Design for RF Performance with the UltraCMOS® Advantage

MTT IMS 2012 – Montreal
We All Have Hard Problems to Solve

Explosion of Data

Handset
- 41 LTE Bands
- MIMO
- Battery Life

Network Operator
- Small Cell
- Network Capacity
- Hetnet

Lower Power Solutions

General RF
- Machine 2 Machine
- Intelligent RF
- Green Electronics

Increased RF Complexity

Aerospace/Defense
- Life Expectancy
- Robots/Drones
- Power Management

Smaller Form Factor
The UltraCMOS® Process Difference
What Makes UltraCMOS® Different?

**Most Widely Used Semiconductor Technology**

- **CMOS**
  - Scalable
  - Lowest Power and Cost
  - Fabless Model

**Near-Perfect Insulating Substrate**

- **SAPPHIRE**
  - Proven SOI Technology
  - Outstanding RF Properties
  - Mature Supply Chain

**Industry-Leading RF Semiconductor Technology**

**Combining the Best of the Best**

- Unique Position in Industry
- Better Performance
- Enables Integration
Key Attributes of UltraCMOS® Technology

- Reduced bulk parasitics
- Fully-depleted is preferred for no kink effect
- High thermal conductivity
- Performance has low thermal sensitivity
- Faster devices
- Reduced \( CV^2f \) power loss
- Improved linearity
- High isolation
- High passive Q

The small signal model is simplified with the removal of the shaded elements associated with the bulk node.
UltraCMOS® Technology has tight tolerance specifications on key performance parameters

- Over temperature
- Over process
- Across a wafer and over lots

4302 DSA, 31.5dB state, Atten Error (dB) at 2200MHz
Std Deviation = 0.15dB >1M units

42551 SPDT
Insertion loss at 1GHz
Std Deviation = 0.03dB
250k units

42440 SP4T
2fo (dBc)
Std Deviation = 0.9dBc
600k units
UltraCMOS® – Linearity

Lack of substrate effects intrinsically delivers excellent linearity

- No non-linear voltage dependent capacitances (Csb, Cdb, Cgb)

Fully depleted
UltraCMOS has no variable capacitor due to depletion region

Passive Mixer IIP3 vs Frequency

SP10T IIP3 vs Temperature

IP3 for Band V meets LTE
Simultaneous Voice + Data Requirement
UltraCMOS® – Isolation

- Highly insulating properties of the sapphire substrate provide excellent broadband isolation
- Replaces mechanical relay

PE42750 High Isolation SPDT Switch
3 x 3 mm QFN
FET can be approximated by a two-terminal device

- Resistor when in strong-inversion (Ron)
- A capacitor network when in deep subthreshold (Coff)
Accelerated UltraCMOS® Roadmap

- Ron Excellence for Excellent RF Performance
  - On resistance (Ron) is the key figure of merit for RFFE components

- UltraCMOS Ron Performance Roadmap
  - Process improvement
  - Process scaling
  - Circuit technology

STeP = Semiconductor Technology Platform
Industry-Leading Performance and Integration

SP9T Cellular RF Switch

GaAs

UltraCMOS®

Scaling

STeP2
STeP3
STeP5

- 83% Smaller*
- Single CSP IC vs. Multi-Chip Design
- UltraCMOS® Switch Eliminates
  - 29 Wire Bonds
  - Custom Multi-Chip Module
  - External Electrostatic Discharge (ESD) Protection Circuitry

* STeP5 Switch compared to GaAs Switch
High-Throw RF Switches Solve Complex Signal Handling

Single-chip 3G/4G MIPI 2-wire Serial Interface

**New SP10T RF Switch**
*PE426161*

- Low Insertion Loss on 8 symmetric TX ports
- Super TX (STX) ports 1 and 10 support extremely low insertion loss
- Improved Linearity

**New SP12T RF Switch**
*PE426171*

- Excellent Insertion Loss up to 2.7 GHz
- High isolation of 38 dB at 900 and 1900 MHz on all paths

10 TX ports

- TX ports capable of any mode, any band on all paths
- RoHS compliant chip-scale packaging for SMD placement and smallest module footprint
- Wide supply range of 2.3 to 4.8V for operation from VBATT
- High ESD tolerance of 4kV HBM at the ANT port, 2kV all pins
- No blocking capacitors required

12 symmetric TX ports
UltraCMOS® – Insertion Loss

- Low RonCoff product of the UltraCMOS® process provide excellent insertion loss
- Rivals the promise of MEMS RF switches

PE426161 Insertion Loss vs. Frequency (LTE path)
Not Everything Wireless Is Mobile

Sony Bravia

Ericsson Base Station

Rohde & Schwarz Communication Tester

Motorola Public Safety Radio

Isolation

Linearity

Speed

Rad Hard

Broadband

Low Distortion

Low Power

Integration

Panasonic Blue Ray

GPS III

Siemens MRI

Mercedes Remote Keyless Entry

Peregrine Semiconductor
Innovative RF Solutions Simplify RF Challenges

New DTCs: PE64101/2

First-to-Market Monolithic Antenna Tuning Solution

- 5-bit, 32-State, 100-3000 MHz
- High quality factor
- SPI (3-wire) Serial Interface with built-in bias voltage generation (102) and stand-by mode for reduced power consumption (101)
- Wide power supply range (2.3 to 3.6V) and low current consumption (typ. IDD=140 μA)
- Shunt or Series configuration
- Applications include UHF band antenna tuning

Digitally Tunable Capacitors for Tunability

PE64101
C = 1.4 – 6.2 pF (4.4:1 tuning ratio)
in discrete 150 fF steps

PE64102
C = 1.7 - 15.5 pF (9.1:1 tuning ratio)
in discrete 431 fF steps
Innovative RF Solutions Simplify RF Challenges

New SP3T RF Switch
PE42430

Designed for WLAN, Bluetooth® and broadband switching applications
- Excellent ESD tolerance 4.5 kV HBM
- Tiny 8-lead DFN package 1.5 x 1.5 mm
- Excellent linearity, isolation and IL

New SP4T RF Switch
PE42540

Designed for T&M and ATE
- HaRP™-enhanced UltraCMOS® device
- Fast settling time
- Eliminates Gate and Phase Lag
- No drift in insertion loss and phase

Low insertion loss
- 0.45 dB @ 1 GHz (typ)
- 0.55 dB @ 2.5 GHz (typ)
IIP3: +66 dBm (typ)
P0.1dB Compression: Typical +30 dBm
Excellent ESD tolerance of 4500V HBM and 250V MM on all ports
No external VDD required. VDD is derived from switch control inputs
Tiny 8-lead 1.5x .5 mm DFN

High linearity: 58 dBm IIP3
Low insertion loss
- 0.8 dB @ 3 GHz
- 1.0 dB @ 6 GHz
- 1.2 dB @ 8 GHz
High isolation 40 dB @ 3 GHz, 34 dB @ 6 GHz and 25 dB @ 8 GHz
1 dB compression point of 33 dBm (typ)
High ESD tolerance of 2 kV HBM on RFC, 1 kV HBM on all other pins
32-lead 5x5 mm QFN
UltraCMOS® Is Green

- Ultra-low Power Consumption
  - No parasitic capacitance or dispersion at high frequencies

- Avoids toxicity and carcinogenic nature of GaAs
  - No arsenic slurries
  - Sapphire substrate intrinsically offers environmental and RF benefits

- Monolithic Integration results in smaller die and fewer external components for measurable power and size savings
  - Increased battery life
  - Smaller batteries
  - Lower power consumption and bills
  - Less electronic waste (eWaste)
  - A greener Earth
Quality/Reliability/Repeatability

At Peregrine Semiconductor, we are committed to achieving excellence through customer satisfaction in everything we do.

Our ISO-9001-2000 and AS9100C certified quality systems, advanced designs, progressive process technology and industry-leading product performance enable us to deliver decidedly superior performance.

TS-16949 Certification Audit Passed and Certification Received February 2012
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Explosion of Data

Handset

Network Operator

Increased RF Complexity

General RF

Aerospace/Defense

Smaller Form Factor

Changing RF Design. Forever.™

High-performance RF CMOS® Technology

Excellent Linearity, Isolation and IL Results

150+ RFICs For Multiple Markets and Applications

Leveraging Mainstream Foundries

One Billion+ UltraCMOS® RFICs Shipped