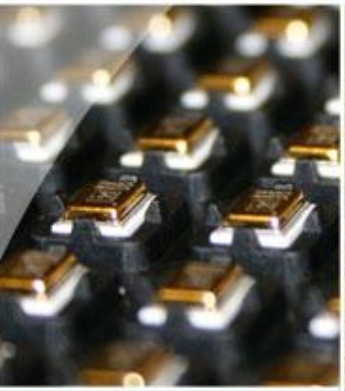
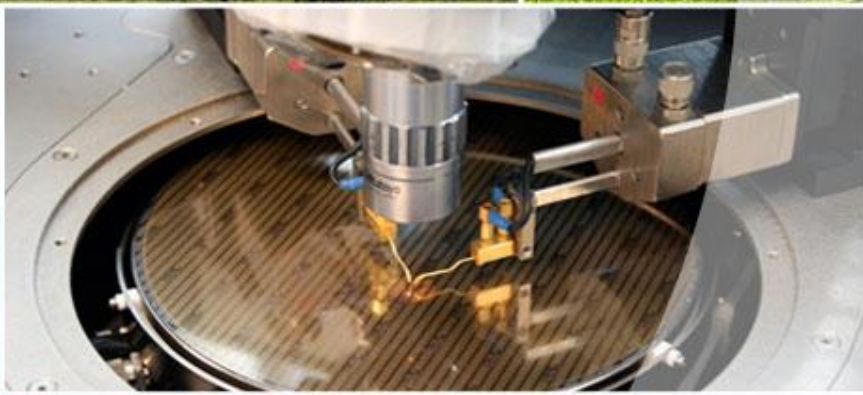
wiSpry

We make wireless work... better!



Integrated RF-CMOS MEMS Capacitors



Jeffrey L. Hilbert, President & Founder

June 22, 2010

WiSpry Overview

- **Fabless RF Semiconductor Product Company**
  - ✓ Enable Optimal Situational Performance for Wireless Devices through Dynamic Tuning
  - ✓ Substantial Reduction in Size, Weight, Cost and Component Count for Frequency Agile Communications
    - Elimination of “Specialty” Passive Components – Integrating the Previously “Un-Integratable”
    - Roadmap to Single Footprint Re-Configurable RF Front-End Solution
- **Uniquely Combine Scalability of CMOS Processing with WiSpry’s Patented Tunable Digital RF Capacitors**
  - ✓ 80 Patents (38 Issued & Allowed; 42 Pending)
- **Strong Technology Leadership Position**
  - ✓ Monolithic RF Integration; RF Performance and Range; Digital Control; Ultra-Low Power Consumption
- **In Design with Tier One Mobile Handset Provider**
- **WiSpry**
  - ✓ Established in October 2002; Core Team Engaged with Technology for >10 Years
  - ✓ Irvine CA (Headquarters); RTP, NC; Seoul, Korea
  - ✓ 37 Employees

3G / 4G Mobile Terminal Challenges

Battery Life

Very High Volumes

BOM Cost

Performance

Form Factor

Quality of Service

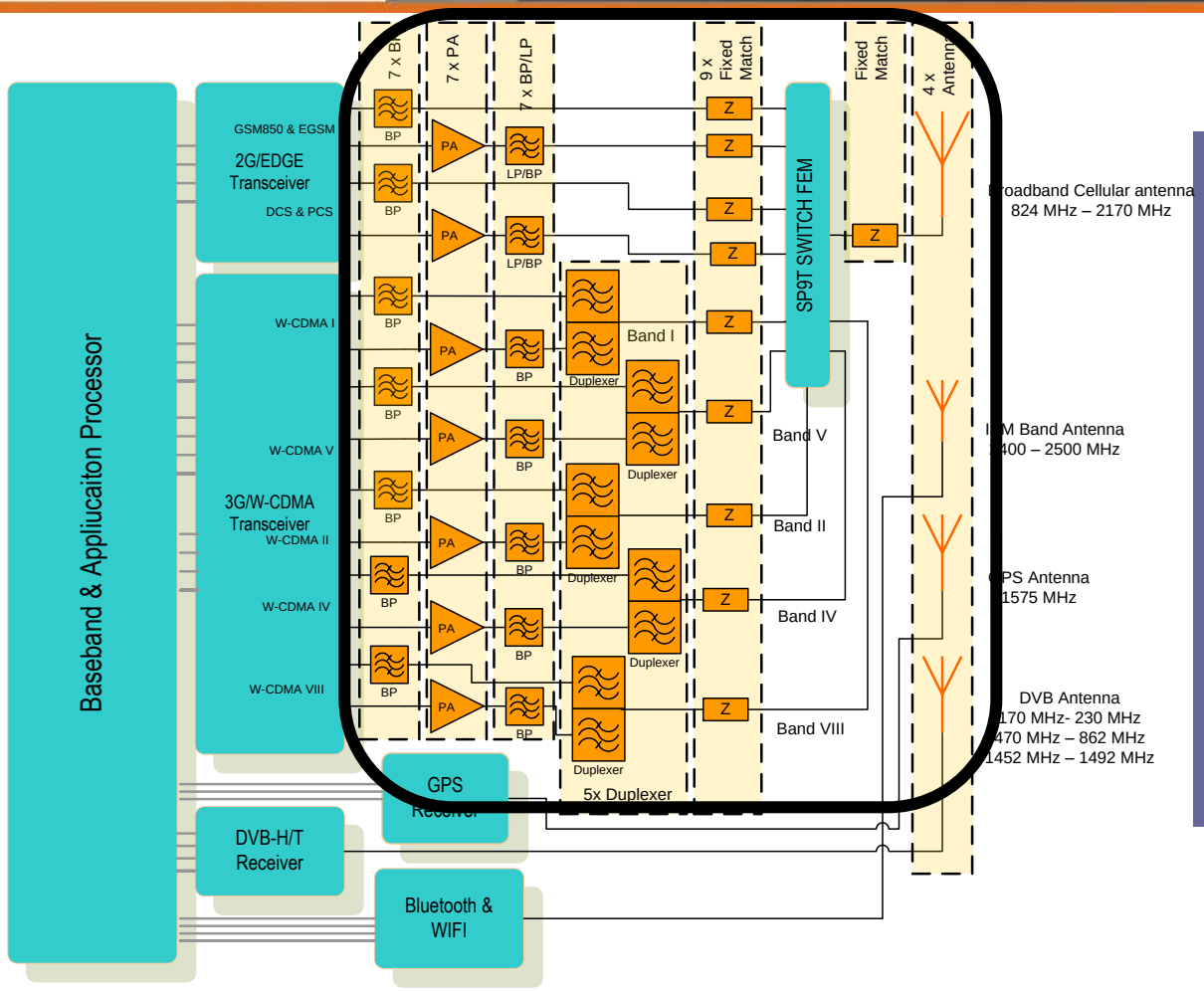
Available Spectrum

Time to Market (Design Cycle)

Short Product Lifetime

Feature and Function Integration

Integration of the RF Has Been Limited by Need for High Performance Specialty Solutions



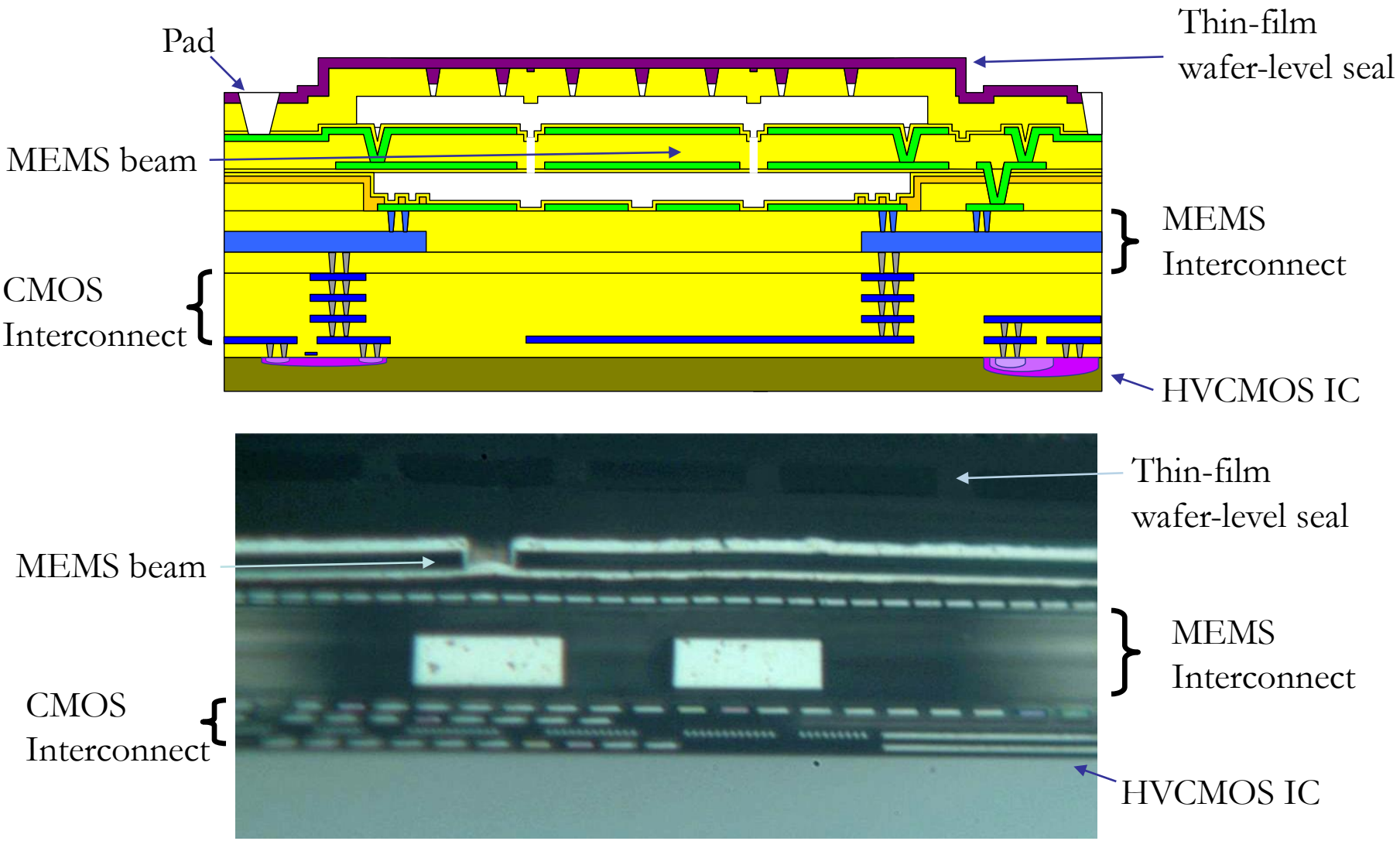
- One Chain of RF Components per Frequency or Mode
  - More Cost, Space, & Power
- Too Long of a Design Cycle for New Products
- Too Much Customization Required for Every New Product
- Compromised Performance

… And it Only Gets More Difficult with 4G / LTE

Removing RF Integration Limits

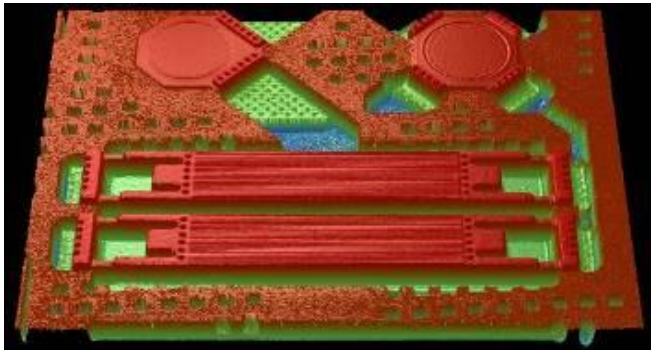
- Dynamically Reconfigure Properties / Performance of RF Functions Using Software
- Tunable, Re-Configurable, or Programmable RF Components
- Approaches Include
  - Switching
  - Modifying Material Properties
  - ***Moving Micro-Scale Structures (RF-MEMS)***

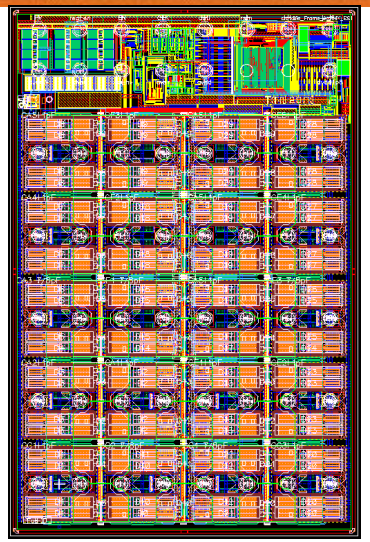
Silicon MEMS (On Top) Fabrication Process
(0.18um, 3/50V RF-CMOS Process; 8" Wafers)

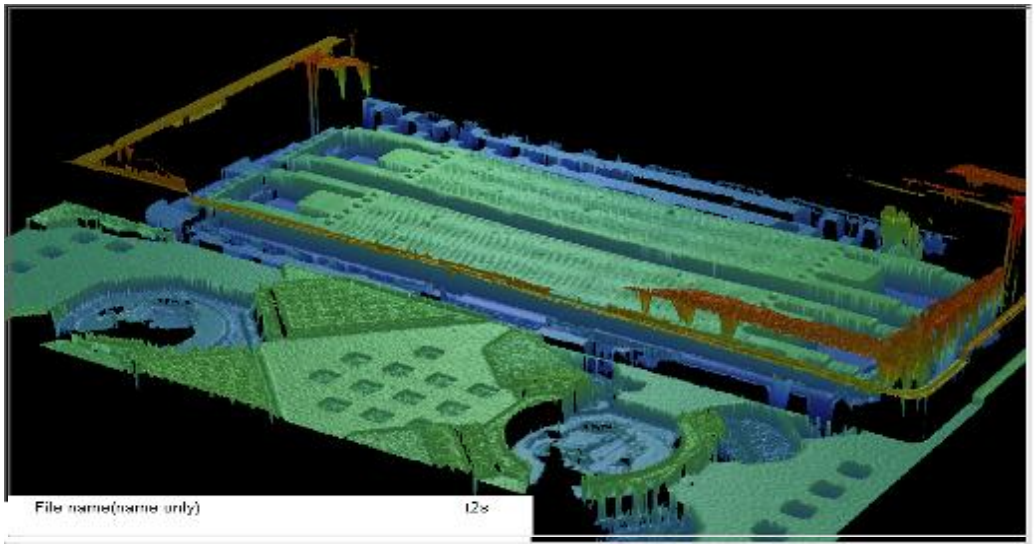


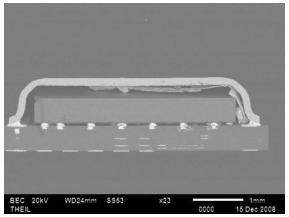
Tunable (MEMS) Digital Capacitor (TDC)

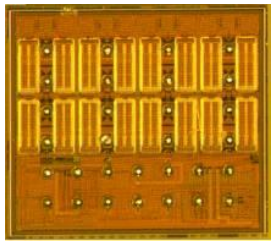
- Ultra Low Power with Superior Measured RF Performance
- High Device Density Provides Excellent Area Efficiency
- Precise Two-State Operation
- Scalable, Digital Architecture Supporting Many Different Tunable RF Applications and Combinations
- Integrated, Single Chip Solution Containing CMOS and MEMS
- Demonstrated Manufacturable and Reliable Structures





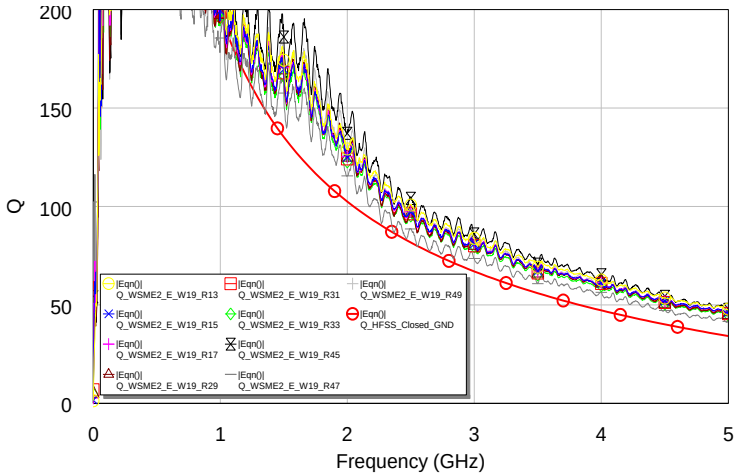




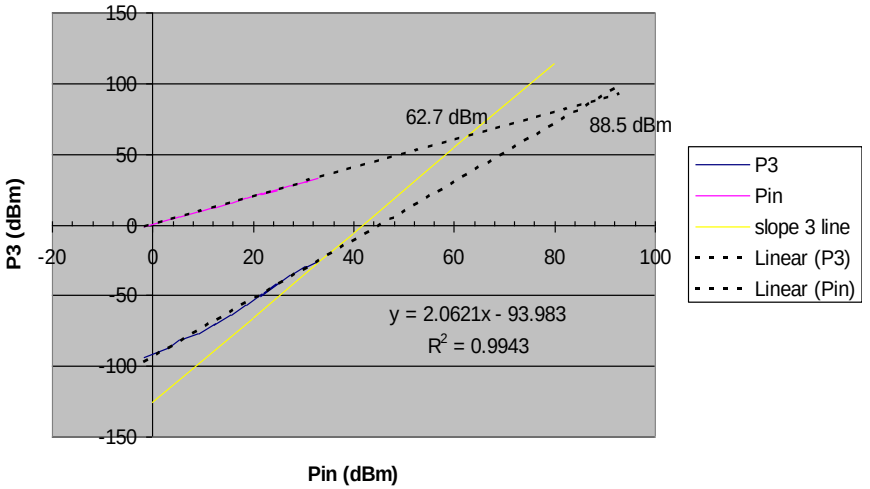


TDC Measured Data
High Performance

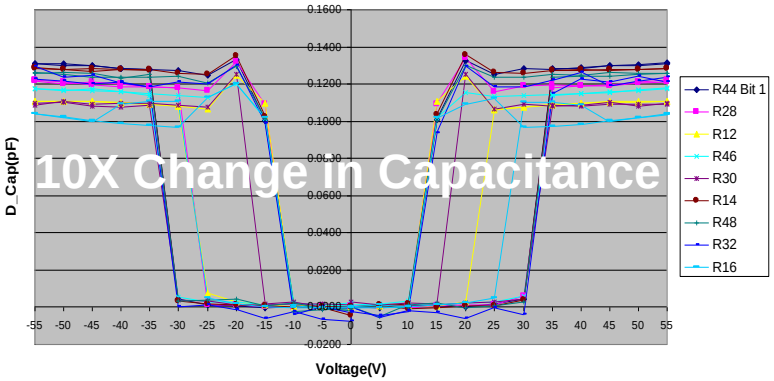
Q > 100 @ 2 GHz for 1pF Cell



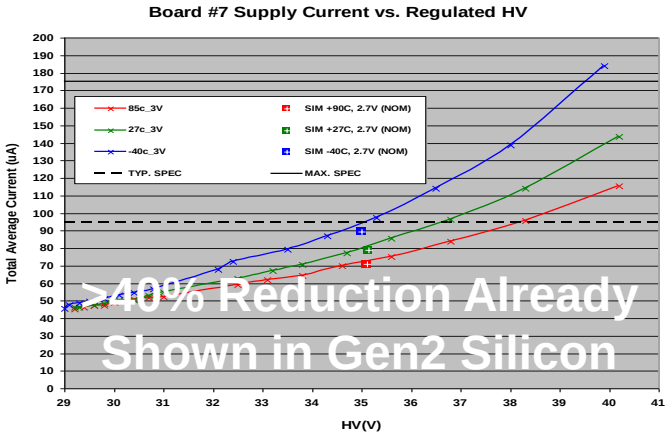
Ultra-Linear



High Capacitance Ratio

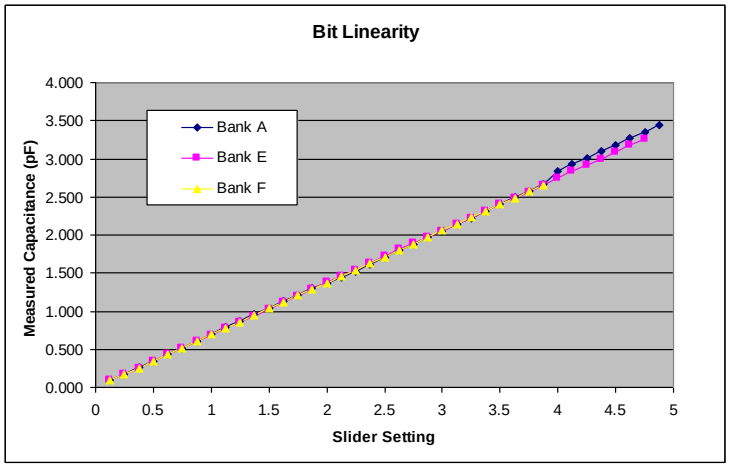


Ultra-Low Power Consumption

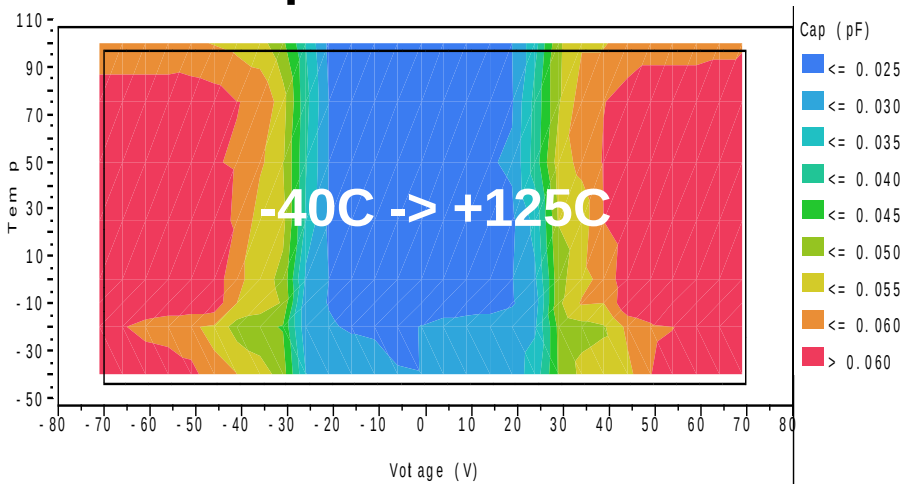


TDC Measured Data
Highly Reliable and Robust

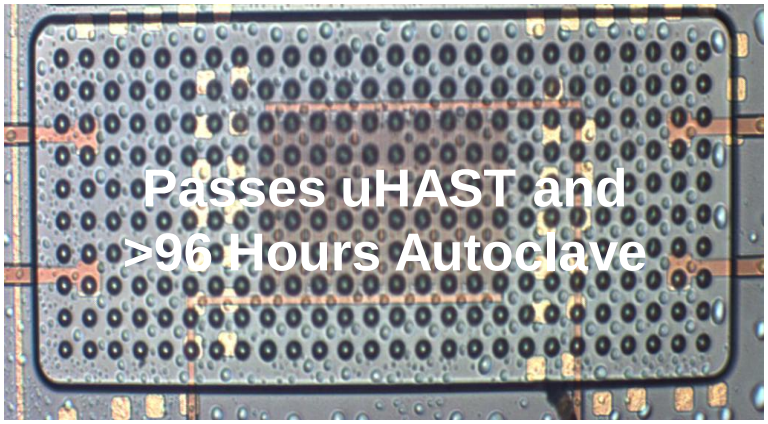
Excellent Bit Linearity



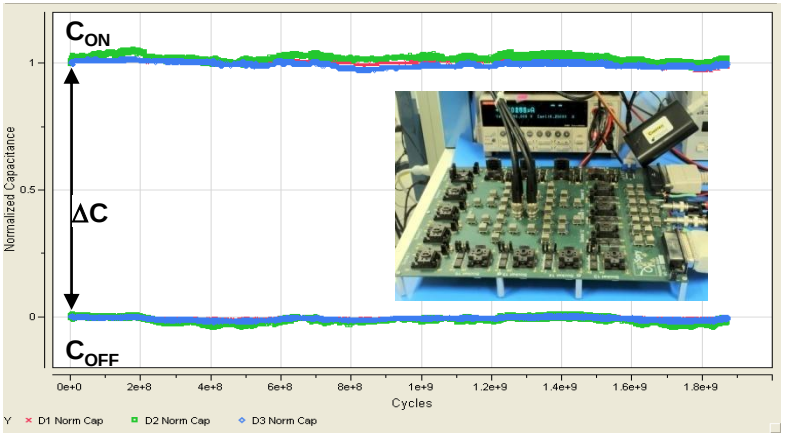
Temperature Stable



Hemeticity
(Wafer-level Encapsulation)



Long Life
(> 1B Cycles in Parallel Testing)



Example Application
Tunable Impedance Matching (TIM) Network

ANT

CLK
Din
/LE
Dout

MEMS Network & Controller IC

3V

SPI 3 Wire Bus Control

Integrated Carrier Transceiver

Multi-band (800-2200 MHz)
Low Loss (~0.3 dB)
80 Tunable Capacitors

TCVR

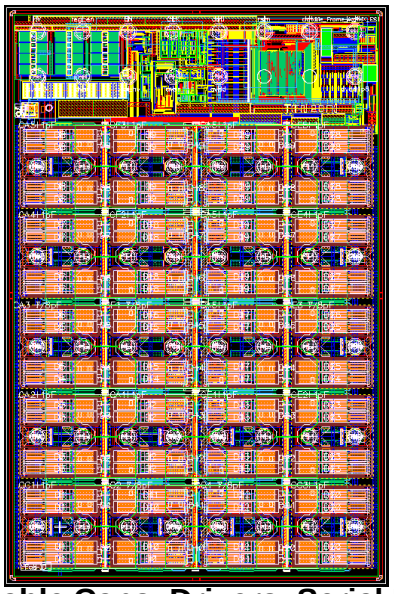
Ceramic **or** Laminate

CMOS / MEMS DIE

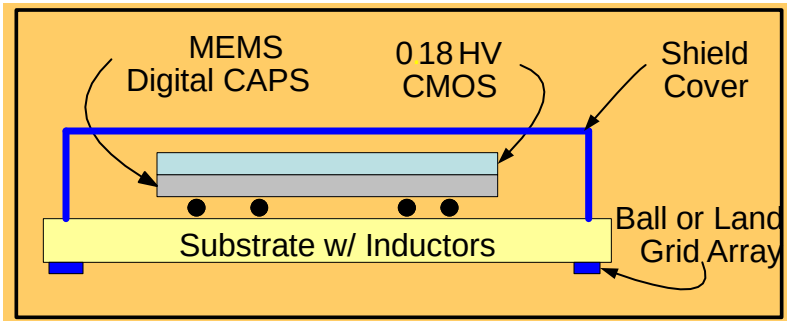
RSTN
EN
DI
DO
CLK
XCLK
VDIG
VANT

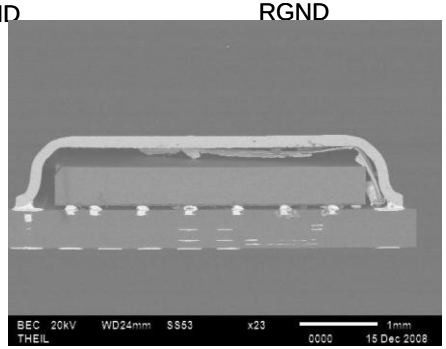
CAP TUNE REGISTERS
SERIAL PORT INTERFACE
CP CNTRL
CHARGE PUMP
35V
HIGH VOLTAGE DRIVERS
MEMS CAPACITOR BANK
L1
L2

AGND DGND VHO VHI HGND RGND ANT



Tunable Caps, Drivers, Serial Port Wafer Level Lid Seal

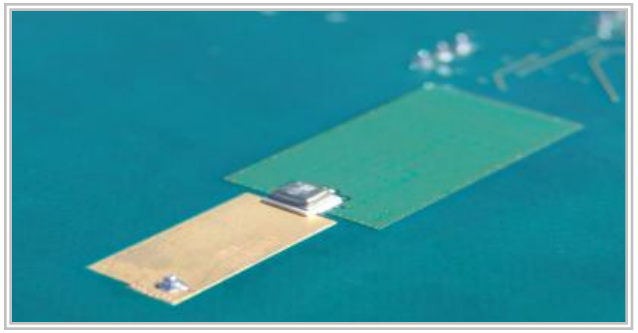




Power Savings
Measured WiSpry Product Performance

Engineering Sample Results on High Volume Production Phone

Tunable Antenna (TA) Demonstrator Measured Data



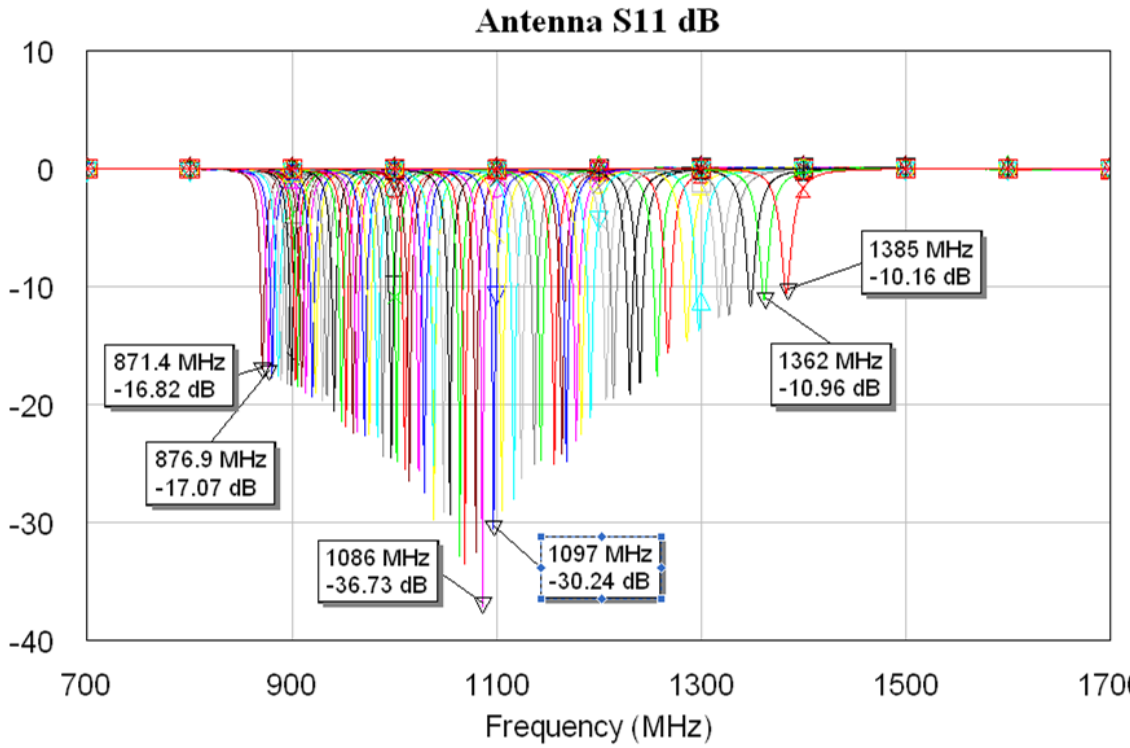
Low loss and highly linear tunable RF ICs enable antennas with:

- Tunability over at least one octave
- Sub-band operation
- Pre-select and spur suppression

- Impact on antenna volume (space) & efficiency by enabling:
- Smaller volume & same efficiency, or
- Same volume & higher efficiency

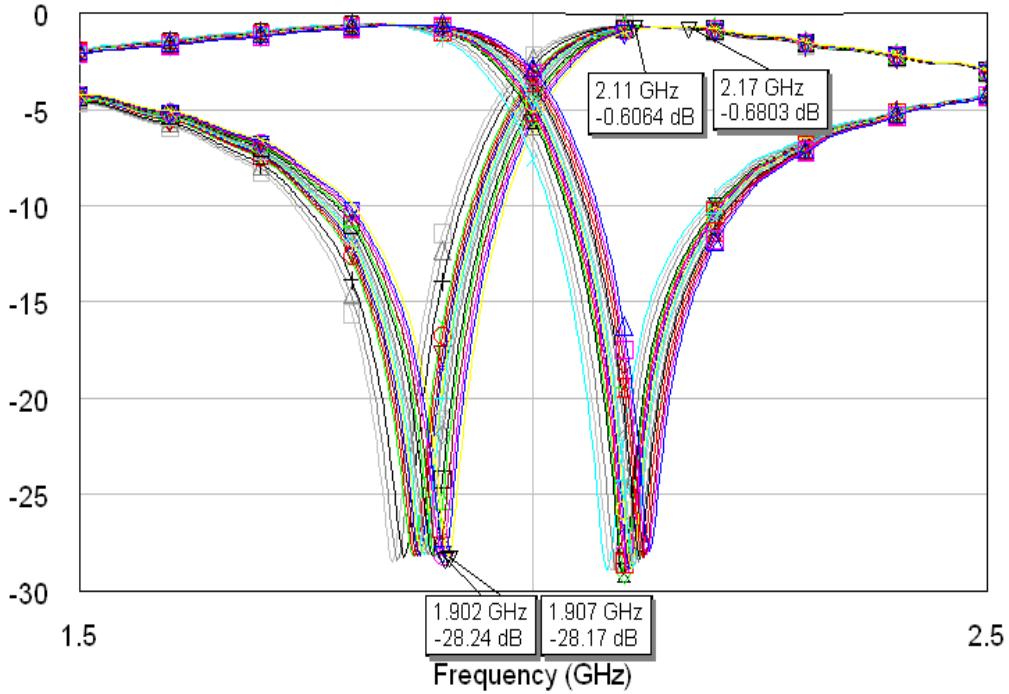
- Fairly omni-directional patterns
- Well-matched
- VSWR < 1.5:1 over passband

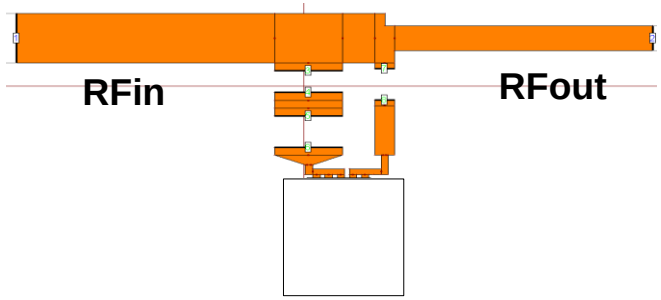
Demo TDCA tuning range – 3 to 11 pF



Tunable Filters (TF): Notch Filter Demonstrator Measured Data

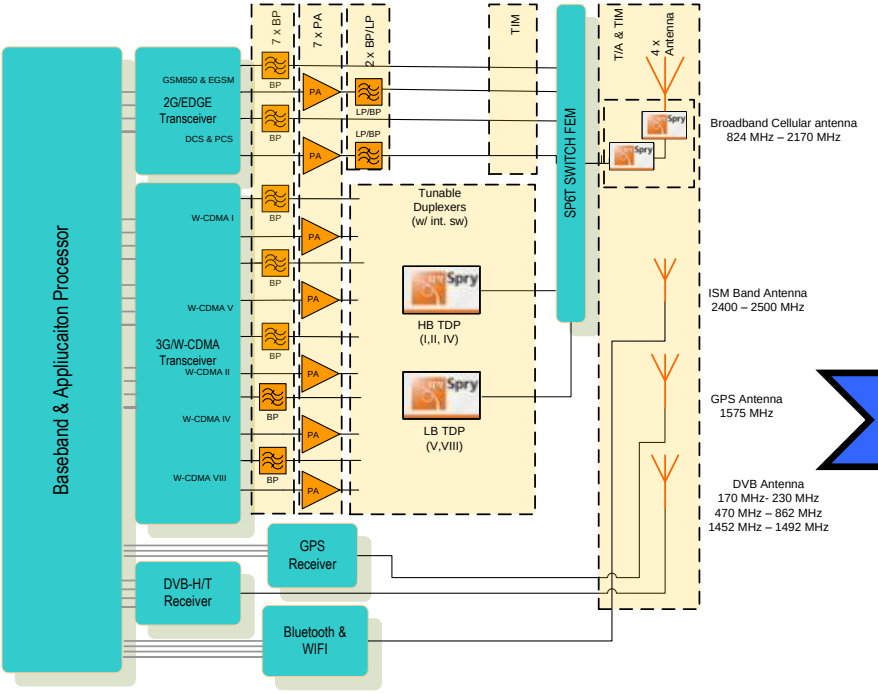
- Components:
  - SMD Air Core Inductor
  - Standard FR-4
  - Microstrip Line Based
  - 50 Ohms Input/Output
- Expected performance:
  - Insertion Loss ~0.7dB
  - Return Loss<-15dB
  - Rejection Level 23 dB
  - High-band Tunability
  - Variable Tx/Rx Spacing



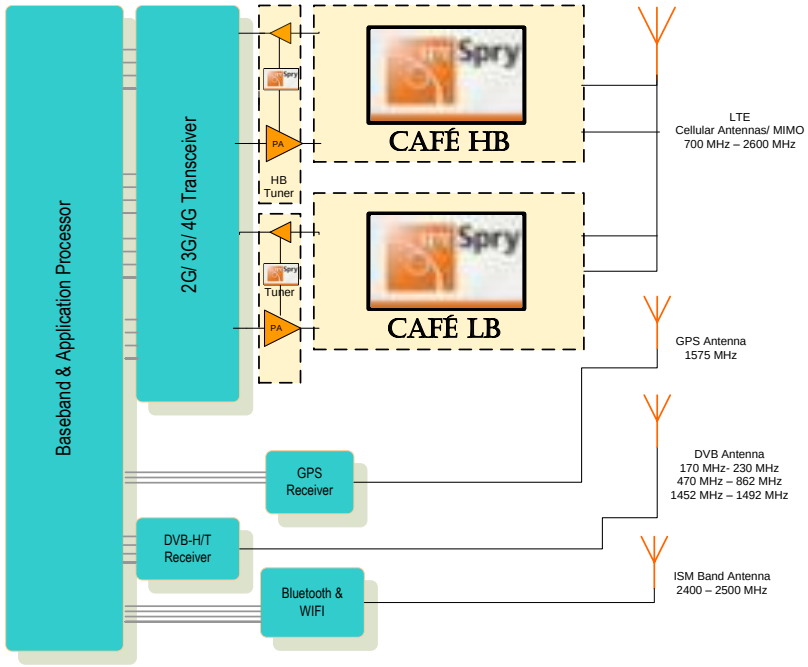


Cooperative R&D Effort with Tier 1 Network Operator

A Completely Tunable RF Integration Platform



Fully integrated Tunable RF Front-End

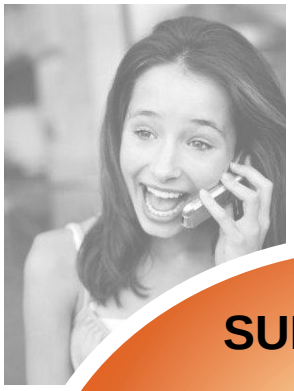


- Tunable Antenna Elements
- Tunable Low Noise Amplifier
- Tunable Antenna – Power Amplifier Matching
- Tunable Filters
- Tunable 3G Power Amplifier Tuners

Tunable RF Benefits the Mobile Eco-System

NETWORK OPERATOR

Lower infrastructure costs
Increased network B/W & Improved OTA
Regional platform programmability
Decreased “churn”



SUBSCRIBER

Fewer dropped calls
Up to 30% better battery life
More features – for less!
Talk everywhere @ anytime

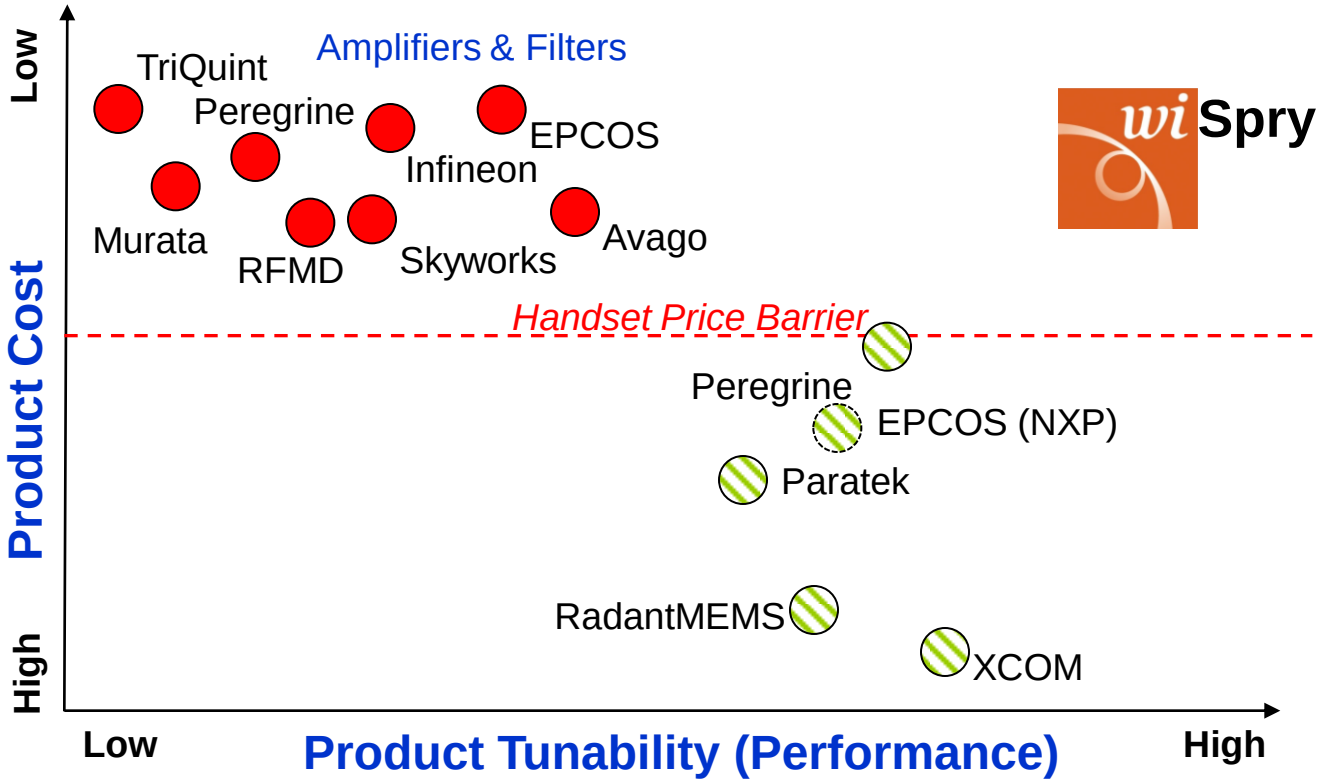
Mobile Innovation 2009 Global Competition
VIRTUAL TOURNAMENT
GLOBAL SEMI-FINALIST

CTIA 2009 Emerging Technology Awards Finalist

TERMINAL OEM

3dB + performance gain
Lower BOM
smaller & thinner form-factor
Increased battery life
Reduced SKUs
Faster time-to-market

Competitive Landscape



WiSpry Integrates

RF IC Cost/Integration + **Tunability (Performance)**

Summary

- 3G / 4G Mobile Terminals Require New Approaches to Integration of RF Front-End Functionality
- Tunable RF Components Based on Integrated RF-CMOS MEMS Balance Risk with Benefits
- Tunable Matching Networks, Antennas, and Filters Have Been Demonstrated Using a Digital Capacitor Array Architecture Implemented in 0.18um CMOS
- Research and Development of a First Generation Multiband Tunable Radio Front-End is in Progress

Questions?

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