An efficient implementation of the ACM MOSFET model in ELDO for VLSI circuit design

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Outline

- Advanced Compact MOSFET (ACM)
- Implementation
- Parameters
- Benchmark tests
- Simulation Time
- Design Example
- Conclusions

Advanced Compact MOSFET

- Charge-based model
- Single-piece expressions with infinite order of continuity for all regions of operation
- Source-drain symmetry of the transistor
- Charge-conserving equations
- Reduced number of parameters
- Developed by Integrated Circuits Laboratory (LCI-UFSC)

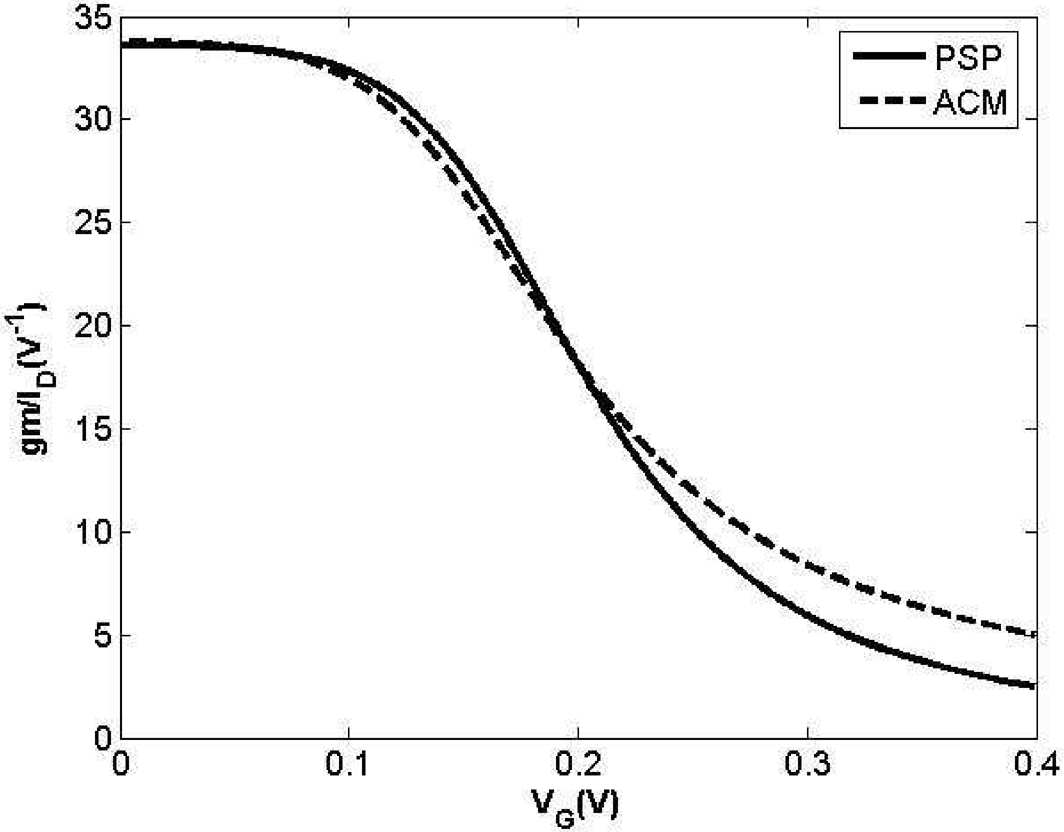
Implementation

- Using the User Definable Model (UDM) tool
- The iterative algorithm used for the numerical calculation of the inversion charge in the UCCM obtains relative errors of less than 10-7.
- The model code was written in C.
- Example.

Parameters

PARAMETERS	DESCRIPTION	UNIT
UO	Carrier mobility	$m^2/V.s$
TOX	Gate oxide thickness	m
VTO	Threshold voltage	V
NA	Acceptor densities	cm^{-3}
PHISO	Surface potential	V
GAMMA	Body effect factor	$V^{0.5}$
LAMBDA	Channel length modulation factor	-
THETA	Mobility reduction factor	1/V
M	Temperature factor	-
VMAX	Velocity saturation	m/s
XJ	Junction depth	m
SIGMA	Drain-induced barrier lowering factor	m^2

Parameter extraction
Threshold Voltage (V_{TO})



For V_{DS}= 1mV

$q'_{ID} \cong q'_{IS}$

$$\frac{g_m}{I_D} \cong \left(\frac{g_m}{I_D}\right)_{max} \frac{1}{\sqrt{1+if}}$$

for if=3

$$\frac{g_m}{I_D} \cong \frac{\left(\frac{g_m}{I_D}\right)_{max}}{2}$$

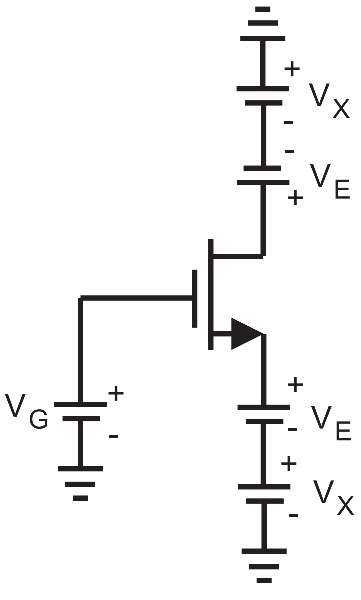
and $V_{TO}=V_G$ =208mV

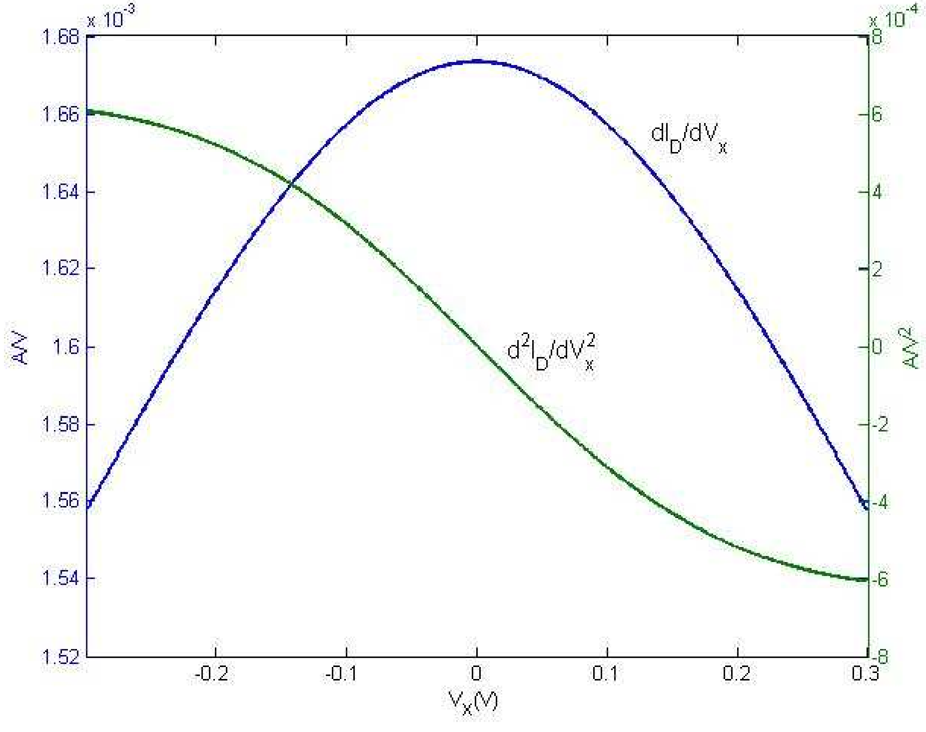
Benckmark Tests

- Gummel Symmetry Test (GST)
- M2M network
- Capacitances

Gummel Symmetry Test (GST)

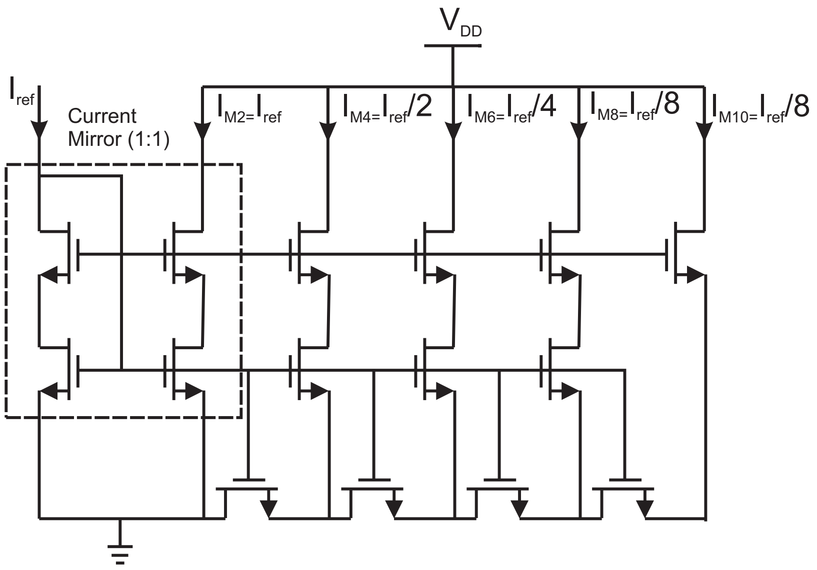
This test is used to show the symmetry of the forward and reverse modes of operation and the continuity, around the origin, of the drain current and charges as well as their derivatives.

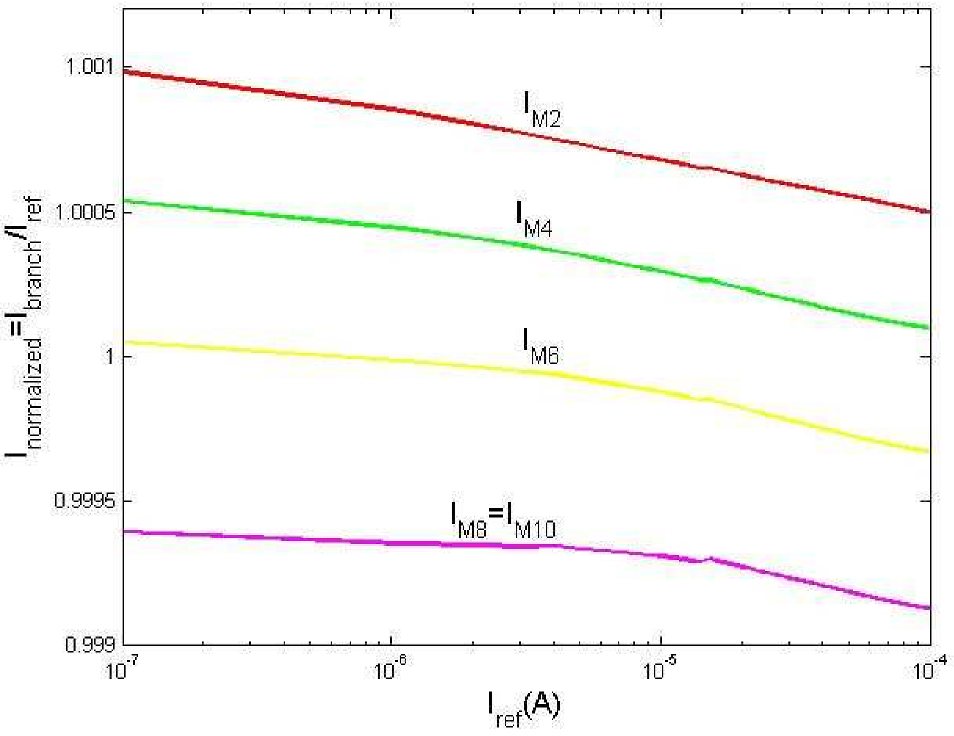




ACM PSP HiSIM

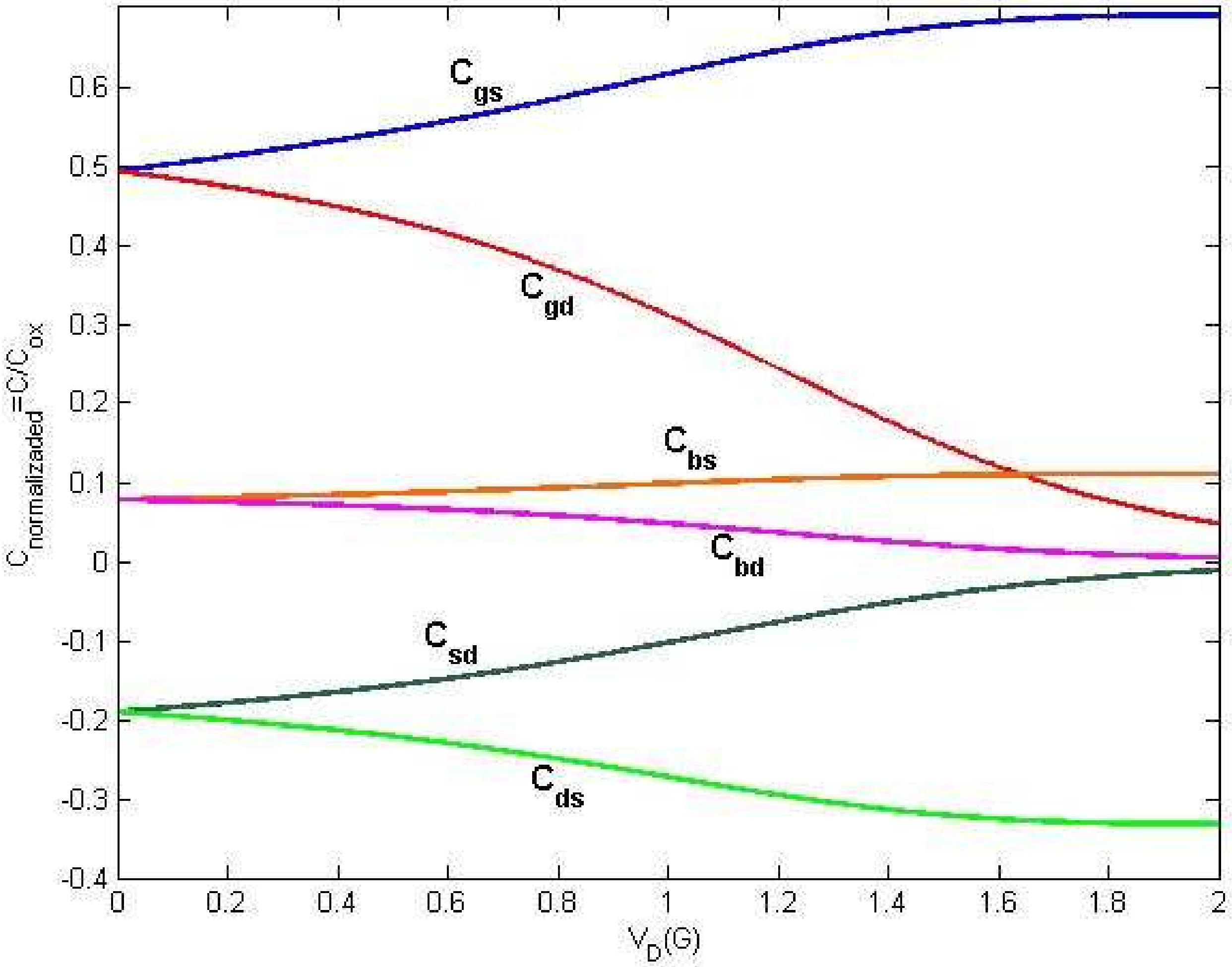
M2M Network





ACM PSP HiSIM

Capacitances



Simulation Time

Normalized simulation times (with respect to ACM_{cap}) using the different models available in ELDO.								
Circuit	**Analysis**	**ACM_{cap}**	**ACM**	**EKV**	**MM11**	**HiSIM**	**PSP**	**BSIM4**
schmitfast	**DC**	**1s580ms**	**1.02**	**0.84**	**2.14**	**1.63**	**1.87**	**1.16**
schmitslow	**DC**	**2s430ms**	**1.00**	**0.70**	**1.75**	**1.60**	**1.93**	**1.28**
g1310	**TRAN**	**640ms**	**0.98**	**0.92**	**1.28**	**1.23**	**1.31**	**1.19**
hussamp	**TRAN**	**3s020ms**	**1.07**	**1.11**	**1.02**	**1.06**	**1.11**	**1.06**
ab_ac	**AC**	**1s400ms**	**1.03**	**1.02**	**2.35**	**1.63**	**1.86**	**1.25**
ab_integer	**TRAN**	**1s370ms**	**1.00**	**0.98**	**1.09**	**1.01**	**1.13**	**0.98**

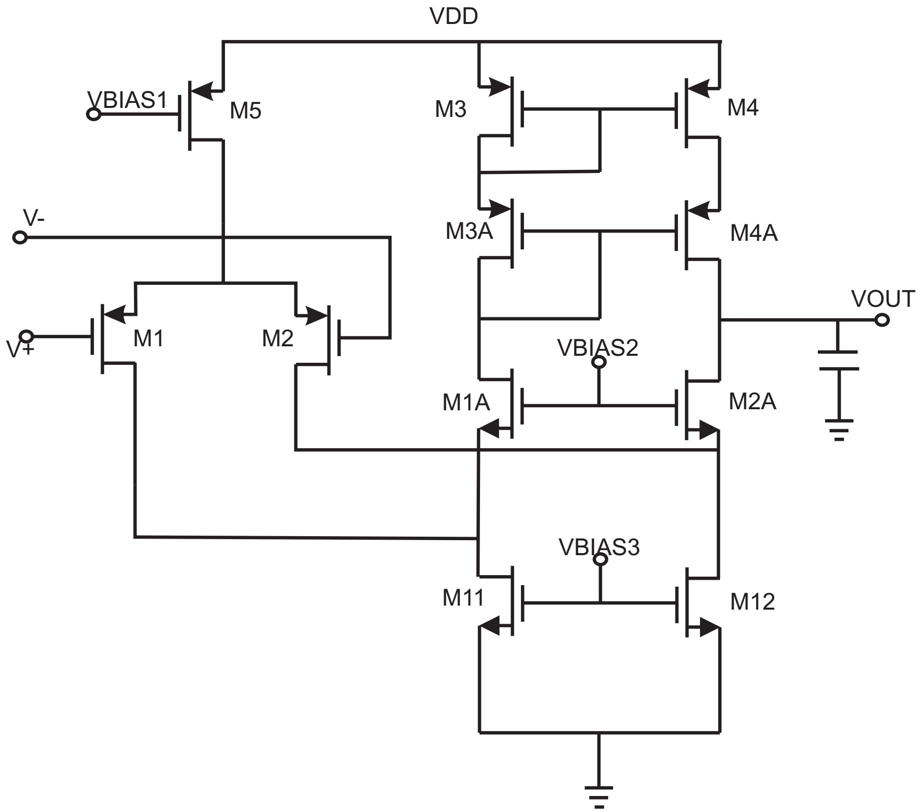
Design Example-I

- Design of a folded cascode amplifier using ACM equations
- Specifications

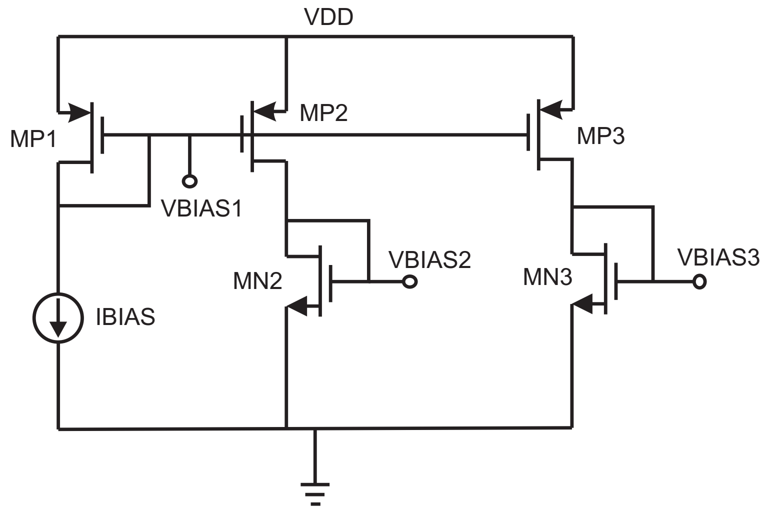
	Spec	**Unit**
GBW	10	MHz
$\mathbf{A_{VO}}$	>100	dB
SR	>4	V/μs
$\mathbf{C_L}$	5	pF

Design Example -II

Folded-cascode op amp



Bias network



Design Example –III Dimensions

Transistor	**L(μm)**	**W(μm)**
M1,M2	0.5	13.5
M11,M12	0.5	27
M3,M4	0.5	13.5
M1A,M2A	0.5	13.5
M3A,M4A	0.5	13.5
M5	0.5	27
MP1,MP2,MP3	0.5	13.5
MN2	2(4x 0.5)	3.5
MN3	0.5	13.5

Design Example –IV
Results

	Spec	**Simulation**	**Unit**
GBW	10	9.77	MHz
$\mathbf{A_{VO}}$	>100	141	dB
SR	>4	5	V/µs

Conclusions

- ACM is a powerful and useful tool for simulation and design because it consists of simple, accurate and single equations together with a small number of physical parameters.

Contacts

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