ADI Technologies
for 5G
5G Challenges

Does everything!

Works everywhere!

Ready in no time!
## Our Customers Pain Points

<table>
<thead>
<tr>
<th>Time to Market</th>
<th>No. Form Factor Variants</th>
<th>No. Frequency Variants</th>
<th>No. Software Variants</th>
<th>System Cost</th>
<th>Increased Antenna Count</th>
</tr>
</thead>
</table>

- Communications customers challenged by time to market, huge increase in portfolio complexity & cost pressures.
ADI Technologies for 5G Solution

Transceivers
- mmW 5G, M-MIMO, Wireless Infrastructure (WIFR) and Diverse Markets

High Speed Converters and RF
- WIFR, Cable, Aero/Defense (ADEF), Instrumentation, Auto

Microwave
- mmW 5G, Point to Point, Fixed Wireless Access, Satellite, ADEF

Clocking, Precision, Power, Isolation, Linear
- Wireless, Wired

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Wideband RF Transceiver Benefits

Highly Reconfigurable
Enables reduced time to market through common HW & SW
Small Signal Radio Platform

ADI Integrated Trx
100MHz – 6GHz
Programmable BW
Integrated uC

DFE/DBB

Unique Design/Product
Common HW + SW Across Products

Lowest Power Consumption
Reduce thermal density, enable lower SWAP radios

Lowest possible power dissipation
• Highest power consumption blocks operate at minimum bandwidth

Desired band
ZIF BW
IF BW
RF converter BW

Highest Level of Integration
Enables higher density radio architectures e.g. M-MIMO

3.5” (90mm)
2x2 Radio Foot Print
Comparison - Discrete vs. Integrated

Lowest System Cost

• Components such as IF filters are eliminated
• RF filters are simplified enabled by the elimination of out-of-band images or aliases

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## Wideband RF Transceiver Portfolio on RadioVerse®

<table>
<thead>
<tr>
<th>Part #</th>
<th>Applications</th>
<th>Bandwidth</th>
<th>Functionality</th>
<th>RF Tuning Range</th>
<th>Rx Image Rejection*</th>
<th>Tx OIP3*</th>
<th>EVM*</th>
<th>Package Size</th>
<th>Data Interface</th>
<th>DPD</th>
</tr>
</thead>
<tbody>
<tr>
<td>AD9361</td>
<td>3G/4G Picocell, SDR, Pt-Pt, Satcom, IoT Aggregator</td>
<td>56 MHz</td>
<td>2 Rx, 2 Tx</td>
<td>70 MHz to 6 GHz</td>
<td>50B</td>
<td>+19dBm</td>
<td>-40 dB</td>
<td>10 mm × 10 mm</td>
<td>CMOS/LVDS</td>
<td>N/A</td>
</tr>
<tr>
<td>AD9364</td>
<td>3G/4G Picocell, SDR</td>
<td>56 MHz</td>
<td>1 Rx, 1 Tx</td>
<td>70 MHz to 6 GHz</td>
<td>50dB</td>
<td>+19dBm</td>
<td>-40 dB</td>
<td>10 mm × 10 mm</td>
<td>CMOS/LVDS</td>
<td>N/A</td>
</tr>
<tr>
<td>AD9363</td>
<td>3G/4G Femtocell, UAV, Wireless Surveillance</td>
<td>20 MHz</td>
<td>2 Rx, 2 Tx</td>
<td>325 MHz to 3.8 GHz</td>
<td>50dB</td>
<td>+19dBm</td>
<td>-34 dB</td>
<td>10 mm × 10 mm</td>
<td>CMOS/LVDS</td>
<td>N/A</td>
</tr>
<tr>
<td>AD9371</td>
<td>3G/4G Macro BTS, Massive MIMO, SDR</td>
<td>100 MHzx Rx, 250 MHzx Tx/Orx</td>
<td>2Tx, 2Rx Orx &amp; SnRx</td>
<td>300 MHz to 6GHz</td>
<td>75dB</td>
<td>13.5dB/22dBm</td>
<td>+27dBm</td>
<td>-40 dB</td>
<td>12 mm × 12 mm</td>
<td>6GHz JESD204B</td>
</tr>
<tr>
<td>AD9375</td>
<td>3G/4G Small Cell, 3G/4G Massive MIMO</td>
<td>100 MHzx Rx, 250 MHzx Tx/Orx</td>
<td>2Tx, 2Rx Orx &amp; SnRx</td>
<td>300 MHz to 6GHz</td>
<td>75dB</td>
<td>13.5dB/22dBm</td>
<td>+27dBm</td>
<td>-40 dB</td>
<td>12 mm × 12 mm</td>
<td>6GHz JESD204B</td>
</tr>
<tr>
<td>ADRV9009</td>
<td>Macro BTS, Massive MIMO, Active Antenna, Phased Array Radar, Portable Test Equipment</td>
<td>200 MHzx Rx, 450 MHzx Tx/Orx</td>
<td>2Tx, 2Rx / 1 ORx</td>
<td>75MHz to 6GHz</td>
<td>75dB</td>
<td>12dB/15dBm</td>
<td>+27dBm</td>
<td>-43 dB</td>
<td>12 mm × 12 mm</td>
<td>12GHz JESD204B</td>
</tr>
<tr>
<td>ADRV9026</td>
<td>Macro BTS, Massive MIMO, Small Cell</td>
<td>200 MHzx Rx, 450 MHzx Tx/Orx</td>
<td>4Tx, 4Rx, 2ORx</td>
<td>75MHz to 6GHz</td>
<td>75dB</td>
<td>12dB/15dBm</td>
<td>+27dBm</td>
<td>-46 dB</td>
<td>14 mm x 14 mm</td>
<td>12GHz JESD204B</td>
</tr>
</tbody>
</table>

* typical performance @ 2.6GHz, ** typical performance @ 2.6GHz, AD9361 assumes internal LNA; AD937x and ADRV9009 no internal LNA, 1Available June 2020
ADRV9026 Functionality and Block Diagram

- **Single-chip TDD/FDD operation**
- **Functionality**: quad transmitters, quad receivers, and dual observation receivers with 2 inputs each
- **Bandwidth**: 200 MHz receiver, 200 MHz large signal/450 MHz synthesis transmitter, and 450 MHz observation receiver
- **Tuning range**: 650 MHz to 6 GHz
- **Interface**: 16 Gbps JESD204B/C
- **Power consumption**: 5 W
- **Multichip LO phase synchronization**
- **Package**: 14 × 14 BGA

1. For 25% Rx 75% Tx, 1x Orx on, 200 MHz/450 MHz/450MHz BW, 0 dB attenuation
2. 75MHz - 650MHz operation and EXT_LO support will be available in 2020.
ADRV9026: Quad-Chanel Wideband RF Transceiver Platform

Key Benefits

- Smallest size reduces footprint and enhances form factor flexibility
- 2x integration and 50% power consumption reduction over ADRV9009 enables increased radio density to support higher antenna count
- Enables ORAN® small cell designs with lowest system power and cost
- Single-chip FDD/TDD solution simplifies hardware and software development
- Reduces product development cycles for band and power variants
- Enables modular architecture for scalable radio solutions

Applications:

- Macrocell
- Massive MIMO
- Small Cell
# ADRV9026 Design Resources

| Evaluation Kits         | ► ADRV9026-HB/PCBZ for 2.8GHz to 6GHz  
|                        | ► ADRV9026-MB/PCBZ for 650 MHz to 2.8GHz |
| Carrier Platforms       | ► ADS9-V2EBZ                                  |
| Software                | ► Windows GUI/API/Firmware                    |
| Design File Package     | ► User Guide                                 |
|                        | ► EVB schematics, layout, BOM, gerber       |
|                        | ► BSDL, IBIS, JCOM, s-parameter models      |
| Design Tools            | ► FPGA Interoperability Report*              |
|                        | ► Filter Wizard*                             |
| Customer Support Forum  | ► [ADRV9026 EngineerZone® Forum](#)         |

* Will be available in 2020.

► Please visit [ADRV9026 Landing Page](#) to download Software Package and Design file package.
ADRV9009: 1-Chip 3G/4G/5G TDD Transceiver

- Integrated Dual Traffic Rx and Tx
  - Tuning Range: 75MHz < Fc < 6GHz
  - TDD Operation only

- Receivers
  - Max Rx BW = 200MHz

- Transmitters
  - Max Tx BW = 450MHz

- Integrated Observation Rx
  - Max ORx BW = 450MHz
  - Shared inputs with Rx

- Total Power (@ max bandwidth)
  - Dual Rx = 3.5W
  - Dual Tx = 3.7W
  - Tx+ORx = 5.6W

- Analog/Digital/Software Features
  - 16bit ADC/DAC
  - Frequency Agility
  - LO phase synchronization
  - Rx: DC offset, QEC, AGC
  - Tx: QEC, LO leakage
  - Programmable FIRs
  - 12GSPS JESD204-B interface
  - Embedded ARM

Applications
- COMS: MC-GSM, 3G/4G/5G Macro BTS, Massive MIMO
- ADEF: Radar, EW, MilCom, SigInt
- ETM: SDR, Portable Test Equipment

Package
- 12x12 BGA

Interface
- 12G JESD204B

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ADRV9008-1: 2R RF Receiver

- Integrated Dual Receiver
  - Tuning Range: 75 MHz < Fc < 6GHz
  - 200MHz Rx
- 75MHz MC-GSM support
  - Low IF mode with External LO
- 12Gbps JESD204b
  - 16b floating-point or fixed output
- 6dB lower LO Phase Noise VS AD9371
  - -131 dBc/Hz @ 1 MHz offset (1.9 GHz)
- Low power: 3.5W for 2Rx GSM Mode
- Digital Software/Features
  - Rx QEC, DC offset, HD2 cancellation, AGC, pFIR
  - Auxiliary ADC, DAC, GPIO
  - SPI interface and API Support
- Package: 12x12 BGA
ADRV9008-2: 2T + ORx RF Transmitter

- Integrated Dual Transmitter
  - Tuning Range: 75 MHz < Fc < 6GHz
- 450MHz synthesis BW
  - 200MHz large signal BW
- Integrated observation receiver
  - Two inputs
- 12Gbps JESD204b
- 6dB lower LO Phase Noise VS AD9371
  - -131 dBc/Hz @ 1 MHz offset (1.9 GHz)
- 5dB lower 1/f noise than previous gen
  - Typically -89dBFS/MHz
- Reduced DAC images
  - ~ 2GHz max DAC rate
  - Improved reconstruction filter
- Low power: 5.6W Tx + ORx, 3.7W Tx Only FDD
- Digital/Software Features
  - Tx QEC, LoL, DC-offset
  - Auxiliary ADC, DAC, GPIO
  - SPI interface and API Support
- Package: 12x12 BGA
| Evaluation Kits            | ► ADRV9009-W/PCBZ – Wideband TDD EVB  
|                           | ► ADRV9008-1W/PCBZ – Wideband Rx EVB  
|                           | ► ADRV9008-2W/PCBZ – Wideband Tx/Orx EVB |
| Carrier Platforms         | ► Xilinx ZC706 ([EVAL-TPG-ZYNQ3](https://analog.com/radioverse-adrv9009)) |
| Simulation Tools          | ► Filter Wizard |
| Software Driver and GUI   | ► Windows GUI  
|                           | ► API Library  
|                           | ► Linux driver  
|                           | ► ADI JESD204B Interface Framework |
| Customer Support Forum    | ► ADI EngineerZone®—wideband RF transceivers, API, Linux® drivers, FPGA reference designs |
| Reference Designs and Partners | ► Dual ADRV9009 SOM (System-on-Module) – Q4  
|                           | ► Epiq Sidekq X4 FMC card with dual ADRV9009  
|                           | ► Panateq FMC card with single ADRV9009  
|                           | ► Intel JESD Interoperability Report |

- Please visit [analog.com/radioverse-adrv9009](https://analog.com/radioverse-adrv9009) for more information

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ADI provides complete JESD204B integration solution

JESD204B Interface Framework

- Open-source HDL and software drivers (Linux & No-OS) for ADI CVT, TRX, CLK solutions
- Support Xilinx and Altera FPGAs
- $5000 for commercial license and one-on-one support

Includes interoperability report with Altera FPGA and Xilinx FPGA

► Please visit ADI JESD204B Framework for more information
Introduce ADRV9009-ZU11EG System-on-Module (RF-SOM)

- Supports up to 4x ADRV9009 that can be synced in Freq & Phase
- Scalable with multiple RF-SOM’s synced together
- I/O connector: USB 3.0, 10Gb Ethernet, PCIe x8
- Approx. size: 94mm x 150mm
- Comes with open source code support package hosted on GitHub

- Qualified ‘production ready’ module to speed up prototyping and integration into final production.
- Allows customers to focus on their own areas of differentiation
- Broad range of applications in cellular infrastructure, radar, portable defence and instrumentation
Based on The Massive MIMO Receiver Front-End ICs Family

- **Dual-channel Receiver Front Ends**
  - **ADRF5545A**  2.4 GHz to 4.2 GHz  **PRODUCTION**
  - **ADRF5547**  3.7 GHz to 5.3 GHz  **Release Sep 2019**
  - **ADRF5549**  1.8 GHz to 2.8 GHz  **Release Oct 2019**

- **Integrated High Power SPDT and 2-stage LNA per channel**
  - High power handling SPDT switch for LNA-protection –
    Solving a huge problem of protecting the receiver’s front end
    In the presence of damaging RF power, while maintaining robust receiver performance.
    - 10W Continuous Wave at 105°C, lifetime operation
    - 10W LTE avg. power (9 dB PAR) at 105°C, lifetime operation
    - 20W LTE avg. power (9 dB PAR) at 105°C, single event
  - Low Noise figure: 1.45 dB at 3.6 GHz at RX operation
  - Low Insertion Loss: 0.65 dB at 3.6 GHz
  - High Channel isolation
  - Integrated bias and matching circuits
  - Single supply, low current operation
4T4R Massive MIMO RF Front-End Reference Design Solution

- Four Channel, scalable to higher channel count
- 3.5 GHz TDD Application
- Receiver
  - 31.5 dB Gain
  - 650 mA
- Transmitter
  - 46 dB Gain
  - 710 mA
Complete 3.5 GHz M-MIMO Transceiver w/ RF Front-End Reference Design

RF FE Board

5W PA

ADR5545A

5W PA

ADR5545A

3W PA

IN DEVELOPMENT
Available Q4, 2019

PCIe Gen 3 x8 Compatible with PC Edge Interface

PMOD
JTAG
RJ45
SFP+
Display Port
USB 3.0
Audio
Full SD-Card

Sony SoM

Status LEDs
Config Switches
FAN

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ADI’s Most Complete mmWave 5G Network Radio Solution in the Industry

MXFE 4T4R Radio

mmW Front-End

Integrated Up/Down Converter

Highest Channel-Count Beamformer

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Next Gen Beamformer

**ADMV4801 / ADMV4821**: 24 To 29.5 GHz 16-Ch Beamformer

**FEATURES**

- 16 Selectable TX/RX Channels
  - ADMV4801: Single Polarization
  - ADMV4821: Horizontal & Vertical Polarization
- Independent TX & RX Vector Modulation Control
- High Resolution Phase Control
- High Resolution DGAs for Amplitude Control
- Compact Package

**ADVANTAGES**

- Highest Channel Count for Cost Effective Scalability
- Smallest Size For Compact Active Antenna Systems
- Flexible Options for Single Polarization or Horizontal and Vertical Polarization

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FEATURES

- RF Input/Output Frequency Range: 24GHz to 29.5GHz, Addressing n257, n258, n261 Bands In One Footprint
- 1.5GHz RF Bandwidth
- Two Up Conversion Modes
- Two Down Conversion Modes
- LO Doubler (x2) and Quadrupler (x4) Modes
- Matched 50 RF Signal and LO Ports
- Temperature Compensation
- 3GPP Specification Compliant

ADVANTAGES

- Pairing With the ADMV4801/ADMV4821 Beamformers, Forms The Highest Performance, Highest Integration and Most Scalable Solution for mmW 5G NR Platforms
- Integrated Solution Speeds Time-To-Market
AD9081: MxFE™ Quad 16-Bit 12GSPS RF DAC and Quad 12-Bit 4GSPS RF ADC

- Flexible re-configurable radio common platform design
  - 4D4A (4x 3-12GSPS 16b DAC + 4x 2-4 GSPS 12b ADC)
  - RFDAC/RFADC output/input -3 dB BW of 5.2 GHz and 7.5 GHz
  - On-chip PLL (6GHz-12GHz) w/ Multi-chip synchronization
  - External RFCLK input option

- Total Power depends on digital configuration and converter sample rate
  - ~7W to 9W typical

- Versatile Digital Features
  - Supports real or complex digital data (8-, 12-, or 16-bit)
  - JESD204B (8b/10b, 16Gbps) and JESD204C (64b/66b, 25Gbps)

- Configurable Digital Up/Down Conversion (DDC/DUC)
  - 8 fine complex DUCs and 4 coarse complex DUCs
  - 8 fine complex DDCs and 4 coarse complex DDCs
  - 2 independent NCO per DUC/DDC
  - Programmable 192-tap FIR filter in Rx Path

- Signal monitoring/peak detection for AGC (Rx); PA protection (Tx). Loopback on analog and digital. Fast Frequency hopping.

- Timing adjustments for QEC optimization (Rx) and configurable transmit signal placement

- 15x15mm, 0.8mm pitch, thermally enhanced BGA

- Power Supplies: 1V, 2V and 1.8V
ADF4372: 62.5 MHz to 16 GHz Wideband Synthesizer w/ VCO

FEATUES
- Integrated Doubler with Harmonic Filter
- Normalized Phase Noise Floor: -234 dBc/Hz
- VCO Phase Noise (@100kHz Offset):
  - Fundamental: -109 dBc/Hz
  - X2 VCO: -103 dBc/Hz
- Typical PFD Spurious: -100 dBc
- Integer Boundary Spur: -90 dBc
- 0.06 – 8 GHz output at RF8
- 0.06 – 16 GHz output at RF4_16
- 8 – 16 GHz output at RF16
- Maintains Frequency Lock -40°C to 105°C
- 3.3V Analog/Digital, 5V VCO supplies
- Integrated Low Noise LDO Regulator
- 7mm x 7mm LGA-48

APPLICATIONS
- Radar Systems
- Microwave Wireless Infrastructure: 5G, PTP
- Test Equipment
- Satellite
For more information, please visit www.analog.com/rf