BSIM Bug Report

BSIM Group

University of California, Berkeley

BSIM 4.6.4

Bug Description	Reported by	File(s)
Uninitialized variable Vtm	Ben Gu and Chip Workman (Freescale)	b4temp.c (line 2045)
Implementation error in tempMod=3	Robin Tan (Synopsys)	b4set.c (line 181)
mobMod=3 temperature coefficients updated twice	Ben Gu and Chip Workman (Freescale)	b4temp.c (line 1165)
Thermal noise error (tnoiMod=1)	BSIM Group	b4noi.c (line 235)
'Esat' not updated in Velocity overshoot model	Joddy Wang (Synopsys)	b4ld.c (line 1622)

Bug 1: Uninitialized Variable Problem

- Reported by Ben Gu and Chip Workman (Freescale)
- **Bug**: Uninitialized variable "Vtm" is used *(b4temp.c line 2045)*

```
T0 = n0 * Vtm;
```

(Vtm is never given a value in b4temp.c)

- **Fix**:

1. Code is modified as follows

```
T0 = n0 * model->BSIM4vtm;
```

Bug 2: Implemenation Error in tempMod=3

- Reported by Robin Tan (Synopsys) for *b4set.c line 181*
- **Bug**: The following code treats tempMod = 3 as tempMod = 0

```
if (!model->BSIM4tempModGiven)
    model->BSIM4tempMod = 0;
else if ((model->BSIM4tempMod != 0) && (model->BSIM4tempMod != 1)
         && (model->BSIM4tempMod != 2))
{   model->BSIM4tempMod = 0;
    printf("Warning: tempMod has been set to its default value: 0.\n");
}
```

- **Fix**: The code is modified as follows:

```
if (!model->BSIM4tempModGiven)
    model->BSIM4tempMod = 0;
else if ((model->BSIM4tempMod != 0) && (model->BSIM4tempMod != 1)
         && (model->BSIM4tempMod != 2) && (model->BSIM4tempMod != 3))
{   model->BSIM4tempMod = 0;
    printf("Warning: tempMod has been set to its default value: 0.\n");
}
```

Bug 3: mobMod=3 Temperature Dependence

- Reported by Ben Gu and Chip Workman (Freescale)
- **Bug**: Temperature coefficient is updated twice *(b4temp.c line 1139-1171)*

```
if (model->BSIM4tempMod == 3)   {
   pParam->BSIM4ua = pParam->BSIM4ua * pow(TRatio, pParam->BSIM4ua1) ;
   pParam->BSIM4uc = pParam->BSIM4uc * pow(TRatio, pParam->BSIM4uc1) ;
   .........

............
if (model->BSIM4mobMod == 3)   {
   pParam->BSIM4ua = pParam->BSIM4ua * pow(TRatio, pParam->BSIM4ua1) ;
   pParam->BSIM4uc = pParam->BSIM4uc * pow(TRatio, pParam->BSIM4uc1) ;
   .........
```

- **Fix**: Redundant lines are removed

Bug 4: Thermal Noise Model (tnoiMod=1)

- **Bug:** *(b4noi.c line 235)*:

```
 gspr = gspr / (1.0 + npart_theta * npart_theta * gspr /
here->BSIM4IdovVds);
……
gdpr = gdpr / (1.0 + npart_theta * npart_theta * gdpr /
here->BSIM4IdovVds);
```

Multiplication should be used instead of division

- **Fix:**

  The two lines have been modified in BSIM 4.7.0:

```
 gspr = gspr * (1.0 + npart_theta * npart_theta * gspr /
here->BSIM4IdovVds);
……
gdpr = gdpr * (1.0 + npart_theta * npart_theta * gdpr /
here->BSIM4IdovVds);
```

Bug 5: Esat Updating Issue

- **Bug** : Reported by Joddy, Synopsys
  - Location: b4ld.c line 1655

```
1655  EsatL *= T10;
1656  here->BSIM4EsatL = EsatL;
```

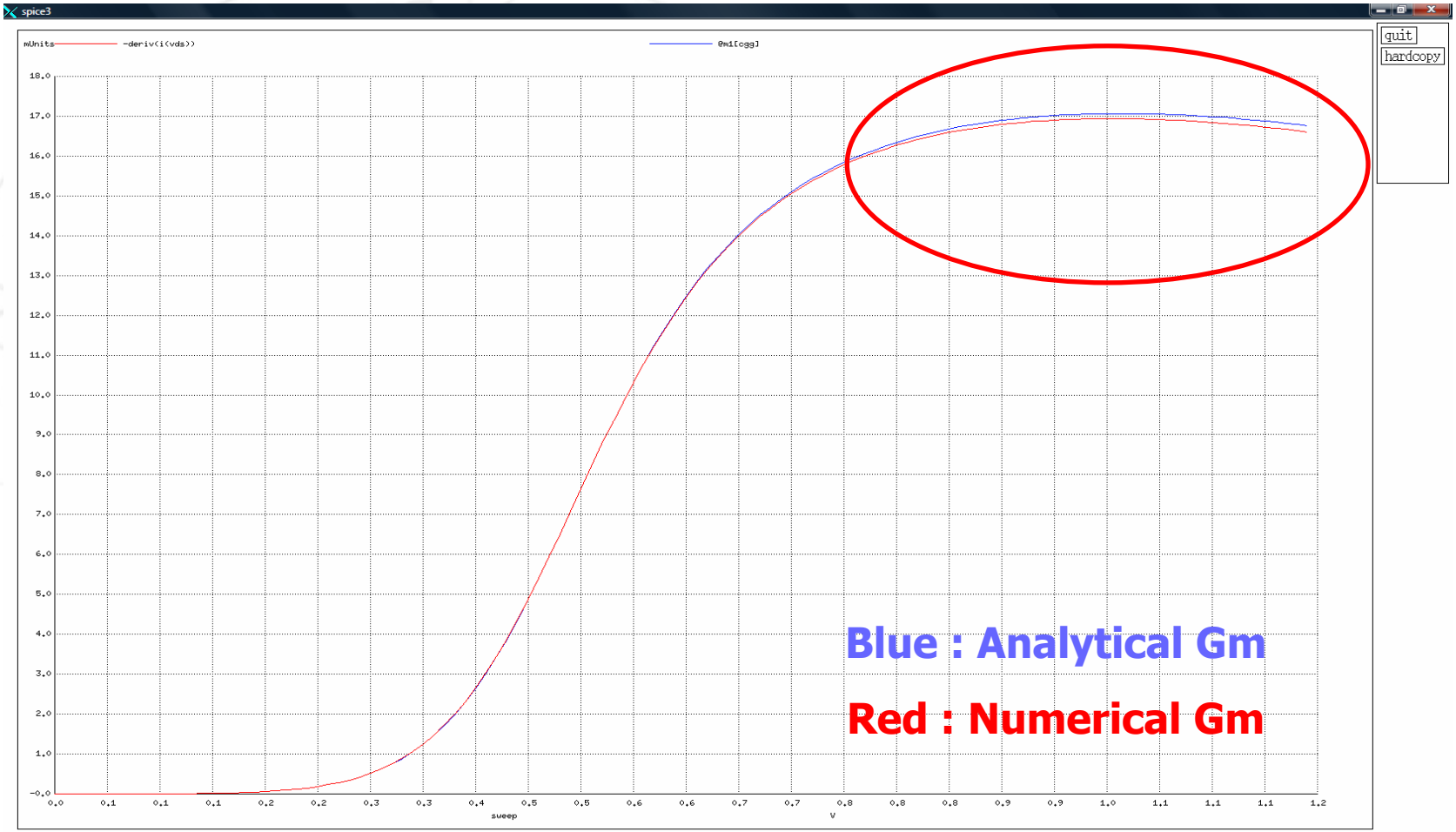
  - Variable "EsatL" is updated , but "Esat" is not

- **Fix** :
  - One line is added after line 1655:

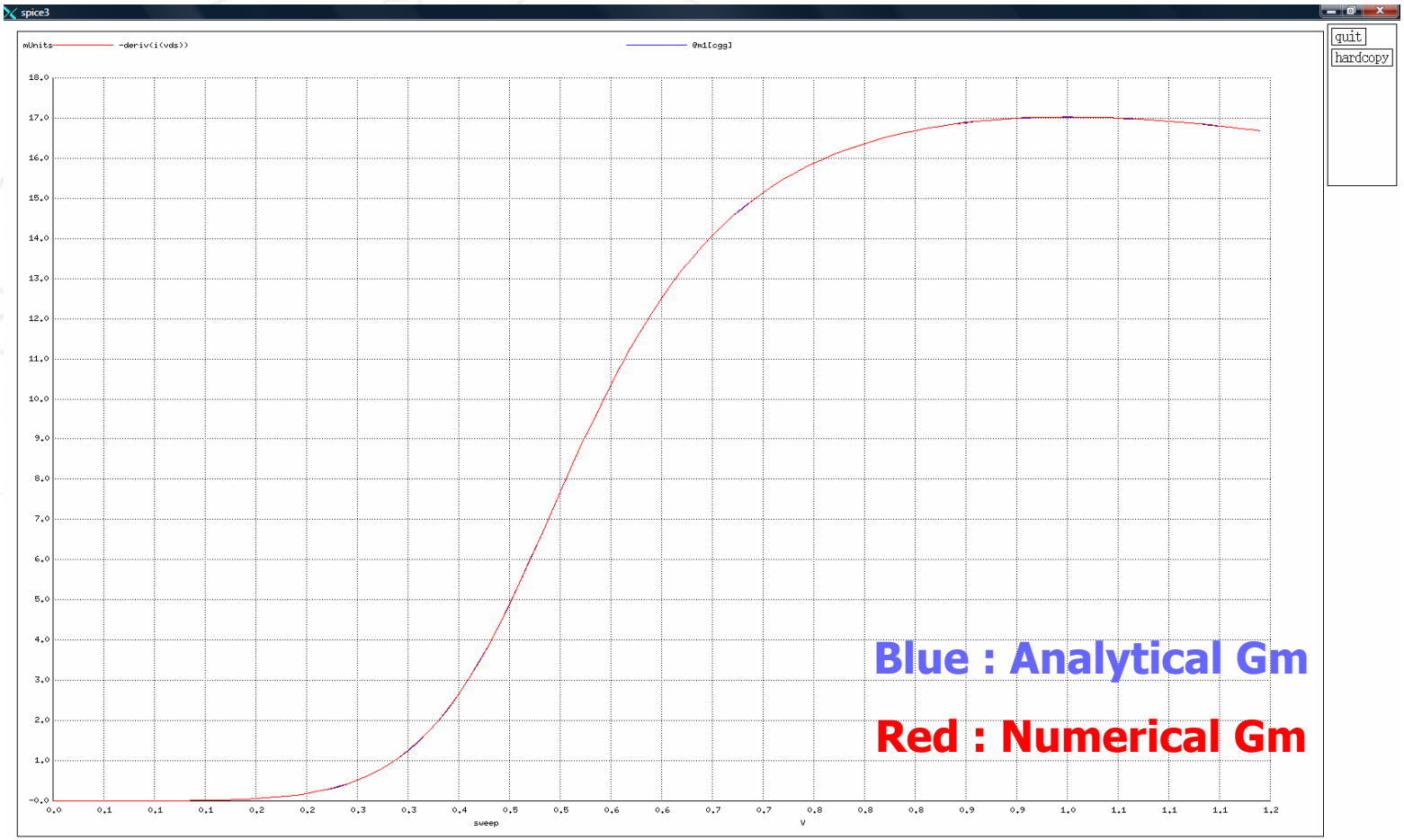
```
1655  EsatL *= T10;
1656  Esat = EsatL / Leff;
1657  here->BSIM4EsatL = EsatL;
```

  - This bug only has effect when LAMBDA > 0.
  - < 0.1% difference in Ids between two versions (with/without bug).

Gm (Before Bug Fix)



Gm (After Bug Fix)



Gm

Vgs (V)

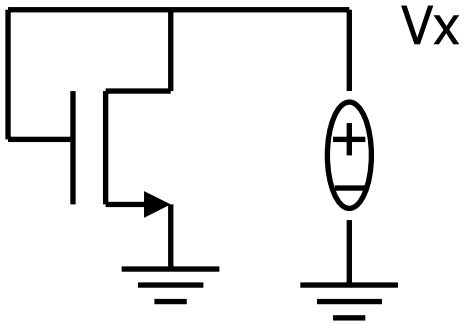
Notes on BSIM4.6.3 Columbic Scattering(1)

- Ben Gu reported that the model is backward compatible with BSIM4.5.0 when Vth is negative. There is no problem when Vth is positive.

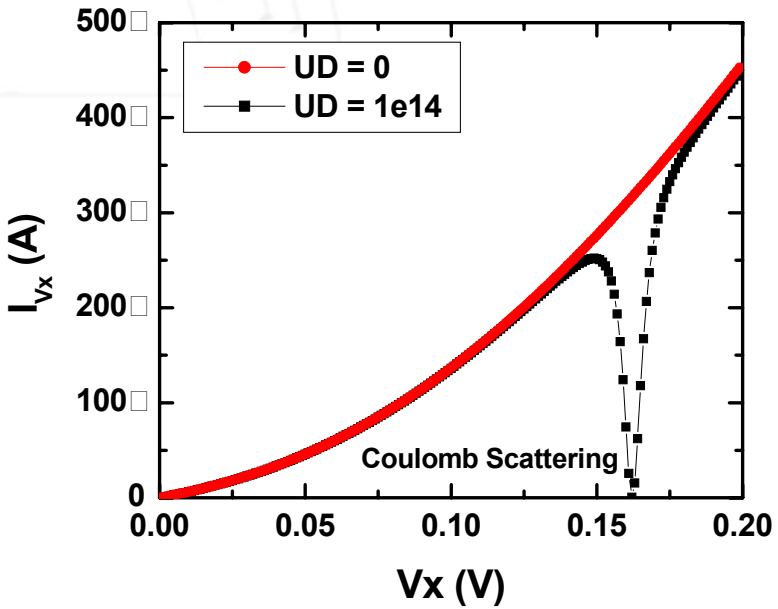
- A proposal in CMC 2008 Q4 was to change the columbic scattering term back to its form in BSIM 4.5.0 to fix the issue of backward incompatibility.

Notes on BSIM4.6.3 Columbic Scattering(2)

- In the BSIM4.5.0 form, if $V_{th} < 0$, $V_{gsteff} + V_{th}$ can become zero and Id is non-monotonic.
- When UD=0 or Vth>=0, there is no such problem.



CMC 2006 2Q



Notes on BSIM4.6.3 Columbic Scattering(3)

- We have concluded that there is no practical way to be backward compatible with a model that yields non-monotonic Id without also producing the non-montonic Id.
- We recommend that no changes be made to the BSIM4.6.0 form.

4.5.0

$$\mu_{eff} = \frac{U0 \cdot f(L_{eff})}{1 + \left(UA + UCV_{bseff}\right)\left(\frac{V_{gsteff} + 2V_{th}}{TOXE}\right) + UB\left(\frac{V_{gsteff} + 2V_{th}}{TOXE}\right)^2 + UD\left(\frac{V_{th} \cdot TOXE}{V_{gsteff} + 2V_{th}}\right)^2}$$

4.6.0

$$\mu_{eff} = \frac{U0 \cdot f(L_{eff})}{1 + \left(UA + UCV_{bseff}\right)\left(\frac{V_{gsteff} + 2V_{th}}{TOXE}\right) + UB\left(\frac{V_{gsteff} + 2V_{th}}{TOXE}\right)^2 + UD\left(\frac{V_{th} \cdot TOXE}{V_{gsteff} + 2\sqrt{V_{th}^2 + 0.0001}}\right)^2}$$