1/f Noise Measurements and SPICE Model Extraction For MOS Transistors

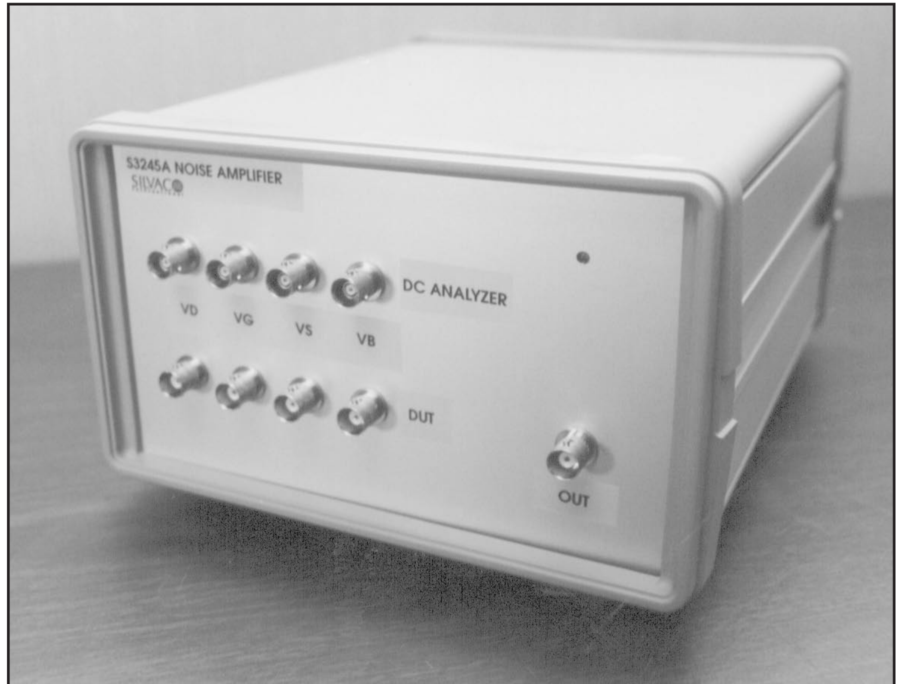
Noise in semiconductor devices has a significant impact on circuits performances.

This is even more important in today's low-voltage, high-performance, mixed-signal ad RF designs.

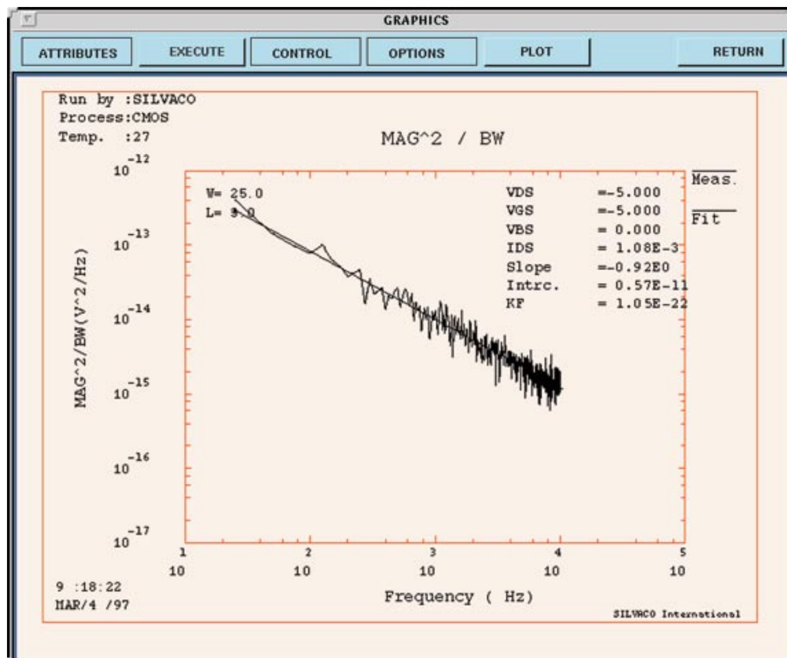
The capability to measure and characterize semiconductor device noise is a fundamental requirement for design.

Noise characterization is also important to monitor semiconductor processes quality.

Silvaco has been offering 1/f noise measurement and SPICE model noise parameters extraction solution for MOS transistors to its customers for several years.



Silvaco noise amplifier.



Single bias point noise measurements data.

This solution consists of:

- S3245A noise amplifier specifically designed for high-performance/high-accuracy MOS transistor 1/f noise measurements.
- UTMOST III software which includes 1/f noise measurement and SPICE models extraction.

Automatic I-V and 1/f noise measurements can be performed on wafer level or on packaged devices. Multiple DC bias points can be specified.

It is possible to setup the bias conditions, measurement frequency range, number of averages and other measurements conditions. These setups can be saved as a file to be used in the future.

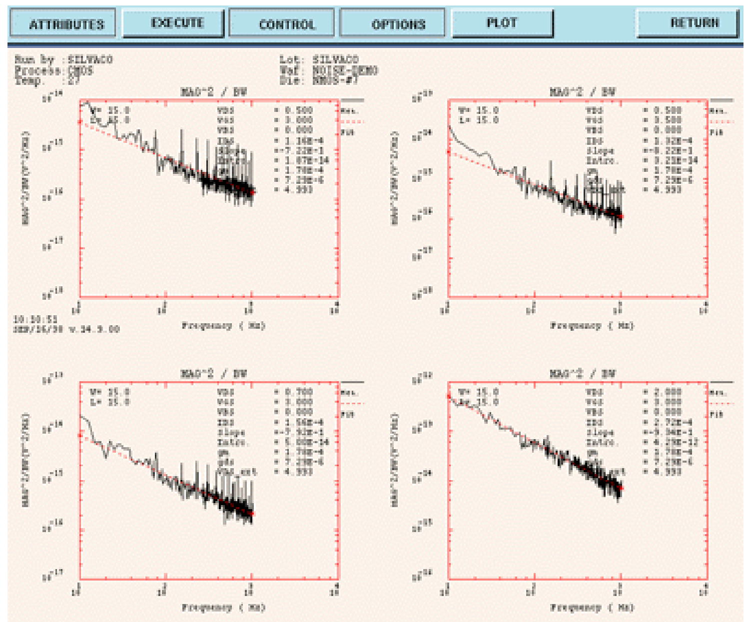
Measurement at multiple bias point within a single measurement session is possible as well.

SPICE parameter extraction is performed by UTMOST by specifying the model type. UTMOST supports SmartSpice and HSPICE noise models NLEV=0,1,2,3 and the physical BSIM3v3 Noise model (Noimod=2).

The NOIMOD=2 model seems to provide better fits (Better than NLEV=2 standard SPICE model) for modeling flicker noise at different DC bias conditions. However the NOIMOD=2 model requires the collection of more data points. In order to find the bias dependency of the model UTMOST III will automatically collect noise data at different DC bias conditions.

The extracted noise parameters are fed back into special NOISE verification circuits and simulated using SmartSpice. This final step completes the verification of the extracted noise parameters.

Existing SPICE models accuracy can be verified as well by simulating noise characteristics.



Multiple bias point noise measurement data.

$$\text{flickernoise}\,(v^2/Hz) = \frac{vt\;q^2\,ids\cdot\mu eff}{f^{EF}\cdot Leff^2\cdot COX\cdot 10^8}\Big[Noia\cdot\log\Big(\frac{N_0+2\cdot 10^{14}}{N_l+2\cdot 10^{14}}\Big) + Noib\cdot(N_0-N_l) + 0.5\cdot Noic\cdot(N_0^2-N_l^2)\Big] + \frac{vt\cdot ids^2\cdot \Delta L_{clm}}{f^{EF}\cdot Leff^2\cdot Weff\cdot 10^8}\cdot\frac{Noia + Noib\cdot N_l + Noic\cdot N_l^2}{(N_l+2\cdot 10^{14})^2}$$

BSIM3 (noimod=2) noise equation implemented in SPICE.

NOISE MEASUREMENT SCREEN

Routine: NOISE | # Of Setups: 1 | Setup: 1

Integ.Time: Short | Pulse Setup | FIT. VARS

Hold Time(ms): 0

Delay Time(ms): 0

MEASUREMENT VARIABLES

#	Variable	Value	#	Variable	Value
1	VDS_start	3	2	VDS_step	0
3	#_of_VDSstep	1	4	VGS_start	3
5	VGS_step	0.5	6	#_of_VGSstep	1
7	VBS	0	8	compl_d,s(A)	0.1
9	compl_g(A)	0.1	10	compl_b(A)	0.1
11	compl_vs(A)	0.1	12	wait	0
13	amp_gain	121	14	IDS_measured	2.7195E-4
15	decade_sweep	0	16	meas_gm	2.0125E-4
17	meas_gds	2.3597E-6	18	vds_ext	5.9874384
19	debias_dc	0	20	R_load	1.1E4
21		0	22		0

QUIT

UTMOST III measurements setup window.

SILVACO

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