Capacity and increased data services drive the evolution from 2G to 3G

**2G**
- IS-95A CDMA
  - 1.2288 Msps
  - 9.6-14.4 kbps
- IS-136
  - 48.6 kbps
- IS-95 B
  - 1.2288 Msps
  - 9.6-115.2 kbps
- GSM
  - 270.833 kbps
  - 9.6-14.4 kbps
- IS-136+
  - 48.6 kbps
  - 43.2 kbps
- PDC
  - 21 kbps

**2.5G**
- IS-136HS
  - 270.833 kbps
  - 384 k-2 Mbps
- EDGE
  - 270.833 kbps
  - 384 kbps
- HSCSD/GPRS
  - 270.833 kbps
  - 28.8-171 kbps
- UMTS
  - 3.84 Msps
  - 384 k-2 Mbps
- W-CDMA
  - 3.84 Msps
  - 384 k-2 Mbps
- EDGE
  - 270.833 kbps
  - 384 kbps

**3G**
- IS-2000 1x
  - (cdma2000)
  - 1.2288 Msps
  - 144 kbps
- IS-2000 3x
  - (cdma2000)
  - 3.6864 Msps
  - 384 k-2 Mbps
- UMTS
  - 3.84 Msps
  - 384 k-2 Mbps
- W-CDMA
  - 3.84 Msps
  - 384 k-2 Mbps

**EU**

**US**

**JPN**
3G Waveforms - Challenging to maintain linearity

Time Domain Waveform

W-CDMA Forward Link, 4 Channels

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Receiver Architectures

Baseband Sampling (Superheterodyne)

IF Under-Sampling (Direct IF)

Baseband, Analog Down-conversion

Multi-carrier RX, Digital Demod

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Transmitter Architectures

Nyquist Baseband

Direct Digital IF

Nyquist Baseband with Digital Interpolation

Multi-Carrier Architecture
SoftCell™ Multicarrier Transceiver

Enabling Technology for Software Radios

Receive Specifications
- >100 MSPS Sampling
- 100+dB Dynamic Range

Transmit Specifications
- >100 MSPS Sampling
- 85+dB Dynamic Range

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Base Station Receiver
Analog Base Band I and Q Architecture

One or Two IF stages….radio dynamic range doesn’t permit Direct Conversion

Narrow band (GSM) Dual ADCs:
- AD7724 (ΣΔ modulator), AD7729 ΣΔ ADC 16-bit

Wide Band (CDMA) Dual ADCs
- AD9066  6-bit
- AD9058/59 8-bit
- AD9288 8-bit
- AD9218 10-bit (pin compatible to 9288)
- AD9238 12-bit
Base Station Receiver
Single Carrier Direct IF Sampling

- Single conversion radio design (WBCDMA shown) reduces radio part count and complexity
- Digital Filtering adds flexibility and reliability

- High Freq. Analog Input ADCs
  - 10-bit: AD9410
  - AD6600 Diversity Receiver (GSM, IS95 CDMA)
  - 12-bit: AD6640, AD9432/33, AD9226, AD9235/38
  - 14-bit: AD6644
Multi-carrier
SoftCell™ Low IF Sampling

- Double conversion radio, multi-carrier digitizer
- High Dynamic range requires Low IF Frequency 5MHz to 25 MHz bandwidth centered at < 70MHz

Diagram:
- 1st IF >200 MHz
- IF <70 MHz
- SAW 5-25MHz
- AD662Z
- RAKE
- AD6624
  - Channel 1
  - Channel 2
  - Channel 3
  - Channel 4
- DSP

ADI Confidential
AD6644 IF Sampling a WCDMA Multicarrier Signal @ 200 MHz

- Encode = 60 MSPS
- Ain Frequency = 200 MHz
GSM Chipset for Single Carrier Diversity
ADI Innovation

Traditional: Two channels required for diversity

- 200 MHz IF
- Hi selectivity filter = $$
- RSSI DAC
- 10.7 MHz filter
- LO
- Baseband I&Q Demod, filter, & digitize
- AD6600
- AD6620
- AD6625
- ADC
- ADC
- DSP

AD6630/8350 moving to DVGA

- 70-250 MHz IF Main
- SAW Filters
- AD6600
- AD6620 AD6625
- DSP

70-250 MHz IF Diversity

Diversity Chipset

Drive down cost & size of receiver... more digital “IF” processing
Analog Baseband I and Q
Classic IF Upconversion - ALL air standards

- Quadrature matching is important in all components
  Dual DACs are perfect, Interpolation eases LPF design
  AD8345 works well at fixed frequency
- ADI’s new line of PLLs work great in both fixed and tunable synthesizers

ADI Confidential
Direct Conversion to RF works for CDMA

- Quadrature matching is critical BUT DIFFICULT AT RF
- 3G can employ direct conversion transmitters
- GSM needs fast LO (AD9858 development)
Direct Digital IF Tx Architecture
Feasibility work underway

- Modulation Performed Digitally hence Near “Perfect” Accuracy
- DAC’s Dynamic Range within Specified “Window” determining 1st IF Passband Tuning Range. Insufficient Tuning Range Will Require a Second Tunable Synthesizer
- Low IF hence requires 2nd IF and tunable analog synthesizer
- LPF must have flat passband and group delay over 1st IF Passband
- Possible to Use “Higher Image” of DAC Output for 1st IF BUT Sinx/x Effect on Passband flatness, and CNR must be evaluated
SAW Filter Requirements
For Direct Digital IF Tx Architecture

- Image Problem of 1st Mixing Stage Often Requires 2 SAW’s to Reduce LO Feedthrough and Image by >80 dBc
- IF Amplifier(s) required to compensate for SAW Filter(s) Losses (i.e. 7-20 dB per SAW filter)
- SAW Filter Losses Combined with Mixer NF Affects Overall Tx Noise Figure and IF Amp Requirements
- SAW filters Passband Amplitude Ripple and Group Delay Variation Affect EVM of Signal.
- Asymmetrical Passband of SAW filter which is sensitive to Matching Network Affects EVM of Signal. Complex Equalizer May be Required for High Level QAM
Multicarrier Tx Challenges

SoftCell

- AD6622 supports 4 narrowband carriers (GSM/EDGE)
- IS136/ EDGE (N.America) is market driver
- CDMA can also be supported from same platform

DAC (AD9772A) and Multi-Carrier Power Amp (MCPA) are limitations on performance
IF Image-Rejection Tx Architecture for Single or Multi-Carrier Applications

I/Q Single/Multi-Carrier Interleaved or Non-interleaved COMPLEX DATA

AD6623 DUC or QAM ASIC

AD9777
Producible Interpolation with Fs/4 or Fs/8 Complex Modulation

14-bit DAC

14-bit DAC

Programmable Interpolation

OSR X F_{SYMBOLE} = F_{LO}/(M*N)

F_{LO}/N

F_{DAC}/4 or F_{DAC}/8

Quadrature Upconverter

SAW

IF Log Amp
IF Image-Rejection Tx Architecture

Benefits
- Requires Single SAW Filter
- Improves Tx Noise Figure and IF Gain Stage Requirements
- Provides Theoretical 3 dB Improvement in CNR and ACP Performance
- Modulation Still Performed Digitally
- LO Suppression and Image Rejection Can be Calibrated

Drawbacks
- Requires Additional DAC to represent Digital IF as Complex Signal and a High Performance Analog Quadrature Modulator