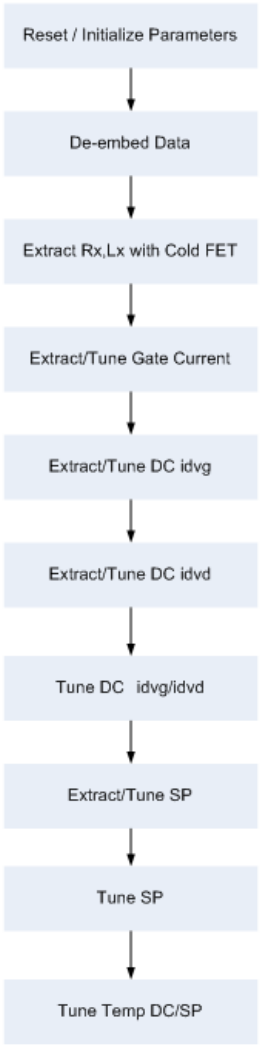
4.2 Hand-Scripts of Angelov Model Parameter Extractions

4.3 Notes on the IC-CAP Help Doc

4.3.1 Parameter Extraction Flow Example

0. Example Parameter Extraction Flow

Based on the parameter extraction flow, following is an example parameter extraction flow to see that DC matches with S-parameter of vgm2.



The following is an orderly description about example extraction flow using the sample data loaded in the Angelov-GaN Toolkit.

1. Initialize

Reset Parameter to Defaults

Reset the values of Model Parameters to the default before you begin the Extraction.

Initialize Parameter and Boundaries for Extraction

Initialize the values of Model Parameters, Opt Min and Opt Max before you begin the Extraction.

Update All Measures Data for Extraction

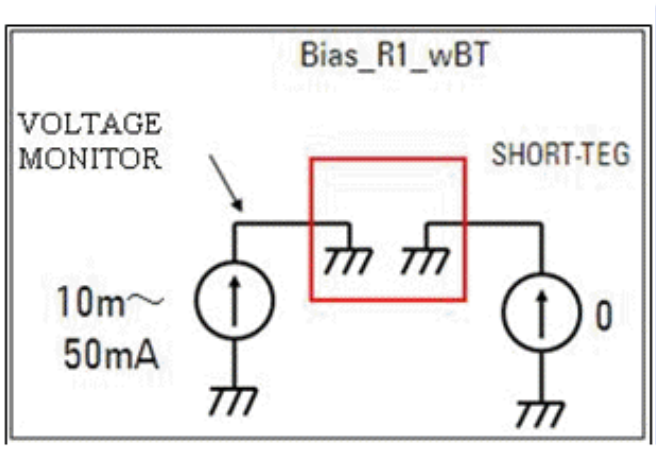
Perform PEL calculation and De-embed with respect to all the data, and update before you begin the extraction.

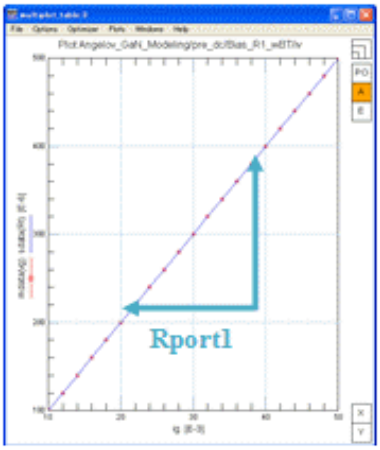
2. DC Port Resistance

PreDC Port1

Calculate Rport1, the DC Path Resistance of Port1 side from the Slope using E:Rport1

Example of iv plot

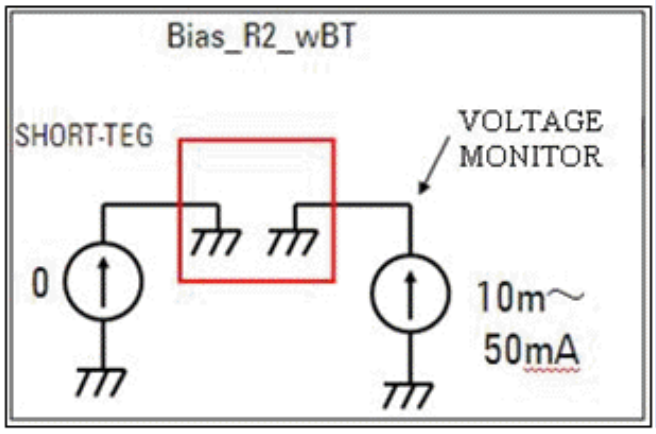


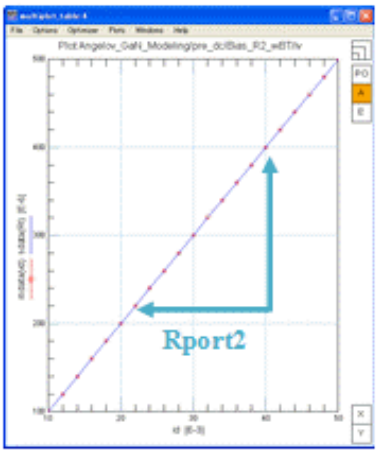


PreDC Port2

Calculate Rport2, the DC Path Resistance of Port2 side from the Slope using E:Rport2

Example of iv plot





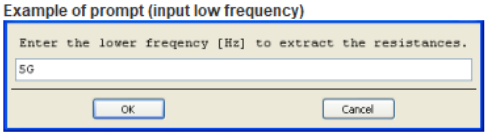
3. SP Cold FET

SP Cold FET

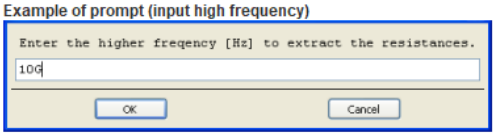
Here you can calculate the resistence and industnce components by ColdFET method.
Since this is the initial value, you need to implement tuning later.

1. Calculate the resistances RG, RD and RS from R11, R22, R30 using E:RG,RD,RS.
   In the frequency input prompt that appears, enter the flat range in low frequency part of R11, R22 and R30 for resistence component and implement the Extraction.
   If there is no flat range, you may also use the region used for design.
   Extraction results in R11=RG, R22=RD and R30=RS.

Example of prompt (input low frequency)

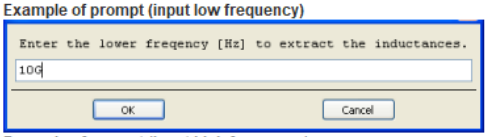


Example of prompt (input high frequency)

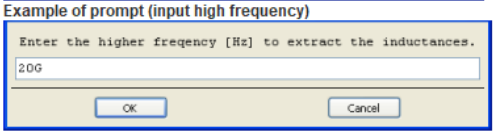


2. Calculate the inductances LG, LD, LS from L11, L22, L30 using E:LG,LD,LS.
   In the frequency input prompt that appears, enter the flat range in high frequency part of L11, L22 and L30 for inductance component and implement the Extraction.
   If there is no flat range, you may also use the region used for design.
   Extraction results in L11=LG, L22=LD, L30=LS.

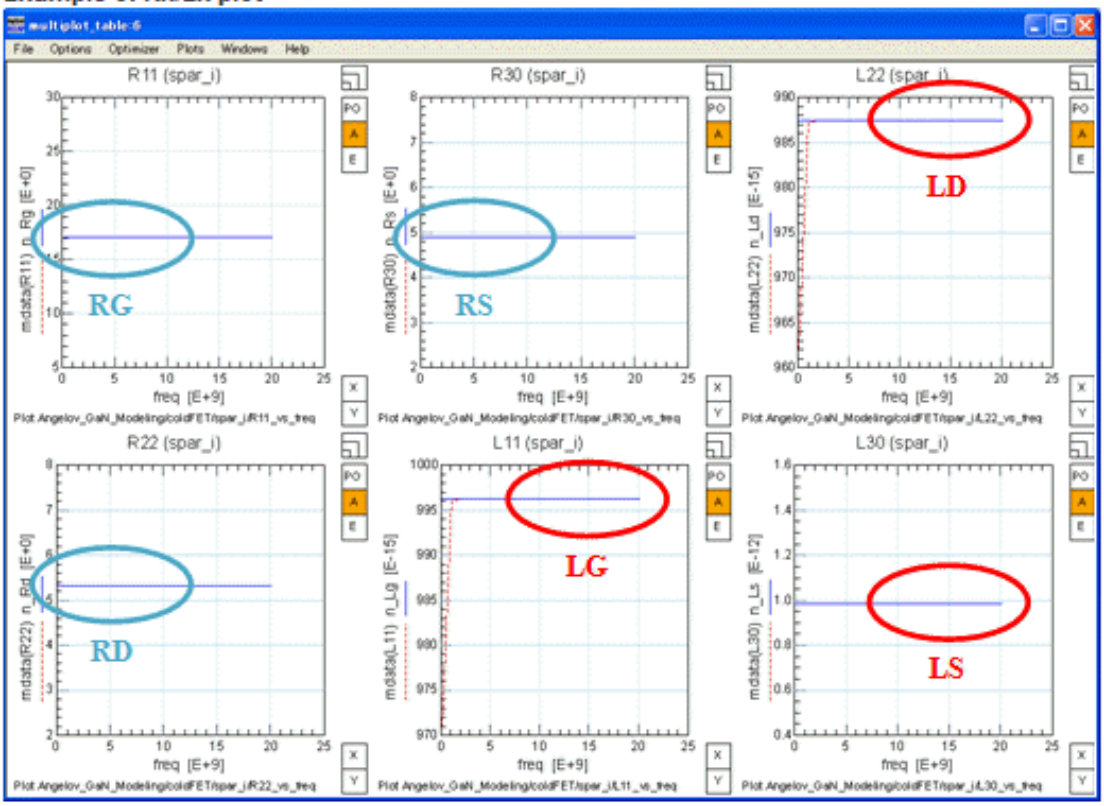
Example of prompt (input low frequency)



Example of prompt (input high frequency)



Example of Rx/Lx plot

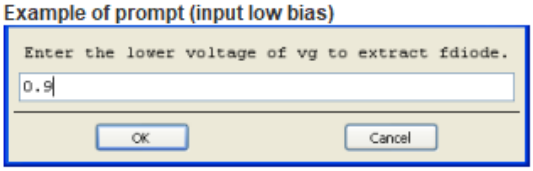


4. Gate Diode

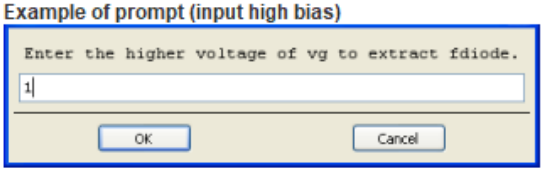
DC gate diode forward

Here you can implement the Extraction and Optimization of forward Gate current.

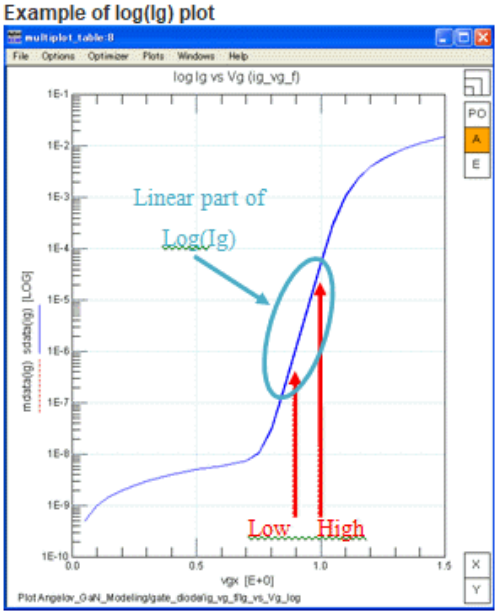
1. Calculate IJ, PG, VJG from Ig, using E: IJ,PG,VJG
   In the bias input prompt that appears, enter the range in linear part of log (Ig) and implement the Extraction of IJ, PG and **VJG**.
   Example of prompt (input low bias)



   Example of prompt (input high bias)

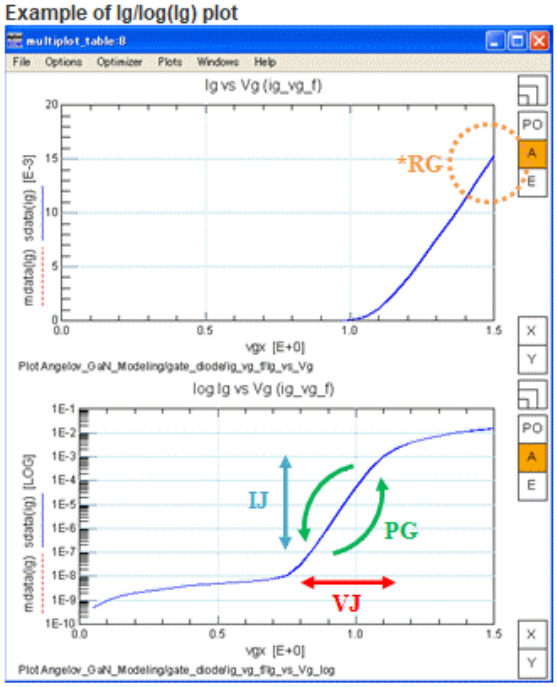


   Example of log(Ig) plot



2. Optimization using O: IJ,VJG,T:IJ,VJG
   Keeping the Gate current (Ig, log-Ig) in view, carry out an optimization using IJ and **VJG** to match the approximate current value.

3. Optimization using O: PG
   Keeping the Gate current (Ig, log-Ig) in view, implement an optimization using PG to match the slope of log (Ig).
   Example of Ig/log(Ig) plot

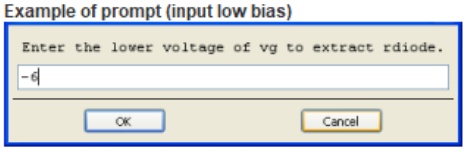


- RG is usually matched with S-parameter.

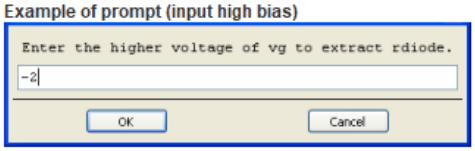
DC gate diode reverse

Here you can implement the Extraction and Optimization of reverse Gate current.

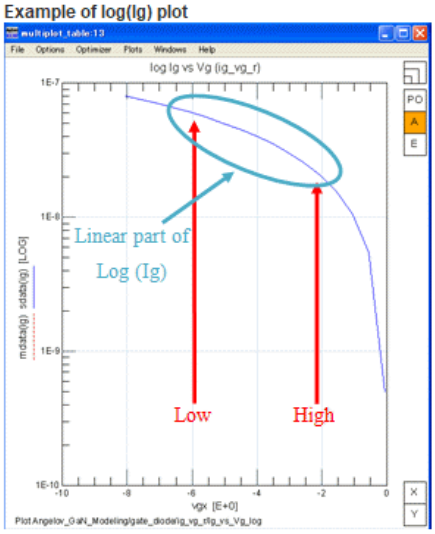
1. Calculate KBGATE, VBDGS, VBDGD and PBGD from Ig using E: KBGATE,VBDGS,VBDGD,PBDG
   In the bias input prompt that appears, enter the range in linear part of log (Ig) and implement the Extraction of KBGATE, VBDGS, VBDGD and PBGD.
   Example of prompt (input low bias)



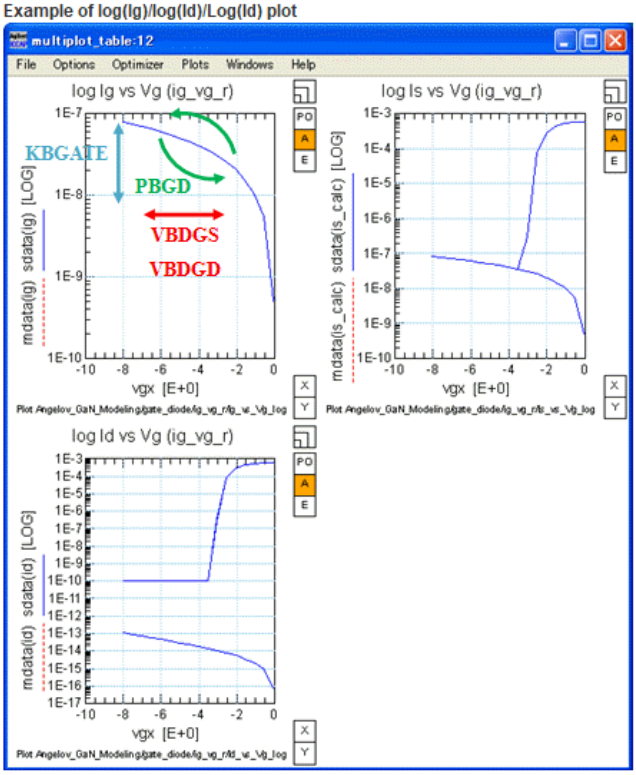
   Example of prompt (input high bias)



   Example of log(Ig) plot



2. Optimize KBGATE, VBDGS, VBDGD and PBGD using
   T: KBGATE,VBDGS,VBDGD,PBDG.
   Keeping the Gate current (log-Ig) in view, implement an optimization using KBGATE, VBDGS, VBDGD and PBGD to match the approximate current value.
   Example of log(Ig)/log(Id)/Log(Id) plot



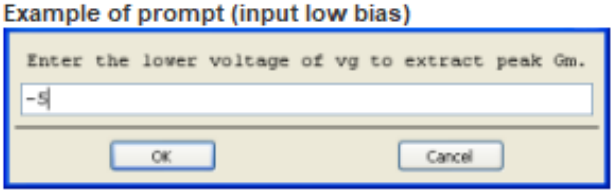
5. idvg & idvd

DC idvg

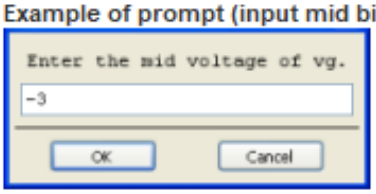
Here you can implement the Extraction and Optimization of idvg characteristics.

1. Calculate IPK0, **VPKS**, **P1**, P2 and P3 from Id using E: IPK0,VPKS,P1,P2,P3{+}{_}.
   In the bias input prompt that appears, enter the range as shown below:
   Bias before gm is rises up
   Bias at which Id starts rising up (Vth vicinity)
   Bias which passes over Gm max
   And then, implement the Extraction of IPK0, **VPKS**, **P1**, P2 and P3.

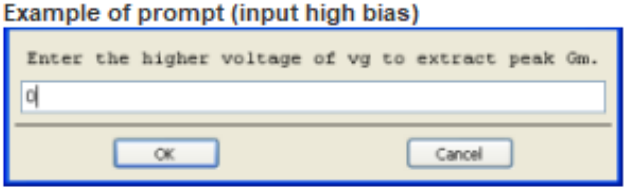
Example of prompt (input low bias)



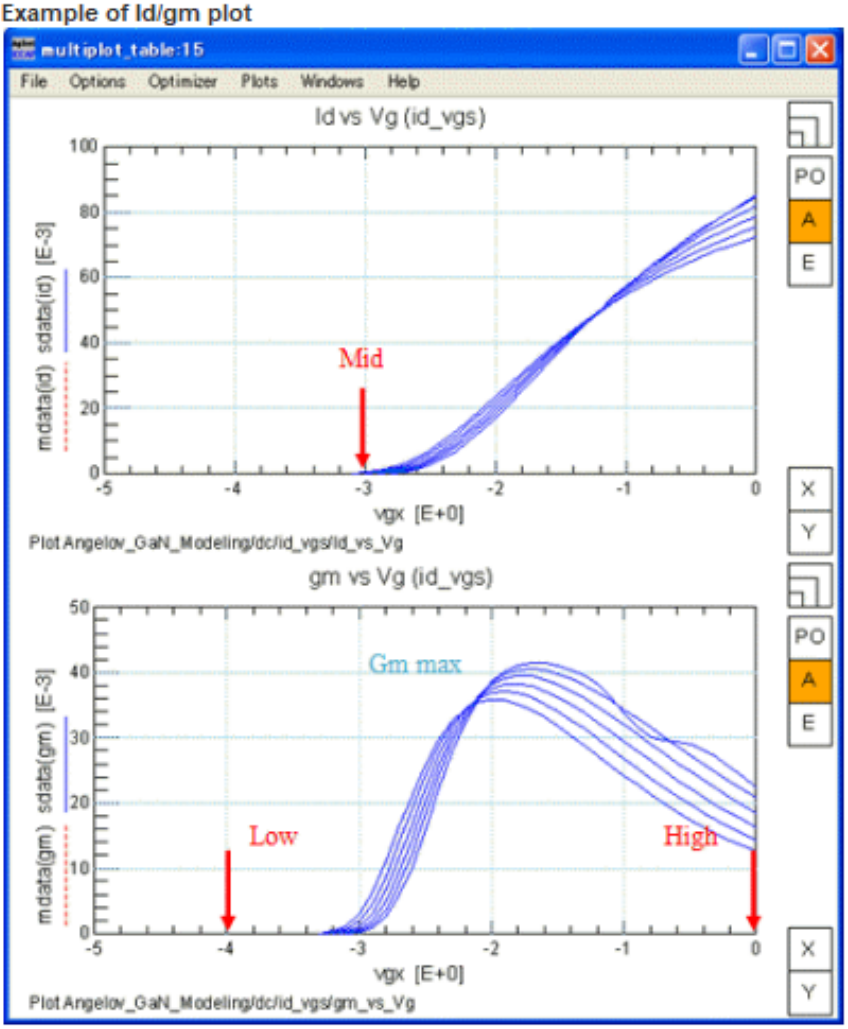
Example of prompt (input mid bias)



Example of prompt (input high bias)

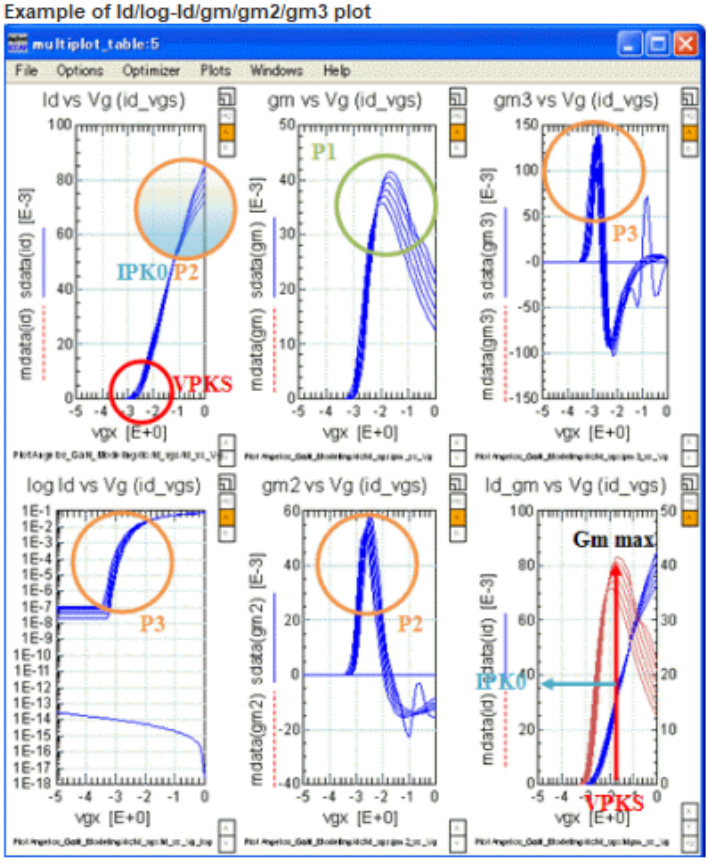


Example of Id/gm plot



2. Optimize **VPKS**, P2 and P3 using O: VPKS,P2,P3{+}{_}.
   Keeping log-Id, gm, gm2 and gm3 in view, match the approximate shape using **VPKS**, P2 and P3.
3. Optimize IPK0, **VPKS**, **P1**, P2 and P3 using O: IPK0,VPKS,P1,P2,P3{+}{_}.
   Keeping Id, log-Id, gm, gm2 and gm3 in view, adjust to make the balance (shape) better on the whole, using IPK0, **VPKS**, **P1**, P2 and P3.
4. Optimize **VPKS** and **P1** using O: VPKS,P1.
   Keeping log-Id and gm in view, match using **VPKS** and **P1.**

Example of Id/log-Id/gm/gm2/gm3 plot

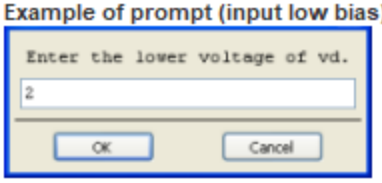


DC idvd

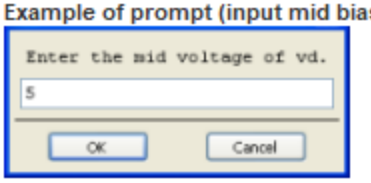
Here you can implement the Extraction and Optimization of idvd characteristics.

1. Calculate LAMBDA from Id using E: LAMBDA.
   In the bias input prompt that appears, enter the range as shown below:
   Bias of linear region
   Bias at which the self heating is observed
   Bias at which Avalanche current is about to appear or Maximum bias
   And then, implement the Extraction of LAMBDA.

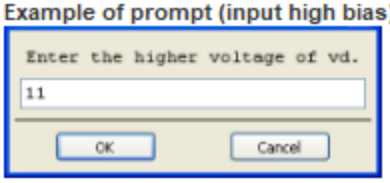
Example of prompt (input low bias)



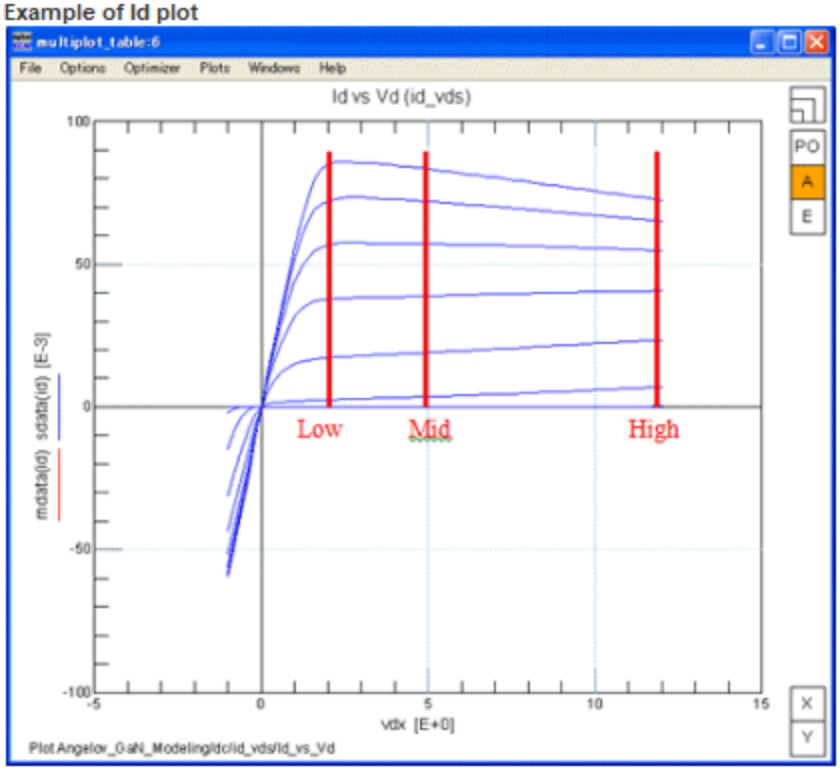
Example of prompt (input mid bias)



Example of prompt (input high bias)



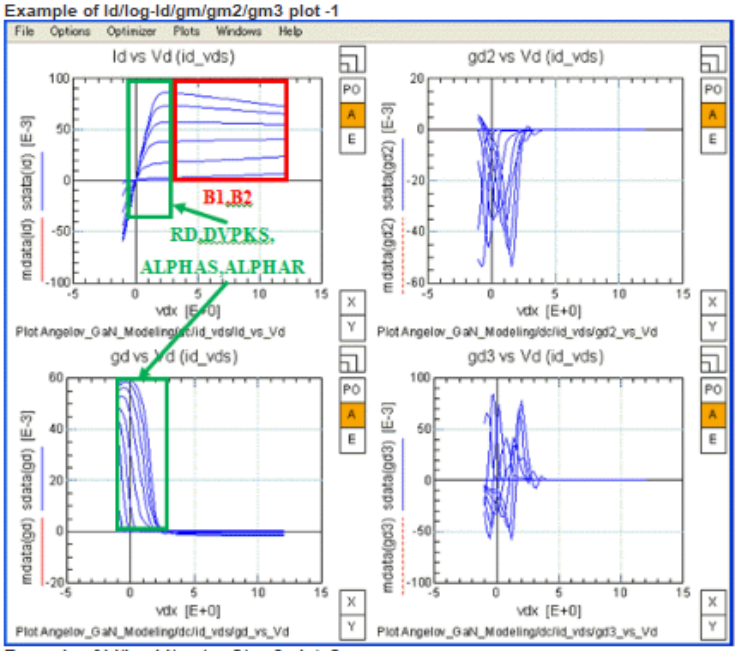
Example of Id plot



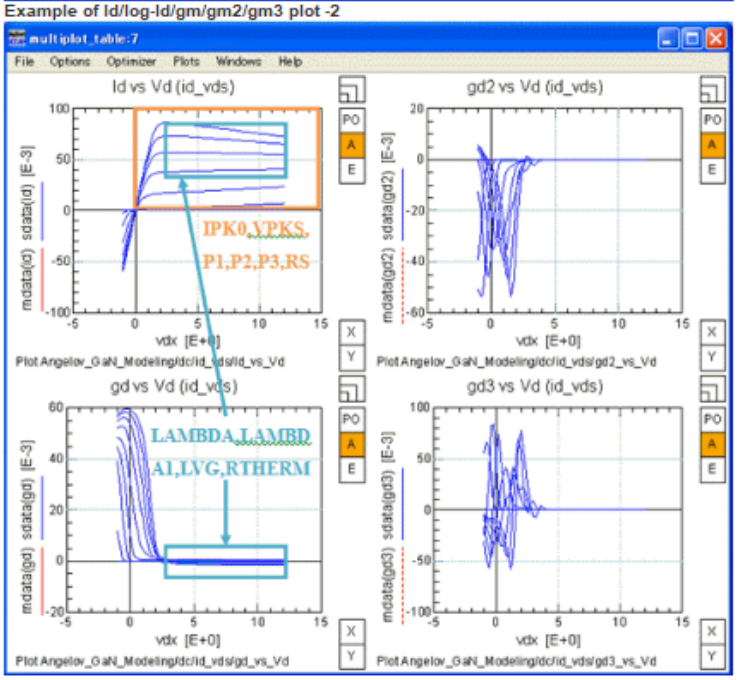
2. Optimize LAMBDA, B1 and B2 using O: LAMBDA,B1,B2{+}{_}.
   Keeping Id and gds in view, adjust for a better balance of the bias interval on the whole, using LAMBDA, B1 and B2.
3. Optimize ALPHAR, ALPHAS and RD using O: ALPHAR,ALPHAS,RD{+}{_}.
   Keeping Id and gds in view, adjust to match with the rising part (linear region) using ALPHAR, ALPHAS and RD.
4. Optimize IPK0, VPKS and P1 using O: IPK0,VPKS,P1{+}{_}.
   Keeping Id in view, adjust on the whole using IPK0, VPKS and P1.

5. Optimize **ALPHAR**, **ALPHAS** and **RD** using O: ALPHAR,ALPHAS,RD{+}{_}.
   Keeping Id and gds in view, adjust to match with the rising part (linear region) using **ALPHAR**, **ALPHAS** and **RD**.
6. Optimize **IPK0**, **VPKS**, **P1**, **P2**, **P3**, **B1**, **B2**, **ALPHAR**, **ALPHAS** and **RD** using O: IPK0,VPKS,P1,P2,P3,B1,B2,ALPHAR,ALPHAS,RD{+}{_}.
   Keeping Id and gds in view, adjust on the whole using **IPK0**, **VPKS**, **P1**, **P2**, **P3**, **B1**, **B2**, **ALPHAR**, **ALPHAS** and **RD**.
7. Optimize **IPK0**, **VPKS**, **DVPKS**, **P1**, **P2**, **P3**, **B1**, **B2**, **LAMBDA**, **LAMBDA1**, **LVG**, **VKN**, **RD**, **RS** and **RTHERM** using O: idvd_all{+}{_}.
   Keeping Id in view, adjust on the whole using **IPK0**, **VPKS**, **DVPKS**, **P1**, **P2**, **P3**, **B1**, **B2**, **LAMBDA**, **LAMBDA1**, **LVG**, **VKN**, **RD**, **RS** and **RTHERM**.

Example of Id/log-Id/gm/gm2/gm3 plot -1



Example of Id/log-Id/gm/gm2/gm3 plot -2



DC idvg

Once the Extraction and Optimization of idvg and idvd are over, the next step is to implement detailed tuning, keeping both the characteristics in view alternately. Here, you will implement Re-optimization of idvg characteristics.

1. Optimize **VPKS** and **P1** using O: VPKS,P1{+}{_}.
   Keeping Id in view, adjust the characteristics using **VPKS** and **P1**.
2. Optimize **IPK0**, **VPKS**, **P1**, P2 and P3 using O: IPK0,VPKS,P1,P2,P3{+}{_}.
   Keeping Id, log-Id, gm, gm2 and gm3in view, adjust on the whole using **IPK0**, **VPKS**, **P1**, P2 and P3.
3. Optimize **VPKS**, P2 and P3 using O: VPKS,P2,P3
   Keeping Log-Id and gm in view, adjust using **VPKS**, P2 and P3.
4. Tuning **IPK0**, **VPKS**, **P1**, P2 and P3 using O: IPK0,VPKS,P1,P2,P3{+}{_}.
   Keeping Id, log-Id, gm, gm2 and gm3 in view, adjust on the whole using **IPK0**, **VPKS**, **P1**, P2 and P3.

DC idvd

Once the Extraction and Optimization of idvg and idvd are over, the next step is to implement detailed tuning, keeping both the characteristics in view alternately. Here, you will implement Re-optimization of idvd characteristics.

1. Optimize **ALPHAR**, **ALPHAS** and **RD** using O: ALPHAR,ALPHAS,RD{+}{_}.
   Keeping Id and gds in view, adjust to match with the rising part (linear region) using **ALPHAR**, **ALPHAS** and **RD**.
2. Optimize **IPK0**, **VPKS**, P1, P2 and **RTHERM** using O: IPK0,VPKS,P1,P2,RTHERM{+}{_}.
   Keeping Id in view, adjust on the whole using **IPK0**, **VPKS**, P1, P2 and **RTHERM**.

DC idvg

Finally, implement the detailed tuning as the last step of DC modeling. Here, you will implement Re-optimization of idvg characteristics.

1. Optimize **IPK0**, **VPKS**, **P1**, P2 and P3 using O: IPK0,VPKS,P1,P2,P3{+}{_}.
   Keeping Id, log-Id, gm, gm2 and gm3 in view, adjust on the whole using **IPK0**, **VPKS**, **P1**, P2 and P3.
   This completes the DC part of the modeling. If all the DC characteristics are good with accuracy, you can proceed next for the RF part of the modeling.

6. SP

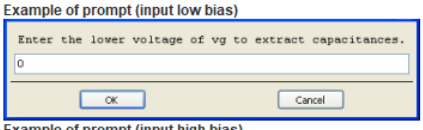
SP vg at vd0 A1

Here, you implement the Extraction of capacitance characteristics when Vd=0.
(Implement initial Extraction at Vd=0, Vg=0, and optimization.)

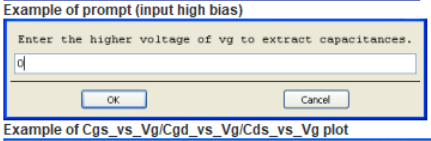
1. Calculate **CGSPI, CGDPI, CDS, CGS0, CGD0, P10, P11, P40** and **P41** from Cgs_vs_Vg, Cgd_vs_Vg and Cds_vs_Vg using E: CGSPI,CGDPI,CDS,CGS0,CGD0,P10,P11,P40,P41{+}{_}.
   In the bias input prompt that appears, enter the range as shown below:
   Bias at which the lower capacitance is calculated
   Bias at which the higher capacitance is calculated
   And then, implement the Extraction of **CGSPI, CGDPI, CDS, CGS0, CGD0, P10, P11, P40** and **P41**.

- If you enter **0** for all, the whole range is specified.

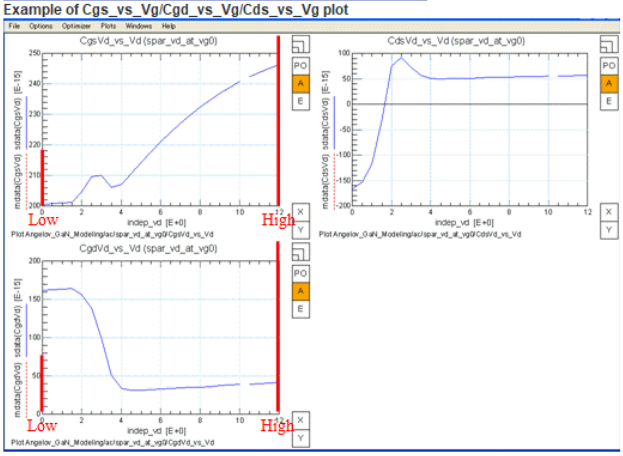
Example of prompt (input low bias)



Example of prompt (input high bias)



Example of Cgs_vs_Vg/Cgd_vs_Vg/Cds_vs_Vg plot



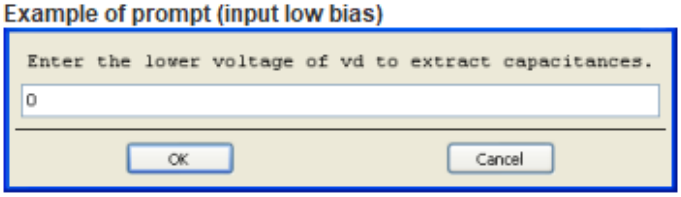
SP vd at vg0

Here, you implement the Extraction of capacitance characteristics when Vg=0.
(Implement initial Extraction at Vd=0, Vg=0, and optimize.)

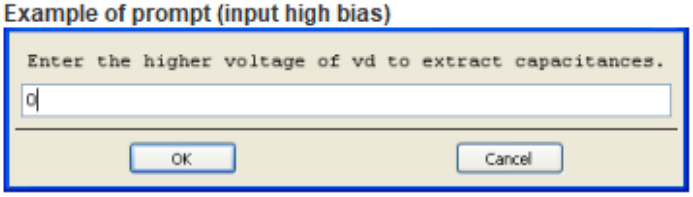
1. Calculate **P20, P21, P30 and P31** from Cgs_vs_Vd, Cgd_vs_Vd and Cds_vs_Vd using E: P20,P21,P30,P31
   In the bias input prompt that appears, enter the range as shown below:
   Bias at which the lower capacitance is calculated
   Bias at which the higher capacitance is calculated
   And then, implement the Extraction of **P20, P21, P30** and **P31**.

- If you enter **0** for all, the whole range is specified.

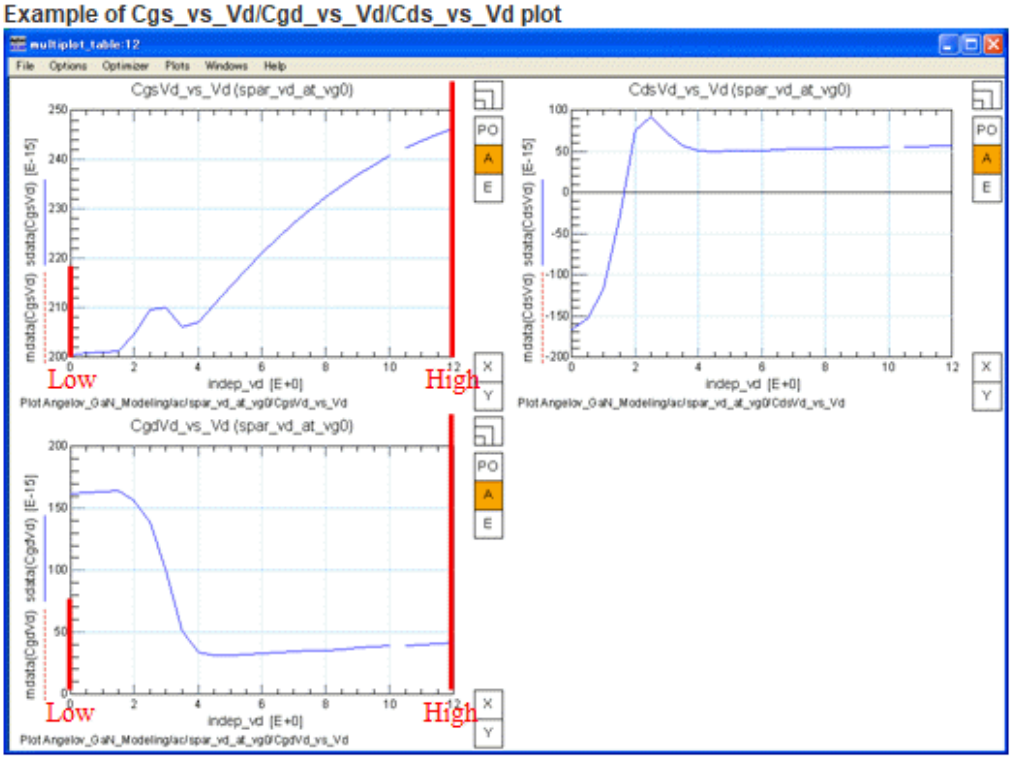
Example of prompt (input low bias)



Example of prompt (input high bias)



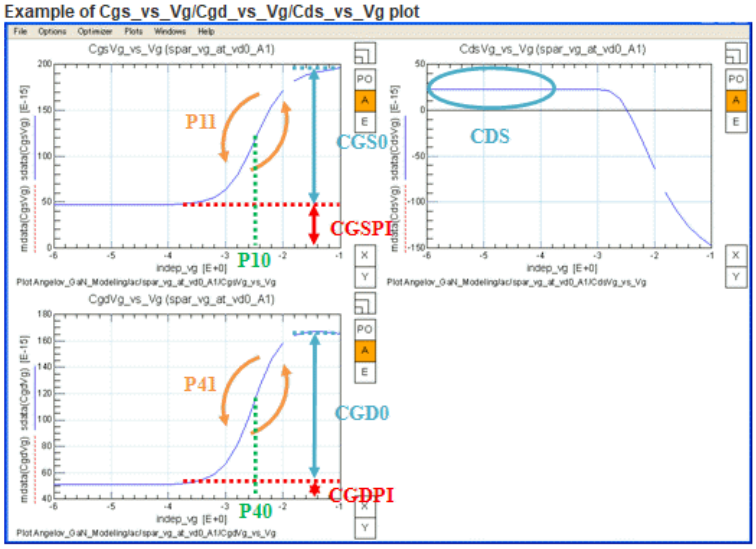
Example of Cgs_vs_Vd/Cgd_vs_Vd/Cds_vs_Vd plot



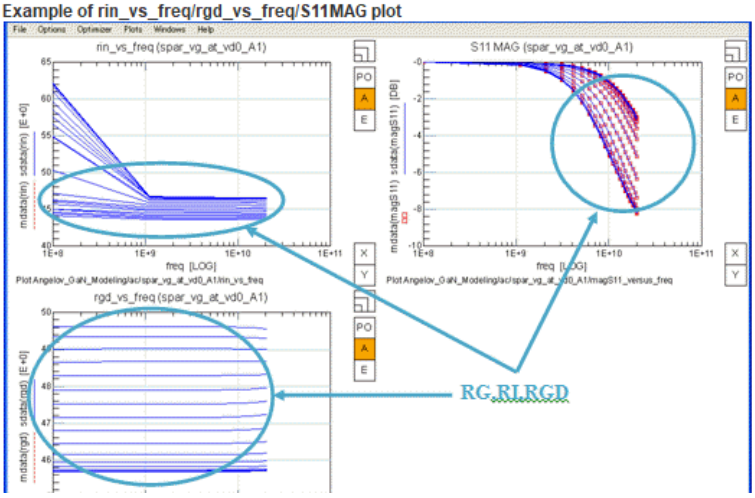
SP vg at vd0 A1

Once the initial Extraction of Cgs, Cgd and Cds are over, the next steps are the optimization of capacitance characteristics and S-Parameter in order. Here, first adjust the capacitance characteristics when Vd=0.

1. Optimize CGSPI, CGDPI, CGS0, CGD0, CDS, P10, P11, P40 and P41 using O: CGS,CGD{+}{_}.
   Adjust the characteristics using
   CGSPI, CGS0, P10 and P11, keeping Cgs in view
   CGDPI, CGD0, P40 and P41, keeping Cgd in view
   CDS, keeping Cds in view
   Example of Cgs_vs_Vg/Cgd_vs_Vg/Cds_vs_Vg plot



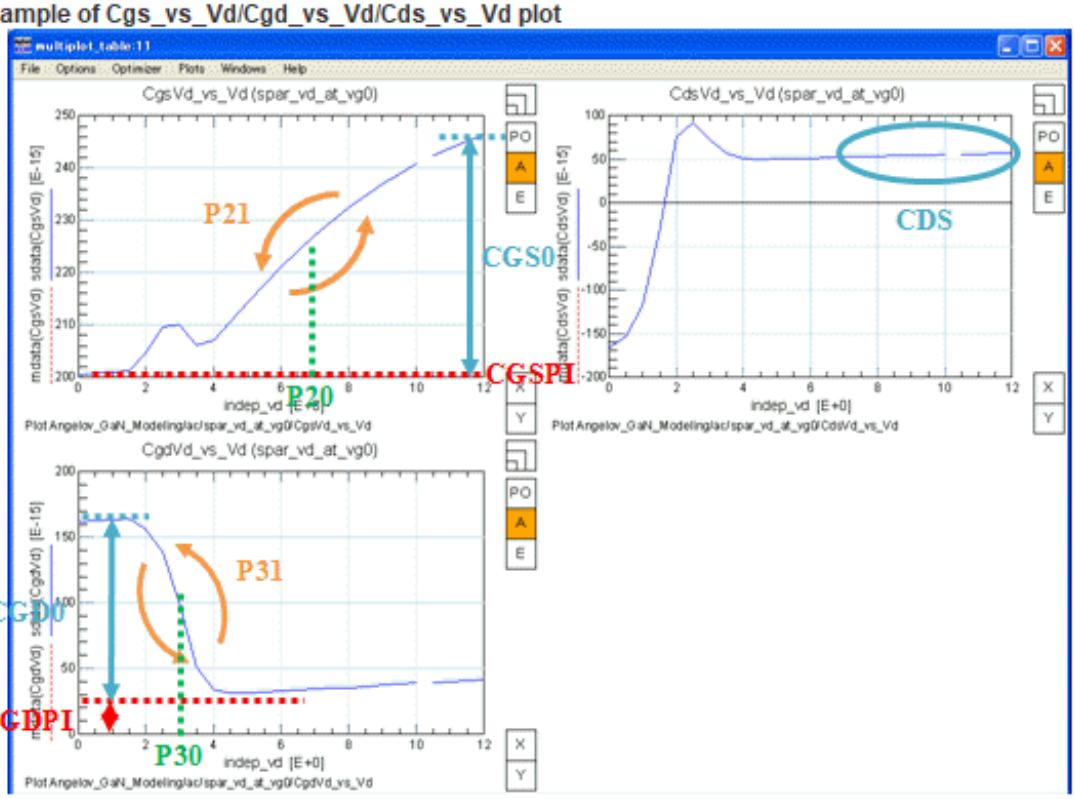
2. Optimize RG, RI and RGD using O: RG,RI,RGD{+}{_}.
   Keeping Rin, rgd and magS11 in view, adjust on the whole using RG, RI and RGD.
   Example of rin_vs_freq/rgd_vs_freq/S11MAG plot



SP vd at vg0

Next go on implementing the optimization of capacitance characteristics and S-Parameter at Vg=0.

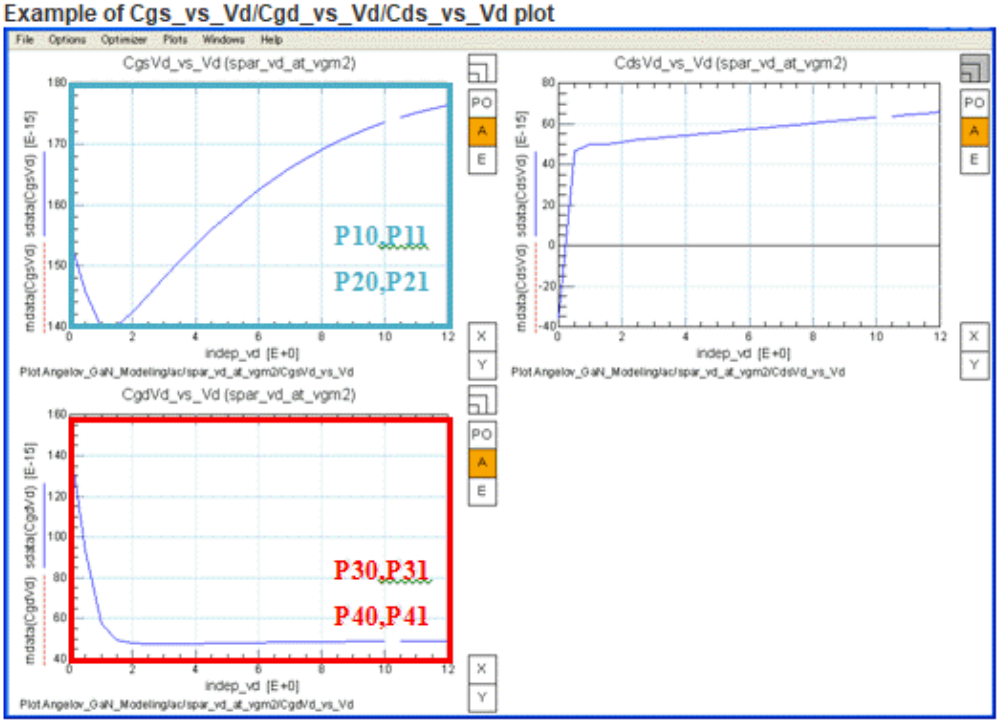
1. Optimize CGSPI, CGDPI, CGS0, CGD0, CDS, P20, P21, P30 and P31 using O: CGS,CGD
   Adjust the characteristics using
   CGSPI, CGS0, P20 and P21, keeping Cgs in view
   CGDPI, CGD0, P30 and P31, keeping Cgd in view
   CDS, keeping Cds in view
   Example of Cgs_vs_Vd/Cgd_vs_Vd/Cds_vs_Vd plot



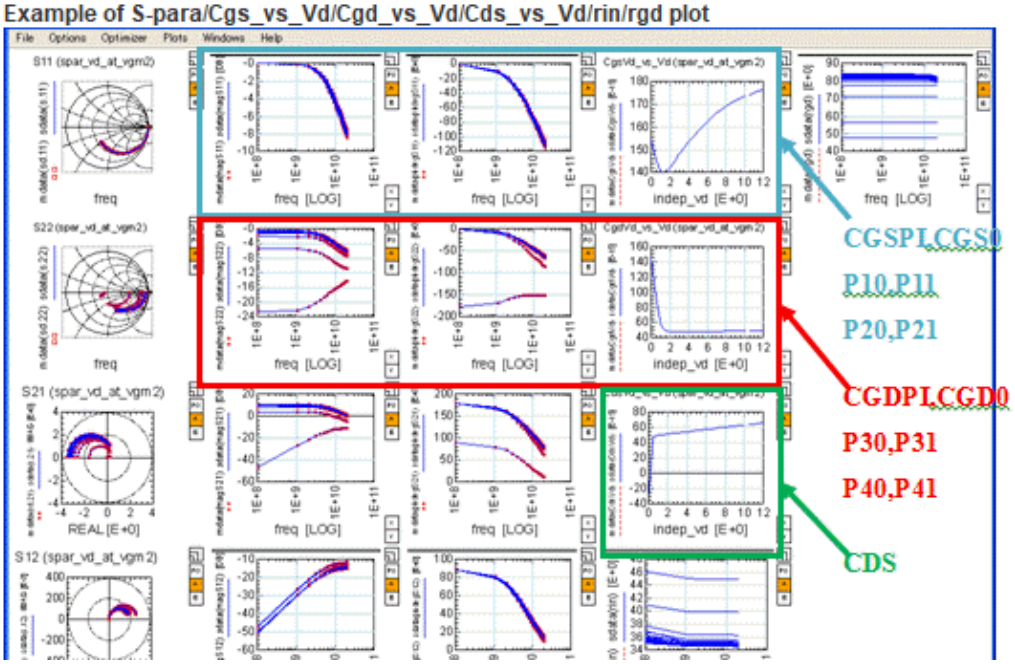
SP vd at vgm2

Finally, go on implementing the optimization of capacitance characteristics and S-Parameter with Target bias.

1. Optimize P10, P11, P20, P21, P30, P31, P40 and P41 using T: CGS,CGD{+}{_}.
   Adjust the characteristics using
   P10, P11, P20 and P21, keeping Cgs in view
   P30, P31, P40 and P41, keeping Cgd in view
   Example of Cgs_vs_Vd/Cgd_vs_Vd/Cds_vs_Vd plot

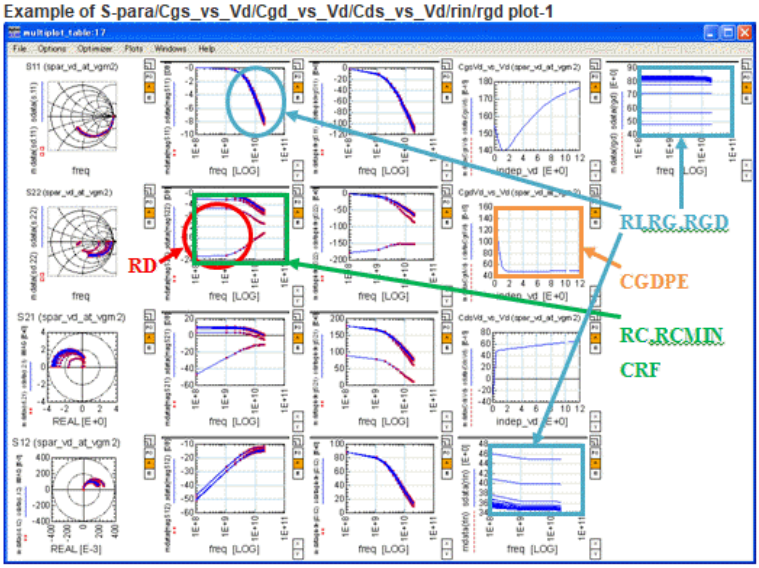


2. Optimize CGSPI, CGDPI, CGS0, CGD0, CDS, P10, P11, P20, P21, P30, P31, P40 and P41 using T: C_all{+}{_}.
   Adjust the characteristics using
   CGSPI, CGS0, P10, P11, P20 and P21, keeping magS11, phaseS11 and Cgs in view
   CGDPI, CGD0, P30, P31, P40 and P41, keeping magS22, phaseS22 and Cgd in view
   CDS keeping in view Cds
   Example of S-para/Cgs_vs_Vd/Cgd_vs_Vd/Cds_vs_Vd/rin/rgd plot

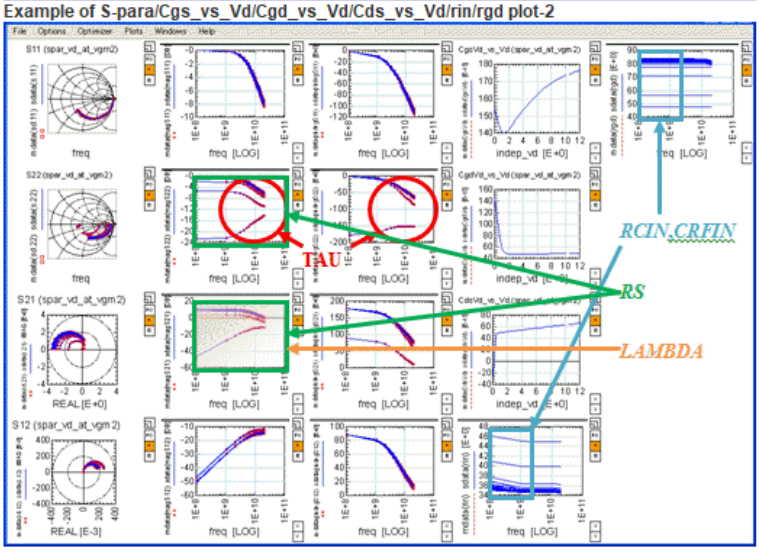


3. Optimize **CGSPI, CGDPI, CGS0, CGD0, CDS,** RI, **RD,** RG, **RC, RCMIN, CRF,** *RCIN, CRFIN,* RGD, CGDPE, ***TAU, RS*** and *LAMBDA* using T: R_all,C_all{_}.
   RI, RG and RGD, keeping magS11, rin and rgd in view
   RD, keeping Low Bias part of magS22 in view
   RC, RCMIN and **CRF,** keeping magS22 in view
   CGDPE, keeping Cgd in view
   RCIN and *CRFIN,* keeping Low Frequency part of rin and rgd in view
   TAU, keeping High Frequency part of magS22 and phaseS22 in view
   RS, keeping magS22 and magS21 in view
   LAMBDA, keeping magS21 in view

Example of S-para/Cgs_vs_Vd/Cgd_vs_Vd/Cds_vs_Vd/rin/rgd plot-1



Example of S-para/Cgs_vs_Vd/Cgd_vs_Vd/Cds_vs_Vd/rin/rgd plot-2



7. Finalize: Saving all parameters in the model files

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