FEATURES

Radio frequency (RF) 2 × 2 transceiver with integrated 12-bit DACs and ADCs
Wide bandwidth: 325 MHz to 3.8 GHz
Supports time division duplex (TDD) and frequency division duplex (FDD) operation
Tunable channel bandwidth (BW): up to 20 MHz
Receivers: 6 differential or 12 single-ended inputs
Superior receiver sensitivity with a noise figure: 3 dB
Receive (Rx) gain control
Real-time monitor and control signals for manual gain
Independent automatic gain control (AGC)
Dual transmitters: 4 differential outputs
Highly linear broadband transmitter
Transmit (Tx) error vector magnitude (EVM): −34 dB
Tx noise: ≤−157 dBm/Hz noise floor
Tx monitor: 66 dB dynamic range with 1 dB accuracy
Integrated fractional N synthesizers
2.4 Hz local oscillator (LO) step size
CMOS/LVDS digital interface

APPLICATIONS
3G enterprise femtocell base stations
4G femtocell base stations
Wireless video transmission

GENERAL DESCRIPTION
The AD9363 is a high performance, highly integrated RF agile transceiver designed for use in 3G and 4G femtocell applications. Its programmability and wideband capability make it ideal for a broad range of transceiver applications. The device combines an RF front end with a flexible mixed-signal baseband section and integrated frequency synthesizers, simplifying design-in by providing a configurable digital interface to a processor. The AD9363 operates in the 325 MHz to 3.8 GHz range, covering most licensed and unlicensed bands. Channel bandwidths from less than 200 kHz to 20 MHz are supported.

The two independent direct conversion receivers have state-of-the-art noise figure and linearity. Each Rx subsystem includes independent automatic gain control (AGC), dc offset correction, quadrature correction, and digital filtering, thereby eliminating the need for these functions in the digital baseband. The AD9363 also has flexible manual gain modes that can be externally controlled. Two high dynamic range ADCs per channel digitize the received I and Q signals and pass them through configurable decimation filters and 128-tap finite impulse response (FIR) filters to produce a 12-bit output signal at the appropriate sample rate.

The transmitters use a direct conversion architecture that achieves high modulation accuracy with ultralow noise. This transmitter design produces a best-in-class Tx EVM of −34 dB, allowing significant system margin for the external power amplifier (PA) selection. The on-board Tx power monitor can be used as a power detector, enabling highly accurate Tx power measurements.

The fully integrated phase-locked loops (PLLs) provide low power fractional N frequency synthesis for all receive and transmit channels. Channel isolation, demanded by FDD systems, is integrated into the design. All voltage controlled oscillators (VCOs) and loop filter components are integrated.

The core of the AD9363 can be powered directly from a 1.3 V regulator. The IC is controlled via a standard 4-wire serial port and four real-time I/O control pins. Comprehensive power-down modes are included to minimize power consumption during normal use. The AD9363 is packaged in a 10 mm × 10 mm, 144-ball chip scale package ball grid array (CSP_BGA).
COMPARABLE PARTS
View a parametric search of comparable parts.

EVALUATION KITS
• AD9361 Wideband Software Defined Radio Board

DOCUMENTATION
Data Sheet
• AD9363: RF Agile Transceiver Data Sheet
Product Highlight
• AD9363 Integrated Programmable RF Transceiver

DESIGN RESOURCES
• AD9363 Material Declaration
• PCN-PDN Information
• Quality And Reliability
• Symbols and Footprints

DISCUSSIONS
View all AD9363 EngineerZone Discussions.

SAMPLE AND BUY
Visit the product page to see pricing options.

TECHNICAL SUPPORT
Submit a technical question or find your regional support number.

DOCUMENT FEEDBACK
Submit feedback for this data sheet.

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# REVISION HISTORY

11/2016—Revision D: Initial Version
## SPECIFICATIONS

Electrical characteristics at VDD_GPO = 3.3 V, VDD_INTERFACE = 1.8 V, and all other VDDx pins (VDDA1P3_TX_LO, VDDA1P3_TX_VCO_LDO, VDDA1P3_RX_LO, VDDA1P3_RX_VCO_LDO, VDDA1P3_RX_RF, VDDA1P3_RX_TX, VDDA1P3_TX_LO_BUFFER, VDDA1P3_TX_SYNTH, VDDA1P3_RX_SYNTH, VDDD1P3_DIG, and VDDA1P3_BB) = 1.3 V, T_a = 25°C, unless otherwise noted.

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### TRANSMITTERS, GENERAL

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### TRANSMITTERS, 3.5 GHz

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^1 When referencing a single function of a multifunction pin in the parameters, only the portion of the pin name that is relevant to the specification is listed. For full pin names of multifunction pins, refer to the Pin Configuration and Function Descriptions section.
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<td>t&lt;sub&gt;CP&lt;/sub&gt;</td>
<td>4.069</td>
<td>245.76 MHz</td>
<td></td>
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<tr>
<td>DATA_CLK_x and FB_CLK_x Pulse Width</td>
<td>t&lt;sub&gt;TX&lt;/sub&gt;</td>
<td>1</td>
<td></td>
<td>ns</td>
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<tr>
<td>Setup to FB_CLK_x</td>
<td>t&lt;sub&gt;Y&lt;/sub&gt;</td>
<td>0</td>
<td></td>
<td>ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hold to FB_CLK_x</td>
<td>t&lt;sub&gt;DURX&lt;/sub&gt;</td>
<td>0</td>
<td></td>
<td>1.5 ns</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DATA_CLK_x to Data Bus Output Delay</td>
<td>t&lt;sub&gt;DURDV&lt;/sub&gt;</td>
<td>0</td>
<td></td>
<td>1.0 ns</td>
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<tr>
<td>Pulse Width</td>
<td>t&lt;sub&gt;ENPW&lt;/sub&gt;</td>
<td>t&lt;sub&gt;CP&lt;/sub&gt;</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>ENABLE</td>
<td>t&lt;sub&gt;TXNRXPW&lt;/sub&gt;</td>
<td>t&lt;sub&gt;CP&lt;/sub&gt;</td>
<td></td>
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<td></td>
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<tr>
<td>TXNRX Setup to ENABLE</td>
<td>t&lt;sub&gt;TXNRXSU&lt;/sub&gt;</td>
<td>0</td>
<td></td>
<td>ns</td>
<td></td>
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</tr>
<tr>
<td>Bus Turnaround Time</td>
<td>t&lt;sub&gt;RPRE&lt;/sub&gt;</td>
<td>2 × t&lt;sub&gt;CP&lt;/sub&gt;</td>
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<td></td>
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<tr>
<td>Before Rx</td>
<td>t&lt;sub&gt;RST&lt;/sub&gt;</td>
<td>2 × t&lt;sub&gt;CP&lt;/sub&gt;</td>
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<tr>
<td>After Rx</td>
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<td>2 × t&lt;sub&gt;CP&lt;/sub&gt;</td>
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<td>Capacitive Load</td>
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<td>3</td>
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<td>pF</td>
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<tr>
<td>Capacitive Input</td>
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<td>3</td>
<td></td>
<td></td>
<td>pF</td>
<td></td>
</tr>
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**SUPPLY CHARACTERISTICS**

| 1.3 V Main Supply | 1.267 | 1.3 | 1.33 | V |
| VDD_INTERFACE Supply | CMOS | 1.2 | 2.5 | V |
| VDD INTERFACE Supply | LVDS | 1.8 | 2.5 | V |
| VDD_GPO Supply | 1.3 | 3.3 | 3.465 | V |

| Current Consumption | VDDx, Sleep Mode | 180 | µA | Sum of all input currents |
| VDD_GPO | 50 | µA | No load |

1 When referencing a single function of a multifunction pin in the parameters, only the portion of the pin name that is relevant to the specification is listed. For full pin names of multifunction pins, refer to the Pin Configuration and Function Descriptions section.
## CURRENT CONSUMPTION—VDD_INTERFACE

Table 3. VDD_INTERFACE = 1.2 V

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
<th>Unit</th>
<th>Test Conditions/Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLEEP MODE</td>
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<td>µA</td>
<td>Power applied, device disabled</td>
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<td>LTE10</td>
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<tr>
<td>Single Port</td>
<td>2.9</td>
<td></td>
<td></td>
<td>mA</td>
<td>30.72 MHz data clock, CMOS</td>
</tr>
<tr>
<td>Dual Port</td>
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<td></td>
<td></td>
<td>mA</td>
<td>15.36 MHz data clock, CMOS</td>
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<tr>
<td>LTE20</td>
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<td></td>
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<td>5.2</td>
<td></td>
<td></td>
<td>mA</td>
<td>30.72 MHz data clock, CMOS</td>
</tr>
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</table>

TWO Rx CHANNELS, TWO Tx CHANNELS, DDR

<p>| LTE3 |     |     |     |      |                          |
| Single Port | 1.3 |     |     | mA   | 7.68 MHz data clock, CMOS |
| LTE10 |     |     |     |      |                          |
| Single Port | 4.6 |     |     | mA   | 61.44 MHz data clock, CMOS |
| Dual Port | 5.0 |     |     | mA   | 30.72 MHz data clock, CMOS |
| LTE20 |     |     |     |      |                          |
| Single Port | 8.2 |     |     | mA   | 61.44 MHz data clock, CMOS |
| GSM |     |     |     |      |                          |
| Dual Port | 0.2 |     |     | mA   | 1.08 MHz data clock, CMOS |
| WiMAX 8.75 MHz |     |     |     |      |                          |
| Dual Port | 3.3 |     |     | mA   | 20 MHz data clock, CMOS |
| WiMAX 10 MHz |     |     |     |      |                          |
| Single Port | 0.5 |     |     | mA   | 22.4 MHz data clock, CMOS |
| TDD Tx | 3.6 |     |     | mA   | 22.4 MHz data clock, CMOS |
| FDD | 3.8 |     |     | mA   | 44.8 MHz data clock, CMOS |
| WiMAX 20 MHz |     |     |     |      |                          |
| Dual Port | 6.7 |     |     | mA   | 44.8 MHz data clock, CMOS |</p>
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Min</th>
<th>Typ</th>
<th>Max</th>
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<tr>
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<td></td>
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</tr>
<tr>
<td>Single Port</td>
<td>4.5</td>
<td>mA</td>
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<td></td>
<td>30.72 MHz data clock, CMOS</td>
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<tr>
<td>Dual Port</td>
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<td>mA</td>
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<td></td>
<td>15.36 MHz data clock, CMOS</td>
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<tr>
<td>Dual Port</td>
<td>8.0</td>
<td>mA</td>
<td></td>
<td></td>
<td>30.72 MHz data clock, CMOS</td>
</tr>
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<td>TWO Rx CHANNELS, TWO Tx CHANNELS, DDR</td>
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<td>mA</td>
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<tr>
<td>Single Port</td>
<td>8.0</td>
<td>mA</td>
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<td>61.44 MHz data clock, CMOS</td>
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<tr>
<td>Dual Port</td>
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<td>mA</td>
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<td></td>
<td>30.72 MHz data clock, CMOS</td>
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<td>mA</td>
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<td>Dual Port</td>
<td>0.3</td>
<td>mA</td>
<td></td>
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<td>1.08 MHz data clock, CMOS</td>
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<td>WiMAX 8.75 MHz</td>
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<td>Dual Port</td>
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<td>mA</td>
<td></td>
<td></td>
<td>20 MHz data clock, CMOS</td>
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<tr>
<td>WiMAX 10 MHz</td>
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<td>Single Port</td>
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<tr>
<td>TDD Rx</td>
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<td>mA</td>
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<td>22.4 MHz data clock, CMOS</td>
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<td>TDD Tx</td>
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<td>mA</td>
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<td>44.8 MHz data clock, CMOS</td>
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<tr>
<td>WiMAX 20 MHz</td>
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<td>mA</td>
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Table 5. VDD_INTERFACE = 2.5 V

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<th>Max</th>
<th>Unit</th>
<th>Test Conditions/Comments</th>
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<td>LTE1</td>
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<td>mA</td>
<td></td>
<td>30.72 MHz data clock, CMOS</td>
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<td>LTE20</td>
<td>Dual Port</td>
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<td>mA</td>
<td></td>
<td>15.36 MHz data clock, CMOS</td>
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<td>LTE20</td>
<td>Dual Port</td>
<td>11.5</td>
<td>mA</td>
<td></td>
<td>30.72 MHz data clock, CMOS</td>
</tr>
<tr>
<td>TWO Rx CHANNELS, TWO Tx CHANNELS, DDR</td>
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<td>LTE3</td>
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<td>mA</td>
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<td>LTE10</td>
<td>Single Port</td>
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<td>mA</td>
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<td>LTE20</td>
<td>Dual Port</td>
<td>10.0</td>
<td>mA</td>
<td></td>
<td>30.72 MHz data clock, CMOS</td>
</tr>
<tr>
<td>GSM</td>
<td>Dual Port</td>
<td>0.5</td>
<td>mA</td>
<td></td>
<td>1.08 MHz data clock, CMOS</td>
</tr>
<tr>
<td>WiMAX 8.75 MHz</td>
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<td>7.3</td>
<td>mA</td>
<td></td>
<td>20 MHz data clock, CMOS</td>
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<td>WiMAX 10 MHz</td>
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<td>mA</td>
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<td>8.0</td>
<td>mA</td>
<td></td>
<td>22.4 MHz data clock, CMOS</td>
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<td>FDD</td>
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<td>mA</td>
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<td>FDD</td>
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<td>mA</td>
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### CURRENT CONSUMPTION—VDDx (COMBINATION OF ALL 1.3 V SUPPLIES)

Table 6. TDD Mode, 800 MHz

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<th>Typ</th>
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<th>Unit</th>
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<td></td>
<td>mA</td>
<td>Continuous Rx</td>
</tr>
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<td>10 MHz BW</td>
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<td></td>
<td></td>
<td>mA</td>
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</tr>
<tr>
<td>20 MHz BW</td>
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<td>mA</td>
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<td><strong>TWO Rx CHANNELS</strong></td>
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<td>5 MHz BW</td>
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<td>mA</td>
<td>Continuous Rx</td>
</tr>
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<td>10 MHz BW</td>
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<td>mA</td>
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<td>20 MHz BW</td>
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<td>mA</td>
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Table 7. TDD Mode, 2.4 GHz

<table>
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<th>Max</th>
<th>Unit</th>
<th>Test Conditions/Comments</th>
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Table 8. FDD Mode, 800 MHz

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<th>Unit</th>
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Table 9. FDD Mode, 2.4 GHz

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<th>Unit</th>
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<tr>
<td>20 MHz BW</td>
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<td></td>
<td></td>
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<td>TWO Rx CHANNELS, TWO Tx CHANNELS, 2.4 GHz</td>
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<tr>
<td>5 MHz BW</td>
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<td>10 MHz BW</td>
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<td></td>
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<td></td>
</tr>
<tr>
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<td>mA</td>
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**ABSOLUTE MAXIMUM RATINGS**

Table 10.

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<th>Parameter</th>
<th>Rating</th>
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<tr>
<td>VDDx to VSSx</td>
<td>−0.3 V to +1.4 V</td>
</tr>
<tr>
<td>VDD_INTERFACE to VSSx</td>
<td>−0.3 V to +3.0 V</td>
</tr>
<tr>
<td>VDD_GPO to VSSx</td>
<td>−0.3 V to +3.9 V</td>
</tr>
<tr>
<td>Logic Inputs and Outputs to VSSx</td>
<td>−0.3 V to VDD_INTERFACE + 0.3 V</td>
</tr>
<tr>
<td>Input Current to Any Pin Except Supplies</td>
<td>±10 mA</td>
</tr>
<tr>
<td>RF Inputs (Peak Power)</td>
<td>2.5 dBm</td>
</tr>
<tr>
<td>Tx Monitor Input Power (Peak Power)</td>
<td>9 dBm</td>
</tr>
<tr>
<td>Package Power Dissipation</td>
<td>(T_{JMAX} − T_A)/θ_{JA}</td>
</tr>
<tr>
<td>Maximum Junction Temperature (T_{JMAX})</td>
<td>110°C</td>
</tr>
<tr>
<td>Temperature Range</td>
<td>Operating: −40°C to +85°C</td>
</tr>
<tr>
<td></td>
<td>Storage: −65°C to +150°C</td>
</tr>
<tr>
<td></td>
<td>Reflow: 260°C</td>
</tr>
</tbody>
</table>

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.

**REFLOW PROFILE**

The AD9363 reflow profile is in accordance with the JEDEC JESD20 criteria for Pb-free devices. The maximum reflow temperature is 260°C.

**THERMAL RESISTANCE**

Thermal performance is directly linked to printed circuit board (PCB) design and operating environment. Careful attention to PCB thermal design is required.

θ_{JA} is the natural convection junction to ambient thermal resistance measured in a one cubic foot sealed enclosure.

θ_{JC} is the junction to case thermal resistance.

Table 11. Thermal Resistance

<table>
<thead>
<tr>
<th>Package Type</th>
<th>Airflow Velocity (m/sec)</th>
<th>θ_{JA}</th>
<th>θ_{JC}</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC-144-71</td>
<td>0</td>
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<td>9.6</td>
<td>°C/W</td>
</tr>
<tr>
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<td>1.0</td>
<td>29.6</td>
<td>N/A4</td>
<td>°C/W</td>
</tr>
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<td>2.5</td>
<td>27.8</td>
<td>N/A4</td>
<td>°C/W</td>
</tr>
</tbody>
</table>

1 Per JEDEC JESD51-7, plus JEDEC JESD51-5 2S2P test board.
2 Per JEDEC JESD51-2 (still air) or JEDEC JESD51-6 (moving air).
3 Per MIL-STD-883, Method 1012.1.
4 N/A means not applicable.

**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.
Table 12. Pin Function Descriptions

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Type</th>
<th>Mnemonic</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1, A2</td>
<td>I</td>
<td>RX2A_N, RX2A_P</td>
<td>Receive Channel 2 Differential A Inputs. Alternatively, each pin can be used as a single-ended input. Unused pins must be tied to ground.</td>
</tr>
<tr>
<td>A3, M3, M11</td>
<td>NC</td>
<td>DNC</td>
<td>Do Not Connect. Do not connect to these pins.</td>
</tr>
<tr>
<td>A4, A6, A12, B1, B2, B12, C2, C7 to C12, F3, G1, H2, H3, H5, H6, J2, K2, L2, L3, L7 to L12, M4, M6</td>
<td>GND</td>
<td>VSSA</td>
<td>Analog Ground. Tie these pins directly to the VSSD digital ground on the PCB (one ground plane).</td>
</tr>
<tr>
<td>A5</td>
<td>I</td>
<td>TX_MON2</td>
<td>Transmit Channel 2 Power Monitor Input. If this pin is unused, tie it to ground.</td>
</tr>
<tr>
<td>A7, A8</td>
<td>O</td>
<td>TX2A_N, TX2A_P</td>
<td>Transmit Channel 2 Differential A Outputs. Unused pins must be tied to 1.3 V.</td>
</tr>
<tr>
<td>A9, A10</td>
<td>O</td>
<td>TX2B_N, TX2B_P</td>
<td>Transmit Channel 2 Differential B Outputs. Unused pins must be tied to 1.3 V.</td>
</tr>
<tr>
<td>A11</td>
<td>P</td>
<td>VDDA1P1_TX_VCO</td>
<td>Transmit VCO Supply Input. Connect to B11.</td>
</tr>
<tr>
<td>B3</td>
<td>O</td>
<td>AUXDAC1</td>
<td>Auxiliary DAC 1 Output. If using the auxiliary DAC, connect a 0.1 µF capacitor from this pin to ground.</td>
</tr>
<tr>
<td>B4 to B7</td>
<td>O</td>
<td>GPO_3 to GPO_0</td>
<td>3.3 V Capable General-Purpose Outputs.</td>
</tr>
<tr>
<td>B8</td>
<td>I</td>
<td>VDD_GPO</td>
<td>2.5 V to 3.3 V Supply for the AUXDAC and General-Purpose Output Pins. If the VDD_GPO supply is not used, this supply must be set to 1.3 V.</td>
</tr>
<tr>
<td>B9</td>
<td>I</td>
<td>VDDA1P3_TX_LO</td>
<td>Transmit Local Oscillator (LO) 1.3 V Supply Input.</td>
</tr>
<tr>
<td>B10</td>
<td>I</td>
<td>VDDA1P3_TX_VCO_LDO</td>
<td>Transmit VCO LDO 1.3 V Supply Input. Connect to B9.</td>
</tr>
<tr>
<td>B11</td>
<td>O</td>
<td>TX_VCO_LDO_OUT</td>
<td>Transmit VCO LDO Output. Connect to A11 and to a 1 µF bypass capacitor in series with a 1 Ω resistor to ground.</td>
</tr>
<tr>
<td>C1, D1</td>
<td>I</td>
<td>RX2C_P, RX2C_N</td>
<td>Receive Channel 2 Differential C Inputs. Alternatively, each pin as a single-ended input. Unused pins must be tied to ground.</td>
</tr>
<tr>
<td>C3</td>
<td>O</td>
<td>AUXDAC2</td>
<td>Auxiliary DAC 2 Output. If using the auxiliary DAC, connect a 0.1 µF capacitor from this pin to ground.</td>
</tr>
<tr>
<td>C4</td>
<td>I</td>
<td>TEST/ENABLE</td>
<td>Test Input. Ground this pin for normal operation.</td>
</tr>
<tr>
<td>C5, C6, D5, D6</td>
<td>I</td>
<td>CTRL_IN0 to CTRL_IN3</td>
<td>Control Inputs. Use these pins for manual Rx gain and Tx attenuation control.</td>
</tr>
<tr>
<td>Pin No.</td>
<td>Type</td>
<td>Mnemonic</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
<td>------</td>
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<td>-------------</td>
</tr>
<tr>
<td>D2</td>
<td>I</td>
<td>VDDA1P3_RX_RF</td>
<td>Receiver 1.3 V Supply Input. Connect to D3.</td>
</tr>
<tr>
<td>D3</td>
<td>I</td>
<td>VDDA1P3_RX_TX</td>
<td>Receiver and Transmitter 1.3 V Supply Input.</td>
</tr>
<tr>
<td>D4, E4 to E6, F4 to F6, G4</td>
<td>O</td>
<td>CTRL_OUT0, CTRL_OUT1 to CTRL_OUT3, CTRL_OUT6 to CTRL_OUT4, CTRL_OUT7</td>
<td>Control Outputs. These pins are multipurpose outputs that have programmable functionality.</td>
</tr>
<tr>
<td>D7</td>
<td>I/O</td>
<td>P0_D9/TX_D4_P</td>
<td>Digital Data Port 0, Data Bit 9/Transmit Differential Input Bus, Data Bit 4. This is a dual function pin. As P0_D9, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D4_P, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>D8</td>
<td>I/O</td>
<td>P0_D7/TX_D3_P</td>
<td>Digital Data Port 0, Data Bit 7/Transmit Differential Input Bus, Data Bit 3. This is a dual function pin. As P0_D7, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D3_P, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>D9</td>
<td>I/O</td>
<td>P0_D5/TX_D2_P</td>
<td>Digital Data Port 0, Data Bit 5/Transmit Differential Input Bus, Data Bit 2. This is a dual function pin. As P0_D5, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D2_P, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>D10</td>
<td>I/O</td>
<td>P0_D3/TX_D1_P</td>
<td>Digital Data Port 0, Data Bit 3/Transmit Differential Input Bus, Data Bit 1. This is a dual function pin. As P0_D3, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D1_P, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>D11</td>
<td>I/O</td>
<td>P0_D1/TX_D0_P</td>
<td>Digital Data Port 0, Data Bit 1/Transmit Differential Input Bus, Data Bit 0. This is a dual function pin. As P0_D1, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D0_P, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>D12, F7, F9, F11, G12, H7, H10, K12</td>
<td>GND</td>
<td>VSSD</td>
<td>Digital Ground. Tie these pins directly to the VSSA analog ground on the PCB (one ground plane).</td>
</tr>
<tr>
<td>E1, F1</td>
<td>I</td>
<td>RX2B_P, RX2B_N</td>
<td>Receive Channel 2 Differential B Inputs. Alternatively, each pin can be used as a single-ended input. Unused pins must be tied to ground.</td>
</tr>
<tr>
<td>E2</td>
<td>I</td>
<td>VDDA1P3_RX_LO</td>
<td>Receive LO 1.3 V Supply Input.</td>
</tr>
<tr>
<td>E3</td>
<td>I</td>
<td>VDDA1P3_TX_LO_BUFFER</td>
<td>Transmitter LO Buffer 1.3 V Supply Input.</td>
</tr>
<tr>
<td>E7</td>
<td>I/O</td>
<td>P0_D11/TX_D5_P</td>
<td>Digital Data Port 0, Data Bit 11/Transmit Differential Input Bus, Data Bit 5. This is a dual function pin. As P0_D11, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D5_P, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>E8</td>
<td>I/O</td>
<td>P0_D8/TX_D4_N</td>
<td>Digital Data Port 0, Data Bit 8/Transmit Differential Input Bus, Data Bit 4. This is a dual function pin. As P0_D8, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D4_N, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>E9</td>
<td>I/O</td>
<td>P0_D6/TX_D3_N</td>
<td>Digital Data Port 0, Data Bit 6/Transmit Differential Input Bus, Data Bit 3. This is a dual function pin. As P0_D6, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D3_N, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>E10</td>
<td>I/O</td>
<td>P0_D4/TX_D2_N</td>
<td>Digital Data Port 0, Data Bit 4/Transmit Differential Input Bus, Data Bit 2. This is a dual function pin. As P0_D4, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D2_N, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>E11</td>
<td>I/O</td>
<td>P0_D2/TX_D1_N</td>
<td>Digital Data Port 0, Data Bit 2/Transmit Differential Input Bus, Data Bit 1. This is a dual function pin. As P0_D2, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D1_N, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>E12</td>
<td>I/O</td>
<td>P0_D0/TX_D0_N</td>
<td>Digital Data Port 0, Data Bit 0/Transmit Differential Input Bus, Data Bit 0. This is a dual function pin. As P0_D0, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D0_N, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>F2</td>
<td>I</td>
<td>VDDA1P3_RX_VCO_LDO</td>
<td>Receive VCO LDO 1.3 V Supply Input. Connect to E2.</td>
</tr>
<tr>
<td>Pin No.</td>
<td>Type</td>
<td>Mnemonic</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
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</tr>
<tr>
<td>F8</td>
<td>I/O</td>
<td>P0_D10/TX_D5_N</td>
<td>Digital Data Port 0, Data Bit 10/Transmit Differential Input Bus, Data Bit 5. This is a dual function pin. As P0_D10, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 0. Alternatively, as TX_D5_N, it functions as part of the LVDS 6-bit Tx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>F10, G10</td>
<td>I</td>
<td>FB_CLK_P, FB_CLK_N</td>
<td>Feedback Clock Inputs. These pins receive the FB_CLK signal that clocks in Tx data. In CMOS mode, use FB_CLK_P as the input and tie FB_CLK_N to ground.</td>
</tr>
<tr>
<td>F12</td>
<td>I</td>
<td>VDD1P3_DIG</td>
<td>1.3 V Digital Supply Input.</td>
</tr>
<tr>
<td>G2</td>
<td>O</td>
<td>RX_VCO_LDO_OUT</td>
<td>Receive VCO LDO Output. Connect to G3 and to a 1 μF bypass capacitor in series with a 1 Ω resistor to ground.</td>
</tr>
<tr>
<td>G3</td>
<td>I</td>
<td>VDDA1P1_RX_VCO</td>
<td>Receive VCO Supply Input. Connect to G2.</td>
</tr>
<tr>
<td>G5</td>
<td>I</td>
<td>EN_AGC</td>
<td>Manual Control Input for Automatic Gain Control (AGC).</td>
</tr>
<tr>
<td>G6</td>
<td>I</td>
<td>ENABLE</td>
<td>Control Input. This pin moves the device through various operational states.</td>
</tr>
<tr>
<td>G7, G8</td>
<td>O</td>
<td>RX_FRAME_N, RX_FRAME_P</td>
<td>Receive Digital Data Framing Outputs. These pins transmit the RX_FRAME signal that indicates whether the Rx output data is valid. In CMOS mode, use RX_FRAME_P as the output and leave RX_FRAME_N unconnected.</td>
</tr>
<tr>
<td>G9, H9</td>
<td>I</td>
<td>TX_FRAME_P, TX_FRAME_N</td>
<td>Transmit Digital Data Framing Inputs. These pins receive the TX_FRAME signal that indicates when Tx data is valid. In CMOS mode, use TX_FRAME_P as the input and tie TX_FRAME_N to ground.</td>
</tr>
<tr>
<td>G11, H11</td>
<td>O</td>
<td>DATA_CLK_P, DATA_CLK_N</td>
<td>Receive Data Clock Outputs. These pins transmit the DATA_CLK signal that the BBP uses to clock the Rx data. In CMOS mode, use DATA_CLK_P as the output and leave DATA_CLK_N unconnected.</td>
</tr>
<tr>
<td>H1, J1</td>
<td>I</td>
<td>RX1B_P, RX1B_N</td>
<td>Receive Channel 1 Differential B Inputs. Alternatively, use each pin as a single-ended input. Unused pins must be tied to ground.</td>
</tr>
<tr>
<td>H4</td>
<td>I</td>
<td>TXNRX</td>
<td>Enable State Machine Control Signal. This pin controls the data port bus direction. A logic low selects the Rx direction; a logic high selects the Tx direction.</td>
</tr>
<tr>
<td>H8</td>
<td>I/O</td>
<td>P1_D11/RX_D5_P</td>
<td>Digital Data Port P1, Data Bit 11/Receive Differential Output Bus, Data Bit 5. This is a dual function pin. As P1_D11, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D5_P, it functions as part of the LVDS 6-bit Rx differential output bus with internal LVDS termination.</td>
</tr>
<tr>
<td>H12</td>
<td>I</td>
<td>VDD_INTERFACE</td>
<td>1.2 V to 2.5 V Supply for Digital I/O Pins (1.8 V to 2.5 V in LVDS Mode).</td>
</tr>
<tr>
<td>J3</td>
<td>I</td>
<td>VDDA1P3_RX_SYNTH</td>
<td>Receiver Synthesizer 1.3 V Supply Input.</td>
</tr>
<tr>
<td>J4</td>
<td>I</td>
<td>SPI_DI</td>
<td>SPI Serial Data Input.</td>
</tr>
<tr>
<td>J5</td>
<td>I</td>
<td>SPI_CLK</td>
<td>SPI Clock Input.</td>
</tr>
<tr>
<td>J6</td>
<td>O</td>
<td>CLK_OUT</td>
<td>Output Clock. This pin can be configured to output either a buffered version of the external input clock (the digital controlled crystal oscillator (DCXO)) or a divided-down version of the internal ADC sample clock (ADC_CLK).</td>
</tr>
<tr>
<td>J7</td>
<td>I/O</td>
<td>P1_D10/RX_D5_N</td>
<td>Digital Data Port 1, Data Bit 10/Receive Differential Output Bus, Data Bit 5. This is a dual function pin. As P1_D10, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D5_N, it functions as part of the LVDS 6-bit Rx differential input bus with internal LVDS termination.</td>
</tr>
<tr>
<td>J8</td>
<td>I/O</td>
<td>P1_D9/RX_D4_P</td>
<td>Digital Data Port 1, Data Bit 9/Receive Differential Output Bus, Data Bit 4. This is a dual function pin. As P1_D9, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D4_P, it functions as part of the LVDS 6-bit Rx differential output bus with internal LVDS termination.</td>
</tr>
<tr>
<td>J9</td>
<td>I/O</td>
<td>P1_D7/RX_D3_P</td>
<td>Digital Data Port 1, Data Bit 7/Receive Differential Output Bus, Data Bit 3. This is a dual function pin. As P1_D7, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D3_P, it functions as part of the LVDS 6-bit Rx differential output bus with internal LVDS termination.</td>
</tr>
<tr>
<td>J10</td>
<td>I/O</td>
<td>P1_D5/RX_D2_P</td>
<td>Digital Data Port 1, Data Bit 5/Receive Differential Output Bus, Data Bit 2. This is a dual function pin. As P1_D5, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D2_P, it functions as part of the LVDS 6-bit Rx differential output bus with internal LVDS termination.</td>
</tr>
<tr>
<td>J11</td>
<td>I/O</td>
<td>P1_D3/RX_D1_P</td>
<td>Digital Data Port 1, Data Bit 3/Receive Differential Output Bus, Data Bit 1. This is a dual function pin. As P1_D3, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D1_P, it functions as part of the LVDS 6-bit Rx differential output bus with internal LVDS termination.</td>
</tr>
<tr>
<td>Pin No.</td>
<td>Type</td>
<td>Mnemonic</td>
<td>Description</td>
</tr>
<tr>
<td>---------</td>
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</tr>
<tr>
<td>J12</td>
<td>I/O</td>
<td>P1_D1/RX_D0_P</td>
<td>Digital Data Port 1, Data Bit 1/Receive Differential Output Bus, Data Bit 0. This is a dual function pin. As P1_D1, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D0_P, it functions as part of the LVDS 6-bit Rx differential output bus with internal LVDS termination.</td>
</tr>
<tr>
<td>K1, L1</td>
<td>I</td>
<td>RX1C_P, RX1C_N</td>
<td>Receive Channel 1 Differential C Inputs. Alternatively, use each pin as a single-ended input. Tie unused pins to ground.</td>
</tr>
<tr>
<td>K3</td>
<td>I</td>
<td>VDDA1P3_TX_SYNTH</td>
<td>Transmitter Synthesizer 1.3 V Supply Input. Connect this pin to a 1.3 V regulator through a separate trace to a common supply point.</td>
</tr>
<tr>
<td>K4</td>
<td>I</td>
<td>VDDA1P3_BB</td>
<td>Baseband 1.3 V Supply Input. Connect this pin to a 1.3 V regulator through a separate trace to a common supply point.</td>
</tr>
<tr>
<td>K5</td>
<td>I</td>
<td>RESET</td>
<td>Asynchronous Reset Input. A logic low resets the device.</td>
</tr>
<tr>
<td>K6</td>
<td>I</td>
<td>SPI_EN</td>
<td>SPI Enable. Set this pin to logic low to enable the SPI bus.</td>
</tr>
<tr>
<td>K7</td>
<td>I/O</td>
<td>P1_D8/RX_D4_N</td>
<td>Digital Data Port 1, Data Bit 8/Receive Differential Output Bus, Data Bit 4. This is a dual function pin. As P1_D8, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D4_N, it functions as part of the LVDS 6-bit Rx differential output bus with internal LVDS termination.</td>
</tr>
<tr>
<td>K8</td>
<td>I/O</td>
<td>P1_D6/RX_D3_N</td>
<td>Digital Data Port 1, Data Bit 6/Receive Differential Output Bus, Data Bit 3. This is a dual function pin. As P1_D6, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D3_N, it functions as part of the LVDS 6-bit Rx differential output bus with internal LVDS termination.</td>
</tr>
<tr>
<td>K9</td>
<td>I/O</td>
<td>P1_D4/RX_D2_N</td>
<td>Digital Data Port 1, Data Bit 4/Receive Differential Output Bus, Data Bit 2. This is a dual function pin. As P1_D4, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D2_N, it functions as part of the LVDS 6-bit Rx differential output bus with internal LVDS termination.</td>
</tr>
<tr>
<td>K10</td>
<td>I/O</td>
<td>P1_D2/RX_D1_N</td>
<td>Digital Data Port 1, Data Bit 2/Receive Differential Output Bus, Data Bit 1. This is a dual function pin. As P1_D2, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D1_N, it functions as part of the LVDS 6-bit Rx differential output bus with internal LVDS termination.</td>
</tr>
<tr>
<td>K11</td>
<td>I/O</td>
<td>P1_D0/RX_D0_N</td>
<td>Digital Data Port 1, Data Bit 0/Receive Differential Output Bus, Data Bit 0. This is a dual function pin. As P1_D0, it functions as part of the 12-bit bidirectional parallel CMOS level Data Port 1. Alternatively, as RX_D0_N, it functions as part of the LVDS 6-bit Rx differential output bus with internal LVDS termination.</td>
</tr>
<tr>
<td>L4</td>
<td>I</td>
<td>RBIAS</td>
<td>Bias Input Reference. Connect this pin through a 14.3 kΩ (1% tolerance) resistor to ground.</td>
</tr>
<tr>
<td>L5</td>
<td>I</td>
<td>AUXADC</td>
<td>Auxiliary ADC Input. If this pin is unused, tie it to ground.</td>
</tr>
<tr>
<td>L6</td>
<td>O</td>
<td>SPI_DO</td>
<td>SPI Serial Data Output in 4-Wire Mode, High-Z in 3-Wire Mode.</td>
</tr>
<tr>
<td>M1, M2</td>
<td>I</td>
<td>RX1A_P, RX1A_N</td>
<td>Receive Channel 1 Differential A Inputs. Alternatively, use each pin as a single-ended input. Tie unused pins to ground.</td>
</tr>
<tr>
<td>M5</td>
<td>I</td>
<td>TX_MON1</td>
<td>Transmit Channel 1 Power Monitor Input. If this pin is unused, tie it to ground.</td>
</tr>
<tr>
<td>M7, M8</td>
<td>O</td>
<td>TX1A_P, TX1A_N</td>
<td>Transmit Channel 1 Differential A Outputs. Tie unused pins to 1.3 V.</td>
</tr>
<tr>
<td>M9, M10</td>
<td>O</td>
<td>TX1B_P, TX1B_N</td>
<td>Transmit Channel 1 Differential B Outputs. Tie unused pins to 1.3 V.</td>
</tr>
<tr>
<td>M12</td>
<td>I</td>
<td>XTALN</td>
<td>Reference Frequency Connection. Connect the external clock source to XTALN.</td>
</tr>
</tbody>
</table>

1 I is input, NC is not connected, GND is ground, O is output, P is power, and I/O is input/output.
TYPICAL PERFORMANCE CHARACTERISTICS

ATTEN is the attenuation setting. \( f_{\text{LO,rx}} \) and \( f_{\text{LO,tx}} \) are the receive and transmit local oscillator frequencies, respectively.

800 MHZ FREQUENCY BAND

Figure 3. Rx Noise Figure vs. RF Frequency

Figure 4. RSSI Error vs. Rx Input Power, LTE 10 MHz Modulation (Referenced to −50 dBm Input Power at 800 MHz)

Figure 5. Rx EVM vs. Interferer Power Level, LTE 10 MHz Signal of Interest with \( P_{\text{IN}} = −90 \) dBm, 5 MHz OFDM Blocker at 17.5 MHz Offset

Figure 6. Rx EVM vs. Interferer Power Level, LTE 10 MHz Signal of Interest with \( P_{\text{IN}} = −82 \) dBm, 5 MHz Orthogonal Frequency Division Multiplexing (OFDM) Blocker at 7.5 MHz Offset

Figure 7. Rx Noise Figure vs. Interferer Power Level, Enhanced Data Rates for GSM Evolution (EDGE) Signal of Interest with \( P_{\text{IN}} = −90 \) dBm, Continuous Wave (CW) Blocker at 3 MHz Offset, Gain Index = 64

Figure 8. Rx Gain vs. Rx LO Frequency, Gain Index = 76 (Maximum Setting)
Figure 9. Third-Order Input Intercept Point (IIP3) vs. Rx Gain Index, f1 = 1.45 MHz, f2 = 2.89 MHz, GSM Mode

Figure 10. Second-Order Input Intercept Point (IIP2) vs. Rx Gain Index, f1 = 2.00 MHz, f2 = 2.01 MHz, GSM Mode

Figure 11. Rx LO Leakage vs. Rx LO Frequency

Figure 12. Rx Emission at LNA Input vs. Frequency, DC to 12 GHz, fLO_RX = 800 MHz, LTE 10 MHz, fLO_TX = 860 MHz

Figure 13. Tx Output Power vs. Tx LO Frequency, Attenuation Setting = 0 dB, Single-Tone Output

Figure 14. Tx Power Control Step Linearity Error vs. Attenuation Setting
Figure 15. Tx Output Power vs. Frequency Offset from Carrier Frequency, \( f_{LO,Tx} = 800 \text{ MHz} \), LTE 10 MHz Downlink (Digital Attenuation Variations Shown)

Figure 16. Integrated Tx LO Phase Noise vs. Frequency, 19.2 MHz REF_CLK

Figure 17. Tx Carrier Rejection vs. Frequency

Figure 18. Tx Second-Order Harmonic Distortion (HD2) vs. Frequency

Figure 19. Tx Third-Order Harmonic Distortion (HD3) vs. Frequency

Figure 20. Tx Third-Order Output Intercept Point (OIP3) vs. Tx Attenuation Setting
Figure 21. Tx Signal-to-Noise Ratio (SNR) vs. Tx Attenuation Setting, LTE 10 MHz Signal of Interest with Noise Measured at 90 MHz Offset

Figure 22. Tx Single Sideband Rejection vs. Frequency, 1.5375 MHz Offset
2.4 GHZ FREQUENCY BAND

Figure 23. Rx Noise Figure vs. RF Frequency

Figure 24. RSSI Error vs. Input Power (Referenced to −50 dBm at 2.4 GHz)

Figure 25. Rx EVM vs. Interferer Power Level, LTE 20 MHz Signal of Interest with $P_{\text{in}} = −75$ dBm, LTE 20 MHz Blocker at 20 MHz Offset

Figure 26. Rx EVM vs. Interferer Power Level, LTE 20 MHz Signal of Interest with $P_{\text{in}} = −75$ dBm, LTE 20 MHz Blocker at 40 MHz Offset

Figure 27. Rx Gain vs. Rx LO Frequency, Gain Index = 76 (Maximum Setting)

Figure 28. Third-Order Input Intercept Point (IIP3) vs. Rx Gain Index, $f_1 = 30$ MHz, $f_2 = 61$ MHz
Figure 29. Second-Order Input Intercept Point (IIP2) vs. Rx Gain Index, 
f1 = 60 MHz, f2 = 61 MHz

Figure 30. Rx Local Oscillator (LO) Leakage vs. Rx LO Frequency

Figure 31. Rx Emission at LNA Input vs. Frequency, DC to 12 GHz, 
fLO,Rx = 2.4 GHz, LTE 20 MHz, fLO,Tx = 2.46 GHz

Figure 32. Tx Output Power vs. Tx LO Frequency, Attenuation Setting = 0 dB, 
Single-Tone Output

Figure 33. Tx Power Control Step Linearity Error vs. Attenuation Setting

Figure 34. Tx Output Power vs. Frequency Offset from Carrier Frequency, 
fLO,Tx = 2.3 GHz, LTE 20 MHz Downlink (Digital Attenuation Variations Shown)
Figure 35. Integrated Tx LO Phase Noise vs. Frequency, 40 MHz REF_CLK

Figure 36. Tx Carrier Rejection vs. Frequency

Figure 37. Tx Second-Order Harmonic Distortion (HD2) vs. Frequency

Figure 38. Tx Third-Order Harmonic Distortion (HD3) vs. Frequency
Figure 39. Tx Third-Order Output Intercept Point (OIP3) vs. Tx Attenuation Setting

Figure 40. Tx Signal-to-Noise Ratio (SNR) vs. Tx Attenuation Setting, LTE 20 MHz Signal of Interest with Noise Measured at 90 MHz Offset

Figure 41. Tx Single Sideband Rejection vs. Frequency, 3.075 MHz Offset
**THEORY OF OPERATION**

**GENERAL**

The AD9363 is a highly integrated radio frequency (RF) transceiver capable of being configured for a wide range of applications. The device integrates all RF, mixed-signal, and digital blocks necessary to provide all transceiver functions in a single device. Programmability allows this broadband transceiver to be adapted for use with multiple communication standards, including FDD and TDD systems. This programmability also allows the device to interface to various BBPs using a single 12-bit parallel data port, dual 12-bit parallel data ports, or a 12-bit low voltage differential signaling (LVDS) interface.

The AD9363 also provides self calibration and AGC systems to maintain a high performance level under varying temperatures and input signal conditions. In addition, the device includes several test modes that allow system designers to insert test tones and create internal loopback modes to debug their designs during prototyping and optimize their radio configuration for a specific application.

**RECEIVER**

The receiver section contains all blocks necessary to receive RF signals and convert them to digital data that is usable by a BBP. Two independently controlled channels can receive signals from different sources, allowing the device to be used in multiple input, multiple output (MIMO) systems while sharing a common frequency synthesizer.

Each channel has three inputs that can be multiplexed to the signal chain, making the AD9363 suitable for use in diversity systems with multiple antenna inputs. The receiver is a direct conversion system that contains a low noise amplifier (LNA) followed by matched in-phase (I) and quadrature (Q) amplifiers, mixers, and band shaping filters that downconvert received signals to baseband for digitization. External LNAs can also be interfaced to the device, allowing designers the flexibility to customize the receiver front end for their specific application.

Gain control is achieved by following a preprogrammed gain index map that distributes gain among the blocks for optimal performance at each level. This gain control can be achieved by enabling the internal AGC in either fast or slow mode or by using manual gain control, allowing the BBP to make the gain adjustments as needed. Additionally, each channel contains independent RSSI measurement capability, dc offset tracking, and all circuitry necessary for self calibration.

The receivers include 12-bit, sigma-delta (Σ-Δ) ADCs and adjustable sample rates that produce data streams from the received signals. The digitized signals can be conditioned further by a series of decimation filters and a fully programmable 128-tap FIR filter with additional decimation settings. The sample rate of each digital filter block can also be adjusted by changing the decimation factors to produce the desired output data rate.

**TRANSMITTER**

The transmitter section consists of two identical and independently controlled channels that provide all digital processing, mixed-signal, and RF blocks necessary to implement a direct conversion system while sharing a common frequency synthesizer. The digital data received from the BBP passes through a fully programmable 128-tap FIR filter with interpolation options. The FIR output is sent to a series of interpolation filters that provide additional filtering and data rate interpolation prior to reaching the DAC. Each 12-bit DAC has an adjustable sampling rate. Both the I and Q channels are fed to the RF block for upconversion.

After being converted to baseband analog signals, the I and Q signals are filtered to remove sampling artifacts and provide band shaping, and then they are passed to the upconversion mixers. At this point, the I and Q signals are recombined and modulated on the carrier frequency for transmission to the output stage. The output stage provides attenuation control that provides a range of output levels while keeping the output impedance at 50 Ω. A wide range of attenuation adjustment with fine granularity is included to help designers optimize SNR.

Self calibration circuitry is included in the transmit channel to provide internal adjustment capability. The transmitter also provides a Tx monitor block that receives the transmitter output and routes it back through an unused receiver channel to the BBP for signal monitoring. The Tx monitor blocks are available only in TDD mode operation while the receiver is idle.

**CLOCK INPUT OPTIONS**

The AD9363 uses a reference clock provided by an external oscillator or clock distribution device (such as the AD9548) connected to the XTALN pin. The frequency of this reference clock can vary from 10 MHz to 80 MHz. This reference clock supplies the synthesizer blocks that generate all data clocks, sample clocks, and local oscillators inside the device.

**SYNTHESIZERS**

**RF PLLs**

The AD9363 contains two identical synthesizers to generate the required LO signals for the RF signal paths—one for the receiver and one for the transmitter. PLL synthesizers are fractional N designs that incorporate completely integrated VCOs and loop filters. In TDD mode, the synthesizers turn on and off as appropriate for the Rx and Tx frames. In FDD mode, the Tx PLL and the Rx PLL can be activated at the same time. These PLLs require no external components.
**BB PLL**

The AD9363 also contains a baseband PLL (BB PLL) synthesizer that generates all baseband related clock signals. These signals include the ADC and DAC sampling clocks, the DATA_CLK signal (see the Digital Data Interface section), and all data framing signals. The BB PLL is programmed from 700 MHz to 1400 MHz based on the data rate and sample rate requirements of the system.

**DIGITAL DATA INTERFACE**

The AD9363 data interface uses parallel data ports (P0 and P1) to transfer data between the device and the BBP. The data ports can be configured in either single-ended CMOS format or differential LVDS format. Both formats can be configured in multiple arrangements to match system requirements for data ordering and data port connections. These arrangements include single port data bus, dual port data bus, single data rate, double data rate, and various combinations of data ordering to transmit data from different channels across the bus at appropriate times.

Bus transfers are controlled using simple hardware handshake signaling. The two ports can be operated in either bidirectional (TDD) mode or in full duplex (FDD) mode, where half the bits are used for transmitting data and half are used for receiving data. The interface can also be configured to use only one of the data ports for applications that do not require high data rates and require fewer interface pins.

**DATA_CLK Signal**

The AD9363 outputs the DATA_CLK signal that the BBP uses to sample receiver data. The signal is synchronized with the receiver data such that data transitions occur out of phase with DATA_CLK. The DATA_CLK can be set to a rate that provides single data rate (SDR) timing, where data is sampled on each rising clock edge, or it can be set to provide double data rate (DDR) timing, where data is captured on both rising and falling clock edges. SDR or DDR timing applies to operation using either a single port or both ports.

**FB_CLK Signal**

For transmit data, the interface uses the FB_CLK signal as the timing reference. The FB_CLK signal allows source synchronous timing with rising edge capture for burst control signals and either rising edge capture (SDR mode) or both edge capture (DDR mode) for transmit signal bursts. The FB_CLK signal must have the same frequency and duty cycle as DATA_CLK.

**RX_FRAME and TX_FRAME Signals**

The device generates an RX_FRAME output signal whenever the receiver outputs valid data. This signal has two modes: level mode (the RX_FRAME signal stays high as long as the data is valid) and pulse mode (the RX_FRAME signal pulses with a 50% duty cycle). Similarly, the BBP must provide a TX_FRAME signal that indicates the beginning of a valid data transmission with a rising edge. Like the RX_FRAME signal, the TX_FRAME signal stays high throughout the burst or it pulses with a 50% duty cycle.

**ENABLE STATE MACHINE**

The AD9363 transceiver includes an ENSM that allows real-time control over the current state of the device. The device can be placed in several different states during normal operation, including

- Wait—power save, synthesizers disabled
- Sleep—wait with all clocks and the BB PLL disabled
- Tx—Tx signal chain enabled
- Rx—Rx signal chain enabled
- FDD—Tx and Rx signal chains enabled
- Alert—synthesizers enabled

The ENSM has two control modes: SPI control and pin control.

**SPI Control Mode**

In SPI control mode, the ENSM is controlled asynchronously by writing to SPI registers to advance the current state to the next state. SPI control is considered asynchronous to the DATA_CLK signal because the SPI clock can be derived from a different clock reference and can still function properly. The SPI control ENSM mode is recommended when real-time control of the synthesizers is not necessary. SPI control can be used for real-time control as long as the BBP can perform timed SPI writes accurately.

**Pin Control Mode**

In pin control mode, the enable functions of the ENABLE pin and the TXNRX pin allow real-time control of the current state. The ENSM allows TDD or FDD operation, depending on the configuration of the corresponding SPI register. The ENABLE and TXNRX pin control mode is recommended if the BBP has extra control outputs that can be controlled in real time, allowing a simple 2-wire interface to control the state of the device. To advance the current state of the ENSM to the next state, drive the enable function of the ENABLE pin by either a pulse (edge detected internally) or a level.

When a pulse is used, it must have a minimum pulse width of one cycle of the FB_CLK signal. In level mode, the ENABLE and TXNRX pins are also edge detected by the AD9363 and must meet the same minimum pulse width requirement of one cycle of the FB_CLK signal.

In FDD mode, the ENABLE and TXNRX pins can be remapped to serve as real-time Rx and Tx data transfer control signals. In this mode, the ENABLE pin assumes the receive on (RXON) function (controls when the Rx path is enabled and disabled), and the TXNRX pin assumes the transmit on (TXON) function (controls when the Tx path is enabled and disabled). The ENSM must be controlled by SPI writes in this mode while the ENABLE and TXNRX pins control all data flow. For more information about RXON and TXON, see the AD9363 reference manual, available from Integrated Wideband RF Transceiver Design Resources.
SPI INTERFACE
The AD9363 uses a serial peripheral interface (SPI) to communicate with the BBP. The SPI can be configured as a 4-wire interface with dedicated receive and transmit ports, or it can be configured as a 3-wire interface with a bidirectional data communication port. This bus allows the BBP to set all device control parameters using a simple address data serial bus protocol.

Write commands follow a 24-bit format. The first six bits set the bus direction and number of bytes to transfer. The next 10 bits set the address where data is to be written. The final eight bits are the data to be transferred to the specified register address (MSB to LSB). The AD9363 also supports an LSB first format that allows the commands to be written in LSB to MSB format. In this mode, the register addresses are incremented for multibyte writes.

Read commands follow a similar format with the exception that the first 16 bits are transferred on the SPI_DI pin, and the final eight bits are read from the AD9363, either on the SPI_DO pin in 4-wire mode or on the SPI_DI pin in 3-wire mode.

CONTROL PINS
Control Outputs (CTRL_OUT7 to CTRL_OUT0)
The AD9363 provides eight simultaneous real-time output signals for use as interrupts to the BBP. These outputs can be configured to output a number of internal settings and measurements that the BBP uses when monitoring transceiver performance in different situations. The control output pointer register selects the information that is output to these pins, and the control output enable register determines which signals are activated for monitoring by the BBP. Signals used for manual gain mode, calibration flags, state machine states, and the ADC output are among the outputs that can be monitored on these pins.

Control Inputs (CTRL_IN3 to CTRL_IN0)
The AD9363 provides four edge detected control input pins. In manual gain mode, the BBP uses these pins to change the gain table index in real time.

GPO PINS (GPO_3 TO GPO_0)
The AD9363 provides four 3.3 V capable general-purpose logic output pins: GPO_3, GPO_2, GPO_1, and GPO_0. These pins control other peripheral devices such as regulators and switches via the AD9363 SPI bus, or they function as slaves for the internal AD9363 state machine.

AUXILIARY CONVERTERS
AUXADC
The AD9363 contains an auxiliary ADC that monitors system functions such as temperature or power output. The converter is 12 bits wide and has an input range of 0.05 V to VDDA1P3_BB − 0.05 V. When enabled, the ADC is free running. SPI reads provide the last value latched at the ADC output. A multiplexer in front of the ADC allows the user to select between the AUXADC input pin and a built-in temperature sensor.

AUXDAC1 and AUXDAC2
The AD9363 contains two identical auxiliary DACs that can provide power amplifier (PA) bias or other system functionality. The auxiliary DACs are 10 bits wide, have an output voltage range of 0.5 V to VDD_GPO − 0.3 V and a current drive of 10 mA, and can be directly controlled by the internal ENSM.

POWERING THE AD9363
The AD9363 must be powered by the following three supplies: the analog supply (VDDx = 1.3 V), the interface supply (VDD_INTERFACE = 1.8 V), and the GPO supply (VDD_GPO = 3.3 V).

For applications requiring optimal noise performance, split and source the 1.3 V analog supply from low noise, low dropout (LDO) regulators. Figure 42 shows the recommended method.

For applications where board space is at a premium, and optimal noise performance is not an absolute requirement, provide the 1.3 V analog rail directly from a switcher, and adopt a more integrated power management unit (PMU) approach. Figure 43 shows this approach.
For additional information about how to program the AD9363 device, see the AD9363 reference manual, and for additional information about the AD9363 registers, see the AD9363 register map reference manual, both of which are available by registering at the Integrated Wideband RF Transceiver Design Resources web page and clicking Download the AD9363 Design File Package. The register map is provided as a convenient and informational resource about low level operation of the device; however, it is not recommended for creating user software.

Analog Devices, Inc., provides complete drivers for the AD9363 for both bare metal/no operating system (no OS) and Linux operating systems. The AD9361, AD9363, and AD9364 share the same application program interface (API). For the AD9361 drivers, visit the following online locations:

- Linux wiki page
- No OS wiki page

For support for these drivers, visit the following online locations:

- Linux Engineer Zone® page
- No OS Engineer Zone page
PACKAGING AND ORDERING INFORMATION

OUTLINE DIMENSIONS

Figure 44. 144-Ball Chip Scale Package Ball Grid Array [CSP_BGA]
(BC-144-7)
Dimensions shown in millimeters

COMPLIANT TO JEDEC STANDARDS MO-275-EEAB-1.

ORDERING GUIDE

<table>
<thead>
<tr>
<th>Model</th>
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<th>Package Description</th>
<th>Package Option</th>
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<tbody>
<tr>
<td>AD9363ABCZ</td>
<td>−40°C to +85°C</td>
<td>144-Ball Chip Scale Package Ball Grid Array [CSP_BGA]</td>
<td>BC-144-7</td>
</tr>
<tr>
<td>AD9363ABCZ-REEL</td>
<td>−40°C to +85°C</td>
<td>144-Ball Chip Scale Package Ball Grid Array [CSP_BGA]</td>
<td>BC-144-7</td>
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<tr>
<td>ADRV9363-W/PCBZ</td>
<td>−40°C to +85°C</td>
<td>Evaluation Board, 325 MHz to 3800 MHz Matching Circuits</td>
<td>BC-144-7</td>
</tr>
</tbody>
</table>

¹ Z = RoHS Compliant Part.