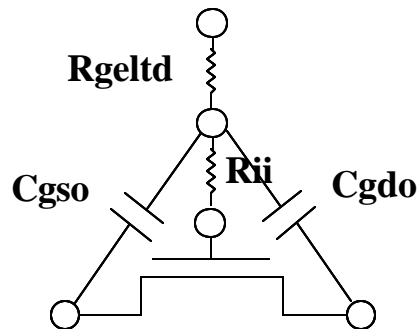
RgateMod = 2 (RII model with variable resistance):

Rgeltd+
Rii

In this case, the gate resistance is the sum of the electrode gate resistance and the intrinsic-input resistance Rii as given by

$$\frac{1}{Rii} = XRCRG1 \cdot \left(\frac{I_{ds}}{V_{dseff}} + XRCRG2 \cdot \frac{W_{eff}\, \boldsymbol{m}_{eff}\, C_{oxeff}\, k_B T}{q L_{eff}} \right)$$

An internal gate node will be generated.

RgateMod = 3 (RII model with two nodes):
In this case, the gate electrode resistance is in series with the intrinsic-input resistance Rii through two internal gate nodes, so that the overlap capacitance current will not pass through the intrinsic-input resistance.

Rgeltd

Cgso   **Rii**   **Cgdo**

New model parameters in BSIMSOIv3.1

Symbol used in equation	Symbol used in SPICE	Description	Unit	Default
$SoiMod$	soiMod	SOI model selector. SoiMod=0: BSIMPD. SoiMod=1: unified model for PD&FD. SoiMod=2: ideal FD.	-	0
$V_{nonideal}$	vbsa	Offset voltage due to non-idealities	V	0
$N_{OFF,FD}$	nofffd	Smoothing parameter in FD module	-	1
$V_{OFF,FD}$	vofffd	Smoothing parameter in FD module	V	0
K_{1b}	K1b	First backgate body effect parameter	-	1
K_{2b}	K2b	Second backgate body effect parameter for short channel effect	-	0
D_{k2b}	dk2b	Third backgate body effect parameter for short channel effect	-	0
D_{vbd0}	dvbd0	First short channel effect parameter in FD module	-	0
D_{vbd1}	dvbd1	Second short channel effect parameter in FD module	-	0
$MoinFD$	moinfd	Gate bias dependence coefficient of surface potential in FD module	-	1e3
$RgateMod$	rgateMod	Gate resistance model selector rgateMod = 0 No gate resistance rgateMod = 1 Constant gate resistance rgateMod = 2 Rii model with variable resistance rgateMod = 3 Rii model with two nodes	-	0
$RSHG$	rshg	Gate sheet resistance	-	0.1
$XRCRG1$	xrcrg1	Parameter for distributed channel-resistance effect for intrinsic input resistance	-	12.0
$XRCRG2$	xrcrg2	Parameter to account for the excess channel diffusion resistance for intrinsic input resistance	-	1.0
$NGCON$	ngcon	Number of gate contacts	-	1
XGW	xgw	Distance from the gate contact to the channel edge	m	0.0
XGL	xgl	Offset of the gate length due to variations in patterning	m	0.0