ADI Views on mmW 5G

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Agenda

► mmW 5G Goals
► Strategies to Achieve These Goals
► Beamforming
► mmW 5G Technical Challenges
► Architecture Discussion
Primary Goals for mmW 5G

- Higher throughput
- Higher capacity
- Higher spectral efficiency
- Less latency
- Lower power
5G Vision

IMMERSIVE EXPERIENCE
Enhanced Mobile Broadband

FOR EVERYTHING
Massive Machine Type Communication

INSTANT ACTION
Ultra Reliable Machine Type Communication

- Immersive entertainment and experiences
- Improved public safety and security
- More autonomous manufacturing
- Sustainable cities and infrastructure
- Reliable access to remote healthcare
- Efficient use of energy/utilities
- Digitized logistics and retail
How to Meet these Goals

► Build on 4G
  – OFDM-like Waveforms
  – Antenna Arrays

► Move to Higher Frequencies
  – Greater Bandwidth
    • More users; more throughput
  – Smaller Antennas
    • Allows higher antenna gains
  – Beamforming
    • Overcome higher path loss
    • Spatial isolation
    • Better use of spectrum

► Increase Integration
Beamforming Solutions

► Digital Beamforming (DBF)
- Pros
  - Most flexible
  - Most capacity
  - Steer multiple beams and nulls
- Cons
  - Very high power and cost of digital processing / transport
  - No spatial rejection from FE

► Analog Beamforming (ABF)
- Pros
  - Relatively low cost
  - Much lower DSP
  - Low power consumption
- Cons
  - Single beam
  - Single stream

► Hybrid Beamforming (HBF)
- Pros
  - More capacity than ABF
  - Much lower complexity / power than DBF
- Cons
  - Harder to perform MIMO processing
Array Size Optimization for 60 dBm EIRP

- Smaller arrays have less gain and therefore require more power per element
  - GaAs or GaN PAs dominate power consumption
  - DPD has large benefit

- Larger arrays have much higher gain and therefore require less power per element
  - Can be SiGe or CMOS (see green curves)
  - DPD has much smaller or even negative impact!

- Conclusion
  - With DPD: 64-128 elements
  - Without DPD: 128-256 elements
  - High power PA's not optimal!
Array Size Optimization for 70 dBm EIRP

Optimum array size
- With DPD: about 256 elements with ≤22 dBm PAs
- Without DPD: >512 elements with ≤20 dBm PAs
Five Significant Challenges for mmW 5G

► Reduce digital power consumption to enable more capacity and move towards DBF
  – Data converters
  – JESD lanes

► Wideband DFE processing
  – QEC and CFR
  – Spur reduction/cancellation

► Improve PA efficiency
  – Currently ~2-4% for each antenna element without DPD
  – How to perform DPD over N PAs in sub-array
  – Or comparable PA efficiency technique (envelope tracking, Doherty, …)

► Calibration of gain/phase to allow accurate beam steering and interference rejection
  – Within a sub-array
  – Between sub-arrays (to allow combining of sub-arrays)
  – Reduce or eliminate phase variation with gain (and gain variation with phase) to reduce calibration complexity
  – Phase synchronize multiple LO’s over M streams

► Shrink mmW electronics to fit in back of antenna array
  – λ/2 between 4-6 mm for the 25 – 39 GHz bands
Chipset Architectures

► HBF block diagram shown at right
► Macrocell may have individual chips for each function (including PA)
  – Many designs use a high IF configuration with digital board and microwave board
► CPE will support fewer (1?) stream and silicon PAs
► UE may have all functions integrated into one chip

► Can CPE chipset be used to construct Macro BTS?
► Will traditional PAs disappear from BTS designs?
Summary

► Full DBF at mmW still a number of years off (if ever!)
  – ADI actively investigating improved transceiver, converter and transport technologies

► HBF is currently most cost effective architecture to achieve mmW 5G goals
  – Different chipset architectures for the various use cases / applications
  – ADI has chipsets / technologies to form the complete HBF radio chain

► Looking to work with ecosystem partners and customers as the standards evolve toward high volume deployments
THANK YOU!