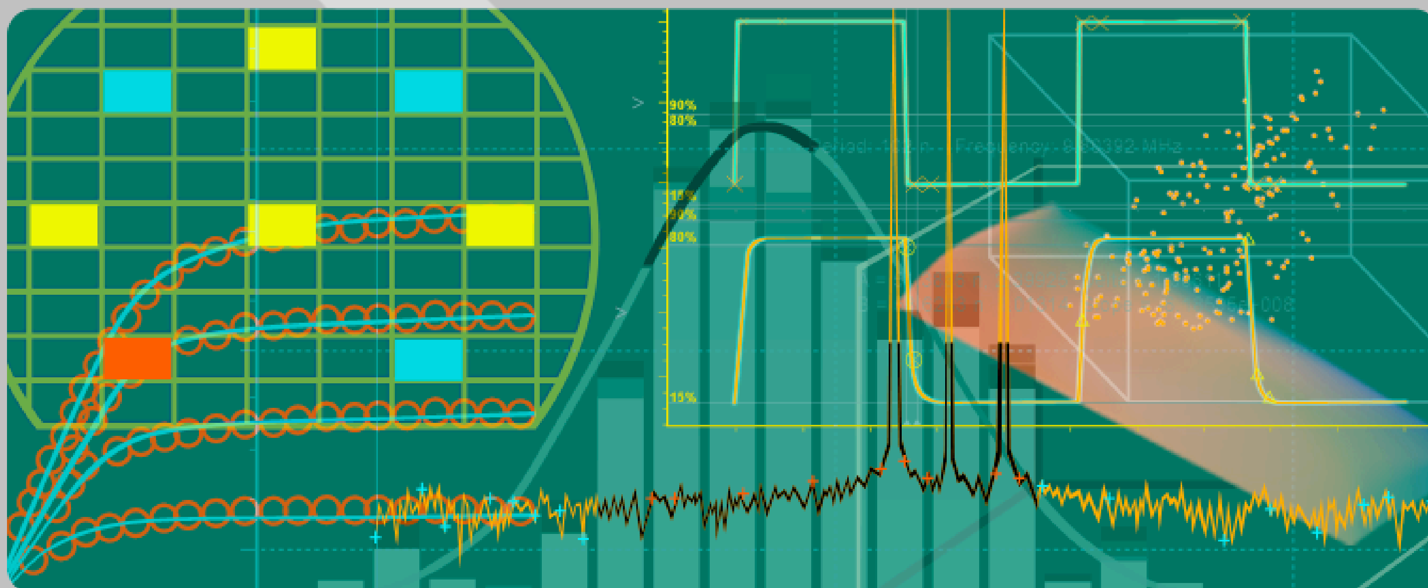
Local Optimization in UTMOST III



10/19/05

Outline

- Parameter Extraction Alternatives
- What is Local Optimization?
- MOSFET Local Optimization Example
- Conclusion

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Parameter Extraction Alternatives

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Fitting/Direct Extraction

- Analytical fitting algorithims
  - (+) Fast
  - (+) Small data sets usually required
  - (+) Reproducible I.e. User-independent
  - (+) Suitable for gathering statistical data
  - (+) Suitable for inclusion in in-line parameteric test
  - (-) Not very accurate for the extraction of SPICE parameters
  - (-) Not flexible
  - (-) Model-dependent

Global Optimization

- Levenburg-Marquardt based algorithms
  - (+) Accurate
  - (+) Flexible
  - (+) Easy to implement
  - (+) Model-independent
  - (-) Slow and a lot of measured data required
  - (-) Non-physical parameter values
  - (-) Too difficult to associate individual parameters to correct data
  - (-)Too dependent on initial estimates
  - (-) Lots of user interaction required

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Local Optimization - Background

- Optimize parameters in stages to very specific data points
- Regional optimization
- Useful alternative to fitting algorithms or global optimization
- User-define
- Extremely flexible and accurate
- Easy to create and modify
- Relatively fast. User can control optimization end criteria and how much data is measured
- Measurement data is not specific to the extraction method. Data can be used to extract parameters for other models also

Local Optimization

- Levenburg-Marquardt based algorithms
  - (+) Accurate
  - (+) Flexible
  - (+) Easy to implement
  - (+) Model-independent
  - (-/+) Not so slow but a lot of measured data often required
  - (+) Good trade-off between optimization accuracy and physical parameters
  - (+) East to associate individual parameters to appropriate data

SIMUCAD DESIGN AUTOMATION

Local Optimization – Details

- MOS:ID/VG-VB, ID/VD-VG. ID/VG-VD, ALL_DC, and ALL_ISUB
- BIP: gummel, rgummel, IC/VCE, IE/VEC, BFvsIC, BR, and ALL_DC
- Also available for JFET, TFT, DIO, and HBT technologies
- Local (regional) optimization to current, derivatives, or both
- Local optimization to a single device or multiple devices
- Target data specified using current limits and/or voltage limits and/or sweep numbers and devices I.D.s
- Specify aboslutely or as a % of maximim meas. Sweep current/voltage

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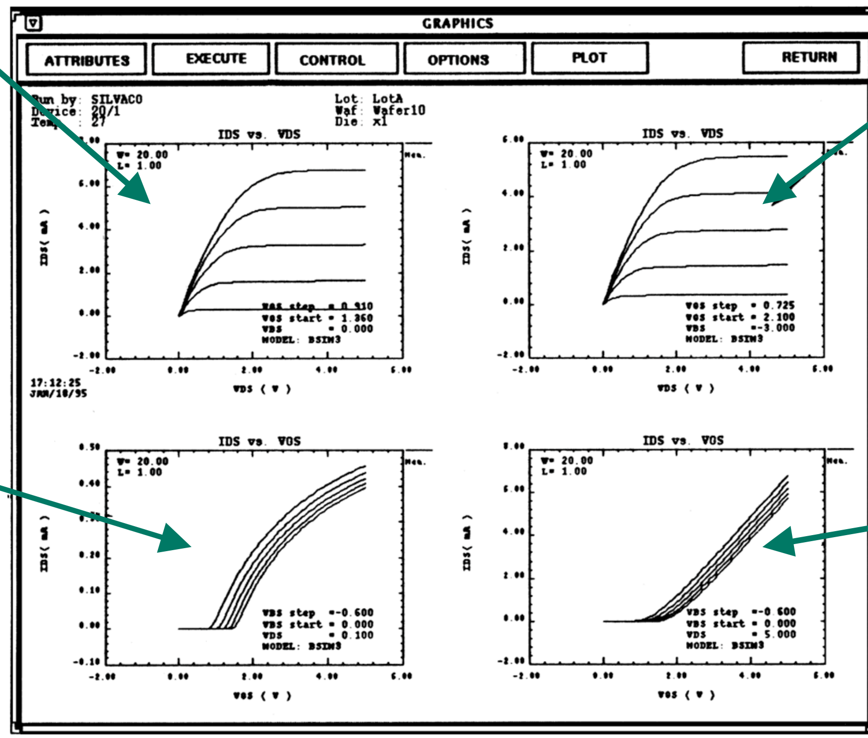
Local Optimization – Measured Data

IDS-VDS @ VGS with VBS = 0.0V

IDS-VDS @ VGS with VBS = -3.0V (optional)

IDS-VGS @ VBS with VDS = 0.1V

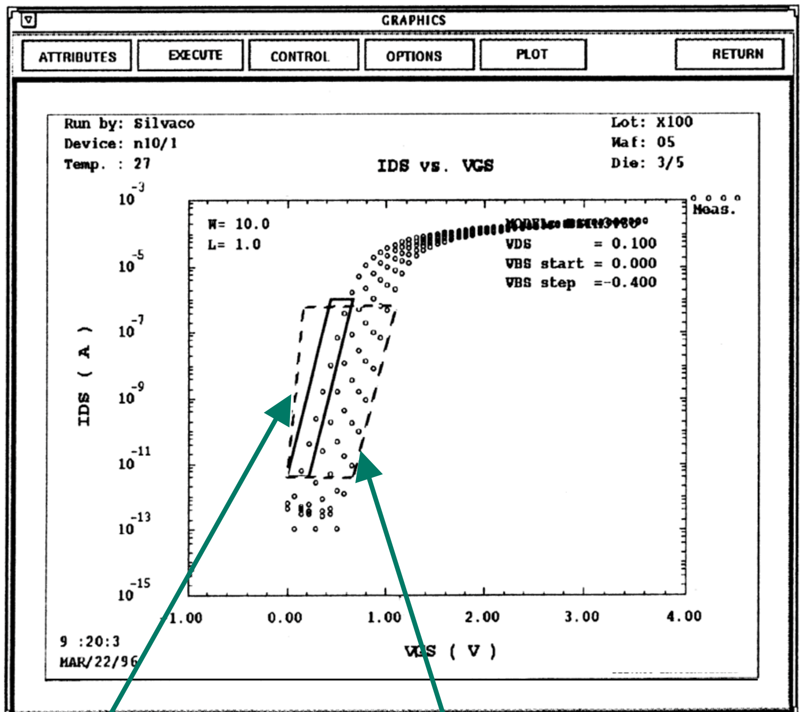
IDS-VGS @ VBS with VDS = 5.0V (optional)

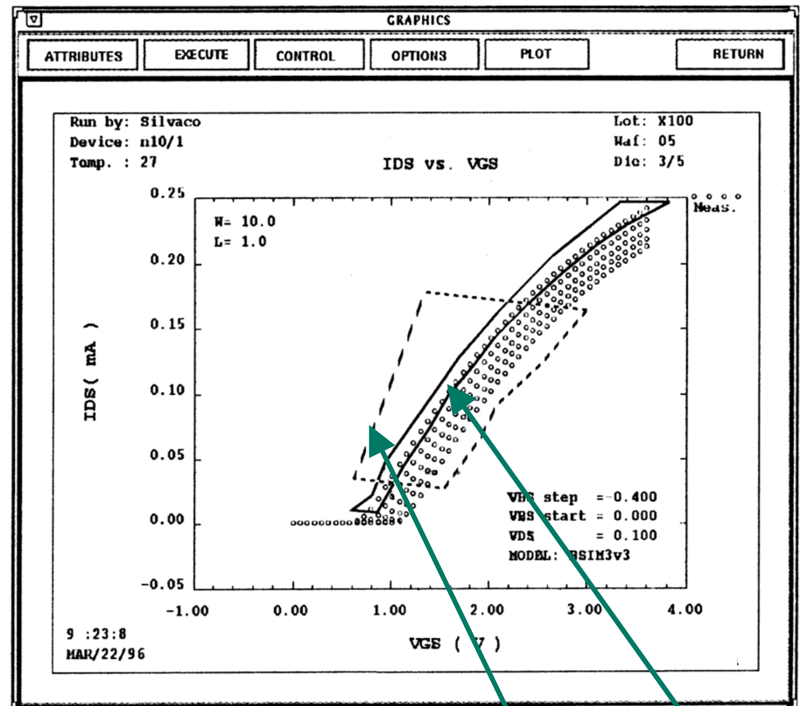


Data must be measured from devices with different geometries.

Selecting Data Region For Optimization:

MOS Examples: Ids-Vgs





IDS_min = 1E-11, IDS_max = 1E-6, Sweep_start = 1, Sweep_stop = 5, Voltages=undefined, Device = 10/1.

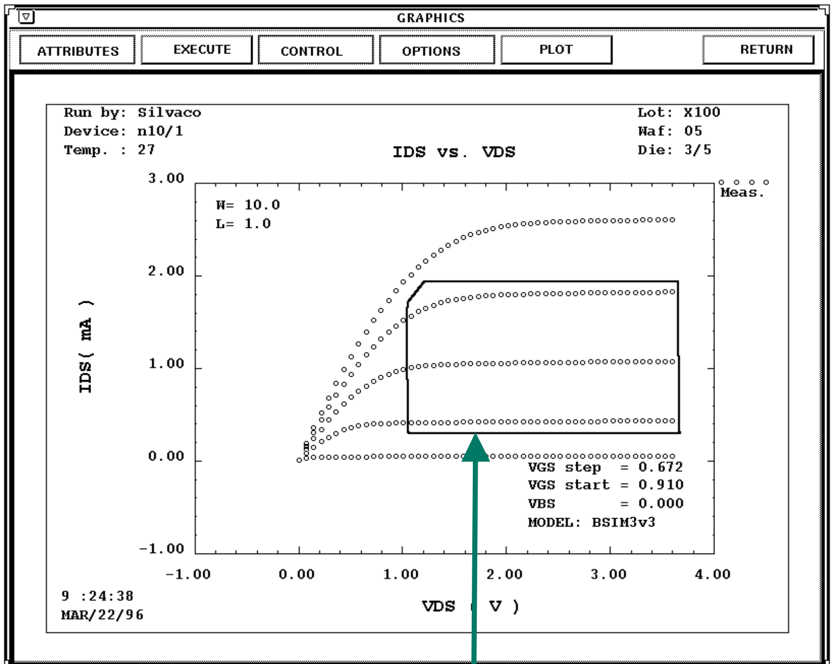
IDS_min = 1E-11, IDS_max = 1E-6, Sweep_start = 1, Sweep_stop = 1, Voltages=undefined, Device = 10/1.

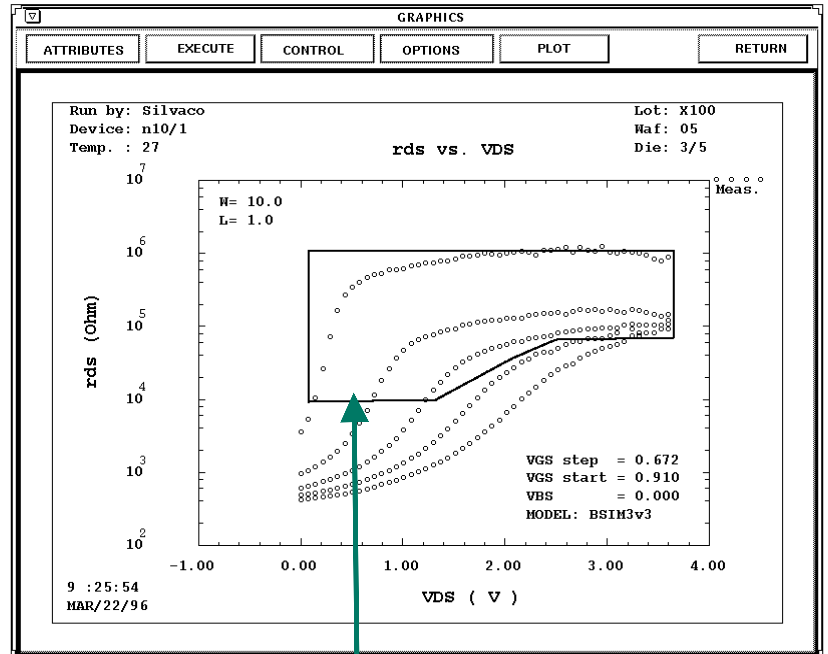
IDS_min = %15, IDS_max = %70, Sweep_start = 1, Sweep_stop = 5, Voltages=undefined, Device = 10/1.

IDS_min = %5, IDS_max = %100, Sweep_start = 1, Sweep_stop = 1, Voltages=undefined, Device = 10/1.

Selecting Data Region For Optimization:

MOS Examples: Ids-Vds



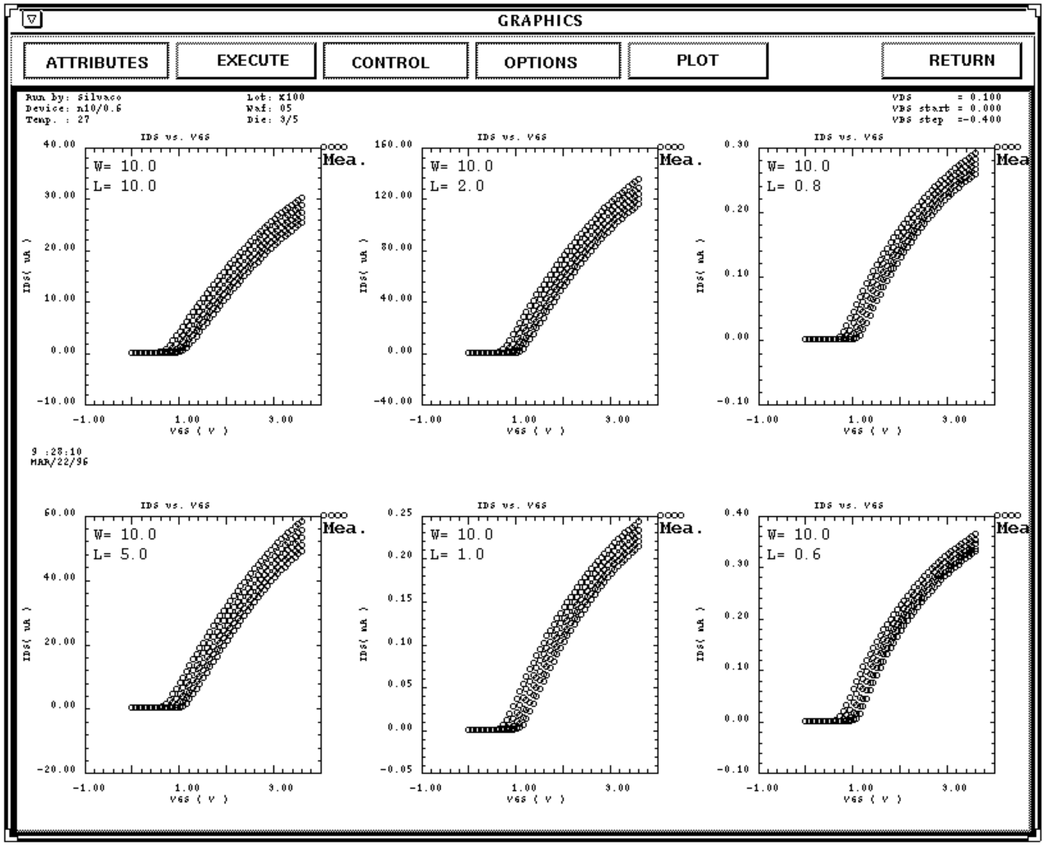


IDS_min = 1E-11, IDS_max = 1, Sweep_start = 2, Sweep_stop = 4, VDS_start = 1V, VDS_stop = undefined VGS & VBS undefined, Device = 10/1

RDS_min = 1E+4, RDS_max = 1E+6, Sweep_start = 1, Sweep_stop = 3, VDS & VGS & VBS undefined, Device = 10/1

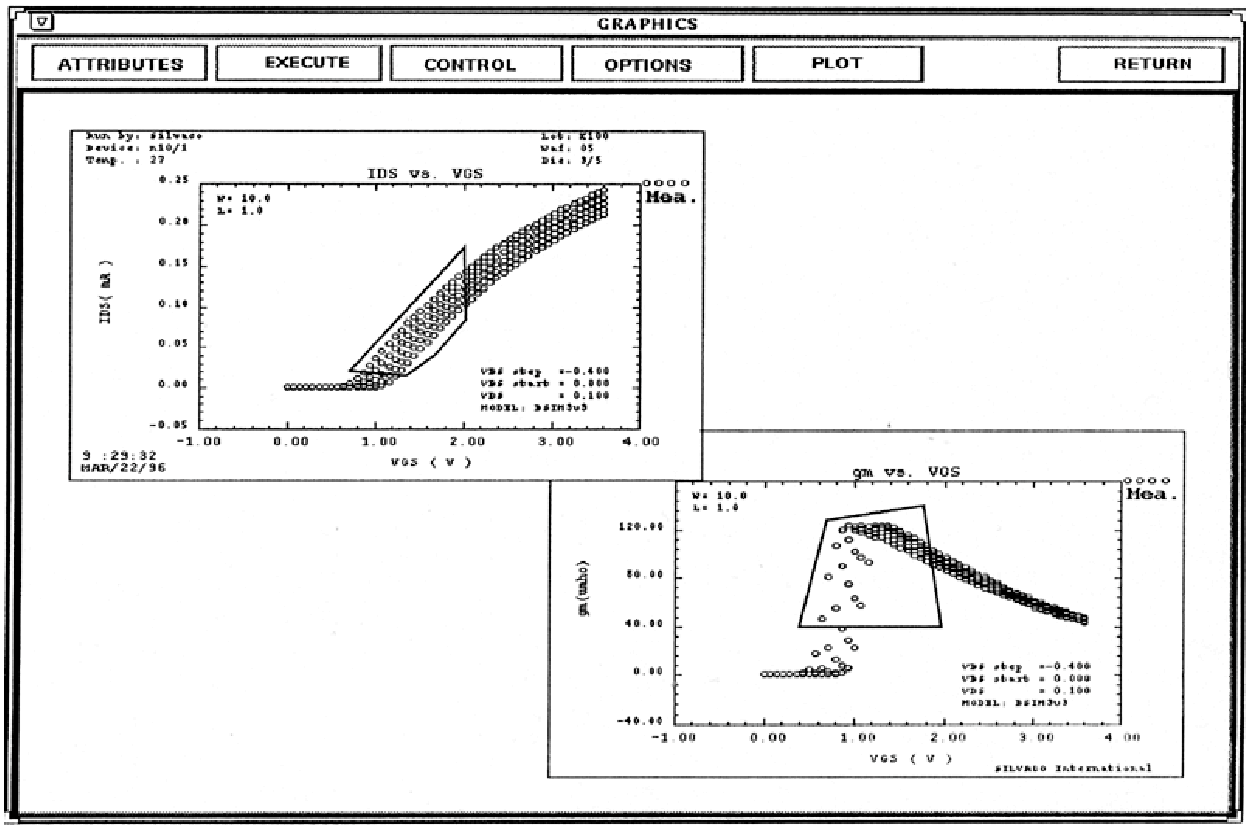
Selecting Data Region For Optimization:

MOS Examples: Multi-Geometry



IDS_min = %10, IDS_max = %100, Sweep_start = 1, Sweep_stop = 5, Voltages = undefined, Device 10/10, 10/5, 10/2, 10/1, 10/0.8, and 10/0.6.

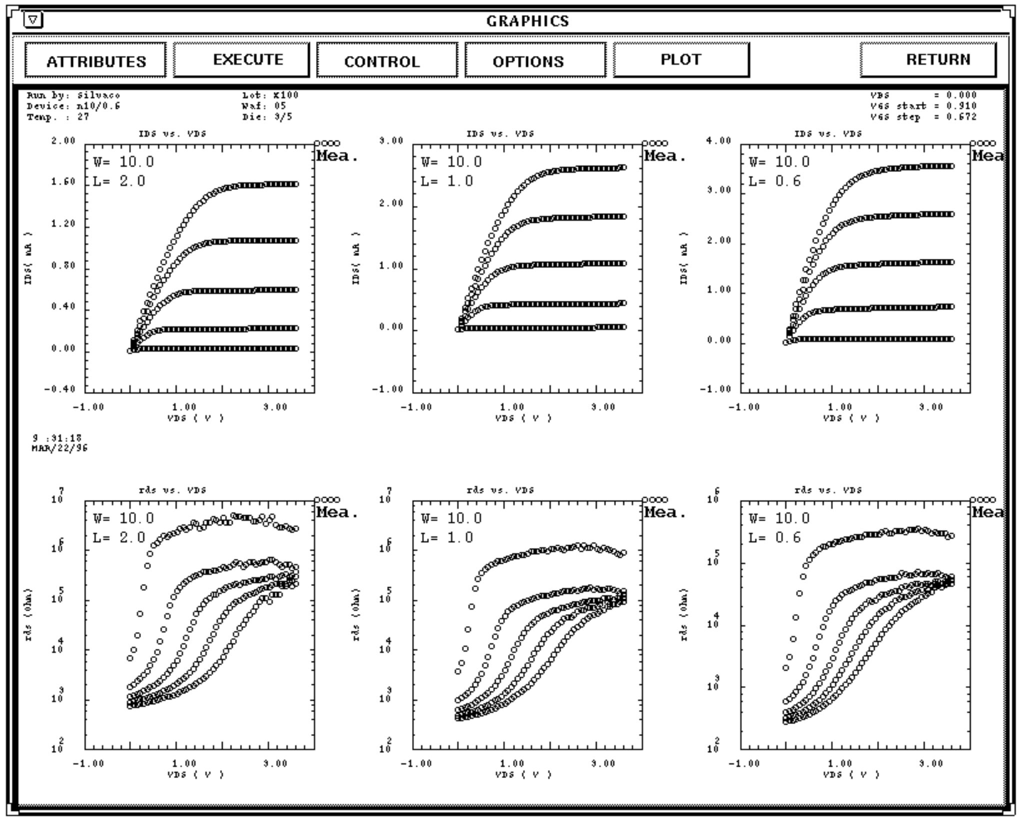
Selecting Data Region For Optimization:
MOS Examples: Multi-Target



IDS_min = %10, IDS_max = %100, GM_max = undefined, Sweep_start = 1, Sweep_stop = 5, VGS_min = undefined, VGS_max = 2.0V, VDS & VBS = undefined, Device 10/1.

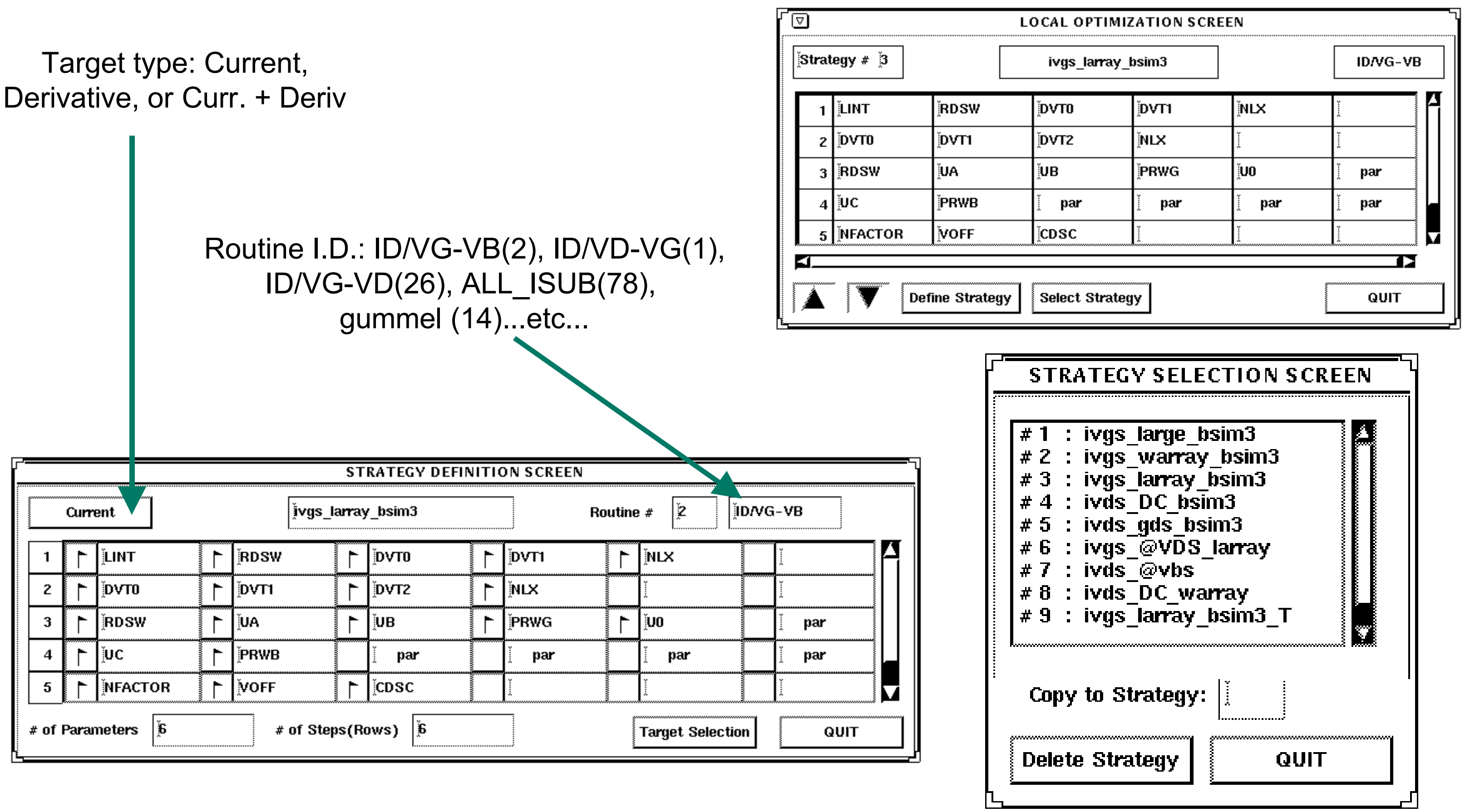
Selecting Data Region For Optimization:

MOS Examples: Multi-Geom. & Target

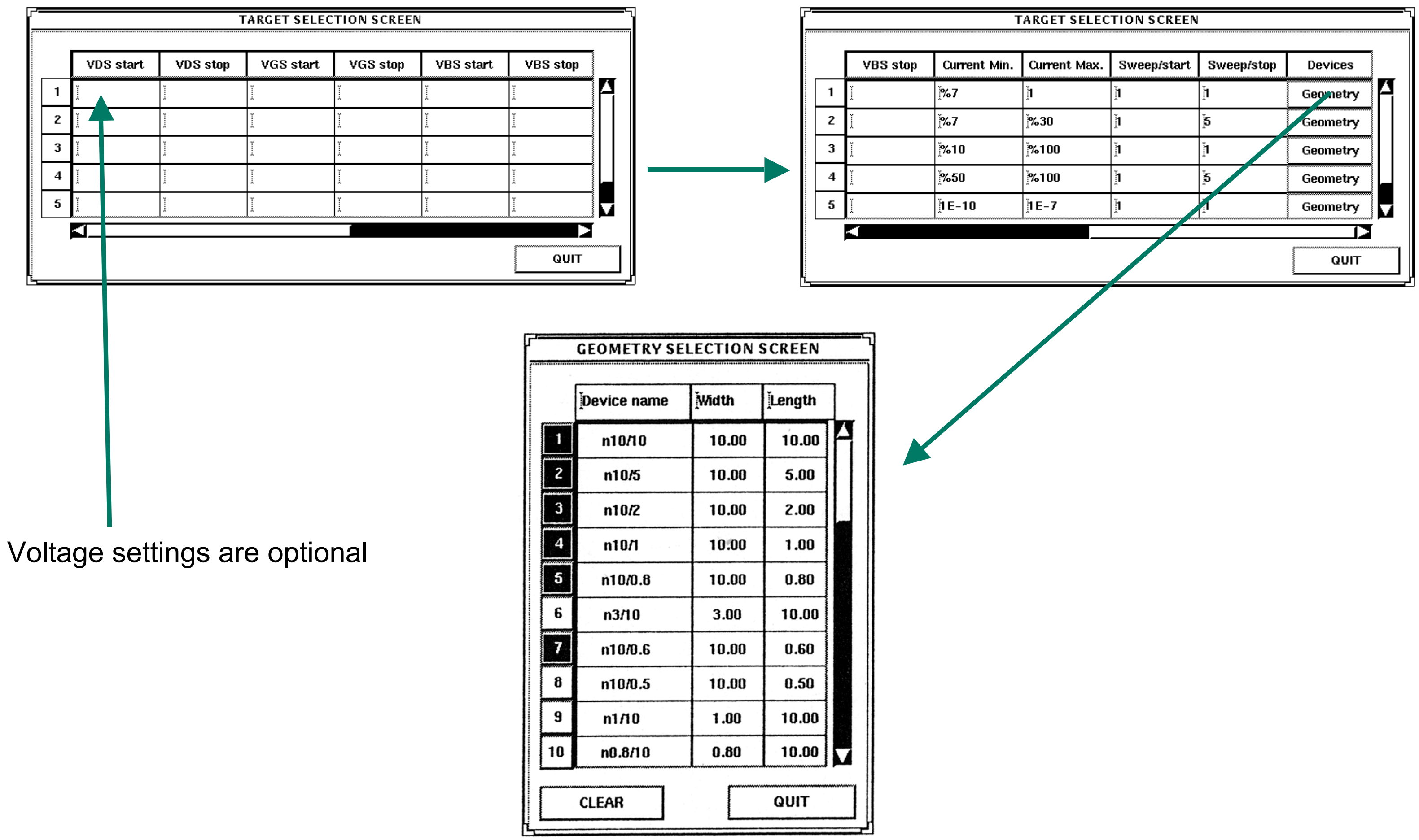


IDS_min = 1E-6, IDS_max = undefined, RDS = undefined, Sweep_start = 1, Sweep_stop = 3, VDS_min = 0.1V, VGS_max = undefined, VGS & VBS, Device = 10/2, 10/1, and 10/0.6.

Selecting Data Region For Optimization:
UTMOST Screens



Selecting Parameters For Optimization



MOSFET BSIM3v3 Local Optimization Sequence

Strategy No. 1	Devices: Large	IDS-VGS @ VBS (VDS = low) T=Room		No. of Steps: 3
Step.	**Parameters**	**IDS low limit**	**IDS high limit**	**VBS**
1	VTH0, U0, UA and UB	7%	100%	0
2	K1, K2 and UC	7%	100%	0 -> VBB
3	NFACTOR and VOFF	1E-10	1E-07	0

Strategy No. 2	Devices: L-array	IDS-VGS @ VBS (VDS = low) T=Room		No. of Steps: 4
Step.	**Parameters**	**IDS low limit**	**IDS high limit**	**VBS**
1	LINT, RDSW, DVTO, DVT1, and NLX	7%	100%	0
2	DVT0, DVTi, DVT2, NLX, and UC	7%	30%	0 -> VBB
3	CDSC, CDSCB, VOFF, and NFACTOR	1E-10	1E-07	0 -> VBB
4	UC, PRWB*, PRWG*, RDSW, and LINT	15%	100%	0 -> VBB

Strategy No. 3	Devices: W-array	IDS-VBS @ VBS (VDS = low) T=Room		No. of Steps: 3
Step.	**Parameters**	**IDS low limit**	**IDS high limit**	**VBS**
1	WINT, K3, and W0	7%	100%	0
2	K3, K3B, and W0	7%	30%	0 -> VBB
3	WINT, DWG*, DWB*	15%	100%	0 -> VBB

MOSFET BSIM3v3 Local Optimization Sequence (con't)

Strategy No. 5	Devices: L-array	IDS-VGS @ VBS (VDS = high) T=Room		No. of Steps: 1
Step.	**Parameters**	**IDS low limit**	**IDS high limit**	**VBS**
1	ETA0, ETAB, DSUB, and CDSCD	1E-10	1E-07	0 ->VBB

Strategy No. 5	Devices: L-array	IDS-VDS @ VGS (VBS = 0V) T=Room		No. of Steps: 2
Step.	**Parameters**	**IDS low limit**	**IDS high limit**	**VBS**
1	A0, AGS (long devices only)	1E-6	0.01	all
2	VSAT, PCLM, PDIBLC1, PDIBLC2 A0, and AGS (all L-array devices)	1E-6	0.01	all

Strategy No. 6	Devices: L-array	RDS-VDS @ VGS (VBS = 0V) T=Room		No. of Steps: 3
Step.	**Parameters**	**IDS low limit**	**IDS high limit**	**VBS**
1	VSAT, PCLM, PDIBLC1, PDIBLC2 PVAG, and ETA0	1E3	1E9	all except lowest
2	PCLM, PDIBLC1, PDIBLC2, PVAG	1E3	1E9	lowest two
3	PCLM, PDIBLC1, PDIBLC2, PVAG, ETA0, and DROUT	1E3	1E9	all

MOSFET BSIM3v3 Local Optimization Sequence (con't)

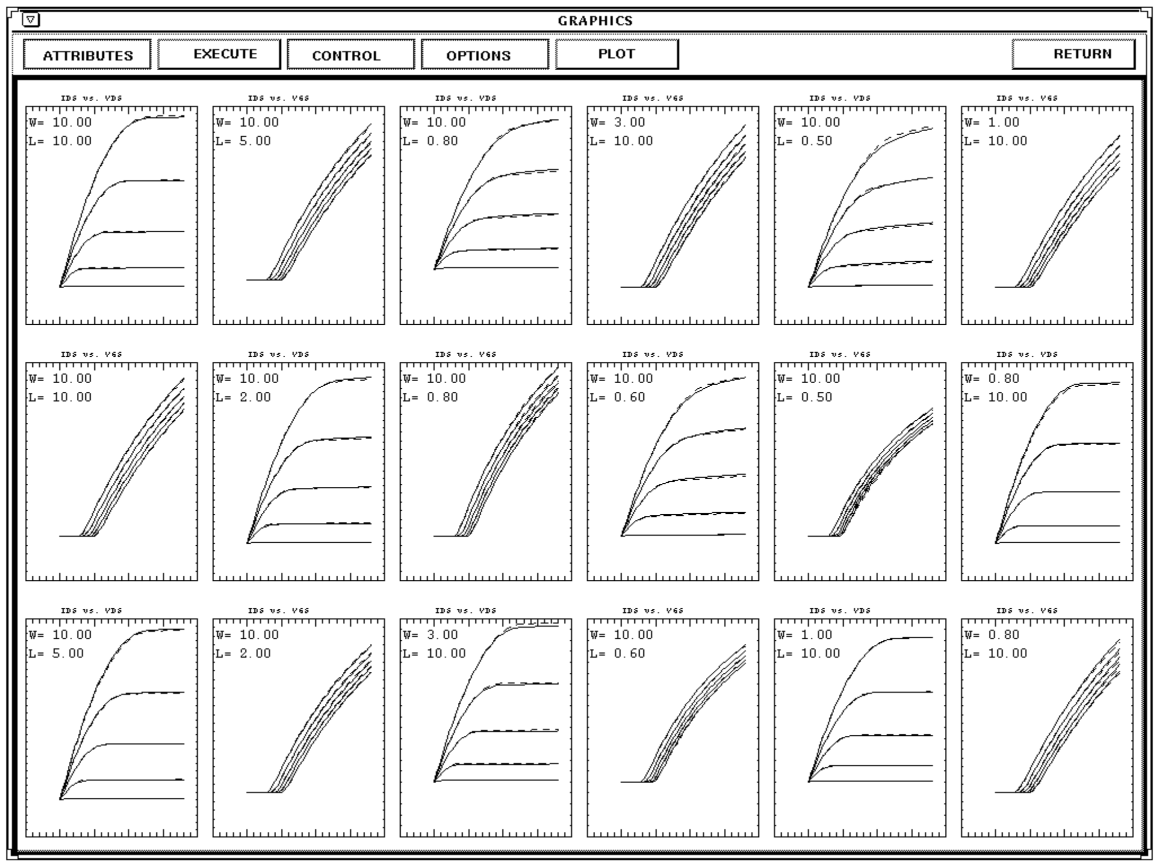
Strategy No. 7	Devices: L-array	IDS-VGS @ VBS (VBS = VBB) T=Room		No. of Steps: 1
Step.	**Parameters**	**IDS low limit**	**IDS high limit**	**VBS**
1	KETA, ETAB, and PDIBLCB	1E-7	0.01	all

Strategy No. 8	Devices: L-array	IDS-VGS @ VBS (VBS = VBB) T=Room		No. of Steps: 1
Step.	**Parameters**	**IDS low limit**	**IDS high limit**	**VBS**
1	B0* and B1*	1E-7	0.01	all

Strategy No. 9	Devices: L-array	IDS-VGS @ VBS (VBS = VBB) T=Room		No. of Steps: 1
Step.	**Parameters**	**IDS low limit**	**IDS high limit**	**VBS**
1	WL, WLN, DVT0W*, and DVT1W*	7%	100%	0 -> VBB

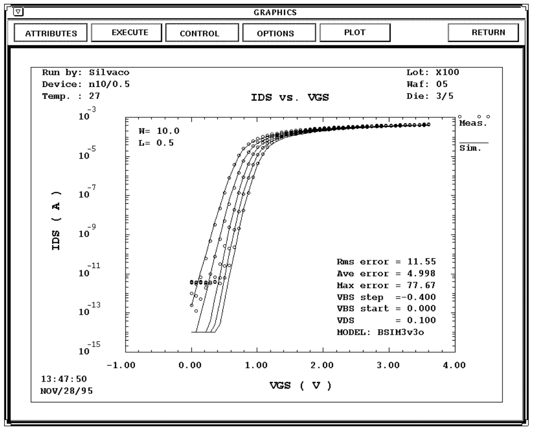
Strategy No. 10	Devices: L-array	IDS-VGS @ VBS (VBS = VBB) T=Room		No. of Steps: 1
Step.	**Parameters**	**IDS low limit**	**IDS high limit**	**VBS**
1	UTE, KT1, UA1, and UA2 (Large device)	7%	100%	0
2	PRT, UA1, UA2, and KTL (L-array)	7%	100%	0
3	KT2 and UC1	7%	80%	0 -> VBB

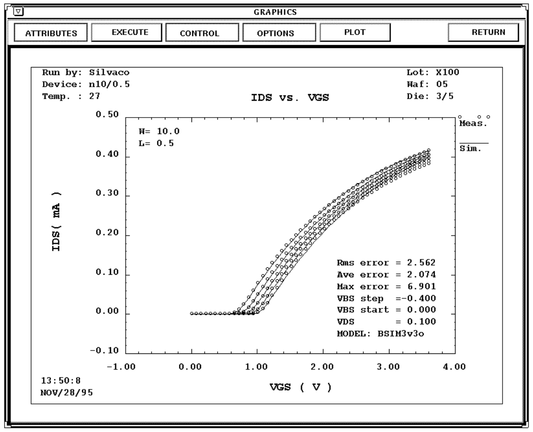
MOSFET Example: Result of Multiple Geometry Local Optimization

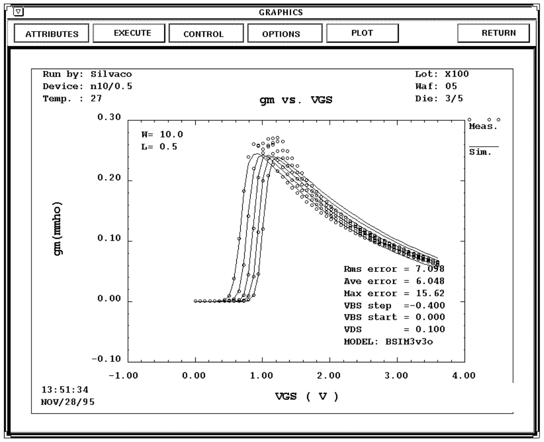


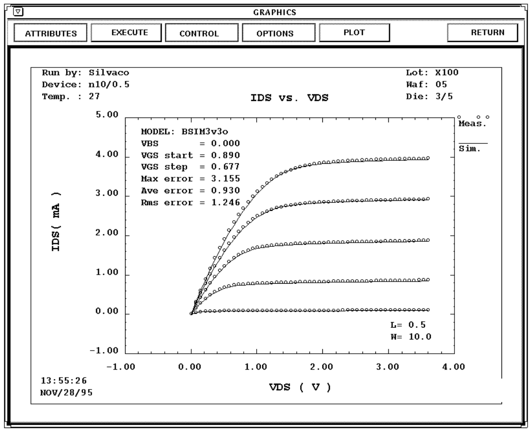
Measured ———— Simulated - - - - - -

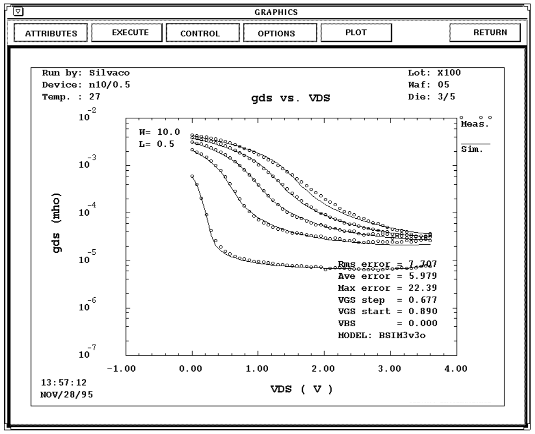
Local Optimization Example: NMOS Single Geometry Results











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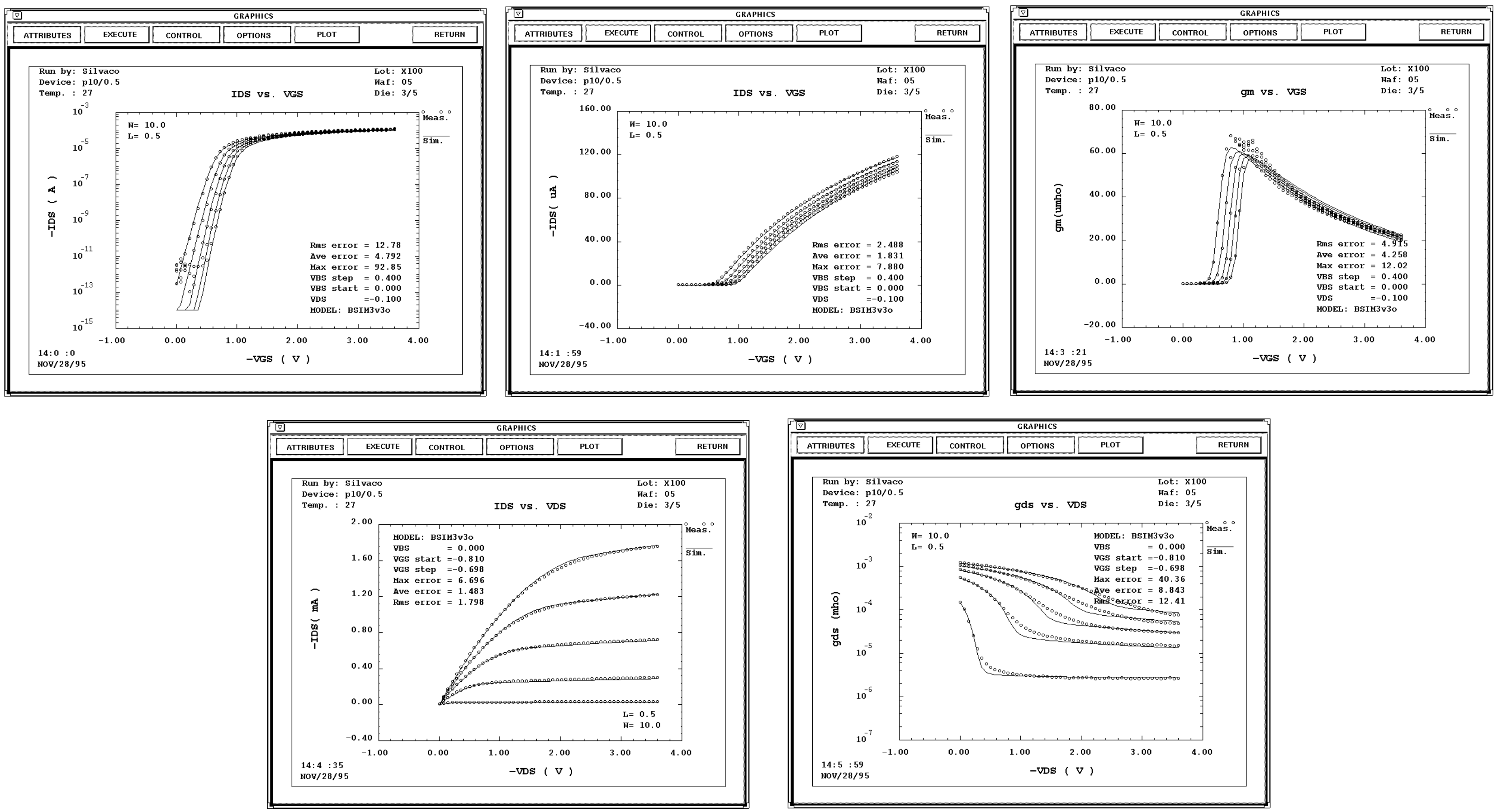

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Conclusion

- Direct extraction is specific to model selected
- Global optimization is slow and requires a lot of interaction
- Local optimization provides flexible, fast and automated model parameter extraction sequence
- Local optimization is fully supported in UTMOST III