A 10-40 GHz Chipset for mmWave Imaging and other Wideband Receive Applications

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Millimeter Wave Imaging is a technology that forms images of a target by measuring the phase and amplitude of a signal that reflects off of that target. Multiple wideband frequency sweeps that are spatially dispersed, are used to build up a multi-layer 3D image. This Microapps talk will describe how a new chipset from Analog Devices addresses the demands of commercial mmWave Imaging and will also explore other applications of this chipset.
mmWave Security Scanner Operation
mmWave Security Scanner Operation

- **Rx**
- **Tx**

- a1 \( \varnothing 1 \)
- a2 \( \varnothing 2 \)
- a3 \( \varnothing 3 \)
- a4 \( \varnothing 4 \)
- a5 \( \varnothing 5 \)
mmWave Security Scanner Operation

- **Rx**
- **Tx**

- **a1 Ø1**
- **a2 Ø2**
- **a3 Ø3**
- **a4 Ø4**
- **a5 Ø5**
mmWave Security Scanner Operation

[Diagram showing Tx and Rx with labels a1, a2, a3, a4, a5 and Ø1, Ø2, Ø3, Ø4, Ø5]
mmWave Security Scanner Operation

Critical Hardware Requirements
► Fast Channel Switching
► Multi-Channel Devices
► Fast Frequency Switching
► Wide Operating Bandwidth
► Tx to Rx Synchronization

► Move to next frequency and repeat

Source: Pacific Northwest National Laboratories
Wideband Multi-Point Transmit/Receive Architecture
ADAR2001 Quad Transmitter

- Input frequency: 2.5 - 10GHz
- Output frequency: 10 - 40GHz
- 4x Frequency Multiplier with programmable harmonic filtering
- Max Output Power: +5 dBm (differential)
- "Sleep", "Ready" and "Enabled" operating modes for fast sweeping and power consumption optimization
- Dual Programmable State Machines for easy control of
  - Multiplier/Filter Configuration (up to 16 States available)
  - Tx Channel Enable and Switching (up to 70 States available)
  - Output Power Level
- 6 mm x 6 mm LGA Package
ADAR2001 Output Power vs. Frequency and Channel-to-Channel Switching

ADAR2001 Output Power for Optimized Band Switching
EV2, “Optimized” Settings, Differential TX3 Output

Output Power (dBm)
TX Frequency (GHz)

<2ns
<3.5ns
ADAR2004 Quad Receiver

- Quad Diff-In/Diff-Out Mixer/VGA
- Input Frequency Range: 10 - 40GHz
- Output IF Range: 0 - 300 MHz
- 4X LO Multiplier with programmable harmonic filtering (LO Input Frequency Range: 2.5 - 10 GHz)
- 25 - 30 dB LO Harmonic Rejection Ratio (HRR) at all frequencies
- “Sleep”, “Ready” and “Enabled” operating modes for fast LO sweeping and power consumption optimization
- Programmable Sequencer for easy control of
  - LO Multiplier/Filter Configuration (up to 16 states available)
  - Rx Channel Configuration and Enable (up to 16 states available)
- 3-wire or 4-wire SPI Port
- 7mm x 7mm LGA Package
ADAR2004 Quad Mixer – RF and IF BW

ADAR2004 Single-Ended Gain vs. Bias Condition
Eval Board, all channels on, FIF=100MHz, Max Gain

ADAR2004 Single-Ended Gain vs. Gain Setting
Frf=29 GHz, Low-Side LO

RF BW

IF BW
AD9083: 16 channel, 125MHz bandwidth ADC

Features and Specifications

- Reconfigurable, variable-rate, 1st-order CT ∑Δ ADC
- Sample rate = 1–2Gsp/s
- Analog Bandwidth ≤ 125MHz
- NSD ≤ –147dBFS/√Hz
- SFDR: >70dBc at 125MHz
- Analog full-scale input: 0.5-1.5Vdpp

Digital Processor
- CIC Decimation Filter
- Programmable DDC with 3 DDC channels/adc
- Programmable FIR filter
- Data gating
- FIFO with 32 sample depth
- JESD204B+ (up to 16Gbps)

- On-chip PLL for ADC and SERDES clock generation

- Supplies: 1.8V / 0.9V

- Power consumption
  - 8-35mW per adc channel
  - 3-10mW per dsp channel
  - 64mW per serdes lane
  - 370-1050mW total
ADI Tile - mmW Screening System-Level Evaluation Board

- System Eval board consists
  - ADAR2001/4 Tx and Rx RF ICs
  - LO distribution,
  - AD9083 16-Channel ADC
  - Control FPGA
  - Interface connector
  - Clock and LO Generation/Distribution
  - Power Management

- Antenna “Edge” boards attach via 2.92mm connectors or cables.

- Local FPGA
  - Configures & Sequences Devices
  - Extracts Baseband Vectors
  - Supports 12.5/15 Gsps JESD

- System reference clock and/or JESD output available to sync LOs or other eval boards

- Image processing occurs off-board with signals routed through FMC connector or XAUI port

- Software GUI for Board setup, API for system operation
RF Connections to Eval Board

- Edge mount PCB to support Vivaldi Antenna
- Cable out to Instrument, external Antenna
- Horizontal PCBs to support Patch, Spiral, Log Periodic Antennas

Adapters:
- Right Angle 2.92mm M-M adapter
- Straight 2.92mm M-M adapter
Non-Imaging Applications: ADAR2001 Wideband LO Multiplier and Distributer

- Input LO Range: 2.5-10 GHz
- Output LO Range 10-40 GHz
- LO Input Power: -20 dBm
- LO Output Drive Power: +5 dBm
- Single-Ended of Differential Output Drive
- Integrated LO Filtering
Non-Imaging Applications: Multi-Channel Wideband Receiver

- Input Frequency Range: 10-40 GHz
- IIP3: -10 dBm @ Min Gain
- IF Gain Range: 20 dB to 40 dB
- Noise Figure: 7.5 dB @ Max Gain
- IF BW: 1 GHz
- Power Consumption: ≈310 mW per Channel
  - 246 mW per RF Channel
  - 65 mW per ADC Channel
Come Visit Us at Booth B585
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