HICUM/L2 version 2.34

Release Notes

August 2015

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Depletion capacitance grading factors

Range of the grading factors changed to exlude 1.0

- applies to all grading factors: zEi, zEp, zCi, zCx, zS and zSp (newly introduced)

```
parameter real zei      = 0.5          from (0:1]
```

changed to

```
parameter real zei      = 0.5          from (0:1)
```

Conditions for noise correlation evaluation

Change requires *both* **alit** *and* **alqf** to be greater than 0

- Conditional statement

```
if ( flcono==1 && (alit > 0 || alqf > 0)) begin
```

changed to

```
if ( flcono==1 && (alit > 0 && alqf > 0)) begin
```

- Notes:
  - Device physics always requires both parameters to be non-zero
  - For test purposes, one or both parameters can still be set to a small value if required

Default value for forward-bias base charge Q_bf

Added Q_bf in both branches of the conditional statment

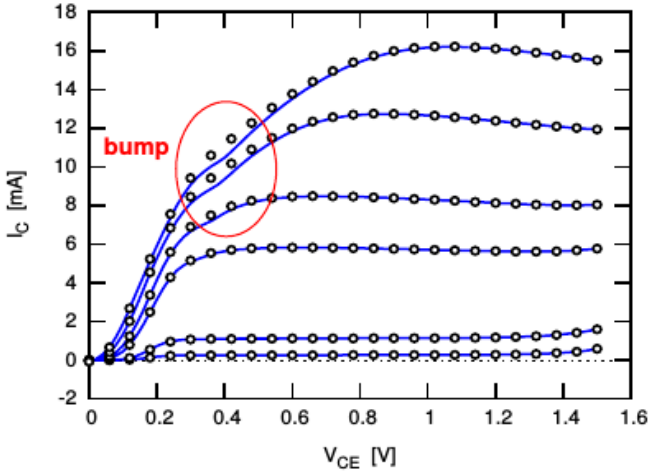
- transit time macro:

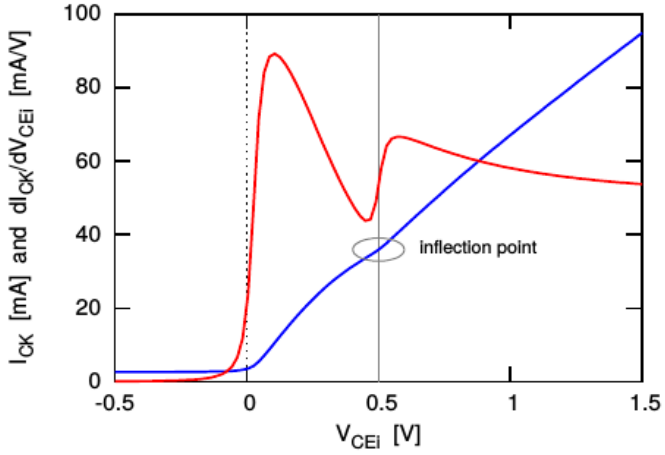
```
if(itf < 1.0e-6*I_CK) begin\
    Q_fT              = Q_f;\
    T_fT              = T_f;\
    Q_bf              = 0;\  <- New line included
 end else begin ...
```

=> defined value for Q_bf in all cases

Improved ICK formulation

- Feature request by ST [1]
  - transition of ICK from (very) low to higher voltages may cause bump





  - adding a formerly fixed smoothing parameter now as model parameter *aick*

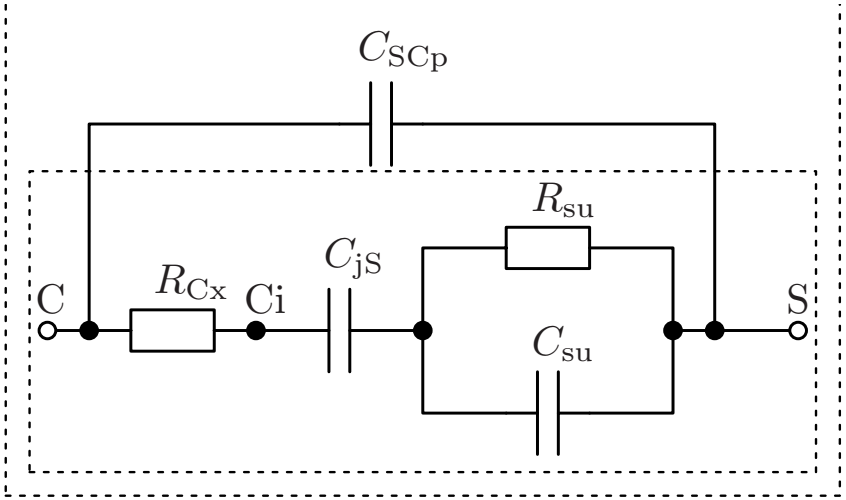
$$I_{CK} = \frac{v_{ceff}}{r_{Ci0}} \frac{1}{\left(1 + \left(\frac{v_{ceff}}{V_{lim}}\right)^{\delta_{ck}}\right)^{1/\delta_{ck}}} \left[1 + \frac{x + \sqrt{x^2 + a_{ick}}}{2}\right]$$

[1] Didier Céli, "Investigation on Bias Dependence of Critical Current ICK in HICUM Models", 27th BAK, Crolles, France, October 24, 2014

Substrate capacitance and coupling network

Extended too simple metwork towards more accurate representation

- Added separate Collector-Substrate perimeter related substrate capacitance C_{SCp}



- separate set of parameters: C_{SCp0}, V_{DSp}, z_{Sp}, V_{PTSp} (to allow DTI and junction isolation)
- C_{SCp}=const. for V_{DSp}=0 => trench isolation
- C_{SCp}=f(V_{SC}) for V_{DSp}>0 => junction isoation
- temperature dependence via existing V_{gS} (for V_{DSp}>0) or constant with T (for V_{DSp}=0)

(V_{DSp} acting as flag)

Depletion capacitances

- at small z and high forward bias, $v/V_D>1$ may occur in $(1-v/V_D)^z$ => overflow
- correction term in calculation of $v_{j,m}$ to avoid $v_{j,m} > V_D$

$$v_{j,m} = -V_{jPCi} + V_r\left[\ln(1+e_{j,m}) - \exp\left(-\frac{V_{jPCi}+V_{fCi}}{V_r}\right)\right]$$

- in the code:

```
Dv_j2 = -Dv_p+Da*ln(1.0+De);\
```

  changed to

```
Dv_j2 = -Dv_p+Da*(ln(1.0+De)-exp(-(Dv_p+DV_f)/Da));\
```

- caused by residual value of smoothing function ln[1+exp(v)] for $v \rightarrow \infty$
  - for calculating the offset, a series expansion of ln(y) with y=1+x at x is applied

$$\ln(1+x) = \ln(x) + \frac{1}{x} - \frac{1}{2x^2} + \frac{1}{3x^3} - \ldots = \ln(x) + \sum_{k=1}^{\infty}(-1)^{k+1}\frac{1}{kx^k}$$

  - note, when stopping the series after an odd k, an overestimation is obtained thus, using only the linear term provides a safe estimate of the offset

Output resistance calculation (OP only)

bug fix in adding avalanche related term

- Wrong sign for the conductance corresponding to avalanche breakdown
- Code for gAVL

```
gAVL = -type*ddx(iavl, V(ci));
ROi  = 1/(gOi+gAVL+`Gmin);
```

changed to

```
gAVL = type*ddx(iavl, V(ci));
ROi  = 1/(gOi+gAVL+`Gmin);
```