

ITRS

RF and Analog/Mixed-Signal Technologies

Jack Pekarik, IBM
Chair, RF and A/MS TWG



Work in progress – do not publish

Outline

- Membership
- Overview
- Results
- Summary & Outlook

Membership

AMD

Emerson Fang

Cree

Scott Sheppard

Freescale

Jay John,
Steve Cosentino,
Jiangkai Zuo

Hitachi Ltd.

Digh Hisamoto

HRL

David Chow

IBM

Jack Pekarik,
Dawn Wang,
Mattias Dahlstrom,
Jean-Olivier Plouchart,
Taffy Kingscott,
Natalie Feilchenfeld

IEEE

Anthony Immorlica Jr.

Infineon

Snezana Jenei,
Carsten Ahrens

Intel

Ian Young,
Jan-Erik Mueller

ITRS

Linda Wilson

TowerJazz Semiconductor

Ed Preisler

NIST

Herbert Bennett, CoChair/
Editor

Northrup Grumman

Augusto Gutierrez

PMC-Sierra

Brian Gerson

Qualcomm

Geoffrey Yeap
Evgeni Gousev

Raytheon

Tom Kazior

RF Micro Devices

Julio Costa

Samsung

Hansu Oh

Skyworks

Peter Zampardi

Sony

Kaneyoshi Takeshita

SRC

David Yeh

ST

Pascal Chevalier

Technology Research Institute

Ginkou Ma

Teledyne Scientific

Bobby Brar

TI

Kamel Benaissa
Wibo van Noort

TSMC

Douglas Pattullo
Alex Kalnitsky

UC Riverside

Albert Wang

Univ. of Toronto

Sorin Voinigescu

UT/Dallas

Sam Shichijo

New Members

Toshiro Futatsugi, Fujitsu
Yoshihiro Hayashi, Renesas
Tatsuya Ohguro, Toshiba

Subgroups

CMOS

Jack Pekarik,
Emerson Fang
Steve Cosentino,

Bipolar

Pascal Chevalier
Jay John,
Jack Pekarik,

III-V

Tom Kazior
Anthony Immorlica Jr.
Herbert Bennett, CoChair/E

Passives

Snezana Jenei,
Jack Pekarik,

HVCMOS

Jack Pekarik,
Jiangkai Zuo

RF&A/MS 2011

Analog - carrier Frequency bands

LF Analog (0-0.4GHz)	RF (0.4-30GHz)	mm-wave (30-300GHz)	THz (>300GHz)
Example applications			
Automotive controls	Cellular	60 GHz point-to-point	No products yet
On-chip regulators	WLAN	Imaging	Coordinate with ERD
Power management	SerDes	Automotive radar	
	ADC,DAC	Wireless backhaul	

- Broaden scope to include analog applications
- Apply M-t-M whitepaper methodology
 - Markets - Applications - Circuits - Device Technology - FOMs
 - Verify proscribed conditions for roadmapping are met (FOM, LEP, WAT, SHR, ECO)
- Contribute to Mixed-Signal section of System Drivers chapter
- Redefine chapter organization to strictly align by device technology
 - WAS: CMOS, Bipolar, Power-amp., mm-wave, MEMS, passives
 - IS: CMOS, Si Bipolar, III-V, Passives, HVMOS

Circuits - System Drivers

- Circuit-level FOMs related to technology FOMs
 - Low-noise amplifier (LNA)
 - Voltage-controlled oscillator (VCO)
 - Power amplifier (PA)
 - Analog-to-digital converter (ADC)
 - Serializer-Deserialzer (SerDes)

1. Device Technology - CMOS

Improved Alignment with PIDS Chapter

- Reflect the RF & Analog performance of PIDS technologies (HP and LSTP)
 - f_T , f_{MAX} , NF_{MIN} , analog gain, flicker noise, matching
- More rigorous attempt to predict effects of parasitic resistances and capacitances
- f_T increases faster compared to 2009 roadmap
- f_{MAX} lower in near-term reflecting parasitic effects

2. Device Technology - Bipolar

Changes in the Bipolar FOM table

1. Removed Power-Amplifier (PA) NPN from the roadmap & general analog NPN parameters moved to *text* (no tables).
2. Updated the HS-NPN roadmap to match recent publications and application requirements
 - a. Adjust the pace of f_T and f_{MAX} increase & W_E reduction.
 - b. Updated of all the other parameters accordingly.
 - c. Added intrinsic slew rate (SL_i).
3. Updated the HS-PNP roadmap to cover the applications in the revised scope
 - a. Increased of the breakdown voltages and decreased f_T accordingly.
 1. Updated of all the other parameters accordingly.
 2. Added collector-base breakdown voltage (BV_{CBO}) & linearity efficiency cut-off frequency (f_{LE}).

3. Device Technologies - III-V

- Analog, Microwave, mm-wave applications
 - Emphasis on mm-wave
- Technology roadmaps truncated at expected end of scaling
 - GaAs PHEMT(2015), GaAs MHEMT(2019), InP HEMT(2021), GaN HEMT(2021) and InP HBT(2023)
- FOMs depending on technology
 - f_T , f_{MAX} , g_m , V_{BD} ,
 - Power, gain, efficiency
 - NF_{MIN} , G_A @ 10, 24, 60, 94GHz
 - LNA NF , G_A @ 140, 220 GHz

4. Device Technology - Passives

Novelties/Changes to 2009/2010:

Tables : On-chip passives only

Resistors

Capacitors

Inductors

Varactors

Text :

Emphasis on “parasitics aware design“

Better definitions of (all) FoM

Antennas

Transmission lines using BEOL wiring

Off-chip passives table omitted

Coordinated/cross-referenced text with Assy &Packaging

Inter-TWG : Interconnects and Assembly and packaging

5. Device Technology - HV MOS

- New section in 2011
- HVNMOS & HVPMOS
- Supporting Power-management & Display-driver applications
- FOM
 - BV_{DSS}
 - R_{ON}
 - Integrated CMOS node
- Truncate the roadmap at 90nm – uncertain of ever needing more dense CMOS

Future Outlook

- Future topics may include:
 - TCAD for RF bipolar device
 - Enhancements to SPICE-based simulations for RF CMOS
 - Simulations that treat wiring parasitics across all transistor technologies
 - Circuit simulations that also treat noise, signal isolation, and signal integrity. increase focus on analog applications
- Further expansion in coming years as determined by member contribution
 - Send topical experts if you want to influence roadmapping of a particular technology