Software Radios for Cellular/PCS Base Stations: Fact or Fiction

presented by:
Tom Gratzek
Analog Devices Inc.
Communications Division
(very) Simple Software Radio
“Follow the Money”

Cellular/PCS Market Structure
Radio Owner Needs

• **Handset** -
  – long battery life (talk/standby)
  – small size, low cost
  – clear voice
  – features: handsfree, messaging, voice activation, etc.

• **Infrastructure**
  – low initial cost
    • BOM, size, site coverage, time to revenue, spectrum utilization
  – low lifecycle costs -
    • low utilities, site rental, radio reliability,
    • inexpensive upgrades - frequency planning, vocoder change
  – network reliability - uptime/service
Software Radios: Marketing Slide
Cost Implications

- Single radio for all RF channels
- Cost per channel decreases with Wideband solution
Cellular Standards Evolution

• 1st Generation - FM - AMPS, NMT, TAC
  – 30 KHz channels - 1 call per channel

• 2nd Generation
  – IS-136 - 3 users/channel - 30KHz channels
  – GSM; 8 users/channel - 200 KHz channels
  – IS-95 CDMA; 16+? Users/channel - 1.25MHz chan.

• 3rd Generation
  – in standardization process
  – 5 + MHz channels; capable of high speed data
GSM Requirements: tough job
Software Radio Business Cases

- Steinbrecher -
  - sold to Tellabs
  - 1998 getting out of wireless; focus on fiber apps
- Watkins Johnson - changing commercial strategy
  - System “Base2” wideband software base station
- Airnet - changing company message
  - mixed success in market; management changes
- Arraycom - changed early technology focus to concentrate on customer needs - WLL/PHS
Software Radio: *the vision*

- **Build one radio for all standards** (gsm, amps, cdma,…)
  - required performance can’t be obtained
  - not much practical need for multi-standard radios
- **Software radios are “future proof”**
  - what are future requirements?
- **Software radios are smaller/lower cost**
  - RF channel count/base station declining
- **Software radios can fit into your network**
  - the value is the network, not the radio
  - Who cares about the network…we need financing?
Multi-Carrier Wide Band Radio Architectures

• “Holy Grail” of System and Converter Designers, offers the promise of…
  – Eliminating redundant RF signal paths (cost, size, complexity, yield, adjustments)
  – Single “software radio” is re-programmable for different air interface standards
  – permits incremental channel or standards changes

• However, there are challenges to implementation……
Multi-Channel RX Challenges

High Dynamic Range Radio

High SFDR ADC
Multi-Channel Receivers need...

• Very large dynamic range (SFDR)
  – No analog channel filter to attenuate blockers
  – Mixers, amplifiers, ADCs need excellent IMD

• Systems with compatible blocker requirements
  – GSM 900 very difficult to implement with current technology…-13 dBm blocker versus -104 dBm floor
  – DCS1800/PCS1900 can be implemented with current technology

• Compelling economic reasons to replace existing solutions
Receiver Architectures
Narrowband Chipset comparison (*IF to digitizer(s)*)}
Transmit Architectures
Wideband TX Challenges
Military roots; commercial needs

- Radio Standard - IS-136, GSM, CDMA, prop., etc.
- Cell Coverage - Macro, Micro (5W), Pico (1W)
- Commercial applications have bounded requirements
- Must meet cost goals and have business reason
  - Component and architectures
  - ADCs, amplifiers, DACs, DSPs, etc. Have all dramatically improved
- Software radio techniques used to fill niches
- Must find channel to network supplier
Multi-Channel Applications
Phased Antenna Arrays

• Increase cell range using beam forming technology to control antenna array pattern (may be dynamic)

• Changes the cost content of Base station
  – Transmit Power amplifiers are expensive. Power and cost are reduced for each element $n$ transceivers per RF channel…
  – An ideal candidate for a Wideband Architecture!

• Simplifies design
  – One Local Oscillator for complete system
  – All tuning done digitally, all NCOs are phase synchronized
  – low incremental cost for added capacity
Transmit Phased Array
Receive Phased Array
Dataquest: “Market forces”

- Replace single channel PA with MCPA
- More robust signal processing algorithms
- Process more base band channels through fewer DSPs
- Move the digital processing of RF/IF signals closer to the antenna
- Increased demand for pico/micro cells and repeaters to fill dead spots in networks
Analog Devices Experience

• Much greater focus on commercial markets…
• “Democratization” of Military Radio technology
• Key application area
  – phased array systems - frequency utilization
  – new radio architectures - lower cost, smaller size
  – new single channel, high IF sampling chip sets
    • lower RF BOM, less factory tweaking,
    • higher factory yields, less development costs
    • dramatically smaller radios
    • predictable digital vs. analog filtering