FEATURES
- 4 differential transmitters
- 4 differential receivers
- 2 observation receivers with 2 inputs each
- Center frequency: 75 MHz to 6000 MHz
- Fully integrated DPD adaptation engine for power amplifier linearization
- Crest factor reduction engine
- Maximum receiver bandwidth: 200 MHz
- Maximum transmitter large signal bandwidth: 200 MHz
- Maximum transmitter synthesis bandwidth: 450 MHz
- Maximum observation receiver bandwidth: 450 MHz
- Fully integrated independent fractional-N radio frequency synthesizers
- Fully integrated clock synthesizer
- Multichip phase synchronization for all local oscillators and baseband clocks
- Support for TDD and FDD applications
- 24.33 Gbps JESD204B/JESD204C digital interface

APPLICATIONS
- 3G/4G/5G TDD and FDD massive MIMO, macro and small cell base stations

GENERAL DESCRIPTION
The ADRV9029 is a highly integrated, radio frequency (RF) agile transceiver offering four independently controlled transmitters, dedicated observation receiver inputs for monitoring each transmitter channel, four independently controlled receivers, integrated synthesizers, and digital signal processing functions providing a complete transceiver solution. The device provides the performance demanded by cellular infrastructure applications, such as small cell base station radios, macro 3G/4G/5G systems, and massive multiple in/multiple out (MIMO) base stations.

The receiver subsystem consists of four independent, wide bandwidth, direct conversion receivers with wide dynamic range. The four independent transmitters use a direct conversion modulator resulting in low noise operation with low power consumption. The device also includes two wide bandwidth, time shared, observation path receivers with two inputs each for monitoring transmitter outputs.

The complete transceiver subsystem includes automatic and manual attenuation control, dc offset correction, quadrature error correction (QEC), and digital filtering, eliminating the need for these functions in the digital baseband. Other auxiliary functions such as analog-to-digital converters (ADCs), digital-to-analog converters (DACs), and general-purpose input/outputs (GPIOs) that provide an array of digital control options are also integrated.

To achieve a high level of RF performance, the transceiver includes five fully integrated phase-locked loops (PLLs). Two PLLs provide low noise and low power fractional-N RF synthesis for the transmitter and receiver signal paths. A third fully integrated PLL supports an independent local oscillator (LO) mode for the observation receiver. The fourth PLL generates the clocks needed for the converters and digital circuits, and a fifth PLL provides the clock for the serial data interface.

A multichip synchronization mechanism synchronizes the phase of all LOs and baseband clocks between multiple ADRV9029 chips. All voltage controlled oscillators (VCOs) and loop filter components are integrated and adjustable through the digital control interface.

This device contains a fully integrated, low power digital predistortion (DPD) adaptation engine for use in power amplifier linearization. DPD enables use of high efficiency power amplifiers, reducing the power consumption of base station radios while also reducing the number of SERDES lanes necessary to interface with baseband processors.

The low power crest factor reduction (CFR) engine of the ADRV9029 reduces the peak to average ratio (PAR) of the input signal, enabling higher efficiency transmit line ups while reducing the processing load on baseband processors.

The serial data interface consists of four serializer lanes and four deserializer lanes. The interface supports both the JESD204B and JESD204C standards, operating at data rates up to 24.33 Gbps. The interface also supports interleaved mode for lower bandwidths, thus reducing the number of high speed data interface lanes to one. Both fixed and floating-point data formats are supported. The floating-point format allows internal automatic gain control (AGC) to be invisible to the demodulator device.

The ADRV9029 is powered directly from 1.0 V, 1.3 V, and 1.8 V regulators and is controlled via a standard serial peripheral interface (SPI) serial port. Comprehensive power-down modes are included to minimize power consumption in normal use. The ADRV9029 is packaged in a 14 mm × 14 mm, 289-ball chip scale ball grid array (CSP_BGA).
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Features</td>
<td>1</td>
</tr>
<tr>
<td>Applications</td>
<td>1</td>
</tr>
<tr>
<td>General Description</td>
<td>1</td>
</tr>
<tr>
<td>Revision History</td>
<td>2</td>
</tr>
<tr>
<td>Functional Block Diagram</td>
<td>3</td>
</tr>
<tr>
<td>Specifications</td>
<td>4</td>
</tr>
<tr>
<td>Transmitters and Receivers</td>
<td>4</td>
</tr>
<tr>
<td>Synthesizers, Auxiliary Converters, and Clock References</td>
<td>11</td>
</tr>
<tr>
<td>Digital Specifications</td>
<td>14</td>
</tr>
<tr>
<td>Power Supply Specifications</td>
<td>15</td>
</tr>
<tr>
<td>Current Consumption</td>
<td>16</td>
</tr>
<tr>
<td>Digital Interface and Timing Specifications</td>
<td>17</td>
</tr>
<tr>
<td>Absolute Maximum Ratings</td>
<td>18</td>
</tr>
<tr>
<td>Junction Temperature</td>
<td>18</td>
</tr>
<tr>
<td>Reflow Profile</td>
<td>18</td>
</tr>
<tr>
<td>Thermal Resistance</td>
<td>18</td>
</tr>
<tr>
<td>ESD Caution</td>
<td>18</td>
</tr>
<tr>
<td>Pin Configuration and Function Descriptions</td>
<td>19</td>
</tr>
<tr>
<td>Typical Performance Characteristics</td>
<td>24</td>
</tr>
<tr>
<td>75 MHz Band</td>
<td>24</td>
</tr>
<tr>
<td>800 MHz Band</td>
<td>37</td>
</tr>
<tr>
<td>1800 MHz Band</td>
<td>52</td>
</tr>
<tr>
<td>2600 MHz Band</td>
<td>67</td>
</tr>
<tr>
<td>3800 MHz Band</td>
<td>82</td>
</tr>
<tr>
<td>4800 MHz Band</td>
<td>97</td>
</tr>
<tr>
<td>5700 MHz Band</td>
<td>112</td>
</tr>
<tr>
<td>Theory of Operation</td>
<td>127</td>
</tr>
<tr>
<td>General</td>
<td>127</td>
</tr>
<tr>
<td>Transmitter</td>
<td>127</td>
</tr>
<tr>
<td>Receiver</td>
<td>127</td>
</tr>
<tr>
<td>Observation Receiver</td>
<td>127</td>
</tr>
<tr>
<td>Clock Input</td>
<td>127</td>
</tr>
<tr>
<td>Synthesizers</td>
<td>128</td>
</tr>
<tr>
<td>SPI Interface</td>
<td>128</td>
</tr>
<tr>
<td>GPIO_x Pins</td>
<td>128</td>
</tr>
<tr>
<td>Auxiliary Converters</td>
<td>128</td>
</tr>
<tr>
<td>Digital Predistortion (DPD)</td>
<td>128</td>
</tr>
<tr>
<td>Crest Factor Reduction (CFR)</td>
<td>131</td>
</tr>
<tr>
<td>JTAG Boundary Scan</td>
<td>131</td>
</tr>
<tr>
<td>Applications Information</td>
<td>132</td>
</tr>
<tr>
<td>Power Supply Sequence</td>
<td>132</td>
</tr>
<tr>
<td>Data Interface</td>
<td>132</td>
</tr>
<tr>
<td>Outline Dimensions</td>
<td>133</td>
</tr>
<tr>
<td>Ordering Guide</td>
<td>133</td>
</tr>
</tbody>
</table>

# REVISION HISTORY

12/2020 — Revision 0: Initial Version
FUNCTIONAL BLOCK DIAGRAM

1VDDA_1P8 REPRESENTS VCONV1_1P8, VCONV2_1P8, VANA1_1P8, VANA2_1P8, VANA3_1P8, VANA4_1P8, AND VJVCO_1P8.
2VDDA_1P3 REPRESENTS VANA1_1P3, VANA2_1P3, VCONV1_1P3, VCONV2_1P3, VRFCDO1_1P3, VRFCDO2_1P3, VAUXVCO_1P3, VCLKVCO_1P3, VRFSYN1_1P3, VRFSYN2_1P3, VCLKSYN1_1P3, VCLKSYN2_1P3, VRXLO_1P3, AND VTXLO_1P3.
3VDDA_1P0 REPRESENTS VJSYN_1P0, VDES_1P0, VTT_DES, AND VSER_1P0.

Figure 1.
SPECIFICATIONS

Electrical characteristics at ambient temperature range. Power supplies are as follows: VDDA_1P8 = 1.8 V, VIF = 1.8 V, VDDA_1P3 = 1.3 V, VDDA_1P0 = 1.0 V, and VDIG_1P0 = 1.0 V. VDDA_1P8 represents VCONV1_1P8, VCONV2_1P8, VANA1_1P8, VANA2_1P8, VANA3_1P8, VANA4_1P8, and VJVC0_1P8. VDDA_1P3 represents VANA1_1P3, VANA2_1P3, VCONV1_1P3, VCONV2_1P3, VRFC01_1P3, VRFVC02_1P3, VAUXVCO_1P3, VCKVC01_1P3, VRFSYN1_1P3, VRFSYN2_1P3, VCLKSYN_1P3, VAUXSYN_1P3, VRXLO_1P3, and VTXLO_1P3. VDDA_1P0 represents VJSYN_1P0, VDES_1P0, VTT_DES, and VSER_1P0. All RF specifications are based on measurements that include printed circuit board (PCB) and matching circuit losses, unless otherwise noted.

Device configuration profile: Receiver = 200 MHz bandwidth, I/Q rate = 245.76 MHz, transmitter = 200 MHz large signal bandwidth plus 450 MHz synthesis bandwidth, I/Q rate = 491.52 MHz, observation receiver (ORX) = 450 MHz bandwidth, I/Q rate = 491.52 MHz, device clock = 245.76 MHz, unless otherwise noted. Characterization at 75 MHz followed this profile: Receiver = 62.5 MHz bandwidth, I/Q rate = 76.8 MHz, transmitter = 62.5 MHz large signal bandwidth plus 141 MHz synthesis bandwidth, I/Q rate = 153.6 MHz, observation receiver = 141 MHz bandwidth, I/Q rate = 153.6 MHz, device clock = 153.6 MHz.

Note: if signals are placed outside of the primary bandwidth, degradation in linearity, image rejection, and flatness may be observed.

TRANSMITTERS AND RECEIVERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
<th>Test Conditions/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRANSMITTERS</td>
<td>Tx</td>
<td>75</td>
<td>6000 MHz</td>
<td></td>
<td></td>
<td>Zero intermediate frequency (IF) mode</td>
</tr>
<tr>
<td>Center Frequency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>450 MHz bandwidth, includes compensation by programmable finite impulse response (FIR) filter</td>
</tr>
<tr>
<td>Tx Synthesis Bandwidth</td>
<td></td>
<td>450 MHz</td>
<td></td>
<td></td>
<td></td>
<td>Any 20 MHz bandwidth span, includes compensation by programmable FIR filter (pFIR)</td>
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<tr>
<td>Tx Large Signal Bandwidth</td>
<td></td>
<td>200 MHz</td>
<td></td>
<td></td>
<td></td>
<td>450 MHz bandwidth</td>
</tr>
<tr>
<td>Peak-to-Peak Gain Deviation</td>
<td></td>
<td>1.0 dB</td>
<td></td>
<td></td>
<td></td>
<td>0 dBFS, 1 MHz signal input, 50 Ω load, 0 dB transmitter attenuation</td>
</tr>
<tr>
<td>Deviation from Linear Phase</td>
<td></td>
<td>0.1 dB</td>
<td></td>
<td></td>
<td></td>
<td>Valid over full power control range for any 4 dB step</td>
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<tr>
<td>Maximum Output Power</td>
<td></td>
<td>0.05 dB</td>
<td></td>
<td></td>
<td></td>
<td>Monotonic</td>
</tr>
<tr>
<td>Power Control Range</td>
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<td>32 dB</td>
<td></td>
<td></td>
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<td>Valid over full power control range</td>
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<tr>
<td>Power Control Resolution</td>
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<td>0.05 dB</td>
<td></td>
<td></td>
<td></td>
<td>20 MHz LTE at −12 dBFS</td>
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<tr>
<td>Integral Nonlinearity (Gain)</td>
<td>INL</td>
<td>0.1 dB</td>
<td></td>
<td></td>
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<td>Valid over full power control range</td>
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<tr>
<td>Differential Nonlinearity (Gain)</td>
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<td>±0.04 dB</td>
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<td>Valid over full power control range</td>
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<tr>
<td>Output Power Temperature Slope</td>
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<td>−4.5 mDB/°C</td>
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<td></td>
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<td>Valid over full power control range</td>
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<td>LO Delay Temperature Slope</td>
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<td>1.05 ps/°C</td>
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<td></td>
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<td>Valid over full power control range</td>
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<td>Adjacent Channel Leakage Power Ratio (ACLR) Long Term Evolution (LTE)</td>
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<tr>
<td>800 MHz</td>
<td></td>
<td>−68 dB</td>
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</tr>
<tr>
<td>1800 MHz</td>
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<td>−67 dB</td>
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<tr>
<td>2600 MHz</td>
<td></td>
<td>−66 dB</td>
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</tr>
<tr>
<td>3800 MHz</td>
<td></td>
<td>−65 dB</td>
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<tr>
<td>4800 MHz</td>
<td></td>
<td>−65 dB</td>
<td></td>
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<tr>
<td>5700 MHz</td>
<td></td>
<td>−65 dB</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Parameter</td>
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<td>Min</td>
<td>Typ</td>
<td>Max</td>
<td>Unit</td>
<td>Test Conditions/Comments</td>
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<tr>
<td>In Band Noise Floor</td>
<td></td>
<td></td>
<td>−154.5</td>
<td>dBFS/Hz</td>
<td></td>
<td>0 dB attenuation; in band noise falls 1 dB for each decibel of attenuation for attenuation settings between 0 dB and 20 dB</td>
</tr>
<tr>
<td>Interpolation Images</td>
<td>−76</td>
<td>dBc</td>
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<td>Tx to Tx Isolation: All Tx Output Effects on All Other Tx Outputs</td>
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<td>dB</td>
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<tr>
<td>Image Rejection</td>
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<td></td>
<td>QEC active up to 20 dB of attenuation, continuous wave tone swept across the large signal bandwidth</td>
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<td>Within 200 MHz Large Signal Bandwidth</td>
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<td>75 MHz</td>
<td>80</td>
<td>dB</td>
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<td>800 MHz</td>
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<td>dB</td>
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<tr>
<td>Beyond Large Signal Bandwidth</td>
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<td></td>
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<td>Assumes that distortion power density is 25 dB below desired power density</td>
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<td>5700 MHz</td>
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<td>dB</td>
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<td>Output Impedance ZOUT</td>
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<td>Ω</td>
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<td>Maximum Output Load Voltage VSWR</td>
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<td>Maximum value to ensure adequate calibration</td>
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<td>Output Return Loss</td>
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<td>dB</td>
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<td></td>
<td></td>
<td>0 dB transmitter attenuation</td>
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<td>Output Third-Order Intercept Point OIP3</td>
<td>OIP3</td>
<td></td>
<td>dBm</td>
<td></td>
<td></td>
<td>With LO leakage correction active, 0 dB transmitter attenuation, scales decibel for decibel with attenuation</td>
</tr>
<tr>
<td>Parameter</td>
<td>Symbol</td>
<td>Min</td>
<td>Typ</td>
<td>Max</td>
<td>Unit</td>
<td>Test Conditions/Comments</td>
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<tr>
<td>-----------------------------------------------</td>
<td>--------</td>
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<tr>
<td>Carrier on the LO</td>
<td>−71</td>
<td></td>
<td></td>
<td></td>
<td>dBFS/MHz</td>
<td>Measured using an LTE 20 MHz signal</td>
</tr>
<tr>
<td>Error Vector Magnitude</td>
<td>EVM</td>
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<td></td>
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<td></td>
<td>PLL optimized for narrow-band noise, measured using LTE 20 MHz signal</td>
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<tr>
<td>75 MHz LO</td>
<td>0.25</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td>50 kHz PLL bandwidth</td>
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<tr>
<td>800 MHz LO</td>
<td>0.38</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td>50 kHz PLL bandwidth</td>
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<td>1800 MHz LO</td>
<td>0.60</td>
<td>%</td>
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<td></td>
<td>50 kHz PLL bandwidth</td>
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<td>2600 MHz LO</td>
<td>0.44</td>
<td>%</td>
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<td>500 kHz PLL bandwidth</td>
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<td>3800 MHz LO</td>
<td>0.53</td>
<td>%</td>
<td></td>
<td></td>
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<td>200 kHz PLL bandwidth</td>
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<td>4800 MHz LO</td>
<td>0.63</td>
<td>%</td>
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<td></td>
<td>400 kHz PLL bandwidth</td>
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<td>5700 MHz LO</td>
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<td>%</td>
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<td>500 kHz PLL bandwidth</td>
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<td>Transmitter Time Division Duplex</td>
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<tr>
<td>Time from SPI_EN Going High to Change in Tx</td>
<td>t_SCH</td>
<td>12</td>
<td>ns</td>
<td></td>
<td></td>
<td>A large change in attenuation can be segmented into a series of smaller attenuation changes</td>
</tr>
<tr>
<td>Change in Attenuation</td>
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<td></td>
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<td></td>
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<tr>
<td>RECEIVERS Rx</td>
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<td>200 MHz bandwidth, includes compensation by programmable FIR filter</td>
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Rev. 0 | Page 6 of 133
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<td>Two tones approximately bandwidth ÷ 6 offset from the LO; test condition: ( P_{\text{HIGH}} - 9 \text{ dB/tone} )</td>
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<td>Maximum Input</td>
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<td>dBc</td>
<td>( P_{\text{HIGH}} ) continuous wave signal, harmonic distortion tones falling within 100 MHz of the LO</td>
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<td>( P_{\text{HIGH}} - 3 \text{ dB} ) continuous wave signal, harmonic distortion tones falling within 100 MHz of the LO</td>
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<tr>
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<td>HD3&lt;sub&gt;MAX&lt;/sub&gt;</td>
<td>−66</td>
<td>dBC</td>
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<td>$P_{\text{HIGH}}$ continuous wave signal, harmonic distortion tones falling within 100 MHz of the LO</td>
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<td>Recommended Input</td>
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<td>dBC</td>
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<td>$P_{\text{HIGH}} - 3$ dB continuous wave signal, harmonic distortion tones falling within 100 MHz of the LO</td>
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<td>$P_{\text{HIGH}}$ continuous wave signal, harmonic distortion tones falling within 100 MHz of the LO</td>
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<td>Recommended Input</td>
<td>HD4</td>
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<td>$P_{\text{HIGH}} - 3$ dB continuous wave signal, harmonic distortion tones falling within 100 MHz of the LO</td>
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<td>dBC</td>
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<td>$P_{\text{HIGH}}$ continuous wave signal, harmonic distortion tones falling within 100 MHz of the LO</td>
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<td>Recommended Input</td>
<td>HD5</td>
<td>−90</td>
<td>dBC</td>
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<td>$P_{\text{HIGH}} - 3$ dB continuous wave signal, harmonic distortion tones falling within 100 MHz of the LO</td>
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<td>Image Rejection</td>
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<td>QEC active, within 200 MHz receiver bandwidth</td>
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<td>Rx Band Spurs Referenced to RF Input at Maximum Gain</td>
<td>SFDR</td>
<td>−95</td>
<td>dBm</td>
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<td>No more than one spur at this level per 10 MHz of receiver bandwidth; excludes harmonics of the reference clock</td>
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<td>Spurious-Free Dynamic Range</td>
<td>SFDR</td>
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<td>dBC</td>
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<td>$P_{\text{HIGH}}$ continuous wave signal anywhere inside the band ±20 MHz, excludes harmonic distortion products</td>
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<td>75 MHz</td>
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<td>−68</td>
<td>dBm</td>
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<td></td>
<td>Leakage decreased decibel for decibel with attenuation for first 12 decibels</td>
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<td>−68</td>
<td>dBm</td>
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<td>1800 MHz</td>
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<td>−68</td>
<td>dBm</td>
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<td>Tx to Rx Signal Isolation: All Tx Output Effects on all Rx Inputs</td>
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<td>Center Frequency</td>
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<td>MHz</td>
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<td>Gain Range</td>
<td></td>
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<td>dB</td>
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<tr>
<td>Attenuation Accuracy</td>
<td></td>
<td>0.5</td>
<td>dB</td>
<td></td>
<td></td>
<td>Attenuator steps from 0 dB to 6 dB</td>
</tr>
<tr>
<td>Analog Gain Step</td>
<td></td>
<td>1</td>
<td>dB</td>
<td></td>
<td></td>
<td>Attenuator steps from 6 dB to 30 dB</td>
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Rev. 0 | Page 8 of 133
<table>
<thead>
<tr>
<th>Parameter</th>
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<th>Max</th>
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<td>Peak-to-Peak Gain Deviation</td>
<td></td>
<td>1</td>
<td>dB</td>
<td></td>
<td></td>
<td>450 MHz RF bandwidth, compensation by programmable FIR filter</td>
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<tr>
<td>Deviation from Linear Phase</td>
<td></td>
<td>0.1</td>
<td>dB</td>
<td></td>
<td></td>
<td>Any 20 MHz bandwidth span, compensation by programmable FIR filter</td>
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<td>ORx Bandwidth</td>
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<td>MHz</td>
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<td>450 MHz RF bandwidth</td>
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<td>ORx Alias Band Rejection</td>
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<td>60</td>
<td>dB</td>
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<td>Due to digital filters</td>
</tr>
<tr>
<td>Maximum Useable Input Level P_HIGH</td>
<td></td>
<td></td>
<td></td>
<td>60</td>
<td>dB</td>
<td>This continuous wave signal level corresponds to the input power that produces −2 dBFS at the digital output with 0 dB channel attenuation</td>
</tr>
<tr>
<td>75 MHz</td>
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<td>Unmatched differential port return loss</td>
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<tr>
<td>1800 MHz</td>
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<td>−11.0</td>
<td>dBm</td>
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<td></td>
<td>Sample rate at maximum value integrated from 500 kHz to 225 MHz, no input signal</td>
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<tr>
<td>2600 MHz</td>
<td></td>
<td>−10.6</td>
<td>dBm</td>
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<td>Sample rate at maximum value integrated from 500 kHz to 245.76 MHz, no input signal</td>
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<tr>
<td>3800 MHz</td>
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<td>−12.0</td>
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<td>Maximum observation receiver gain; test condition: P_HIGH − 11 dB/tone</td>
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<td>Third-Order Input Intermodulation Intercept Point</td>
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<td>IIP3W</td>
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<td>IM3 products &gt; 130 MHz at baseband; test condition: P_HIGH − 11 dB/tone, 491.52 MSPS</td>
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<td>Parameter</td>
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<td>Min</td>
<td>Typ</td>
<td>Max</td>
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<td>Test Conditions/Comments</td>
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<td>IM3NB</td>
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<td>IM3 product &lt; 130 MHz at baseband; test condition: two tones, each at $P_{\text{HIGH}}$ − 11 dB, 491.52 MSPS</td>
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<tr>
<td>800 MHz</td>
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<td>dBc</td>
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<td>Wide Band</td>
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<td>IM3 product &gt; 130 MHz at baseband; test condition: two tones, each at $P_{\text{HIGH}}$ − 11 dB, 491.52 MSPS</td>
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<td>IM5NB</td>
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<td>IM5 product &lt; 130 MHz at baseband; test condition: two tones, each at $P_{\text{HIGH}}$ − 11 dB, 491.52 MSPS</td>
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<tr>
<td>800 MHz</td>
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<tr>
<td>4800 MHz</td>
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<td>dBc</td>
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<td>Wide Band</td>
<td>IM5WB</td>
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<td>IM5 product &gt; 130 MHz at baseband; test condition: two tones, each at $P_{\text{HIGH}}$ − 11 dB, 491.52 MSPS</td>
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<td>800 MHz</td>
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<td>Narrow Band</td>
<td>IM7NB</td>
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<td>IM7 product &lt; 130 MHz at baseband; test condition: two tones, each at $P_{\text{HIGH}}$ − 11 dB, 491.52 MSPS</td>
</tr>
<tr>
<td>800 MHz</td>
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<td>dBc</td>
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<td>1800 MHz</td>
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<td>3800 MHz</td>
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### Data Sheet ADRV9029

## Wide Band IM7WB

<table>
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<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
<th>Test Conditions/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>800 MHz</td>
<td>−83</td>
<td>dBC</td>
<td></td>
<td></td>
<td></td>
<td>IM7 product &gt; 130 MHz at baseband; test condition: two tones, each at ( P_{\text{HIGH}} - 11 ) dB, 491.52 MSPS</td>
</tr>
<tr>
<td>1800 MHz</td>
<td>−82</td>
<td>dBC</td>
<td></td>
<td></td>
<td></td>
<td>Nonintermodulation related spurs; does not include harmonic distortion; input set at ( P_{\text{HIGH}} - 8 ) dB</td>
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<tr>
<td>2600 MHz</td>
<td>−83</td>
<td>dBC</td>
<td></td>
<td></td>
<td></td>
<td>In-band harmonic distortion falls within ±100 MHz</td>
</tr>
<tr>
<td>3800 MHz</td>
<td>−83</td>
<td>dBC</td>
<td></td>
<td></td>
<td></td>
<td>Out of band harmonic distortion falls within ±225 MHz</td>
</tr>
<tr>
<td>4800 MHz</td>
<td>−85</td>
<td>dBC</td>
<td></td>
<td></td>
<td></td>
<td>Harmonic distortion falls within ±225 MHz</td>
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<tr>
<td>5700 MHz</td>
<td>−81</td>
<td>dBC</td>
<td></td>
<td></td>
<td></td>
<td>After online tone calibration, QEC active</td>
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## Spurious-Free Dynamic Range SFDR

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<th>Max</th>
<th>Unit</th>
<th>Test Conditions/Comments</th>
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<td>64</td>
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<tr>
<td>2600 MHz</td>
<td>64</td>
<td>dB</td>
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<tr>
<td>3800 MHz</td>
<td>64</td>
<td>dB</td>
<td></td>
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<td>4800 MHz</td>
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<td>64</td>
<td>dB</td>
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## Second-Order Harmonic Distortion HD2

<table>
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<th>Typ</th>
<th>Max</th>
<th>Unit</th>
<th>Test Conditions/Comments</th>
</tr>
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<tr>
<td>In Band</td>
<td>−80</td>
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<tr>
<td>Out of Band</td>
<td>−73</td>
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## Third-Order Harmonic Distortion HD3

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<th>Test Conditions/Comments</th>
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<tbody>
<tr>
<td>In Band</td>
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## Image Rejection

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<tbody>
<tr>
<td>Tx to ORx Signal Isolation: All Tx Output Effects on all ORx Inputs</td>
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<td>dB</td>
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### SYNTHESIZERS, AUXILIARY CONVERTERS, AND CLOCK REFERENCES

#### Table 2.

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<th>Symbol</th>
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<th>Unit</th>
<th>Test Conditions/Comments</th>
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</thead>
<tbody>
<tr>
<td>LO1 and LO2 SYNTHESIZER Frequency Step</td>
<td>LO1, LO2</td>
<td>7.3</td>
<td>Hz</td>
<td></td>
<td></td>
<td>1.6 GHz to 3.2 GHz, 245.76 MHz phase frequency detector (PFD) frequency</td>
</tr>
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<td>Spectral Purity</td>
<td></td>
<td>−80</td>
<td>dBc</td>
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<td></td>
<td>Integrated from 1 kHz to 100 MHz PLL bandwidth optimized to minimize phase noise at offsets &gt; 200 kHz</td>
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<td>Integrated Phase Noise Narrow Bandwidth Optimized</td>
<td></td>
<td>0.12</td>
<td>&quot;rms&quot;</td>
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<td>PLL bandwidth optimized for integrated phase noise and phase noise at offsets &gt; 1 MHz</td>
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<td>800 MHz</td>
<td></td>
<td>0.27</td>
<td>&quot;rms&quot;</td>
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<td>PLL bandwidth optimized to minimize phase noise at offsets &gt; 200 kHz</td>
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<td>1800 MHz</td>
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<td>0.66</td>
<td>&quot;rms&quot;</td>
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<td>0.53</td>
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<td>0.91</td>
<td>&quot;rms&quot;</td>
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<td>PLL bandwidth optimized to minimize phase noise at offsets &gt; 1 MHz</td>
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<td>PLL bandwidth optimized to minimize phase noise at offsets &gt; 200 kHz</td>
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<td>PLL bandwidth optimized to minimize phase noise at offsets &gt; 1 MHz</td>
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<td>PLL bandwidth optimized to minimize phase noise at offsets &gt; 1 MHz</td>
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Rev. 0 | Page 11 of 133
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<td></td>
</tr>
<tr>
<td>Resolution</td>
<td>Input Voltage</td>
<td>0.2</td>
<td>V</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>Maximum</td>
<td>VDDA_1P8 − 0.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AUXDAC_0</td>
<td>AUXDAC_1 To AUXDAC_7</td>
<td>10</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resolution</td>
<td>Output Voltage</td>
<td>10</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>Maximum</td>
<td>VDDA_1P8 − 0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive Capability</td>
<td>DIGITAL SPECIFICATIONS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parameter</td>
<td>Min</td>
<td>Typ</td>
<td>Max</td>
<td>Unit</td>
<td>Test Conditions/Comments</td>
</tr>
<tr>
<td>DIGITAL SPECIFICATIONS—SINGLE-ENDED SIGNALS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Applies to the following pins: GPIO_x, GPINTx, TXx_EN, RXx_EN, ORX_CTRL_x, TEST_EN, RESET, SPI_EN, SPI_CLK, SPI_DO, and SPI_DIO</td>
</tr>
<tr>
<td>Logic Inputs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Voltage</td>
<td>High Level</td>
<td>VIF × 0.65</td>
<td>VIF + 0.18</td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Low Level</td>
<td>−0.30</td>
<td>VIF × 0.35</td>
<td>V</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Data Sheet ADRV9029

#### Input Current
- **High Level**: Min: −10 μA, Typ: +10 μA, Max: +10 μA
- **Low Level**: Min: −10 μA, Typ: +10 μA, Max: +10 μA

#### Logic Outputs
- **Output Voltage**
  - **High Level**: VIF – 0.45 V
  - **Low Level**: 0.45 V
- **Drive Capability**: 10 mA

#### DIGITAL SPECIFICATIONS—DIFFERENTIAL SIGNALS
- **Logic Inputs**
  - **Input Voltage Range**: 825 mV to 1675 mV
  - **Input Differential Voltage Threshold**: −100 mV to +100 mV
  - **Receiver Differential Input Impedance**: 100 Ω
- **Logic Outputs**
  - **Output Voltage**
    - **High**: 1375 mV
    - **Low**: 1025 mV
    - **Differential**: 225 mV
    - **Offset**: 1200 mV

#### DIGITAL SPECIFICATIONS—VDDA_1P8 REFERENCED SIGNALS
- **Logic Inputs**
  - **Input Voltage**
    - **High Level**: VDDA_1P8 × 0.65 V to VDDA_1P8 + 0.18 V
    - **Low Level**: −0.30 V
  - **Input Current**
    - **High Level**: −10 μA to +10 μA
    - **Low Level**: −10 μA to +10 μA
- **Logic Outputs**
  - **Output Voltage**
    - **High**: VDDA_1P8 − 0.45 V
    - **Low**: 0.45 V
  - **Drive Capability**: 10 mA

#### POWER SUPPLY SPECIFICATIONS

**Table 4. Power Supply Voltages**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SUPPLY CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VDDA_1P0 Supply</td>
<td>0.95</td>
<td>1.0</td>
<td>1.05</td>
<td>V</td>
</tr>
<tr>
<td>VDIG Supply</td>
<td>0.95</td>
<td>1.0</td>
<td>1.05</td>
<td>V</td>
</tr>
<tr>
<td>VDDA_1P3 Supply</td>
<td>1.235</td>
<td>1.3</td>
<td>1.365</td>
<td>V</td>
</tr>
<tr>
<td>VDDA_1P8 Supply</td>
<td>1.71</td>
<td>1.8</td>
<td>1.89</td>
<td>V</td>
</tr>
<tr>
<td>VIF Supply</td>
<td>1.71</td>
<td>1.8</td>
<td>1.89</td>
<td>V</td>
</tr>
</tbody>
</table>
CURRENT CONSUMPTION

In Table 5, Table 6, and Table 7, the first row contains the data for the UC13-NLS profile and subsequent rows provide UC13-NLS profile details. Note that all current measurements reported in Table 5, Table 6, and Table 7 are obtained at room temperature without a heat sink.

**TDD Operation—Four Receiver Channels Enabled**

Maximum gain and typical values.

**Table 5.**

<table>
<thead>
<tr>
<th>Profile Conditions</th>
<th>Supply (A)</th>
<th>Total Average Power (W)</th>
<th>75% Tx, 25% Rx Average Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USE CASE UC13-NLS (16 BITS)</td>
<td>1.0 V</td>
<td>1.181</td>
<td>4.19</td>
</tr>
<tr>
<td></td>
<td>1.3 V</td>
<td>2.003</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.8 V</td>
<td>0.217</td>
<td></td>
</tr>
<tr>
<td>245.76 MSPS Tx/ORx Data Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>122.88 MSPS Rx Data Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>245.76 MHz Device Clock</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TDD Operation—Four Transmitter and One Observation Receiver Channels Enabled**

Maximum gain, 0 dB attenuation, typical values.

**Table 6.**

<table>
<thead>
<tr>
<th>Profile Conditions</th>
<th>Supply (A)</th>
<th>Total Average Power (W)</th>
<th>75% Tx, 25% Rx Average Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USE CASE UC13-NLS (16 BITS)</td>
<td>1.0 V</td>
<td>1.419</td>
<td>5.28</td>
</tr>
<tr>
<td></td>
<td>1.3 V</td>
<td>2.084</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.8 V</td>
<td>0.633</td>
<td></td>
</tr>
<tr>
<td>245.76 MSPS Tx/ORx Data Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>122.88 MSPS Rx Data Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>245.76 MHz Device Clock</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**FDD Operation—LO1 and LO2, Four Receiver, Four Transmitter, and One Observation Receiver Channels Enabled**

Maximum gain, 0 dB attenuation, typical values.

**Table 7.**

<table>
<thead>
<tr>
<th>Profile Conditions</th>
<th>Supply (A)</th>
<th>Total Average Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>USE CASE UC13-NLS (16 BITS)</td>
<td>1.0 V</td>
<td>1.664</td>
</tr>
<tr>
<td></td>
<td>1.3 V</td>
<td>2.929</td>
</tr>
<tr>
<td></td>
<td>1.8 V</td>
<td>0.762</td>
</tr>
<tr>
<td>245.76 MSPS Tx/ORx Data Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>122.88 MSPS Rx Data Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>245.76 MHz Device Clock</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# DIGITAL INTERFACE AND TIMING SPECIFICATIONS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
<th>Test Conditions/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SERIAL PERIPHERAL INTERFACE (SPI) TIMING</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPI_CLK Period</td>
<td>$t_{CP}$</td>
<td>40</td>
<td></td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>SPI_CLK Pulse Width</td>
<td>$t_{MP}$</td>
<td>10</td>
<td></td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>SPI_EN Setup to First SPI_CLK Rising Edge</td>
<td>$t_{SC}$</td>
<td>4</td>
<td></td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Last SPI_CLK Falling Edge to SPI_EN Hold</td>
<td>$t_{HC}$</td>
<td>0</td>
<td></td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>SPI_DIO Data Input Setup to SPI_CLK</td>
<td>$r_s$</td>
<td>4</td>
<td></td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>SPI_DIO Data Input Hold to SPI_CLK</td>
<td>$r_h$</td>
<td>0</td>
<td></td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>SPI_CLK Falling Edge to Output Data Delay</td>
<td>$t_{CO}$</td>
<td>10</td>
<td>8</td>
<td></td>
<td>ns</td>
<td>3- or 4-wire mode</td>
</tr>
<tr>
<td>Bus Turnaround Time After Baseband Processor Drives Last Address Bit</td>
<td>$t_{HZM}$</td>
<td>$t_h$</td>
<td>$t_{CO}$</td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Bus Turnaround Time After ADRV9029 Drives Last Address Bit</td>
<td>$t_{HZS}$</td>
<td>0</td>
<td>$t_{CO}$</td>
<td></td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td><strong>DIGITAL TIMING</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TXx_EN Pulse Width</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td>μs</td>
<td></td>
</tr>
<tr>
<td>RXx_EN Pulse Width</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td>μs</td>
<td></td>
</tr>
<tr>
<td>ORX_CTRL_x Pulse Width</td>
<td></td>
<td>10</td>
<td></td>
<td></td>
<td>μs</td>
<td></td>
</tr>
<tr>
<td>TXx_EN to Valid Data</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>μs</td>
<td></td>
</tr>
<tr>
<td>RXx_EN to Valid Data</td>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>μs</td>
<td></td>
</tr>
<tr>
<td>ORX_CTRL_x to Valid Data</td>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td>μs</td>
<td></td>
</tr>
<tr>
<td><strong>JESD204B/JESD204C DATA OUTPUT TIMING</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit Interval</td>
<td>$UI$</td>
<td>41.1</td>
<td>333</td>
<td></td>
<td>ps</td>
<td></td>
</tr>
<tr>
<td>Data Rate per Channel (No Return to Zero (NRZ))</td>
<td></td>
<td>3000</td>
<td>24330.24</td>
<td></td>
<td>Mbps</td>
<td>20% to 80% in 100 Ω load</td>
</tr>
<tr>
<td>Rise Time</td>
<td>$t_r$</td>
<td>17</td>
<td>20</td>
<td></td>
<td>ps</td>
<td>20% to 80% in 100 Ω load</td>
</tr>
<tr>
<td>Fall Time</td>
<td>$t_f$</td>
<td>17</td>
<td>20</td>
<td></td>
<td>ps</td>
<td>AC-coupled</td>
</tr>
<tr>
<td>Output Common-Mode Voltage</td>
<td>$V_{CM}$</td>
<td>0</td>
<td>1.8</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Differential Output Voltage</td>
<td>$V_{DIFF}$</td>
<td>475</td>
<td>1050</td>
<td></td>
<td>mV p-p</td>
<td></td>
</tr>
<tr>
<td>Short-Circuit Current</td>
<td>$I_{SHORT}$</td>
<td>−100</td>
<td>+100</td>
<td></td>
<td>mA</td>
<td></td>
</tr>
<tr>
<td>Differential Termination Impedance</td>
<td>$Z_{DIFF}$</td>
<td>80</td>
<td>100</td>
<td>120</td>
<td>Ω</td>
<td></td>
</tr>
<tr>
<td>SYSREF± Input Signal Setup Time to DEV_CLK± Input Signal</td>
<td>$t_s$</td>
<td>200</td>
<td></td>
<td></td>
<td>ps</td>
<td></td>
</tr>
<tr>
<td>SYSREF± Input Signal Hold Time to DEV_CLK± Input Signal</td>
<td>$t_h$</td>
<td>200</td>
<td></td>
<td></td>
<td>ps</td>
<td></td>
</tr>
<tr>
<td><strong>JESD204B/C DATA INPUT TIMING</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unit Interval</td>
<td>$UI$</td>
<td>41.1</td>
<td>333</td>
<td></td>
<td>ps</td>
<td>AC-coupled</td>
</tr>
<tr>
<td>Data Rate per Channel (NRZ)</td>
<td></td>
<td>3000</td>
<td>24330.24</td>
<td></td>
<td>Mbps</td>
<td>DC-coupled (not recommended)</td>
</tr>
<tr>
<td>Input Common-Mode Voltage</td>
<td>$V_{CM}$</td>
<td>0.05</td>
<td>1.65</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>Termination Voltage = 1.0 V</td>
<td>$V_{TT}$</td>
<td>720</td>
<td>1200</td>
<td></td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>Differential Input Voltage</td>
<td>$V_{DIFF}$</td>
<td>110</td>
<td>1050</td>
<td></td>
<td>mV</td>
<td></td>
</tr>
<tr>
<td>$V_{TT}$ Source Impedance</td>
<td>$Z_{TT}$</td>
<td>7.5</td>
<td>30</td>
<td></td>
<td>Ω</td>
<td></td>
</tr>
<tr>
<td>Differential Termination Impedance</td>
<td>$Z_{DIFF}$</td>
<td>80</td>
<td>100</td>
<td>120</td>
<td>Ω</td>
<td></td>
</tr>
<tr>
<td>$V_{TT}$ AC-Coupled</td>
<td></td>
<td>0.95</td>
<td>1.05</td>
<td></td>
<td>V</td>
<td></td>
</tr>
<tr>
<td>$V_{TT}$ DC-Coupled</td>
<td></td>
<td>0.95</td>
<td>1.05</td>
<td></td>
<td>V</td>
<td></td>
</tr>
</tbody>
</table>
ABSOLUTE MAXIMUM RATINGS

Table 9.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>VDDA_1P8 to VSSA</td>
<td>−0.3 V to +2.2 V</td>
</tr>
<tr>
<td>VDDA_1P3 to VSSA</td>
<td>−0.2 V to +1.5 V</td>
</tr>
<tr>
<td>VDDA_1P0, VDIG_1P0 to VSSD, VSSA</td>
<td>−0.2 V to +1.2 V</td>
</tr>
<tr>
<td>VIF Referenced Logic Inputs and Outputs to VSSD</td>
<td>−0.3 V to VIF + 0.3 V</td>
</tr>
<tr>
<td>JESD204B/JESD204C Logic Outputs to VSSA</td>
<td>−0.3 V to VSER_1P0</td>
</tr>
<tr>
<td>JESD204B/JESD204C Logic Inputs to VSSA</td>
<td>−0.3 V to VDES_1P0</td>
</tr>
<tr>
<td>Input Current to Any Pin Except Supplies</td>
<td>±10 mA</td>
</tr>
<tr>
<td>Maximum Input Power into RF Ports</td>
<td>See Table 11 for limits vs. survival time</td>
</tr>
<tr>
<td>Reflow Temperature</td>
<td>260°C</td>
</tr>
<tr>
<td>Junction Temperature Range</td>
<td>−40°C to +110°C</td>
</tr>
<tr>
<td>Storage Temperature Range</td>
<td>−65°C to +150°C</td>
</tr>
</tbody>
</table>

1 The maximum junction temperature for continuous operation is 110°C. See the Junction Temperature section for more details.

Stresses at or above those listed under Absolute Maximum Ratings may cause permanent damage to the product. This is a stress rating only; functional operation of the product at these or any other conditions above those indicated in the operational section of this specification is not implied. Operation beyond the maximum operating conditions for extended periods may affect product reliability.

JUNCTION TEMPERATURE

The maximum junction temperature for continuous operation is 110°C. Although operation up to 125°C is supported, specification compliance is only guaranteed up to 110°C. To avoid a reduction in operating lifetime by operating at temperatures greater than 110°C, the device must operate at a temperature less than 110°C for a period determined by the following equation:

\[ T_{\text{UNITS}} < 110 = \frac{(AF_{T > 110} - 1)}{(1 - AF_{T < 110})} \]

where:

- \( AF \) is the acceleration factor.
- \( AF_{T > 110} \) and \( AF_{T < 110} \) are acceleration factors obtained from Table 10.

For example, if the device operates at 125°C for 1 hour, expected device lifetime is maintained if the device operates at 100°C for 4.5 hours to offset the time operating above 110°C.

Table 10. Acceleration Factors for High Temperature Operation

<table>
<thead>
<tr>
<th>Operating Junction Temperature (°C)</th>
<th>Acceleration Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>125</td>
<td>3.75</td>
</tr>
<tr>
<td>120</td>
<td>2.44</td>
</tr>
<tr>
<td>115</td>
<td>1.57</td>
</tr>
<tr>
<td>110</td>
<td>1.00</td>
</tr>
<tr>
<td>105</td>
<td>0.63</td>
</tr>
<tr>
<td>100</td>
<td>0.39</td>
</tr>
<tr>
<td>95</td>
<td>0.24</td>
</tr>
<tr>
<td>90</td>
<td>0.14</td>
</tr>
</tbody>
</table>

Table 11. Maximum Input Power into RF Ports vs. Lifetime

<table>
<thead>
<tr>
<th>RF Port Input Power, Continuous Wave Signal (dBm)</th>
<th>Lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gain = −30 dB</td>
</tr>
<tr>
<td>7</td>
<td>&gt;10 years</td>
</tr>
<tr>
<td>10</td>
<td>&gt;10 years</td>
</tr>
<tr>
<td>20</td>
<td>&gt;10 years</td>
</tr>
<tr>
<td>23</td>
<td>&gt;10 years</td>
</tr>
<tr>
<td>25</td>
<td>&gt;7 years</td>
</tr>
</tbody>
</table>

REFLOW PROFILE

The ADRV9029 reflow profile is in accordance with the JEDEC JESD20 criteria for lead-free (Pb-free) devices. The maximum reflow temperature is 260°C.

THERMAL RESISTANCE

Thermal resistance values specified in Table 12 are calculated based on JEDEC specifications and should be used in compliance with JESD51-2. Note that using enhanced heat removal techniques (PCB, heat sink, airflow, and so forth) improves thermal resistance.

Table 12. Thermal Resistance Values

<table>
<thead>
<tr>
<th>Package Type</th>
<th>( \theta_{JA} )</th>
<th>( \theta_{JCTOP} )</th>
<th>( \theta_{JB} )</th>
<th>( \psi_{JC} )</th>
<th>( \psi_{JB} )</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC-289-6</td>
<td>14.8</td>
<td>0.03</td>
<td>3.4</td>
<td>0.02</td>
<td>3.4</td>
<td>(°C/W)</td>
</tr>
</tbody>
</table>

ESD CAUTION

ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.
### PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

<table>
<thead>
<tr>
<th>Column 1</th>
<th>Column 2</th>
<th>Column 3</th>
<th>Column 4</th>
<th>Column 5</th>
<th>Column 6</th>
<th>Column 7</th>
<th>Column 8</th>
<th>Column 9</th>
<th>Column 10</th>
<th>Column 11</th>
<th>Column 12</th>
<th>Column 13</th>
<th>Column 14</th>
<th>Column 15</th>
<th>Column 16</th>
<th>Column 17</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>VSSA</td>
<td>VSSA</td>
<td>VSSA</td>
<td>TX3+</td>
<td>TX3−</td>
<td>VSSA</td>
<td>VSSA</td>
<td>TX3+</td>
<td>TX3−</td>
<td>VSSA</td>
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<td>VSSA</td>
<td>VSSA</td>
<td>VSSA</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>RX3−</td>
<td>VSSA</td>
<td>VSSA</td>
<td>VSSA</td>
<td>RX3−</td>
<td>VSSA</td>
<td>VSSA</td>
<td>RX3−</td>
<td>RX3+</td>
<td>RX3−</td>
<td>RX3+</td>
<td>RX3−</td>
<td>RX3+</td>
<td>RX3−</td>
<td>RX3+</td>
<td>RX3−</td>
</tr>
<tr>
<td>C</td>
<td>RX3+</td>
<td>NIC</td>
<td>GPIO_8</td>
<td>GPIO_7</td>
<td>GPIO_6</td>
<td>GPIO_5</td>
<td>GPIO_4</td>
<td>GPIO_3</td>
<td>GPIO_2</td>
<td>GPIO_1</td>
<td>GPIO_0</td>
<td>RX2_RBIAS</td>
<td>RX2+</td>
<td>RX2−</td>
<td>RX2+</td>
<td>RX2−</td>
</tr>
<tr>
<td>D</td>
<td>VSSA</td>
<td>VSSA</td>
<td>VSSA</td>
<td>VSSA</td>
<td>VSSA</td>
<td>VSSA</td>
<td>VSSA</td>
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<td>VSSA</td>
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<td>VSSA</td>
<td>VSSA</td>
<td>VSSA</td>
<td>VSSA</td>
<td>VSSA</td>
<td></td>
</tr>
</tbody>
</table>

**NOTES**

1. NIC = NOT INTERNALLY CONNECTED. THESE PINS MUST REMAIN DISCONNECTED.

---

**Figure 2. Pin Configuration**
## Table 13. Pin Function Descriptions

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Mnemonic</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 to A3, A6, A8, A10 to A12, A15 to A17, B2, B3, B5 to B10, B12, B13, B15, B16, C2, C7, C10, C14, C16, D1, D2, D4 to D7, D10 to D14, D16, D17, E3, E6, E12, E15, F3 to F6, F12 to F15, G1, G2, G4, G6, G12, G14, G16, G17, H2, H4 to H6, H12 to H14, H16, J2, J4, J6, J12, J14, J16, K1, K2, K4 to K6, K12 to K14, K16, L3, L6, L12, L15, M1 to M6, M12 to M17, N3, N4, P2 to P4, P9, P16, R1, R2, R5, R6, R8, R10, R12 to R14, R16, T1, T2, T5, T6, T9, T12, T13, T16, T17, U3, U4, U7 to U11, U14, U15</td>
<td>TX3+, TX3−</td>
<td>O</td>
<td>Differential Output for Transmitter Channel 3. If unused, do not connect these pins.</td>
</tr>
<tr>
<td>A4, A5</td>
<td>VSSA</td>
<td>I</td>
<td>Analog Ground.</td>
</tr>
<tr>
<td>A7</td>
<td>VTXLO_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>A9</td>
<td>VRXLO_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>A13, A14</td>
<td>TX2+, TX2−</td>
<td>O</td>
<td>Differential Output for Transmitter Channel 2. When unused, do not connect.</td>
</tr>
<tr>
<td>B1, C1</td>
<td>RX3−, RX3+</td>
<td>I</td>
<td>Differential Input for Receiver Channel 3. If unused, connect these pins to VSSA.</td>
</tr>
<tr>
<td>B4</td>
<td>VANA3_1P8</td>
<td>I</td>
<td>1.8 V Supply Input.</td>
</tr>
<tr>
<td>B11</td>
<td>VAUXVCO_1P0</td>
<td>O</td>
<td>1.0 V Internal Supply Node. Bypass Pin B11 with a 4.7 μF capacitor.</td>
</tr>
<tr>
<td>B14</td>
<td>VANA2_1P8</td>
<td>I</td>
<td>1.8 V Supply Input.</td>
</tr>
<tr>
<td>B17, C17</td>
<td>RX2+, RX2−</td>
<td>I</td>
<td>Differential Input for Receiver Channel 2. If unused, connect these pins to VSSA.</td>
</tr>
<tr>
<td>C3, R11</td>
<td>NIC</td>
<td>N/A</td>
<td>Not Internally Connected. These pins must remain disconnected.</td>
</tr>
<tr>
<td>C4, C5, L1, L2, L17, L16, C12, C13</td>
<td>GPIO_ANA_7 to GPIO_ANA_0</td>
<td>I/O</td>
<td>General-Purpose Inputs and Outputs. The GPIO_ANA_7 to GPIO_ANA_0 pins are referenced to 1.8 V and can also function as auxiliary DAC outputs. If unused, these pins can be connected to VSSA with a 10 kΩ resistor or configured as outputs, driven low, and left disconnected.</td>
</tr>
<tr>
<td>C6</td>
<td>VAUXSYN_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>C8, C9</td>
<td>DEVCCLK+, DEVCCLK−</td>
<td>I</td>
<td>Device Clock Differential Input.</td>
</tr>
<tr>
<td>C11</td>
<td>VAUXVCO_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>C15</td>
<td>RBIAS</td>
<td>I</td>
<td>Bias Resistor Connection. Pin C15 generates an internal current based on an external 1% resistor. Connect a 4.99 kΩ resistor between Pin C15 and analog ground (VSSA).</td>
</tr>
<tr>
<td>D3</td>
<td>VANA2_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>D8, D9</td>
<td>SYSREF+, SYSREF−</td>
<td>I</td>
<td>LVDS System Reference Clock Inputs for the SERDES Interface. Connect a 100 Ω termination between these pins.</td>
</tr>
<tr>
<td>D15</td>
<td>VANA1_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>E1</td>
<td>AUXADC_3</td>
<td>I</td>
<td>Auxiliary ADC 3 Input. If Pin E1 is unused, do not connect.</td>
</tr>
<tr>
<td>E2, F2</td>
<td>EXT_LO2−, EXT_LO2+</td>
<td>I/O</td>
<td>Differential External LO Input/Output 2. If used for the external LO input, the input frequency must be 2× the desired carrier frequency. Do not connect if unused. External LO functionality not supported currently.</td>
</tr>
<tr>
<td>E4, E5</td>
<td>ORX3+, ORX3−</td>
<td>I</td>
<td>Differential Input for Observation Receiver Channel 3. Connect to VSSA if unused.</td>
</tr>
<tr>
<td>E7</td>
<td>TX3_EN</td>
<td>I</td>
<td>Enable Input for Transmitter Channel 3. Connect to VSSA if unused.</td>
</tr>
<tr>
<td>Pin No.</td>
<td>Mnemonic</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>----------</td>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>H11, K11, N11, E10, F10, G10, H10, J10, K10, E9, F9, E8, F8, G8, H8, J8, K8, H7, K7</td>
<td>GPIO_0 to GPIO_18</td>
<td>I/O</td>
<td>General-Purpose Digital Inputs and Outputs. See Figure 2 to match the ball location to the GPIO_x signal name. If unused, these pins can be connected to VSSA with a 10 kΩ resistor or configured as outputs, driven low, and left disconnected.</td>
</tr>
<tr>
<td>E11</td>
<td>TX2_EN</td>
<td>I</td>
<td>Enable Input for Transmitter Channel 2. Connect to VSSA if unused.</td>
</tr>
<tr>
<td>E13, E14</td>
<td>ORX1+, ORX1−</td>
<td>I</td>
<td>Differential Input for Observation Receiver Channel 1. Connect to VSSA if unused.</td>
</tr>
<tr>
<td>E16, F16</td>
<td>EXT_LO1+, EXT_LO1−</td>
<td>I/O</td>
<td>Differential External LO Input/Output 1. If used for the external LO input, the input frequency must be 2× the desired carrier frequency. Do not connect if unused. External LO functionality not currently supported.</td>
</tr>
<tr>
<td>E17</td>
<td>AUXADC_1</td>
<td>I</td>
<td>Auxiliary ADC 1 Input. Do not connect if unused.</td>
</tr>
<tr>
<td>F1</td>
<td>AUXADC_2</td>
<td>I</td>
<td>Auxiliary ADC 2 Input. Do not connect if unused.</td>
</tr>
<tr>
<td>F7, F11, L7, L11</td>
<td>ORX_CTRL_C, ORX_CTRL_B, ORX_CTRL_D, ORX_CTRL_A</td>
<td>I</td>
<td>Determine Active Observation Receiver Path. Connect to VSSA directly or with a pull-down resistor if unused.</td>
</tr>
<tr>
<td>F17</td>
<td>AUXADC_0</td>
<td>I</td>
<td>Auxiliary ADC 0 Input. Do not connect if unused.</td>
</tr>
<tr>
<td>G3</td>
<td>VRFVCO2_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>G5</td>
<td>VRFVCO2_1P0</td>
<td>O</td>
<td>1.0 V Internal Supply Node. Bypass this pin with a 4.7 μF capacitor.</td>
</tr>
<tr>
<td>G7</td>
<td>RX3_EN</td>
<td>I</td>
<td>Enable Input for Receiver Channel 3. Connect to VSSA if unused.</td>
</tr>
<tr>
<td>G9, J9, L9</td>
<td>VDIG_1P0</td>
<td>I</td>
<td>1.0 V Digital Supply Input.</td>
</tr>
<tr>
<td>G11</td>
<td>RX2_EN</td>
<td>I</td>
<td>Enable Input for Receiver Channel 2. Connect to VSSA if unused.</td>
</tr>
<tr>
<td>G13</td>
<td>VRFVCO1_1P0</td>
<td>O</td>
<td>1.0 V Internal Supply Node. Bypass this pin with a 4.7 μF capacitor.</td>
</tr>
<tr>
<td>G15</td>
<td>VRFVCO1_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>H1, J1</td>
<td>RX4−, RX4+</td>
<td>I</td>
<td>Differential Input for Receiver Channel 4. If unused, connect to VSSA.</td>
</tr>
<tr>
<td>H3</td>
<td>VCONV2_1P8</td>
<td>I</td>
<td>1.8 V Supply Input.</td>
</tr>
<tr>
<td>H9, K9, M9</td>
<td>VSSD</td>
<td>I</td>
<td>Digital Ground.</td>
</tr>
<tr>
<td>H15</td>
<td>VCONV1_1P8</td>
<td>I</td>
<td>1.8 V Supply Input.</td>
</tr>
<tr>
<td>H17, J17</td>
<td>RX1+, RX1−</td>
<td>I</td>
<td>Differential Input for Receiver Channel 1. If unused, connect to VSSA.</td>
</tr>
<tr>
<td>J3</td>
<td>VCONV2_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>J5</td>
<td>VRFSYN2_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>J7</td>
<td>RX4_EN</td>
<td>I</td>
<td>Enable Input for Receiver Channel 4. If unused, connect to VSSA.</td>
</tr>
<tr>
<td>J11</td>
<td>RX1_EN</td>
<td>I</td>
<td>Enable Input for Receiver Channel 1. If unused, connect to VSSA.</td>
</tr>
<tr>
<td>J13</td>
<td>VRFSYN1_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>J15</td>
<td>VCONV1_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>K3</td>
<td>VCONV2_1P0</td>
<td>O</td>
<td>1.0 V Internal Supply Node. Bypass this pin with a 4.7 μF capacitor.</td>
</tr>
<tr>
<td>K15</td>
<td>VCONV1_1P0</td>
<td>O</td>
<td>1.0 V Internal Supply Node. Bypass this pin with a 4.7 μF capacitor.</td>
</tr>
<tr>
<td>L4, L5</td>
<td>ORX4+, ORX4−</td>
<td>I</td>
<td>Differential Input for Observation Receiver Channel 4. If unused, connect to VSSA.</td>
</tr>
<tr>
<td>Pin No.</td>
<td>Mnemonic</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>-----------</td>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>L8</td>
<td>SPI_DIO</td>
<td>I/O</td>
<td>Serial Data Input. SPI_DIO is the serial data input in 4-wire mode or input/output in 3-wire mode.</td>
</tr>
<tr>
<td>L10</td>
<td>SPI_EN</td>
<td>I</td>
<td>Serial Data Bus Chip Select. Active low.</td>
</tr>
<tr>
<td>L13, L14</td>
<td>ORX2+, ORX2−</td>
<td>I</td>
<td>Differential Input for Observation Receiver Channel 2. If unused, connect to VSSA.</td>
</tr>
<tr>
<td>M7</td>
<td>TX4_EN</td>
<td>I</td>
<td>Enable Input for Transmitter Channel 4. If unused, connect to VSSA.</td>
</tr>
<tr>
<td>M8</td>
<td>SPI_DO</td>
<td>O</td>
<td>Serial Data Output.</td>
</tr>
<tr>
<td>M10</td>
<td>SPI_CLK</td>
<td>I</td>
<td>Serial Data Bus Clock Input.</td>
</tr>
<tr>
<td>M11</td>
<td>TX1_EN</td>
<td>I</td>
<td>Enable Input for Transmitter Channel 1. If unused, connect to VSSA.</td>
</tr>
<tr>
<td>N1, P1</td>
<td>TX4−, TX4+</td>
<td>O</td>
<td>Differential Output for Transmitter Channel 4. If unused, do not connect.</td>
</tr>
<tr>
<td>N2</td>
<td>VANA4_1P8</td>
<td>I</td>
<td>1.8 V Supply Input.</td>
</tr>
<tr>
<td>N5</td>
<td>VCLKVCO_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>N6, P6</td>
<td>SYNCIN3+, SYNCIN3−</td>
<td>I</td>
<td>LVDS Sync Signal Input 3. If unused, connect to VSSA.</td>
</tr>
<tr>
<td>N7</td>
<td>GPINT2</td>
<td>O</td>
<td>General-Purpose Interrupt Output 2. If unused, do not connect.</td>
</tr>
<tr>
<td>N8</td>
<td>GPINT1</td>
<td>O</td>
<td>General-Purpose Interrupt Output 1. If unused, do not connect.</td>
</tr>
<tr>
<td>N9</td>
<td>VIF</td>
<td>I</td>
<td>1.8 V Interface Supply Input.</td>
</tr>
<tr>
<td>N10</td>
<td>RESET</td>
<td>I</td>
<td>Active Low Chip Reset.</td>
</tr>
<tr>
<td>N12, N13</td>
<td>SYNCIN1+, SYNCIN1−</td>
<td>I</td>
<td>LVDS Sync Signal Input 1. If unused, connect to VSSA.</td>
</tr>
<tr>
<td>N14, N15</td>
<td>SYNCOUT2+, SYNCOUT2−</td>
<td>O</td>
<td>LVDS Sync Signal Output 2. If unused, do not connect.</td>
</tr>
<tr>
<td>N16</td>
<td>VANA1_1P8</td>
<td>I</td>
<td>1.8 V Supply Input.</td>
</tr>
<tr>
<td>N17, P17</td>
<td>TX1+, TX1−</td>
<td>O</td>
<td>Differential Output for Transmitter Channel 1. Do not connect if unused.</td>
</tr>
<tr>
<td>P5</td>
<td>VCLKVCO_1P0</td>
<td>O</td>
<td>1.0 V Internal Supply Node. Bypass this pin with a 4.7 μF capacitor.</td>
</tr>
<tr>
<td>P7, P8</td>
<td>SYNCIN2+, SYNCIN2−</td>
<td>I</td>
<td>LVDS Sync Signal Input 2. If unused, connect to VSSA.</td>
</tr>
<tr>
<td>P10</td>
<td>TEST_EN</td>
<td>I</td>
<td>Test Input for JTAG Boundary Scan. Pull high to enable boundary scan. If unused, tie to VSSA.</td>
</tr>
<tr>
<td>P11</td>
<td>VJVCO_1P8</td>
<td>I</td>
<td>1.8 V Supply Input.</td>
</tr>
<tr>
<td>P12, P13</td>
<td>VDES_1P0</td>
<td>I</td>
<td>1.0 V Analog Supply Input.</td>
</tr>
<tr>
<td>P14</td>
<td>VTT_DES</td>
<td>I</td>
<td>1.0 V Analog Supply Input.</td>
</tr>
<tr>
<td>P15, R15</td>
<td>SYNCOUT1+, SYNCOUT1−</td>
<td>O</td>
<td>LVDS Sync Signal Output 1. If unused, do not connect.</td>
</tr>
<tr>
<td>R3, R4</td>
<td>VSER_1P0</td>
<td>I</td>
<td>1.0 V Analog Supply Input.</td>
</tr>
<tr>
<td>R7</td>
<td>VCLKSYN_1P3</td>
<td>I</td>
<td>1.3 V Supply Input.</td>
</tr>
<tr>
<td>R9</td>
<td>VJSYN_1P0</td>
<td>I</td>
<td>1.0 V Analog Supply Input.</td>
</tr>
<tr>
<td>T3, T4</td>
<td>SERDOUTC+, SERDOUTC−</td>
<td>O</td>
<td>SERDES Differential Output C. If unused, do not connect.</td>
</tr>
<tr>
<td>T7, T8</td>
<td>SERDOUTA+, SERDOUTA−</td>
<td>O</td>
<td>SERDES Differential Output A. If unused, do not connect.</td>
</tr>
<tr>
<td>T10, T11</td>
<td>SERDINA−, SERDINA+</td>
<td>I</td>
<td>SERDES Differential Input A. If unused, do not connect.</td>
</tr>
<tr>
<td>T14, T15</td>
<td>SERDINC−, SERDINC+</td>
<td>I</td>
<td>SERDES Differential Input C. If unused, do not connect.</td>
</tr>
<tr>
<td>U1, U2</td>
<td>SERDOUTD+, SERDOUTD−</td>
<td>O</td>
<td>SERDES Differential Output D. If unused, do not connect.</td>
</tr>
<tr>
<td>U5, U6</td>
<td>SERDOUTB+, SERDOUTB−</td>
<td>O</td>
<td>SERDES Differential Output B. If unused, do not connect.</td>
</tr>
<tr>
<td>Pin No.</td>
<td>Mnemonic</td>
<td>Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------</td>
<td>------------------</td>
<td>------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>U12, U13</td>
<td>SERDINB+, SERDINB—</td>
<td>I</td>
<td>SERDES Differential Input B. If unused, do not connect.</td>
</tr>
<tr>
<td>U16, U17</td>
<td>SERDIND+, SERDIND—</td>
<td>I</td>
<td>SERDES Differential Input D. If unused, do not connect.</td>
</tr>
</tbody>
</table>

1 I is input, O is output, I/O is input/output, and N/A is not applicable.
**TYPICAL PERFORMANCE CHARACTERISTICS**

Device configuration profile: receiver = 62.5 MHz bandwidth, I/Q rate = 76.8 MHz, transmitter = 62.5 MHz large signal bandwidth plus 141 MHz synthesis bandwidth, I/Q rate = 153.6 MHz, observation receiver (ORX) = 141 MHz bandwidth, I/Q rate = 153.6 MHz, device clock = 153.6 MHz, unless otherwise noted.

**75 MHZ BAND**

The temperature settings refer to the die temperature. All LO frequencies set to 75 MHz, unless otherwise noted.

---

**Figure 3. Transmitter Continuous Wave Output Power vs. Transmitter LO Frequency, 10 MHz Offset, 0 dB Attenuation**

**Figure 4. Transmitter Output Power Spectrum, Tx1, 5 MHz LTE, 10 MHz Offset, –10 dBFS RMS, 1 MHz Resolution Bandwidth, Tj = 25°C**

**Figure 5. Transmitter Image Rejection Across Large Signal Bandwidth vs. Baseband Offset Frequency**

**Figure 6. Transmitter Noise vs. Transmitter Attenuation, 10 MHz Offset**

**Figure 7. Transmitter Pass Band Flatness vs. Baseband Offset Frequency**

**Figure 8. Adjacent Channel Power Level vs. Transmitter Attenuation, 21 MHz Baseband Offset, 5 MHz LTE, Peak to Average Ratio (PAR) = 12 dB**
Figure 9. Adjacent Channel Power Level vs. Transmitter Attenuation, 44 MHz Baseband Offset, 5 MHz LTE, PAR = 12 dB

Figure 10. Transmitter Second-Order Harmonic Distortion (HD2) vs. Transmitter Attenuation, 10 MHz Offset

Figure 11. Transmitter Third-Order Harmonic Distortion (HD3) vs. Transmitter Attenuation, 10 MHz Offset

Figure 12. Transmitter Attenuator Step Error vs. Transmitter Attenuation, 10 MHz Offset

Figure 13. Transmitter Error Vector Magnitude vs. Transmitter Attenuation, 5 MHz LTE Signal Centered at LO Frequency, Sample Rate = 153.6 MSPS, Loop Filter Bandwidth = 50 kHz, Loop Filter Phase Margin = 40°

Figure 14. Transmitter OIP3, $2f_1 - f_2$ vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, $f_1 = 45.5$ MHz, $f_2 = 50.5$ MHz
Figure 15. Transmitter OIP3, 2f2 – f1 vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, f1 = 45.5 MHz, f2 = 50.5 MHz

Figure 16. Transmitter OIP3, 2f1 – f2 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 17. Transmitter OIP3, 2f2 – f1 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 18. Transmitter LO Leakage vs. Transmitter LO Frequency

Figure 19. Transmitter to Transmitter Isolation vs. Transmitter LO Frequency

Figure 20. Transmitter to Receiver Isolation vs. Receiver LO Frequency
Figure 21. Transmitter to Observation Receiver Isolation vs. Transmitter LO Frequency

Figure 22. Receiver to Receiver Isolation vs. Receiver LO Frequency

Figure 23. Receiver Integrated Noise Figure vs. Receiver Attenuation, 62.5 MHz Bandwidth, Sample Rate = 76.8 MSPS, Integration Bandwidth = 500 kHz to 30 MHz

Figure 24. Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 62.5 MHz Bandwidth, Sample Rate = 76.8 MSPS, Integrated in 200 kHz Steps

Figure 25. Receiver LO Leakage vs. Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 76.8 MSPS

Figure 26. Receiver Gain vs. Receiver Attenuation, 20 MHz Offset, 62.5 MHz Bandwidth, Sample Rate = 76.8 MSPS
Figure 27. Receiver Gain Step Error vs. Receiver Attenuation, 10 MHz Offset, −5 dBFS Input Signal

Figure 28. Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 76.8 MSPS

Figure 29. Receiver Image vs. Receiver Attenuation, 10 MHz Offset, Tracking Calibration Active, Sample Rate = 76.8 MSPS

Figure 30. Receiver DC Offset vs. Receiver Attenuation, 10 MHz Offset, −5 dBFS Input Signal

Figure 31. Receiver DC Offset vs. Receiver LO Frequency, 10 MHz Offset, −5 dBFS Input Signal

Figure 32. Receiver HD2, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz (HD2 Canceller Enabled)
**Figure 33. Receiver HD2, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz (HD2 Canceller Enabled)**

**Figure 34. Receiver HD3, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz**

**Figure 35. Receiver HD3, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz**

**Figure 36. Receiver IIP2, $f_1 + f_2$ vs. Tone 2 Frequency, Both Tones at −11 dBFS, $f_1 = f_2 + 2$ MHz**

**Figure 37. Receiver IIP2, $f_1 − f_2$ vs. Tone 2 Frequency, Both Tones at −11 dBFS, $f_1 = f_2 + 2$ MHz**

**Figure 38. Receiver IIP2, $f_1 + f_2$ vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, $f_2 = 2$ MHz**
RECEIVER IIP3, 2f2 – f1 (dBm)

-40°C, Rx1
+25°C, Rx1
+110°C, Rx1

-40°C, Rx2
+25°C, Rx2
+110°C, Rx2

-40°C, Rx3
+25°C, Rx3
+110°C, Rx3

-40°C, Rx4
+25°C, Rx4
+110°C, Rx4

TWO-TONE FREQUENCY SPACING (MHz)

4 8 16 20 24 28

Figure 45. Receiver IIP3, 2f2 – f1 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz

RECEIVER ERROR VECTOR MAGNITUDE (dB)

-50 –40 –30 –20 –10 0 10 20 30 40

RECEIVER INPUT POWER (dBm)

-60 –50 –40 –30 –20 –10 0 10 20 30

Figure 46. Receiver Error Vector Magnitude vs. Receiver Input Power, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 153.6 MSPS, Loop Filter Bandwidth = 50 kHz, Loop Filter Phase Margin = 40°

Figure 47. Observation Receiver (ORx) Integrated Noise Figure vs. Observation Receiver Attenuation, 14.1 MHz Offset, 141 MHz Bandwidth, Sample Rate = 153.6 MSPS, Integrated in 200 kHz Steps

OBSERVATION RECEIVER LO FREQUENCY (MHz)

75 175 275 375 475 525

BASEBAND OFFSET FREQUENCY (MHz)

-50 –40 –30 –20 –10 0 10 20

OBSERVATION RECEIVER LO LEAKAGE (dBm)


Figure 48. Observation Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 141 MHz Bandwidth, Sample Rate = 153.6 MSPS, Integrated in 200 kHz Steps

OBSERVATION RECEIVER LO FREQUENCY (MHz)

40°C
+25°C
+110°C

Figure 49. Observation Receiver LO Leakage vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 153.6 MSPS

OBSERVATION RECEIVER GAIN (dB)

0 5 10 15 20 25 30 35 40

OBSERVATION RECEIVER ATTENUATION (dB)

0 5 10 15 20

Figure 50. Observation Receiver Gain vs. Observation Receiver Attenuation, 14.1 MHz Offset, 141 MHz Bandwidth, Sample Rate = 153.6 MSPS
Figure 51. Observation Receiver Gain Step Error vs. Observation Receiver Attenuation, 14.1 MHz Offset, −10 dBFS Input Signal

Figure 52. Normalized Observation Receiver Flatness vs. Baseband Offset Frequency, −10 dBFS Input Signal

Figure 53. Observation Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 153.6 MSPS

Figure 54. Observation Receiver Image vs. Observation Receiver Attenuation, 14.1 MHz Offset, Tracking Calibration Active, Sample Rate = 153.6 MSPS

Figure 55. Observation Receiver DC Offset vs. Observation Receiver Attenuation, 14.1 MHz Offset, −10 dBFS Input Signal

Figure 56. Observation Receiver HD2, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz
OBSERVATION RECEIVER HD2, RIGHT SIDE (dBc)

<table>
<thead>
<tr>
<th>BASEBAND OFFSET FREQUENCY (MHz)</th>
<th>–40°C, ORx1</th>
<th>+25°C, ORx1</th>
<th>+110°C, ORx1</th>
<th>–40°C, ORx2</th>
<th>+25°C, ORx2</th>
<th>+110°C, ORx2</th>
<th>–40°C, ORx3</th>
<th>+25°C, ORx3</th>
<th>+110°C, ORx3</th>
<th>–40°C, ORx4</th>
<th>+25°C, ORx4</th>
<th>+110°C, ORx4</th>
</tr>
</thead>
</table>

Figure 57. Observation Receiver HD2, Right Side vs. Baseband Offset Frequency, –10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

OBSERVATION RECEIVER HD3, LEFT SIDE (dBc)

<table>
<thead>
<tr>
<th>BASEBAND OFFSET FREQUENCY (MHz)</th>
<th>–40°C, ORx1</th>
<th>+25°C, ORx1</th>
<th>+110°C, ORx1</th>
<th>–40°C, ORx2</th>
<th>+25°C, ORx2</th>
<th>+110°C, ORx2</th>
<th>–40°C, ORx3</th>
<th>+25°C, ORx3</th>
<th>+110°C, ORx3</th>
<th>–40°C, ORx4</th>
<th>+25°C, ORx4</th>
<th>+110°C, ORx4</th>
</tr>
</thead>
</table>

Figure 58. Observation Receiver HD3, Left Side vs. Baseband Offset Frequency, –10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

OBSERVATION RECEIVER HD3, RIGHT SIDE (dBc)

<table>
<thead>
<tr>
<th>BASEBAND OFFSET FREQUENCY (MHz)</th>
<th>–40°C, ORx1</th>
<th>+25°C, ORx1</th>
<th>+110°C, ORx1</th>
<th>–40°C, ORx2</th>
<th>+25°C, ORx2</th>
<th>+110°C, ORx2</th>
<th>–40°C, ORx3</th>
<th>+25°C, ORx3</th>
<th>+110°C, ORx3</th>
<th>–40°C, ORx4</th>
<th>+25°C, ORx4</th>
<th>+110°C, ORx4</th>
</tr>
</thead>
</table>

Figure 59. Observation Receiver HD3, Right Side vs. Baseband Offset Frequency, –10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

OBSERVATION RECEIVER IIP2, f1 + f2 (dBm)

<table>
<thead>
<tr>
<th>TONE 2 FREQUENCY (MHz)</th>
<th>–40°C, ORx1</th>
<th>+25°C, ORx1</th>
<th>+110°C, ORx1</th>
<th>–40°C, ORx2</th>
<th>+25°C, ORx2</th>
<th>+110°C, ORx2</th>
<th>–40°C, ORx3</th>
<th>+25°C, ORx3</th>
<th>+110°C, ORx3</th>
<th>–40°C, ORx4</th>
<th>+25°C, ORx4</th>
<th>+110°C, ORx4</th>
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</thead>
</table>

Figure 60. Observation Receiver IIP2, f1 + f2 vs. Tone 2 Frequency, Both Tones at –13 dBFS, f1 = f2 + 2 MHz

OBSERVATION RECEIVER IIP2, f1 − f2 (dBm)

<table>
<thead>
<tr>
<th>TONE 2 FREQUENCY (MHz)</th>
<th>–40°C, ORx1</th>
<th>+25°C, ORx1</th>
<th>+110°C, ORx1</th>
<th>–40°C, ORx2</th>
<th>+25°C, ORx2</th>
<th>+110°C, ORx2</th>
<th>–40°C, ORx3</th>
<th>+25°C, ORx3</th>
<th>+110°C, ORx3</th>
<th>–40°C, ORx4</th>
<th>+25°C, ORx4</th>
<th>+110°C, ORx4</th>
</tr>
</thead>
</table>

Figure 61. Observation Receiver IIP2, f1 − f2 vs. Tone 2 Frequency, Both Tones at –13 dBFS, f1 = f2 + 2 MHz

OBSERVATION RECEIVER IIP2, f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at –13 dBFS, f2 = 2 MHz

<table>
<thead>
<tr>
<th>TWO-TONE FREQUENCY SPACING (MHz)</th>
<th>–40°C, ORx1</th>
<th>+25°C, ORx1</th>
<th>+110°C, ORx1</th>
<th>–40°C, ORx2</th>
<th>+25°C, ORx2</th>
<th>+110°C, ORx2</th>
<th>–40°C, ORx3</th>
<th>+25°C, ORx3</th>
<th>+110°C, ORx3</th>
<th>–40°C, ORx4</th>
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<td>44</td>
<td>56</td>
<td>52</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>

Figure 62. Observation Receiver IIP2, f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at –13 dBFS, f2 = 2 MHz
OBSERVATION RECEIVER IIP2, f1 – f2 (dBm)

-40°C, ORx1  
+25°C, ORx1  
+110°C, ORx1  
-40°C, ORx2  
+25°C, ORx2  
+110°C, ORx2  
-40°C, ORx3  
+25°C, ORx3  
+110°C, ORx3  
-40°C, ORx4  
+25°C, ORx4  
+110°C, ORx4

Figure 63. Observation Receiver IIP2, f1 – f2 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

OBSERVATION RECEIVER IIP2, f1 + f2 (dBm)

-40°C, ORx1  
+25°C, ORx1  
+110°C, ORx1  
-40°C, ORx2  
+25°C, ORx2  
+110°C, ORx2  
-40°C, ORx3  
+25°C, ORx3  
+110°C, ORx3  
-40°C, ORx4  
+25°C, ORx4  
+110°C, ORx4

Figure 64. Observation Receiver IIP2, f1 + f2 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 45 MHz, f2 = 2 MHz

OBSERVATION RECEIVER IIP2, f1 − f2 (dBm)

-40°C, ORx1  
+25°C, ORx1  
+110°C, ORx1  
-40°C, ORx2  
+25°C, ORx2  
+110°C, ORx2  
-40°C, ORx3  
+25°C, ORx3  
+110°C, ORx3  
-40°C, ORx4  
+25°C, ORx4  
+110°C, ORx4

Figure 65. Observation Receiver IIP2, f1 – f2 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 45 MHz, f2 = 2 MHz

OBSERVATION RECEIVER IIP3, 2f1 + f2 (dBm)

-40°C, ORx1  
+25°C, ORx1  
+110°C, ORx1  
-40°C, ORx2  
+25°C, ORx2  
+110°C, ORx2  
-40°C, ORx3  
+25°C, ORx3  
+110°C, ORx3  
-40°C, ORx4  
+25°C, ORx4  
+110°C, ORx4

Figure 66. Observation Receiver IIP3, 2f1 + f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

OBSERVATION RECEIVER IIP3, 2f2 + f1 (dBm)

-40°C, ORx1  
+25°C, ORx1  
+110°C, ORx1  
-40°C, ORx2  
+25°C, ORx2  
+110°C, ORx2  
-40°C, ORx3  
+25°C, ORx3  
+110°C, ORx3  
-40°C, ORx4  
+25°C, ORx4  
+110°C, ORx4

Figure 67. Observation Receiver IIP3, 2f2 + f1 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

OBSERVATION RECEIVER IIP3, 2f1 − f2 (dBm)

-40°C, ORx1  
+25°C, ORx1  
+110°C, ORx1  
-40°C, ORx2  
+25°C, ORx2  
+110°C, ORx2  
-40°C, ORx3  
+25°C, ORx3  
+110°C, ORx3  
-40°C, ORx4  
+25°C, ORx4  
+110°C, ORx4

Figure 68. Observation Receiver IIP3, 2f1 − f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz
Figure 69. Observation Receiver IIP3, $2f_2 - f_1$ vs. Tone 2 Frequency, Both Tones at −13 dBFS, $f_1 = f_2 + 2$ MHz

Figure 70. Observation Receiver IIP3, $2f_1 + f_2$ vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, $f_2 = 2$ MHz

Figure 71. Observation Receiver IIP3, $2f_2 + f_1$ vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, $f_2 = 2$ MHz

Figure 72. Observation Receiver IIP3, $2f_1 - f_2$ vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, $f_2 = 2$ MHz
Figure 73. Observation Receiver IIP3, $2f_2 - f_1$ vs. Two-Tone Frequency Spacing, Both Tones at $-13$ dBFS, $f_2 = 2$ MHz

Figure 74. Observation Receiver IIP3, $2f_2 + f_1$ vs. Observation Receiver Attenuation, Both Tones at $-13$ dBFS, $f_1 = 45$ MHz, $f_2 = 2$ MHz

Figure 75. Observation Receiver IIP3, $2f_2 - f_1$ vs. Observation Receiver Attenuation, Both Tones at $-13$ dBFS, $f_1 = 45$ MHz, $f_2 = 2$ MHz
800 MHz BAND

The temperature settings refer to the die temperature. All LO frequencies set to 800 MHz, unless otherwise noted.

Figure 76. Transmitter Continuous Wave Output Power vs. Transmitter LO Frequency, 10 MHz Offset, 0 dB Attenuation

Figure 77. Transmitter Output Power Spectrum, Tx1, 5 MHz LTE, 10 MHz Offset, –10 dBFS RMS, 1 MHz Resolution Bandwidth, $T_J = 25^\circ C$

Figure 78. Transmitter Image Rejection Across Large Signal Bandwidth vs. Baseband Offset Frequency

Figure 79. Transmitter Noise vs. Transmitter Attenuation, 10 MHz Offset

Figure 80. Transmitter Pass Band Flatness vs. Baseband Offset Frequency

Figure 81. Adjacent Channel Power Level vs. Transmitter Attenuation, –10 MHz Baseband Offset, 20 MHz LTE, Peak to Average Ratio (PAR) = 12 dB
Figure 82. Adjacent Channel Power Level vs. Transmitter Attenuation, 90 MHz Baseband Offset, 20 MHz LTE, PAR = 12 dB

Figure 83. Transmitter Second-Order Harmonic Distortion (HD2) vs. Transmitter Attenuation, 10 MHz Offset

Figure 84. Transmitter Third-Order Harmonic Distortion (HD3) vs. Transmitter Attenuation, 10 MHz Offset

Figure 85. Transmitter Attenuator Step Error vs. Transmitter Attenuation, 10 MHz Offset

Figure 86. Transmitter Error Vector Magnitude vs. Transmitter Attenuation, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 491.52 MSPS, Loop Filter Bandwidth = 50 kHz, Loop Filter Phase Margin = 85°

Figure 87. Transmitter OIP3, 2f1 − f2 vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, f1 = 50.5 MHz, f2 = 55.5 MHz
Figure 88. Transmitter OIP3, $2f_2 - f_1$ vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, $f_1 = 50.5$ MHz, $f_2 = 55.5$ MHz

Figure 89. Transmitter OIP3, $2f_1 - f_2$ vs. f1 Baseband Offset Tone Frequency, $f_2 = f_1 + 5$ MHz, 15 dB Digital Back Off per Tone

Figure 90. Transmitter OIP3, $2f_2 - f_1$ vs. f1 Baseband Offset Tone Frequency, $f_2 = f_1 + 5$ MHz, 15 dB Digital Back Off per Tone

Figure 91. Transmitter OIP3, $2f_1 + f_2$ vs. f1 Baseband Offset Tone Frequency, $f_2 = f_1 + 5$ MHz, 15 dB Digital Back Off per Tone

Figure 92. Transmitter OIP3, $2f_2 + f_1$ vs. f1 Baseband Offset Tone Frequency, $f_2 = f_1 + 5$ MHz, 15 dB Digital Back Off per Tone

Figure 93. Transmitter LO Leakage vs. Transmitter LO Frequency
Figure 94. Transmitter to Transmitter Isolation vs. Transmitter LO Frequency

Figure 95. Transmitter to Receiver Isolation vs. Receiver LO Frequency

Figure 96. Transmitter to Observation Receiver Isolation vs. Transmitter LO Frequency

Figure 97. Receiver to Receiver Isolation vs. Receiver LO Frequency

Figure 98. Receiver Integrated Noise Figure vs. Receiver Attenuation, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz

Figure 99. Receiver Integrated Noise Figure vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz
Figure 100. Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integrated in 200 kHz Steps

Figure 101. Receiver LO Leakage vs. Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 245.76 MSPS

Figure 102. Receiver Gain vs. Receiver Attenuation, 20 MHz Offset, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 103. Receiver Gain vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 104. Receiver Gain Step Error vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal

Figure 105. Normalized Receiver Flatness vs. Baseband Offset Frequency, −5 dBFS Input Signal
Figure 106. Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 107. Receiver Image vs. Receiver Attenuation, 20 MHz Offset, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 108. Receiver DC Offset vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal

Figure 109. Receiver DC Offset vs. Receiver LO Frequency, 20 MHz Offset, −5 dBFS Input Signal

Figure 110. Receiver HD2, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz (HD2 Canceller Enabled)

Figure 111. Receiver HD2, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz (HD2 Canceller Enabled)
Figure 112. Receiver HD3, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 113. Receiver HD3, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 114. Receiver IIP2, $f_1 + f_2$ vs. Tone 2 Frequency, Both Tones at −11 dBFS, $f_2 = 2$ MHz

Figure 115. Receiver IIP2, $f_1 - f_2$ vs. Tone 2 Frequency, Both Tones at −11 dBFS, $f_2 = 2$ MHz

Figure 116. Receiver IIP2, $f_1 + f_2$ vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, $f_2 = 2$ MHz

Figure 117. Receiver IIP2, $f_1 - f_2$ vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, $f_2 = 2$ MHz
Figure 118. Receiver $I_{IP2}, f_1 + f_2$ vs. Receiver Attenuation, Both Tones at $-11$ dBFS, $f_1 = 92$ MHz, $f_2 = 2$ MHz

Figure 119. Receiver $I_{IP2}, f_1 - f_2$ vs. Receiver Attenuation, Both Tones at $-11$ dBFS, $f_1 = 92$ MHz, $f_2 = 2$ MHz

Figure 120. Receiver $I_{IP3}, 2f_1 + f_2$ vs. Tone 2 Frequency, Both Tones at $-11$ dBFS, $f_1 = f_2 + 2$ MHz

Figure 121. Receiver $I_{IP3}, 2f_1 - f_2$ vs. Tone 2 Frequency, Both Tones at $-11$ dBFS, $f_1 = f_2 + 2$ MHz

Figure 122. Receiver $I_{IP3}, 2f_2 + f_1$ vs. Tone 2 Frequency, Both Tones at $-11$ dBFS, $f_1 = f_2 + 2$ MHz

Figure 123. Receiver $I_{IP3}, 2f_2 - f_1$ vs. Tone 2 Frequency, Both Tones at $-11$ dBFS, $f_1 = f_2 + 2$ MHz
Figure 124. Receiver IIP3, 2f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 125. Receiver IIP3, 2f2 + f1 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 126. Receiver IIP3, 2f1 − f2 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 127. Receiver IIP3, 2f2 − f1 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 128. Receiver Error Vector Magnitude vs. Receiver Input Power, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 245.76 MSPS, Loop Filter Bandwidth = 50 kHz, Loop Filter Phase Margin = 85°

Figure 129. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 50 kHz, Phase Margin = 85°
Figure 130. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 100 kHz, Phase Margin = 60°

Figure 131. Observation Receiver (ORx) Integrated Noise Figure vs. Observation Receiver Attenuation, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integrated in 200 kHz Steps

Figure 132. Observation Receiver Integrated Noise Figure vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS, Integration Bandwidth = 500 kHz to 245.76 MHz

Figure 133. Observation Receiver LO Leakage vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

Figure 134. Observation Receiver Gain vs. Observation Receiver Attenuation, 45 MHz Offset, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS

Figure 135. Observation Receiver Gain vs. Observation Receiver Attenuation, 45 MHz Offset, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS
### Observation Receiver Gain vs. Observation Receiver LO Frequency

<table>
<thead>
<tr>
<th>Observation Receiver LO Frequency (MHz)</th>
<th>800</th>
<th>1800</th>
</tr>
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<tbody>
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<td>–40°C, ORx1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+25°C, ORx1</td>
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<td>+110°C, ORx1</td>
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<tr>
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### Observation Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active

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### Observation Receiver GAIN STEP ERROR vs. Observation Receiver Attenuation

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</tr>
<tr>
<td>+110°C, ORx4</td>
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### Observations

- **Figure 136**: Observation Receiver Gain vs. Observation Receiver LO Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS
- **Figure 137**: Observation Receiver Gain Step Error vs. Observation Receiver Attenuation, 45 MHz Offset, −10 dBFS Input Signal
- **Figure 138**: Normalized Observation Receiver Flatness vs. Baseband Offset Frequency, −10 dBFS Input Signal
- **Figure 139**: Observation Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 491.52 MSPS
- **Figure 140**: Observation Receiver Image vs. Observation Receiver Attenuation, 45 MHz Offset, Tracking Calibration Active, Sample Rate = 491.52 MSPS
- **Figure 141**: Observation Receiver DC Offset vs. Observation Receiver Attenuation, 45 MHz Offset, −10 dBFS Input Signal
Figure 142. Observation Receiver DC Offset vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

Figure 143. Observation Receiver HD2, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 144. Observation Receiver HD2, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 145. Observation Receiver HD3, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 146. Observation Receiver HD3, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 147. Observation Receiver IIP2, f1 + f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz
Figure 148. Observation Receiver IIP2, $f_1 - f_2$ vs. Tone 2 Frequency, Both Tones at $-13$ dBFS, $f_1 = f_2 + 2$ MHz

Figure 149. Observation Receiver IIP2, $f_1 + f_2$ vs. Two-Tone Frequency Spacing, Both Tones at $-13$ dBFS, $f_1 = 102$ MHz, $f_2 = 2$ MHz

Figure 150. Observation Receiver IIP2, $f_1 - f_2$ vs. Two-Tone Frequency Spacing, Both Tones at $-13$ dBFS, $f_2 = 2$ MHz

Figure 151. Observation Receiver IIP2, $f_1 + f_2$ vs. Observation Receiver Attenuation, Both Tones at $-13$ dBFS, $f_1 = 102$ MHz, $f_2 = 2$ MHz

Figure 152. Observation Receiver IIP2, $f_1 - f_2$ vs. Observation Receiver Attenuation, Both Tones at $-13$ dBFS, $f_1 = 102$ MHz, $f_2 = 2$ MHz

Figure 153. Observation Receiver IIP3, $2f_1 + f_2$ vs. Tone 2 Frequency, Both Tones at $-13$ dBFS, $f_1 = f_2 + 2$ MHz
Figure 154. Observation Receiver IIP3, 2f2 + f2 vs. Tone 2 Frequency, Both Tones at –13 dBFS, f1 = f2 + 2 MHz

Figure 155. Observation Receiver IIP3, 2f1 – f2 vs. Tone 2 Frequency, Both Tones at –13 dBFS, f1 = f2 + 2 MHz

Figure 156. Observation Receiver IIP3, 2f2 – f1 vs. Tone 2 Frequency, Both Tones at –13 dBFS, f1 = f2 + 2 MHz

Figure 157. Observation Receiver IIP3, 2f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at –13 dBFS, f2 = 2 MHz

Figure 158. Observation Receiver IIP3, 2f2 + f1 vs. Two-Tone Frequency Spacing, Both Tones at –13 dBFS, f2 = 2 MHz

Figure 159. Observation Receiver IIP3, 2f1 – f2 vs. Two-Tone Frequency Spacing, Both Tones at –13 dBFS, f2 = 2 MHz
Figure 160. Observation Receiver IIP3, 2f2 − f1 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

Figure 161. Observation Receiver IIP3, 2f2 + f1 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 122 MHz, f2 = 2 MHz

Figure 162. Observation Receiver IIP3, 2f2 − f1 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 122 MHz, f2 = 2 MHz
1800 MHz BAND

The temperature settings refer to the die temperature. All LO frequencies set to 1800 MHz, unless otherwise noted.

Figure 163. Transmitter Continuous Wave (CW) Output Power vs. Transmitter LO Frequency, 10 MHz Offset, 0 dB Attenuation

Figure 166. Transmitter Noise vs. Transmitter Attenuation, 10 MHz Offset

Figure 164. Transmitter Output Power Spectrum, TX1, 5 MHz LTE, 10 MHz Offset, −10 dBFS RMS, 1 MHz Resolution Bandwidth, $T_J = 25°C$

Figure 167. Transmitter Pass Band Flatness vs. Baseband Offset Frequency

Figure 165. Transmitter Image Rejection Across Large Signal Bandwidth vs. Baseband Offset Frequency

Figure 168. Adjacent Channel Power Level vs. Transmitter Attenuation, −10 MHz Baseband Offset, 20 MHz LTE, PAR = 12 dB
Figure 169. Adjacent Channel Power Level vs. Transmitter Attenuation, 90 MHz Baseband Offset, 20 MHz LTE, PAR = 12 dB

Figure 170. Transmitter Second Harmonic Distortion (HD2) vs. Transmitter Attenuation, 10 MHz Offset

Figure 171. Transmitter Third Harmonic Distortion (HD3) vs. Transmitter Attenuation, 10 MHz Offset

Figure 172. Transmitter Attenuator Step Error vs. Transmitter Attenuation, 10 MHz Offset

Figure 173. Transmitter Error Vector Magnitude vs. Transmitter Attenuation, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 491.52 MSPS, Loop Filter Bandwidth = 500 kHz, Loop Filter Phase Margin = 60°

Figure 174. Transmitter OIP3, 2f1 − f2 vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, f1 = 50.5 MHz, f2 = 55.5 MHz
**Figure 181. Transmitter to Transmitter Isolation vs. Transmitter LO Frequency**

**Figure 182. Transmitter to Receiver Isolation vs. Receiver LO Frequency**

**Figure 183. Transmitter to Observation Receiver Isolation vs. Transmitter LO Frequency**

**Figure 184. Receiver to Receiver Isolation vs. Receiver LO Frequency**

**Figure 185. Receiver Integrated Noise Figure vs. Receiver Attenuation, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz**

**Figure 186. Receiver Integrated Noise Figure vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz**
Figure 187. Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integrated in 200 kHz Steps

Figure 188. Receiver LO Leakage vs. Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 245.76 MSPS

Figure 189. Receiver Gain vs. Receiver Attenuation, 20 MHz Offset, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 190. Receiver Gain vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 191. Receiver Gain Step Error vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal

Figure 192. Normalized Receiver Flatness vs. Baseband Offset Frequency, −5 dBFS Input Signal
Figure 193. Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 194. Receiver Image vs. Receiver Attenuation, 20 MHz Offset, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 195. Receiver DC Offset vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal

Figure 196. Receiver DC Offset vs. Receiver LO Frequency, 20 MHz Offset, −5 dBFS Input Signal

Figure 197. Receiver HD2, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz (HD2 Canceller Not Enabled)

Figure 198. Receiver HD2, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz (HD2 Canceller Not Enabled)
Figure 199. Receiver HD3, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 200. Receiver HD3, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 201. Receiver IIP2, f1 + f2 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 202. Receiver IIP2, f1 − f2 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 203. Receiver IIP2, f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 204. Receiver IIP2, f1 − f2 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz
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<th>Receiver IIP2, f1 + f2 (dBm)</th>
<th>Receiver IIP2, f1 − f2 (dBm)</th>
<th>Receiver IIP3, 2f1 + f2 (dBm)</th>
<th>Receiver IIP3, 2f2 + f1 (dBm)</th>
<th>Receiver IIP3, 2f1 − f2 (dBm)</th>
<th>Receiver IIP3, 2f2 − f1 (dBm)</th>
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**Figure 205.** Receiver IIP2, f1 + f2 vs. Receiver Attenuation, Both Tones at −11 dBFS, f1 = 92 MHz, f2 = 2 MHz

**Figure 206.** Receiver IIP2, f1 − f2 vs. Receiver Attenuation, Both Tones at −11 dBFS, f1 = 92 MHz, f2 = 2 MHz

**Figure 207.** Receiver IIP3, 2f1 + f2 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

**Figure 208.** Receiver IIP3, 2f2 + f1 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

**Figure 209.** Receiver IIP3, 2f1 − f2 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

**Figure 210.** Receiver IIP3, 2f2 − f1 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz
Figure 211. Receiver IIP3, 2f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz

Figure 212. Receiver IIP3, 2f2 + f1 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz

Figure 213. Receiver IIP3, 2f1 – f2 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz

Figure 214. Receiver IIP3, 2f2 – f1 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz

Figure 215. Receiver Error Vector Magnitude vs. Receiver Input Power, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 245.76 MSPS, Loop Filter Bandwidth = 500 kHz, Loop Filter Phase Margin = 60°

Figure 216. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 50 kHz, Phase Margin = 85°
Figure 217. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 200 kHz, Phase Margin = 60°

Figure 218. Observation Receiver Integrated Noise Figure vs. Observation Receiver Attenuation, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integrated in 200 kHz Steps

Figure 219. Observation Receiver Integrated Noise Figure vs. Observation Receiver LO Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integration Bandwidth = 500 kHz to 245.76 MHz

Figure 220. Observation Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integrated in 200 kHz Steps

Figure 221. Observation Receiver LO Leakage vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

Figure 222. Observation Receiver Gain vs. Observation Receiver Attenuation, 45 MHz Offset, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS
OBSERVATION RECEIVER GAIN (dB)

-40°C, ORx1
-40°C, ORx2
-40°C, ORx3
-40°C, ORx4
+25°C, ORx1
+25°C, ORx2
+25°C, ORx3
+25°C, ORx4
+110°C, ORx1
+110°C, ORx2
+110°C, ORx3
+110°C, ORx4

OBSERVATION RECEIVER LO FREQUENCY (MHz)

1400 1500 1600 1700 1800 1900 2000 2100 2200

Figure 223. Observation Receiver Gain vs. Observation Receiver LO Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS

OBSERVATION RECEIVER GAIN STEP ERROR (dB)

-40°C, ORx1
-40°C, ORx2
-40°C, ORx3
-40°C, ORx4
+25°C, ORx1
+25°C, ORx2
+25°C, ORx3
+25°C, ORx4
+110°C, ORx1
+110°C, ORx2
+110°C, ORx3
+110°C, ORx4

Figure 224. Observation Receiver Gain Step Error vs. Observation Receiver Attenuation, 45 MHz Offset, −10 dBFS Input Signal

OBSERVATION RECEIVER ATTENUATION (dB)

0 5 10 15 20 25 30

Figure 225. Normalized Observation Receiver Flatness vs. Baseband Offset Frequency, −10 dBFS Input Signal

OBSERVATION RECEIVER IMAGE (dBc)

-40°C, ORx1
-40°C, ORx2
-40°C, ORx3
-40°C, ORx4
+25°C, ORx1
+25°C, ORx2
+25°C, ORx3
+25°C, ORx4
+110°C, ORx1
+110°C, ORx2
+110°C, ORx3
+110°C, ORx4

Figure 226. Observation Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 491.52 MSPS

Figure 227. Observation Receiver Image vs. Observation Receiver Attenuation, 45 MHz Offset, Tracking Calibration Active, Sample Rate = 491.52 MSPS

Figure 228. Observation Receiver DC Offset vs. Observation Receiver Attenuation, 45 MHz Offset, −10 dBFS Input Signal
Figure 229. Observation Receiver DC Offset vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

Figure 230. Observation Receiver HD2, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 231. Observation Receiver HD2, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 232. Observation Receiver HD3, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 233. Observation Receiver HD3, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 234. Observation Receiver IIP2, f1 + f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz
Figure 235. Observation Receiver IIP2, f1 − f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

Figure 236. Observation Receiver IIP2, f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

Figure 237. Observation Receiver IIP2, f1 − f2 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

Figure 238. Observation Receiver IIP2, f1 + f2 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 102 MHz, f2 = 2 MHz

Figure 239. Observation Receiver IIP2, f1 + f2 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 102 MHz, f2 = 2 MHz

Figure 240. Observation Receiver IIP3, 2f1 + f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz
Figure 241. Observation Receiver IIP3, 2f2 + f1 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

Figure 242. Observation Receiver IIP3, 2f1 − f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

Figure 243. Observation Receiver IIP3, 2f2 − f1 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

Figure 244. Observation Receiver IIP3, 2f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

Figure 245. Observation Receiver IIP3, 2f2 + f1 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

Figure 246. Observation Receiver IIP3, 2f1 − f2 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz
Figure 247. Observation Receiver IIP3, $2f_2 - f_1$ vs. Two-Tone Frequency Spacing, Both Tones at $-13$ dBFS, $f_2 = 2$ MHz

Figure 248. Observation Receiver IIP3, $2f_2 + f_1$ vs. Observation Receiver Attenuation, Both Tones at $-13$ dBFS, $f_1 = 122$ MHz, $f_2 = 2$ MHz

Figure 249. Observation Receiver IIP3, $2f_2 - f_1$ vs. Observation Receiver Attenuation, Both Tones at $-13$ dBFS, $f_1 = 122$ MHz, $f_2 = 2$ MHz
2600 MHz BAND

The temperature settings refer to the die temperature. All LO frequencies set to 2600 MHz, unless otherwise noted.

![Figure 250. Transmitter Continuous Wave Output Power vs. Transmitter LO Frequency, 10 MHz Offset, 0 dB Attenuation](image1)

![Figure 251. Transmitter Output Power Spectrum, Tx1, 5 MHz LTE, 10 MHz Offset, –10 dBFS RMS, 1 MHz Resolution Bandwidth, Tj = 25°C](image2)

![Figure 252. Transmitter Image Rejection Across Large Signal Bandwidth vs. Baseband Offset Frequency](image3)

![Figure 253. Transmitter Noise vs. Transmitter Attenuation, 10 MHz Offset](image4)

![Figure 254. Transmitter Pass Band Flatness vs. Baseband Offset Frequency](image5)

![Figure 255. Adjacent Channel Power Level vs. Transmitter Attenuation, –10 MHz Baseband Offset, 20 MHz LTE, PAR = 12 dB](image6)
Figure 256. Adjacent Channel Power Level vs. Transmitter Attenuation, 90 MHz Baseband Offset, 20 MHz LTE, PAR = 12 dB

Figure 257. Transmitter Second Harmonic Distortion (HD2) vs. Transmitter Attenuation, 10 MHz Offset

Figure 258. Transmitter Third Harmonic Distortion (HD3) vs. Transmitter Attenuation, 10 MHz Offset

Figure 259. Transmitter Attenuator Step Error vs. Transmitter Attenuation, 10 MHz Offset

Figure 260. Transmitter Error Vector Magnitude vs. Transmitter Attenuation, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 491.52 MSPS, Loop Filter Bandwidth = 500 kHz, Loop Filter Phase Margin = 60°

Figure 261. Transmitter OIP3, 2f1 − f2 vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, f1 = 50.5 MHz, f2 = 55.5 MHz
Figure 262. Transmitter OIP3, 2f2 – f1 vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, f1 = 50.5 MHz, f2 = 55.5 MHz

Figure 263. Transmitter OIP3, 2f1 – f2 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 264. Transmitter OIP3, 2f2 – f1 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 265. Transmitter OIP3, 2f1 + f2 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 266. Transmitter OIP3, 2f2 + f1 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 267. Transmitter LO Leakage vs. Transmitter LO Frequency
Figure 268. Transmitter to Transmitter Isolation vs. Transmitter LO Frequency

Figure 269. Transmitter to Receiver Isolation vs. Receiver LO Frequency

Figure 270. Transmitter to Observation Receiver Isolation vs. Transmitter LO Frequency

Figure 271. Receiver to Receiver Isolation vs. Receiver LO Frequency

Figure 272. Receiver Integrated Noise Figure vs. Receiver Attenuation, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz

Figure 273. Receiver Integrated Noise Figure vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz
Figure 274. Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integrated in 200 kHz Steps

Figure 276. Receiver Gain vs. Receiver Attenuation, 20 MHz Offset, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 277. Receiver Gain vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 278. Receiver Gain Step Error vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal

Figure 279. Normalized Receiver Flatness vs. Baseband Offset Frequency, −5 dBFS Input Signal
Figure 280. Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 281. Receiver Image vs. Receiver Attenuation, 20 MHz Offset, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 282. Receiver DC Offset vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal

Figure 283. Receiver DC Offset vs. Receiver LO Frequency, 20 MHz Offset, −5 dBFS Input Signal

Figure 284. Receiver HD2, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz (HD2 Canceller Not Enabled)

Figure 285. Receiver HD2, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz (HD2 Canceller Not Enabled)
### Receiver HD3, Left Side (dBc)

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### Receiver HD3, Right Side (dBc)

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### Receiver HD3, Left Side vs. Baseband Offset Frequency, –5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

### Receiver HD3, Right Side vs. Baseband Offset Frequency, –5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

### Receiver IIP2, f1 + f2 (dBm) vs. Tone 2 Frequency

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<tr>
<th>Tone 2 Frequency (MHz)</th>
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<th>+25°C, Rx1</th>
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### Receiver IIP2, f1 − f2 (dBm) vs. Tone 2 Frequency

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<th>Tone 2 Frequency (MHz)</th>
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<th>+40°C, Rx1</th>
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### Receiver IIP2, f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f1 = f2 + 2 MHz

### Receiver IIP2, f1 − f2 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f1 = f2 + 2 MHz
Figure 292. Receiver IIP2, f1 + f2 vs. Receiver Attenuation, Both Tones at −11 dBFS, f1 = 92 MHz, f2 = 2 MHz

Figure 293. Receiver IIP2, f1 – f2 vs. Receiver Attenuation, Both Tones at −11 dBFS, f1 = 92 MHz, f2 = 2 MHz

Figure 294. Receiver IIP3, 2f1 + f2 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 295. Receiver IIP3, 2f2 + f1 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 296. Receiver IIP3, 2f1 − f2 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 297. Receiver IIP3, 2f2 − f1 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz
Figure 298. Receiver IIP3, 2f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 299. Receiver IIP3, 2f2 + f1 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 300. Receiver IIP3, 2f1 − f2 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 301. Receiver IIP3, 2f2 − f1 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 302. Receiver Error Vector Magnitude vs. Receiver Input Power, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 245.76 MSPS, Loop Filter Bandwidth = 500 kHz, Loop Filter Phase Margin = 60°

Figure 303. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 75 kHz, Phase Margin = 85°
Figure 304. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 500 kHz, Phase Margin = 60°

Figure 305. Observation Receiver Integrated Noise Figure vs. Observation Receiver Attenuation, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integration Bandwidth = 500 kHz to 245.76 MHz

Figure 306. Observation Receiver Integrated Noise Figure vs. Observation Receiver LO Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integration Bandwidth = 500 kHz to 245.76 MHz

Figure 307. Observation Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integrated in 200 kHz Steps

Figure 308. Observation Receiver LO Leakage vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

Figure 309. Observation Receiver Gain vs. Observation Receiver Attenuation, 45 MHz Offset, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS
Figure 310. Observation Receiver Gain vs. Observation Receiver LO Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS

Figure 311. Observation Receiver Gain Step Error vs. Observation Receiver Attenuation, 45 MHz Offset, −10 dBFS Input Signal

Figure 312. Normalized Observation Receiver Flatness vs. Baseband Offset Frequency, −10 dBFS Input Signal

Figure 313. Observation Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 491.52 MSPS

Figure 314. Observation Receiver Image vs. Observation Receiver Attenuation, 45 MHz Offset, Tracking Calibration Active, Sample Rate = 491.52 MSPS

Figure 315. Observation Receiver DC Offset vs. Observation Receiver Attenuation, 45MHz Offset, −10 dBFS Input Signal
Figure 316. Observation Receiver DC Offset vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

Figure 317. Observation Receiver HD2, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 318. Observation Receiver HD2, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 319. Observation Receiver HD3, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 320. Observation Receiver HD3, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 321. Observation Receiver IIP2, f1 + f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz
OBSERVATION RECEIVER IIP2, \( f_1 - f_2 \) (dBm)

<table>
<thead>
<tr>
<th>Tone 2 Frequency (MHz)</th>
<th>+110°C, ORx1</th>
<th>+25°C, ORx1</th>
<th>-40°C, ORx1</th>
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<tbody>
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<td>60</td>
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<td>+110°C, ORx2</td>
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Figure 322. Observation Receiver IIP2, \( f_1 - f_2 \) vs. Tone 2 Frequency, Both Tones at -13 dBFS, \( f_1 = f_2 + 2 \) MHz

Figure 325. Observation Receiver IIP2, \( f_1 + f_2 \) vs. Observation Receiver Attenuation, Both Tones at -13 dBFS, \( f_1 = 102 \) MHz, \( f_2 = 2 \) MHz

OBSERVATION RECEIVER IIP2, \( f_1 + f_2 \) (dBm)

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<tr>
<th>Two-Tone Frequency Spacing (MHz)</th>
<th>+110°C, ORx1</th>
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Figure 323. Observation Receiver IIP2, \( f_1 + f_2 \) vs. Two-Tone Frequency Spacing, Both Tones at -13 dBFS, \( f_2 = 2 \) MHz

Figure 326. Observation Receiver IIP2, \( f_1 - f_2 \) vs. Observation Receiver Attenuation, Both Tones at -13 dBFS, \( f_1 = 102 \) MHz, \( f_2 = 2 \) MHz

OBSERVATION RECEIVER IIP3, \( 2f_1 + f_2 \) (dBm)

<table>
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Figure 327. Observation Receiver IIP3, \( 2f_1 + f_2 \) vs. Tone 2 Frequency, Both Tones at -13 dBFS, \( f_2 = f_2 + 2 \) MHz
Figure 328. Observation Receiver IIP3, 2f2 + f1 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

Figure 329. Observation Receiver IIP3, 2f1 − f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

Figure 330. Observation Receiver IIP3, 2f2 − f1 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

Figure 331. Observation Receiver IIP3, 2f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

Figure 332. Observation Receiver IIP3, 2f2 + f1 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

Figure 333. Observation Receiver IIP3, 2f1 − f2 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz
Figure 334. Observation Receiver IIP3, 2f2 – f1 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

Figure 335. Observation Receiver IIP3, 2f2 + f1 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 122 MHz, f2 = 2 MHz

Figure 336. Observation Receiver IIP3, 2f2 – f1 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 122 MHz, f2 = 2 MHz
3800 MHZ BAND

The temperature settings refer to the die temperature. All LO frequencies set to 3800 MHz, unless otherwise noted.

Figure 337. Transmitter Continuous Wave Output Power vs. Transmitter LO Frequency, 10 MHz Offset, 0 dB Attenuation

Figure 338. Transmitter Output Power Spectrum, Tx1, 5 MHz LTE, 10 MHz Offset, –10 dBFS RMS, 1 MHz Resolution Bandwidth, $T_J = 25^\circ$C (Step at 3600 MHz Due to Spectrum Analyzer)

Figure 339. Transmitter Image Rejection Across Large Signal Bandwidth vs. Baseband Offset Frequency

Figure 340. Transmitter Noise vs. Transmitter Attenuation, 10 MHz Offset Frequency

Figure 341. Transmitter Pass Band Flatness vs. Baseband Offset Frequency

Figure 342. Adjacent Channel Power Level vs. Transmitter Attenuation, –10 MHz Baseband Offset, 20 MHz LTE, PAR = 12 dB
Figure 343. Adjacent Channel Power Level vs. Transmitter Attenuation, 90 MHz Baseband Offset, 20 MHz LTE, PAR = 12 dB

Figure 344. Transmitter Second Harmonic Distortion (HD2) vs. Transmitter Attenuation, 10 MHz Offset

Figure 345. Transmitter Third Harmonic Distortion (HD3) vs. Transmitter Attenuation, 10 MHz Offset

Figure 346. Transmitter Attenuator Step Error vs. Transmitter Attenuation, 10 MHz Offset

Figure 347. Transmitter Error Vector Magnitude vs. Transmitter Attenuation, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 491.52 MSPS, Loop Filter Bandwidth = 200 kHz, Loop Filter Phase Margin = 60°

Figure 348. Transmitter OIP3, 2f1 – f2 vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, f1 = 50.5 MHz, f2 = 55.5 MHz
Figure 349. Transmitter OIP3, 2f2 – f1 vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, f1 = 50.5 MHz, f2 = 55.5 MHz

Figure 350. Transmitter OIP3, 2f1 – f2 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 351. Transmitter OIP3, 2f2 – f1 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 352. Transmitter OIP3, 2f1 + f2 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 353. Transmitter OIP3, 2f2 + f1 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 354. Transmitter LO Leakage vs. Transmitter LO Frequency
TRANSMITTER TO TRANSMITTER ISOLATION (dB)

TRANSMITTER LO FREQUENCY (MHz)

Figure 355. Transmitter to Transmitter Isolation vs. Transmitter LO Frequency

TRANSMITTER TO RECEIVER ISOLATION (dB)

RECEIVER LO FREQUENCY (MHz)

Figure 356. Transmitter to Receiver Isolation vs. Receiver LO Frequency

TRANSMITTER TO OBSERVATION RECEIVER ISOLATION (dB)

TRANSMITTER LO FREQUENCY (MHz)

Figure 357. Transmitter to Observation Receiver Isolation vs. Transmitter LO Frequency

RECEIVER TO RECEIVER ISOLATION (dB)

RECEIVER LO FREQUENCY (MHz)

Figure 358. Receiver to Receiver Isolation vs. Receiver LO Frequency

RECEIVER INTEGRATED NOISE FIGURE (dB)

RECEIVER ATTENUATION (dB)

Figure 359. Receiver Integrated Noise Figure vs. Receiver Attenuation, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz

RECEIVER NOISE FIGURE (dB)

RECEIVER LO FREQUENCY (MHz)

Figure 360. Receiver Integrated Noise Figure vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz
Figure 361. Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integrated in 200 kHz Steps

Figure 362. Receiver LO Leakage vs. Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 245.76 MSPS

Figure 363. Receiver Gain vs. Receiver Attenuation, 20 MHz Offset, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 364. Receiver Gain vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 365. Receiver Gain Step Error vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal

Figure 366. Normalized Receiver Flatness vs. Baseband Offset Frequency, −5 dBFS Input Signal
Figure 367. Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 368. Receiver Image vs. Receiver Attenuation, 20 MHz Offset, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 369. Receiver DC Offset vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal, Sample Rate = 245.76 MSPS

Figure 370. Receiver DC Offset vs. Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 245.76 MSPS

Figure 371. Receiver HD2, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz (HD2 Canceller Not Enabled)

Figure 372. Receiver HD2, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz (HD2 Canceller Not Enabled)
Figure 373. Receiver HD3, Left Side vs. Baseband Offset Frequency, −5 dBFS
Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 374. Receiver HD3, Right Side vs. Baseband Offset Frequency, −5 dBFS
Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 375. Receiver IIP2, f1 + f2 vs. Tone 2 Frequency,
Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 376. Receiver IIP2, f1 − f2 vs. Tone 2 Frequency,
Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 377. Receiver IIP2, f1 + f2 vs. Two-Tone Frequency Spacing,
Both Tones at −11 dBFS, f2 = 2 MHz

Figure 378. Receiver IIP2, f1 − f2 vs. Two-Tone Frequency Spacing,
Both Tones at −11 dBFS, f2 = 2 MHz
Figure 379. Receiver IIP2, f1 + f2 vs. Receiver Attenuation, Both Tones at –11 dBFS, f1 = 92 MHz, f2 = 2 MHz

Figure 380. Receiver IIP2, f1 – f2 vs. Receiver Attenuation, Both Tones at –11 dBFS, f1 = 92 MHz, f2 = 2 MHz

Figure 381. Receiver IIP3, 2f1 + f2 vs. Tone 2 Frequency, Both Tones at –11 dBFS, f1 = f2 + 2 MHz

Figure 382. Receiver IIP3, 2f2 + f1 vs. Tone 2 Frequency, Both Tones at –11 dBFS, f1 = f2 + 2 MHz

Figure 383. Receiver IIP3, 2f1 – f2 vs. Tone 2 Frequency, Both Tones at –11 dBFS, f1 = f2 + 2 MHz

Figure 384. Receiver IIP3, 2f2 – f1 vs. Tone 2 Frequency, Both Tones at –11 dBFS, f1 = f2 + 2 MHz
Figure 385. Receiver IIP3, 2f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 386. Receiver IIP3, 2f2 + f1 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 387. Receiver IIP3, 2f1 − f2 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 388. Receiver IIP3, 2f2 − f1 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 389. Receiver Error Vector Magnitude vs. Receiver Input Power, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 245.76 MSPS, Loop Filter Bandwidth = 200 kHz, Loop Filter Phase Margin = 60°

Figure 390. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 75 kHz, Phase Margin = 85°
Figure 391. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 200 kHz, Phase Margin = 60°

Figure 394. Observation Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integrated in 200 kHz Steps

Figure 392. Observation Receiver Integrated Noise Figure vs. Observation Receiver Attenuation, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integration Bandwidth = 500 kHz to 245.76 MHz

Figure 395. Observation Receiver LO Leakage vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

Figure 393. Observation Receiver Integrated Noise Figure vs. Observation Receiver LO Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integration Bandwidth = 500 kHz to 245.76 MHz

Figure 396. Observation Receiver Gain vs. Observation Receiver Attenuation, 45 MHz Offset, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS
Figure 397. Observation Receiver Gain vs. Observation Receiver LO Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS

Figure 398. Observation Receiver Gain Step Error vs. Observation Receiver Attenuation, 45 MHz Offset, –10 dBFS Input Signal

Figure 399. Normalized Observation Receiver Flatness vs. Baseband Offset Frequency, –10 dBFS Input Signal

Figure 400. Observation Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 491.52 MSPS

Figure 401. Observation Receiver Image vs. Observation Receiver Attenuation, 45 MHz Offset, Tracking Calibration Active, Sample Rate = 491.52 MSPS

Figure 402. Observation Receiver DC Offset vs. Observation Receiver Attenuation, Sample Rate = 491.52 MSPS
Figure 403. Observation Receiver DC Offset vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

Figure 404. Observation Receiver HD2, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 405. Observation Receiver HD2, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 406. Observation Receiver HD3, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 407. Observation Receiver HD3, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 408. Observation Receiver IIP2, f1 + f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz
OBSERVATION RECEIVER IIP2, $f_1 - f_2$ (dBm)

TONE 2 FREQUENCY (MHz)

90 80 70 60 50 40 30 20 10 0

Observed at:

-40°C, ORx1
+25°C, ORx1
+110°C, ORx1
-40°C, ORx2
+25°C, ORx2
+110°C, ORx2
-40°C, ORx3
+25°C, ORx3
+110°C, ORx3
-40°C, ORx4
+25°C, ORx4
+110°C, ORx4

Figure 409. Observation Receiver IIP2, $f_1 - f_2$ vs. Tone 2 Frequency, Both Tones at $-13$ dBFS, $f_1 = f_2 + 2$ MHz

OBSERVATION RECEIVER IIP3, $2f_1 + f_2$ (dBm)

TONE 2 FREQUENCY (MHz)

90 80 70 60 50 40 30 20 10 0

Observed at:

-40°C, ORx1
+25°C, ORx1
+110°C, ORx1
-40°C, ORx2
+25°C, ORx2
+110°C, ORx2
-40°C, ORx3
+25°C, ORx3
+110°C, ORx3
-40°C, ORx4
+25°C, ORx4
+110°C, ORx4

Figure 414. Observation Receiver IIP3, $2f_1 + f_2$ vs. Tone 2 Frequency, Both Tones at $-13$ dBFS, $f_1 = f_2 + 2$ MHz
### Observation Receiver IIP3, $2f_2 + f_1$ (dBm)

<table>
<thead>
<tr>
<th>Tone 2 Frequency (MHz)</th>
<th>$3805$</th>
<th>$3865$</th>
<th>$3855$</th>
<th>$3845$</th>
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Figure 415. Observation Receiver IIP3, $2f_2 + f_1$ vs. Tone 2 Frequency, Both Tones at $-13$ dBFS, $f_1 = f_2 + 2$ MHz

### Observation Receiver IIP3, $2f_1 - f_2$ (dBm)

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Figure 416. Observation Receiver IIP3, $2f_1 - f_2$ vs. Tone 2 Frequency, Both Tones at $-13$ dBFS, $f_1 = f_2 + 2$ MHz

### Observation Receiver IIP3, $2f_2 - f_1$ (dBm)

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Figure 417. Observation Receiver IIP3, $2f_2 - f_1$ vs. Two-Tone Frequency Spacing, Both Tones at $-13$ dBFS, $f_2 = 2$ MHz

### Observation Receiver IIP3, $2f_1 + f_2$ (dBm)

<table>
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Figure 418. Observation Receiver IIP3, $2f_1 + f_2$ vs. Two-Tone Frequency Spacing, Both Tones at $-13$ dBFS, $f_2 = 2$ MHz

### Observation Receiver IIP3, $2f_1 - f_2$ (dBm)

<table>
<thead>
<tr>
<th>Two-Tone Frequency Spacing (MHz)</th>
<th>$10$</th>
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Figure 420. Observation Receiver IIP3, $2f_1 - f_2$ vs. Two-Tone Frequency Spacing, Both Tones at $-13$ dBFS, $f_2 = 2$ MHz
Figure 421. Observation Receiver IIP3, 2f2 – f1 vs. Two-Tone Frequency Spacing, Both Tones at –13 dBFS, f2 = 2 MHz

Figure 422. Observation Receiver IIP3, 2f2 + f1 vs. Observation Receiver Attenuation, Both Tones at –13 dBFS, f1 = 122 MHz, f2 = 2 MHz

Figure 423. Observation Receiver IIP3, 2f2 – f1 vs. Observation Receiver Attenuation, Both Tones at –13 dBFS, f1 = 122 MHz, f2 = 2 MHz
4800 MHZ BAND

The temperature settings refer to the die temperature. All LO frequencies set to 4800 MHz, unless otherwise noted.

Figure 424. Transmitter CW Output Power vs. Transmitter LO Frequency, 10 MHz Offset, 0 dB Attenuation

Figure 425. Transmitter Output Power Spectrum, Tx1, 5 MHz LTE, 10 MHz Offset, –10 dBFS RMS, 1 MHz Resolution Bandwidth, Tj = 25°C

Figure 426. Transmitter Image Rejection Across Large Signal Bandwidth vs. Baseband Offset Frequency

Figure 427. Transmitter Noise vs. Transmitter Attenuation, 10 MHz Offset Frequency

Figure 428. Transmitter Pass Band Flatness vs. Baseband Offset Frequency

Figure 429. Adjacent Channel Power Level vs. Transmitter Attenuation, –10 MHz Baseband Offset, 20 MHz LTE, PAR = 12 dB
Figure 430. Adjacent Channel Power Level vs. Transmitter Attenuation, 90 MHz Baseband Offset, 20 MHz LTE, PAR = 12 dB

Figure 431. Transmitter Second Harmonic Distortion (HD2) vs. Transmitter Attenuation, 10 MHz Offset

Figure 432. Transmitter Third Harmonic Distortion (HD3) vs. Transmitter Attenuation, 10 MHz Offset

Figure 433. Transmitter Attenuator Step Error vs. Transmitter Attenuation, 10 MHz Offset

Figure 434. Transmitter Error Vector Magnitude vs. Transmitter Attenuation, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 491.52 MSPS, Loop Filter Bandwidth = 400 kHz, Loop Filter Phase Margin = 60°

Figure 435. Transmitter OIP3, 2f1 − f2 vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, f1 = 50.5 MHz, f2 = 55.5 MHz
Figure 436. Transmitter OIP3, 2f2 – f1 vs. Transmitter Attenuation,
15 dB Digital Back Off per Tone, f1 = 50.5 MHz, f2 = 55.5 MHz

Figure 437. Transmitter OIP3, 2f1 − f2 vs. f1 Baseband Offset Tone Frequency,
f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 438. Transmitter OIP3, 2f2 − f1 vs. f1 Baseband Offset Tone Frequency,
f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 439. Transmitter OIP3, 2f1 + f2 vs. f1 Baseband Offset Tone Frequency,
f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 440. Transmitter OIP3, 2f2 + f1 vs. f1 Baseband Offset Tone Frequency,
f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 441. Transmitter LO Leakage vs. Transmitter LO Frequency
Figure 442. Transmitter to Transmitter Isolation vs. Transmitter LO Frequency

Figure 443. Transmitter to Receiver Isolation vs. Receiver LO Frequency

Figure 444. Transmitter to Observation Receiver Isolation vs. Transmitter LO Frequency

Figure 445. Receiver to Receiver Isolation vs. Receiver LO Frequency

Figure 446. Receiver Integrated Noise Figure vs. Receiver Attenuation, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz

Figure 447. Receiver Integrated Noise Figure vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz
Figure 448. Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integrated in 200 kHz Steps

Figure 449. Receiver LO Leakage vs. Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 245.76 MSPS

Figure 450. Receiver Gain vs. Receiver Attenuation, 20 MHz Offset, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 451. Receiver Gain vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 452. Receiver Gain Step Error vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal

Figure 453. Normalized Receiver Flatness vs. Baseband Offset Frequency, −5 dBFS Input Signal
Figure 454. Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 455. Receiver Image vs. Receiver Attenuation, 20 MHz Offset, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 456. Receiver DC Offset vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal, Sample Rate = 245.76 MSPS

Figure 457. Receiver DC Offset vs. Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 245.76 MSPS

Figure 458. Receiver HD2, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz (HD2 Canceller Not Enabled)

Figure 459. Receiver HD2, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz (HD2 Canceller Not Enabled)
Figure 460. Receiver HD3, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 461. Receiver HD3, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 463. Receiver IIP2, $f_1 - f_2$ vs. Tone 2 Frequency, Both Tones at −11 dBFS, $f_1 = f_2 + 2$ MHz

Figure 464. Receiver IIP2, $f_1 + f_2$ vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, $f_2 = 2$ MHz

Figure 465. Receiver IIP2, $f_1 - f_2$ vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, $f_2 = 2$ MHz
Figure 466. Receiver IIP2, f1 + f2 vs. Receiver Attenuation,
Both Tones at −11 dBFS, f1 = 92 MHz, f2 = 2 MHz

Figure 467. Receiver IIP2, f1 − f2 vs. Receiver Attenuation,
Both Tones at −11 dBFS, f1 = 92 MHz, f2 = 2 MHz

Figure 468. Receiver IIP3, 2f1 + f2 vs. Tone 2 Frequency,
Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 469. Receiver IIP3, 2f2 + f1 vs. Tone 2 Frequency,
Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 470. Receiver IIP3, 2f1 − f2 vs. Tone 2 Frequency,
Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 471. Receiver IIP3, 2f2 − f1 vs. Tone 2 Frequency,
Both Tones at −11 dBFS, f1 = f2 + 2 MHz
Figure 472. Receiver IIP3, 2f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz

Figure 473. Receiver IIP3, 2f2 + f1 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz

Figure 474. Receiver IIP3, 2f1 − f2 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz

Figure 475. Receiver IIP3, 2f2 − f1 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz

Figure 476. Receiver Error Vector Magnitude vs. Receiver Input Power, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 245.76 MSPS, Loop Filter Bandwidth = 400 kHz, Loop Filter Phase Margin = 60°

Figure 477. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 75 kHz, Phase Margin = 85°
Figure 478. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 400 kHz, Phase Margin = 60°

Figure 479. Observation Receiver Integrated Noise Figure vs. Observation Receiver Attenuation, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integration Bandwidth = 500 kHz to 245.76 MHz

Figure 480. Observation Receiver Integrated Noise Figure vs. Observation Receiver LO Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integration Bandwidth = 500 kHz to 245.76 MHz

Figure 481. Observation Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integrated in 200 kHz Steps

Figure 482. Observation Receiver LO Leakage vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

Figure 483. Observation Receiver Gain vs. Observation Receiver Attenuation, 45 MHz Offset, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS
**Observation Receiver LO Frequency (MHz)**

-40°C, ORx1
+25°C, ORx1
+110°C, ORx1

-40°C, ORx2
+25°C, ORx2
+110°C, ORx2

-40°C, ORx3
+25°C, ORx3
+110°C, ORx3

-40°C, ORx4
+25°C, ORx4
+110°C, ORx4

**Observation Receiver Gain (dB)**

Figure 484. Observation Receiver Gain vs. Observation Receiver LO Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS

**Observation Receiver Gain Step Error (dB)**

**Observation Receiver Attenuation (dB)**

-40°C, ORx1
+25°C, ORx1
+110°C, ORx1

-40°C, ORx2
+25°C, ORx2
+110°C, ORx2

-40°C, ORx3
+25°C, ORx3
+110°C, ORx3

-40°C, ORx4
+25°C, ORx4
+110°C, ORx4

Figure 485. Observation Receiver Gain Step Error vs. Observation Receiver Attenuation, 45 MHz Offset, −10 dBFS Input Signal

**Observation Receiver Flatness (dB)**

**Observation Receiver Flatness (dB)**

-40°C, ORx1
+25°C, ORx1
+110°C, ORx1

-40°C, ORx2
+25°C, ORx2
+110°C, ORx2

-40°C, ORx3
+25°C, ORx3
+110°C, ORx3

-40°C, ORx4
+25°C, ORx4
+110°C, ORx4

Figure 486. Normalized Observation Receiver Flatness vs. Baseband Offset Frequency, −10 dBFS Input Signal

**Observation Receiver Image (dBc)**

**Observation Receiver Attenuation (dB)**

-40°C, ORx1
+25°C, ORx1
+110°C, ORx1

-40°C, ORx2
+25°C, ORx2
+110°C, ORx2

-40°C, ORx3
+25°C, ORx3
+110°C, ORx3

-40°C, ORx4
+25°C, ORx4
+110°C, ORx4

Figure 487. Observation Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 491.52 MSPS

**Observation Receiver DC Offset (dBFS)**

**Observation Receiver DC Offset (dBFS)**

-40°C, ORx1
+25°C, ORx1
+110°C, ORx1

-40°C, ORx2
+25°C, ORx2
+110°C, ORx2

-40°C, ORx3
+25°C, ORx3
+110°C, ORx3

-40°C, ORx4
+25°C, ORx4
+110°C, ORx4

Figure 488. Observation Receiver Image vs. Observation Receiver Attenuation, 45 MHz Offset, Tracking Calibration Active, Sample Rate = 491.52 MSPS

Figure 489. Observation Receiver DC Offset vs. Observation Receiver Attenuation, Sample Rate = 491.52 MSPS
OBSERVATION RECEIVER DC OFFSET (dBFS)

-40°C, ORx1 +25°C, ORx1 +110°C, ORx1
-40°C, ORx2 +25°C, ORx2 +110°C, ORx2
-40°C, ORx3 +25°C, ORx3 +110°C, ORx3
-40°C, ORx4 +25°C, ORx4 +110°C, ORx4

Figure 490. Observation Receiver DC Offset vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

OBSERVATION RECEIVER HD2, LEFT SIDE (dBc)

BASEBAND OFFSET FREQUENCY (MHz)

-40°C, ORx1 +25°C, ORx1 +110°C, ORx1
-40°C, ORx2 +25°C, ORx2 +110°C, ORx2
-40°C, ORx3 +25°C, ORx3 +110°C, ORx3
-40°C, ORx4 +25°C, ORx4 +110°C, ORx4

Figure 491. Observation Receiver HD2, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

OBSERVATION RECEIVER HD2, RIGHT SIDE (dBc)

BASEBAND OFFSET FREQUENCY (MHz)

-40°C, ORx1 +25°C, ORx1 +110°C, ORx1
-40°C, ORx2 +25°C, ORx2 +110°C, ORx2
-40°C, ORx3 +25°C, ORx3 +110°C, ORx3
-40°C, ORx4 +25°C, ORx4 +110°C, ORx4

Figure 492. Observation Receiver HD2, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

OBSERVATION RECEIVER IIP2, f1 + f2 (dBm)

TONE 2 FREQUENCY (MHz)

-40°C, ORx1 +25°C, ORx1 +110°C, ORx1
-40°C, ORx2 +25°C, ORx2 +110°C, ORx2
-40°C, ORx3 +25°C, ORx3 +110°C, ORx3
-40°C, ORx4 +25°C, ORx4 +110°C, ORx4

Figure 493. Observation Receiver HD3, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 494. Observation Receiver HD3, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 495. Observation Receiver IIP2, f1 + f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz
Figure 496. Observation Receiver IIP2, f1 – f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

Figure 497. Observation Receiver IIP2, f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

Figure 498. Observation Receiver IIP2, f1 – f2 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

Figure 499. Observation Receiver IIP2, f1 + f2 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 102 MHz, f2 = 2 MHz

Figure 500. Observation Receiver IIP2, f1 – f2 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 102 MHz, f2 = 2 MHz

Figure 501. Observation Receiver IIP3, 2f1 + f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz
Figure 502. Observation Receiver IIP3, $2f_2 + f_1$ vs. Tone 2 Frequency, Both Tones at $-13\,\text{dBFS}$, $f_1 = f_2 + 2\,\text{MHz}$

Figure 503. Observation Receiver IIP3, $2f_1 - f_2$ vs. Tone 2 Frequency, Both Tones at $-13\,\text{dBFS}$, $f_1 = f_2 + 2\,\text{MHz}$

Figure 504. Observation Receiver IIP3, $2f_2 - f_1$ vs. Tone 2 Frequency, Both Tones at $-13\,\text{dBFS}$, $f_1 = f_2 + 2\,\text{MHz}$

Figure 505. Observation Receiver IIP3, $2f_1 + f_2$ vs. Two-Tone Frequency Spacing, Both Tones at $-13\,\text{dBFS}$, $f_2 = 2\,\text{MHz}$

Figure 506. Observation Receiver IIP3, $2f_2 + f_1$ vs. Two-Tone Frequency Spacing, Both Tones at $-13\,\text{dBFS}$, $f_2 = 2\,\text{MHz}$

Figure 507. Observation Receiver IIP3, $2f_1 - f_2$ vs. Two-Tone Frequency Spacing, Both Tones at $-13\,\text{dBFS}$, $f_2 = 2\,\text{MHz}$
Figure 508. Observation Receiver IIP3, 2f2 − f1 vs. Two-Tone Frequency Spacing, Both Tones at −13 dBFS, f2 = 2 MHz

Figure 509. Observation Receiver IIP3, 2f2 + f1 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 122 MHz, f2 = 2 MHz

Figure 510. Observation Receiver IIP3, 2f2 − f1 vs. Observation Receiver Attenuation, Both Tones at −13 dBFS, f1 = 122 MHz, f2 = 2 MHz
5700 MHz BAND

The temperature settings refer to the die temperature. All LO frequencies set to 5700 MHz, unless otherwise noted.
Figure 517. Adjacent Channel Power Level vs. Transmitter Attenuation, 90 MHz Baseband Offset, 20 MHz LTE, PAR = 12 dB

Figure 520. Transmitter Attenuator Step Error vs. Transmitter Attenuation, 10 MHz Offset

Figure 518. Transmitter Second Harmonic Distortion (HD2) vs. Transmitter Attenuation, 10 MHz Offset

Figure 519. Transmitter Third Harmonic Distortion (HD3) vs. Transmitter Attenuation, 10 MHz Offset

Figure 521. Transmitter Error Vector Magnitude vs. Transmitter Attenuation, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 491.52 MSPS, Loop Filter Bandwidth = 400 kHz, Loop Filter Phase Margin = 60°

Figure 522. Transmitter OIP3, 2f1 − f2 vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, f1 = 50.5 MHz, f2 = 55.5 MHz
Figure 523. Transmitter OIP3, 2f2 − f1 vs. Transmitter Attenuation, 15 dB Digital Back Off per Tone, f1 = 50.5 MHz, f2 = 55.5 MHz

Figure 524. Transmitter OIP3, 2f1 − f2 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 525. Transmitter OIP3, 2f2 − f1 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 526. Transmitter OIP3, 2f1 + f2 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 527. Transmitter OIP3, 2f2 + f1 vs. f1 Baseband Offset Tone Frequency, f2 = f1 + 5 MHz, 15 dB Digital Back Off per Tone

Figure 528. Transmitter LO Leakage vs. Transmitter LO Frequency
Figure 529. Transmitter to Transmitter Isolation vs. Transmitter LO Frequency

Figure 530. Transmitter to Receiver Isolation vs. Receiver LO Frequency

Figure 531. Transmitter to Observation Receiver Isolation vs. Transmitter LO Frequency

Figure 532. Receiver to Receiver Isolation vs. Receiver LO Frequency

Figure 533. Receiver Integrated Noise Figure vs. Receiver Attenuation, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz

Figure 534. Receiver Integrated Noise Figure vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integration Bandwidth = 500 kHz to 100 MHz
Figure 535. Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS, Integrated in 200 kHz Steps

Figure 536. Receiver LO Leakage vs. Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 245.76 MSPS

Figure 537. Receiver Gain vs. Receiver Attenuation, 20 MHz Offset, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 538. Receiver Gain vs. Receiver LO Frequency, 200 MHz Bandwidth, Sample Rate = 245.76 MSPS

Figure 539. Receiver Gain Step Error vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal

Figure 540. Normalized Receiver Flatness vs. Baseband Offset Frequency, −5 dBFS Input Signal
Figure 541. Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 542. Receiver Image vs. Receiver Attenuation, 20 MHz Offset, Tracking Calibration Active, Sample Rate = 245.76 MSPS

Figure 543. Receiver DC Offset vs. Receiver Attenuation, 20 MHz Offset, −5 dBFS Input Signal, Sample Rate = 245.76 MSPS

Figure 544. Receiver DC Offset vs. Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 245.76 MSPS

Figure 545. Receiver HD2, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz (HD2 Canceller Not Enabled)

Figure 546. Receiver HD2, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz (HD2 Canceller Not Enabled)
Figure 547. Receiver HD3, Left Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 548. Receiver HD3, Right Side vs. Baseband Offset Frequency, −5 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 549. Receiver IIP2, f1 + f2 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 550. Receiver IIP2, f1 − f2 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 551. Receiver IIP2, f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz

Figure 552. Receiver IIP2, f1 − f2 vs. Two-Tone Frequency Spacing, Both Tones at −11 dBFS, f2 = 2 MHz
Figure 553. Receiver IIP2, f1 + f2 vs. Receiver Attenuation, Both Tones at −11 dBFS, f1 = 92 MHz, f2 = 2 MHz

Figure 554. Receiver IIP2, f1 − f2 vs. Receiver Attenuation, Both Tones at −11 dBFS, f1 = 92 MHz, f2 = 2 MHz

Figure 555. Receiver IIP3, 2f1 + f2 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 556. Receiver IIP3, 2f2 + f1 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 557. Receiver IIP3, 2f1 − f2 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz

Figure 558. Receiver IIP3, 2f2 − f1 vs. Tone 2 Frequency, Both Tones at −11 dBFS, f1 = f2 + 2 MHz
**ADRV9029**

**Receiver IIP3, 2f1 + f2 (dBm) vs. Two-Tone Frequency Spacing (MHz)**

- **–40°C, Rx1**
- **+25°C, Rx1**
- **+110°C, Rx1**
- **–40°C, Rx2**
- **+25°C, Rx2**
- **+110°C, Rx2**
- **–40°C, Rx3**
- **+25°C, Rx3**
- **+110°C, Rx3**
- **–40°C, Rx4**
- **+25°C, Rx4**
- **+110°C, Rx4**

**Figure 559. Receiver IIP3, 2f1 + f2 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz**

**Receiver IIP3, 2f2 + f1 (dBm) vs. Two-Tone Frequency Spacing (MHz)**

- **–40°C, Rx1**
- **+25°C, Rx1**
- **+110°C, Rx1**
- **–40°C, Rx2**
- **+25°C, Rx2**
- **+110°C, Rx2**
- **–40°C, Rx3**
- **+25°C, Rx3**
- **+110°C, Rx3**
- **–40°C, Rx4**
- **+25°C, Rx4**
- **+110°C, Rx4**

**Figure 560. Receiver IIP3, 2f2 + f1 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz**

**Receiver IIP3, 2f1 − f2 (dBm) vs. Two-Tone Frequency Spacing (MHz)**

- **–40°C, Rx1**
- **+25°C, Rx1**
- **+110°C, Rx1**
- **–40°C, Rx2**
- **+25°C, Rx2**
- **+110°C, Rx2**
- **–40°C, Rx3**
- **+25°C, Rx3**
- **+110°C, Rx3**
- **–40°C, Rx4**
- **+25°C, Rx4**
- **+110°C, Rx4**

**Figure 561. Receiver IIP3, 2f1 − f2 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz**

**Receiver IIP3, 2f2 − f1 (dBm) vs. Two-Tone Frequency Spacing (MHz)**

- **–40°C, Rx1**
- **+25°C, Rx1**
- **+110°C, Rx1**
- **–40°C, Rx2**
- **+25°C, Rx2**
- **+110°C, Rx2**
- **–40°C, Rx3**
- **+25°C, Rx3**
- **+110°C, Rx3**
- **–40°C, Rx4**
- **+25°C, Rx4**
- **+110°C, Rx4**

**Figure 562. Receiver IIP3, 2f2 − f1 vs. Two-Tone Frequency Spacing, Both Tones at –11 dBFS, f2 = 2 MHz**

**Receiver EVM (dB) vs. Receiver Input Power (dBm)**

- **–80 dBm to –5 dBm**

**Figure 563. Receiver Error Vector Magnitude vs. Receiver Input Power, 20 MHz LTE Signal Centered at LO Frequency, Sample Rate = 245.76 MSPS, Loop Filter Bandwidth = 400 kHz, Loop Filter Phase Margin = 60°**

**LO Phase Noise (dBc/Hz) vs. Frequency Offset (Hz)**

- **–150 kHz to 150 kHz**

**Figure 564. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 75 kHz, Phase Margin = 85°**
Figure 565. LO Phase Noise vs. Frequency Offset, Loop Bandwidth = 500 kHz, Phase Margin = 60°

Figure 566. Observation Receiver Integrated Noise Figure vs. Observation Receiver Attenuation, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integration Bandwidth = 500 kHz to 245.76 MHz

Figure 567. Observation Receiver Integrated Noise Figure vs. Observation Receiver LO Frequency, 45 MHz Offset, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integration Bandwidth = 500 kHz to 245.76 MHz

Figure 568. Observation Receiver Integrated Noise Figure vs. Baseband Offset Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS, Integrated in 200 kHz Steps

Figure 569. Observation Receiver LO Leakage vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

Figure 570. Observation Receiver Gain vs. Observation Receiver Attenuation, 45 MHz Offset, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS

Rev. 0 | Page 121 of 133
Figure 571. Observation Receiver Gain vs. Observation Receiver LO Frequency, 450 MHz Bandwidth, Sample Rate = 491.52 MSPS

Figure 572. Observation Receiver Gain Step Error vs. Observation Receiver Attenuation, 45 MHz Offset, −10 dBFS Input Signal

Figure 573. Normalized Observation Receiver Flatness vs. Baseband Offset Frequency, −10 dBFS Input Signal

Figure 574. Observation Receiver Image vs. Baseband Offset Frequency, Tracking Calibration Active, Sample Rate = 491.52 MSPS

Figure 575. Observation Receiver Image vs. Observation Receiver Attenuation, 20 MHz Offset, Tracking Calibration Active, Sample Rate = 491.52 MSPS

Figure 576. Observation Receiver DC Offset vs. Observation Receiver Attenuation, Sample Rate = 491.52 MSPS
Data Sheet ADRV9029

Figure 577. Observation Receiver DC Offset vs. Observation Receiver LO Frequency, Attenuation = 0 dB, Sample Rate = 491.52 MSPS

Figure 578. Observation Receiver HD2, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 579. Observation Receiver HD2, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 580. Observation Receiver HD3, Left Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Left of 0 Hz

Figure 581. Observation Receiver HD3, Right Side vs. Baseband Offset Frequency, −10 dBFS Input Signal, Distortion Tone Measured Right of 0 Hz

Figure 582. Observation Receiver IP2, f1 + f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz
Figure 583. Observation Receiver IIP2, \( f_1 - f_2 \) vs. Tone 2 Frequency, Both Tones at \(-13\, \text{dBFS}, f_1 = f_2 + 2\, \text{MHz}\)

Figure 584. Observation Receiver IIP2, \( f_1 + f_2 \) vs. Two-Tone Frequency Spacing, Both Tones at \(-13\, \text{dBFS}, f_2 = 2\, \text{MHz}\)

Figure 585. Observation Receiver IIP2, \( f_1 - f_2 \) vs. Two-Tone Frequency Spacing, Both Tones at \(-13\, \text{dBFS}, f_2 = 2\, \text{MHz}\)

Figure 586. Observation Receiver IIP2, \( f_1 + f_2 \) vs. Observation Receiver Attenuation, Both Tones at \(-13\, \text{dBFS}, f_1 = 102\, \text{MHz}, f_2 = 2\, \text{MHz}\)

Figure 587. Observation Receiver IIP2, \( f_1 - f_2 \) vs. Observation Receiver Attenuation, Both Tones at \(-13\, \text{dBFS}, f_1 = 102\, \text{MHz}, f_2 = 2\, \text{MHz}\)

Figure 588. Observation Receiver IIP3, \( 2f_1 + f_2 \) vs. Tone 2 Frequency, Both Tones at \(-13\, \text{dBFS}, f_1 = f_2 + 2\, \text{MHz}\)
OBSERVATION RECEIVER IIP3, 2f2 + f1 (dBm)

-40°C, ORx1
-25°C, ORx1
+10°C, ORx1
-40°C, ORx2
-25°C, ORx2
+10°C, ORx2
-40°C, ORx3
-25°C, ORx3
+10°C, ORx3
-40°C, ORx4
-25°C, ORx4
+10°C, ORx4

Figure 589. Observation Receiver IIP3, 2f2 + f1 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

OBSERVATION RECEIVER IIP3, 2f2 − f1 (dBm)

-40°C, ORx1
-25°C, ORx1
+10°C, ORx1
-40°C, ORx2
-25°C, ORx2
+10°C, ORx2
-40°C, ORx3
-25°C, ORx3
+10°C, ORx3
-40°C, ORx4
-25°C, ORx4
+10°C, ORx4

Figure 590. Observation Receiver IIP3, 2f2 − f1 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

OBSERVATION RECEIVER IIP3, 2f1 + f2 (dBm)

-40°C, ORx1
-25°C, ORx1
+10°C, ORx1
-40°C, ORx2
-25°C, ORx2
+10°C, ORx2
-40°C, ORx3
-25°C, ORx3
+10°C, ORx3
-40°C, ORx4
-25°C, ORx4
+10°C, ORx4

Figure 591. Observation Receiver IIP3, 2f2 − f1 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

OBSERVATION RECEIVER IIP3, 2f1 − f2 (dBm)

-40°C, ORx1
-25°C, ORx1
+10°C, ORx1
-40°C, ORx2
-25°C, ORx2
+10°C, ORx2
-40°C, ORx3
-25°C, ORx3
+10°C, ORx3
-40°C, ORx4
-25°C, ORx4
+10°C, ORx4

Figure 592. Observation Receiver IIP3, 2f1 − f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

Figure 593. Observation Receiver IIP3, 2f1 + f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz

Figure 594. Observation Receiver IIP3, 2f1 − f2 vs. Tone 2 Frequency, Both Tones at −13 dBFS, f1 = f2 + 2 MHz
Figure 595. Observation Receiver IIP3, 2f2 – f1 vs. Two-Tone Frequency Spacing, Both Tones at –13 dBFS, f2 = 2 MHz

Figure 596. Observation Receiver IIP3, 2f2 + f1 vs. Observation Receiver Attenuation, Both Tones at –13 dBFS, f1 = 122 MHz, f2 = 2 MHz

Figure 597. Observation Receiver IIP3, 2f2 – f1 vs. Observation Receiver Attenuation, Both Tones at –13 dBFS, f1 = 122 MHz, f2 = 2 MHz
THEORY OF OPERATION

GENERAL

The ADRV9029 is a highly integrated RF transceiver capable of configuration for a wide range of applications. The device integrates all the RF, mixed-signal, and digital blocks necessary to provide all transmitter, traffic receiver, and observation receiver functions in a single device. Programmability allows the device to be adapted for use in many 3G/4G/5G cellular standards in frequency division duplex (FDD) and time division duplex (TDD) modes.

Four observation receiver channels monitor the transmitter outputs and provide tracking correction of dc offset, quadrature error, and transmitter LO leakage to maintain a high performance level under varying temperatures and input signal conditions. Firmware supplied with the device implements all initialization and calibration with no user interaction. Additionally, the device includes test modes allowing system designers to debug designs during prototyping and to optimize radio configurations.

The ADRV9029 contains four high speed serial interface (SERDES) links for the transmit chain and four high speed links shared by the receiver and observation receiver chains (JESD204B Subclass 1 compliant and supports JESD204C).

TRANSMITTER

The ADRV9029 transmitter section consists of four identical and independently controlled channels that provide all the digital processing, mixed-signal, and RF blocks necessary to implement a direct conversion system while sharing a common frequency synthesizer. The digital data from the SERDES lanes pass through a digital processing block that includes a series of programmable half-band filters, interpolation stages, and FIR filters, including a programmable FIR filter with variable interpolation rates and up to 80 taps. The output of this digital chain is connected to the digital-to-analog converter (DAC). The DAC sample rate is adjustable up to 2.5 GHz. The in-phase (I) and quadrature (Q) channels are identical in each transmitter signal chain.

After conversion to baseband analog signals, the I and Q signals are filtered to remove sampling artifacts and fed to the upconversion mixers. Each transmit chain provides a wide attenuation adjustment range with fine granularity to help designers optimize signal-to-noise ratio (SNR).

RECEIVER

The ADRV9029 provides four independent receiver channels. Each channel contains all the blocks necessary to receive RF signals and convert these signals to digital data usable by a baseband processor. Each receiver can be configured as a direct conversion system that supports up to a bandwidth of 200 MHz. Each channel contains a programmable attenuator stage, followed by matched I and Q mixers that downconvert received signals to baseband for digitization.

Two gain control options are available, as follows:
- Users can implement their own gain control algorithms using their baseband processor to manage manual gain control mode
- Users can use the on-chip automatic gain control (AGC) system.

Performance is optimized by mapping each gain control setting to specific attenuation levels at each adjustable gain block in the receive signal path. Additionally, each channel contains independent receive signal strength indication (RSSI) measurement capability, dc offset tracking, and all the circuitry necessary for self calibration.

The receivers include analog-to-digital converters (ADCs) and adjustable sample rates that produce data streams from the received signals. The signals can be conditioned further by a series of decimation filters and a programmable FIR filter with additional decimation settings. The sample rate of each digital filter block is adjustable by changing decimation factors to produce the desired output data rate. All receiver outputs are connected to the SERDES block, where the data is formatted and serialized for transmission to the baseband processor.

OBSERVATION RECEIVER

The ADRV9029 provides four independent observation receiver inputs. These inputs are similar in implementation to the standard receiver channels in terms of the mixers, ADCs, and filtering blocks. The main difference is that these receivers operate with an observation bandwidth up to 450 MHz, allowing the receivers to receive all the transmitter channel information needed for implementing digital correction algorithms.

Each input is used as the feedback monitor channel for a corresponding transmitter channel. Table 14 shows the possible combinations of transmitter and observation channels.

<table>
<thead>
<tr>
<th>Transmitter Channel</th>
<th>Observation Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>TX1±</td>
<td>ORX1± or ORX2±</td>
</tr>
<tr>
<td>TX2±</td>
<td>ORX1± or ORX2±</td>
</tr>
<tr>
<td>TX3±</td>
<td>ORX3± or ORX4±</td>
</tr>
<tr>
<td>TX4±</td>
<td>ORX3± or ORX4±</td>
</tr>
</tbody>
</table>

CLOCK INPUT

The ADRV9029 requires a differential clock connected to the DEVCLK± pins. The frequency of the clock input must be between 15 MHz and 1000 MHz and must have low phase noise because this signal generates the RF LO and internal sampling clocks.
**SYNTHESIZERS**

The ADRV9029 contains four fractional-N PLLs to generate the RF LO for the signal paths and all internal clock sources. This group of PLLs includes two RF PLLs for transmit and receive LO generation, an auxiliary PLL that can be used by the observation receivers, and a clock PLL. Each PLL is independently controlled with no need for external components to set frequencies.

**RF Synthesizers**

The two RF synthesizers use fractional-N PLLs to generate RF LOs for multiple receiver and transmitter channels. The fractional-N PLL incorporates a four-core internal voltage controlled oscillator (VCO) and loop filter, capable of generating low phase noise signals with no external components required. An internal LO multiplexer (mux) enables each PLL to supply LOs to any or all receivers and transmitters (for example, LO1 to all transmitters, LO2 to all receivers), resulting in maximum flexibility when configuring the device for TDD operation. The LOs on multiple devices can be phase synchronized to support active antenna systems and beam forming applications.

**Auxiliary Synthesizer**

The auxiliary synthesizer uses a single core VCO fractional-N PLL to generate the signals necessary to calibrate the device. The output of this block uses a separate mux system to route LOs for calibrating different functions during initialization. The auxiliary synthesizer can also be used to generate LO signals for the observation receivers or as an offset LO used in the receiver signal chains.

**Clock Synthesizer**

The ADRV9029 contains a single core VCO fractional-N PLL synthesizer that generates all baseband related clock signals and SERDES clocks. This fractional-N PLL is programmed based on the data rate and sample rate requirements of the system, which typically require the system to operate in integer mode.

For JESD204B configurations with Np = 12 and JESD204C configurations, a dedicated PLL included in the SERDES block generates the SERDES clocks.

**SPI INTERFACE**

The ADRV9029 uses a SPI to communicate with the baseband processor. This interface can be configured as a 4-wire interface with dedicated receive and transmit ports, or the interface can be configured as a 3-wire interface with a bidirectional data communications port. This bus allows the baseband processor to set all device control parameters using a simple address data serial bus protocol.

Write commands follow a 24-bit format. The first bit sets the bus direction of the bus transfer. The next 15 bits set the address where data is written. The final eight bits are the data being transferred to the specific register address.

Read commands follow a similar format with the exception that the first 16 bits are transferred on the SPI_DIO pin, and the final eight bits are read from the ADRV9029, either on the SPI_DO pin in 4-wire mode or on the SPI_DIO pin in 3-wire mode.

**GPIO_X PINS**

The ADRV9029 provides 19 general-purpose input/output signals (GPIOs) referenced to VIF that can be configured for numerous functions. When configured as outputs, certain pins can provide real-time signal information to the baseband processor, allowing the baseband processor to determine receiver performance. A pointer register selects what information is output to these pins.

Signals used for manual gain mode, calibration flags, state machine status, and various receiver parameters are among the outputs that can be monitored on the GPIO pins. Additionally, certain GPIO pins can be configured as inputs and used for various functions, such as setting the receiver gain in real time.

**AUXILIARY CONVERTERS**

**GPIO_ANA_x/AUXDAC_x**

The ADRV9029 contains eight analog GPIOs (the GPIO_ANA_x pins) that are multiplexed with eight identical auxiliary DACs (AUXDAC_x). The analog GPIO ports can be used to control other analog devices or receive control inputs referenced to the VDDA_1P8 supply. The auxiliary DACs are 12-bit converters capable of supplying up to 10 mA. These outputs are typically used to supply bias current or variable control voltages for other related components with analog control inputs.

**AUXDACA_x**

The ADRV9029 contains two auxiliary ADCs with four total input pins (AUXDACA_x). These auxiliary ADCs provide 10-bit monotonic outputs with an input voltage range of 0.05 V to 0.95 V. When enabled, each auxiliary ADC is free running. An application programming interface (API) command latches the ADC output value to a register. The ADRV9029 also contains an ADC that supports a built-in diode-based temperature sensor.

**DIGITAL PREDISTORTION (DPD)**

The ADRV9029 provides a fully integrated DPD system that linearizes the output of the transmitter power amplifier by altering the digital waveform to compensate for nonlinearities in the power amplifier response. Both the DPD actuator and coefficient calculation engine are integrated within the device. This system uses an ORx channel to monitor the output of the power amplifier and calculates the appropriate predistortion that must be inserted into the transmitter datapath to linearize the output. The integrated DPD capability allows the system to drive the power amplifier closer to saturation, enabling a higher efficiency power amplifier while maintaining linearity. The DPD is optimized for power amplifiers with rms output powers in the 250 mW to 10 W range. The DPD engine is highly configurable and can operate over a range of clock rates, which allows the DPD system to scale so this system can support different carrier configurations within the transmitter bandwidth. The additional
power consumed by the DPD block when enabled ranges from 20 mW per channel (minimum bandwidth) to 325 mW per channel (maximum bandwidth).

**DPD Improvement Example: 2600 MHz**

DPD performance enhancement is shown in Figure 598 for a 20 MHz LTE signal and in Figure 599 for a 100 MHz 5G NR signal. A Band 41 Skyworks SKY66398-11 high efficiency power amplifier was used for both the 20 MHz LTE signal and the 100 MHz 5G NR signal to demonstrate the adjacent channel level reduction (ACLR) improvement for a particular device.

Table 15 and Table 16 show the details of the ACLR improvement achieved for these two scenarios when DPD is activated. Note that the magnitude of improvement in ACLR is heavily dependent on the power amplifier used and generally degrades as signal bandwidth increases.

**DPD Improvement Example: 3500 MHz**

Performance enhancement is shown in Figure 600 for a 20 MHz LTE signal, in Figure 601 for a 100 MHz 5G NR signal, and in Figure 602 for a 2×, 100 MHz 5G NR signal. An NXP AFSC5G35D37 high efficiency power amplifier was used for the 20 MHz LTE signal, the 100 MHz 5G NR signal, and the 2×, 100 MHz 5G NR signal to demonstrate the ACLR improvement for a particular device.

Table 15, Table 16, and Table 17 show the details of ACLR improvement achieved for these two scenarios when DPD is activated. Note that the magnitude of improvement in ACLR is heavily dependent on the power amplifier used and generally degrades as signal bandwidth increases.
Figure 602. Transmitter Output Spectrum for Normal Operation (Red) and with DPD Activated (Blue) for a 2x, 100 MHz, 5G NR200 Waveform, 37 dBm, LO = 3500 MHz, and RBW = 100 kHz

Table 15. 20 MHz LTE Waveform ACLR Comparison With and Without DPD

<table>
<thead>
<tr>
<th>Mode</th>
<th>20 MHz Offset (dBc)</th>
<th>40 MHz Offset (dBc)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>2600 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal Operation</td>
<td>−38.6</td>
<td>−43.5</td>
</tr>
<tr>
<td>DPD Activated</td>
<td>−60.3</td>
<td>−60.5</td>
</tr>
<tr>
<td>3500 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal Operation</td>
<td>−31.9</td>
<td>−31.0</td>
</tr>
<tr>
<td>DPD Activated</td>
<td>−60.7</td>
<td>−59.8</td>
</tr>
</tbody>
</table>

Table 16. 100 MHz 5G NR Waveform ACLR Comparison With and Without DPD

<table>
<thead>
<tr>
<th>Mode</th>
<th>100 MHz Offset (dBc)</th>
<th>200 MHz Offset (dBc)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
<td>Upper</td>
</tr>
<tr>
<td>2600 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal Operation</td>
<td>−31.9</td>
<td>−42.0</td>
</tr>
<tr>
<td>DPD Activated</td>
<td>−49.5</td>
<td>−51.0</td>
</tr>
<tr>
<td>3500 MHz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal Operation</td>
<td>−30.8</td>
<td>−28.3</td>
</tr>
<tr>
<td>DPD Activated</td>
<td>−50.9</td>
<td>−50.7</td>
</tr>
</tbody>
</table>

Table 17. 2x 100 MHz 5G NR Waveform ACLR Comparison With and Without DPD

<table>
<thead>
<tr>
<th>Mode</th>
<th>200 MHz Offset (dBc)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
</tr>
<tr>
<td>3500 MHz</td>
<td></td>
</tr>
<tr>
<td>Normal Operation</td>
<td>−27.5</td>
</tr>
<tr>
<td>DPD Activated</td>
<td>−49.0</td>
</tr>
</tbody>
</table>

1 Waveform is LTE evolved universal terrestrial radio access (E-UTRA) Test Model 3.1 (E-TM 3.1) at 8 dB PAR, with CFR active, 18.015 MHz occupied bandwidth, 28 dBm output at LO = 2600 MHz, and 37 dBm output at LO = 3500 MHz.

1 Waveform is NR-FR1-TM3.1 64 QAM (mu = 1:30 kHz subcarrier spacing) at 8 dB PAR with CFR active, 98.28 MHz occupied bandwidth, 28 dBm output at LO = 2600 MHz, and 37 dBm output at LO = 3500 MHz.

1 Waveform is two adjacent NR-FR1-TM3.1 64 QAM (mu = 1:30 kHz subcarrier spacing) at 8 dB PAR with CFR active, 196.56 MHz occupied bandwidth, and 37 dBm output.
CREST FACTOR REDUCTION (CFR)

The ADRV9029 includes a low power CFR feature that enables power amplifiers to operate more efficiently. When nonconstant envelope modulation schemes are used, the signal can have a high PAR. The CFR algorithm reduces the PAR, enabling the power amplifier to operate more efficiently while minimizing the impact to signal quality parameters such as EVM and out of band emission levels. System designers can configure the CFR algorithm to ensure these performance parameters are within the system specification limits.

JTAG BOUNDARY SCAN

The ADRV9029 provides support for a JTAG boundary scan. There are five dual function pins associated with the JTAG interface. These pins, listed in Table 18, are used to access the on-chip test access port. To enable the JTAG functionality, set the GPIO_0 pin through the GPIO_2 pin according to Table 19, depending on how the desired JESD204B sync signals are configured in the software (differential or single-ended mode). Pull the TEST_EN pin high to the VIF supply to enable the JTAG mode.

<table>
<thead>
<tr>
<th>Mnemonic</th>
<th>JTAG Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPIO_14</td>
<td>TRST</td>
<td>Test access port reset</td>
</tr>
<tr>
<td>GPIO_15</td>
<td>TDO</td>
<td>Test data output</td>
</tr>
<tr>
<td>GPIO_16</td>
<td>TDI</td>
<td>Test data input</td>
</tr>
<tr>
<td>GPIO_17</td>
<td>TMS</td>
<td>Test access port mode select</td>
</tr>
<tr>
<td>GPIO_18</td>
<td>TCK</td>
<td>Test clock</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test Pin Level</th>
<th>GPIO_2 to GPIO_0</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>XXX(^1)</td>
<td>Normal operation</td>
</tr>
<tr>
<td>1</td>
<td>000</td>
<td>JTAG mode with differential JESD204B sync signals</td>
</tr>
<tr>
<td>1</td>
<td>011</td>
<td>JTAG mode with single-ended JESD204B sync signals</td>
</tr>
</tbody>
</table>

\(^1\) X means any combination.
APPLICATIONS INFORMATION

POWER SUPPLY SEQUENCE

The ADRV9029 requires a specific power-up sequence to avoid undesired power-up currents. In the optimal power-up sequence, the VDIG_1P0 supply is activated first. When VDIG_1P0 powers VDDA_1P0, then all 1.0 V supplies can be powered on at the same time.

If VDIG_1P0 is isolated, all VDDA_1P8, VDDA_1P3, and VDDA_1P0 supplies must be powered up after VDIG_1P0 is activated. The VIF supply can be powered up at any time.

It is also recommended prior to configuration to toggle the RESET signal after power has stabilized.

If a power-down sequence is followed, to avoid any back biasing of the digital control lines, remove the VDIG_1P0 supply last. If no sequencing is used, it is recommended to power down all supplies simultaneously.

DATA INTERFACE

The digital data interface for the ADRV9029 implements JEDEC Standard JESD204B Subclass 1 and JESD204C. The serial interface operates at speeds of up to 24,330.24 Mbps. Table 20, Table 21, and Table 22 list example parameters for various JESD interface settings. Other output rates, bandwidth, and number of lanes are also supported for each of the interface rates reported in Table 20, Table 21, and Table 22.

Table 20. Example Receiver Interface Rates with Four Channels Active (M = 8)

<table>
<thead>
<tr>
<th>Bandwidth (MHz)</th>
<th>Output Rate (MSPS)</th>
<th>JESD Np Parameter</th>
<th>JESD204B Lane Rate (Mbps)</th>
<th>JESD204B Number of Lanes</th>
<th>JESD204C Lane Rate (Mbps)</th>
<th>JESD204C Number of Lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>61.44</td>
<td>16</td>
<td>16</td>
<td>9830.4</td>
<td>1</td>
<td>16</td>
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<tr>
<td>60</td>
<td>76.8</td>
<td>16</td>
<td>16</td>
<td>12288</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>100</td>
<td>122.88</td>
<td>16</td>
<td>8</td>
<td>9830.4</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>150</td>
<td>184.32</td>
<td>16</td>
<td>4</td>
<td>7372.8</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>200</td>
<td>245.76</td>
<td>16</td>
<td>4</td>
<td>9830.4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>200</td>
<td>245.76</td>
<td>12</td>
<td>3</td>
<td>7372.8</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>200</td>
<td>245.76</td>
<td>12</td>
<td>6</td>
<td>14745.6</td>
<td>2</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 21. Transmitter Interface Rates with Four Channels Active (M = 8)

<table>
<thead>
<tr>
<th>Primary Signal Bandwidth (MHz)</th>
<th>Total Bandwidth (MHz)</th>
<th>Input Rate (MSPS)</th>
<th>JESD Np Parameter</th>
<th>JESD204B Lane Rate (Mbps)</th>
<th>JESD204B Number of Lanes</th>
<th>JESD204C Lane Rate (Mbps)</th>
<th>JESD204C Number of Lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>113</td>
<td>122.88</td>
<td>16</td>
<td>9830.4</td>
<td>2</td>
<td>8</td>
<td>8110.08</td>
</tr>
<tr>
<td>75</td>
<td>150</td>
<td>184.32</td>
<td>16</td>
<td>7372.8</td>
<td>4</td>
<td>8</td>
<td>12165.12</td>
</tr>
<tr>
<td>100</td>
<td>225</td>
<td>245.76</td>
<td>16</td>
<td>9830.4</td>
<td>4</td>
<td>4</td>
<td>8110.08</td>
</tr>
<tr>
<td>100</td>
<td>225</td>
<td>245.76</td>
<td>12</td>
<td>7372.8</td>
<td>4</td>
<td>6</td>
<td>12165.12</td>
</tr>
<tr>
<td>200</td>
<td>450</td>
<td>491.52</td>
<td>12</td>
<td>14745.6</td>
<td>4</td>
<td>8</td>
<td>24330.24</td>
</tr>
</tbody>
</table>

Table 22. Observation Path Interface Rates with 1 Channel Active (M = 2)

<table>
<thead>
<tr>
<th>Total Bandwidth (MHz)</th>
<th>Output Rate (MSPS)</th>
<th>JESD Np Parameter</th>
<th>JESD204B Lane Rate (Mbps)</th>
<th>JESD204B Number of Lanes</th>
<th>JESD204C Lane Rate (Mbps)</th>
<th>JESD204C Number of Lanes</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>184.32</td>
<td>16</td>
<td>4</td>
<td>7372.8</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>225</td>
<td>245.76</td>
<td>16</td>
<td>4</td>
<td>9830.4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>225</td>
<td>245.76</td>
<td>12</td>
<td>3</td>
<td>7372.8</td>
<td>1</td>
<td>3</td>
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<tr>
<td>250</td>
<td>307.2</td>
<td>16</td>
<td>4</td>
<td>12288</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>300</td>
<td>368.64</td>
<td>16</td>
<td>2</td>
<td>7372.8</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>450</td>
<td>491.52</td>
<td>16</td>
<td>2</td>
<td>9830.4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>450</td>
<td>491.52</td>
<td>12</td>
<td>3</td>
<td>14745.6</td>
<td>1</td>
<td>4</td>
</tr>
</tbody>
</table>
OUTLINE DIMENSIONS

Figure 603. 289-Ball Chip Scale Package Ball Grid Array [CSP_BGA] (BC-289-6)
Dimensions shown in millimeters

ORDERING GUIDE

<table>
<thead>
<tr>
<th>Model</th>
<th>Temperature Range</th>
<th>Package Description</th>
<th>Package Option</th>
</tr>
</thead>
<tbody>
<tr>
<td>ADRV9029BBCZ</td>
<td>−40°C to +110°C</td>
<td>289-Ball Chip Scale Package Ball Grid Array [CSP_BGA]</td>
<td>BC-289-6</td>
</tr>
<tr>
<td>ADRV9029BBCZ-REEL</td>
<td>−40°C to +110°C</td>
<td>289-Ball Chip Scale Package Ball Grid Array [CSP_BGA]</td>
<td>BC-289-6</td>
</tr>
<tr>
<td>ADRV9029-HB/PCBZ</td>
<td></td>
<td>High Band Evaluation Board for 2.8 GHz to 6 GHz</td>
<td></td>
</tr>
<tr>
<td>ADRV9029-MB/PCBZ</td>
<td></td>
<td>Mid Band Evaluation Board for 650 MHz to 2.8 GHz</td>
<td></td>
</tr>
<tr>
<td>ADRV9029-LB/PCBZ</td>
<td></td>
<td>Low Band Evaluation Board for 50 MHz to 1.0 GHz</td>
<td></td>
</tr>
<tr>
<td>ADS9-V2EBZ</td>
<td></td>
<td>ADS9-V2 Motherboard</td>
<td></td>
</tr>
</tbody>
</table>

1 Z = RoHS Compliant Part.
2 The ADS9-V2EBZ motherboard (ordered separately) must be used with the ADRV9029-HB/PCBZ, ADRV9029-MB/PCBZ, or ADRV9020-LB/PCBZ evaluation board.
3 See the Junction Temperature section.