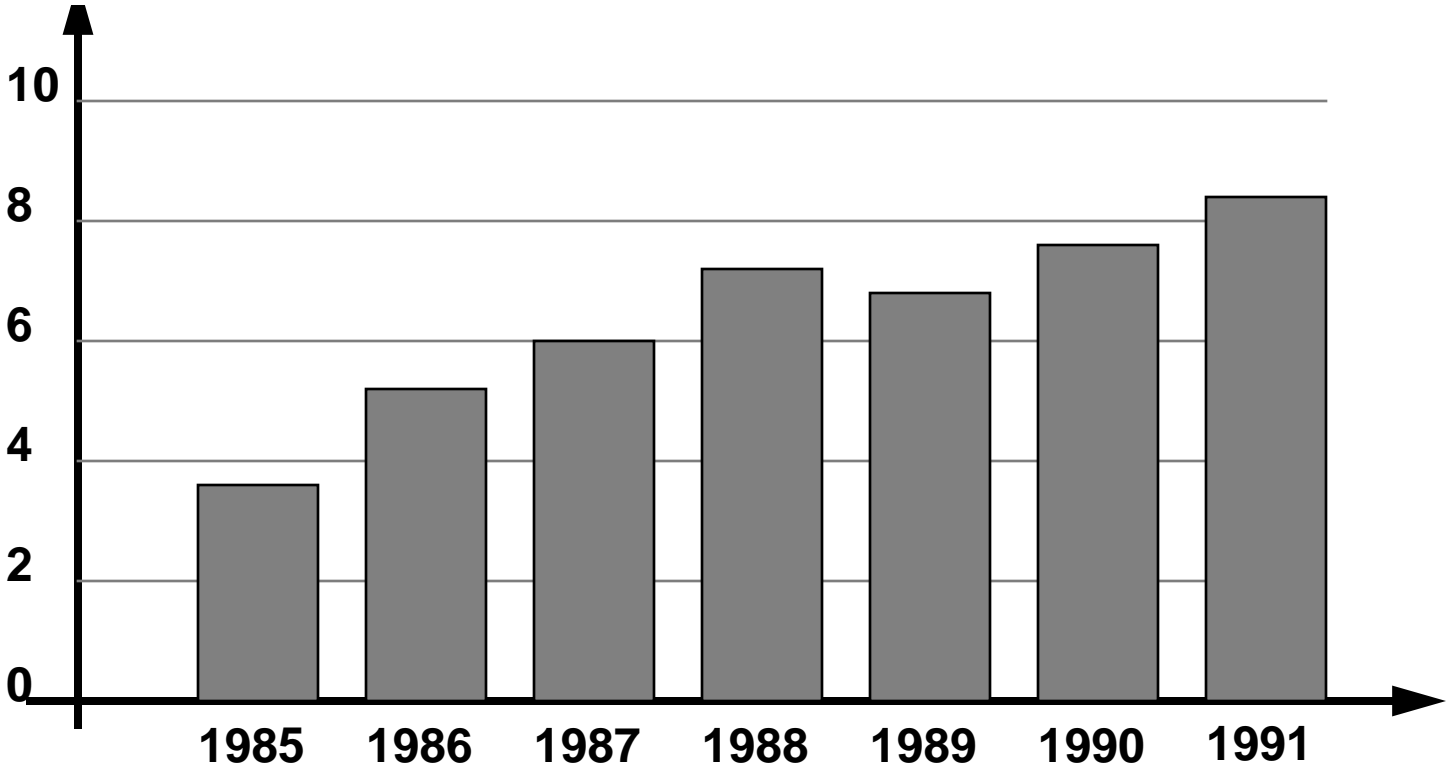


Possible Analog IC Scenarios for the 90s

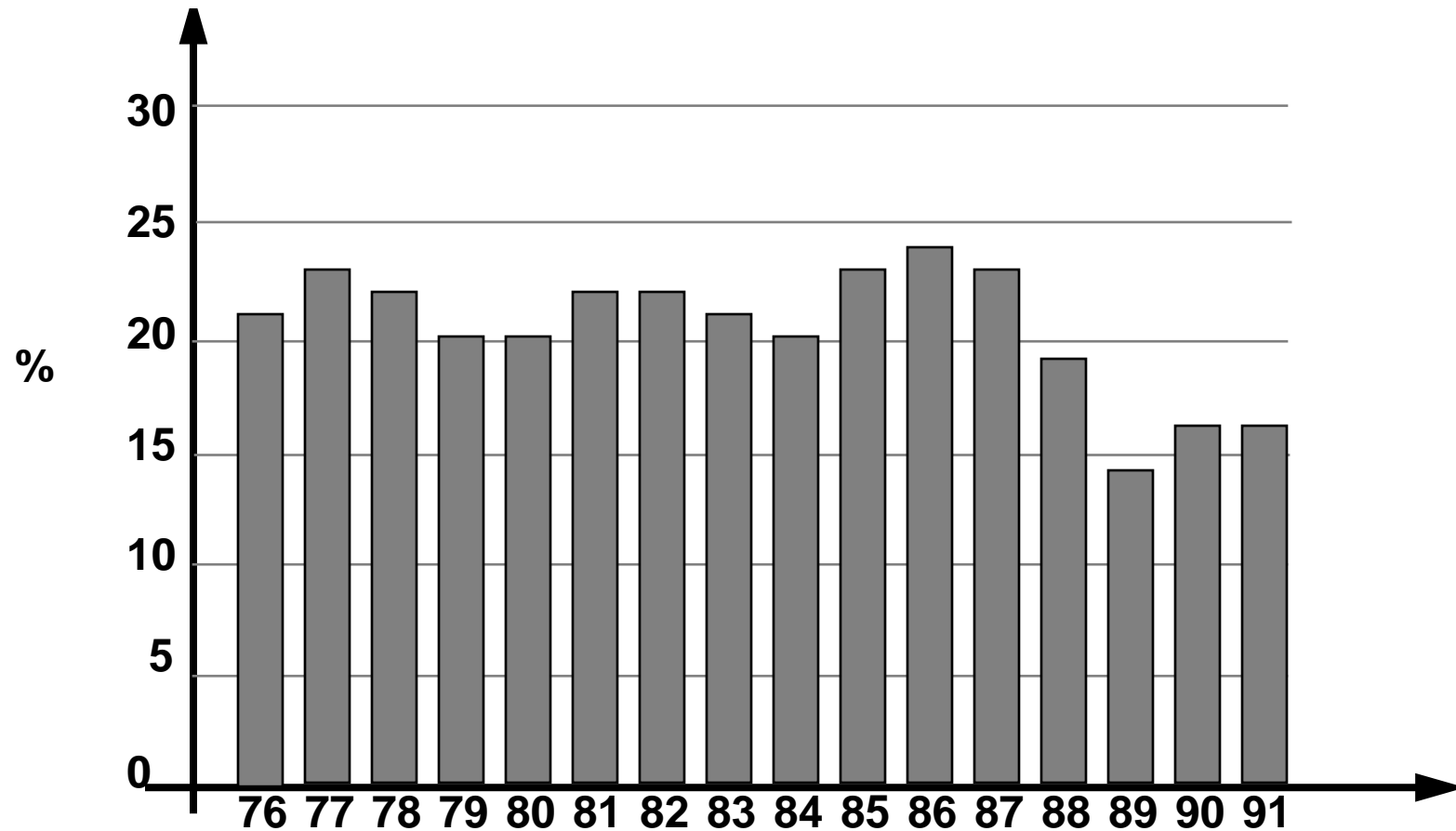
- **Analog Will Die as an IC Implementation Methodology, Digital will take Over**
- **Mixed Signal ASICs will Displace Analog Building Block ICs**
- **The Pace of Analog IC Innovation will Slow- All the Good Ideas Have Been Thought Of**
- **Analog Design Skills will Become Obsolete**

Worldwide Analog IC Market Size (\$Billions)



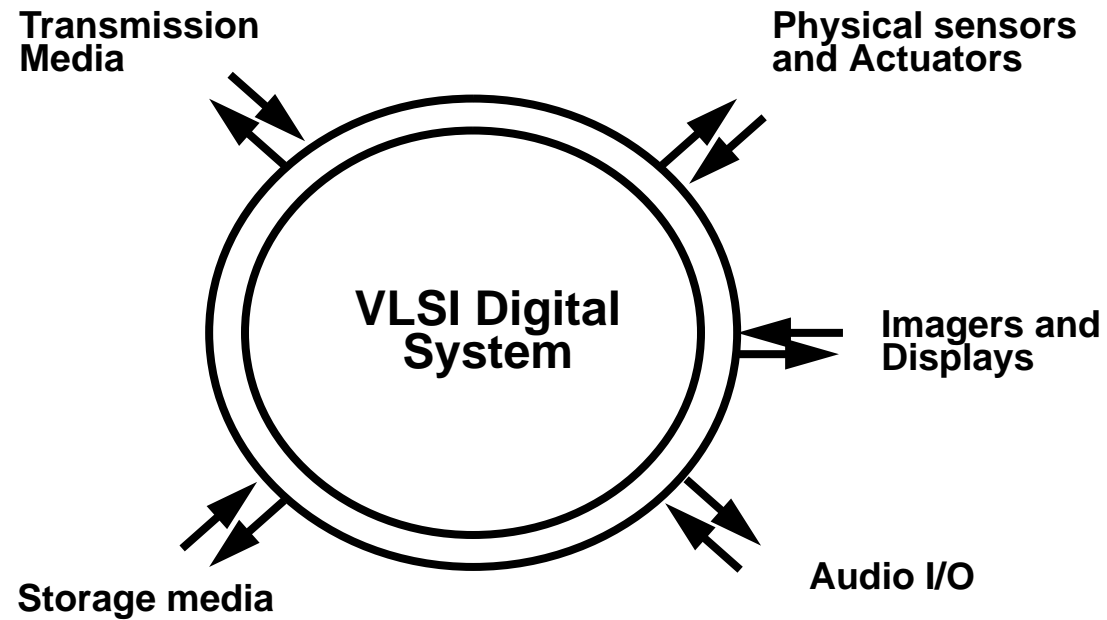
Source: SIA

Analog IC Sales as % of Total IC Sales



Source: SIA

Role of Analog Interfaces in VLSI Digital Systems



Possible Analog IC Scenarios for the 90s

- **Analog Will Die as an IC Implementation Methodology, Digital will take Over**

Key Mission in the 90s is utilization of scaled VLSI technologies to drive down the cost of A/D interface functions through higher levels of integration

SIA Technology Roadmap for the 90s:

SIA Workshop Report, 1993

	1992	1995	1998	2001	2004	2007
Feature size, micron	0.5	0.35	0.25	0.18	0.12	0.10
Wafer diam, mm	200	200	300	300	300	400
Pwr Supply Voltage	5	3.3	2.2	2.2	1.5	1.5
Max on-chip clock	120	200	350	500	700	1000

Grand Challenge for Mixed-Signal ICs in the next Decade:

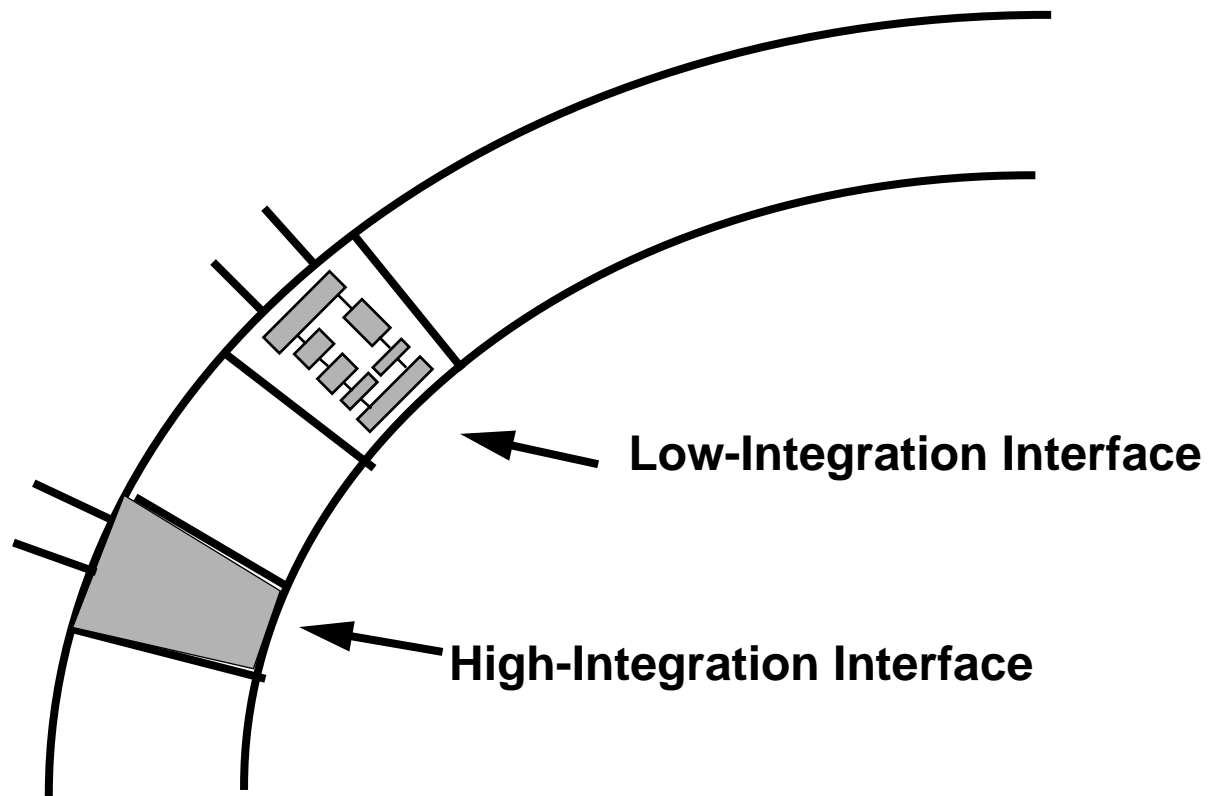
Utilize upcoming scaled VLSI technologies to continue to increase integration levels in systems containing analog-digital interfaces

- **1.5 Volt Power Supply**
- **90% or more digital functionality- hostile noise environment**
- **Power often critical**
- **Bandwidths \gg 100Mhz**
- **Resolutions/SNR to 16 bits**
- **Minimum burden on digital process cost and defect density**
- **Minimum test cost increment**
- **Minimum design time and risk increment**

Possible Analog IC Scenarios for the 90s

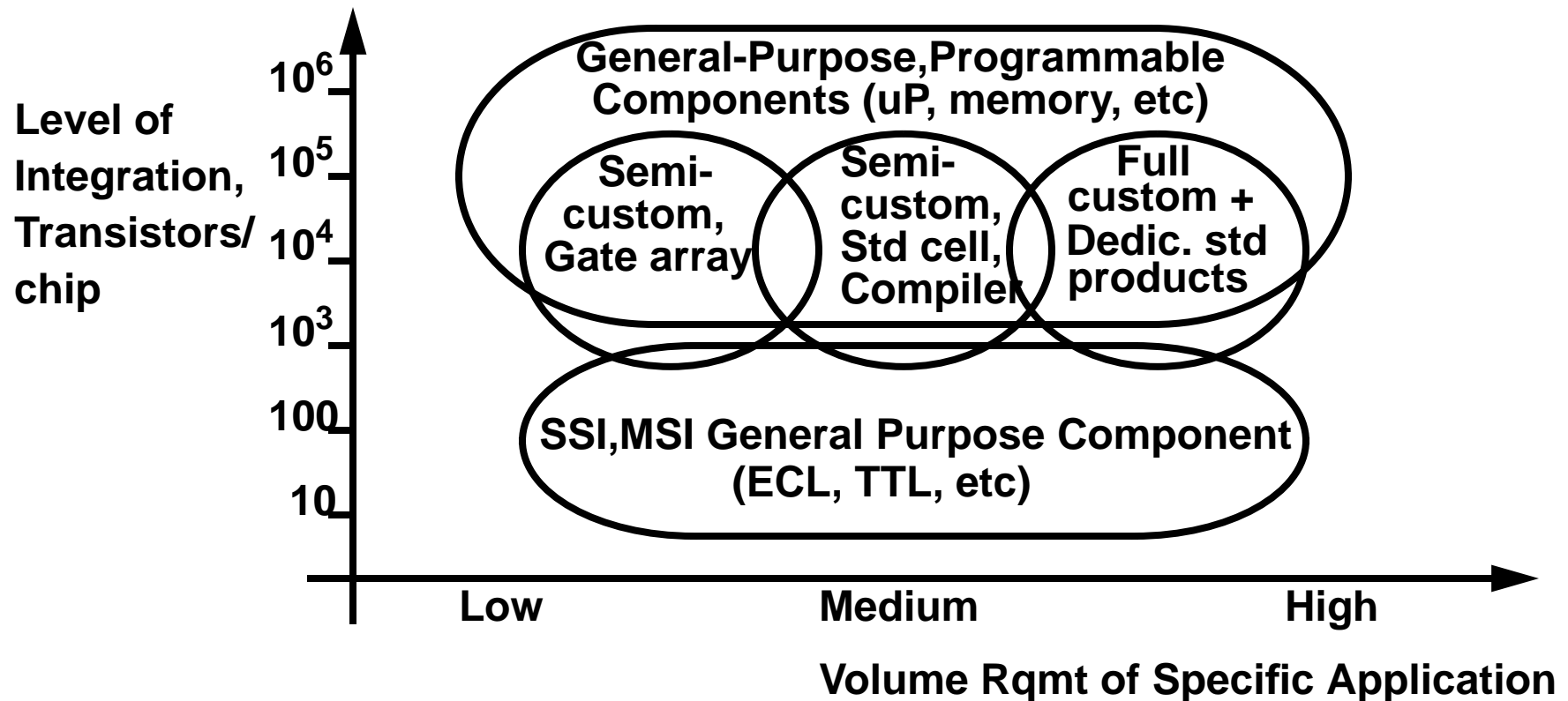
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High vs Low Integration level in A/D Interface Systems



An Implementation Methodology Viewpoint

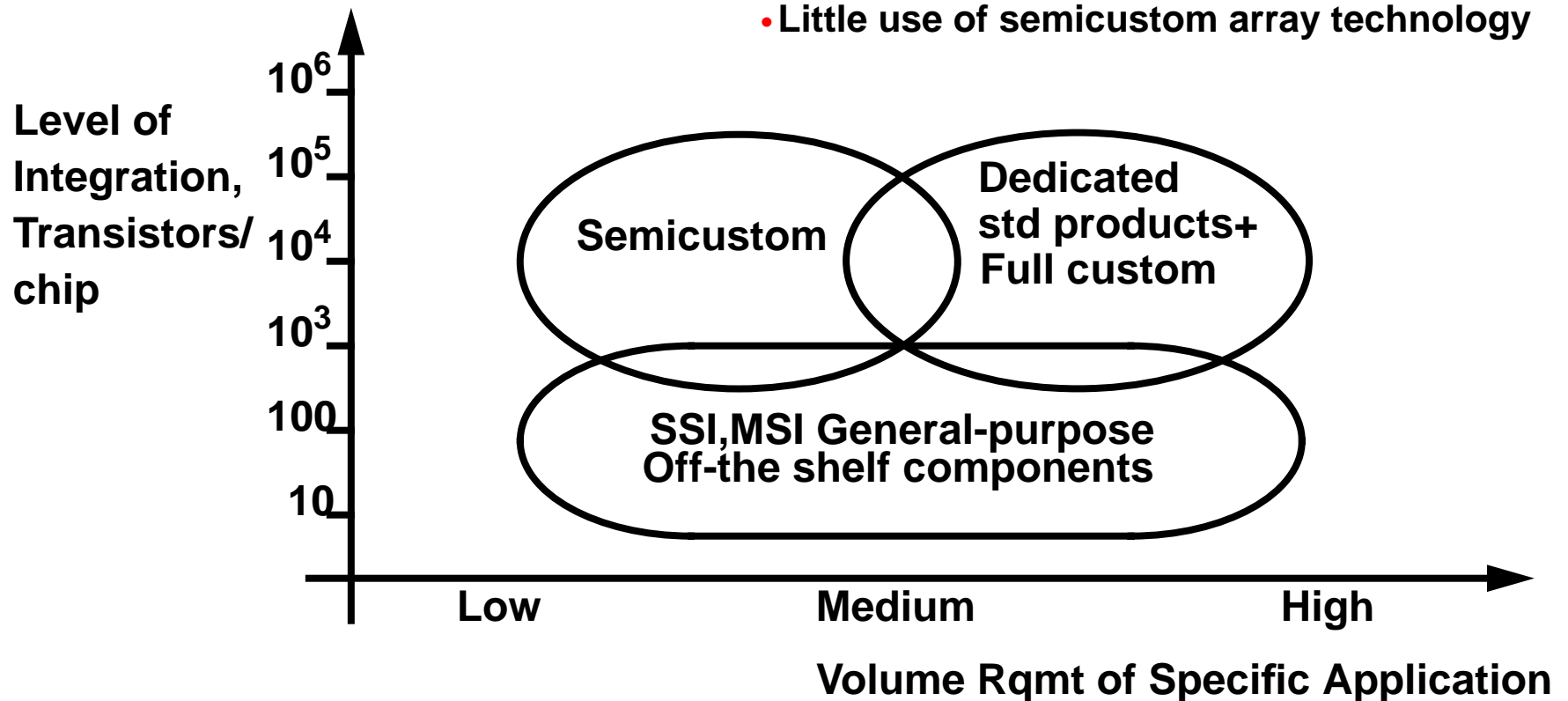
Digital Integrated Circuits



An Implementation Methodology Viewpoint

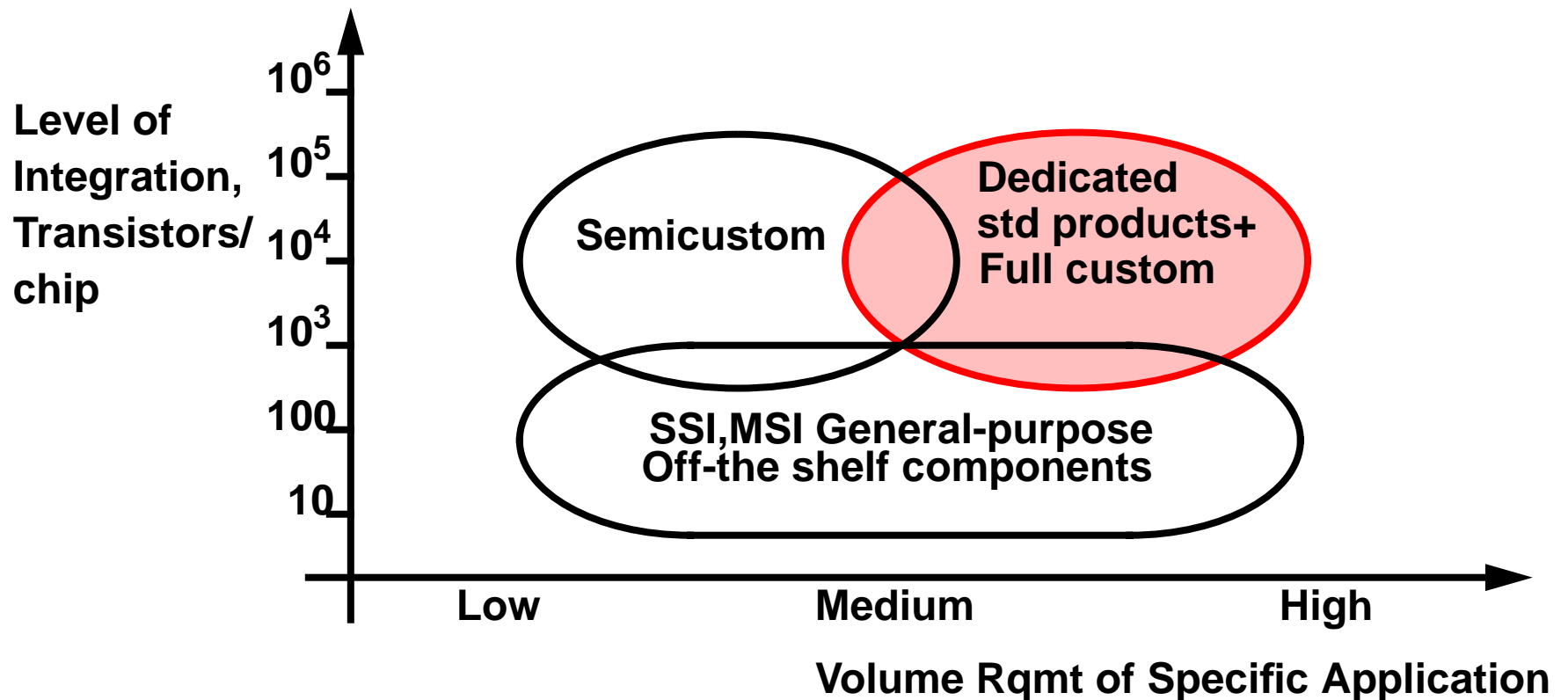
Analog and Mixed-Signal Integrated Circuits

- No equivalent of microprocessor, memory
- Little use of semicustom array technology



An Implementation Methodology Viewpoint

Analog and Mixed-Signal Integrated Circuits



Characteristics of Dedicated Interface Components

- **High Manufacturing Volume**
- **Standardized Specs**
- **Medium Analog Performance**
- **Predominantly CMOS**

Examples:

- **Digital Telephony Components**
- **Voiceband Data Modems**
- **LAN Transceivers**
- **Consumer Audio, Video Interfaces**
- **PC Video DAC Functions**

Modem block diag

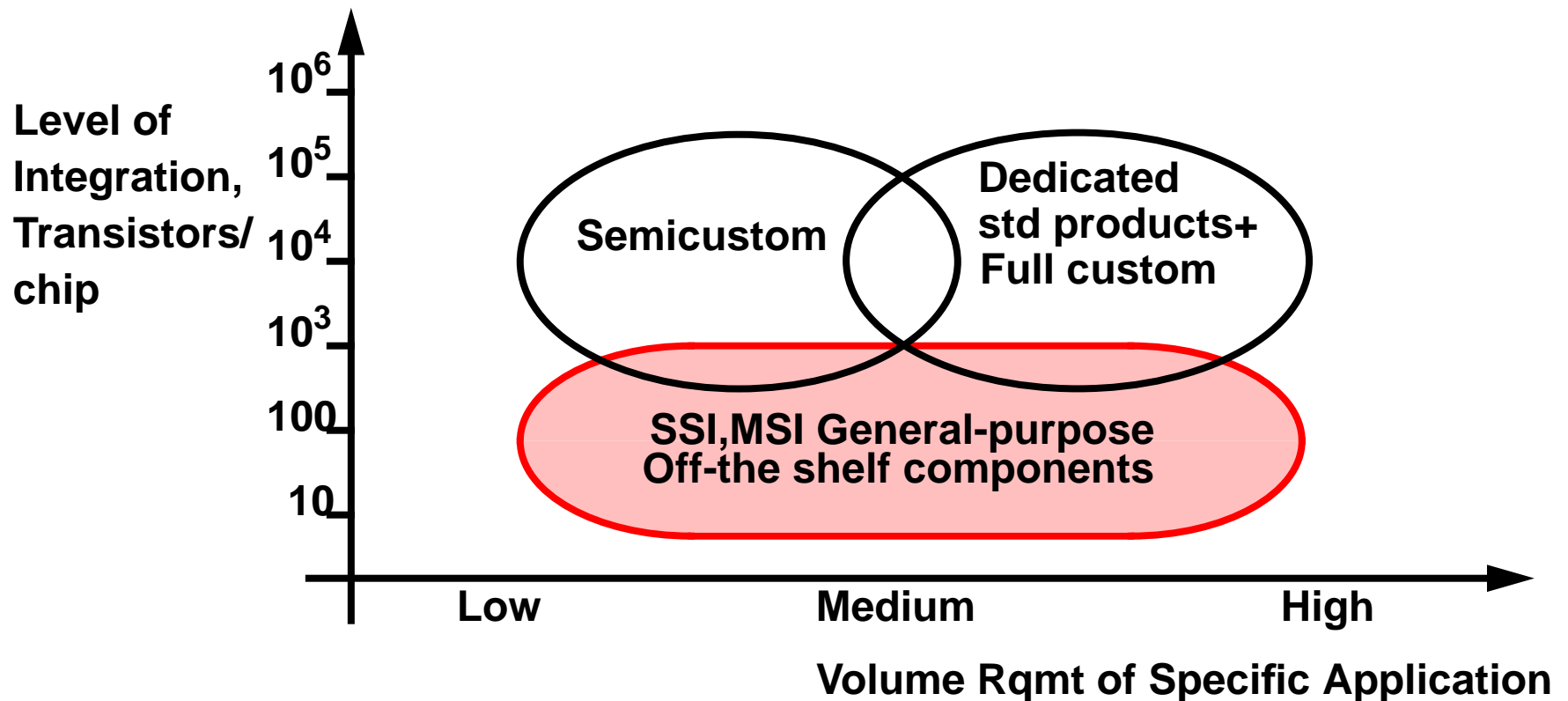
Future Dedicated Interface Applications

- **Multi-Channel Voiceband Codecs**
- **High-Integration ISDN, HDSL, ADSL Components**
- **High Speed Modems**
- **NTSC, PAL, HDTV Coders/Decoders**
- **Fiber Optic Receivers, Xmitters**
- **Magnetic Storage Read Channel, Servo**
- **Consumer, Automotive**
- **CATV Video Modems**
- **RF LAN, Personal Communications Transceivers**

**Key Issue: Exploitation of Scaled CMOS, BiCMOS
at Low Voltage and/or Low Power**

An Implementation Methodology Viewpoint

Analog and Mixed-Signal Integrated Circuits



General Purpose Component Examples

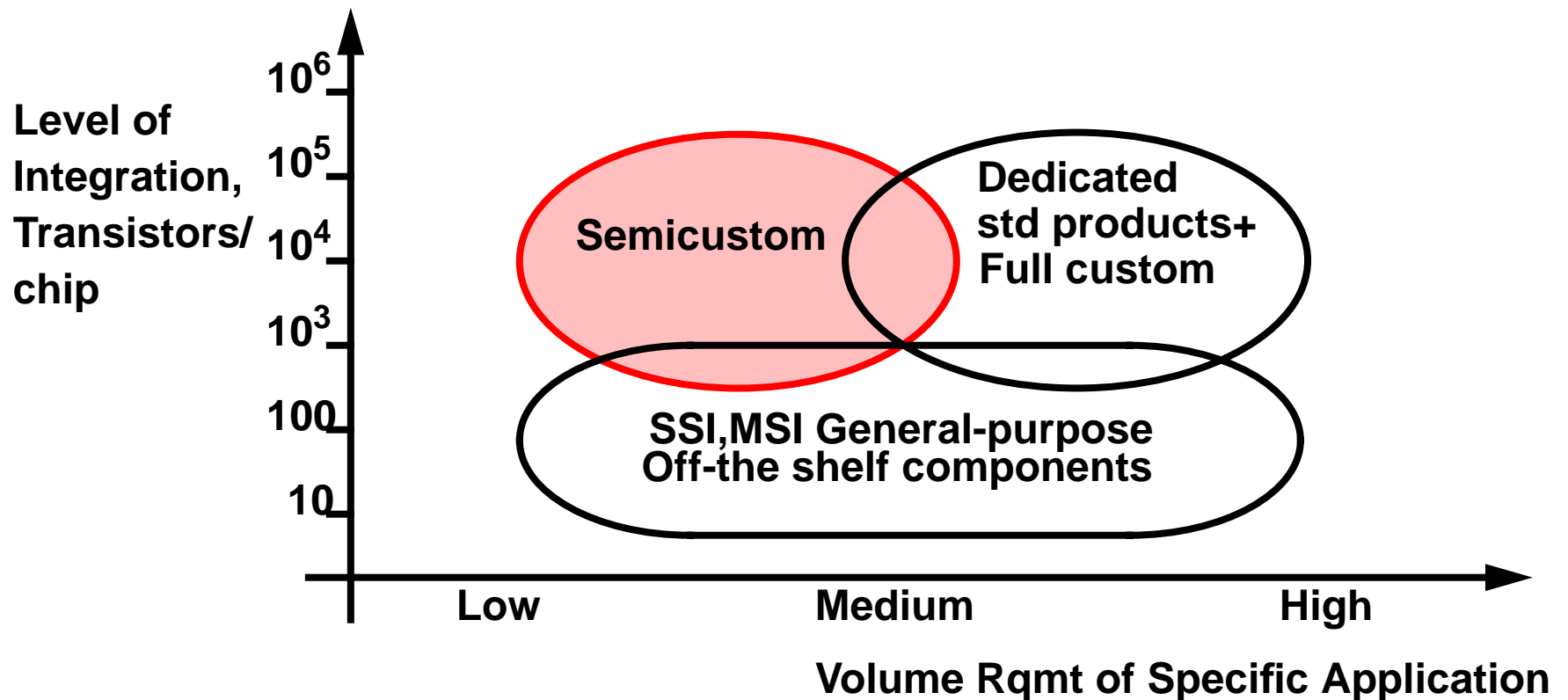
- **Operational Amplifiers**
- **Instrumentation Amplifiers**
- **Voltage References**
- **Sample/Hold Amplifiers**
- **A/D Converters**
- **Analog Multiplexers**
- **Phase-Locked Loops**
- **Analog Multiplexers**
- **Comparators**
- **Video/wideband Amplifiers**
- **Power Amplifiers**

Characteristics of GP Analog Components

- **Flexibility is Key**
- **Performance is Often Critical**
- **Wide Variety of Functionality**
 - Supply Voltage
 - Output Drive/Input Level
 - Speed
 - Precision
 - Cost
- **Wide Spectrum of Technologies**
- **Bipolar and BiCMOS Dominate**

An Implementation Methodology Viewpoint

Analog and Mixed-Signal Integrated Circuits



Characteristics of Semicustom Interface Components

Objectives:

- Design by System Designer
- High Integration/Low Volume

Key Elements:

- Precharacterized Cells, Arrays
- CAD Tools

Examples:

- Bipolar Transistor Arrays
- CMOS Std Cell Analog

Trends in Semicustom Interface Components

- **Slow Penetration of the Technology**
- **Key Issue is CAD**
 - Design Capture
 - Simulation
 - Layout
 - Debug
 - Test Generation
- **Often “Semicustom” is really Custom**

Semicustom Methodology Issues- PRETAPEOUT

Architectural Design

- Spec Definition and Capture
- System Optimization
- Algorithm Development
- Behavioral Simulation
- High-Level Design Capture

Circuit Design

- Custom Block Design (or Compilation)

Physical Design

- Custom Cell Layout/verific/resimulation
- Block Layout/Compilation
- Block Extraction/back annotation/resim
- Global Place&Route
- Global extract/back annot/resim
- DRC

TAPEOUT

Semicustom Methodology Issues- POST TAPEOUT

First Silicon Eval and Debug

- Design Verification-temp and supply
- Debug Parameter Marginalities
- Customer Sample Evaluation

Rev 1 Redesign

- Conceive and Verify Fixes
- Full tapeout flow, rev 1
- Rev 1 tapeout

Rev 1 Eval and Testing

Characterization and Qualification

- Multi-lot Characterization (temp, supply)
- Select Bin Limits
- Burnin/Parametric Shift Eval

Production Test Development

- Test Strategy Development, Test Software Development
- Load Board Design, Temp Test Strategy, Bench test Correlation

Production Release

Key Goals for Analog CAD

Short Term:

- **High-Level Tools for Analog Design/Synthesis**
- **Shorter Design Cycles for Custom and Standard Mixed-Signal ICs**

Long Term:

- **Create Viable Mixed-Signal Semicustom ASIC Methodology**

Possible Analog IC Scenarios for the 90s

- **Analog Will Die as an IC Implementation Methodology, Digital will take Over**
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Semicustom Analog was a failure in the 1980s. Key task in the 90s is to revive it!

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Examples of IC Circuit Innovation

Bipolar Analog Technology

- Pole-split Compensation
- Gilbert Multiplier
- Band-Gap Reference

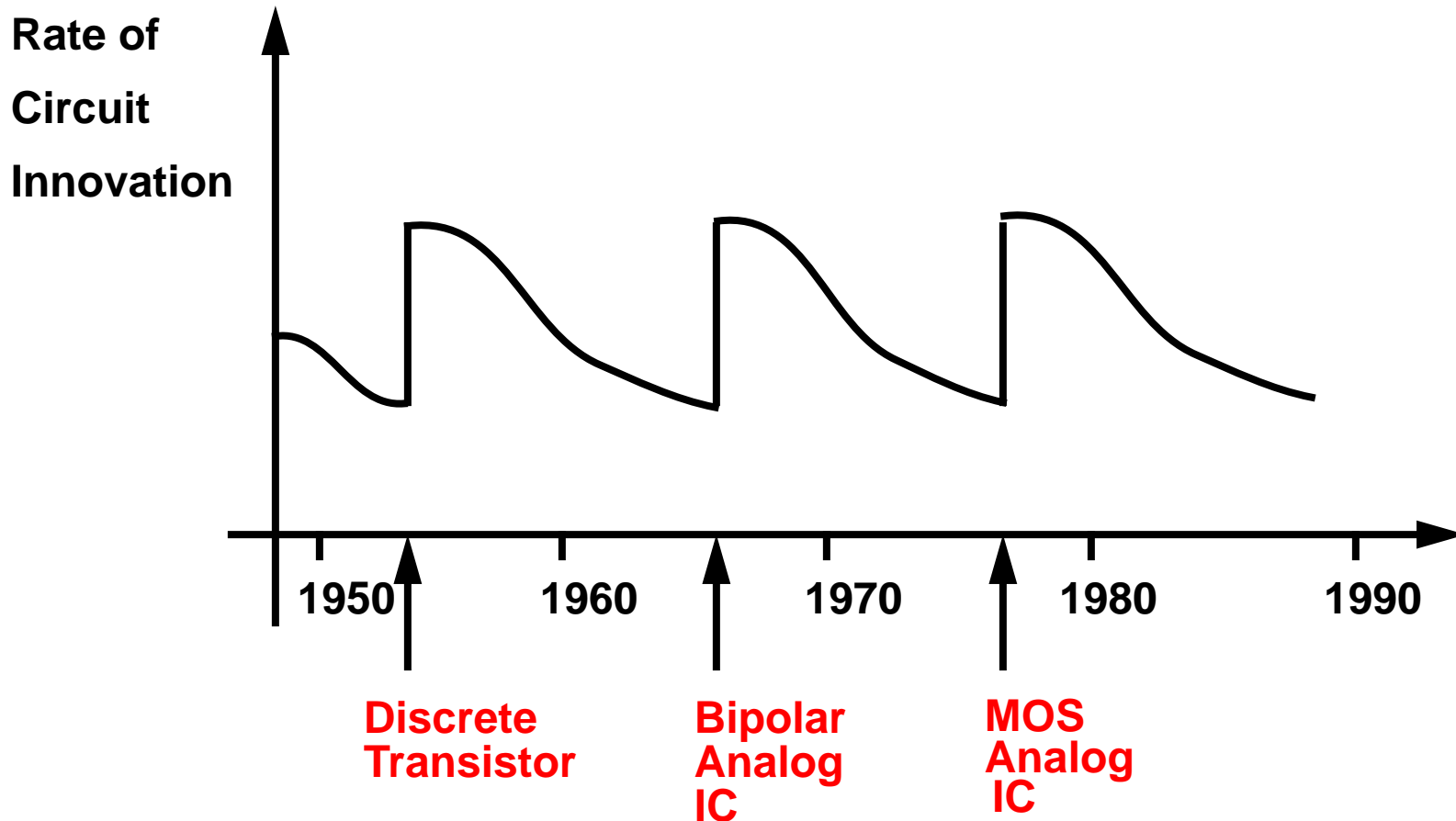
MOS Analog Technology

- Switched Capacitor Filters
- Monolithic Continuous Filters
- A/D Converter Self-Calibration
- Sigma-Delta Modulators

Common Theme:

Application of New Technology to a Generic Function

Circuit Innovation and the Introduction of New Technology



Candidates for the 90s:

BiCMOS, GaAS MESFET, HBT, Josephson,??



Technology Driven vs Application Driven Innovation in IC Circuits

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Innovation Will Become More Applications-driven

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Future Role of “The Analog Circuit Designer”

No more “Pure Analog” ICs

Broad Understanding of System-Level Issues Essential

Task Involves Many Aspects

- Analog, Transistor-Level Design
- DSP,ASP,Filter Concepts
- System Implications of Component Performance
- Digital VLSI Design Using Latest Tools

Key Issue: Breadth of Skill and Knowledge

Future Trends in A/D Interface ICs

- **The Shell is Getting Thinner**
- **The Egg is Getting Bigger**
- **High-Integration, Dedicated Mixed-Signal Solutions on Low Voltage will become Predominant**
- **Semicustom Mixed-Signal Technology Will Evolve**
- **Generic Building Block Era is Passing**
- **Interface Designer Must Know:**
 - Analog Circuit Design**
 - VLSI Digital Design**
 - System Applications Concepts**