

ANALOG/ MIXED-SIGNAL INTEGRATION TRENDS AND OPPORTUNITIES

**How STM, TI, ADI, National, Maxim, and Linear Leverage
Mixed-Signal and Analog Technologies**

TABLE OF CONTENTS

1.	INTRODUCTION.....	1-1
1.1.	ABOUT US	1-1
1.1.1.	Why Should You Engage Our Services.....	1-1
1.1.2.	Our Primary Research and Sources.....	1-2
	1.1.2.1 Our Information Acquisition and Analysis Process.....	1-3
1.1.3.	Relationship and Benefits	1-3
1.1.4.	Client Confidentiality Is Our Foremost Commitment	1-4
1.1.5.	This Report—Examples of Follow-up Engagements.....	1-5
1.2.	OTHER EXECUTIVE REPORTS AND STUDIES: AVAILABLE NOW OR IN DEVELOPMENT.....	1-6
1.2.1.	The 2003 Study of IBM Semiconductor Capabilities and Strategy.....	1-7
1.2.2.	Sony Electronics Inc.—How Sony Markets, Sells, Services, and Develops in the U.S.	1-8
1.2.3.	The 2003 Executive Guide to Deep Submicron Lithography	1-9
	1.2.3.1 Study Scope.....	1-10
1.2.4.	The 2003 Executive Guide to Interconnect Technology.....	1-11
	1.2.4.1 Study Scope.....	1-13
1.2.5.	The 2003 Executive Guide to IC Design Factory	1-14
	1.2.5.1 Study Scope.....	1-15
2.	REPORT SCOPE AND TERMS OF USE.....	2-1
2.1.	REPORT SCOPE.....	2-1
2.2.	METHODOLOGY USED—PRIMARY SOURCES.....	2-18
2-3.	TERMS OF PETROV GROUP LICENSE AGREEMENT	2-19
	2.3.1. License.....	2-20
	2.3.2. Term.....	2-20
	2.3.3. Limited warranty.....	2-20
	2.3.4. General	2-21
3.	EXECUTIVE SUMMARY	3-1
4.	ANALOG COMPETENCY: THE KEY COMPETITIVE ADVANTAGE IN THE POST-PC AGE.....	4-1
4.1.	INTRODUCTION.....	4-1
	4.1.1. Analog Components	4-4
	4.1.2. Digital Components.....	4-6
4.2.	KEY CHARACTERISTICS OF ANALOG, MIXED-SIGNAL AND DIGITAL COMPONENTS.....	4-6
	4.2.1. Analog Components—Nature and Implications.....	4-8
	4.2.2. Digital Components—Nature and Implications.....	4-9
	4.2.3. System-Board—An Analog Sea With Few Digital Islands.....	4-12
	4.2.4. Primary Roles of Analog and Digital Components	4-13
	4.2.5. Mixed-Signal Component Challenges	4-14
	4.2.6. The Three Major Segments of Mixed-Signal Components	4-15
	4.2.7. Integration of Passive and Discrete Components	4-16

4.3.	THE PRIMARY DRIVERS OF THE ANALOG AND MIXED-SIGNAL BUSINESS	4-16
4.3.1.	How to Make Consumer Electronics More Profitable	4-16
4.3.2.	The Analog Color of Wireless Communications	4-18
4.3.3.	Power Management Opportunity	4-20
5.	SOLUTIONS-FACTOR (S-FACTOR™)	5-1
5.1.	END-SYSTEM SOLUTIONS-FACTOR™: THE KEY METRIC FOR THE ANALOG/MIXED-SIGNAL BUSINESS LEVERAGE.....	5-1
5.1.1.	Strategies To Achieve Large S-Factors™	5-4
5.2.	END-SYSTEM SPECIFIC PLATFORMS	5-7
5.3.	S-FACTOR™ IMPLICATIONS—A SUMMARY	5-10
5.3.1.	Microchip S-factor™ Example	5-12
6.	CONSUMER AND WIRELESS: ANALOG/MIXED-SIGNAL GROWTH DRIVERS	6-1
6.1.	INTRODUCTION.....	6-1
6.1.1.	Key Personalization Requirements of Consumer Electronics Products.....	6-1
6.1.2.	The Main Common Feature of Consumer Electronics	6-2
6.1.1.	The Pareto Rule Extended to Consumer Electronics Components	6-2
6.2.	ANATOMY OF CONSUMER ELECTRONICS PRODUCTS	6-3
6.2.1.	Two Sides of a Winning Consumer Product.....	6-3
6.2.2.	Three Integrated Strategies of Consumer Electronics Products	6-5
6.2.3.	Growing Number of Analog Components in Consumer Electronics	6-5
6.2.4.	Two Technology-Based Strategies to Add Value to a Digital Component	6-8
6.2.5.	Key Attributes of Active Analog Components.....	6-11
6.2.6.	Analog and Mixed-Signal Competence Is Becoming a Mandatory Requirement	6-12
6.2.7.	DNA of Consumer Electronics Products and Brand Management Implications	6-14
6.3.	THREE PROFIT AND REVENUE PILLARS OF CONSUMER ELECTRONICS PRODUCTS	6-15
6.4.	IMPLICATIONS FOR MIXED-SIGNAL INTEGRATION STRATEGY	6-18
7.	END-SYSTEM BOARD DESIGN AND INTEGRATION TRENDS.....	7-1
7.1.	INTRODUCTION.....	7-1
7.1.1.	Digital Consumer Electronics Systems—A Misnomer.....	7-2
7.1.2.	Two Key Design and Integration Trends on the System Board	7-3
7.2.	SYSTEM BOARD ENVIRONMENT PERSPECTIVE.....	7-5
7.2.1.	Digital CMOS Process As A Natural Enemy Of Analog Design And Fabrication.....	7-6
7.2.2.	End-System Trends Are Detrimental To Analog Board Environment	7-8
7.2.3.	Analog Design Is Know-how Based Versus Automation Based Digital Design	7-9
7.2.4.	Different End-Systems And Applications Require Dedicated Solutions	7-10
8.	LITHOGRAPHY IMPACT: ISSUES AND OPPORTUNITIES	8-1
8.1.	INTRODUCTION.....	8-1
8.1.1.	Vendor-Specific Design Approaches	8-2
8.2.	LITHOGRAPHY SCALING AND ANALOG DESIGN	8-3
8.2.1.	Lower Operating Supply Voltages	8-5
8.2.2.	Reduced Lithography Features	8-6
8.2.3.	Higher Wafer Processing Cost	8-7
8.2.4.	New Circuit Architectures	8-7

8.2.5.	Approaches to Reduce Lithography Impact on Analog Design.....	8-8
8.3.	ANALOG/MIXED-SIGNAL PRODUCT TYPES BY LITHOGRAPHY.....	8-10
8.3.1.	Significant Lag in Lithography Requirements.....	8-12
8.3.2.	Impact of Voltage in the 0.5 μ to 0.1 μ Lithography Region.....	8-12
8.3.3.	Analog/Mixed-Signal Process Types.....	8-15
8.3.4.	IC Vendor Design and Implementation Approaches Are Different and Unique.....	8-16
9.	ANALOG-DIGITAL SPECTRUM MODEL: A BUSINESS DECISION-MAKING TOOL.....	9-1
9.1	SEGMENTATION OF ANALOG-DIGITAL SPECTRUM.....	9-3
9.1.1.	System Board Perspective—Component’s Role.....	9-3
9.1.2.	Misclassification in Market Data and Statistics.....	9-5
9.1.3.	Component Perspective—Component’s Relationships.....	9-6
9.1.4.	Mixed-Signal Designs as Analog Designs.....	9-7
9.1.5.	Mixed-Signal Component Processing Requirements.....	9-8
9.2.	KEY VARIABLES OF ANALOG-DIGITAL SPECTRUM MODEL.....	9-9
9.3.	HOW TO USE ANALOG-DIGITAL SPECTRUM MODEL AS A DECISION-MAKING TOOL.....	9-13
10.	KEY VARIABLES OF A-D SPECTRUM MODEL.....	10-1
10.1.	COMPONENT VENDOR POSITIONING.....	10-1
10.1.1.	Category One: Companies Originating in the Analog Part of the Spectrum....	10-1
10.1.2.	Category Two: Companies Originating in the Digital Part of the Spectrum.....	10-7
10.1.3.	Category Three: Large IC Vendors Which Have Selectively Extended into the Analog Direction.....	10-8
10.2.	CAPITAL AND KNOWLEDGE BASE REQUIREMENTS.....	10-9
10.3.	LINKAGE OF APPLICATION, DESIGN AND PROCESS TECHNOLOGY.....	10-10
10.4.	LEVERAGE OF ANALOG DESIGN KNOW-HOW.....	10-11
10.5.	TECHNOLOGY KNOW-HOW RESOURCES AND APPROACHES.....	10-11
10.6.	ANALOG PERFORMANCE.....	10-12
10.7.	DESIGN ENVIRONMENT AND DESIGN PROCESS.....	10-14
10.7.1.	Vertical Versus Horizontal Design Process.....	10-15
10.8.	DESIGN AUTOMATION.....	10-18
10.8.1.	No Substitute for Human Expertise In Analog and Mixed-Signal Design In Foreseeable Future.....	10-19
10.9.	LITHOGRAPHY GAP.....	10-21
10.10.	PROCESS TECHNOLOGIES.....	10-22
10.10.1.	Analog-enhanced Digital Process Platforms.....	10-22
10.10.2.	Digital-enhanced Analog Processes.....	10-23
10.11.	IC INTEGRATION STRATEGY.....	10-24
10.11.1.	Horizontal Versus Vertical Functional Integration.....	10-25
10.11.2.	Are You Implementing A Well-Defined Mixed-Signal/Analog Strategy Today?.....	10-26
10.11.3.	The Key Barrier To Mixed-Signal Integration.....	10-27
10.12.	SYSTEM-ON-CHIP (SOC) INTEGRATION OPPORTUNITIES.....	10-28
10.12.1.	The Age Of Mixed-Signal SoC (MSoC™).....	10-29
10.13.	NEW PRODUCT INTRODUCTIONS.....	10-31
10.14.	PRODUCT LIFE CYCLE.....	10-32

10.14.1.	Mixed-Signal Products and the Leverage of Analog Knowledge Base	10-32
10.15.	SECOND-SOURCING OF PRODUCTS.....	10-34
10.16.	OUTSOURCING OF MANUFACTURING	10-34
10.17.	MARKET APPROACHES AND CHANNELS.....	10-36
10.17.1.	Implications Of Analog Market Microsegmentation	10-36
10.17.2.	The Role Of Distribution Channels	10-37
10.18.	PR AND MEDIA MARKETING COVERAGE OBJECTIVES.....	10-39
10.19.	COMPONENT BRANDING OPPORTUNITIES	10-41
11.	ANALOG/MIXED-SIGNAL INTEGRATION STRATEGY BLUEPRINT.....	11-1
11.1.	INTRODUCTION.....	11-1
11.1.1	How To Determine Business Position in A-D Spectrum.....	11-3
11.2.	BLUEPRINT FOR MIXED-SIGNAL AND ANALOG STRATEGY	11-5
11.2.1.	A Tight Linkage of the Analog Design Environment.....	11-5
11.2.2.	The Four-step Analog/Mixed-Signal Technology Build-up	11-5
11.2.3.	Profit-driven Business Model	11-8
11.2.4.	Common Product Strategy Approach	11-12
11.2.5.	Specific Business Objectives and Roles of Analog Products.....	11-14
11.2.6.	Leverage of Capital and Knowledge Resources Across the Entire System-Level Silicon (Integration Wheel) TM	12-15
11.3.	FOUNDRIES' PERSPECTIVE AND STRATEGIES IN THE ANALOG-DIGITAL SPECTRUM.....	11-18
12.	COMPARATIVE OVERVIEW OF THE LEADING ANALOG VENDORS.....	12-1
12.1.	INTRODUCTION.....	12-1
12.2.	LINEAR TECHNOLOGY	12-3
12.3.	MAXIM INTEGRATED PRODUCTS (WITH DALLAS SEMICONDUCTOR).....	12-3
12.4.	ANALOG DEVICES (ADI).....	12-4
12.5.	NATIONAL SEMICONDUCTOR.....	12-5
12.6.	TEXAS INSTRUMENTS (TI).....	12-7
12.7.	STMICROELECTRONICS (STM).....	12-8
12.8.	FOUR KEY FINDINGS.....	12-10
13.	CASE STUDY: LINEAR TECHNOLOGY.....	13-1
13.1.	INTRODUCTION.....	13-1
13.2.	PRODUCT LINE OVERVIEW WITH EMPHASIS ON NEW PRODUCTS.....	13-2
13.3.	PROCESS TECHNOLOGIES OVERVIEW	13-5
13.4.	DEPLOYMENT OF PRODUCTS AND PROCESSES.....	13-6
13.5.	ROLE OF FOUNDRY AND PARTNERS	13-8
13.6.	KEY AREAS OF R&D EXPENDITURES	13-9

14. CASE STUDY: MAXIM INTEGRATED PRODUCTS.....	14-1
14.1. INTRODUCTION.....	14-1
14.2. PRODUCT LINE ANALYSIS WITH EMPHASIS ON NEW PRODUCTS.....	14-2
14.2.1. Product Portfolio Expansion Trends	14-3
14.2.2. Ten Major New Product Categories.....	14-3
14.2.3. Major Baseline Product Categories	14-6
14.2.4. Five Major Mixed-Signal Product Categories	14-7
14.2.5. Maxim Product Category Summary.....	14-7
14.2.6. Product Introduction Trends In Baseline Categories.....	14-8
14.3. PROCESS TECHNOLOGIES OVERVIEW	14-10
14.3.1. Wafer Manufacturing Facilities	14-10
14.3.2. Wafer Processing Technologies	14-11
14.3.3. Key Findings on Maxim Fabrication Processes.....	14-15
14.4. DEPLOYMENT OF PRODUCTS AND PROCESSES	14-16
14.4.1. Product Families with a Large Number of Products	14-16
14.4.2. Product Categories Using Submicron Processes.....	14-18
14.5. ROLE OF FOUNDRY AND PARTNERS	14-22
14.6. KEY AREAS OF R & D EXPENDITURES	14-23
15. CASE STUDY: ANALOG DEVICES (ADI).....	15-1
15.1. INTRODUCTION.....	15-1
15.2. ADI'S STRATEGY TO DOMINATE CORE A/M-S FUNCTIONALITY	15-3
15.3. PRODUCT LINE OVERVIEW WITH EMPHASIS ON NEW PRODUCTS.....	15-5
15.3.1. Generic (Standard) Products	15-5
15.3.2. Application-Oriented (Differentiated) Products	15-6
15.4. OVERVIEW OF PROCESS TECHNOLOGIES	15-9
15.5. DEPLOYMENT OF PRODUCTS AND PROCESSES	15-11
15.5.1. 0.25 μ CMOS (Digital).....	15-11
15.5.2. 0.35 μ CMOS (Digital).....	15-12
15.5.3. 0.5 μ CMOS (Analog).....	15-13
15.5.4. 0.6 μ CMOS (Analog).....	15-13
15.5.5. 0.8 μ CMOS (Analog).....	15-14
15.5.6. 0.6 μ BiCMOS	15-15
15.5.7. Summary of Product Deployment in Submicron Processes.....	15-15
15.5.8. Product Distribution By Process Type	15-16
15.6. ROLE OF FOUNDRY AND PARTNERS	15-17
15.7. KEY AREAS OF R&D EXPENDITURES	15-19
16. CASE STUDY: NATIONAL SEMICONDUCTOR.....	16-1
16.1. INTRODUCTION.....	16-1
16.1.1. Recent Announcement Has Major Potential Without Any Near-Term Material Effect.....	16-1
16.2. PRODUCT LINE OVERVIEW WITH EMPHASIS N NEW PRODUCTS.....	16-4
16.3. PROCESS TECHNOLOGIES OVERVIEW	16-7
16.4. DEPLOYMENT OF PRODUCTS AND PROCESSES	16-11
16.5. ROLE OF FOUNDRY AND PARTNERS	16-12
16.6. KEY AREAS OF R&D EXPENDITURES	16-12

17. CASE STUDY: TEXAS INSTRUMENTS (TI)	17-1
17.1. INTRODUCTION.....	17-1
17.1.1. In 1997 The CEO Initiated TI's Strategic Repositioning	17-3
17.1.2. TI's Net and The Four Pillars of TI's A/M-S Component Business.....	17-3
17.2. PRODUCT LINE OVERVIEW WITH EMPHASIS ON NEW PRODUCTS	17-10
17.3. PROCESS TECHNOLOGIES OVERVIEW	17-13
17.4. DEPLOYMENT OF PRODUCTS AND PROCESSES	17-17
17.5. ROLE OF FOUNDRY AND PARTNERS	17-18
17.6. KEY AREAS OF R&D EXPENDITURES	17-20
18. CASE STUDY: STMICROELECTRONICS	18-1
18.1. INTRODUCTION.....	18-1
18.2. PRODUCT LINE OVERVIEW WITH EMPHASIS ON NEW PRODUCTS	18-11
18.2.1. Major Generic Analog and Mixed-Signal Product Categories	18-12
18.2.2. Major Dedicated Analog and Mixed-Signal Product Categories	18-14
18.3. PROCESS TECHNOLOGIES OVERVIEW	18-17
18.4. DEPLOYMENT OF PRODUCTS AND PROCESSES	18-25
18.5. ROLE OF FOUNDRY AND PARTNERS	18-28
18.6. KEY AREAS OF R & D EXPENDITURES	18-31

ANALOG/ MIXED-SIGNAL INTEGRATION TRENDS AND OPPORTUNITIES

**How STM, TI, ADI, National, Maxim, and Linear Leverage
Mixed-Signal and Analog Technologies**

LIST OF FIGURES

2-1	The 2003 Mixed-Signal Integration Report Scope.....	2-2
4-1	Two Evolution Paths of the Semiconductor Industry	4-2
4-2	Post-PC Semiconductor Competitive Repositioning	4-3
4-3	Digital Chip Costs and Prices	4-6
4-4	Different Natures of Analog and Digital Components.....	4-7
4-5	How to Increase the Profitability of Digital ICs.....	4-19
4-5	RF System Board Solution/Platform	4-21
5-1	End-System Solution-Factor (S-Factor™): Metric of Revenue, Profit, and Unit Volume Leverage	5-2
5-2	IBM ME Semiconductor Foundry Shift.....	5-4
5-3	S-Factor™ Leverage of End-System Platform	5-10

6-1	From Technology to Consumer Dreams.....	6-4
6-2	Two Faces of Sony—Top View.....	6-6
6-3	Integrated Approach to Consumer Electronics Products Branding and Development.....	6-7
6-4	Two Technology-Based Strategies to Add Value to a Digital Component	6-9
6-5	DNA of Consumer Electronics Products	6-13
6-6	Three Profit Pillars of Consumer Electronics Products: Sony Case.....	6-17
7-1	Analog/Mixed-Signal Products Deployment Trends	7-4
8-1	Lithography Scaling Impact on Analog Product Performance	8-4
8-2	Analog/Mixed-Signal Product Types by Lithography Feature Sizes	8-11
9-1	Analog-Digital Components/Technologies Spectrum	9-2
9-2	Analog-Digital Spectrum Model	9-11
9-3	Business Decision-Making Matrix for Mixed-Signal Integration.....	9-14, 9-19
10-1	Positioning of the Leading Analog/Mixed-Signal Vendors	10-2
10-2	Analog Versus Digital Design Process Differences.....	10-17
10-3	System-Level Integration Options.....	10-29
11-1	The End-Systems Solution Product.....	11-10
11-2	Silicon Integration Wheel™	11-15
11-3	Foundries' Strategies in the Analog-Digital Spectrum	11-17
12-1	Positioning of the Leading A/M-S Vendors	12-3
12-2	Comparison of Analog/Mixed-Signal Business & Technology: Metrics for the Leading Vendors	12-4
13-1	Linear Technology Product Portfolio Overview.....	13-3
14-1	Maxim Product Categories with Largest Number of Products.....	14-18
15-1	Overview of ADI Products versus Process Type and Lithography.....	15-18
16-1	National Semiconductor—Analog/Mixed-Signal Products Overview	16-6, 16-7
16-2	National Semiconductor—Analog, BiCMOS and CMOS Platform Processes	16-9, 16-10
17-1	The Battle for the Analog-Digital Spectrum	17-2
17-2	TI End-Systems Driven Product Portfolio—1998.....	17-3
17-3	TI Product Portfolio Overview (\$7B+)—1998	17-4
17-4	TI's Product End-System and Product Business Unit Matrix—1998	17-5
18-1	ST Three-Tiered Process Technologies	18-4
18-2	STMicroelectronics Process Technologies Framework and Product Deployment.....	18-5
18-3	STM Organizational Structure Mirrors Its Product Coverage of the A-D Spectrum	18-8
18-4	FY 2001 Revenue Breakdown Estimate.....	18-15
18-5	STM Core Process Technology Competencies.....	18-17
18-6	STMicroelectronics Analog/Mixed-Signal Processes (sub-0.6μ Lithography).....	18-19