Model Bug Fixes for BSIM4.2.1

- 1/f noise model bug fix
- Memory pointer bug
- ACDE check
- Temperature parameters for parasitic diodes
- Bug fix for narrow width effect
- Addition of Gate Induced Source Leakage
- L,W,Tox parameter warning limit checking

1/f Noise Model Bug Fix

Requested by David Zweidinger Keith Green Britt Brooks

Texas Instruments

Problem: negative DelClm under certain conditions of voltage bias, temperature, L, and W

$$S_{id,inv}(f)=\frac{k_B T q^2 m_{eff} I_{ds}}{C_{oxe} L_{eff}^{\ 2} A_{bulk} f^{ef}\cdot 10^{10}}\left(NOIA\log\left(\frac{N_0+N^*}{N_l+N^*}\right)+NOIB\left(N_0-N_l\right)+\frac{NOIC}{2}\left(N_0^{\ 2}-N_l^{\ 2}\right)\right)$$

$$+\frac{k_B T I_{ds}^{\ 2}\Delta L_{clm}}{W_{eff}\cdot L_{eff}^{\ 2} f^{ef}\cdot 10^{10}}\cdot\frac{NOIA+NOIB N_l+NOIC N_l^{\ 2}}{\left(N_l+N^*\right)^2}$$

$$\Delta L_{\text{clm}} = Litl\cdot\log\left(\frac{\frac{V_{ds}-V_{dseff}}{Litl}+EM}{E_{sat}}\right)$$

$$E_{sat}=\frac{2VSAT}{m_{eff}}$$

In b4noi.c:

```
if(model->BSIM4em<=0.0) DelClm = 0.0; /* flicker noise modified -JX  */
   else {
            T0 = ((((Vds - here->BSIM4Vdseff) / pParam->BSIM4litl)
                    + model->BSIM4em) / esat);
            DelClm = pParam->BSIM4litl * log (MAX(T0, N_MINLOG));
   }
```

Memory Pointer Bug

Requested by David Zweidinger Keith Green Britt Brooks

Texas Instruments

Problem: No value assignment to pParam for no-binning approach.

In b4temp.c:

```
while ((pSizeDependParamKnot != NULL) && Size_Not_Found)
{   if ((here->BSIM4l == pSizeDependParamKnot->Length)
            && (here->BSIM4w == pSizeDependParamKnot->Width)
            && (here->BSIM4nf == pSizeDependParamKnot->NFinger))
        {   Size_Not_Found = 0;
            here->pParam = pSizeDependParamKnot;
            pParam = here->pParam; /*bug-fix  */
        }
}
```

ACDE (capMod 2) Checking

Requested by David Zweidinger Keith Green Britt Brooks

Texas Instruments

Problem: warning message for other capacitance models

In b4check.c:

```
if(model->BSIM4capMod ==2) {
        if (pParam->BSIM4acde < 0.4)
        {   fprintf(fplog, "Warning:  Acde = %g is too small.\n", pParam->BSIM4acde);
            printf("Warning:  Acde = %g is too small.\n", pParam->BSIM4acde);
        }
        if (pParam->BSIM4acde > 1.6)
        {   fprintf(fplog, "Warning:  Acde = %g is too large.\n", pParam->BSIM4acde);
            printf("Warning:  Acde = %g is too large.\n", pParam->BSIM4acde);
        }
}
```

Temperature Parameters for Parasitic Diodes

Requested by Alex Zavorine Circuit Semantics

Jane Xi UC Berkeley

Problems: Model parameters be reassigned with new value for parasitic diode parameters in b4temp.c

In bsim4def.h, new Pre-calculated constants added:

```
double BSIM4SunitAreaTempJctCap;
double BSIM4DunitAreaTempJctCap;
double BSIM4SunitLengthSidewallTempJctCap;
double BSIM4DunitLengthSidewallTempJctCap;
double BSIM4SunitLengthGateSidewallTempJctCap;
double BSIM4DunitLengthGateSidewallTempJctCap;
```

Modifications needed in bsim4def.h, b4temp.c, b4ld.c.

Bug Fix for Narrow Width Effect

Requested by Mark Cao Jane Xi UC Berkeley

In b4ld.c:

```
T0 = pParam->BSIM4dvt1w * pParam->BSIM4weff * Leff / ltw;
if (T0 < EXP_THRESHOLD)
{   T1 = exp(T0);
    T2 = T1 - 1.0;
    T3 = T2 * T2;
    T4 = T3 + 2.0 * T1 * MIN_EXP;
    T5 = T1 / T4;
    dT1_dVb = -T0 * T1 * dltw_dVb / ltw; /* bug fix -JX */
    dT5_dVb = dT1_dVb * (T4 - 2.0 * T1 * (T2 + MIN_EXP)) / T4 / T4;
}
```

Addition of GISL(Gate Induced Source Leakage) in BSIM4 (bug fix)

Requested by David Zweidinger Keith Green Britt Brooks
Tom Vrotsos Vinod Gupta John Krick
Texas Instruments

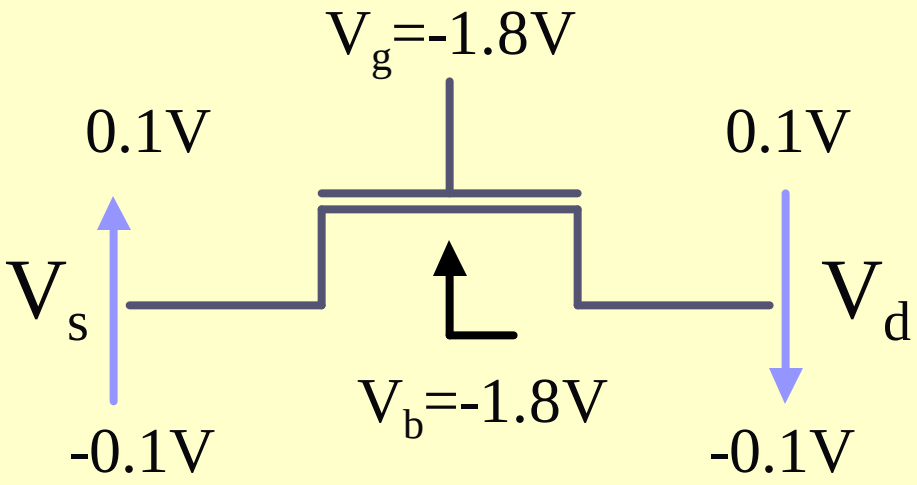
Advantage: an enormous impact on circuit simulation convergence

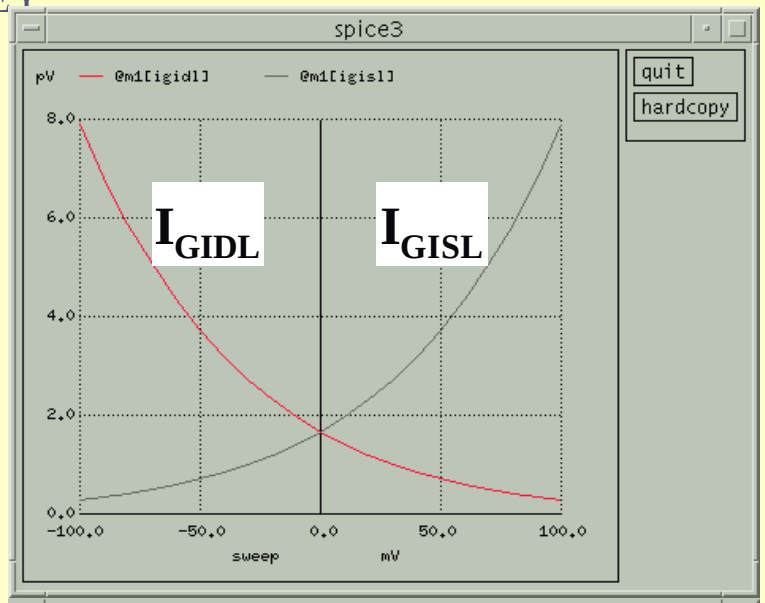
Follow the same model of I_{GIDL}:

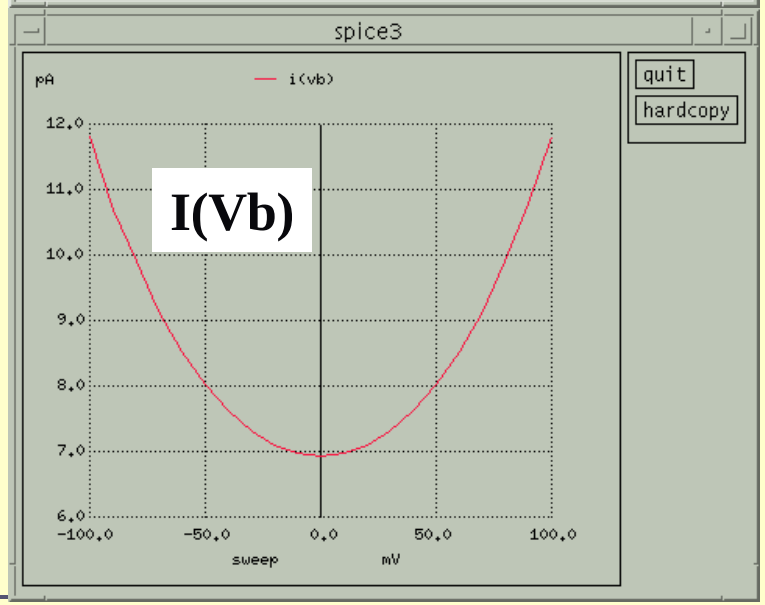
$$I_{GISL} = AGIDL \cdot W_{effCJ} \cdot Nf \cdot \frac{-V_{ds} - V_{gde} - EGIDL}{3 \cdot T_{oxe}} \cdot \exp\left(- \frac{3 \cdot T_{oxe} \cdot BGIDL}{-V_{ds} - V_{gde} - EGIDL} \right) \cdot \frac{V_{sb}^3}{CGIDL + V_{sb}^3}$$

Modifications needed in b4ld.c, b4acld.c, b4pzld.c, b4cvtest.c

Gummel's Symmetry Test for GIDL & GISL







L,W,Tox Parameter Warning Limit

Requested by David Zweidinger Keith Green Britt Brooks

Texas Instruments

	Original	Now	Recommened
Leff (m)	5e-8	1e-9	1e-8
Leffcv (m)	5e-8	1e-9	1e-8
Weff (m)	1e-7	1e-9	1e-7
Weffcv (m)	1e-7	1e-9	1e-7
Toxe (m)	1e-9	1e-10	5e-10
Toxp (m)	1e-9	1e-10	5e-10
Toxm (m)	1e-9	1e-10	5e-10

- If(L,W,Tox <=0) {fatal message; Fatal_Flag =1;}
- If(L,W,Tox < warning limit) {warning messages;}
- Recommended value here are for a meanful output from BSIM4