FSA MIXED-SIGNAL/RF SPICE MODEL CHECKLIST

Tutorial

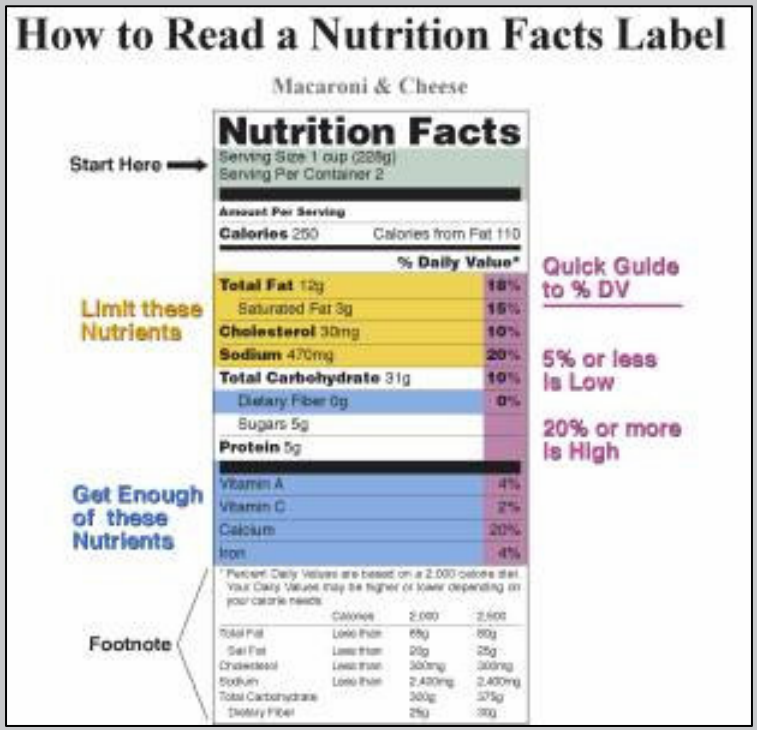
Kenneth Brock
VP Marketing, Silvaco
August 11, 2005

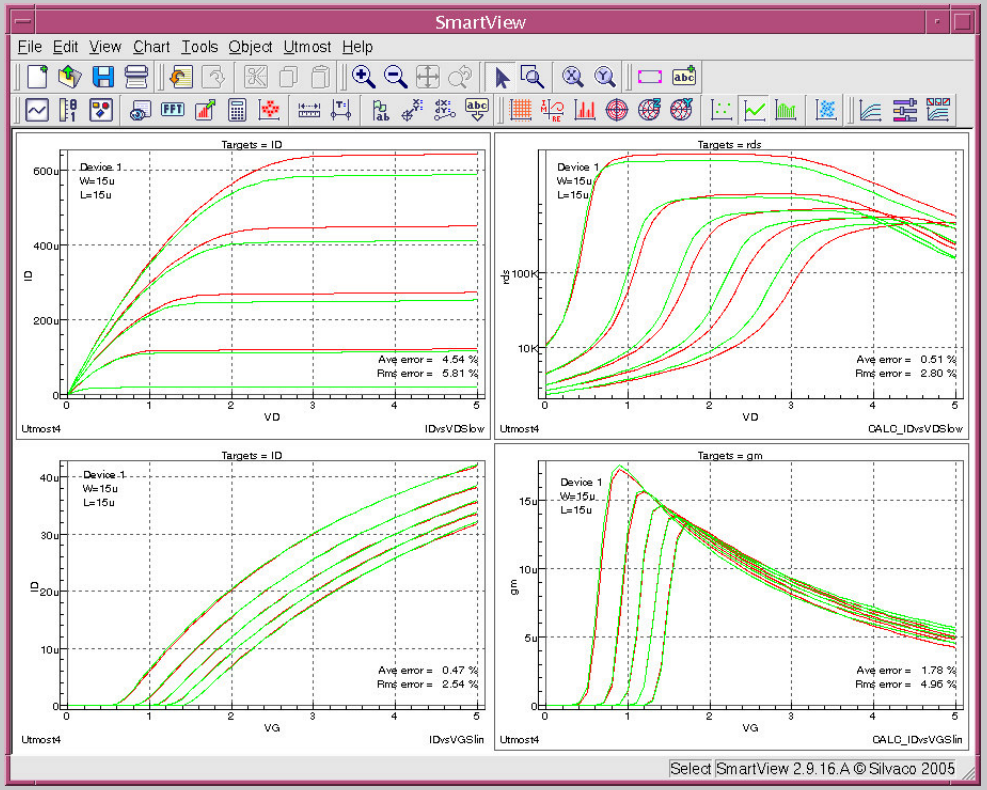
MS/RF FOUNDRY SUBCOMMITTEE: SPICE MODEL CHECKLIST

What is the FSA SPICE Model Checklist?

- A three-page, FSA-endorsed document completed by the SPICE model developer and delivered with each new release of an SPICE Model
  - Page 1 - foundry, process and support contact information and versions of foundry modeling documents
  - Page 2 - versions of circuit simulators used to validate the model and a rigorous model classification
  - Page 3 - device list with the deliverables and tests performed for each device.
- Serves as a combination ingredients list and "nutrition facts label" for a MS/RF SPICE model
- Helps you better understand the source data, completeness and quality of the model before using it to design ICs or to re-extract it to fit into your specific product needs.

SPICE MODEL CHECKLIST SERVES AS NUTRITION FACTS LABEL





Standard measured vs. simulated plots of a typical MOSFET
(ID vs. VD and its derivative RDS, ID vs. VG and its derivate, GM)

WHAT IS INCLUDED WITH THE SPICE MODEL CHECKLIST?

Documents on-line at www.fsa.org/SpiceModelChecklist

- FSA MS/RF SPICE Model Checklist (3 pages) in editable Word format.
- FSA MS/RF SPICE Model Checklist User's Guide (9 pages) in PDF format
  - For Fabless companies, this document describes the meaning of each part of the checklist.
  - For Foundries, this document describes the "balls and strikes" consistent rules for completing the Checklist.
- FSA MS/RF SPICE Model Checklist Definitions and Taxonomy (10 pages)
  - Includes consistent definitions of SPICE modeling terms used in the other documents

FOUNDRY AND SUPPORT CONTACT INFORMATION

Section 1 – Foundry and Support Contact Information

Foundry _____

Process _____

Date _____

SPICE Model Support Contact

Name _____

Phone _____

Email _____

SECTION 2
FOUNDRY MODELING DOCUMENTS

Document	Document Number & Title	Section	Revision	Date
SPICE Model Library				
Measured vs. Simulated Data				
Noise Model				
Matching Models				
Design Rules				
Process Flow/X-section				
Device Characterization Report				
PCM Structure & Test Report				
Device Parasitic Methods				

SECTION 3
CIRCUIT SIMULATORS

Simulator	Vendor and Tool	Level Support	Version	Version Date
Circuit Simulator (A)				
Circuit Simulator (B)				
Circuit Simulator (C)				
Circuit Simulator (D)				

Comments

1
2
3
4
5

SECTION 4
TYPES OF DEVICES MODELED

Device Type	Subtypes	Typical Attributes
MOS	NMOS, PMOS, twin/triple well, DMOS, LDMOS	Voltage, Range of lengths, Finger width, Temperature, Max Frequency, Noise Figure
BJT	NPN, PNP, Lateral, Vertical	Voltage, Range of sizes, Temperature, Max Frequency, Noise Figure
Diodes	N+/PW, P+/NW	
Capacitors	poly-poly, MIM, MOM, Tunnel, Hi-Q	2 port S parameters, Sizes of samples, Empirical and measured rules, Resonant Frequency, Q
Resistors	n-diff, p-diff, n-well, poly0, poly1 polyN, fuse, metal	2 port S parameters, silicide, Range of Resistance, sizes, layers
Inductors	Spiral, Differential	2 port S parameters, Inductance, Turns, size, square, octagonal, size, metal width, stacked, balanced, Q
Varactors	MOS, Junction, Hyperabrupt	2 port S parameters, Range of capacitances, sizes, and bias conditions

MODEL CLASSIFICATION, NOISE, MATCHING, STATISTICAL VARIATION, RESULTS

Device Type	Device Name	Model Name	Model Type	Version	Model Style	Comments	Terminals	No of Bins	1/f Noise	HF Noise	RF Params	HV Params	Stat Model	Stat Method	Samples/Lots	Model Val	Corner Val	Max Error	No of Plots
MOS	NMOS	mymos	Bsim3	3.2	C	1	4	1	M	M	YSNFL	HBSP	SMC	CPB	20/10	PR	PR	PR	20
MOS	PMOS	mypmos																	
BJT	NPN	qnpn																	
BJT	PNP	qpnp																	
Diode																			
CAP																			
RES																			
IND																			
VAR																			

MODEL IDENTIFICATION

1. Device type – (list) see table
2. Device name – (name) – the foundry-defined unique name that invokes the schematic symbol in the PDK, invokes the model card in simulation, and the correct Pcell in layout.
3. Model name – (name) name of the model card and individual model file if models are not combined into a single library
4. Model Type – (name) e.g. (BSIM3, BSIM4, EKV, HICUM, GP, etc.)
5. Version (#.#) – ex. (3.2, 3.3, 4.4)
6. Model Style – (same as the PDK Checklist column Spice Model) – means that the model is one of the following types (C=compact model, B=behavioral, and S=.SUBCKT).
7. Comments
8. Terminals – (#) defines the number of terminals on the device.

GENERAL MODEL CAPABILITIES

9. No of Bins (#) - e.g. (1, 2, 3, 4, 5 etc. for number of model cards to cover device's full operating range through automatic binning of W, L) – measure of continuity
10. 1/f Noise (list) means that the SPICE model was characterized for what is called 1/f, flicker, or low frequency noise by the following methods: (M=measured, T=TCAD, E=estimated, or blank if not included).
11. HF Noise (list) –means the SPICE model was characterized for what is called high-frequency or RF noise (M=Measured, T=TCAD, E=Estimated, or blank if not included) in the gigahertz range
12. RF Parameters (list) – means that the SPICE model includes any number of the following extracted RF parameters that were verified as per the model documentation: (Y= Y-parameters, S=S-parameters, N=NF or Noise Figure, F=FT or transition frequency, and L= NLE or non-linear effects)
13. High Voltage (list) – means that the model was extracted and characterized for high voltage applications and includes any number of the following parameters that were verified as per the model documentation: (H=Self Heating, B=Breakdown, S=Safe Operating Area, P=Pulsed Measurements).

STATISTICAL MODEL PARAMETERS

14. Statistical Model (list) –summarizes the SPICE model included for the device (S=Statistical Monte Carlo models have been extracted and verified, M=match models documented in Matching Models document, and C=Corner models – 4 [FF,SS,FS,SF] corners are included)
15. Statistical Method (list) – describes the method(s) used for the generation of statistical models (C=PCA or primary component analysis, P=PFA or primary factor analysis, B=BPV Backward propagation of variance by Colin McAndrew). Foundries may use a combination of these methods.
16. Samples/Lots (#/#) – is a two part number, the first part is the number of sample die that were used to generate the statistical models, the second part after the "/" is the total number of lots from which those sample die were taken. There is no mandated distribution of those die over the lots, but model users may assume that it is random and reflects the process distribution.

MODEL VALIDATION METRICS

17. Model Validation (list) – means the model validation procedures are performed (P = Procedure for model validation is described in the model documentation, R = Results of the model validation procedure for this device are published in the model documentation).
18. Corner Validation (list) – means the corner validation procedures are performed (P = Procedure for corner validation is described in the model documentation, R = Results of the corner validation procedure for this device are published in the model documentation). Corner validation includes tables or graphs that show how the statistical model corners correlate to the published PCM specification for the process.
19. Max Error (list) – means the maximum error of Simulated vs. Measured plots (P = Procedure for error calculation is described in the model documentation, R = Results of the error calculation for this device are published in the model documentation). Maximum error is the absolute percentage or RMS percentage (as defined in the model documentation) that is acceptable for each type of plot for this device.
20. Number of plots (#) – means the number of Simulated vs. Measured plots are included for this device in documentation. These plots may include DC plots, AC plots, RF plots, S parameter, Y parameter, W elements, and ring oscillator performance.

Device Specific Extraction and Model Parameters

Device Type	Device Name	Model Name	Geom	Min Width	Max Width	Min Length	Max Length	Max Finger	Min Temp	Max Temp	Max Freq
MOS	nmos	mynmos	10	0.5	100	0.3	100	10	-55	125	2.5
MOS	pmos	mypmos	10	0.5	100	0.3	100	10	-55	125	2.5
MOS	IOnmos	Nio	10	0.5	100	0.3	100	10	-55	125	2.5
MOS	IOpmos	Pio	10	0.5	100	0.3	100	10	-55	125	2.5
Device Type	**Device Name**	**Model Name**	**Geom**	**Min E Width**	**Max Width**	**Min Length**	**Max Length**	**Max Config**	**Min Temp**	**Max Temp**	**Max Freq**
BJT	npn	Qnpn5_7	8	5	5	7	7	1	-55	125	2.5
BJT	pnp	Qnpn9_12	8	9	9	12	12	1	-55	125	2.5
Device Type	**Device Name**	**Model Name**	**Geom**	**Min Width**	**Max Width**	**Min Length**	**Max Length**	**Max Finger**	**Min Temp**	**Max Temp**	**Max Freq**
JFET	jfet	myjfet	10	1	50	.5	10	5	-55	125	2.5

SECTION 6
PASSIVE DEVICE SPECIFIC PARAMETERS

Device Specific Extraction and Model Parameters

Device Type	Device Name	Model Name	Geom	Min Width	Max Width	Min Length	Max Length	Min Temp	Max Temp	Max Freq
Diode	ND0	NSD010		1	10	1	100	-55	125	2.5
Diode										
Device Type	**Device Name**	**Model Name**	**Geom**	**Min Width**	**Max Width**	**Min Length**	**Max Length**	**Min Temp**	**Max Temp**	**Max Freq**
VAR	VAR1	VAR1		1	10	1	100	-55	125	2.5
VAR										
Device Type	**Device Name**	**Model Name**	**Geom**	**Min Width**	**Max Width**	**Min Length**	**Max Length**	**Min Temp**	**Max Temp**	**Max Freq**
IND	IND1	IND01		5	8	2.4	6.2	-55	125	2.5
IND										
Device Type	**Device Name**	**Model Name**	**Geom**	**Min Width**	**Max Width**	**Min Length**	**Max Length**	**Min Temp**	**Max Temp**	**Max Freq**
CAP	Momcap	MOMCA1		1	100	1	100	-55	125	2.5
CAP										
Device Type	**Device Name**	**Model Name**	**Geom**	**Min Width**	**Max Width**	**Min Length**	**Max Length**	**Min Temp**	**Max Temp**	**Max Freq**
RES	Rppt	rpptLxW		1	10	1	1000	-55	125	2.5
RES										

MS/RF FOUNDRY SUBCOMMITTEE: SPICE MODEL CHECKLIST

What it is:

- Enhances communication within MS/RF supply chain with a common language
- Tracks versions of foundry documents, EDA tools, SPICE models
- Lists contents of the model library
- Serves as a "nutrition facts label" for foundry supplied SPICE models, showing both the good and bad characteristics in a consistent, easy to read format.

What it is not:

- Marketing brochure
- Process Spec Sheet
- Device Spec sheet