Software Defined Radios for Third Generation (SDR for 3G)

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…. Motto ….

- ➤ **Anywhere**
  - ➤ **Anytime**
    - ➤ **Anywave**

Wireless

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- Introduction.
- Basic SDR.
- 3G Network.
- Design Tradeoffs.
- Soft ADC

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Part(1): Thesis Overview

➢ **Introduction.**
➢ **Basic SDR.**
➢ **3G Network.**
➢ **Design Tradeoffs.**
➢ **Soft ADC.**

Introduction

❑ Software defined radio uses programmable digital devices to perform the signal processing necessary to transmit and receive baseband information at radio frequency.

❑ Devices such as digital signal processors (DSPs) and field programmable gate arrays (FPGAs) use software to provide them with the required signal processing functionality.

❑ This technology offers greater flexibility and potentially longer product life, since the radio can be upgraded very cost effectively with software.

Terms Used:

Software Defined Radio (SDR); This is the term adopted by the SDRForum—an international body looking at the standards aspects of software radio.

Multi-Standard Terminal (MST): It refers to a terminal which is capable of operation on a number of differing air interface standards.

Reconfigurable Radio; This term is used to encompass both software and firmware reconfiguration. Both forms of reconfiguration are likely to be necessary in any cost and power-efficient software radio implementation.

Flexible Architecture Radio (FAR): This is a wider definition still than those above. It indicates that all aspects of the radio system are flexible. A true FAR should allow parameters such as the number and type of up/down conversion stages to be altered by software as well as, for example, IF filter bandwidths and even the RF frequency band of operation. This is clearly a utopian goal for software radio.
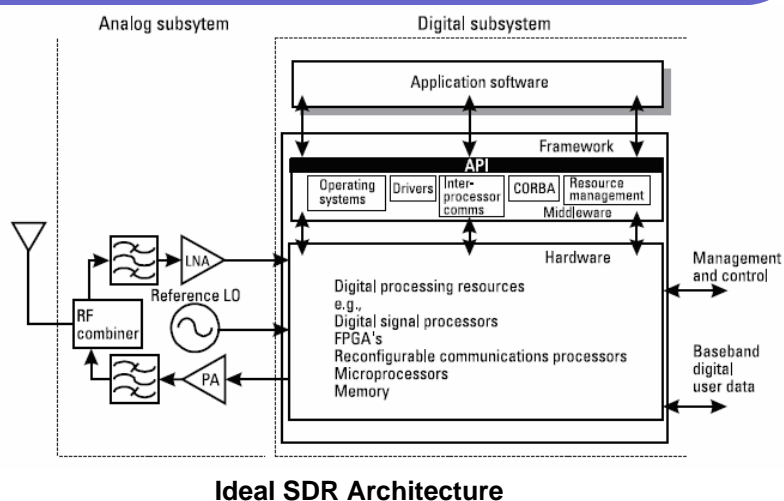
SDR Forum

The SDR Forum is an open, non-profit corporation dedicated to supporting the development, deployment, and use of open architectures for advanced wireless systems.

❑ **Membership is represented by software radio manufacturers, telecommunications infrastructure and terminal manufacturers, silicon chip vendors, test equipment makers, telecommunications companies, scientific and research organizations.**

❑ **There are three parts to the Forum's technical committee**:

   ✓ The download/ handheld

   ✓ Base station/smart antennas

   ✓ Mobile working groups.

Basic SDR
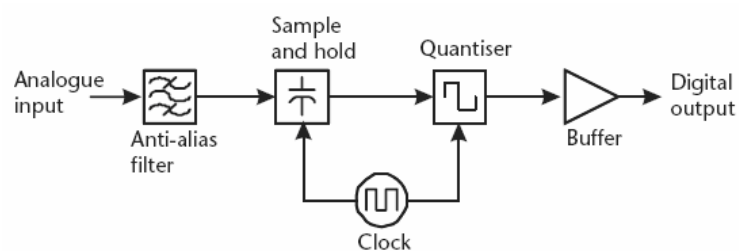

Ideal SDR Architecture

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SDR Limitation

An ideal software-defined radio receiver is often considered as an A/D converter connected directly to an antenna, the specifications for an A/D converter, which would be appropriate for use in the ideal software-defined radio are given in the Table below:

Table 2.2 Specifications for an Ideal Software Defined Radio ADC

Parameter	Value	Comments
Resolution	20 bits	= 121.76-dB dynamic range, assuming a perfect converter; this value results from assuming that >100-dB signal range is required (e.g., from −20 to −120 dBm) and that a 12-dB signal-to-noise ratio is required at minimum sensitivity
Sample rate	40 Msps	Based on 4× Nyquist sampling of a single UMTS WCDMA carrier, with alias downconversion
RF Input bandwidth	DC/100 MHz–2.2 GHz	To cover PMR, cellular, PCN/PCS, UMTS, mobile satellite
Spurious-free dynamic range	>121.76 dB	Assumed not to be the limiting factor in receiver sensitivity

SDR Limitation (Cont…)

- ✓ **RF access.**
- ✓ **Digital access bandwidth.**
- ✓ **Digital processing (flexibility and capacity).**

3G Network

Cellular System

- In order to increase the capacity of the Network, there are three possibilities, either:
    - ✓ **Increase channel number.**
    - ✓ **Employed efficient modulation and multiple access techniques.**
    - ✓ **The same channels are re-used, separated by a distance witch would not cause an unacceptable level of co-channel interference.**
- Cellular Networks Operate by dividing the service coverage area into zones or cells.

3G Network

Generation Changes in Mobile Network:

- **1G;** 1980's, Analog, FDMA/FM, Voice, **AMPS**.
- **2G;** 1990's, Digital, TDMA/GMSK, Data, **GSM**.
- **2.5G;** HSCSD, GPRS, EDGE.
- **3G;** 2000's, CDMA/OFDM, 5MHz, **UMTS**.
- **4G;** 2010-2015, QoS, Universal Access.

Mobile Satellite Systems

Mobile Satellite Systems

- **Satellite have been used to provide telecommunication services since mide-1960's.**

- **Mobile-Satellite services have been around since the start of 1980's.**

- **Example of Successful Systems;**
  - ✓ **Inmarsat;** 1979, 4 GEO Sat. (AOR-E, AOR-W, POR, IOR).
  - ✓ **Thuraya;** GEO, 2001, -22ºW/100ºE/60ºN/22ºS, 13 750 simultaneous calls.
  - ✓ **IRIDUM™;** 1996, 66 LEO Sat.

WCDMA

- **WCDMA bandwidth is 5 MHz or more, and its the nominal bandwidth of all 3G WCDMA proposals.**
- **This bandwidth was chosen because:**
  - ✓ It is enough to provide data rates of 144 and 384 Kbps, and even 2 Mbps in good conditions.
  - ✓ Bandwidth is always scarce, and the smallest possible allocation should be used.
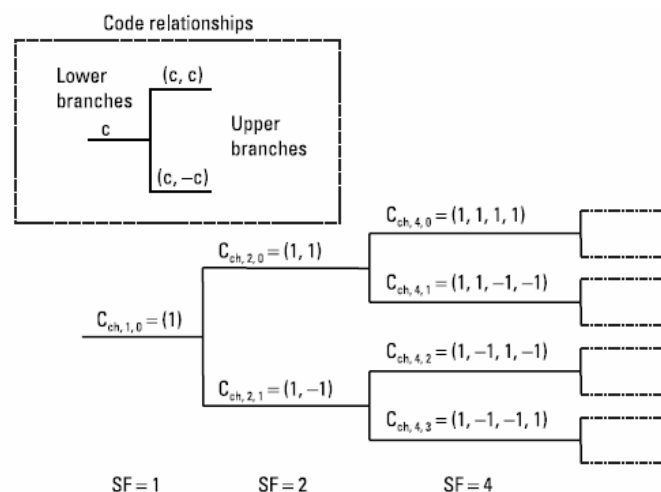 - ✓ This bandwidth can resolve more multipaths than narrower bandwidths.

Spreading

The spreading codes exhibit good orthogonal properties between each other, and they are used to multiplex users on the downlink and for identification of terminals on the uplink.

These codes use the orthogonal variable spreading factor (OVSF) technique and are generated from a single base Walsh-Handmaid matrix:
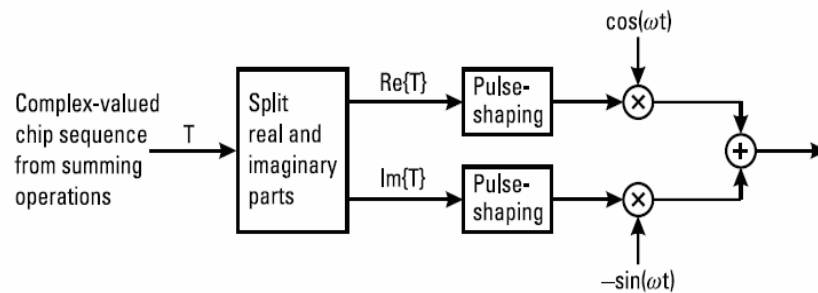
$$C_{2N} = \begin{bmatrix} C_N & C_N \\ C_N & -C_N \end{bmatrix}$$
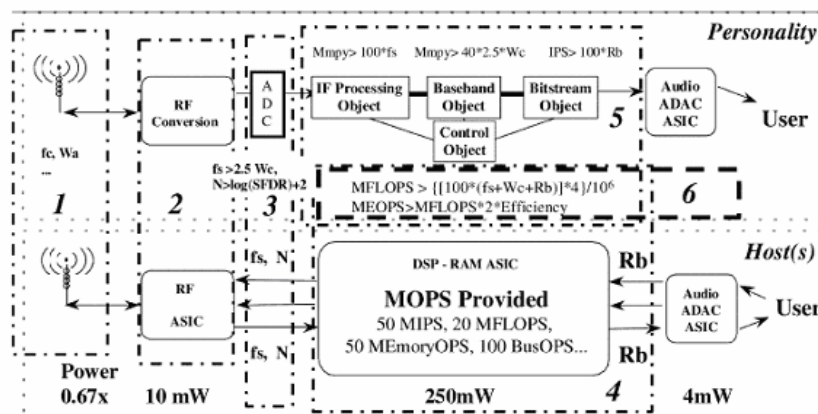
Spreading (Cont…)

Code relationships

Lower branches
c
(c, c)
(c, −c)
Upper branches

$C_{ch, 1, 0} = (1)$

$C_{ch, 2, 0} = (1, 1)$

$C_{ch, 2, 1} = (1, -1)$

$C_{ch, 4, 0} = (1, 1, 1, 1)$

$C_{ch, 4, 1} = (1, 1, -1, -1)$

$C_{ch, 4, 2} = (1, -1, 1, -1)$

$C_{ch, 4, 3} = (1, -1, -1, 1)$

SF = 1   SF = 2   SF = 4

Modulation

WCDMA uses QPSK to modulate the complex valued chip sequences
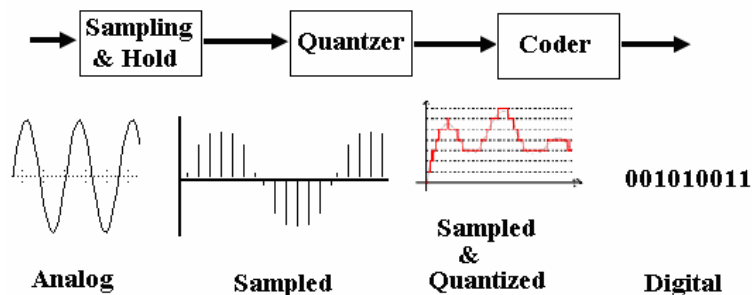

Design Tradeoffs

Soft ADC

Software defined radios, as with all wireless digital communications devices, must at some point convert their discrete and digitized information stream into analog form for transmission.
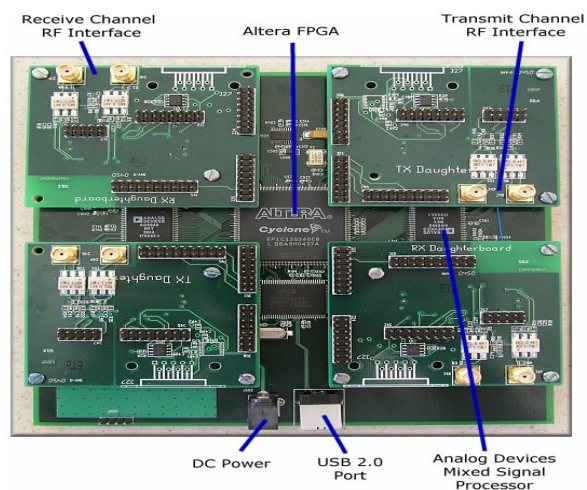
Basic ADC

Time / Amplitude	Continuous	Discrete
Continuous	Analog	Sampled
Discrete	Quantized	Digital

Sampling & Hold → Quantzer → Coder →

Analog

Sampled

Sampled & Quantized

001010011

Digital

Part(2): Successful SDR Examples

- ➢ **SDR Kits.**
- ➢ **Spectrum Analyzer.**
- ➢ **SDR BTS.**

SDR Kit

Receive Channel RF Interface · Altera FPGA · Transmit Channel RF Interface · DC Power · USB 2.0 Port · Analog Devices Mixed Signal Processor

Spectrum Analyzer

SDR BTS

Flexent® OneBTS™ Base Station
For TDMA PCS Networks

Lucent Technologies' Flexent® OneBTS™ Base Station for TDMA PCS Networks is a high capacity and high coverage base station for stand-alone and co-located indoor configurations. The Flexent OneBTS common platform architecture leverages market proven hardware and software technologies developed for the Flexent TDMA platforms. This innovative base station uses a Multiple Carrier Power Amplifier (MCPA) that supports seamless IS-136 voice growth in the 1900 MHz spectrum. Initial configurations will support up to 10 ANSI-136 carriers per sector with future releases supporting up to 20 ANSI-136 carriers per sector to deliver maximum spectral efficiency and substantially reduce your cost per carrier.
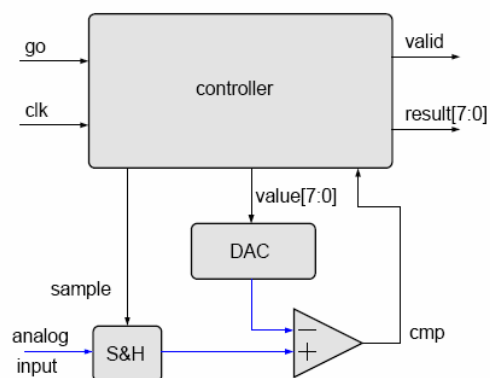
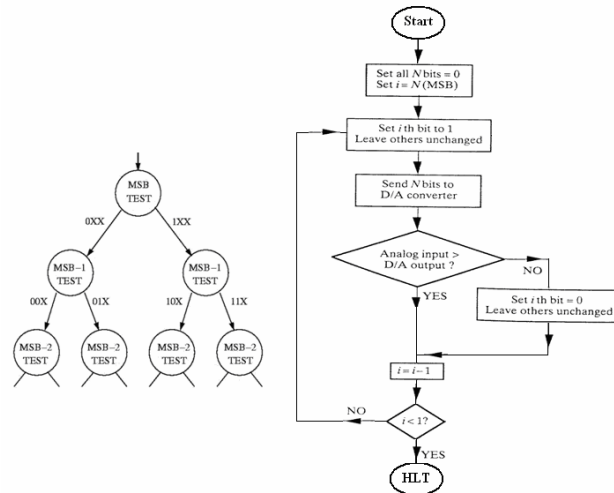Lucent Technologies
Bell Labs Innovations

Part(3): Practice SDR

- ➢ **Block Diagram**
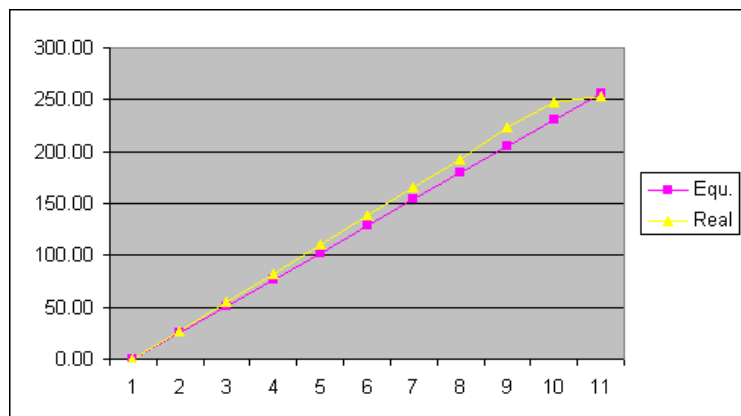- ➢ **System Flow-Chart**
- ➢ **ADC Specifications**

Block Diagram

System Flow-Chart

ADC Specifications

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Conclusion & Future Recommendations

- From the perspective of keeping pace with an ever-changing air interface environment and enabling multi-technology roaming, SDR has key advantages for the network operator.
- In addition, the same techniques needed to solve user application space.
- SDR designs create major computational challenges for ASICs and DSPs.
- It's recommended that future works can improve the circuit design by improve the resolution and other factors. Also many researches can cover other stages like frequency up- and down-conversion or signal processing part.

Thank You

SDR for 3G

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