

Contents

1	Introduction	1
1.1	Motivation	1
1.2	Scaling Fundamentals	3
1.2.1	New Materials: High-k Gate Dielectrics	5
1.2.2	New Device Architectures: Multi-Gate MOSFETs	6
1.2.3	New Device Concepts: Tunneling FETs	8
1.3	Variability from Analog and Mixed-Signal Perspective	9
1.3.1	Systematic Static Variations	9
1.3.2	Static Random Variations—Mismatch	11
1.3.3	Transient Random Variations—Noise	12
1.3.4	Transient Systematic Variations	13
2	Analog Properties of Multi-Gate MOSFETs	15
2.1	Introduction to Recent FinFET Technology	15
2.2	DC Characteristics	16
2.3	Analog and RF Characteristics	18
2.3.1	Small Signal Parameters	19
2.3.2	Noise Performance	21
2.4	Matching Behavior	23
2.5	Charge-Trapping	26
2.6	Self-Heating	29
3	High-k Related Design Issues	33
3.1	Flicker Noise	33
3.1.1	Linear Analog Circuits and Converters	33
3.1.2	Voltage Controlled Oscillator	34
3.1.3	Flicker Noise Reduction Techniques	35
3.2	Transient V_T Variations and Hysteresis Effects	37
3.2.1	Linear and Continuous Time Building Blocks	37
3.2.2	Non-Linear and Discrete Time Building Blocks	39
3.2.3	Flash ADC	46
3.2.4	Successive Approximation ADC	47
3.2.5	$\Sigma\Delta$ ADC	53
3.2.6	Conclusions on Transient V_T Shift	55

4	Multi-Gate Related Design Aspects	57
4.1	Biasing Circuits	57
4.1.1	Matching Optimized Current Mirrors	57
4.1.2	Current Reference Circuits	60
4.2	Operational Amplifiers	64
4.2.1	Gain-Bandwidth-Power Trade-off	65
4.2.2	Design Example	67
4.2.3	Common Mode and Power Supply Rejection Ratio	68
4.3	Bandgap Reference Circuits	69
4.3.1	Gated p-i-n Diodes	70
4.3.2	Low Voltage Bandgap Reference	72
4.3.3	Design Considerations	74
4.3.4	Measurement Results	77
4.4	D/A Converter	79
4.4.1	Design Considerations	80
4.4.2	Measurement Results	81
4.5	Phase-Locked-Loop Circuit	84
4.5.1	Design Considerations	84
4.5.2	Measurement Results	86
4.6	RF Building Blocks	88
4.6.1	LC-VCO	88
4.6.2	LNA	90
4.7	Self-Heating	91
4.7.1	Thermal Coupling	92
4.7.2	Transient Thermal Mismatch	93
4.7.3	Linear and Continuous Time Circuits	93
4.7.4	Non-Linear and Discrete Time Circuits	94
4.8	Selective Fin Width Tuning	95
4.8.1	Self Cascode	96
4.8.2	VIP3 Enhancement	97
5	Multi-Gate Tunneling FETs	99
5.1	Principle of Operation and Implementation of MuGTFETs	99
5.2	Measurement Results	100
5.2.1	I–V Characteristics	100
5.2.2	Digital and Analog Performance	102
5.2.3	Temperature Characteristics	103
5.2.4	Variations	104
5.3	Device Simulation	105
5.4	MuGTFET Reference Circuit	107
6	Conclusions and Outlook	111
	Symbols and Abbreviations	115
	References	119



<http://www.springer.com/978-90-481-3279-9>

Variation Aware Analog and Mixed-Signal Circuit Design
in Emerging Multi-Gate CMOS Technologies

Fulde, M.

2010, X, 127 p., Hardcover

ISBN: 978-90-481-3279-9