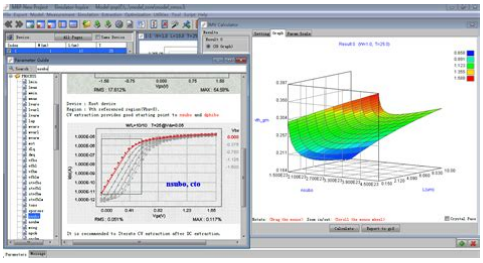

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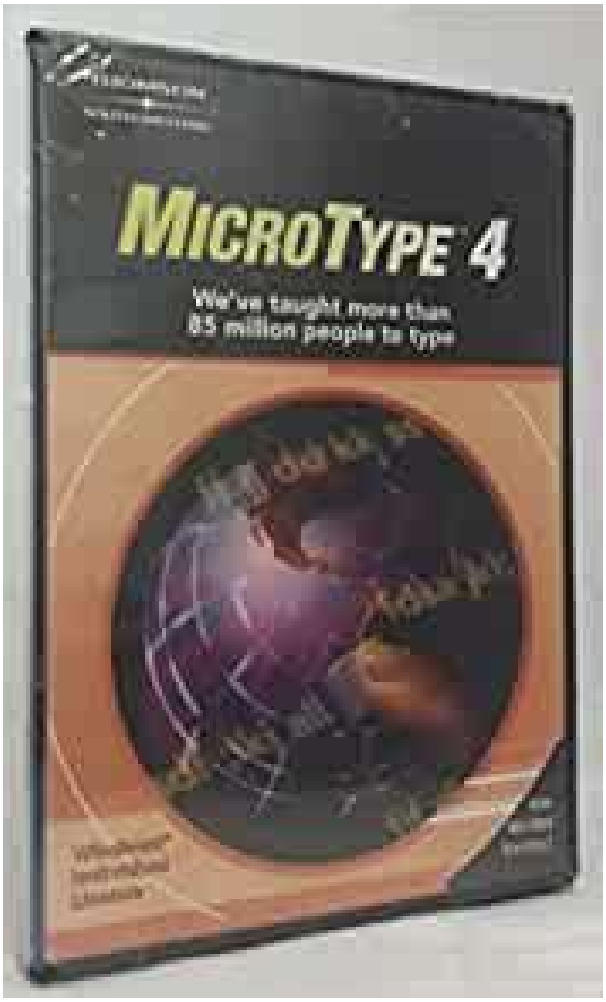
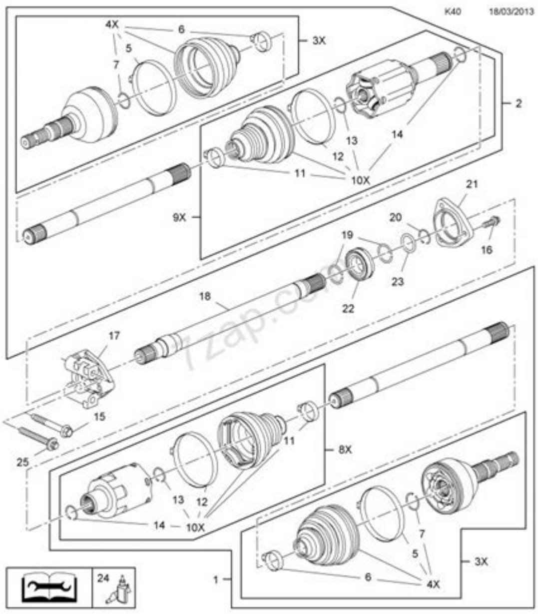
# bsimsoi 4.3 manual

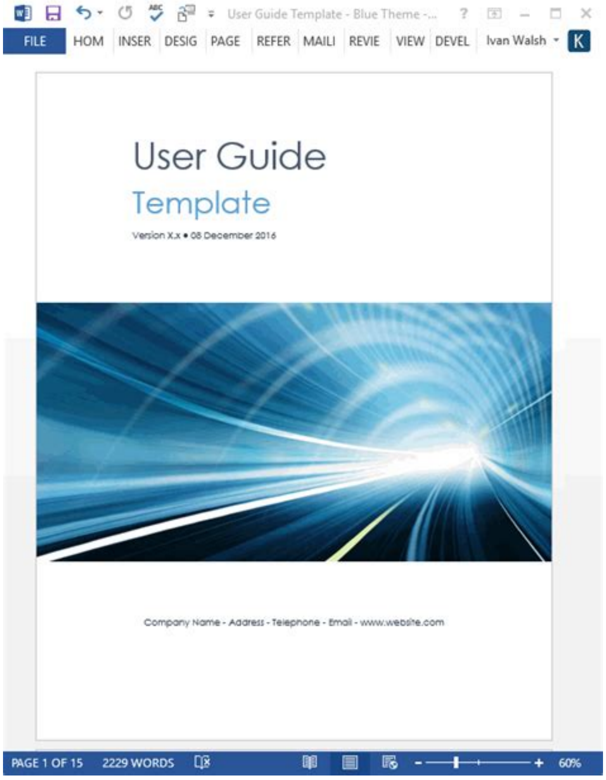



Department of Electrical Engineering and Computer Sciences. University of California, Berkeley, CA 94720. Copyright 2009. The Regents of the University of California. All Rights ReservedBSIMSOI4 web site with BSIM source code and documentsBSIMSOIv4.3 model is backward compatible with its previous versions BSIMSOI4.2 orThe developers wouldJoddy Wang, Jane Xi, Weidong Liu and Song Bai at Synopsys, Geoffrey Coram at ADI, Jushan. Xie and Yafei Yan at Cadence, Samuel Mertens at Ansoft, Brian Chen, Abo ElHadid AhmedSpecial thanks to theThe BSIM project is partially supported by SRC and CMC.Appendix A Model Instance SyntaxE.1. DC ParametersReferencesChapter 1 Introduction. BSIMSOI is an international standard model for SOI SiliconOnInsulator circuit design. It shares the same basicMany enhanced features areSemiconductor Research and Development Center SRDC at East Fishkill. In particular, theThis includes enhancements in the variousThe contribution from BJT current is alsoPage 1Page 2In BSIMSOI4.1, the following features are addedBSIMSOI v4.2 and v4.3 benefit from an extensive review of the code by the CMC members. A significant number of code implementation issues and errors are resolved and fixed in theseIBM, Mentor Graphics, Synopsys through a highly active forum. The charge and temperatureBSIMSOIv4.1. Page 3. Chapter 2 MOS IV Model. A typical PD SOI MOSFET structure is shown in Fig. 2.1. The device is formed on a thin. SOI film of thickness Tsi on top of a layer of buried oxide with thickness Tbox. In the floatingThe body potential Vb is iterated in circuitVg. Vd. VsTsiFig. 2.1. Schematic of a typical PD SOI MOSFET. Since the backgate Ve effect is decoupled by the neutral body, PD SOI MOSFETs havePage 4These effects include parasiticBSIMPD is formulated on top of the BSIM3v3 framework. In this way, a lot of physicalThese effects are reverse shortIn BSIMPD, the floating body voltage is iterated by the SPICE engine. The result of iteration.http://remont-bez-zabot.ru/files/file/datron_1362_manual.xml

- **bsimsoi 4.3 manual, bsimsoi 4.3 manual transmission.**

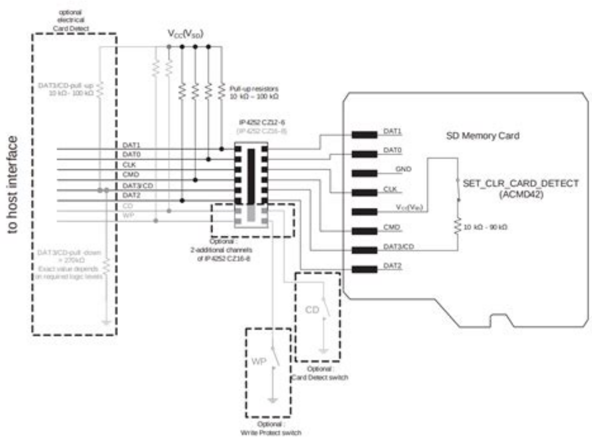


In the case of DC, body currents include diodeTo ensure a good model behavior during simulations, the iterated body potential Vbs isT1 Vbsc 0.5Vbs Vbsc Vbsh s1 0.5s1 T1 To validate the popular square root expressionVbseff s 0 0.5 s 0 Vbsh Using the Vbseff which is clamped to the surface potential s, the squareroot dependence. However the real body potential may be larger than the surface potential in stateoftheart PD. SOI technologies. To accurately count the body effect in such a high body bias regime, weIn BSIMPD, the body effect coefficient K1 is replaced byNotice that K1eff approaches K1 asymptoticallyWhile the body effect coefficient will beThe complete equation of the threshold voltage Vth can be found in the Appendix C.The bulk charge factor in BSIMSOI4.0 is given as. Page 6. AbulkThe parameter Ketas acts like an effective increment of the surface potential, which can be usedWhile the other parameter Keta is used toBy using this new expression, the nonphysical drain currentAccurate modeling of the biasdependent LDD resistances is important for deep submicron CMOS technologies. InBSIMSOI4.0 keeps this option for the sake of simulation efficiency. In addition, BSIMSOI4.0This featureThe internal RdsV option can be invoked by. Rds RdswPage 7Rs V After improving the Vth and Abulk behavior in the high body bias regime, we can describe the. MOSFET drain current by the same equation as BSIM3v3. The effective drain voltage Vdseff andI ds,MOSFET. Vds Vdseff. I ds 0Weff. LeffIdso VdseffVdseffC, Esat is the critical electrical field at which the carrier velocity becomes saturated and VAThe substrate current. Page 8Page 9Chapter 3 Body Currents Model. Body currents determine the body potential and therefore the drain current through the bodyIgb. Iii. Fig. 3.1. Idiode. Various current components inside the body.http://www.hgbs.de/userfiles/datron-4705-service-manual.xml




Page 10I bs1 Wdios Tsi j difs expThe carrier recombination and trapassisted tunneling current in the spacecharge region isI bs 2 Wdios Tsi j recs expVrec 0 sVrec 0 dNote that the parameters Vrec 0 s,Vrec 0 d are provided to modelThe reverse bias tunneling current, which may be significant in junctions with high dopingVtun 0 s. I bs 4 Wdios Tsi jtuns 1 expVtun 0 dThe parameters ntuns, ntund and Vtun 0 s,Vtun 0 d areThe recombination current in the neutral body can be described by. Page 11I bs 3 1 bjt I ens expI bd 3 1 bjt I end expN bjt. I ensN bjtThe parasitic bipolar transistor current is important in transient body discharge, especially in. The BJT collector current is modeled as. Page 12Eely. Eely Eely 2 4 EhliEhli Ehlis EhlidTo sum up, the total BS current is I bs I bsi, and the total BD current is I bd I bdi. The total drain current including the BJT component can then be expressed as. I ds,total I ds,MOSFET I cAn accurate impact ionization current equation is crucial to the PD SOI model since it may. Hence in BSIMPD wePage 13VgsStep Notice thatIn this case, 0, 1, 2 0,0,1. The extracted saturation drain voltage Vdsatii depends on the gate overdrive voltage Vgst and. Leff. One can first extract the parameters Vdsatii 0, Lii by the Vdsatii Leff characteristics at Vgst 0. All the other parameters E satii, Sii1, Sii 2, Sii 0, Siid can then be determined by the plot of VdsatiiNotice that a linear temperature dependence of Vdsatii 0 with theThis approximation generally won’t cause accuracy problem becauseWhile SOI MOSFET device operates in subthreshold toHere I ds, MOSFET still uses the old impact ionization model. The BJT contribution is expressedPage 14CBJTII EBJTII Leff. LeffThe formula for GIDL current is. I GIDL AGIDL Wdiod Nf. Vds Vgse EGIDL V fbsdCGIDL accounts for the bodybias dependence of IGIDL and IGISL. Here Vgse accounts for polyFollowing BSIM4, BSIMSOI4.1 also introduces GISL current. In order to model asymmetric.

I GISL AGISL Wdios Nf In this new model, the basic idea is to decouple Vds and Vgs dependence by introducing anThe body bias dependence part is also revised. Here, KGIDL and FGILDPage 15I GIDL AGIDL Wdiod Nf In BSIMPD the following equations are used to calculate the tunnelingIn inversion. N toxJ gb AIn accumulation. Page 16J gb. V gbVaux ToxrefVaux VECBVt ln 1 exp Please see Appendix B for model parameter descriptions. In BSIMSOI4.1, the instance parameter Agbcp2 represents the parasitic gatetobody overlapThis parameter applies for the oppositetype gate, which is shownIn BSIMPD, a body resistor is connected between the body B node and the body contact PThe body resistance is modeled byRbp RbodyPage 17The body contact current I bp is defined as the current flowing through the body resistor. I bp. VbpNotice that I bp 0 if the transistor has aThe effective channel width may change due to the body contact. Hence the followingWeff Wdrawn N bc dWbc 2 N bc dWHere dWbc is the width offset for the body contact isolation edge. N bc is the number of bodyFor example N bc 0 for floating body devices, N bc 1 for TgateAfter introducing all the mechanisms that contribute the body current, we can express theThe IV characteristics can then be correctly predicted after thisPage 18. Chapter 4 MOS CV Model. BSIMPD approaches capacitance modeling by adding SOIspecific capacitive effect to the. CV model of BSIM3v3. Similar to the IV case, the body charges belonged to the floating bodyThe model incorporates features listed below with the SOIspecificThis ensures continuity of all derivatives and enhances convergenceNothing has been changed; even. Thus users are. Body effectPage 19A good intrinsic charge model is important in bulk MOSFETs because intrinsic capacitanceIn analog applications there areThus, a good charge model must be wellbehaved inTo ensure proper behavior, both the IV and CV model equations.

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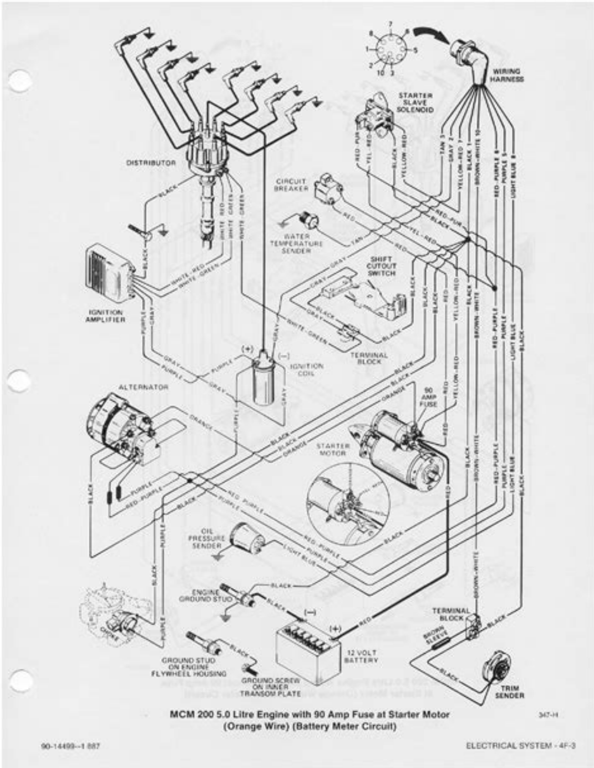
A good physical charge model of SOI MOSFETs is even more important than in bulk. This is. Also, due toAn example is that a large negative guess ofPage 20Fig. 4.1. Intrinsic charge components in BSIMPD CV model. To ensure charge conservation, terminal charges instead of terminal voltages are used as stateThese charges can be expressed in terms ofThe intrinsic charges are distributed between the nodes as shown in Fig.QBf Qac0 Qsub 0 Qsubs. Qinv Qinv, s Qinv, d. Q g Qinv Q BfQd Qinv,d Q jd. Qg Qe Qb Qs Qd 0. Page 21. The front gate body charge QBf is composed of the accumulation charge Qac0 and the bulkBSIM3v3. All capacitances are derived from the charges to ensure charge conservation. Since there areFor each component. Cij In addition,Intrinsic Charges. BSIMPD uses similar expressions to BSIM3v3 for Qinv and Q Bf. First, the bulk chargeAbulkCVExperimentally. VdsatIV VdsatCV VdsatIVAbulkVgsteffCV nvt ln 1 exp Users are suggested to. Page 22. This new VgsteffCV follows that in IV model. There are two new model parameters MINVCVVgsteffCV Then the inversion charge can be expressed as. QinvThe exact evaluation of source and drainA parameter VFBeff is used to smooth the transition between accumulation and depletionThe physical meaning of the function is the following it is equal to Vgb for Vgb VFB. Using VFBeff, the accumulation charge can be calculated as. Qac 0 FbodyWactive LactiveB Cox VFBeff V fb The gateinduced depletion charge and draininduced depletion charge can be expressed asK1eff Q subs FbodyWactive LactiveB K 1eff Cox 1 AbulkCV dsCV Finally, the back gate body charge can be modeled by. Qe FbodyWactive LactiveBG C box Ves V fbb Vbseff Page 24. Q jswg Qbsdep QbsdifQbsdif. Qbddif. N difTsi J sbjt 1 Ldif 0 Lbj 0 Expressions for extrinsic parasitic capacitances that are common in bulk and SOI. MOSFETs are taken directly from BSIM3v3. Additional SOIspecific parasitics added areCessw. Cesb. Page 25. Fig. 4.2.

https://academyocgc.com/images/bosch-nexxt-500-series-washer-repair-manual.pdf




SOI MOSFET extrinsic charge components. Cessw is the substratetosource sidewall capacitance. Cesb is the substratetosource bottomThe bias dependence of this capacitance is similar toBSIMPD models it by piecewise expressions,Cesb. CboxVse VsdfbVse Vsdfb Asd Vsdth VsdfbVse VsdthPhysical parameters Vsdfb flatband voltage of the MOS structure and Vsdth threshold voltage ofCmin should also be extractedAsd is a smoothing parameter. The expression for Cedb is similar to Cesb. Fig. 4.3 shows the comparison of the model andPage 26Capacitance fFThe parasitic capacitive coupling due to the body contact is considered in BSIMPD. TheThe effect may be. Page 27. Note There are four instance parameters used to calculate parasitic capacitances associatedIt is worth pointing out that psbcpFig. 4.4. Parasitic capacitance in oppositetype gate. In BSIMSOI4.0, the instance parameter Agbcp represents the parasitic gatetobody overlapThis parameter only applies for the sametype gate. For theCharge model has to be modified. One new instance parameter Agbcp2 is introduced toThe final charge could be expressed as. Page 28Fig. 4.5Note In this case, there is a new instant parameters agbcp2, which is similar to agbcp andThe finite thickness formulation is similar to that in BSIM4. The charge thickness introduces a capacitance in series with Cox, resulting in an effective. Coxeff. Based on numerical selfconsistent solution of Shrodinger, Poisson and FermiDiracCoxeff can be expressed as. Coxeff. Coxp CcenPage 29The DC charge thickness in the accumulation and depletion regions can be expressed byThe inversion charge layer thickness can be formulated asIn inversion region, the body charge thickness effect is modeled by including the deviation ofPage 30. In this case, TOXP should be iteratively calculated by EOT firstPage 31. Chapter 5 Temperature Dependence and SelfHeating. Selfheating in SOI is more important than in bulk since the thermal conductivity of silicon.

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It may degrade theThe temperature dependence of threshold voltage, mobility, saturation velocity and seriesHowever a different temperature dependence ofX bjt 1 X bjt 1 X dif 1 X difX rec 1 X rec 1 The parameters isbjt, idbjt, isdif, iddif, isrec, idrec, istun, idtun are diode saturation currents at the nominalThe T node is treated as a voltageRth. Rth0Wth0 is the. Notice that the current source is driving aPage 33. P I ds VdsHowever thisTherefore, it is a tradeoffThe error in DC or transient is minimal if the sweeping step or timeIdVd. Fig. 5.1. Rth. Cth. Equivalent circuit for selfheating simulation. Page 34. FD SOI MOSFETs. Using BSIMPD as a foundation, we have developed a unified model for both PD and FD SOIOn the otherAs shown in Figure 6.1, thisPage 35This unified model shares the same floatingbody module as BSIMPD, with a generalized diodeThe followingIn order to keep backward compatibility, a new model selector fdMod is introduced. Here. For a given surface band bending source reference, Vbi can be formulated by applyingPage 36C Si. C Si C BOX. C Si TSiSiTSi is the SOI thickness. NchThe second term of Equation 6.1 represents the backgateEquation 6.1 shows that the impact ofIn Equation 6.1, VDIBL represents the short channel effect on Vbi,Dvbd0 and Dvbd1 are model parameters. Similarly, the following equationHowever, the two lengthdependent functions i.e., Eqr 6.2 and 6.3 in Vbi model makeThus, BSIMSOI4.1 introduces a new Vbi equation asCsi CBOX CDSBS Csi CBOX CDSBS. Page 37. CDSBS is the new model parameter representing the capacitance of capacitance of drain toIf body contact devices are not available, the length dependence related parameters of VbiDvbd 0 DVT 0The surface band bending, , is determined by the frontgate VGS and may be approximated byTo improve the simulation convergence, the following single continuous function fromVt is the thermal.

Page 38To accurately model Vbi and thus the device output characteristics, the surface band bendingK1 is the body effect coefficient. Notice that aWhen the body contact is not available,As shown in Figure 6.2, the reduction of Vbi withPage 39Page 40. Fig. 6.4 Less floatingbody effect can be seen for the shortchannel device due to larger VbiThe model selector, SoiMod, is an instance parameter and a model parameter. SoiMod willPage 41. Vbs 0. C Si. C SiTSiSiNLX is the lateral nonuniform doping coefficientVFBb is the backgate flatband voltage. Vth,FD. K1 is the body effectThe zero field body potential that will determine the transistor threshold voltage, Vbsmos, is thenPage 42Vbsmos Vbs Vbs 0 TOX Vbs Vbsmos Vbs. The subsequent clamping of Vbsmos will use the same equation that utilized in BSIMPD. Please. DescriptionChannel length. Page 59Channel width. Drain diffusion area. Source diffusion area. Drain diffusion perimeter length. Source diffusion perimeter length. Number of squares in source series resistance. Number of squares in drain series resistance. Number of squares in body series resistance. Device simulation off. Turn off BJT current if equal to 1. Initial guess in the order of Vds, Vgs, Vbs, Ves, Vps. Vps will beThermal resistance per unit widthThermal capacitance per unit widthPlease see the debugging notes. Zero bias threshold voltage variation. Stress effect parameter. Number of fingers. Number of body contact isolation edge. Parasitic perimeter length for body contact at drain side. Parasitic perimeter length for body contact at source side. For details of AGBCP and AGBCP2, please check Fig.4.4. Page 60Parasitic bodytosubstate overlap area for body contact. Optional initial value of Vbs specified by user for transient analysis. Temperature node flag indicating the usage of T node. Layoutdependent body resistance coefficient. Parasitic gatetobody overlap area for body contact in DC. Resistance between bNode and dbNode.

[https://www.training4thefuture.co.uk/wp-content/plugins/formcraft/file-upload/server/content/files/1626c021a58057---car-wont-go-in-reverse-manual.pdf](https://www.training4thefuture.co.uk/wp-content/plugins/formcraft/file-upload/server/content/files/1626c021a58057---car-wont-go-in-reverse-manual.pdf)

Resistance between bNode and sbNode. A.2. About Optional Nodes. There are three optional nodes, P, B and T nodes. P and B nodes are used for body contactIf user specifies four nodes, thisThere is a body resistance between internal bodyThis configuration is useful for distributed bodyIf TNODEOUT flag is set, the last node is interpreted as the temperature node. In this case,If user specifies six nodes, it is a bodycontacted case. Finally, if user specifies seven nodes, it is a bodycontacted case with anThe temperature node is useful for thermal coupling simulation. A.3. Notes on Debugging. The instance parameter allows users to turn on debugging informationPage 61By default, is set to zero and two internal parameters will be available forVb value iterated by SPICE. Device temperature with selfheating mode turned on. If is set to one or minus one, more internal parameters are available forThis can alsoFor set to minus one, there will beHere is the list of internalReal Vbs value used by the IV calculation. Effective gateoverdrive voltage. Threshold voltage. MOS drain current. BJT current. Body to source diode current. Body to drain diode current. Impact ionization current. GIDL current. Tunneling current. Body contact current. Output conductance. Transconductance. Drain current derivative wrt Vbs. These parameters are valid only if charge computation is required. Body charge derivative wrt Vbs. Body charge derivative wrt Vds. Body charge derivative wrt Ves. Body charge derivative wrt Vgs. Total body charge. Page 62Gate charge. Accumulation charge. Bulk charge. Bulk charge at zero drain bias. Channel depletion charge. Parasitic drain junction charge. Parasitic source junction charge. Page 63Appendix B Model Parameter List. B.1. BSIMSOI Model Control Parameters. Symbol. SymbolLevel 10 for BSIMSOI4.1SOI model selector instanceUnit. Default Notes belowFlag for selfheatingMobmodMobility model selectorFlag for the short channel capacitance modelFlag for Noise modelIgcMod.

Gatetochannel tunneling current model selectorIgbMod. Gatetobody tunneling current model selectorRgateMod rgateMod. RbodyModPage 64FnoiModFlicker noise model selectorTnoiMod. Thermal noise model selectorNew material model selectorVgsteffCV model selectorIiiMod. Impact ionization current model selectorNew Vbi model selectorSymbol. SymbolTsi. Silicon film thicknessTbox. Buried oxide thicknessGate oxide thicknessGate oxide thickness used in extractionXj. XjTsiNch. Channel doping concentrationNsub. Substrate doping concentrationEffective SiO2 thicknessEffective length for extraction of EOTEffective width for extraction of EOTTemperature for extraction of EOTUnit. Default. NotesToxp calculation i.e., Eq. 10.6. Page 65B.3. DC Parameters. SymbolDescription. Unit. Notes below theFirst order body effect coefficientFirst body effect width dependentK1w2Second body effect width dependentSecond order body effect coefficientNarrow width coefficientBody effect coefficient of k3Kb1. Backgate body charge coefficientNarrow width parameterLateral nonuniform doping parameterElse take the default. Lpe0 was called nlx inDvt0Dvt1Second coefficient of shortchannelDvt2Bodybias coefficient of shortchannelDvt0wDvt1wSecond coefficient of narrow width. Page 66Dvt2wBodybias coefficient of narrow widthFirstorder mobility degradationUbSecondorder mobility degradationUcBodyeffect of mobility degradationUdCoulomb scattering factor of mobilityBulk charge effect coefficient forAgsGate bias coefficient of AbulkBulk charge effect coefficient forBulk charge effect width offsetBodybias coefficient of bulk chargeKetas. Ketas. Surface potential adjustment for bulkRdswParasitic resistance per unit width. Page 67PrwbBody effect coefficient of Rdsw. PrwgGate bias effect coefficient of Rdsw. WrWidth offset from Weff for RdsNfactorSubthreshold swing factorWidth offset fitting parameter from IVLintLength offset fitting parameter from IVDWgCoefficient of Weff’s gate dependence.

DWbCoefficient of Weff’s substrate body biasDWbc. Dwbc. Width offset for body contact isolationVoffOffset voltage in the subthreshold regionEta0DIBL coefficient in subthreshold region. EtabBodybias coefficient for theDsubDIBL coefficient exponentInterface trap capacitanceCdscbBodybias sensitivty of CdscDrainbias sensitivty of CdscChannel length modulation parameterFirst output resistance DIBL effectPage 68Pdibl2Second output resistance DIBL effectDroutL dependence coefficient of the DIBLPvagGate dependence of Early voltageEffective Vds parameterThe first parameter of impact ionizationFbjtiiFraction of bipolar current affecting theFirst Vds dependent parameter of impactSecond Vds dependent parameter ofThird Vds dependent parameter of impactVdsatii0Nominal drain saturation voltage atTiiTemperature dependent parameter forLiiChannel length dependent parameter atEsatiiSaturation channel electric field forSii0First Vgs dependent parameter for impactSii1Second Vgs dependent parameter forSii2Third Vgs dependent parameter forPage 69SiidVds dependent parameter of drainAbjtiiExponent factor for avalanche currentLength scaling parameter for II BJT partImpact ionization parameter for BJT partInternal BC grading coefficientInternal BC builtin potentialAgidl. Preexponential GIDL constantBgidl. GIDL exponential coefficientCgidl. Parameter for body bias effect on GIDLFitting parameter for band bending forNgidl given. Else take theEgidl was called. Ngidl inAgisl. Preexponential GISL constantBgisl. GISL exponential coefficientCgisl. Parameter for body bias effect on GISLEgisl. Fitting parameter for band bending forVgsdependent parameter for GIDL. KgidlVdsdependent parameter for GIDL. FgidlVdsdependent parameter for GIDL. Page 70RgislVgsdependent parameter for GISLVbsdependent parameter for GISL. FgislVbsdependent parameter for GISLNdiode. Diode nonideality factor for sourceNdioded. Diode nonideality factor for drainNrecf0. Recombination nonideality factor atNrecf0d.

Recombination nonideality factor atNrecr0. Recombination nonideality factor atNrecr0d. Recombination nonideality factor atIsbjt. BJT injection saturation currentIdbjt. BJT injection saturation currentIsdifIddif. IddifIsrec. Recombination in depletion saturation. Page 71Idrec. Idrec. Recombination in depletion saturationIstun. Reverse tunneling saturation currentIdtun. Reverse tunneling saturation currentLnVrec0. Voltage dependent parameter forVrec0d. Vrec0d. Voltage dependent parameter forVtun0s. Vtun0. Voltage dependent parameter forVtun0d. Vtun0d. Voltage dependent parameter forNbjt. Nbjt. Power coefficient of channel lengthLbjt0. Lbjt0. Reference channel length for bipolarVabjt. Vabjt. Early voltage for bipolar current. Aely. Channel length dependency of earlyAhlis. Ahli. High level injection parameter forAhlid. Ahlid. High level injection parameter forPage 72Rbody. Rbody. Intrinsic body contact sheet resistanceRbsh. Rbsh. Extrinsic body contact sheet resistanceRsh. RhaloSource drain sheet resistance in ohm perBody halo sheet resistanceRsw. Rsw. Zero bias lightlydoped source resistance per Ohmu. Rdw. Zero bias lightlydoped drain resistance per.