2008
International Technology Roadmap for Semiconductors

Radio Frequency and Analog/Mixed-Signal Technologies for Wireless Communications Working Group

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2008 Wireless ITWG Organization

Name	Company	Name	Company
Rick Amos	RFMD	Takahiro Kamei	Oki
Pascal Ancey	ST Micro	Tom Kazior	Raytheon
Kamel Benaissa	TI	Yukihiro Kiyota	Sony
Bobby Brar	TSC	Sebastian Liau	ITRI
Joost. Van Beek	NXP	Pete Loeppert	Knowles
Herbert Bennett	NIST	Ginkou Ma	ITRI
Pascal Chevalier	ST Micro	John Magerlein	IBM
David Chow	HRL	Mel Miller	Freescale
Julio Costa	RFMD	Jan-Erik Mueller	Infineon
Stefaan Decoutere	IMEC	Gerry O'Brien	MEMSIC
Masanori Fujisawa	Rohm	Hansu Oh	Samsung
Evgeni Gousev	Qualcomm	Jack Pekarik	IBM
John Hammond	RFMD	Ed Priesler	Jazz
Erwin Hijzen	NXP	Marco Racanelli	Jazz
Digh Hisamoto	Hitachi	Bernard Sautreuil	ST Micro
Dave Howard	Jazz	Sorin Voinigescu	UT
W. Margaret Huang	Freescale	Albert Wang	UC Riverside
Matthias Illing	Bosch	Dawn Wang	IBM
Anthony Immorlica	BAE Systems	Chuck Weitzel	Freescale
Jay John	Freescale	Geoffrey Yeap	Qualcomm
Alvin Joseph	IBM	Peter Zampardi	Skyworks
Michael Judy	ADI	Herbert Zirath	Chalmers U

2008 New members. 2008 44 members / 2007 36 members

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2008 Organization

Chair:	Margaret Huang, Freescale	44 Members / 2007 36
Co-chairs:	Jan-Erik Mueller, Infineon	28 US/Canada, 9 EU, 7 AP
	Sebastian Liau, ITRI	
	Jack Pekarik, IBM	
Editor:	Herbert Bennett, NIST	

• Subgroup CMOS	Jack Pekarik, IBM
• Subgroup Bipolar	Marco Racanelli, Jazz
• Subgroup Passives	Stefaan Decoutere, IMEC (acting)
• Subgroup PA	Peter Zampardi, Skyworks
	Chuck Weitzel, Freescale
• Subgroup mm-Wave	Tony Immorlica, BAE Systems
• Subgroup MEMS	Dave Howard, Jazz

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Wireless ITWG Background

- Scope of work remains the same; wireless transceiver IC as technology driver, with active contribution to ITRS-defined More than Moore thrust.
- Chapter subdivided into <10Ghz applications and mm-wave applications.
- 5 technology subgroups cover <10GHz applications: CMOS, bipolar, passives, Power Amplifier and MEMs. mm-wave focuses on power and low-noise using III-V and silicon-based devices.
- Some portion of the roadmap reflects prototype capability more than volume production. Production requires applications (especially emerging mm-wave connectivity and imaging) that currently lag technology capability.
- Collaborate with iNEMI to generate matrix of applications vs. technologies, covering emerging applications such as ultra low-power, medical and security etc.

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Wireless ITWG Methodology

Communication System
- Protocols/Standards
- Frequencies 0.8 – 100GHz
- Architecture

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Circuit Figures-of-Merit
- Dynamic Range, Bandwidth
- Gain, Noise Figure, Linearity
- Phase Noise
- Output Power, Gain, PAE
- Power Consumption
- Thermal Management

→

Device Figures-of-Merit
- Mismatch, Gain
- f_T & f_{MAX}
- NFmin & 1/f noise
- Breakdown
- Quality factor, linearity
- Power density, PAE
- COST

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Wireless Roadmap

Material systems : Si, SiGe, GaAS, InP, SiC, GaN
Device structures : MOSFET, LDMOS, HBT, MESFET, PHEMT, MHEMT, passives,
And More than Moore - Embedded passives and MEMs

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Wireless Communication Application Spectrum

InP – HBT, HEMT GaAs MHEMT

GaAs - HBT, PHEMT

SiGe – HBT, BiCMOS

GaN - HEMT

Si – RF CMOS

SiC - MESFET

0.8 GHz	2 GHz	5 GHz	10 GHz	28 GHz	77 GHz	94 GHz

GSM CDMA ISM	PDC GPS SAT Radio	DCS PCS DECT CDMA	WLAN 802.11b/g Bluetooth ZigBee	SAT TV	WLAN 802.11a	SAT TV WLAN Hyperlink UWB	LMDS WLAN	60GHz WPAN AUTO RADAR	All Weather Landing **Imaging**

Applications drive Noise Figure, Power, Power Added Efficiency, Linearity and Cost.

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2008 Requirement Tables Updates

- **CMOS**
  - Maintain links of Performance RF to LSTP CMOS with 1 year lag and mm-wave CMOS to HP CMOS with 2 year lag. Adjust RF analog parameters to reflect ORTC update.
  - Correct 1/f noise scaling in Precision Analog table.
  - Update mm-wave noise figure scaling and adjust to match published data, add 94Ghz requirements.
- **Bipolar**
  - Minor adjustments: HS bipolar ft/fmax colors, update PA bipolar requirements per publication data.
- **Passive**
  - Update MIM and MOM cap density vs published data, update varactor Q, update inductor Q's.
  - PA passives adjust inductor color, lowered capacitor density requirement to reflect actual application need.

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2008 Requirement Tables Updates

- **PA**
  - Push out 2.4V end of life battery voltage.
- **MEMS**
  - Expanded membership (added 7 new members).
  - Stay with device choice (1) BAW, (2) Resonator, (3) switch - capacitive contact, and (4) switch - metal contact. Expansion planned for 2009.
  - Clarify whether design tool requirements are for device or system implementation.
  - XTWG with Assy&Pkg, update terminology used and clarify package requirements for die level only
  - Add specific performance and cost driver requirements.
- **mm-wave**
  - Push out geometry scaling 1-2 years for most III-V technologies reflecting industry trend
  - In general, roadmap reflect migration from GaAs PHEMT to alternate III-V technologies.

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2009 Challenges

- Overall chapter, add discussion on prototype-capable vs production definition and application/technology matrix.
- CMOS possible dropping of half node, add alternate high gain and high-voltage device, review impact of transition to FD/DG device. Continued XTWG discussion with ERD on RF performance and PIDS and Design on I/O support for FD/DG technology.
- Bipolar considering dropping "HV" device which is generally integrated as a parasitic device and not driving the roadmap.
- PA increase foundry member participation and add semiconductor switch parameters, both for integration in IC and module.
- MEMS expand device list to cover microphone, accelerometer and gyro, expand membership to cover users.

Wireless Working Group Key Considerations

Traditional Roadmap Drivers:

- Cost (scaling, die size, part count)
- Power Consumption
- Chip Functionality

Non-traditional Roadmap Drivers:

- Government regulations determining system spectrum and specifications
- Standards and protocols drive frequencies, power and performance
- Color coding “Manufacturing solutions exist” does not imply product volume shipment per ITRS definition
- RF module form factor (size and height requirements)

Cost / Performance Drives Integration:

- Multi-band Multi-mode system applications (embedded passives, filter, switch integration)
- Signal Isolation and integrity
- Analog Shrink (power supply, area, design innovations)

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Challenges and Trends

Radio Integration:

- Performance and cost trade off for SoC vs SiP solution
- Signal isolation - challenge to technologists, designers and EDA tool providers
- CAD solution for Integrated Radio SiP design (chip, passive, MEMS, package, tool compatibility, model accuracies)

Device Technology:

- Optimizing analog/RF CMOS devices with scaled technologies. Fundamental changes in CMOS device structure device to double gate need PIDS plan for IO device.
- Cost and performance tradeoff of integrating passive devices
- Predictability of battery technology (end-of-life) and its impact on PA roadmap
- Compound semiconductor substrate quality, reliability, new thermal management

Design:

- Design approach for PA ruggedness
- Digitizing analog functions, Software Define Radio (SDR)

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