Integrated DPD for Small Cell and Massive MIMO

Peadar Forbes

Product Marketing Manager

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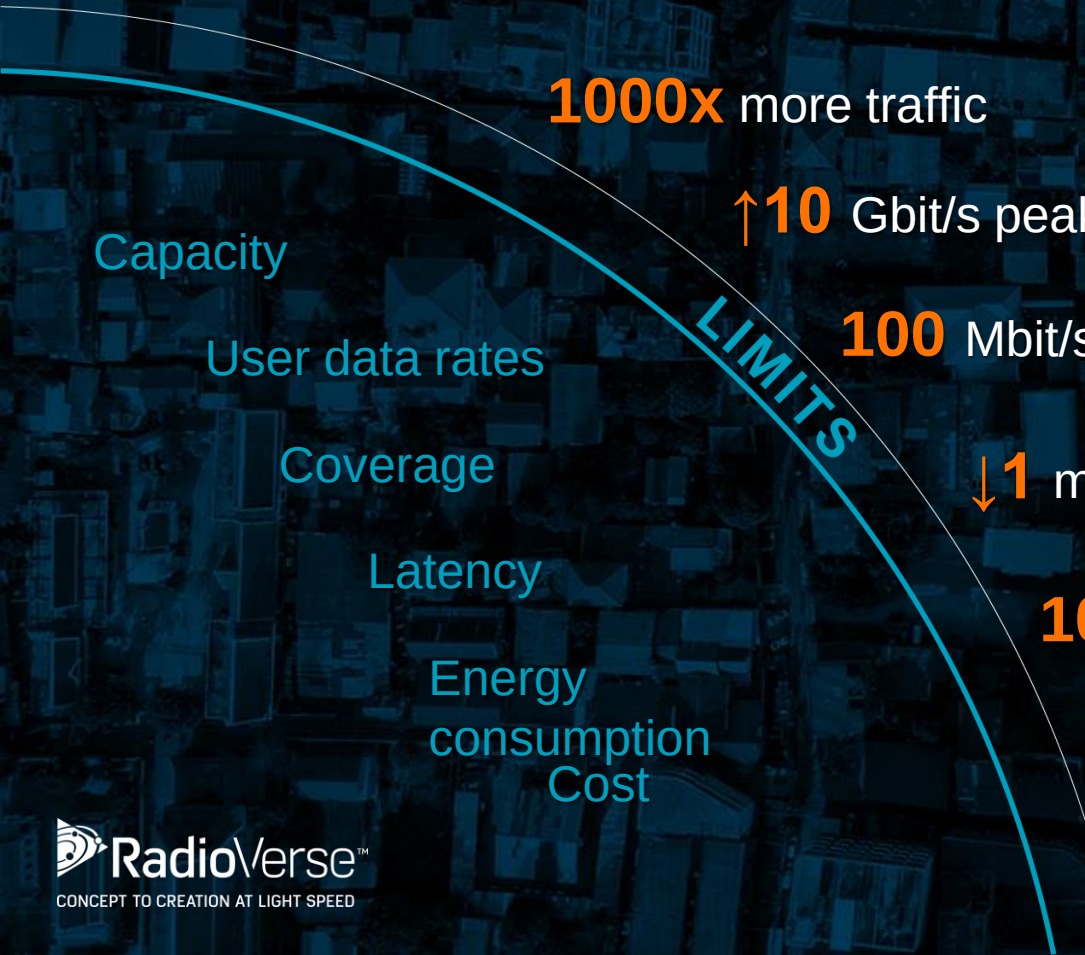
Agenda

- Background: 4G to 5G Transition
- Small Cell & Massive MIMO Overview
- AD9375 Wideband RF Transceiver With Integrated DPD
- AD9375 Design Resources
- Summary

4G and the transition to 5G
will require ULTRA connectivity...



1000x more traffic

↑10 Gbit/s peak data rates

100 Mbit/s wherever needed

↓1 millisecond latency

10—100x more devices

Ultra Connectivity

5G
Performance requirements 2020+

RadioVerse™
CONCEPT TO CREATION AT LIGHT SPEED

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As Networks migrate from 4G to 5G operators are challenged to keep pace with the demand for data & connectivity everywhere

Mobile data traffic grows @ 40% CAGR*

Building penetration increasingly difficult

Spectrum is scarce & expensive

*2016-2022, source: Ericsson Mobility report 2016

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Sub 6GHz Small Cell & Massive MIMO

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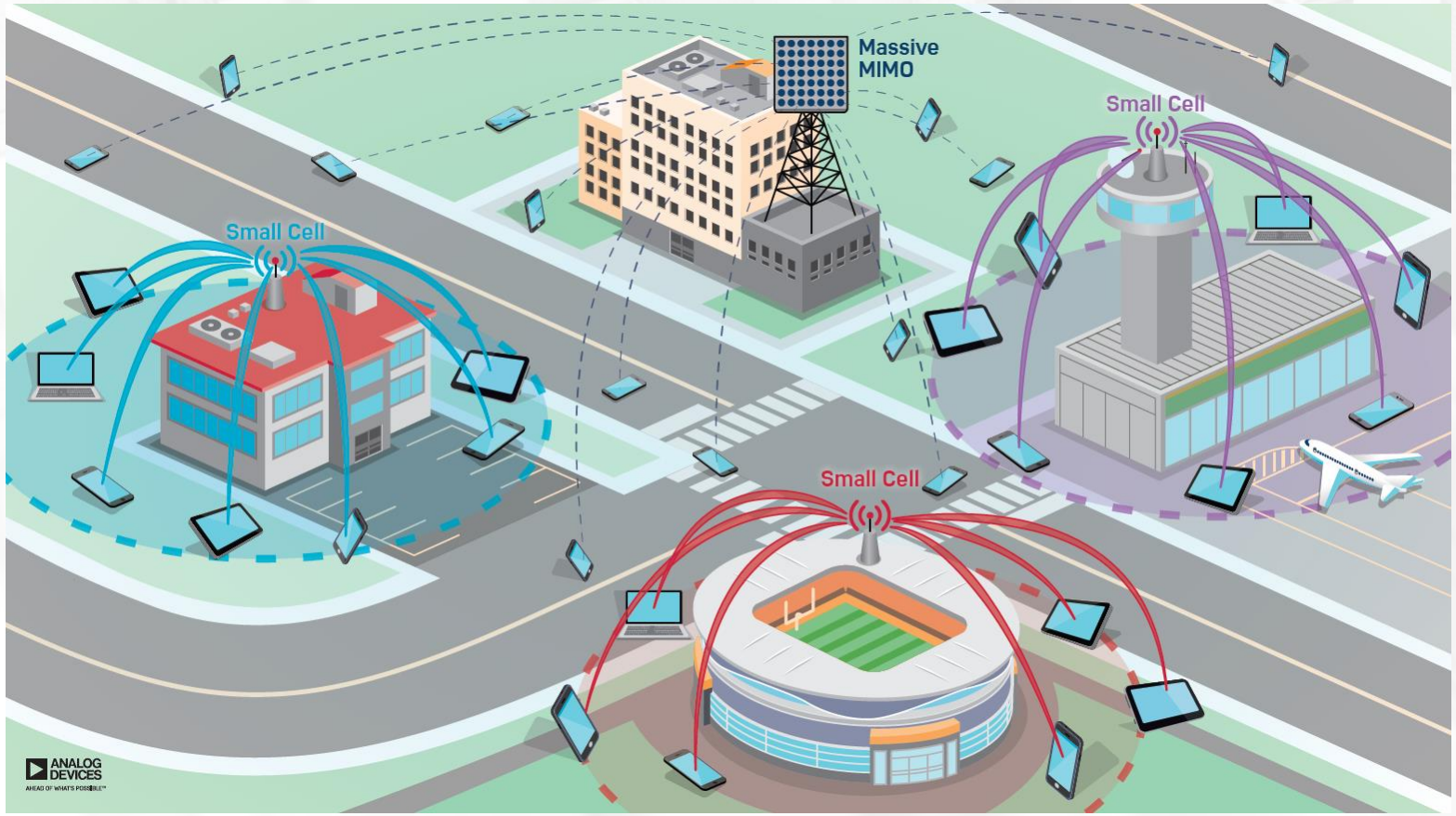
Small Cells & Massive MIMO are **key building block technologies** to enhance network coverage & capacity



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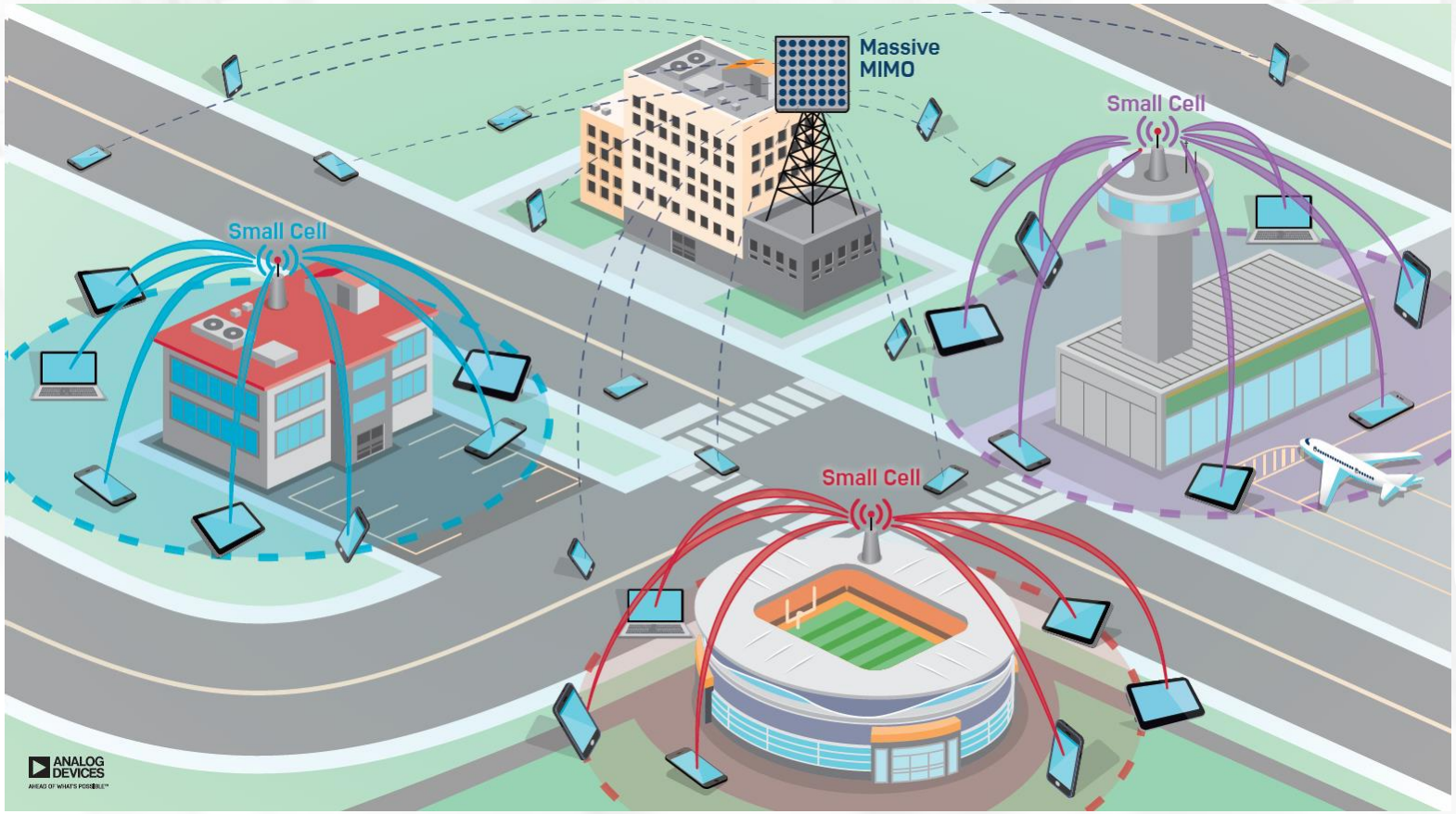
Small Cells densify the network to provide **enhanced capacity** and coverage



Small Cells

- Coverage & Capacity Improvement
- Spectrum Re-use
- Network Densification
- Indoor/Outdoor & Rural

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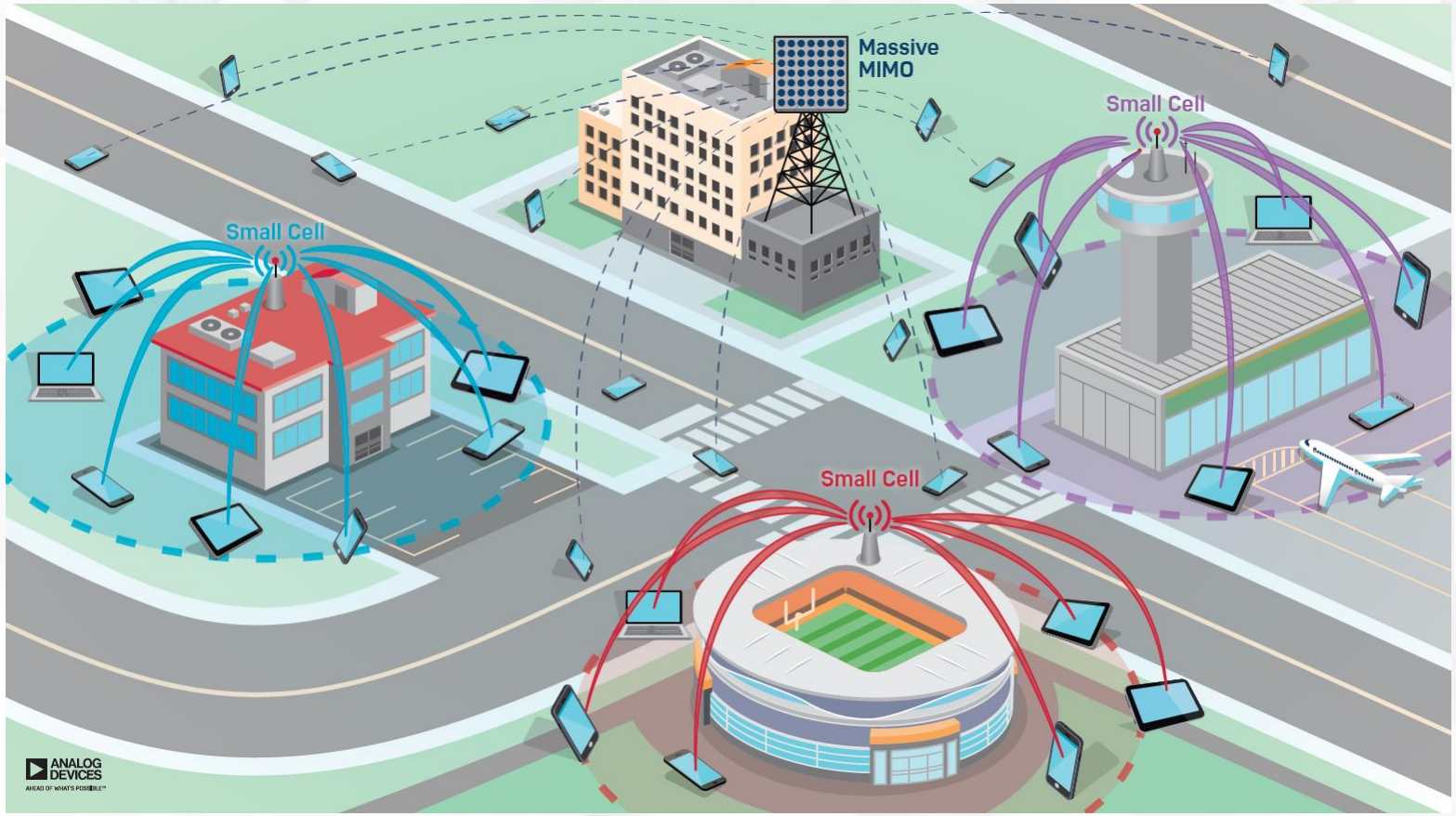
Massive MIMO base-stations use beamforming to provide **higher data rates and enhanced capacity**



5x Capacity Improvement

Spectrum Re-use through Beam-forming

Massive MIMO

Higher Data Rates

Dense Urban Areas

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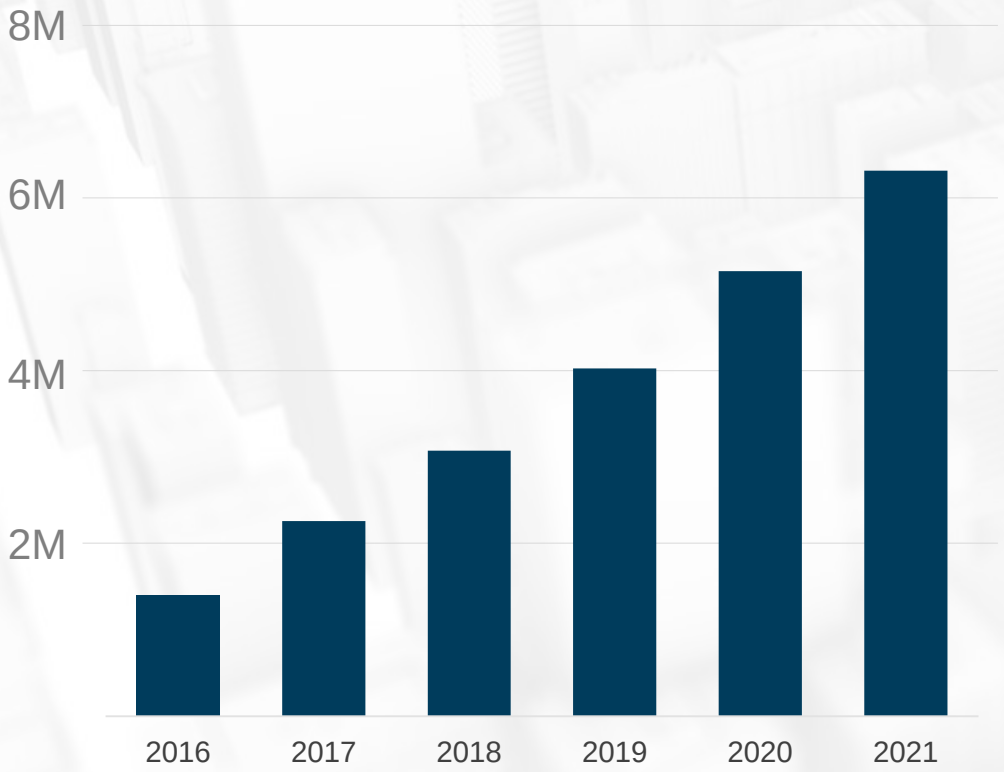
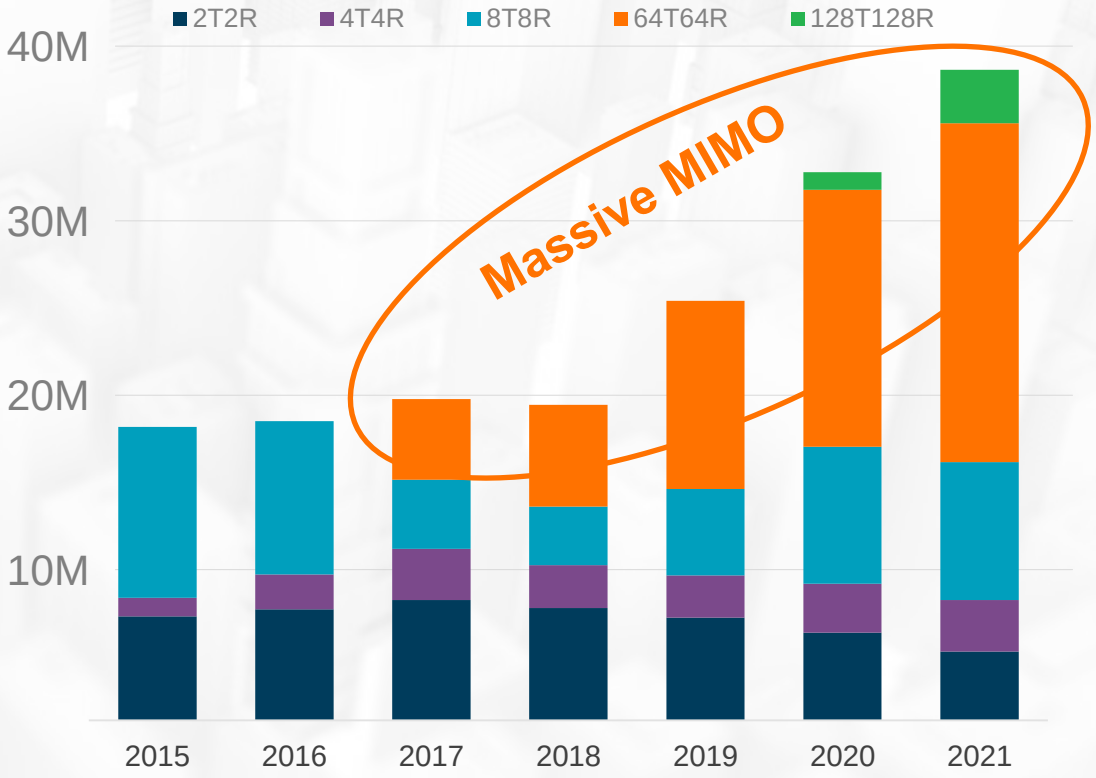
4G to 5G migration has started with **deployment of Small Cell** and Massive MIMO base stations

Small Cell BTS Forecast



Source: Mobile Experts Apr 2017. Excl Residential Femto

Macro BTS Transceiver Forecast



Source: Mobile Experts Apr 2017

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Small Cell & Massive MIMO Radio Design Challenges

Reduce Radio SWaP to enable increased radio density

Proliferation of band variants and output powers

Time to market pressure

Small Cell & Massive MIMO Systems place pressure on radio **Size, Weight & Power**

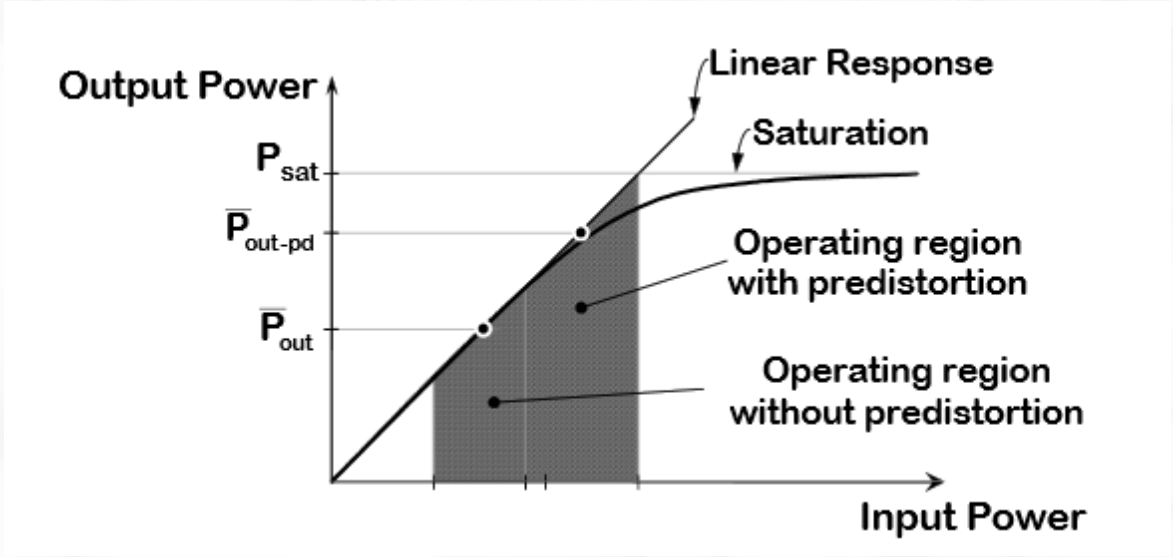
Small Cell radios need to support multiple bands while minimizing impact on power consumption & size

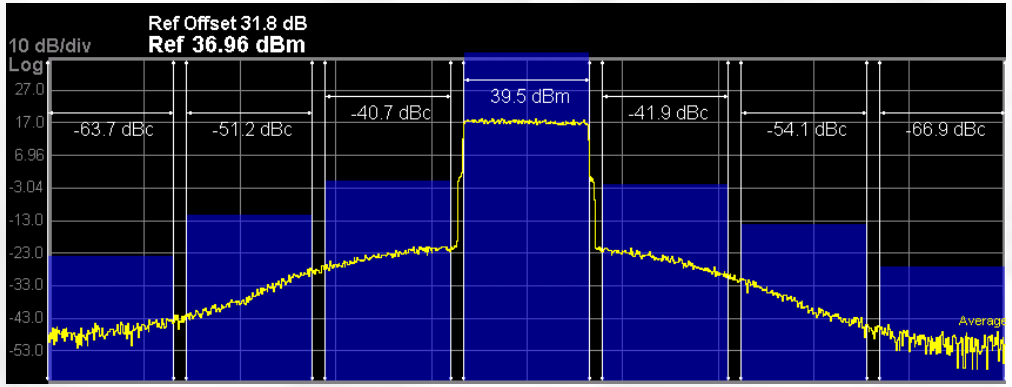
Single Band per system → **Small Cells** → 3 - 4 bands per system

Massive MIMO radios increase antenna count from 2T2R to 128T128R while minimizing size, power dissipation, weight and cost

2T2R or 4T4R → **Massive MIMO** → 64T64R or 128T128R

High efficiency Power Amplifiers (PAs) are required to **minimize power consumption**





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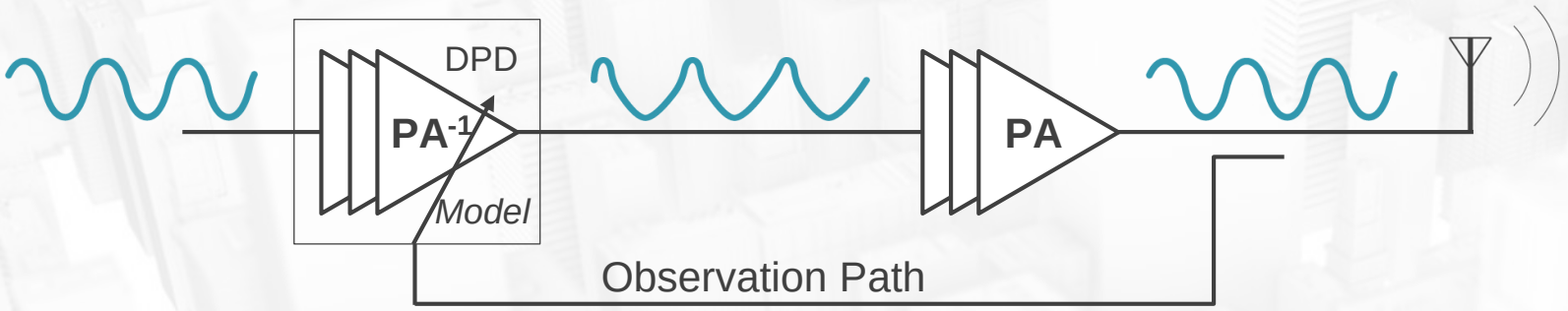
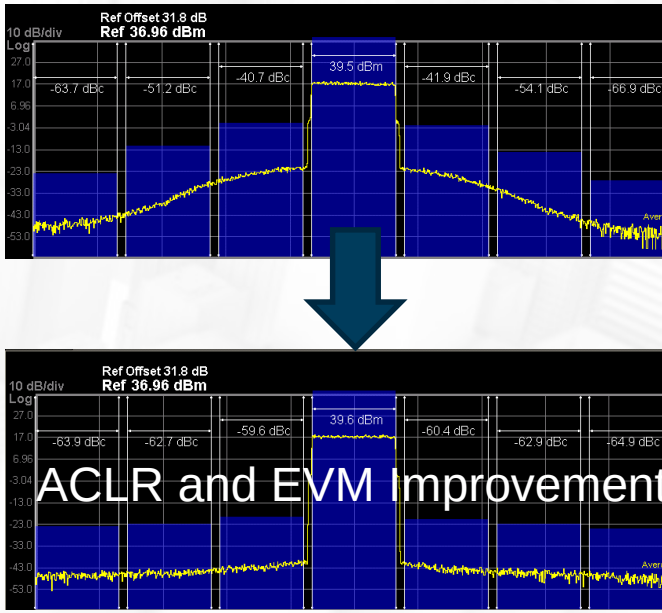
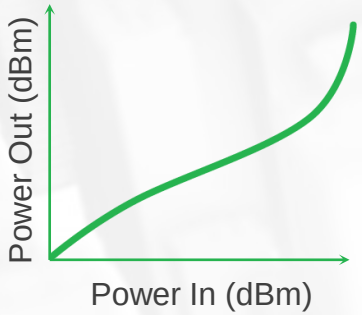
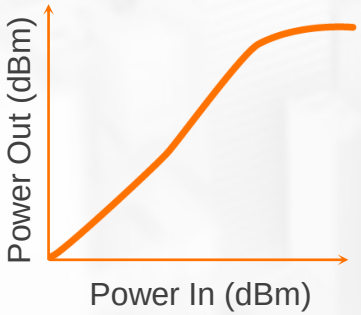
Digital Pre-Distortion (DPD) enables the use of High Efficiency Power Amplifiers (PAs)



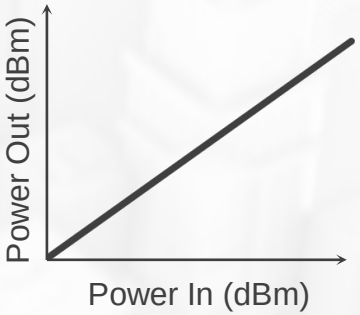




DPD AM-AM



PA AM-AM



DPD+PA AM-AM

…. But existing FPGA based DPD algorithms are inefficient and do not scale with antenna count

Introducing AD9375

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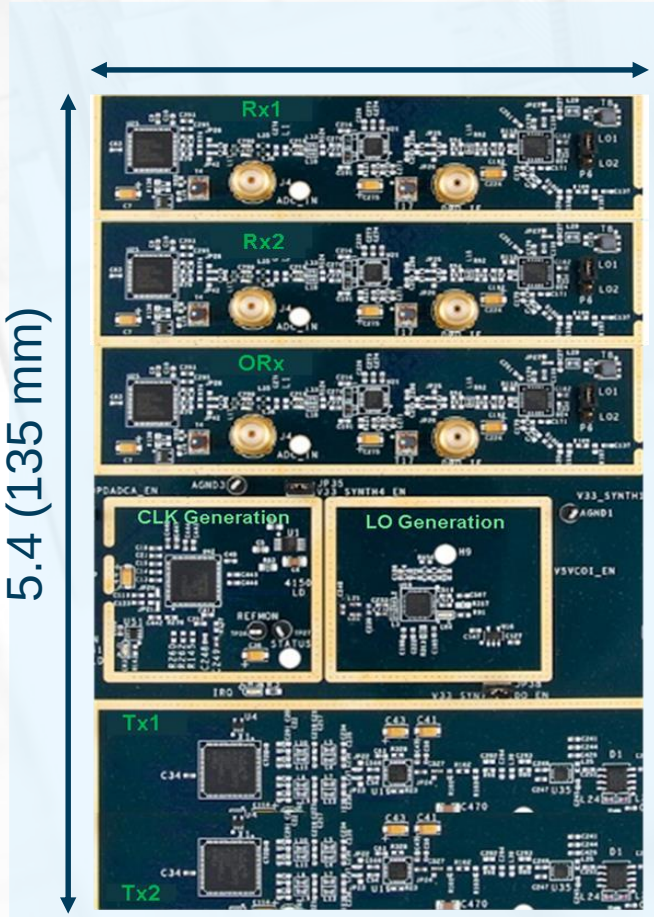
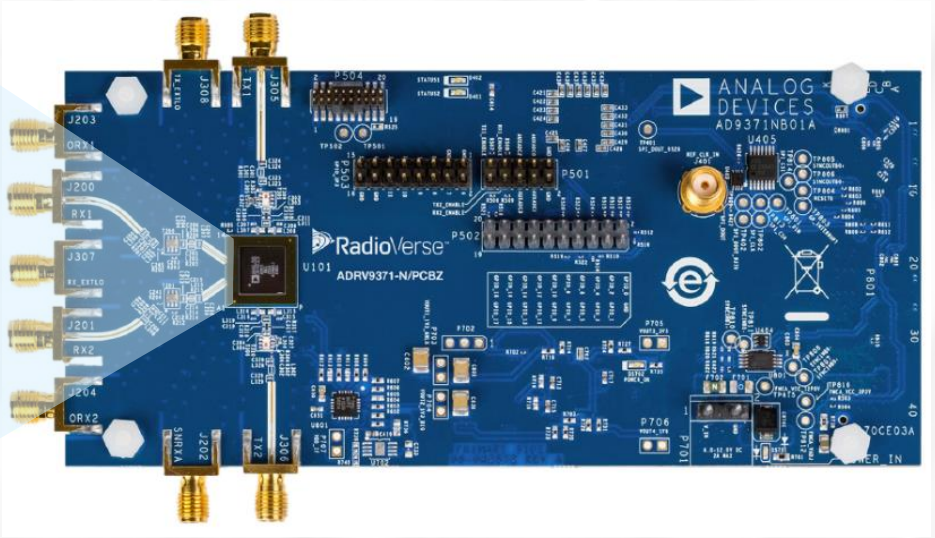
The Predecessor -- **AD9371** Introduced in June 2016, **replacing 20 Discrete Parts**



- 2× Receivers
- 2× Transmitters
- 1× Obs Receiver
- 3× LO Gen
- 1× Clock Gen



12 mm × 12 mm BGA

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Introducing the AD9375

The 1st Wideband RF Transceiver with Integrated DPD

- DPD Signal Bandwidth 40MHz
- 3G & 4G Waveforms
- TDD & FDD Operation
- Tuning Range 300MHz – 6GHz

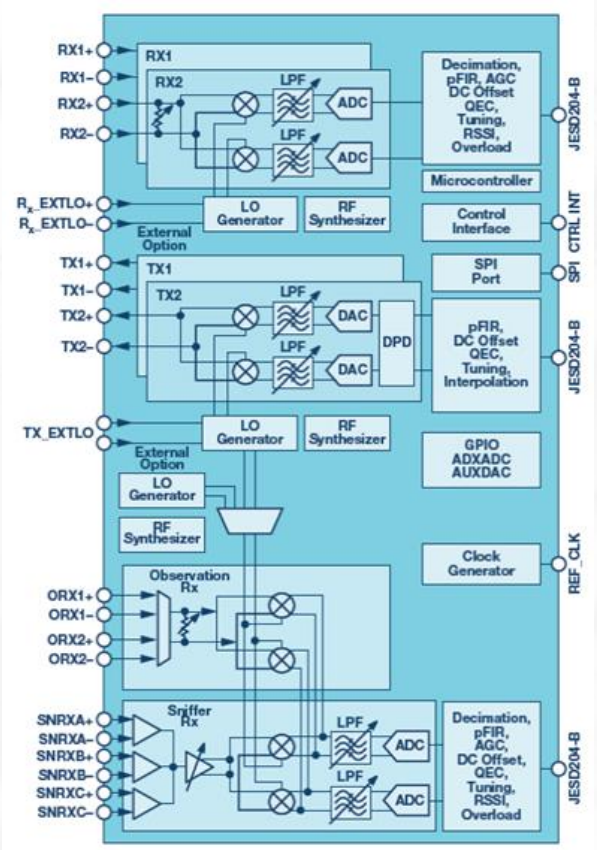
Receivers
BW: 100MHz
Rx NF: 12.5dB
IIP3: 22dBm

Transmitters
Synthesis BW: 250MHz
Tx Pout: +7dBm
OIP3: 27dBm

Observation Path
BW: 250MHz
2 inputs

- Integrated Tx & Rx Los
- Tx/Rx QEC, DC Offset, LO Leakage, API Support
- Transmit Closed Loop Gain Control & VSWR Monitor
- 6Gbps JESD204B interface
- Power Consumption: 4.8W @ max bandwidth

- **Applications**
  - 3G/4G small cell base stations (BTS)
  - 3G/4G massive MIMO/active antenna systems



Pin compatible with AD9371

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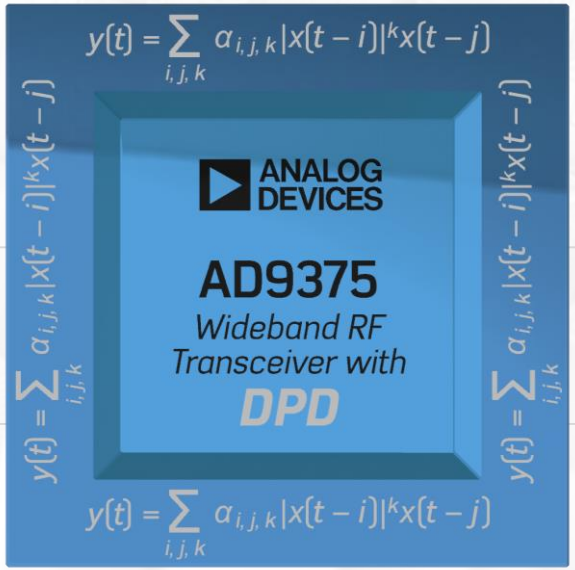
AD9375 with Integrated DPD Benefits

1. Reduces DPD power by 90% over FPGA based solutions
2. Cuts SERDES lanes in half
3. Requires fewer FPGA resources reducing complexity and cost
4. Provides ease of use – Tested PA library, API, evaluation kits, customer support
5. Accelerates time to market with proven Small Cell Radio Reference Design



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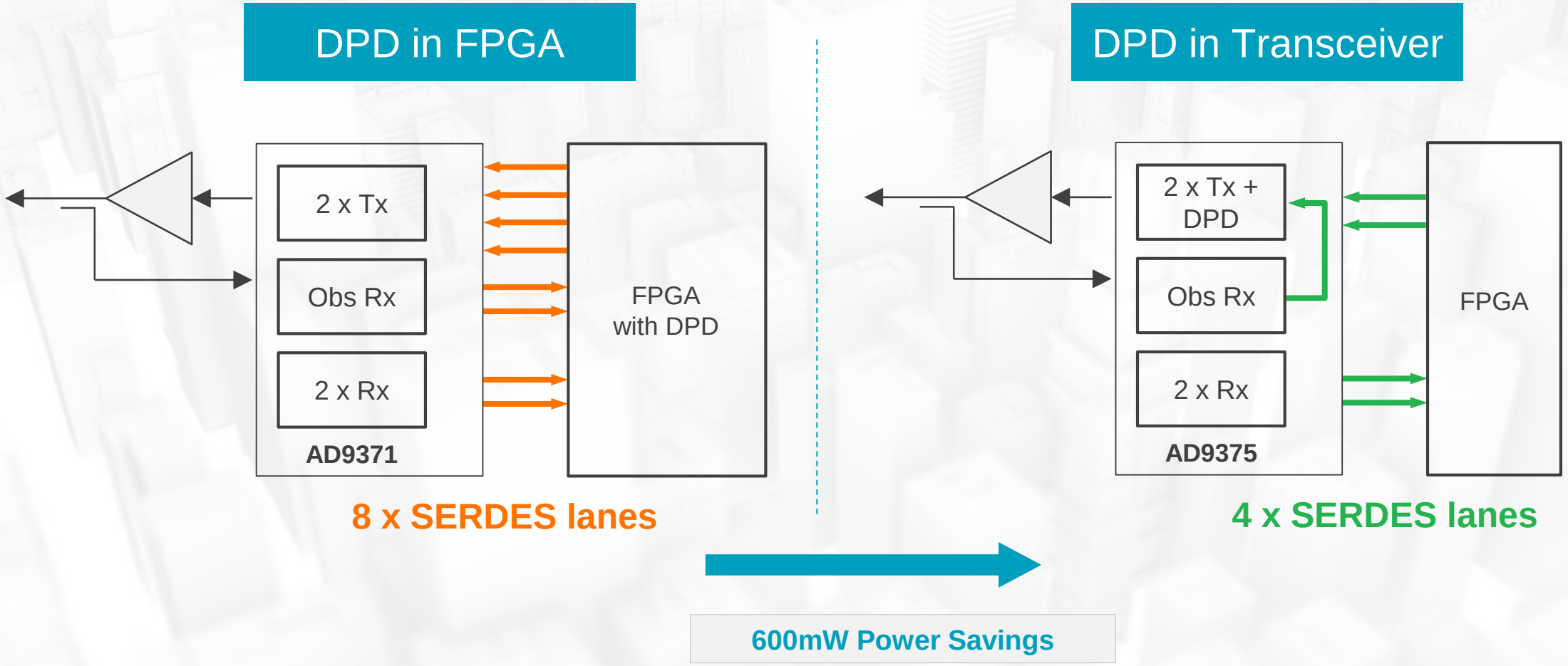
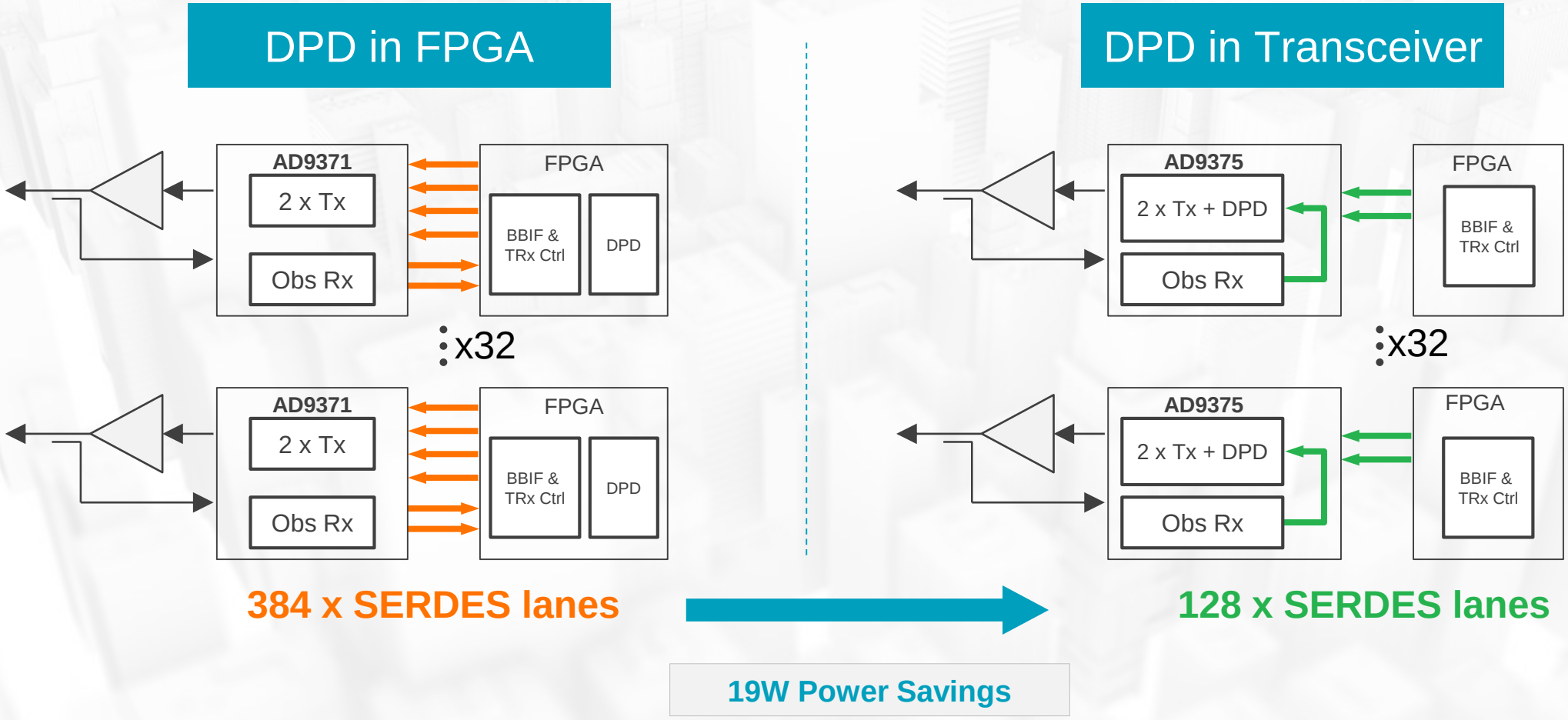
Integrated DPD enables **Smart System Partition**
2T2R Example

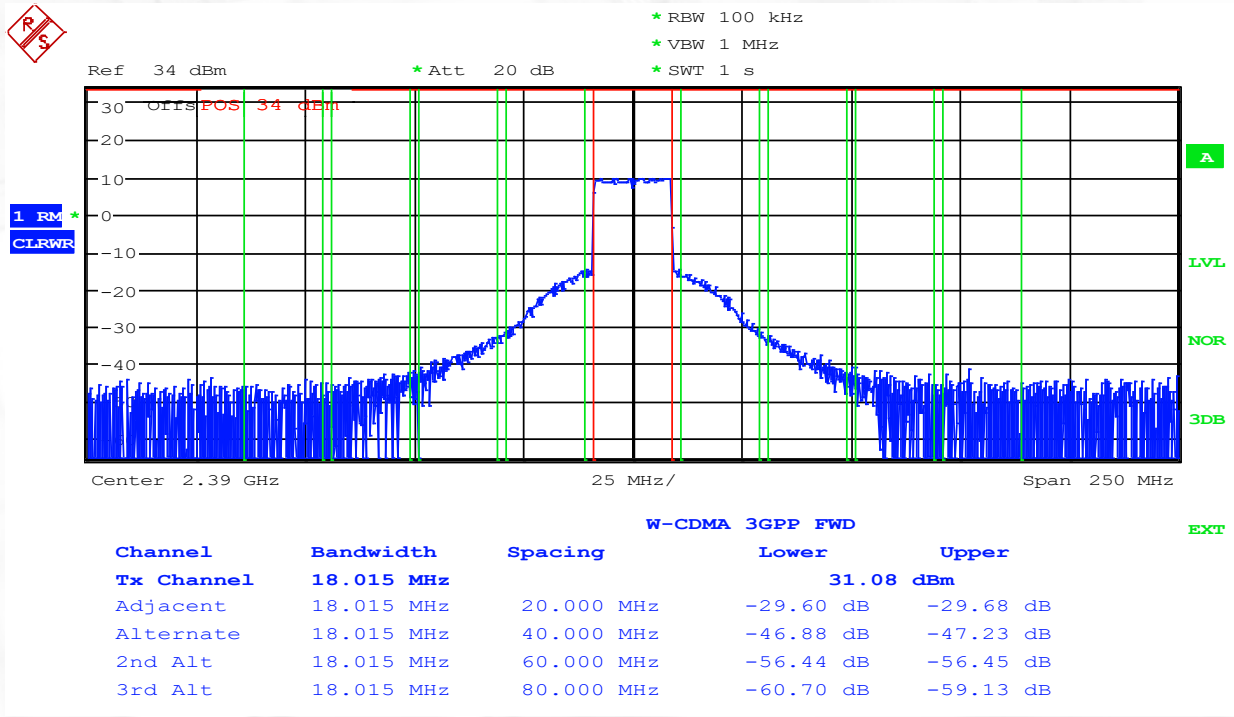


Power & SERDES Lane Savings Scale
in 64T64R Massive MIMO



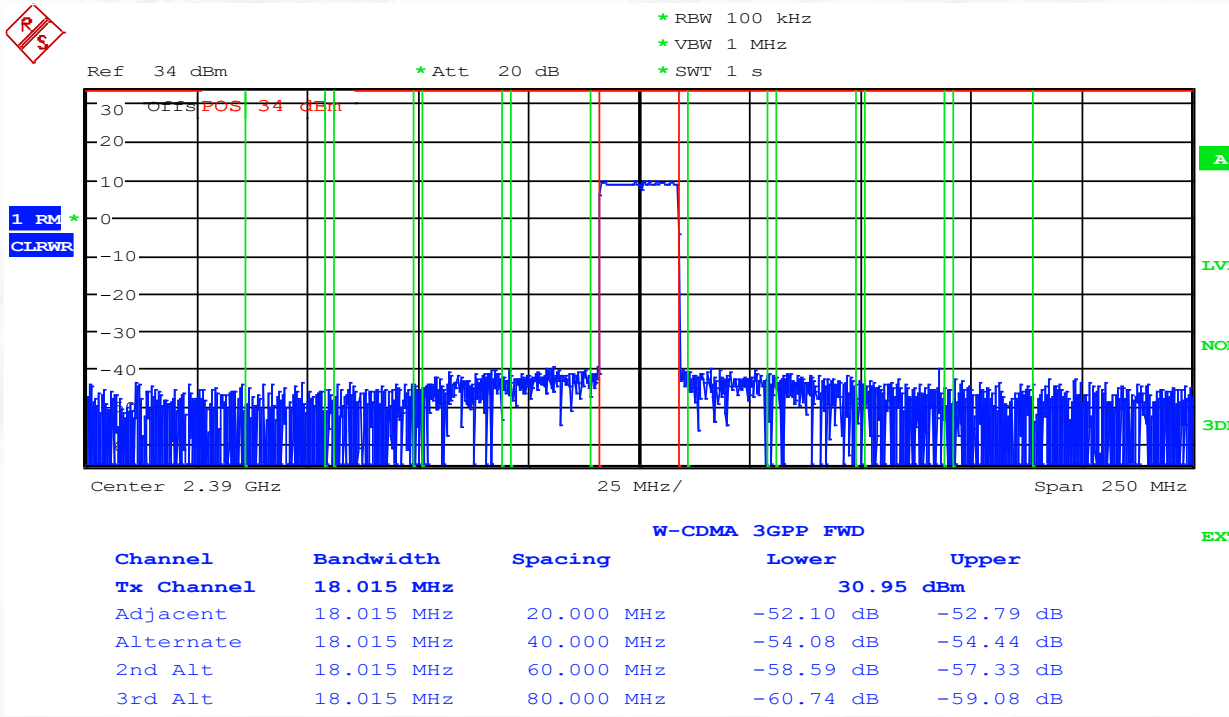
Typical Performance – 20MHz Bandwidth

LDMOS Doherty PA, 42% drain efficiency, 2.39GHz, 38dBm rms Pout, 20MHz LTE, 7.5dB PAR



Channel	Bandwidth	Spacing	Lower	Upper
Tx Channel	18.015 MHz		31.08 dBm	
Adjacent	18.015 MHz	20.000 MHz	-29.60 dB	-29.68 dB
Alternate	18.015 MHz	40.000 MHz	-46.88 dB	-47.23 dB
2nd Alt	18.015 MHz	60.000 MHz	-56.44 dB	-56.45 dB
3rd Alt	18.015 MHz	80.000 MHz	-60.70 dB	-59.13 dB

Before DPD
-28dBc ACLR

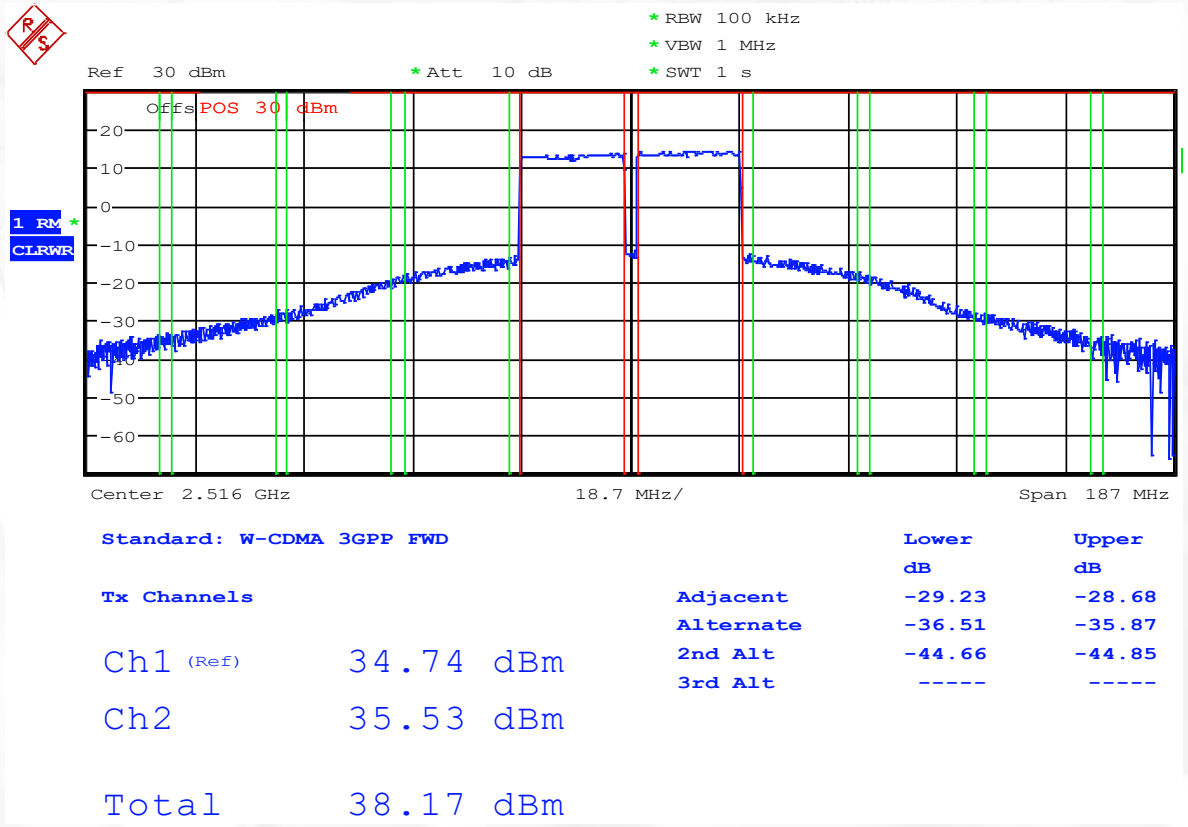


Channel	Bandwidth	Spacing	Lower	Upper
Tx Channel	18.015 MHz		30.95 dBm	
Adjacent	18.015 MHz	20.000 MHz	-52.10 dB	-52.79 dB
Alternate	18.015 MHz	40.000 MHz	-54.08 dB	-54.44 dB
2nd Alt	18.015 MHz	60.000 MHz	-58.59 dB	-57.33 dB
3rd Alt	18.015 MHz	80.000 MHz	-60.74 dB	-59.08 dB

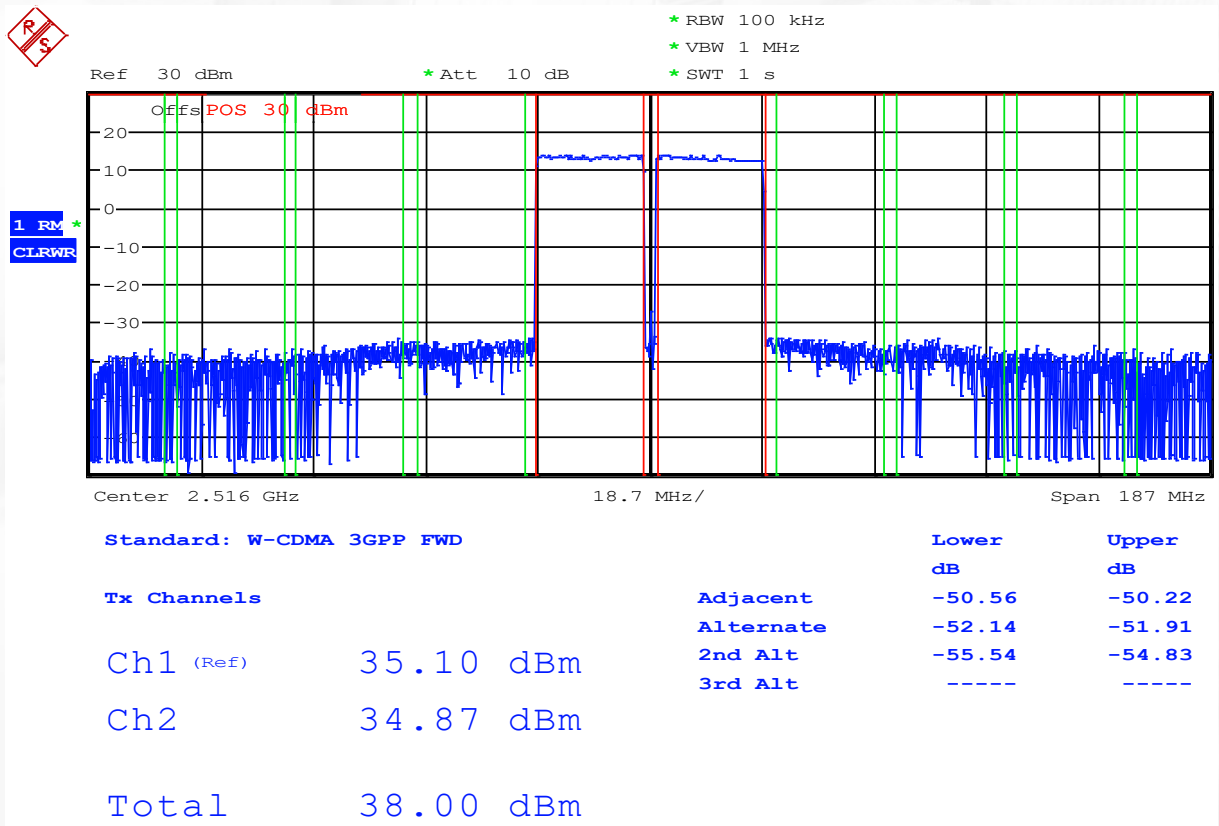
After DPD
-52dBc ACLR

Typical Performance – 40MHz Bandwidth

LDMOS Doherty PA, 42% drain efficiency, 2.6GHz, 38dBm rms Pout, 2 x 20MHz LTE, 7.5dB PAR



Before DPD
-28dBc ACLR



After DPD
-50dBc ACLR

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AD9375 Design Resources on RadioVerse & Small Cell Radio Reference Design

Launched RadioVerse to help customers **solve complex radio challenges**

Market-leading ADI radio technologies

Ecosystem of tools, documentation, reference designs, modules

Best of breed partners

Market specific insights, support, ideas for roadmap planning

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CONCEPT TO CREATION AT LIGHT SPEED

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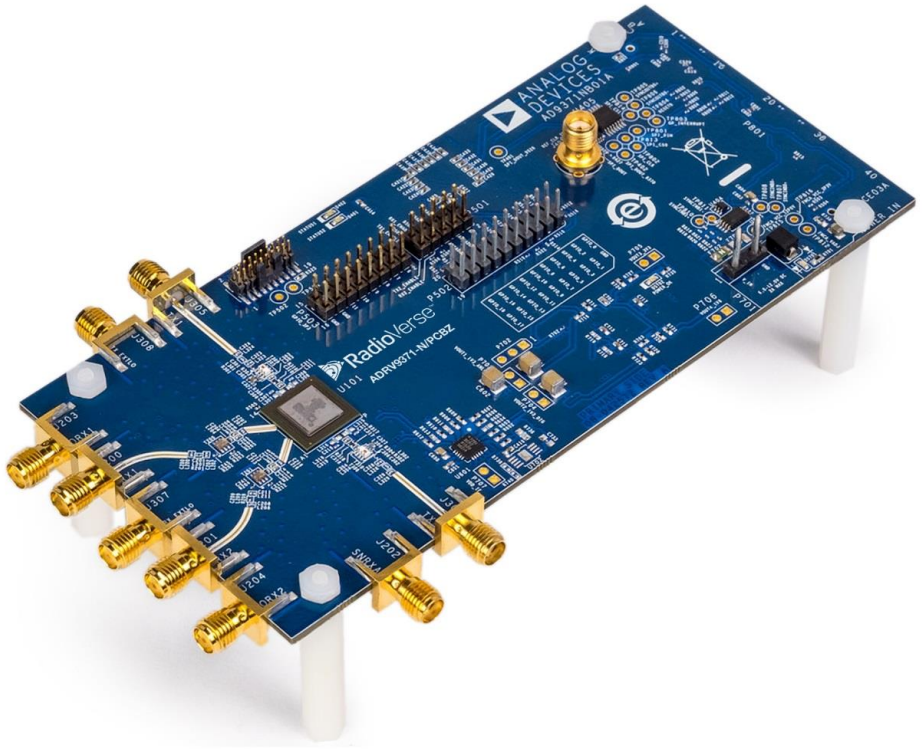
AD9375 Design Resources on RadioVerse

Evaluation Kits	▶ ADRV9375-N/PCBZ with SKY66297 PA evaluation card
Carrier Platforms	▶ Xilinx ZC706 (order separately)
Simulation Tools	▶ MATLAB® Filter Wizard ▶ MathWorks Simulink® Model
Software Driver and GUI	▶ DPD GUI ▶ Windows GUI ▶ API
Customer Support Forum	▶ ADI EngineerZone®—wideband RF transceivers, API, Linux® drivers, FPGA reference designs
Reference Designs and Partners	▶ Small cell radio reference design ▶ Tested PA reports in collaboration with PA vendors

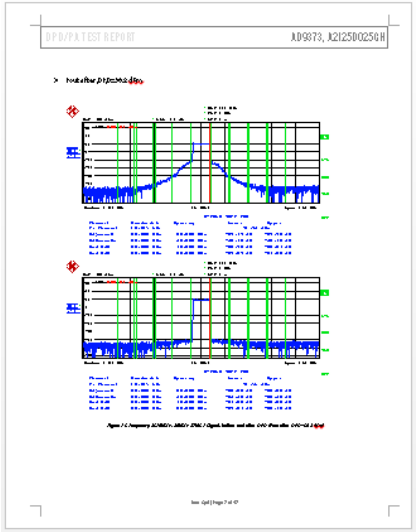


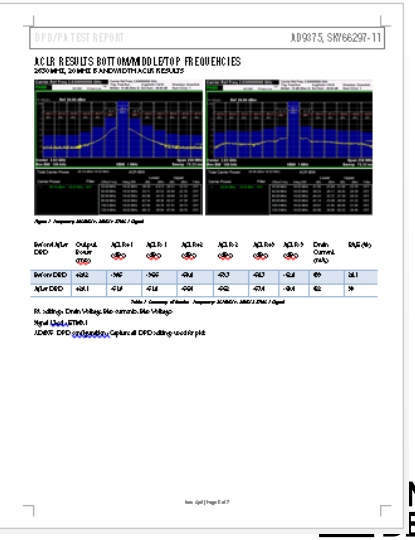
Please visit analog.com/RadioVerse-DPD for more information

Tested PA Reports

In Collaboration with Key Power Amplifier Vendors

- Accelerate customer time to market with ready-to-go PA & DPD solutions
- Selection of PAs tested and optimized for performance with AD9375 DPD
- Complete Reports detail linearization performance before and after DPD, efficiency across frequency and output power
- All PA and DPD settings captured for ease of use





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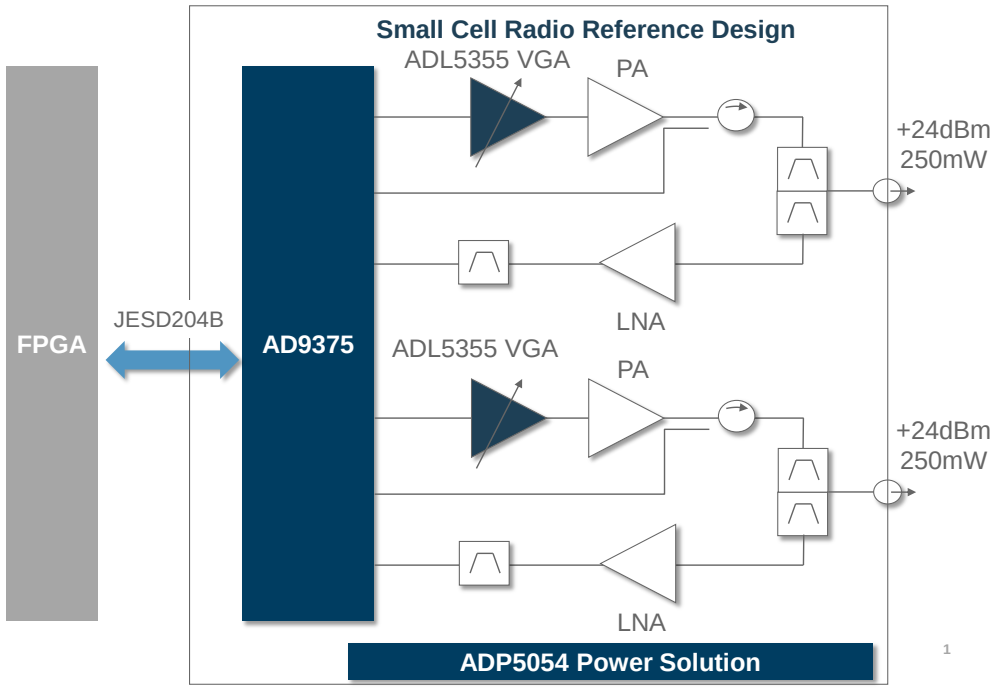
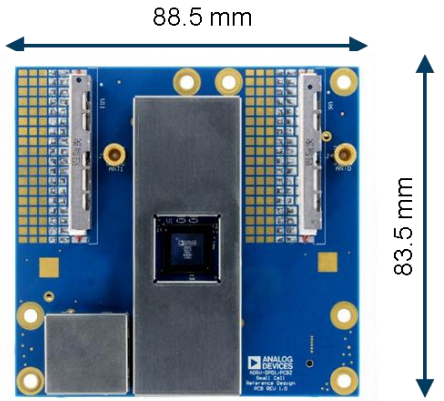
Introducing Small Cell Radio Reference Design with DPD

- Complete JESD204B to antenna design
- 2 × 2 LTE 20 MHz, 250 mW output power per antenna
- BOM reconfigurable to other bands
- Contains all components: transceivers, PAs, LNAs, filters, power solution
- Small form factor—88 mm × 83 mm

Key Benefits

- Get to market faster with a proven reference design for small cell radios
- Enhance R&D efficiency with a common platform design easily reconfigured to other bands
- Lowest power, smallest form factor 250 mW small cell radio available on the market





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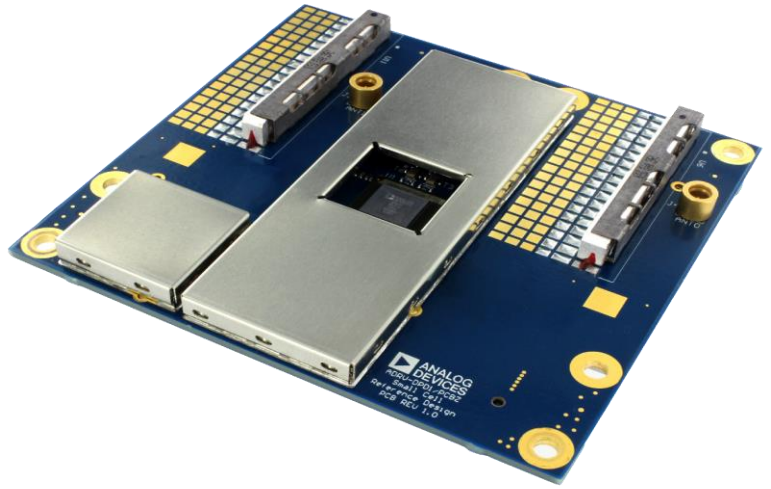
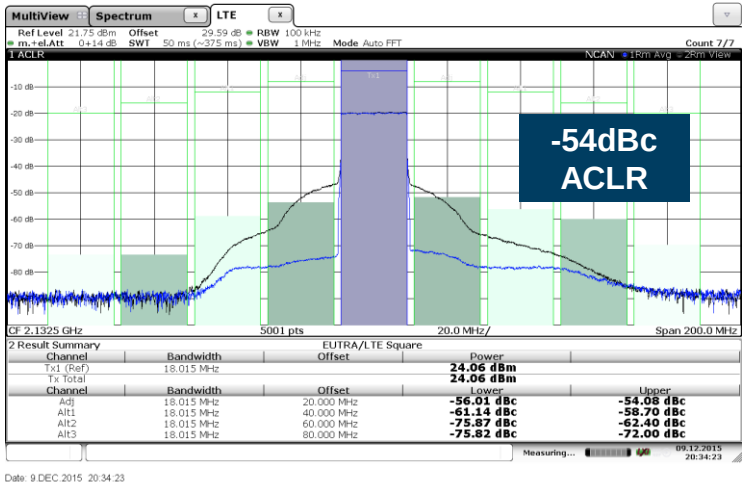
AD9375 250mW Small Radio Cell Reference Design

- Single 5 V supply
- Low power: <10 W total power consumption
- ACLR <–54 dBc typ @ 24 dBm P_{OUT}
- Broadband design
  - LTE band 7 FDD design
  - BOM reconfigurable to other 3GPP bands:
- High efficiency PA SKY66279 (29% PAE)
- Interfaces to Xilinx® ZC706 motherboard via interposer





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Summary

- The transition from 4G to 5G technology is underway
  - Small Cell and Massive MIMO are the key building blocks enabling enhanced capacity and coverage

- Small Cell & Massive MIMO solutions introduce challenges for the radio designer
  - Reduce Radio Size Weight & Power to enable increased Radio density
  - Proliferation of band variants and output powers
  - Time to market pressure

- AD9375 launch targeting Small Cell & Massive MIMO markets
  - First wideband RF transceiver with integrated DPD
  - Enables disruptive system partition reducing radio size, weight & power
  - Wide RF tuning range enables common platform
  - Complete ecosystem of PA reports, evaluation tools and a small cell radio reference design to accelerate time to market

Thank You For Watching!

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