

# Jitter Cleaner and Clock Generator with 6 Differential or 13 LVCMOS Outputs

## FEATURES

- ▶ Output frequency: <1 MHz to 1 GHz
- ▶ Start-up frequency accuracy: <±100 ppm (determined by VCXO reference accuracy)
- ▶ Zero delay operation
  - ▶ Input-to-output edge timing: <±150 ps
- ▶ 6 outputs: configurable LVPECL, LVDS, HSTL, and LVCMOS
- ▶ 6 dedicated output dividers with jitter-free adjustable delay
- ▶ Adjustable delay: 63 resolution steps of ½ period of VCO output divider
- ▶ Output-to-output skew: <±50 ps
- ▶ Duty-cycle correction for odd divider settings
- ▶ Automatic synchronization of all outputs on power-up
- ▶ Absolute output jitter: <200 fs at 122.88 MHz
  - ▶ Integration range: 12 kHz to 20 MHz
- ▶ Distribution phase noise floor: -160 dBc/Hz
- ▶ Digital lock detect
- ▶ Nonvolatile EEPROM stores configuration settings
- ▶ SPI- and I<sup>2</sup>C-compatible serial control port
- ▶ Dual PLL architecture
  - ▶ PLL1
    - ▶ Low bandwidth for reference input clock cleanup with external VCXO
    - ▶ Phase detector rate up to 130 MHz
    - ▶ Redundant reference inputs
    - ▶ Automatic and manual reference switchover modes
    - ▶ Revertive and nonrevertive switching
    - ▶ Loss of reference detection with holdover mode
    - ▶ Low noise LVCMOS output from VCXO used for RF/IF synthesizers
  - ▶ PLL2
    - ▶ Phase detector rate of up to 259 MHz
    - ▶ Integrated low noise VCO

## APPLICATIONS

- ▶ LTE and multicarrier GSM base stations
- ▶ Wireless and broadband infrastructure
- ▶ Medical instrumentation
- ▶ Clocking high speed ADCs, DACs, DDSs, DDCs, DUCs, MxFEs
- ▶ Low jitter, low phase noise clock distribution
- ▶ Clock generation and translation for SONET, 10Ge, 10G FC, and other 10 Gbps protocols
- ▶ Forward error correction (G.710)
- ▶ High performance wireless transceivers

- ▶ ATE and high performance instrumentation

## FUNCTIONAL BLOCK DIAGRAM

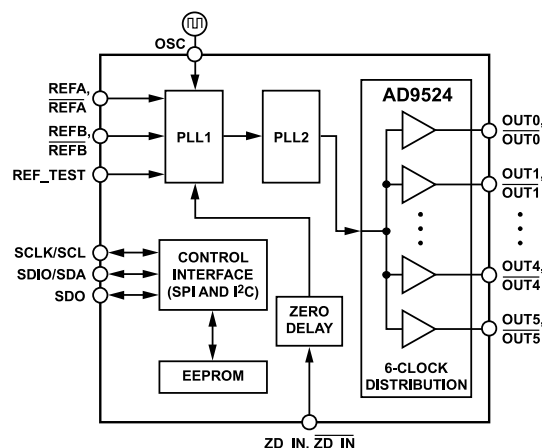


Figure 1.

## GENERAL DESCRIPTION

The AD9524 provides a low power, multi-output, clock distribution function with low jitter performance, along with an on-chip PLL and VCO. The on-chip VCO tunes from 3.6 GHz to 4.0 GHz.

The AD9524 is defined to support the clock requirements for long term evolution (LTE) and multicarrier GSM base station designs. It relies on an external VCXO to provide the reference jitter cleanup to achieve the restrictive low phase noise requirements necessary for acceptable data converter SNR performance.

The input receivers, oscillator, and zero delay receiver provide both single-ended and differential operation. When connected to a recovered system reference clock and a VCXO, the device generates six low noise outputs with a range of 1 MHz to 1 GHz, and one dedicated buffered output from the input PLL (PLL1). The frequency and phase of one clock output relative to another clock output can be varied by means of a divider phase select function that serves as a jitter-free coarse timing adjustment in increments that are equal to one-half the period of the signal coming out of the VCO.

An in-package EEPROM can be programmed through the serial interface to store user defined register settings for power-up and chip reset.

Rev. G

DOCUMENT FEEDBACK

TECHNICAL SUPPORT

Information furnished by Analog Devices is believed to be accurate and reliable "as is". However, no responsibility is assumed by Analog Devices for its use, nor for any infringements of patents or other rights of third parties that may result from its use. Specifications subject to change without notice. No license is granted by implication or otherwise under any patent or patent rights of Analog Devices. Trademarks and registered trademarks are the property of their respective owners.

## TABLE OF CONTENTS

|                                                                                           |    |                                                        |    |
|-------------------------------------------------------------------------------------------|----|--------------------------------------------------------|----|
| Features.....                                                                             | 1  | Theory of Operation.....                               | 18 |
| Applications.....                                                                         | 1  | Detailed Block Diagram.....                            | 18 |
| Functional Block Diagram.....                                                             | 1  | Overview.....                                          | 18 |
| General Description.....                                                                  | 1  | Component Blocks—Input PLL (PLL1).....                 | 18 |
| Specifications.....                                                                       | 3  | Component Blocks—Output PLL (PLL2).....                | 20 |
| Conditions.....                                                                           | 3  | Clock Distribution.....                                | 21 |
| Supply Current.....                                                                       | 3  | Zero Delay Operation.....                              | 23 |
| Power Dissipation.....                                                                    | 4  | Lock Detect.....                                       | 24 |
| REFA, REFA, REFB, REFB, OSC_IN,<br>OSC_IN, and ZD_IN, ZD_IN Input<br>Characteristics..... | 5  | Reset Modes.....                                       | 24 |
| OSC_CTRL Output Characteristics.....                                                      | 5  | Power-Down Mode.....                                   | 25 |
| REF_TEST Input Characteristics.....                                                       | 6  | Serial Control Port.....                               | 26 |
| PLL1 Characteristics.....                                                                 | 6  | SPI/I <sup>2</sup> C Port Selection.....               | 26 |
| PLL1 Output Characteristics.....                                                          | 6  | I <sup>2</sup> C Serial Port Operation.....            | 26 |
| Distribution Output Characteristics (OUT0,<br>OUT0 to OUT5, OUT5).....                    | 6  | SPI Serial Port Operation.....                         | 29 |
| Timing Alignment Characteristics.....                                                     | 7  | SPI Instruction Word (16 Bits).....                    | 30 |
| Jitter and Noise Characteristics.....                                                     | 8  | SPI MSB/LSB First Transfers.....                       | 30 |
| PLL2 Characteristics.....                                                                 | 8  | EEPROM Operations.....                                 | 33 |
| Logic Input Pins—PD, SYNC, RESET,<br>EEPROM_SEL, REF_SEL.....                             | 8  | Writing to the EEPROM.....                             | 33 |
| Status Output Pins—STATUS1, STATUS0.....                                                  | 9  | Reading from the EEPROM.....                           | 33 |
| Serial Control Port—SPI Mode.....                                                         | 9  | Programming the EEPROM Buffer Segment...               | 34 |
| Serial Control Port—I <sup>2</sup> C Mode.....                                            | 10 | Power Dissipation and Thermal Considerations..         | 36 |
| Absolute Maximum Ratings.....                                                             | 11 | Clock Speed and Driver Mode.....                       | 36 |
| Thermal Resistance.....                                                                   | 11 | Evaluation of Operating Conditions.....                | 36 |
| ESD Caution.....                                                                          | 11 | Thermally Enhanced Package Mounting<br>Guidelines..... | 37 |
| Pin Configuration and Function Descriptions.....                                          | 12 | Control Registers.....                                 | 38 |
| Typical Performance Characteristics.....                                                  | 14 | Control Register Map.....                              | 38 |
| Input/Output Termination Recommendations.....                                             | 16 | Control Register Map Bit Descriptions.....             | 41 |
| Terminology.....                                                                          | 17 | Outline Dimensions.....                                | 53 |
|                                                                                           |    | Ordering Guide.....                                    | 53 |
|                                                                                           |    | Evaluation Boards.....                                 | 53 |

## REVISION HISTORY

## 11/2024—Rev. F to Rev. G

|                                                                   |    |
|-------------------------------------------------------------------|----|
| Changed Master to Main and Slave to Subordinate (Throughout)..... | 1  |
| Updated Outline Dimensions.....                                   | 53 |

## SPECIFICATIONS

$f_{VCO} = 122.88$  MHz single-ended, REFA and REFB on differential at 30.72 MHz,  $f_{VCO} = 3932.16$  MHz, doubler is off, channel control low power mode off, divider phase = 1, unless otherwise noted. Typical is given for  $V_{DD} = 3.3 \text{ V} \pm 5\%$ , and  $T_A = 25^\circ\text{C}$ , unless otherwise noted. Minimum and maximum values are given over the full  $V_{DD}$  and  $T_A$  ( $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ ) variation, as listed in Table 1.

## CONDITIONS

Table 1.

| Parameter                                                       | Min | Typ | Max | Unit             | Test Conditions/Comments |
|-----------------------------------------------------------------|-----|-----|-----|------------------|--------------------------|
| SUPPLY VOLTAGE                                                  |     |     |     |                  |                          |
| VDD3_PLL1, Supply Voltage for PLL1                              |     | 3.3 |     | V                | $3.3 \text{ V} \pm 5\%$  |
| VDD3_PLL2, Supply Voltage for PLL2                              |     | 3.3 |     | V                | $3.3 \text{ V} \pm 5\%$  |
| VDD3_REF, Supply Voltage Clock Output Drivers Reference         |     | 3.3 |     | V                | $3.3 \text{ V} \pm 5\%$  |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 3.3 |     | V                | $3.3 \text{ V} \pm 5\%$  |
| VDD1.8_OUT[x:y], <sup>1</sup> Supply Voltage Clock Dividers     |     | 1.8 |     | V                | $1.8 \text{ V} \pm 5\%$  |
| TEMPERATURE                                                     |     |     |     |                  |                          |
| Ambient Temperature Range, $T_A$                                | -40 | +25 | +85 | $^\circ\text{C}$ |                          |
| Junction Temperature, $T_J$                                     |     |     | 115 | $^\circ\text{C}$ |                          |

<sup>1</sup> x and y are the pair of differential outputs that share the same power supply. For example, VDD3\_OUT[0:1] is Supply Voltage Clock Output OUT0,  $\overline{\text{OUT0}}$  (Pin 41 and Pin 40, respectively) and Supply Voltage Clock Output OUT1,  $\overline{\text{OUT1}}$  (Pin 38 and Pin 37, respectively).

## SUPPLY CURRENT

Table 2.

| Parameter                                                                | Min | Typ  | Max  | Unit | Test Conditions/Comments                                                                                                 |
|--------------------------------------------------------------------------|-----|------|------|------|--------------------------------------------------------------------------------------------------------------------------|
| SUPPLIES OTHER THAN CLOCK OUTPUT DRIVERS                                 |     |      |      |      |                                                                                                                          |
| VDD3_PLL1, Supply Voltage for PLL1                                       |     | 37   | 43   | mA   | Decreases by 9 mA typical if REFB is turned off                                                                          |
| VDD3_PLL2, Supply Voltage for PLL2                                       |     | 67   | 77.7 | mA   |                                                                                                                          |
| VDD3_REF, Supply Voltage Clock Output Drivers Reference                  |     |      |      |      |                                                                                                                          |
| LVPECL Mode                                                              |     | 5    | 6    | mA   | Only one output driver turned on; for each additional output that is turned on, the current increments by 1.2 mA maximum |
| LVDS Mode                                                                |     | 4    | 4.8  | mA   | Only one output driver turned on; for each additional output that is turned on, the current increments by 1.2 mA maximum |
| HSTL Mode                                                                |     | 3    | 3.6  | mA   | Values are independent of the number of outputs turned on                                                                |
| CMOS Mode                                                                |     | 3    | 3.6  | mA   | Values are independent of the number of outputs turned on                                                                |
| VDD1.8_OUT[x:y], <sup>1</sup> Supply Voltage Clock Dividers <sup>2</sup> |     | 3.5  | 4.2  | mA   | Current for each divider: $f = 245.76 \text{ MHz}$                                                                       |
| CLOCK OUTPUT DRIVERS—LOWER POWER MODE OFF                                |     |      |      |      |                                                                                                                          |
| LVDS Mode, 7 mA                                                          |     |      |      |      | Channel x control register, Bit 4 = 0                                                                                    |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers          |     | 11.5 | 13.2 | mA   | $f = 122.88 \text{ MHz}$                                                                                                 |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers          |     | 40   | 45   | mA   | $f = 983.04 \text{ MHz}$                                                                                                 |
| LVDS Mode, 3.5 mA                                                        |     |      |      |      |                                                                                                                          |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers          |     | 6.5  | 7.5  | mA   | $f = 122.88 \text{ MHz}$                                                                                                 |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers          |     | 23   | 26.3 | mA   | $f = 983.04 \text{ MHz}$                                                                                                 |
| LVPECL Compatible Mode                                                   |     |      |      |      |                                                                                                                          |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers          |     | 13   | 14.4 | mA   | $f = 122.88 \text{ MHz}$                                                                                                 |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers          |     | 41   | 46.5 | mA   | $f = 983.04 \text{ MHz}$                                                                                                 |
| HSTL Mode, 8 mA                                                          |     |      |      |      |                                                                                                                          |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers          |     | 14   | 16.3 | mA   | $f = 122.88 \text{ MHz}$                                                                                                 |

## SPECIFICATIONS

Table 2. (Continued)

| Parameter                                                       | Min | Typ | Max  | Unit | Test Conditions/Comments              |
|-----------------------------------------------------------------|-----|-----|------|------|---------------------------------------|
| CMOS Mode (Single-Ended)                                        |     |     |      |      |                                       |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 2   | 2.4  | mA   | f = 15.36 MHz, 10 pF load             |
| CLOCK OUTPUT DRIVERS—LOWER POWER MODE ON                        |     |     |      |      | Channel x control register, Bit 4 = 1 |
| LVDS Mode, 7 mA                                                 |     |     |      |      |                                       |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 10  | 10.8 | mA   | f = 122.88 MHz                        |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 27  | 29.8 | mA   | f = 983.04 MHz                        |
| LVDS Mode, 3.5 mA                                               |     |     |      |      |                                       |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 6.5 | 7.5  | mA   | f = 122.88 MHz                        |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 23  | 26.3 | mA   | f = 983.04 MHz                        |
| LVPECL Compatible Mode                                          |     |     |      |      |                                       |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 11  | 12.4 | mA   | f = 122.88 MHz                        |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 28  | 31.2 | mA   | f = 983.04 MHz                        |
| HSTL Mode, 16 mA                                                |     |     |      |      |                                       |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 20  | 24.3 | mA   | f = 122.88 MHz                        |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 50  | 59.1 | mA   | f = 983.04 MHz                        |
| HSTL Mode, 8 mA                                                 |     |     |      |      |                                       |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 11  | 12.7 | mA   | f = 122.88 MHz                        |
| VDD3_OUT[x:y], <sup>1</sup> Supply Voltage Clock Output Drivers |     | 27  | 31.8 | mA   | f = 983.04 MHz                        |

<sup>1</sup> x and y are the pair of differential outputs that share the same power supply. For example, VDD3\_OUT[0:1] is Supply Voltage Clock Output OUT0,  $\overline{\text{OUT0}}$  (Pin 41 and Pin 40, respectively) and Supply Voltage Clock Output OUT1,  $\overline{\text{OUT1}}$  (Pin 38 and Pin 37, respectively).

<sup>2</sup> The current for Pin 34 (VDD1.8\_OUT[0:3]) is 2× that of the other VDD1.8\_OUT[x:y] pairs.

## POWER DISSIPATION

Table 3.

| Parameter                                           | Min | Typ   | Max   | Unit | Test Conditions/Comments                                                                                                                                                                                                                                                    |
|-----------------------------------------------------|-----|-------|-------|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| POWER DISSIPATION                                   |     |       |       |      |                                                                                                                                                                                                                                                                             |
| Typical Configuration                               |     | 559   | 593   | mW   | Clock distribution outputs running as follows: four LVPECL outputs at 122.88 MHz, two LVDS outputs (3.5 mA) at 122.88 MHz, one differential input reference at 30.72 MHz; $f_{\text{VCXO}}$ = 122.88 MHz, $f_{\text{VCO}}$ = 3932.16 MHz; PLL2 BW = 530 kHz; doubler is off |
| $\overline{\text{PD}}$ , Power-Down                 |     | 101   | 132.2 | mW   | $\overline{\text{PD}}$ pin pulled low, with typical configuration conditions                                                                                                                                                                                                |
| INCREMENTAL POWER DISSIPATION                       |     |       |       |      |                                                                                                                                                                                                                                                                             |
| Low Power Typical Configuration                     |     | 389   | 450.4 | mW   | Absolute total power with clock distribution; one LVPECL output running at 122.88 MHz; one differential input reference at 30.72 MHz; $f_{\text{VCXO}}$ = 122.88 MHz, $f_{\text{VCO}}$ = 3932.16 MHz; doubler is off                                                        |
| Switched to One Input, Reference Single-Ended Mode  |     | -28.5 | -8    | mW   | Running at 30.72 MHz                                                                                                                                                                                                                                                        |
| Switched to Two Inputs, Reference Differential Mode |     | 26    | 44.6  | mW   | Running at 30.72 MHz                                                                                                                                                                                                                                                        |
| Switched to Two Inputs, Reference Single-Ended Mode |     | -27.5 | -5.1  | mW   | Running at 30.72 MHz                                                                                                                                                                                                                                                        |
| Output Distribution, Driver On                      |     |       |       |      | Incremental power increase (OUT1) from low power typical (3.3 V)                                                                                                                                                                                                            |
| LVDS                                                |     | 15.3  | 18.4  | mW   | Single 3.5 mA LVDS output at 245.76 MHz                                                                                                                                                                                                                                     |
|                                                     |     | 47.8  | 55.4  | mW   | Single 7 mA LVDS output at 61.44 MHz                                                                                                                                                                                                                                        |
| LVPECL Compatible                                   |     | 50.1  | 54.9  | mW   | Single LVPECL output at 122.88 MHz                                                                                                                                                                                                                                          |
| HSTL                                                |     | 40.2  | 46.3  | mW   | Single 8 mA HSTL output at 122.88 MHz                                                                                                                                                                                                                                       |
|                                                     |     | 43.7  | 50.3  | mW   | Single 16 mA HSTL output at 122.88 MHz                                                                                                                                                                                                                                      |
| CMOS                                                |     | 6.6   | 7.9   | mW   | Single 3.3 V CMOS output at 15.36 MHz                                                                                                                                                                                                                                       |

## SPECIFICATIONS

Table 3. (Continued)

| Parameter | Min | Typ | Max  | Unit | Test Conditions/Comments                          |
|-----------|-----|-----|------|------|---------------------------------------------------|
|           |     | 9.9 | 11.9 | mW   | Dual complementary 3.3 V CMOS output at 15.36 MHz |
|           |     | 9.9 | 11.9 | mW   | Dual in-phase 3.3 V CMOS output at 15.36 MHz      |

REFA,  $\overline{\text{REFA}}$ , REFB,  $\overline{\text{REFB}}$ , OSC\_IN,  $\overline{\text{OSC\_IN}}$ , AND ZD\_IN,  $\overline{\text{ZD\_IN}}$  INPUT CHARACTERISTICS

Table 4.

| Parameter                                                      | Min   | Typ | Max   | Unit       | Test Conditions/Comments                                                                                                                                                            |
|----------------------------------------------------------------|-------|-----|-------|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| DIFFERENTIAL MODE                                              |       |     |       |            |                                                                                                                                                                                     |
| Input Frequency Range                                          |       |     | 400   | MHz        |                                                                                                                                                                                     |
| Input Slew Rate (OSC_IN)                                       | 400   |     |       | V/ $\mu$ s | Minimum limit imposed for jitter performance                                                                                                                                        |
| Common-Mode Internally Generated Input Voltage                 | 0.6   | 0.7 | 0.8   | V          |                                                                                                                                                                                     |
| Input Common-Mode Range                                        | 1.025 |     | 1.475 | V          | For dc-coupled LVDS (maximum swing)                                                                                                                                                 |
| Differential Input Voltage, Sensitivity<br>Frequency < 250 MHz | 100   |     |       | mV p-p     | Capacitive coupling required; can accommodate single-ended input by ac grounding of unused input; the instantaneous voltage on either pin must not exceed the 1.8 V dc supply rails |
| Differential Input Voltage, Sensitivity<br>Frequency > 250 MHz | 200   |     |       | mV p-p     | Capacitive coupling required; can accommodate single-ended input by ac grounding of unused input; the instantaneous voltage on either pin must not exceed the 1.8 V dc supply rails |
| Differential Input Resistance                                  |       | 4.8 |       | k $\Omega$ |                                                                                                                                                                                     |
| Differential Input Capacitance                                 |       | 1   |       | pF         |                                                                                                                                                                                     |
| Duty Cycle                                                     |       |     |       |            | Duty cycle bounds are set by pulse width high and pulse width low                                                                                                                   |
| Pulse Width Low                                                | 1     |     |       | ns         |                                                                                                                                                                                     |
| Pulse Width High                                               | 1     |     |       | ns         |                                                                                                                                                                                     |
| CMOS MODE SINGLE-ENDED INPUT                                   |       |     |       |            |                                                                                                                                                                                     |
| Input Frequency Range                                          |       |     | 250   | MHz        |                                                                                                                                                                                     |
| Input High Voltage                                             | 1.6   |     |       | V          |                                                                                                                                                                                     |
| Input Low Voltage                                              |       |     | 0.52  | V          |                                                                                                                                                                                     |
| Input Threshold Voltage                                        |       | 1.0 |       | V          | When ac coupling to the input receiver, the user must dc bias the input to 1 V; the single-ended CMOS input is 3.3 V compatible                                                     |
| Input Capacitance                                              |       | 1   |       | pF         |                                                                                                                                                                                     |
| Duty Cycle                                                     |       |     |       |            | Duty cycle bounds are set by pulse width high and pulse width low                                                                                                                   |
| Pulse Width Low                                                | 1.6   |     |       | ns         |                                                                                                                                                                                     |
| Pulse Width High                                               | 1.6   |     |       | ns         |                                                                                                                                                                                     |

## OSC\_CTRL OUTPUT CHARACTERISTICS

Table 5.

| Parameter      | Min              | Typ | Max | Unit | Test Conditions/Comments          |
|----------------|------------------|-----|-----|------|-----------------------------------|
| OUTPUT VOLTAGE |                  |     |     |      |                                   |
| High           | VDD3_PLL1 – 0.15 |     |     | V    | R <sub>LOAD</sub> > 20 k $\Omega$ |
| Low            |                  |     | 150 | mV   |                                   |

## SPECIFICATIONS

## REF\_TEST INPUT CHARACTERISTICS

Table 6.

| Parameter             | Min | Typ | Max | Unit | Test Conditions/Comments |
|-----------------------|-----|-----|-----|------|--------------------------|
| REF_TEST INPUT        |     |     |     |      |                          |
| Input Frequency Range |     |     | 250 | MHz  |                          |
| Input High Voltage    | 2.0 |     |     | V    |                          |
| Input Low Voltage     |     |     | 0.8 | V    |                          |

## PLL1 CHARACTERISTICS

Table 7.

| Parameter                  | Min | Typ  | Max | Unit   | Test Conditions/Comments                                                                                                                                                                                                  |
|----------------------------|-----|------|-----|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| PLL1 FIGURE OF MERIT (FOM) |     | -226 |     | dBc/Hz |                                                                                                                                                                                                                           |
| MAXIMUM PFD FREQUENCY      |     |      |     |        | High is the initial PLL1 antibacklash pulse width setting. The user must program Register 0x019[4] = 1b to enable SPI control of the antibacklash pulse width to the setting defined in Register 0x019[3:2] and Table 40. |
| Antibacklash Pulse Width   |     |      |     |        |                                                                                                                                                                                                                           |
| Minimum                    |     |      | 130 | MHz    |                                                                                                                                                                                                                           |
| Low                        |     |      | 90  | MHz    |                                                                                                                                                                                                                           |
| High                       |     |      | 65  | MHz    |                                                                                                                                                                                                                           |
| Maximum                    |     |      | 45  | MHz    |                                                                                                                                                                                                                           |

## PLL1 OUTPUT CHARACTERISTICS

Table 8.

| Parameter <sup>1</sup>      | Min              | Typ | Max | Unit | Test Conditions/Comments |
|-----------------------------|------------------|-----|-----|------|--------------------------|
| MAXIMUM OUTPUT FREQUENCY    |                  | 250 |     | MHz  |                          |
| Rise/Fall Time (20% to 80%) |                  | 387 | 665 | ps   | 15 pF load               |
| Duty Cycle                  | 45               | 50  | 55  | %    | f = 250 MHz              |
| OUTPUT VOLTAGE HIGH         | VDD3_PLL1 – 0.25 |     |     | V    | Output driver static     |
|                             | VDD3_PLL1 – 0.1  |     |     | V    | Load current = 10 mA     |
| OUTPUT VOLTAGE LOW          |                  |     | 0.2 | V    | Load current = 10 mA     |
|                             |                  |     | 0.1 | V    | Load current = 1 mA      |

<sup>1</sup> CMOS driver strength = strong (see Table 53).

DISTRIBUTION OUTPUT CHARACTERISTICS (OUT0,  $\overline{\text{OUT0}}$  TO OUT5,  $\overline{\text{OUT5}}$ )

Duty cycle performance is specified with the invert divider bit set to 1, and the divider phase bits set to 0.5. (For example, for Channel 0, 0x196[7] = 1 and 0x198[7:2] = 000001.) Output Voltage Reference VDD in Table 9 refers to the 3.3 V supply VDD3\_OUT[x:y] supply.

Table 9.

| Parameter                        | Min | Typ | Max | Unit | Test Conditions/Comments                    |
|----------------------------------|-----|-----|-----|------|---------------------------------------------|
| LVPECL MODE <sup>1</sup>         |     |     |     |      |                                             |
| Maximum Output Frequency         |     | 1   |     | GHz  | Minimum VCO/maximum dividers                |
| Rise Time/Fall Time (20% to 80%) |     | 117 | 147 | ps   | 100 $\Omega$ termination across output pair |
| Duty Cycle                       | 47  | 50  | 52  | %    | f < 500 MHz                                 |
|                                  | 43  | 48  | 52  | %    | f = 500 MHz to 800 MHz                      |

## SPECIFICATIONS

Table 9. (Continued)

| Parameter                             | Min        | Typ       | Max        | Unit  | Test Conditions/Comments                                                     |
|---------------------------------------|------------|-----------|------------|-------|------------------------------------------------------------------------------|
| Differential Output Voltage Magnitude | 40         | 49        | 54         | %     | f = 800 MHz to 1 GHz                                                         |
| Common-Mode Output Voltage            | 643        | 775       | 924        | mV    | Voltage across pins; output driver static                                    |
|                                       | VDD – 1.5  | VDD – 1.4 | VDD – 1.25 | V     | Output driver static                                                         |
| SCALED HSTL MODE, 16 mA               |            |           |            |       |                                                                              |
| Maximum Output Frequency              |            | 1         |            | GHz   | Minimum VCO/maximum dividers                                                 |
| Rise Time/Fall Time (20% to 80%)      |            | 112       | 141        | ps    | 100 $\Omega$ termination across output pair                                  |
| Duty Cycle                            | 47         | 50        | 52         | %     | f < 500 MHz                                                                  |
|                                       | 44         | 48        | 51         | %     | f = 500 MHz to 800 MHz                                                       |
|                                       | 40         | 49        | 54         | %     | f = 800 MHz to 1 GHz                                                         |
| Differential Output Voltage Magnitude | 1.3        | 1.6       | 1.7        | V     | Voltage across pins, output driver static; nominal supply                    |
| Supply Sensitivity                    |            | 0.6       |            | mV/mV | Change in output swing vs. VDD3_OUT[x:y]<br>( $\Delta V_{OD}/\Delta VDD3$ )  |
| Common-Mode Output Voltage            | VDD – 1.76 | VDD – 1.6 | VDD – 1.42 | V     |                                                                              |
| LVDS MODE, 3.5 mA                     |            |           |            |       |                                                                              |
| Maximum Output Frequency              |            | 1         |            | GHz   |                                                                              |
| Rise Time/Fall Time (20% to 80%)      |            | 138       | 161        | ps    | 100 $\Omega$ termination across output pair                                  |
| Duty Cycle                            | 48         | 51        | 53         | %     | f < 500 MHz                                                                  |
|                                       | 43         | 49        | 53         | %     | f = 500 MHz to 800 MHz                                                       |
|                                       | 41         | 49        | 55         | %     | f = 800 MHz to 1 GHz                                                         |
| Differential Output Voltage Magnitude |            |           |            |       |                                                                              |
| Balanced                              | 247        |           | 454        | mV    | Voltage across pins; output driver static                                    |
| Unbalanced                            |            |           | 50         | mV    | Absolute difference between voltage magnitude of normal pin and inverted pin |
| Common-Mode Output Voltage            | 1.125      |           | 1.375      | V     | Output driver static                                                         |
| Common-Mode Difference                |            |           | 50         | mV    | Voltage difference between output pins; output driver static                 |
| Short-Circuit Output Current          |            | 3.5       | 24         | mA    | Output driver static                                                         |
| CMOS MODE                             |            |           |            |       |                                                                              |
| Maximum Output Frequency              |            | 250       |            | MHz   |                                                                              |
| Rise Time/Fall Time (20% to 80%)      |            | 387       | 665        | ps    | 15 pF load                                                                   |
| Duty Cycle                            | 45         | 50        | 55         | %     | f = 250 MHz                                                                  |
| Output Voltage High                   |            |           |            |       | Output driver static                                                         |
|                                       | VDD – 0.25 |           |            | V     | Load current = 10 mA                                                         |
|                                       | VDD – 0.1  |           |            | V     | Load current = 1 mA                                                          |
| Output Voltage Low                    |            |           | 0.2        | V     | Output driver static                                                         |
|                                       |            |           | 0.1        | V     | Load current = 10 mA                                                         |
|                                       |            |           |            |       | Load current = 1 mA                                                          |

<sup>1</sup> See the [Multimode Output Drivers](#) section.

## TIMING ALIGNMENT CHARACTERISTICS

Table 10.

| Parameter                              | Min | Typ | Max | Unit  | Test Conditions/Comments                                                                                                 |
|----------------------------------------|-----|-----|-----|-------|--------------------------------------------------------------------------------------------------------------------------|
| OUTPUT TIMING SKEW                     |     |     |     |       |                                                                                                                          |
| Between LVPECL, HSTL, and LVDS Outputs |     | 38  | 234 | ps    | Delay off on all outputs; maximum deviation between rising edges of outputs; all outputs are on, unless otherwise noted. |
| Between CMOS Outputs                   |     | 100 | 300 | ps    | Single-ended true phase high-Z mode                                                                                      |
| Adjustable Delay                       | 0   |     | 63  | Steps | Resolution step; for example, $8 \times 0.5/1$ GHz                                                                       |
| Resolution Step                        |     | 500 |     | ps    | $\frac{1}{2}$ period of 1 GHz                                                                                            |

## SPECIFICATIONS

Table 10. (Continued)

| Parameter                                                                                                     | Min | Typ | Max | Unit | Test Conditions/Comments                                                                                                                                                             |
|---------------------------------------------------------------------------------------------------------------|-----|-----|-----|------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Zero Delay<br>Between Input Clock Edge on REFA or REFB to ZD_IN<br>Input Clock Edge, External Zero Delay Mode |     | 150 | 500 | ps   | PLL1 settings: PFD = 7.68 MHz, $I_{CP}$ = 63.5 $\mu$ A, $R_{ZERO}$ = 10 k $\Omega$ , antibacklash pulse width is at maximum, BW = 40 Hz, REFA and ZD_IN are set to differential mode |

## JITTER AND NOISE CHARACTERISTICS

Table 11.

| Parameter                                                                | Min | Typ | Max | Unit | Test Conditions/Comments                                                   |
|--------------------------------------------------------------------------|-----|-----|-----|------|----------------------------------------------------------------------------|
| OUTPUT ABSOLUTE RMS TIME JITTER<br><br>LVPECL Mode, HSTL Mode, LVDS Mode |     |     |     |      | Application example based on a typical setup (see Table 3); f = 122.88 MHz |
|                                                                          |     | 125 |     | fs   | Integrated BW = 200 kHz to 5 MHz                                           |
|                                                                          |     | 136 |     | fs   | Integrated BW = 200 kHz to 10 MHz                                          |
|                                                                          |     | 169 |     | fs   | Integrated BW = 12 kHz to 20 MHz                                           |
|                                                                          |     | 212 |     | fs   | Integrated BW = 10 kHz to 61 MHz                                           |
|                                                                          |     | 223 |     | fs   | Integrated BW = 1 kHz to 61 MHz                                            |

## PLL2 CHARACTERISTICS

Table 12.

| Parameter                        | Min  | Typ  | Max  | Unit   | Test Conditions/Comments                                                                                                                                                                                                  |
|----------------------------------|------|------|------|--------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VCO (ON CHIP)<br>Frequency Range | 3600 |      | 4000 | MHz    |                                                                                                                                                                                                                           |
| Gain                             |      | 45   |      | MHz/V  |                                                                                                                                                                                                                           |
| PLL2 FIGURE OF MERIT (FOM)       |      | -226 |      | dBc/Hz |                                                                                                                                                                                                                           |
| MAXIMUM PFD FREQUENCY            |      |      |      |        | High is the initial PLL1 antibacklash pulse width setting. The user must program Register 0x019[4] = 1b to enable SPI control of the antibacklash pulse width to the setting defined in Register 0x0F2[3:2] and Table 47. |
| Antibacklash Pulse Width         |      |      |      |        |                                                                                                                                                                                                                           |
| Minimum                          |      |      | 259  | MHz    |                                                                                                                                                                                                                           |
| Low                              |      |      | 200  | MHz    |                                                                                                                                                                                                                           |
| High                             |      |      | 135  | MHz    |                                                                                                                                                                                                                           |
| Maximum                          |      |      | 80   | MHz    |                                                                                                                                                                                                                           |

LOGIC INPUT PINS— $\overline{PD}$ ,  $\overline{SYNC}$ ,  $\overline{RESET}$ ,  $\overline{EEPROM\_SEL}$ ,  $\overline{REF\_SEL}$ 

Table 13.

| Parameter                                 | Min | Typ      | Max       | Unit    | Test Conditions/Comments                                                                                  |
|-------------------------------------------|-----|----------|-----------|---------|-----------------------------------------------------------------------------------------------------------|
| VOLTAGE                                   |     |          |           |         |                                                                                                           |
| Input High                                | 2.0 |          |           | V       |                                                                                                           |
| Input Low                                 |     |          | 0.8       | V       |                                                                                                           |
| INPUT LOW CURRENT                         |     | $\pm 80$ | $\pm 250$ | $\mu$ A | The minus sign indicates that, due to the internal pull-up resistor, current is flowing out of the AD9524 |
| CAPACITANCE                               |     | 3        |           | pF      |                                                                                                           |
| RESET TIMING                              |     |          |           |         |                                                                                                           |
| Pulse Width Low                           | 50  |          |           | ns      |                                                                                                           |
| Inactive to Start of Register Programming | 100 |          |           | ns      |                                                                                                           |

## SPECIFICATIONS

Table 13. (Continued)

| Parameter                 | Min | Typ | Max | Unit | Test Conditions/Comments             |
|---------------------------|-----|-----|-----|------|--------------------------------------|
| SYN $\overline{C}$ TIMING |     |     |     |      |                                      |
| Pulse Width Low           | 1.5 |     |     | ns   | High speed clock is CLK input signal |

## STATUS OUTPUT PINS—STATUS1, STATUS0

Table 14.

| Parameter   | Min  | Typ | Max | Unit | Test Conditions/Comments |
|-------------|------|-----|-----|------|--------------------------|
| VOLTAGE     |      |     |     |      |                          |
| Output High | 2.94 |     |     | V    |                          |
| Output Low  |      |     | 0.4 | V    |                          |

## SERIAL CONTROL PORT—SPI MODE

Table 15.

| Parameter                                  | Min | Typ  | Max | Unit    | Test Conditions/Comments                                                                                  |
|--------------------------------------------|-----|------|-----|---------|-----------------------------------------------------------------------------------------------------------|
| $\overline{CS}$ (INPUT)                    |     |      |     |         | $\overline{CS}$ has an internal 40 k $\Omega$ pull-up resistor                                            |
| Voltage                                    |     |      |     |         |                                                                                                           |
| Input Logic 1                              |     | 2.0  |     | V       |                                                                                                           |
| Input Logic 0                              |     | 0.8  |     | V       |                                                                                                           |
| Current                                    |     |      |     |         |                                                                                                           |
| Input Logic 1                              |     | 30   |     | $\mu$ A |                                                                                                           |
| Input Logic 0                              |     | -110 |     | $\mu$ A | The minus sign indicates that, due to the internal pull-up resistor, current is flowing out of the AD9524 |
| Input Capacitance                          |     | 2    |     | pF      |                                                                                                           |
| SCLK (INPUT) IN SPI MODE                   |     |      |     |         | SCLK has an internal 40 k $\Omega$ pull-down resistor in SPI mode but not in I <sup>2</sup> C mode        |
| Voltage                                    |     |      |     |         |                                                                                                           |
| Input Logic 1                              |     | 2.0  |     | V       |                                                                                                           |
| Input Logic 0                              |     | 0.8  |     | V       |                                                                                                           |
| Current                                    |     |      |     |         |                                                                                                           |
| Input Logic 1                              |     | 240  |     | $\mu$ A |                                                                                                           |
| Input Logic 0                              |     | 1    |     | $\mu$ A |                                                                                                           |
| Input Capacitance                          |     | 2    |     | pF      |                                                                                                           |
| SDIO (WHEN INPUT IS IN BIDIRECTIONAL MODE) |     |      |     |         |                                                                                                           |
| Voltage                                    |     |      |     |         |                                                                                                           |
| Input Logic 1                              |     | 2.0  |     | V       |                                                                                                           |
| Input Logic 0                              |     | 0.8  |     | V       |                                                                                                           |
| Current                                    |     |      |     |         |                                                                                                           |
| Input Logic 1                              |     | 1    |     | $\mu$ A |                                                                                                           |
| Input Logic 0                              |     | 1    |     | $\mu$ A |                                                                                                           |
| Input Capacitance                          |     | 2    |     | pF      |                                                                                                           |
| SDIO, SDO (OUTPUTS)                        |     |      |     |         |                                                                                                           |
| Output Logic 1 Voltage                     | 2.7 |      |     | V       |                                                                                                           |
| Output Logic 0 Voltage                     |     |      | 0.4 | V       |                                                                                                           |
| TIMING                                     |     |      |     |         |                                                                                                           |
| Clock Rate (SCLK, 1/ $t_{SCLK}$ )          |     |      | 25  | MHz     |                                                                                                           |
| Pulse Width High, $t_{HIGH}$               | 8   |      |     | ns      |                                                                                                           |
| Pulse Width Low, $t_{LOW}$                 | 12  |      |     | ns      |                                                                                                           |
| SDIO to SCLK Setup, $t_{DS}$               | 3.3 |      |     | ns      |                                                                                                           |

## SPECIFICATIONS

Table 15. (Continued)

| Parameter                                           | Min | Typ | Max | Unit | Test Conditions/Comments |
|-----------------------------------------------------|-----|-----|-----|------|--------------------------|
| SCLK to SDIO Hold, $t_{DH}$                         | 0   |     |     | ns   |                          |
| SCLK to Valid SDIO and SDO, $t_{DV}$                |     |     | 14  | ns   |                          |
| $\overline{CS}$ to SCLK Setup, $t_s$                | 10  |     |     | ns   |                          |
| $\overline{CS}$ to SCLK Setup and Hold, $t_s, t_c$  | 0   |     |     | ns   |                          |
| $\overline{CS}$ Minimum Pulse Width High, $t_{pWH}$ | 6   |     |     | ns   |                          |

SERIAL CONTROL PORT—I<sup>2</sup>C MODE

VDD = VDD3\_REF, unless otherwise noted.

Table 16.

| Parameter                                                                                          | Min                | Typ | Max              | Unit | Test Conditions/Comments                                                                                                                        |
|----------------------------------------------------------------------------------------------------|--------------------|-----|------------------|------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| SDA, SCL (WHEN INPUTTING DATA)                                                                     |                    |     |                  |      |                                                                                                                                                 |
| Input Logic 1 Voltage                                                                              | $0.7 \times VDD$   |     |                  | V    |                                                                                                                                                 |
| Input Logic 0 Voltage                                                                              |                    |     | $0.3 \times VDD$ | V    |                                                                                                                                                 |
| Input Current with an Input Voltage Between $0.1 \times VDD$ and $0.9 \times VDD$                  | -10                |     | +10              | μA   |                                                                                                                                                 |
| Hysteresis of Schmitt Trigger Inputs                                                               | $0.015 \times VDD$ |     |                  | V    |                                                                                                                                                 |
| Pulse Width of Spikes That Must Be Suppressed by the Input Filter, $t_{SPIKE}$                     |                    |     | 50               | ns   |                                                                                                                                                 |
| SDA (WHEN OUTPUTTING DATA)                                                                         |                    |     |                  |      |                                                                                                                                                 |
| Output Logic 0 Voltage at 3 mA Sink Current                                                        |                    |     | 0.4              | V    |                                                                                                                                                 |
| Output Fall Time from $V_{IH_{MIN}}$ to $V_{IL_{MAX}}$ with a Bus Capacitance from 10 pF to 400 pF | $20 + 0.1 C_B^1$   |     | 250              | ns   |                                                                                                                                                 |
| TIMING                                                                                             |                    |     |                  |      |                                                                                                                                                 |
| Clock Rate (SCL, $f_{I2C}$ )                                                                       |                    |     | 400              | kHz  | Note that all I <sup>2</sup> C timing values are referred to $V_{IH_{MIN}}$ ( $0.3 \times VDD$ ) and $V_{IL_{MAX}}$ levels ( $0.7 \times VDD$ ) |
| Bus Free Time Between a Stop and Start Condition, $t_{IDLE}$                                       | 1.3                |     |                  | μs   |                                                                                                                                                 |
| Setup Time for a Repeated Start Condition, $t_{SET; STR}$                                          | 0.6                |     |                  | μs   |                                                                                                                                                 |
| Hold Time (Repeated) Start Condition, $t_{HLD; STR}$                                               | 0.6                |     |                  | μs   |                                                                                                                                                 |
| Setup Time for Stop Condition, $t_{SET; STP}$                                                      | 0.6                |     |                  | μs   |                                                                                                                                                 |
| Low Period of the SCL Clock, $t_{LOW}$                                                             | 1.3                |     |                  | μs   |                                                                                                                                                 |
| High Period of the SCL Clock, $t_{HIGH}$                                                           | 0.6                |     |                  | μs   |                                                                                                                                                 |
| SCL, SDA Rise Time, $t_{RISE}$                                                                     | $20 + 0.1 C_B^1$   |     | 300              | ns   |                                                                                                                                                 |
| SCL, SDA Fall Time, $t_{FALL}$                                                                     | $20 + 0.1 C_B^1$   |     | 300              | ns   |                                                                                                                                                 |
| Data Setup Time, $t_{SET; DAT}$                                                                    | 100                |     |                  | ns   |                                                                                                                                                 |
| Data Hold Time, $t_{HLD; DAT}$                                                                     | 100                |     | 880              | ns   | This is a minor deviation from the original I <sup>2</sup> C specification of 0 ns minimum <sup>2</sup>                                         |
| Capacitive Load for Each Bus Line, $C_B^1$                                                         |                    |     | 400              | pF   |                                                                                                                                                 |

<sup>1</sup>  $C_B$  is the capacitance of one bus line in picofarads (pF).

<sup>2</sup> According to the original I<sup>2</sup>C specification, an I<sup>2</sup>C main must also provide a minimum hold time of 300 ns for the SDA signal to bridge the undefined region of the SCL falling edge.

## ABSOLUTE MAXIMUM RATINGS

Table 17.

| Parameter                                                                      | Rating           |
|--------------------------------------------------------------------------------|------------------|
| VDD3_PLL1, VDD3_PLL2, VDD3_REF, VDD3_OUT, LDO_VCO to GND                       | −0.3 V to +3.6 V |
| REFA, REFA, REF1N, REFB, REFB to GND                                           | −0.3 V to +3.6 V |
| SCLK/SCL, SDIO/SDA, SDO, CS to GND                                             | −0.3 V to +3.6 V |
| OUT0, OUT0, OUT1, OUT1, OUT2, OUT2, OUT3, OUT3, OUT4, OUT4, OUT5, OUT5, to GND | −0.3 V to +3.6 V |
| SYNC, RESET, PD to GND                                                         | −0.3 V to +3.6 V |
| STATUS0, STATUS1 to GND                                                        | −0.3 V to +3.6 V |
| SP0, SP1, EEPROM_SEL to GND                                                    | −0.3 V to +3.6 V |
| VDD1.8_OUT, LDO_PLL1, LDO_PLL2 to GND                                          | 2 V              |
| Storage Temperature Range                                                      | −65°C to +150°C  |
| Lead Temperature (10 sec)                                                      | 300°C            |

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.

## THERMAL RESISTANCE

$\theta_{JA}$  is specified for the worst-case conditions, that is, a device soldered in a circuit board for surface-mount packages.

Table 18. Thermal Resistance

| Package Type               | Airflow Velocity (m/sec) | $\theta_{JA}^{1,2}$ | $\theta_{JC}^{1,3}$ | $\theta_{JB}^{1,4}$ | $\psi_{JT}^{1,2}$ | Unit |
|----------------------------|--------------------------|---------------------|---------------------|---------------------|-------------------|------|
| 48-Lead LFCSP, 7 mm × 7 mm | 0                        | 26.1                | 1.7                 | 13.8                | 0.2               | °C/W |
|                            | 1.0                      | 22.8                |                     |                     | 0.2               | °C/W |
|                            | 2.5                      | 20.4                |                     |                     | 0.3               | °C/W |

<sup>1</sup> Per JEDEC 51-7, plus JEDEC 51-5 2S2P test board.

<sup>2</sup> Per JEDEC JESD51-2 (still air) or JEDEC JESD51-6 (moving air).

<sup>3</sup> Per MIL-Std 883, Method 1012.1.

<sup>4</sup> Per JEDEC JESD51-8 (still air).

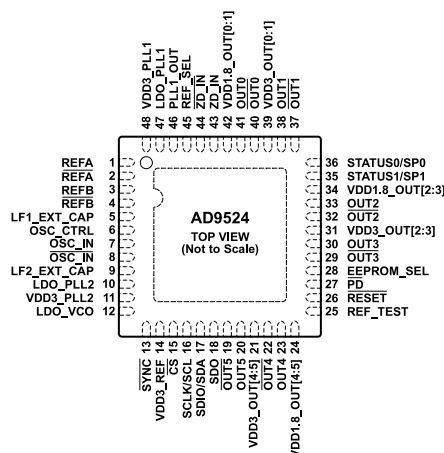
For information about power dissipation, refer to the [Power Dissipation and Thermal Considerations](#) section.

## 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



## NOTES

1. PINS LABELED NC CAN BE ALLOWED TO FLOAT, BUT IT IS BETTER TO CONNECT THESE PINS TO GROUND. AVOID ROUTING HIGH SPEED SIGNALS THROUGH THESE PINS BECAUSE NOISE COUPLING MAY RESULT. ON EXISTING PCB DESIGNS, IT IS ACCEPTABLE TO LEAVE PIN 42 CONNECTED TO 1.8V SUPPLY.
2. THE EXPOSED PADDLE IS THE GROUND CONNECTION ON THE CHIP. IT MUST BE SOLDERED TO THE ANALOG GROUND OF THE PCB TO ENSURE PROPER FUNCTIONALITY AND HEAT DISSIPATION, NOISE, AND MECHANICAL STRENGTH BENEFITS.

202

Figure 2. Pin Configuration

Table 19. Pin Function Descriptions

| Pin No. | Mnemonic                    | Type <sup>1</sup> | Description                                                                                                                                                                                                                                   |
|---------|-----------------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1       | REFA                        | I                 | Reference Clock Input A. Along with $\overline{\text{REFA}}$ , this pin is the differential input for the PLL reference. Alternatively, this pin can be programmed as a single-ended 3.3 V CMOS input.                                        |
| 2       | $\overline{\text{REFA}}$    | I                 | Complementary Reference Clock Input A. Along with REFA, this pin is the differential input for the PLL reference. Alternatively, this pin can be programmed as a single-ended 3.3V CMOS input.                                                |
| 3       | REFB                        | I                 | Reference Clock Input B. Along with $\overline{\text{REFB}}$ , this pin is the differential input for the PLL reference. Alternatively, this pin can be programmed as a single-ended 3.3 V CMOS input.                                        |
| 4       | $\overline{\text{REFB}}$    | I                 | Complementary Reference Clock Input B. Along with REFB, this pin is the differential input for the PLL reference. Alternatively, this pin can be programmed as a single-ended 3.3 V CMOS input.                                               |
| 5       | LF1_EXT_CAP                 | O                 | PLL1 External Loop Filter Capacitor. Connect a loop filter capacitor to this pin and to ground.                                                                                                                                               |
| 6       | OSC_CTRL                    | O                 | Oscillator Control Voltage. Connect this pin to the voltage control pin of the external oscillator.                                                                                                                                           |
| 7       | OSC_IN                      | I                 | PLL1 Oscillator Input. Along with $\overline{\text{OSC\_IN}}$ , this pin is the differential input for the PLL reference. Alternatively, this pin can be programmed as a single-ended 3.3 V CMOS input.                                       |
| 8       | $\overline{\text{OSC\_IN}}$ | I                 | Complementary PLL1 Oscillator Input. Along with OSC_IN, this pin is the differential input for the PLL reference. Alternatively, this pin can be programmed as a single-ended 3.3 V CMOS input.                                               |
| 9       | LF2_EXT_CAP                 | O                 | PLL2 External Loop Filter Capacitor Connection. Connect a capacitor to this pin and LDO_VCO.                                                                                                                                                  |
| 10      | LDO_PLL2                    | P/O               | LDO Decoupling Pin for PLL2 1.8 V Internal Regulator. Connect a 0.47 $\mu\text{F}$ decoupling capacitor from this pin to ground. Note that for best performance, the LDO bypass capacitor must be placed in close proximity to the device.    |
| 11      | VDD3_PLL2                   | P                 | 3.3 V Supply for PLL2.                                                                                                                                                                                                                        |
| 12      | LDO_VCO                     | P/O               | 2.5 V LDO Internal Regulator Decoupling Pin for VCO. Connect a 0.47 $\mu\text{F}$ decoupling capacitor from this pin to ground. Note that, for best performance, the LDO bypass capacitor must be placed in close proximity to the device.    |
| 13      | $\overline{\text{SYNC}}$    | I                 | Manual Synchronization. This pin initiates a manual synchronization and has an internal 40 k $\Omega$ pull-up resistor.                                                                                                                       |
| 14      | VDD3_REF                    | P                 | 3.3 V Supply for Output Clock Drivers Reference.                                                                                                                                                                                              |
| 15      | $\overline{\text{CS}}$      | I                 | Serial Control Port Chip Select, Active Low. This pin has an internal 40 k $\Omega$ pull-up resistor.                                                                                                                                         |
| 16      | SCLK/SCL                    | I                 | Serial Control Port Clock Signal for SPI Mode (SCLK) or I <sup>2</sup> C Mode (SCL). Data clock for serial programming. This pin has an internal 40 k $\Omega$ pull-down resistor in SPI mode but is high impedance in I <sup>2</sup> C mode. |
| 17      | SDIO/SDA                    | I/O               | Serial Control Port Bidirectional Serial Data In/Data Out for SPI Mode (SDIO) or I <sup>2</sup> C Mode (SDA).                                                                                                                                 |
| 18      | SDO                         | O                 | Serial Data Output. Use this pin to read data in 4-wire mode (high impedance in 3-wire mode). There is no internal pull-up/pull-down resistor on this pin.                                                                                    |
| 19      | $\overline{\text{OUT5}}$    | O                 | Complementary Clock Output 5. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                              |

## PIN CONFIGURATION AND FUNCTION DESCRIPTIONS

Table 19. Pin Function Descriptions (Continued)

| Pin No. | Mnemonic                   | Type <sup>1</sup> | Description                                                                                                                                                                                                                                                                                               |
|---------|----------------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 20      | OUT5                       | O                 | Clock Output 5. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                                                                                                        |
| 21      | VDD3_OUT[4:5]              | P                 | 3.3 V Supply for Output 4 and Output 5 Clock Drivers.                                                                                                                                                                                                                                                     |
| 22      | $\overline{\text{OUT4}}$   | O                 | Complementary Clock Output 4. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                                                                                          |
| 23      | OUT4                       | O                 | Clock Output 4. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                                                                                                        |
| 24      | VDD1.8_OUT[4:5]            | P                 | 1.8 V Supply for Output 4 and Output 5 Clock Dividers.                                                                                                                                                                                                                                                    |
| 25      | REF_TEST                   | I                 | Test Input to PLL1 Phase Detector.                                                                                                                                                                                                                                                                        |
| 26      | RESET                      | I                 | Digital Input, Active Low. Resets internal logic to default states. This pin has an internal 40 k $\Omega$ pull-up resistor.                                                                                                                                                                              |
| 27      | $\overline{\text{PD}}$     | I                 | Chip Power-Down, Active Low. This pin has an internal 40 k $\Omega$ pull-up resistor.                                                                                                                                                                                                                     |
| 28      | EEPROM_SEL                 | I                 | EEPROM Select. Setting this pin high selects the register values stored in the internal EEPROM to be loaded at reset and/or power-up. Setting this pin low causes the AD9524 to load the hard-coded default register values at power-up/reset. This pin has an internal 40 k $\Omega$ pull-down resistor. |
| 29      | $\overline{\text{OUT3}}$   | O                 | Complementary Clock Output 3. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                                                                                          |
| 30      | OUT3                       | O                 | Square Wave Clocking Output 3. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                                                                                         |
| 31      | VDD3_OUT[2:3]              | P                 | 3.3 V Supply Output 2 and Supply Output 3 Clock Drivers.                                                                                                                                                                                                                                                  |
| 32      | $\overline{\text{OUT2}}$   | O                 | Complementary Clock Output 2. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                                                                                          |
| 33      | OUT2                       | O                 | Clock Output 2. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                                                                                                        |
| 34      | VDD1.8_OUT[2:3]            | P                 | 1.8 V Supply for Output 2 and Output 3 Clock Dividers.                                                                                                                                                                                                                                                    |
| 35      | STATUS1/SP1                | I/O               | Lock Detect and Other Status Signals (STATUS1)/I <sup>2</sup> C Address (SP1).                                                                                                                                                                                                                            |
| 36      | STATUS0/SP0                | I/O               | Lock Detect and Other Status Signals (STATUS0)/I <sup>2</sup> C Address (SP0).                                                                                                                                                                                                                            |
| 37      | $\overline{\text{OUT1}}$   | O                 | Complementary Clock Output 1. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                                                                                          |
| 38      | OUT1                       | O                 | Clock Output 1. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                                                                                                        |
| 39      | VDD3_OUT[0:1]              | P                 | 3.3 V Supply Output 0 and Supply Output 1 Clock Drivers.                                                                                                                                                                                                                                                  |
| 40      | $\overline{\text{OUT0}}$   | O                 | Complementary Clock Output 0. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                                                                                          |
| 41      | OUT0                       | O                 | Clock Output 0. This pin can be configured as one side of a differential LVPECL/LVDS/HSTL output or as a single-ended CMOS output.                                                                                                                                                                        |
| 42      | VDD1.8_OUT[0:1]            | P                 | 1.8 V Supply for Output 0 and Output 1 Clock Dividers.                                                                                                                                                                                                                                                    |
| 43      | ZD_IN                      | I                 | External Zero Delay Clock Input. Along with $\overline{\text{ZD\_IN}}$ , this pin is the differential input for the PLL reference. Alternatively, this pin can be programmed as a single-ended 3.3 V CMOS input.                                                                                          |
| 44      | $\overline{\text{ZD\_IN}}$ | I                 | Complementary External Zero Delay Clock Input. Along with ZD_IN, this pin is the differential input for the PLL reference. Alternatively, this pin can be programmed as a single-ended 3.3 V CMOS input.                                                                                                  |
| 45      | REF_SEL                    | I                 | Reference Input Select. This pin has an internal 40 k $\Omega$ pull-down resistor.                                                                                                                                                                                                                        |
| 46      | PLL1_OUT                   | O                 | Single-Ended CMOS Output from PLL1. This pin has settings for weak and strong in Register 0x1BA, Bit 4 (see Table 53).                                                                                                                                                                                    |
| 47      | LDO_PLL1                   | P/O               | 1.8 V Internal LDO Regulator Decoupling Pin for PLL1. Connect a 0.47 $\mu\text{F}$ decoupling capacitor from this pin to ground. Note that, for best performance, the LDO bypass capacitor must be placed in close proximity to the device.                                                               |
| 48      | VDD3_PLL1                  | P                 | 3.3 V Supply PLL1. Use the same supply as VCXO.                                                                                                                                                                                                                                                           |
| EP      | EP, GND                    | GND               | Exposed Paddle. The exposed paddle is the ground connection on the chip. It must be soldered to the analog ground of the PCB to ensure proper functionality and heat dissipation, noise, and mechanical strength benefits.                                                                                |

<sup>1</sup> P = power, I = input, O = output, I/O = input/output, P/O = power/output, GND = ground.

## TYPICAL PERFORMANCE CHARACTERISTICS

$f_{VCO} = 122.88$  MHz, REFA differential at 30.72 MHz,  $f_{VCO} = 3686.4$  MHz, and doubler is off, unless otherwise noted.

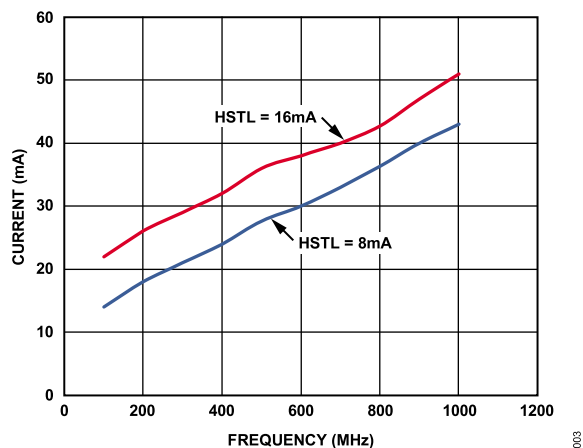


Figure 3. VDD3\_OUT[x:y] Current (Typical) vs. Frequency; HSTL Mode, 16 mA and 8 mA

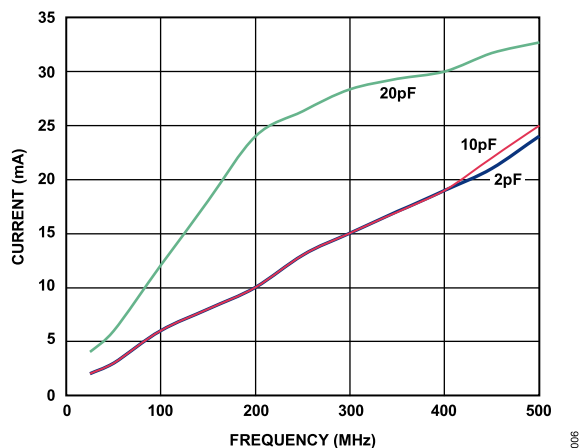


Figure 6. VDD3\_OUT[x:y] Current (Typical) vs. Frequency; CMOS Mode, 20 pF, 10 pF, and 2 pF Load

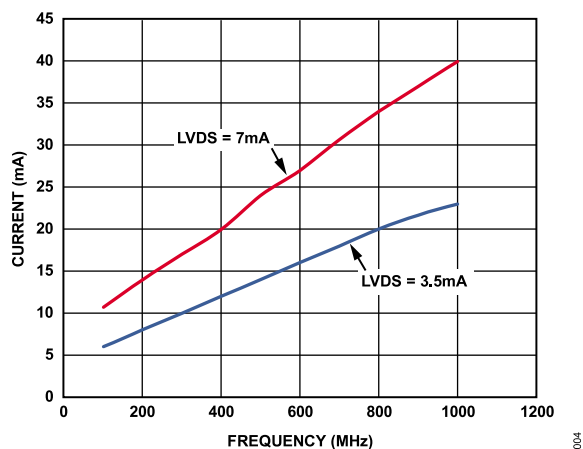


Figure 4. VDD3\_OUT[x:y] Current (Typical) vs. Frequency; LVDS Mode, 7 mA and 3.5 mA

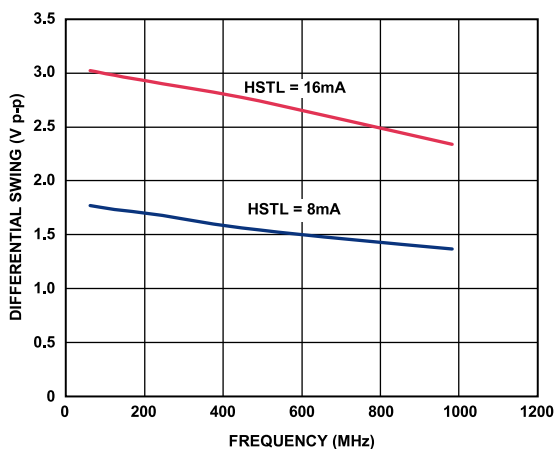


Figure 7. Differential Voltage Swing vs. Frequency; HSTL Mode, 16 mA and 8 mA

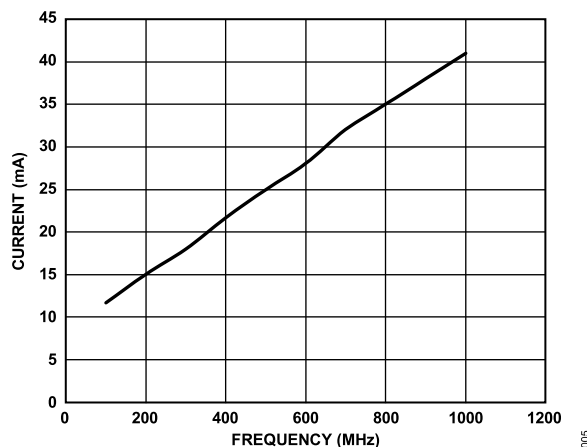


Figure 5. VDD3\_OUT[x:y] Current (Typical) vs. Frequency, LVPECL Mode

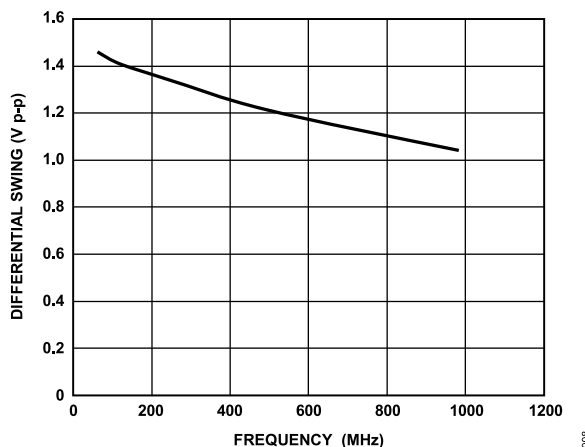


Figure 8. Differential Voltage Swing vs. Frequency, LVPECL Mode

## TYPICAL PERFORMANCE CHARACTERISTICS

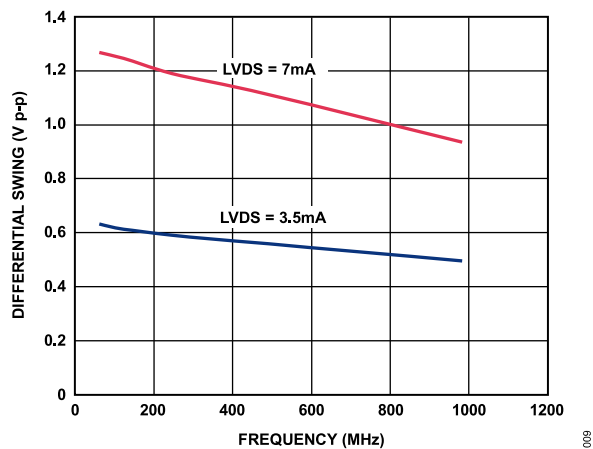


Figure 9. Differential Voltage Swing vs. Frequency; LVDS Mode, 7 mA and 3.5 mA

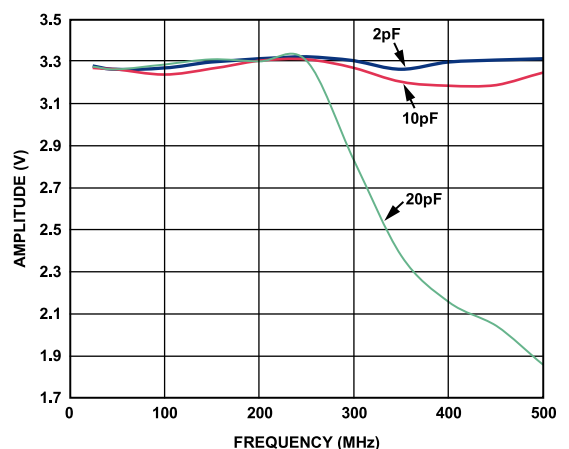


Figure 10. Amplitude vs. Frequency and Capacitive Load; CMOS Mode, 2 pF, 10 pF, and 20 pF

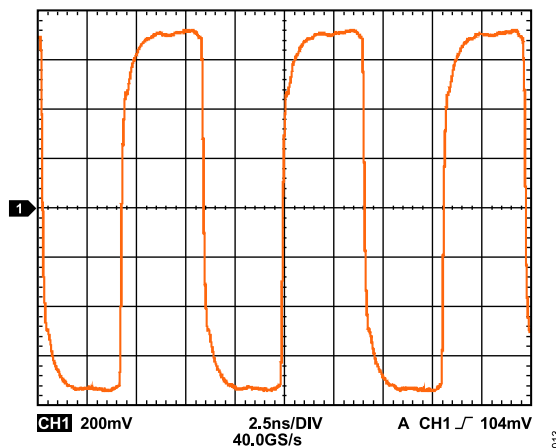


Figure 11. Output Waveform (Differential), LVPECL at 122.88 MHz

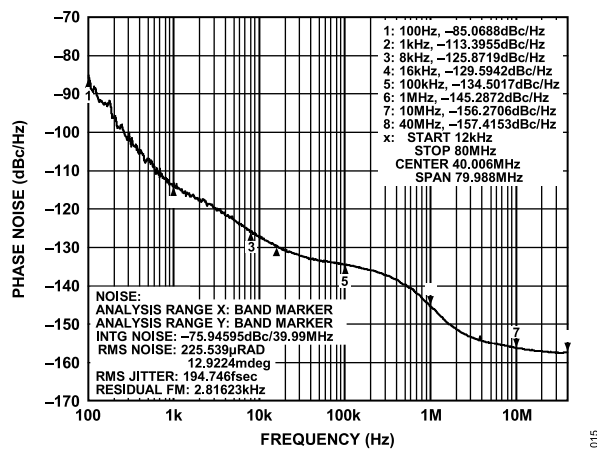


Figure 12. Phase Noise, Output = 184.32 MHz (VCXO = 122.88 MHz, Crystek VCXO CVHD-950)

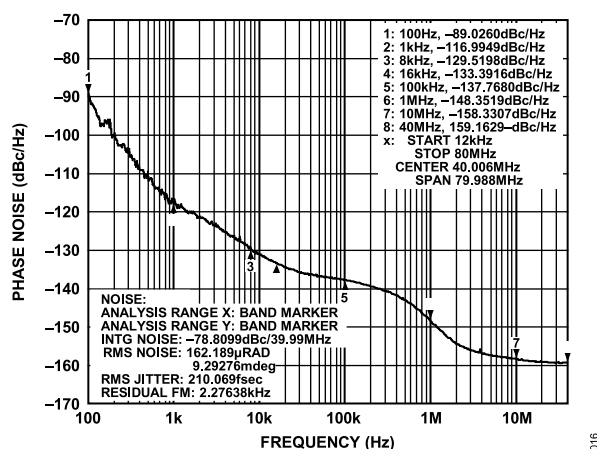


Figure 13. Phase Noise, Output = 122.88 MHz (VCXO = 122.88 MHz, Crystek VCXO CVHD-950; Doubler Is Off)

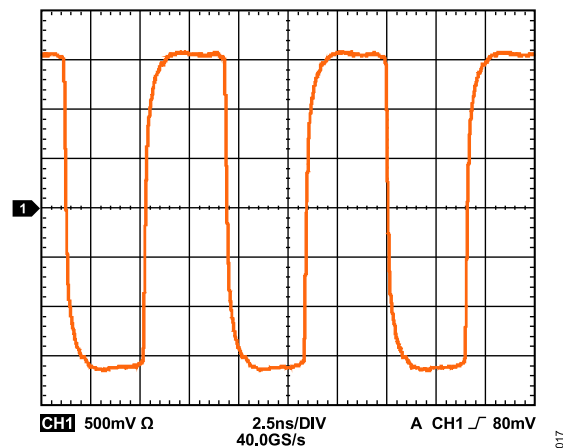


Figure 14. Output Waveform (Differential), HSTL at 16 mA, 122.88 MHz

## INPUT/OUTPUT TERMINATION RECOMMENDATIONS

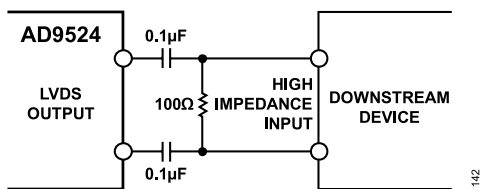


Figure 15. AC-Coupled LVDS Output Driver

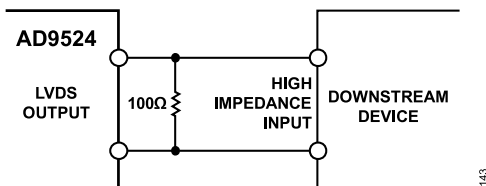


Figure 16. DC-Coupled LVDS Output Driver

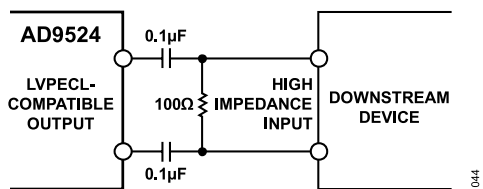


Figure 17. AC-Coupled LVPECL Output Driver

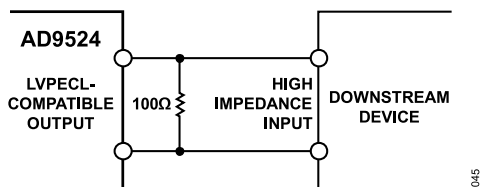


Figure 18. DC-Coupled LVPECL Output Driver

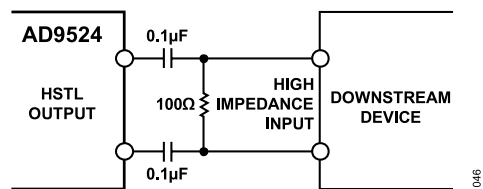


Figure 19. AC-Coupled HSTL Output Driver

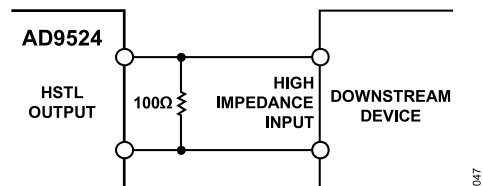
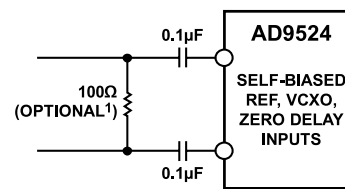


Figure 20. DC-Coupled HSTL Output Driver



<sup>1</sup>RESISTOR VALUE DEPENDS UPON  
REQUIRED TERMINATION OF SOURCE.

Figure 21. REF, VCXO, and Zero Delay Input, Differential Mode (When In CMOS Single-Ended Input Mode, the Unused Input Can Be Left Unconnected)

## TERMINOLOGY

### Phase Jitter and Phase Noise

An ideal sine wave can be thought of as having a continuous and even progression of phase with time from  $0^\circ$  to  $360^\circ$  for each cycle. Actual signals, however, display a certain amount of variation from ideal phase progression over time. This phenomenon is called phase jitter. Although many causes can contribute to phase jitter, one major cause is random noise, which is characterized statistically as being Gaussian (normal) in distribution.

This phase jitter leads to a spreading out of the energy of the sine wave in the frequency domain, producing a continuous power spectrum. This power spectrum is usually reported as a series of values whose units are dBc/Hz at a given offset in frequency from the sine wave (carrier). The value is a ratio (expressed in decibels) of the power contained within a 1 Hz bandwidth with respect to the power at the carrier frequency. For each measurement, the offset from the carrier frequency is also given.

It is meaningful to integrate the total power contained within some interval of offset frequencies (for example, 10 kHz to 10 MHz). This is called the integrated phase noise over that frequency offset interval and can be readily related to the time jitter due to the phase noise within that offset frequency interval.

Phase noise has a detrimental effect on the performance of ADCs, DACs, and RF mixers. It lowers the achievable dynamic range of the converters and mixers, although they are affected in somewhat different ways.

### Time Jitter

Phase noise is a frequency domain phenomenon. In the time domain, the same effect is exhibited as time jitter. When observing a sine wave, the time of successive zero crossings varies. In a square wave, the time jitter is a displacement of the edges

from their ideal (regular) times of occurrence. In both cases, the variations in timing from the ideal are the time jitter. Because these variations are random in nature, the time jitter is specified in seconds root mean square (rms) or 1 sigma ( $\Sigma$ ) of the Gaussian distribution.

Time jitter that occurs on a sampling clock for a DAC or an ADC decreases the signal-to-noise ratio (SNR) and dynamic range of the converter. A sampling clock with the lowest possible jitter provides the highest performance from a given converter.

### Additive Phase Noise

Additive phase noise is the amount of phase noise that can be attributed to the device or subsystem being measured. The phase noise of any external oscillators or clock sources is subtracted. This makes it possible to predict the degree to which the device impacts the total system phase noise when used in conjunction with the various oscillators and clock sources, each of which contributes its own phase noise to the total. In many cases, the phase noise of one element dominates the system phase noise. When there are multiple contributors to phase noise, the total is the square root of the sum of squares of the individual contributors.

### Additive Time Jitter

Additive time jitter is the amount of time jitter that can be attributed to the device or subsystem being measured. The time jitter of any external oscillators or clock sources is subtracted. This makes it possible to predict the degree to which the device impacts the total system time jitter when used in conjunction with the various oscillators and clock sources, each of which contributes its own time jitter to the total. In many cases, the time jitter of the external oscillators and clock sources dominates the system time jitter.

## THEORY OF OPERATION

## DETAILED BLOCK DIAGRAM

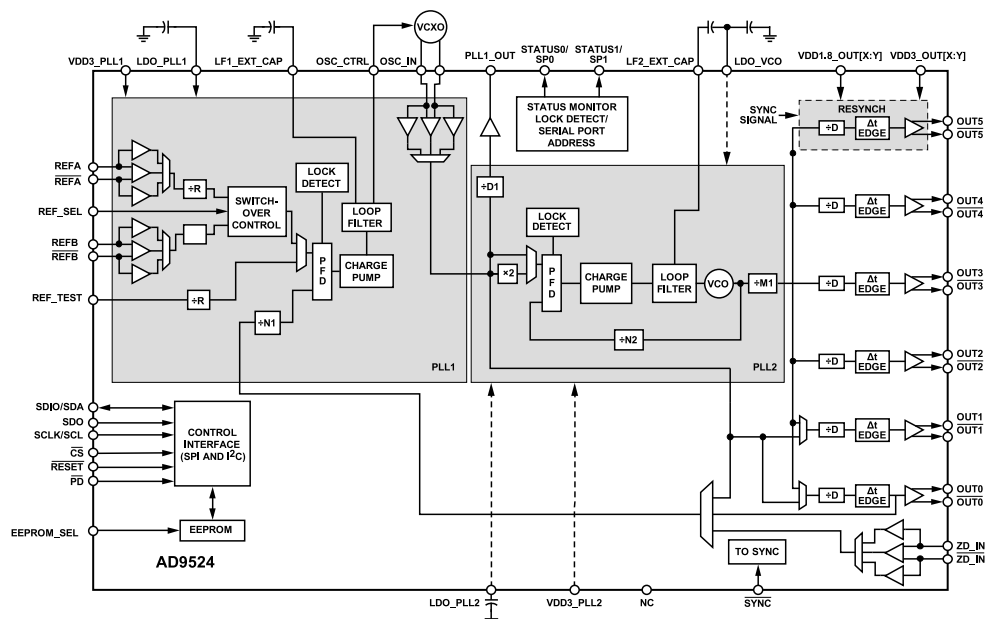


Figure 22. Top Level Diagram

## OVERVIEW

The AD9524 is a clock generator that employs integer-N-based phase-locked loops (PLL). The device architecture consists of two cascaded PLL stages. The first stage, PLL1, consists of an integer division PLL that uses an external voltage-controlled crystal oscillator (VCXO) of up to 250 MHz. PLL1 has a narrow-loop bandwidth that provides initial jitter cleanup of the input reference signal. The second stage, PLL2, is a frequency multiplying PLL that translates the first stage output frequency to a range of 3.6 GHz to 4.0 GHz. PLL2 incorporates an integer-based feedback divider that enables integer frequency multiplication. Programmable integer dividers (1 to 1024) follow PLL2, establishing a final output frequency of 1 GHz or less.

The AD9524 includes reference signal processing blocks that enable a smooth switching transition between two reference inputs. This circuitry automatically detects the presence of the reference input signals. If only one input is present, the device uses it as the active reference. If both are present, one becomes the active reference and the other becomes the backup reference. If the active reference fails, the circuitry automatically switches to the backup reference (if available), making it the new active reference. A register setting determines what action to take if the failed reference is once again available: either stay on Reference B or revert to Reference A. If neither reference can be used, the AD9524 supports a holdover mode. A reference select pin (REF\_SEL, Pin 45) is available to manually select which input reference is active (see Table 43). The accuracy of the holdover is dependent on the external VCXO frequency stability at half supply voltage.

Any of the divider settings are programmable via the serial programming port, enabling a wide range of input/output frequency ratios under program control. The dividers also include a programmable delay to adjust timing of the output signals, if required.

The output is compatible with LVPECL, LVDS, or HSTL logic levels (see the [Input/Output Termination Recommendations](#) section); however, the AD9524 is implemented only in CMOS.

The loop filters of each PLL are integrated and programmable. Only a single external capacitor for each of the two PLL loop filters is required.

The AD9524 operates over the extended industrial temperature range of  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ .

## COMPONENT BLOCKS—INPUT PLL (PLL1)

## PLL1 General Description

Fundamentally, the input PLL (referred to as PLL1) consists of a phase-frequency detector (PFD), charge pump, passive loop filter, and an external VCXO operating in a closed loop.

PLL1 has the flexibility to operate with a loop bandwidth of approximately 10 Hz to 100 Hz. This relatively narrow loop bandwidth gives the AD9524 the ability to suppress jitter that appears on the input references (REF\_A and REF\_B). The output of PLL1 then becomes a low jitter phase-locked version of the reference input system clock.

# THEORY OF OPERATION

## PLL1 Reference Clock Inputs

The AD9524 features two separate differential reference clock inputs, REFA and REFB. These inputs can be configured to operate in full differential mode or single-ended CMOS mode.

In differential mode, these pins are internally self biased. If REFA or REFB is driven single-ended, the unused side ( $\overline{\text{REFA}}$ ,  $\overline{\text{REFB}}$ ) should be decoupled via a suitable capacitor to a quiet ground. [Figure 21](#) shows the equivalent circuit of REFA or REFB. It is possible to dc couple to these inputs, but the dc operation point should be set as specified in the [Specifications](#) tables.

To operate either the REFA or the REFB inputs in 3.3 V CMOS mode, the user must set Bit 5 or Bit 6, respectively, in Register 0x01A (see [Table 41](#)). The single-ended inputs can be driven by either a dc-coupled CMOS level signal or an ac-coupled sine wave or square wave.

The differential reference input receiver is powered down when the differential reference input is not selected, or when the PLL is powered down. The single-ended buffers power-down when the PLL is powered down, when their respective individual power-down registers are set, or when the differential receiver is selected.

The REFB R divider uses the same value as the REFA R divider unless Bit 7, the enable REFB R divider independent division control bit in Register 0x01C, is programmed as shown in [Table 43](#).

## PLL1 Loop Filter

The PLL1 loop filter requires the connection of an external capacitor from LF1\_EXT\_CAP (Pin 5) to ground. The value of the external capacitor depends on the use of an external VCXO, as well as such configuration parameters as input clock rate and desired bandwidth. Normally, a 0.3  $\mu\text{F}$  capacitor allows the loop bandwidth to range from 10 Hz to 100 Hz and ensures loop stability over the intended operating parameters of the device (see [Table 44](#) for  $R_{\text{ZERO}}$  values).

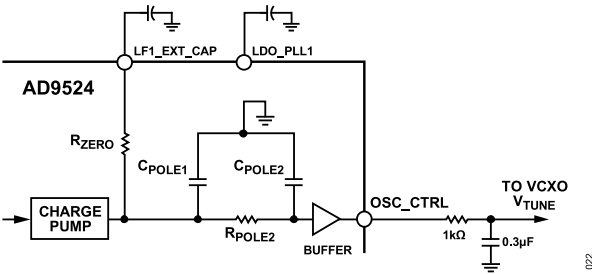


Figure 23. PLL1 Loop Filter

Table 20. PLL1 Loop Filter Programmable Values

| $R_{\text{ZERO}}$ (k $\Omega$ ) | $C_{\text{POLE1}}$ (nF) | $R_{\text{POLE2}}$ (k $\Omega$ ) | $C_{\text{POLE2}}$ (nF) | LF1_EXT_CAP <sup>1</sup> ( $\mu\text{F}$ ) |
|---------------------------------|-------------------------|----------------------------------|-------------------------|--------------------------------------------|
| 883                             | 1.5 fixed               | 165 fixed                        | 0.337 fixed             | 0.3                                        |
| 677                             |                         |                                  |                         |                                            |
| 341                             |                         |                                  |                         |                                            |
| 135                             |                         |                                  |                         |                                            |

Table 20. PLL1 Loop Filter Programmable Values (Continued)

| $R_{\text{ZERO}}$ (k $\Omega$ ) | $C_{\text{POLE1}}$ (nF) | $R_{\text{POLE2}}$ (k $\Omega$ ) | $C_{\text{POLE2}}$ (nF) | LF1_EXT_CAP <sup>1</sup> ( $\mu\text{F}$ ) |
|---------------------------------|-------------------------|----------------------------------|-------------------------|--------------------------------------------|
| 10                              |                         |                                  |                         |                                            |
| External                        |                         |                                  |                         |                                            |

<sup>1</sup> External loop filter capacitor.

An external R-C low-pass filter should be used at the OSC\_CTRL output. The values shown in [Figure 23](#) add an additional low-pass pole at ~530 Hz. This R-C network filters the noise associated with the OSC\_CTRL buffer to achieve the best noise performance at the 1 kHz offset region.

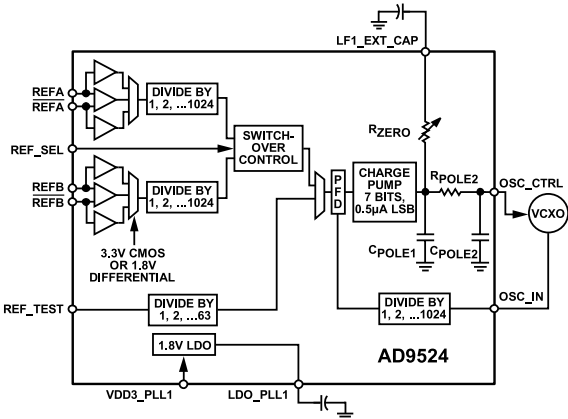


Figure 24. Input PLL (PLL1) Block Diagram

## PLL1 Input Dividers

Each reference input feeds a dedicated reference divider block. The input dividers provide division of the reference frequency in integer steps from 1 to 1023. They provide the bulk of the frequency prescaling that is necessary to reduce the reference frequency to accommodate the bandwidth that is typically desired for PLL1.

## PLL1 Reference Switchover

The reference monitor verifies the presence/absence of the pre-scaled REFA and REFB signals (that is, after division by the input dividers). The status of the reference monitor guides the activity of the switchover control logic. The AD9524 supports automatic and manual PLL reference clock switching between REFA (the REFA and  $\overline{\text{REFA}}$  pins) and REFB (the REFB and  $\overline{\text{REFB}}$  pins). This feature supports networking and infrastructure applications that require redundant references.

There are several configurable modes of reference switchover. The manual switchover is achieved either via a programming register setting or by using the REF\_SEL pin. The automatic switchover occurs when REFA disappears and there is a reference on REFB.

The reference automatic switchover can be set to work as follows:

## THEORY OF OPERATION

- Nonrevertive: stay on REFB. Switch from REFA to REFB when REFA disappears, but do not switch back to REFA if it reappears. If REFB disappears, then go back to REFA.
- Revert to REFA. Switch from REFA to REFB when REFA disappears. Return to REFA from REFB when REFA returns.

See Table 43 for the PLL1 miscellaneous control register bit settings.

### PLL1 Holdover

In the absence of both input references, the device enters holdover mode. Holdover is a secondary function that is provided by PLL1. Because PLL1 has an external VCXO available as a frequency source, it continues to operate in the absence of the input reference signals. When the device switches to holdover, the charge pump tristates. The device continues operating in this mode until a reference signal becomes available. Then the device exits holdover mode, and PLL1 resynchronizes with the active reference. In addition to tristate, the charge pump can be forced to VCC/2 during holdover (see Table 43, Bit 6 in Register 0x01C).

## COMPONENT BLOCKS—OUTPUT PLL (PLL2)

### PLL2 General Description

The output PLL (referred to as PLL2) consists of an optional input reference doubler, phase-frequency detector (PFD), a partially inte-

grated analog loop filter (see Figure 25), an integrated voltage-controlled oscillator (VCO), and a feedback divider. The VCO produces a nominal 3.8 GHz signal with an output divider that is capable of division ratios of 4 to 11.

The PFD of the output PLL drives a charge pump that increases, decreases, or holds constant the charge stored on the loop filter capacitors (both internal and external). The stored charge results in a voltage that sets the output frequency of the VCO. The feedback loop of the PLL causes the VCO control voltage to vary in a way that phase locks the PFD input signals.

The gain of PLL2 is proportional to the current delivered by the charge pump. The loop filter bandwidth is chosen to reduce noise contributions from PLL sources that could degrade phase noise requirements.

The output PLL has a VCO with multiple bands spanning a range of 3.6 GHz to 4.0 GHz. However, the actual operating frequency within a particular band depends on the control voltage that appears on the loop filter capacitor. The control voltage causes the VCO output frequency to vary linearly within the selected band. This frequency variability allows the control loop of the output PLL to synchronize the VCO output signal with the reference signal applied to the PFD. Typically, the device automatically selects the appropriate band as part of its calibration process (invoked via the VCO control register at Address 0x0F3).

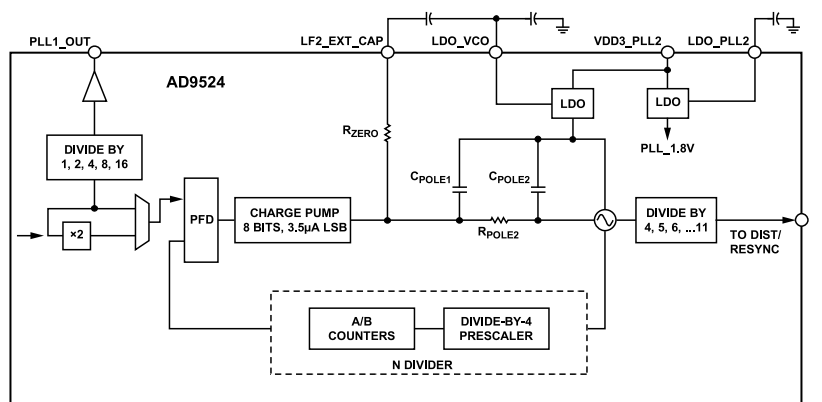


Figure 25. Output PLL (PLL2) Block Diagram

## THEORY OF OPERATION

### Input 2× Frequency Multiplier

The 2× frequency multiplier provides the option to double the frequency at the PLL input. This allows the user to take advantage of a higher frequency at the input to the PLL (PFD) and, thus, allows for reduced in-band phase noise and greater separation between the frequency generated by the PLL and the modulation spur associated with PFD. However, increased reference spur separation results in harmonic spurs introduced by the frequency multiplier that increase as the duty cycle deviates from 50% at the OSC\_IN inputs. As such, beneficial use of the frequency multiplier is application-specific. Typically, a VCXO with proper interfacing has a duty cycle that is approximately 50% at the OSC\_IN inputs. Note that the maximum output frequency of the 2× frequency multipliers must not exceed the maximum PFD rate that is specified in [Table 12](#).

### PLL2 Feedback Divider

PLL2 has a feedback divider (N divider) that enables it to provide integer frequency up-conversion. The PLL2 N divider is a combination of a prescaler (P) and two counters, A and B. The total divider value is

$$N = (P \times B) + A \quad (1)$$

where  $P = 4$ .

The feedback divider is a dual modulus prescaler architecture, with a nonprogrammable P that is equal to 4. The value of the B counter can be from 4 to 63, and the value of the A counter can be from 0 to 3. However, due to the architecture of the divider, there are constraints, as listed in [Table 46](#).

### PLL2 Loop Filter

The PLL2 loop filter requires the connection of an external capacitor from LF2\_EXT\_CAP (Pin 9) to LDO\_VCO (Pin 12), as illustrated in [Figure 25](#). The value of the external capacitor depends on the operating mode and the desired phase noise performance. For example, a loop bandwidth of approximately 500 kHz produces the lowest integrated jitter. A lower bandwidth produces lower phase noise at 1 MHz but increases the total integrated jitter.

**Table 21. PLL2 Loop Filter Programmable Values**

| R_ZERO (Ω) | C_POLE1 (pF) | R_POLE2 (Ω) | C_POLE2 (pF) | LF2_EXT_CAP <sup>1</sup> (pF) |
|------------|--------------|-------------|--------------|-------------------------------|
| 3250       | 48           | 900         | Fixed at 16  | Typical at 1000               |
| 3000       | 40           | 450         |              |                               |
| 2750       | 32           | 300         |              |                               |
| 2500       | 24           | 225         |              |                               |
| 2250       | 16           |             |              |                               |
| 2100       | 8            |             |              |                               |
| 2000       | 0            |             |              |                               |
| 1850       |              |             |              |                               |

<sup>1</sup> External loop filter capacitor.

### VCO Divider

The VCO divider provides frequency division between the internal VCO and the clock distribution. The VCO divider can be set to divide by 4, 5, 6, 7, 8, 9, 10, or 11.

### VCO Calibration

The AD9524 on-chip VCO must be manually calibrated to ensure proper operation over process and temperature. This is accomplished by setting the calibrate VCO bit (Register 0x0F3, Bit 1) to 1. (This bit is not self clearing.) The setting can be performed as part of the initial setup before executing the IO\_Update bit (Register 0x234, Bit 0 = 1). A readback bit, VCO calibration in progress (Register 0x22D, Bit 0), indicates when a VCO calibration is in progress by returning a logic true (that is, Bit 0 = 1). If the EEPROM is in use, setting the calibrate VCO bit (Register 0x0F3, Bit 1) to 1 before saving the register settings to the EEPROM ensures that the VCO calibrates automatically after the EEPROM has loaded. After calibration, it is recommended that a sync be initiated (for more information, see the [Clock Distribution Synchronization](#) section).

Note that the calibrate VCO bit defaults to 0. This bit must change from 0 to 1 to initiate a calibration sequence. Therefore, any subsequent calibrations require the following sequence:

1. Register 0x0F3, Bit 1 (calibrate VCO bit) = 0
2. Register 0x234, Bit 0 (IO\_Update bit) = 1
3. Register 0x0F3, Bit 1 (calibrate VCO bit) = 1
4. Register 0x234, Bit 0 (IO\_Update bit) = 1

VCO calibration is controlled by a calibration controller that runs off the VCXO input clock. The calibration requires that PLL2 be set up properly to lock the PLL2 loop and that the VCXO clock be present.

During power-up or reset, the distribution section is automatically held in sync until the first VCO calibration is finished. Therefore, no outputs can occur until VCO calibration is complete and PLL2 is locked.

Initiate a VCO calibration under the following conditions:

- After changing any of the PLL2 B counter and A counter settings or after a change in the PLL2 reference clock frequency. This means that a VCO calibration should be initiated any time that a PLL2 register or reference clock changes such that a different VCO frequency is the result.
- Whenever system calibration is desired. The VCO is designed to operate properly over extremes of temperature even when it is first calibrated at the opposite extreme. However, a VCO calibration can be initiated at any time, if desired.

## CLOCK DISTRIBUTION

The clock distribution block provides an integrated solution for generating multiple clock outputs based on frequency dividing the PLL2 VCO divider output. The distribution output consists of six channels (OUT0 to OUT5). Each of the output channels has a

## THEORY OF OPERATION

dedicated divider and output driver, as shown in Figure 25. The AD9524 also has the capability to route the VCXO output to two of the outputs (OUT0 and OUT1).

### Clock Dividers

The output clock distribution dividers are referred to as D0 to D5, corresponding to output channels OUT0 through OUT5, respectively. Each divider is programmable with 10 bits of division depth that is equal to 1 to 1024. Dividers have duty cycle correction to always give 50% duty cycle, even for odd divides.

### Output Power-Down

Each of the output channels offers independent control of the power-down functionality via the Channel 0 to Channel 5 control registers (see Table 52). Each output channel has a dedicated power-down bit for powering down the output driver. However, if all six outputs are powered down, the entire distribution output enters a deep sleep mode. Although each channel has a channel power-down control signal, it may sometimes be desirable to power down an output driver while maintaining the divider's synchronization with the other channel dividers. This is accomplished by placing the output in tristate mode (this works in CMOS mode, as well).

### Multimode Output Drivers

The user has independent control of the operating mode of each of the fourteen output channels via the Channel 0 to Channel 5 control registers (see Table 52). The operating mode control includes the following:

- ▶ Logic family and pin functionality
- ▶ Output drive strength
- ▶ Output polarity

The four least significant bits (LSBs) of each of the six Channel 0 to Channel 5 control registers comprise the driver mode bits. The mode value selects the desired logic family and pin functionality of an output channel, as listed in Table 52. This driver design allows a common 100  $\Omega$  external resistor for all the different driver modes of operation that are illustrated in Figure 26.

If the output channel is ac-coupled to the circuit to be clocked, changing the mode varies the voltage swing to determine sensitivity to the drive level. For example, in LVDS mode, a current of 3.5 mA causes a 350 mV peak voltage. Likewise, in LVPECL compatible mode, a current of 8 mA causes an 800 mV peak voltage at the 100  $\Omega$  load resistor. Using any termination other than those specified in the [Input/Output Termination Recommendations](#) section may result in damage or decrease end of life performance.

In addition to the four mode bits, each of the six Channel 0 to Channel 5 control registers includes the following control bits:

- ▶ Invert divider output. Enables the user to choose between normal polarity and inverted polarity. Normal polarity is the default state. Inverted polarity reverses the representation of Logic 0 and Logic 1, regardless of the logic family.
- ▶ Ignore sync. Makes the divider ignore the  $\overline{\text{SYNC}}$  signal from any source.
- ▶ Power-down channel. Powers down the entire channel.
- ▶ Lower power mode.
- ▶ Driver mode.
- ▶ Channel divider.
- ▶ Divider phase.

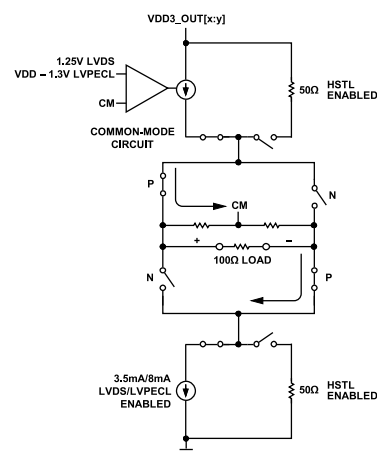


Figure 26. Multimode Driver

### Clock Distribution Synchronization

A block diagram of the clock distribution synchronization functionality is shown in Figure 27. The synchronization sequence begins with the primary synchronization signal, which ultimately results in delivery of a synchronization strobe to the clock distribution logic.

As indicated, the primary synchronization signal originates from one of the following sources:

- ▶ Direct synchronization source via the sync dividers bit (see Register 0x232, Bit 0 in Table 56)
- ▶ Device pin,  $\overline{\text{SYNC}}$  (Pin 13)

An automatic synchronization of the divider is initiated the first time that PLL2 locks after a power-up or reset event. Subsequent lock/unlock events do not initiate a resynchronization of the distribution dividers unless they are preceded by a power-down or reset of the part.

## THEORY OF OPERATION

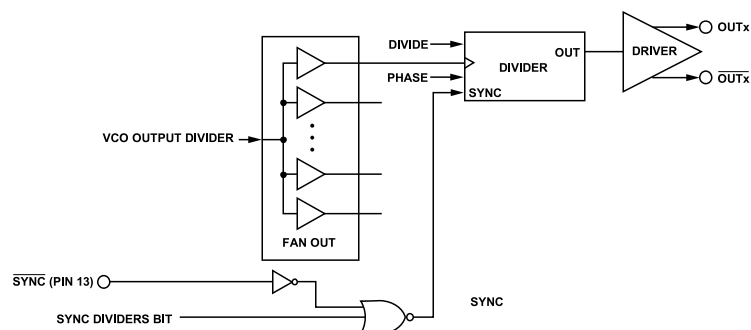


Figure 27. Clock Output Synchronization Block Diagram

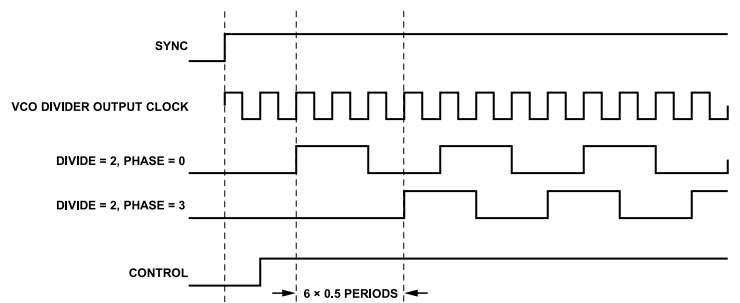


Figure 28. Clock Output Synchronization Timing Diagram

Both sources of the primary synchronization signal are logic OR'd; therefore, any one of them can synchronize the clock distribution output at any time. When using the sync dividers bit, the user first sets and then clears the bit.

The synchronization event is the clearing operation (that is, the Logic 1 to Logic 0 transition of the bit). The dividers are all automatically synchronized to each other when PLL2 is ready. The dividers support programmable phase offsets from 0 to 63 steps, in half periods of the input clock (for example, the VCO divider output clock). The phase offsets are incorporated in the dividers through a preset for the first output clock period of each divider. Phase offsets are supported only by programming the initial phase and divide value and then issuing a sync to the distribution (automatically at startup or manually, if desired).

When using the  $\overline{\text{SYNC}}$  pin (Pin 17), there are 11 VCO divider output pipe line delays plus one period of the clock from the rising edge of  $\overline{\text{SYNC}}$  to the clock output. There is at least one extra VCO divider period of uncertainty because the  $\overline{\text{SYNC}}$  signal and the VCO divider output are asynchronous.

In normal operation, the phase offsets are already programmed through the EEPROM or the SPI/I<sup>2</sup>C port before the AD9524 starts to provide outputs. Although the user cannot adjust the phase offsets while the dividers are operating, it is possible to adjust the phase of all the outputs together without powering down PLL1 and PLL2. This is accomplished by programming the new phase offset, using Bits[7:2] in Register 0x198 (see Table 52) and then issuing a

divide sync signal by using the  $\overline{\text{SYNC}}$  pin or the sync dividers bit (Register 0x232, Bit 0).

All outputs that are not programmed to ignore the sync are disabled temporarily while the sync is active. Note that, if an output is used for the zero delay path, it also disappears momentarily. However, this is desirable because it ensures that all the synchronized outputs have a deterministic phase relationship with respect to the zero delay output and, therefore, also with respect to the input.

## ZERO DELAY OPERATION

Zero delay operation aligns the phase of the output clocks with the phase of the external PLL reference input. The OUT0 output is designed to be used as the output for zero delay. There are two zero delay modes on the AD9524: internal and external (see Figure 29). Note that the external delay mode provides better matching than the internal delay mode because the output drivers are included in the zero delay path. Setting the antibacklash pulse width control of PLL1 to maximum gives the best zero delay matching.

### Internal Zero Delay Mode

The internal zero delay function of the AD9524 is achieved by feeding the output of Channel Divider 0 back to the PLL1 N divider. Bit 5 in Register 0x01B is used to select internal zero delay mode (see Table 42). In the internal zero delay mode, the output of Channel Divider 0 is routed back to the PLL1 (N divider) through a mux. PLL1 synchronizes the phase/edge of the output of Channel Divider 0 with the phase/edge of the reference input.

## THEORY OF OPERATION

Because the channel dividers are synchronized to each other, the outputs of the channel divider are synchronous with the reference input.

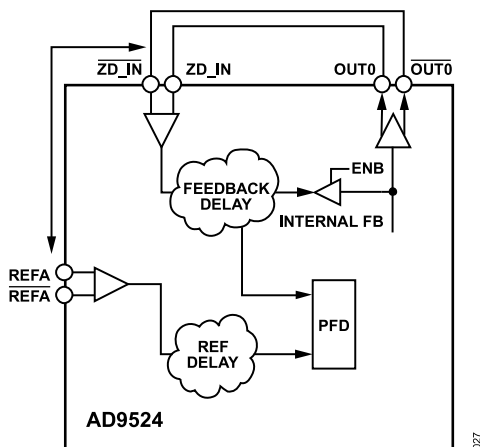


Figure 29. Zero Delay Function

### External Zero Delay Mode

The external zero delay function of the AD9524 is achieved by feeding OUT0 back to the ZD\_IN input and, ultimately, back to the PLL1 N divider. In Figure 29, the change in signal routing for external zero delay is external to the AD9524.

Bit 5 in Register 0x01B is used to select the external zero delay mode. In external zero delay mode, OUT0 must be routed back to PLL1 (the N divider) through the ZD\_IN and ZD\_IN pins.

PLL1 synchronizes the phase/edge of the feedback output clock with the phase/edge of the reference input. Because the channel dividers are synchronized to each other, the clock outputs are synchronous with the reference input. Both the reference path delay and the feedback delay from ZD\_IN are designed to have the same propagation delay from the output drivers and PLL components to minimize the phase offset between the clock output and the reference input to achieve zero delay.

### LOCK DETECT

PLL1 and PLL2 lock detectors issue an unlock condition when the frequency error is greater than the threshold of the lock detector. When the PLL is unlocked, there is a random phase between the reference clock and feedback clock. Due to the random phase relationship that exists the unlock condition could take between  $2^{15} \times T_{PFD}$  cycles to  $1 \times T_{PFD}$  cycles. For a lock condition it will always take  $2^{16} \times T_{PFD}$  to lock, but it could potentially take  $2^{31} \times T_{PFD}$  cycles depending on how big the phase jump is and when it occurs in relation to the lock detect restart.

## RESET MODES

The AD9524 has a power-on reset (POR) and several other ways to apply a reset condition to the chip.

### Power-On Reset

During chip power-up, a power-on reset pulse is issued when 3.3 V supply reaches  $\sim 2.6$  V ( $< 2.8$  V) and restores the chip either to the setting stored in EEPROM (EEPROM pin = 1) or to the on-chip setting (EEPROM pin = 0). At power-on, the AD9524 executes a SYNC operation, which brings the outputs into phase alignment according to the default settings. The output drivers are held in sync for the duration of the internally generated power-up sync timer ( $\sim 70$  ms). The outputs begin to toggle after this period.

### Reset Via the RESET Pin

$\overline{\text{RESET}}$ , a reset (an asynchronous hard reset is executed by briefly pulling  $\overline{\text{RESET}}$  low), restores the chip either to the setting stored in EEPROM (EEPROM pin = 1) or to the on-chip setting (EEPROM pin = 0). A reset also executes a sync operation, which brings the outputs into phase alignment according to the default settings. When EEPROM is inactive (EEPROM pin = 0), it takes  $\sim 2$   $\mu$ s for the outputs to begin toggling after  $\overline{\text{RESET}}$  is issued. When EEPROM is active (EEPROM pin = 1), it takes  $\sim 40$  ms for the outputs to toggle after  $\overline{\text{RESET}}$  is brought high.

### Reset Via the Serial Port

The serial port control register allows for a reset by setting Bit 2 and Bit 5 in Register 0x000. When Bit 5 and Bit 2 are set, the chip enters a reset mode and restores the chip either to the setting stored in EEPROM (EEPROM pin = 1) or to the on-chip setting (EEPROM pin = 0), except for Register 0x000. Except for the self clearing bits, Bit 2 and Bit 5, Register 0x000 retains its previous value prior to reset. During the internal reset, the outputs hold static. Bit 2 and Bit 5 are self clearing. However, the self clearing operation does not complete until an additional serial port SCLK cycle completes, and the AD9524 is held in reset until Bit 2 and Bit 5 self clear.

### Reset to Settings in EEPROM When EEPROM Pin = 0 Via the Serial Port

The serial port control register allows the chip to be reset to settings in EEPROM when the EEPROM pin = 1 via Register 0xB02, Bit 1. This bit is self clearing. This bit does not have any effect when the EEPROM pin = 0. It takes  $\sim 40$  ms for the outputs to begin toggling after the Soft\_EEPROM register is cleared.

## THEORY OF OPERATION

### POWER-DOWN MODE

#### Chip Power-Down Via $\overline{\text{PD}}$

Place the AD9524 into a power-down mode by pulling the  $\overline{\text{PD}}$  pin low. Power-down turns off most of the functions and currents inside

the AD9524. The chip remains in this power-down state until  $\overline{\text{PD}}$  is returned to a logic high state. When taken out of power-down mode, the AD9524 returns to the settings programmed into its registers prior to the power-down, unless the registers are changed by new programming while the  $\overline{\text{PD}}$  pin is held low.

## SERIAL CONTROL PORT

The AD9524 serial control port is a flexible, synchronous serial communications port that allows an easy interface with many industry-standard microcontrollers and microprocessors. The AD9524 serial control port is compatible with most synchronous transfer formats, including Philips I<sup>2</sup>C®, Motorola® SPI, and Intel® SSR protocols. The AD9524 I<sup>2</sup>C implementation deviates from the classic I<sup>2</sup>C specification in two specifications, and these deviations are documented in Table 16 of this data sheet. The serial control port allows read/write access to all registers that configure the AD9524.

## SPI/I<sup>2</sup>C PORT SELECTION

The AD9524 has two serial interfaces, SPI and I<sup>2</sup>C. Users can select either the SPI or I<sup>2</sup>C, depending on the states (logic high, logic low) of the two logic level input pins, SP1 and SP0, when power is applied or after a RESET (each pin has an internal 40 kΩ pull-down resistor). When both SP1 and SP0 are low, the SPI interface is active. Otherwise, I<sup>2</sup>C is active with three different I<sup>2</sup>C subordinate address settings (seven bits wide), as shown in Table 22. The five MSBs of the subordinate address are hardware coded as 11000, and the two LSBs are determined by the logic levels of the SP1 and SP0 pins.

Table 22. Serial Port Mode Selection

| SP1  | SP0  | Address                   |
|------|------|---------------------------|
| Low  | Low  | SPI                       |
| Low  | High | I <sup>2</sup> C: 1100000 |
| High | Low  | I <sup>2</sup> C: 1100001 |
| High | High | I <sup>2</sup> C: 1100010 |

## I<sup>2</sup>C SERIAL PORT OPERATION

The AD9524 I<sup>2</sup>C port is based on the I<sup>2</sup>C fast mode standard. The AD9524 supports both I<sup>2</sup>C protocols: standard mode (100 kHz) and fast mode (400 kHz).

The AD9524 I<sup>2</sup>C port has a 2-wire interface consisting of a serial data line (SDA) and a serial clock line (SCL). In an I<sup>2</sup>C bus system, the AD9524 is connected to the serial bus (data bus SDA and clock bus SCL) as a subordinate device, meaning that no clock is generated by the AD9524. The AD9524 uses direct 16-bit (two bytes) memory addressing instead of traditional 8-bit (one byte) memory addressing.

## I<sup>2</sup>C Bus Characteristics

Table 23. I<sup>2</sup>C Bus Definitions

| Abbreviation | Definition     |
|--------------|----------------|
| S            | Start          |
| Sr           | Repeated start |
| P            | Stop           |
| A            | Acknowledge    |
| $\bar{A}$    | No acknowledge |
| W            | Write          |
| R            | Read           |

One pulse on the SCL clock line is generated for each data bit that is transferred.

The data on the SDA line must not change during the high period of the clock. The state of the data line can change only when the clock on the SCL line is low.

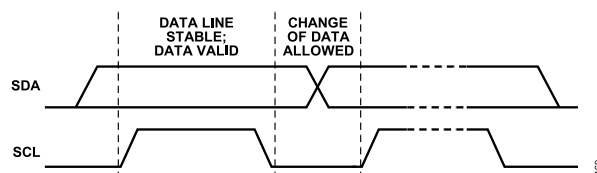


Figure 30. Valid Bit Transfer

A start condition is a transition from high to low on the SDA line while SCL is high. The start condition is always generated by the main to initialize the data transfer.

A stop condition is a transition from low to high on the SDA line while SCL is high. The stop condition is always generated by the main to end the data transfer.

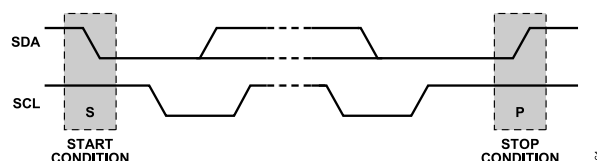


Figure 31. Start and Stop Conditions

A byte on the SDA line is always eight bits long. An acknowledge bit must follow every byte. Bytes are sent MSB first.

## SERIAL CONTROL PORT

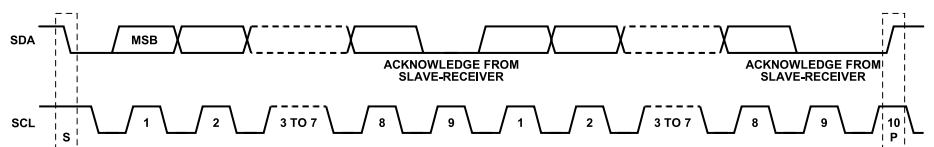


Figure 32. Acknowledge Bit

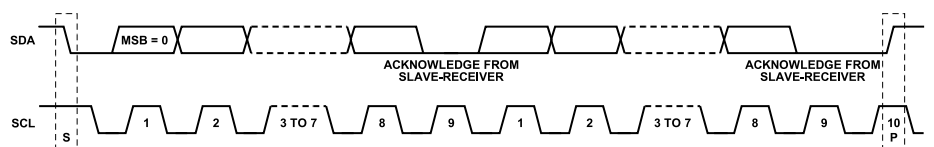


Figure 33. Data Transfer Process (Main Write Mode, 2-Byte Transfer Used for Illustration)

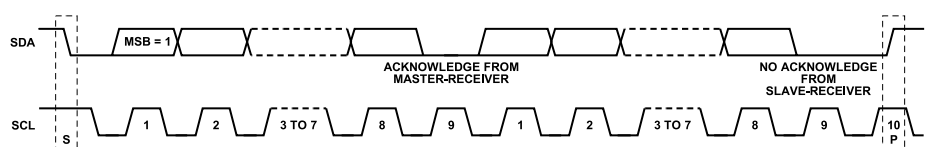


Figure 34. Data Transfer Process (Main Read Mode, 2-Byte Transfer Used for Illustration)

The acknowledge bit is the ninth bit attached to any 8-bit data byte. An acknowledge bit is always generated by the receiving device (receiver) to inform the transmitter that the byte has been received. It is accomplished by pulling the SDA line low during the ninth clock pulse after each 8-bit data byte.

The no acknowledge bit is the ninth bit attached to any 8-bit data byte. A no acknowledge bit is always generated by the receiving device (receiver) to inform the transmitter that the byte has not been received. It is accomplished by leaving the SDA line high during the ninth clock pulse after each 8-bit data byte.

### Data Transfer Process

The main initiates data transfer by asserting a start condition. This indicates that a data stream follows. All I<sup>2</sup>C subordinate devices connected to the serial bus respond to the start condition.

The main then sends an 8-bit address byte over the SDA line, consisting of a 7-bit subordinate address (MSB first), plus an R/W bit. This bit determines the direction of the data transfer, that is, whether data is written to or read from the subordinate device (0 = write, 1 = read).

The peripheral whose address corresponds to the transmitted address responds by sending an acknowledge bit. All other devices on the bus remain idle while the selected device waits for data to be read from or written to it. If the R/W bit is 0, the main (transmitter) writes to the subordinate device (receiver). If the R/W bit is 1, the main (receiver) reads from the subordinate device (transmitter). The format for these commands is described in the [Data Transfer Format](#) section.

Data is then sent over the serial bus in the format of nine clock pulses: one data byte (eight bits) from either main (write mode)

or subordinate (read mode), followed by an acknowledge bit from the receiving device. The number of bytes that can be transmitted per transfer is unrestricted. In write mode, the first two data bytes immediately after the subordinate address byte are the internal memory (control registers) address bytes with the high address byte first. This addressing scheme gives a memory address of up to  $2^{16} - 1 = 65,535$ . The data bytes after these two memory address bytes are register data written into the control registers. In read mode, the data bytes after the subordinate address byte are register data read from the control registers. A single I<sup>2</sup>C transfer can contain multiple data bytes that can be read from or written to control registers whose address is automatically incremented starting from the base memory address.

When all data bytes are read or written, stop conditions are established. In write mode, the main (transmitter) asserts a stop condition to end data transfer during the 10th clock pulse following the acknowledge bit for the last data byte from the subordinate device (receiver). In read mode, the main device (receiver) receives the last data byte from the subordinate device (transmitter) but does not pull it low during the ninth clock pulse. This is known as a no acknowledge bit. Upon receiving the no acknowledge bit, the subordinate device knows that the data transfer is finished and releases the SDA line. The main then takes the data line low during the low period before the 10th clock pulse and high during the 10th clock pulse to assert a stop condition.

A repeated start (Sr) condition can be used in place of a stop condition. Furthermore, a start or stop condition can occur at any time, and partially transferred bytes are discarded.

For an I<sup>2</sup>C data write transfer containing multiple data bytes, the peripheral drives a no acknowledge for the data byte that follows a write to Register 0x234, thereby ending the I<sup>2</sup>C transfer. For an

# SERIAL CONTROL PORT

I<sup>2</sup>C data read transfer containing multiple data bytes, the peripheral drives data bytes of 0x00 for subsequent reads that follow a read from Register 0x234.

## Data Transfer Format

Send byte format. The send byte protocol is used to set up the register address for subsequent commands.

|   |                     |   |   |                       |   |                      |   |   |
|---|---------------------|---|---|-----------------------|---|----------------------|---|---|
| S | Subordinate Address | W | A | RAM Address High Byte | A | RAM Address Low Byte | A | P |
|---|---------------------|---|---|-----------------------|---|----------------------|---|---|

Write byte format. The write byte protocol is used to write a register address to the RAM, starting from the specified RAM address.

|   |                     |   |   |                       |   |                      |   |            |   |            |   |            |   |   |
|---|---------------------|---|---|-----------------------|---|----------------------|---|------------|---|------------|---|------------|---|---|
| S | Subordinate Address | W | A | RAM Address High Byte | A | RAM Address Low Byte | A | RAM Data 0 | A | RAM Data 1 | A | RAM Data 2 | A | P |
|---|---------------------|---|---|-----------------------|---|----------------------|---|------------|---|------------|---|------------|---|---|

Receive byte format. The receive byte protocol is used to read the data byte(s) from the RAM, starting from the current address.

|   |                     |   |   |            |   |            |   |            |           |   |
|---|---------------------|---|---|------------|---|------------|---|------------|-----------|---|
| S | Subordinate Address | R | A | RAM Data 0 | A | RAM Data 1 | A | RAM Data 2 | $\bar{A}$ | P |
|---|---------------------|---|---|------------|---|------------|---|------------|-----------|---|

Read byte format. The combined format of the send byte and the receive byte.

|   |                     |   |   |                       |   |                      |   |    |                     |   |   |            |   |            |   |            |           |   |
|---|---------------------|---|---|-----------------------|---|----------------------|---|----|---------------------|---|---|------------|---|------------|---|------------|-----------|---|
| S | Subordinate Address | W | A | RAM Address High Byte | A | RAM Address Low Byte | A | Sr | Subordinate Address | R | A | RAM Data 0 | A | RAM Data 1 | A | RAM Data 2 | $\bar{A}$ | P |
|---|---------------------|---|---|-----------------------|---|----------------------|---|----|---------------------|---|---|------------|---|------------|---|------------|-----------|---|

## I<sup>2</sup>C Serial Port Timing

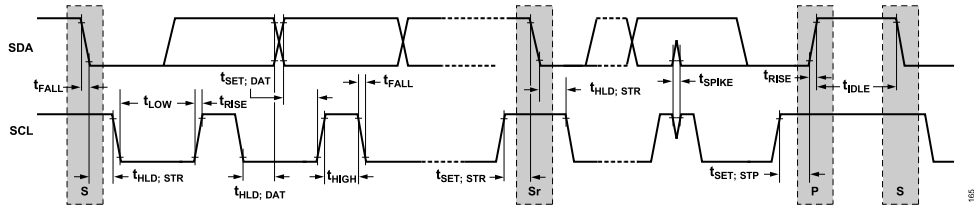


Figure 35. I<sup>2</sup>C Serial Port Timing

Table 24. I<sup>2</sup>C Timing Definitions

| Parameter             | Description                                                           |
|-----------------------|-----------------------------------------------------------------------|
| f <sub>I2C</sub>      | I <sup>2</sup> C clock frequency                                      |
| t <sub>IDLE</sub>     | Bus idle time between stop and start conditions                       |
| t <sub>HLD; STR</sub> | Hold time for repeated start condition                                |
| t <sub>SET; STR</sub> | Setup time for repeated start condition                               |
| t <sub>SET; STP</sub> | Setup time for stop condition                                         |
| t <sub>HLD; DAT</sub> | Hold time for data                                                    |
| t <sub>SET; DAT</sub> | Setup time for data                                                   |
| t <sub>LOW</sub>      | Duration of SCL clock low                                             |
| t <sub>HIGH</sub>     | Duration of SCL clock high                                            |
| t <sub>RISE</sub>     | SCL/SDA rise time                                                     |
| t <sub>FALL</sub>     | SCL/SDA fall time                                                     |
| t <sub>SPIKE</sub>    | Voltage spike pulse width that must be suppressed by the input filter |

## SERIAL CONTROL PORT

### SPI SERIAL PORT OPERATION

#### Pin Descriptions

SCLK (serial clock) is the serial shift clock. This pin is an input. SCLK is used to synchronize serial control port reads and writes. Write data bits are registered on the rising edge of this clock, and read data bits are registered on the falling edge. This pin is internally pulled down by a 40 k $\Omega$  resistor to ground.

SDIO (serial data input/output) is a dual-purpose pin and acts either as an input only (unidirectional mode) or as an input/ output (bidirectional mode). The AD9524 defaults to the bidirectional I/O mode.

SDO (serial data out) is used only in the unidirectional I/O mode as a separate output pin for reading back data.  $\overline{CS}$  (chip select bar) is an active low control that gates the read and write cycles. When  $\overline{CS}$  is high, the SDO and SDIO pins enter a high impedance state. This pin is internally pulled up by a 40 k $\Omega$  resistor to VDD3\_REF.

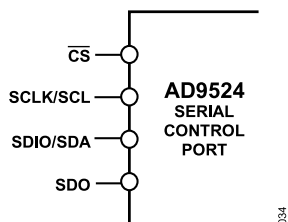


Figure 36. Serial Control Port

#### SPI Mode Operation

In SPI mode, single or multiple byte transfers are supported, as well as MSB first or LSB first transfer formats. The AD9524 serial control port can be configured for a single bidirectional I/O pin (SDIO only) or for two unidirectional I/O pins (SDIO/ SDO). By default, the AD9524 is in bidirectional mode. Short instruction mode (8-bit instructions) is not supported. Only long (16-bit) instruction mode is supported. A write or a read operation to the AD9524 is initiated by pulling  $\overline{CS}$  low.

The  $\overline{CS}$  stalled high mode is supported in data transfers where three or fewer bytes of data (plus instruction data) are transferred (see Table 25). In this mode, the  $\overline{CS}$  pin can temporarily return high on any byte boundary, allowing time for the system controller to process the next byte.  $\overline{CS}$  can go high only on byte boundaries; however, it can go high during either phase (instruction or data) of the transfer.

During this period, the serial control port state machine enters a wait state until all data is sent. If the system controller decides to abort the transfer before all of the data is sent, the state machine must be reset either by completing the remaining transfers or by returning  $\overline{CS}$  low for at least one complete SCLK cycle (but fewer than eight SCLK cycles). Raising the  $\overline{CS}$  pin on a nonbyte boundary terminates the serial transfer and flushes the buffer.

In streaming mode (see Table 25), any number of data bytes can be transferred in a continuous stream. The register address is automatically incremented or decremented (see the SPI MSB/LSB First Transfers section).  $\overline{CS}$  must be raised at the end of the last byte to be transferred, thereby ending streaming mode.

#### Communication Cycle—Instruction Plus Data

There are two parts to a communication cycle with the AD9524. The first part writes a 16-bit instruction word into the AD9524, coincident with the first 16 SCLK rising edges. The instruction word provides the AD9524 serial control port with information regarding the data transfer, which is the second part of the communication cycle. The instruction word defines whether the upcoming data transfer is a read or a write, the number of bytes in the data transfer, and the starting register address for the first byte of the data transfer.

#### Write

If the instruction word is for a write operation, the second part is the transfer of data into the serial control port buffer of the AD9524. Data bits are registered on the rising edge of SCLK.

The length of the transfer (one, two, or three bytes or streaming mode) is indicated by two bits (W1, W0) in the instruction byte. When the transfer is one, two, or three bytes, but not streaming,  $\overline{CS}$  can be raised after each sequence of eight bits to stall the bus (except after the last byte, where it ends the cycle). When the bus is stalled, the serial transfer resumes when  $\overline{CS}$  is lowered. Raising the  $\overline{CS}$  pin on a nonbyte boundary resets the serial control port. During a write, streaming mode does not skip over reserved or blank registers, and the user can write 0x00 to the reserved register addresses.

Because data is written into a serial control port buffer area, and not directly into the actual control registers of the AD9524, an additional operation is needed to transfer the serial control port buffer contents to the actual control registers of the AD9524, thereby causing them to become active. The update registers operation consists of setting the self clearing IO\_Update bit, Bit 0 of Register 0x234 (see Table 58). Any number of data bytes can be changed before executing an update registers operation. The update registers simultaneously actuates all register changes that have been written to the buffer since any previous update.

#### Read

The AD9524 supports only the long instruction mode. If the instruction word is for a read operation, the next N  $\times$  8 SCLK cycles clock out the data from the address specified in the instruction word, where N is 1 to 3 as determined by Bits[W1:W0]. If N = 4, the read operation is in streaming mode, continuing until  $\overline{CS}$  is raised. During an SPI read, serial data on SDIO (or SDO in the case of 4-wire mode) transitions on the SCLK falling edge, and is normally sampled on the SCLK rising edge. To read the last bit correctly, the

## SERIAL CONTROL PORT

SPI host must be able to tolerate a zero hold time. In cases where zero hold time is not possible, the user can either use streaming mode and delay the rising edge of  $\overline{CS}$ , or sample the serial data on the SCLK falling edge. However, to sample the data correctly on the SCLK falling edge, the user must ensure that the setup time is greater than  $t_{DV}$  (time data valid). Streaming mode does not skip over reserved or blank registers.

The default mode of the AD9524 serial control port is the bidirectional mode. In bidirectional mode, both the sent data and the readback data appear on the SDIO pin. It is also possible to set the AD9524 to unidirectional mode. In unidirectional mode, the readback data appears on the SDO pin.

A readback request reads the data that is in the serial control port buffer area or the data that is in the active registers (see Figure 37).

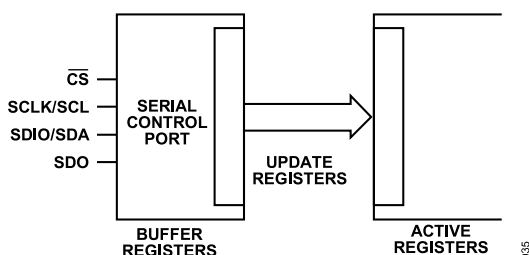


Figure 37. Relationship Between Serial Control Port Buffer Registers and Active Registers

## SPI INSTRUCTION WORD (16 BITS)

The MSB of the instruction word is  $R/\overline{W}$ , which indicates whether the instruction is a read or a write. The next two bits ( $[W1:W0]$ ) indicate the length of the transfer in bytes. The final 13 bits are the address ( $[A12:A0]$ ) at which to begin the read or write operation.

For a write, the instruction word is followed by the number of bytes of data indicated by Bits  $[W1:W0]$  (see Table 25).

Table 25. Byte Transfer Count

| W1 | W0 | Bytes to Transfer |
|----|----|-------------------|
| 0  | 0  | 1                 |
| 0  | 1  | 2                 |
| 1  | 0  | 3                 |
| 1  | 1  | Streaming mode    |

Bits  $[A12:A0]$  select the address within the register map that is written to or read from during the data transfer portion of the communications cycle. Only Bits  $[A11:A0]$  are needed to cover the range of the 0x234 registers used by the AD9524. Bit A12 must

Table 27. Serial Control Port, 16-Bit Instruction Word, MSB First

| MSB               |     |     |         |     |     |    |    |    |    |    |    |    |    |    | LSB |
|-------------------|-----|-----|---------|-----|-----|----|----|----|----|----|----|----|----|----|-----|
| I15               | I14 | I13 | I12     | I11 | I10 | I9 | I8 | I7 | I6 | I5 | I4 | I3 | I2 | I1 | I0  |
| R/ $\overline{W}$ | W1  | W0  | A12 = 0 | A11 | A10 | A9 | A8 | A7 | A6 | A5 | A4 | A3 | A2 | A1 | A0  |

always be 0. For multibyte transfers, this address is the starting byte address. In MSB first mode, subsequent bytes decrement the address.

## SPI MSB/LSB FIRST TRANSFERS

The AD9524 instruction word and byte data can be MSB first or LSB first. Any data written to Register 0x000 must be mirrored: Bit 7 is mirrored to Bit 0, Bit 6 to Bit 1, Bit 5 to Bit 2, and Bit 4 to Bit 3. This makes it irrelevant whether LSB first or MSB first is in effect. The default for the AD9524 is MSB first.

When LSB first is set by Register 0x000, Bit 1 and Register 0x000, Bit 6, it takes effect immediately because it affects only the operation of the serial control port and does not require that an update be executed.

When MSB first mode is active, the instruction and data bytes must be written from MSB to LSB. Multibyte data transfers in MSB first format start with an instruction byte that includes the register address of the most significant data byte. Subsequent data bytes must follow in order from the high address to the low address. In MSB first mode, the serial control port internal address generator decrements for each data byte of the multibyte transfer cycle.

When LSB first mode is active, the instruction and data bytes must be written from LSB to MSB. Multibyte data transfers in LSB first format start with an instruction byte that includes the register address of the least significant data byte, followed by multiple data bytes. In a multibyte transfer cycle, the internal byte address generator of the serial port increments for each byte.

The AD9524 serial control port register address decrements from the register address just written toward 0x000 for multibyte I/O operations if the MSB first mode is active (default). If the LSB first mode is active, the register address of the serial control port increments from the address just written toward 0x234 for multibyte I/O operations. Unused addresses are not skipped for these operations.

For multibyte accesses that cross Address 0x234 or Address 0x000 in MSB first mode, the SPI internally disables writes to subsequent registers and returns zeros for reads to subsequent registers.

Streaming mode always terminates when crossing address boundaries (as shown in Table 26).

Table 26. Streaming Mode (No Addresses Are Skipped)

| Write Mode | Address Direction | Stop Sequence           |
|------------|-------------------|-------------------------|
| MSB First  | Decrement         | ..., 0x001, 0x000, stop |

SERIAL CONTROL PORT

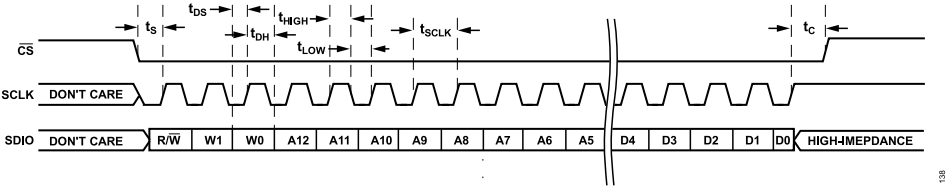


Figure 38. Serial Control Port Read—MSB First, 16-Bit Instruction, One Byte of Data

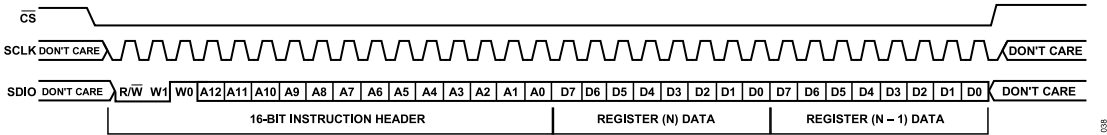


Figure 39. Serial Control Port Write—MSB First, 16-Bit Instruction, Two Bytes of Data

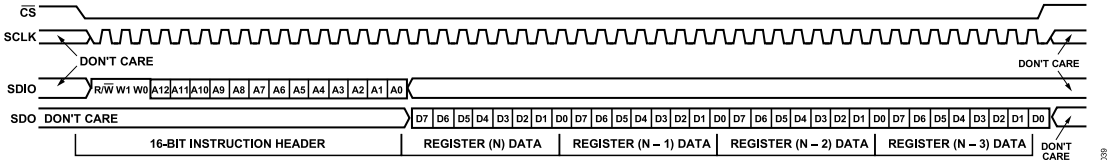


Figure 40. Serial Control Port Read—MSB First, 16-Bit Instruction, Four Bytes of Data

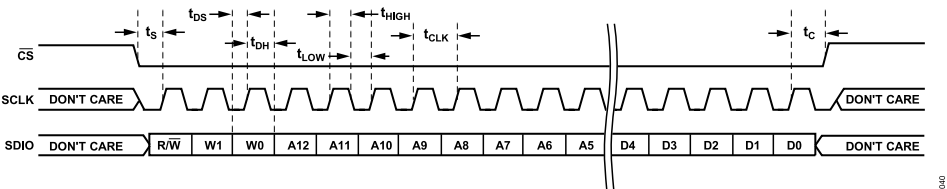


Figure 41. Serial Control Port Write—MSB First, 16-Bit Instruction, Timing Measurements

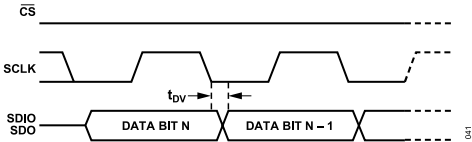


Figure 42. Timing Diagram for Serial Control Port Register Read

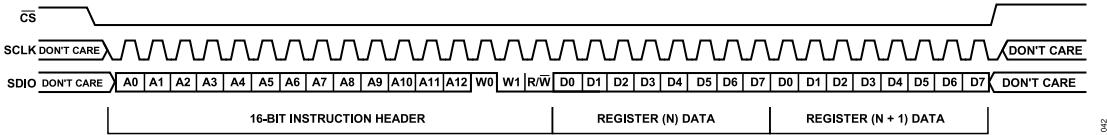


Figure 43. Serial Control Port Write—LSB First, 16-Bit Instruction, Two Bytes of Data

## SERIAL CONTROL PORT

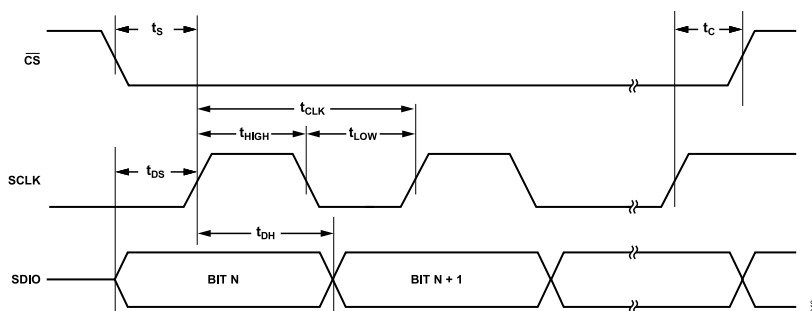


Figure 44. Serial Control Port Timing—Write

Table 28. Serial Control Port Timing

| Parameter  | Description                                                                                             |
|------------|---------------------------------------------------------------------------------------------------------|
| $t_{DS}$   | Setup time between data and rising edge of SCLK                                                         |
| $t_{DH}$   | Hold time between data and rising edge of SCLK                                                          |
| $t_{CLK}$  | Period of the clock                                                                                     |
| $t_s$      | Setup time between the $\overline{CS}$ falling edge and SCLK rising edge (start of communication cycle) |
| $t_c$      | Setup time between the SCLK rising edge and $\overline{CS}$ rising edge (end of communication cycle)    |
| $t_{HIGH}$ | Minimum period that SCLK should be in a logic high state                                                |
| $t_{LOW}$  | Minimum period that SCLK should be in a logic low state                                                 |
| $t_{DV}$   | SCLK to valid SDIO and SDO (see Figure 42)                                                              |

## EEPROM OPERATIONS

The AD9524 contains an internal EEPROM (nonvolatile memory). The EEPROM can be programmed by the user to create and store a user defined register setting file when the power is off. This setting file can be used for power-up and chip reset as a default setting. The EEPROM size is 512 bytes. Descriptions of the EEPROM registers that control EEPROM operation can be found in [Table 59](#) and [Table 60](#).

During the data transfer process, the write and read registers are generally not available via the serial port, except for one readback bit: Status\_EEPROM (Register 0xB00, Bit 0).

To determine the data transfer state through the serial port in SPI mode, users can read the value of the Status\_EEPROM bit (1 = data transfer in process and 0 = data transfer complete).

In I<sup>2</sup>C mode, the user can address the AD9524 subordinate port with the external I<sup>2</sup>C main (send an address byte to the AD9524). If the AD9524 responds with a no acknowledge bit, the data transfer was not received. If the AD9524 responds with an acknowledge bit, the data transfer process is complete. The user can monitor the Status\_EEPROM bit or use Register 0x232, Bit 4 to program the STATUS0 pin to monitor the status of the data transfer (see [Table 56](#)).

To transfer all 512 bytes to the EEPROM, it takes approximately 46 ms. To transfer the contents of the EEPROM to the active register, it takes approximately 40 ms.

**RESET**, a hard reset (an asynchronous hard reset is executed by briefly pulling **RESET** low), restores the chip either to the setting stored in EEPROM (the EEPROM pin = 1) or to the on-chip setting (the EEPROM pin = 0). A hard reset also executes a SYNC operation, which brings the outputs into phase alignment according to the default settings. When EEPROM is inactive (the EEPROM pin = 0), it takes ~2  $\mu$ s for the outputs to begin toggling after **RESET** is issued. When EEPROM is active (the EEPROM pin = 1), it takes ~40 ms for the outputs to toggle after **RESET** is brought high.

### WRITING TO THE EEPROM

The EEPROM cannot be programmed directly through the serial port interface. To program the EEPROM and store a register setting file, follow these steps:

1. Program the AD9524 registers to the desired circuit state. If the user wants PLL2 to lock automatically after power-up, the calibrate VCO bit (Bit 1, Register 0x0F3) must be set to 1. This allows VCO calibration to start automatically after register loading. Note that a valid input reference signal must be present during VCO calibration.
2. Set the IO\_Update bit (Bit 0, Register 0x234) to 1.
3. Program the EEPROM buffer registers, if necessary (see the [Programming the EEPROM Buffer Segment](#) section). This step is necessary only if users want to use the EEPROM to control the default settings of some (but not all) of the AD9524

registers, or if they want to control the register setting update sequence during power-up or chip reset.

4. Set the enable EEPROM write bit (Bit 0, Register 0xB02) to 1 to enable the EEPROM.
  5. Set the REG2EEPROM bit (Bit 0, Register 0xB03) to 1. This starts the process of writing data into the EEPROM to create the EEPROM setting file. This enables the EEPROM controller to transfer the current register values, as well as the memory address and instruction bytes from the EEPROM buffer segment, into the EEPROM. After the write process is completed, the internal controller sets bit REG2EEPROM back to 0.
- Bit 0 of the Status\_EEPROM register (Register 0xB00) is used to indicate the data transfer status between the EEPROM and the control registers (1 = data transfer in process, and 0 = data transfer complete). At the beginning of the data transfer, the Status\_EEPROM bit is set to 1 by the EEPROM controller and cleared to 0 at the end of the data transfer. The user can access Status\_EEPROM via the STATUS0 pin when the STATUS0 pin is programmed to monitor the Status\_EEPROM bit. Alternatively, the user can monitor the Status\_EEPROM bit directly.
6. When the data transfer is complete (Status\_EEPROM = 0), set the enable EEPROM write bit (Bit 0 in Register 0xB02) to 0. Clearing the enable EEPROM write bit to 0 disables writing to the EEPROM.

To ensure that the data transfer has completed correctly, verify that the EEPROM data error bit (Bit 0 in Register 0xB01) = 0. A value of 1 in this bit indicates a data transfer error.

### READING FROM THE EEPROM

The following reset-related events can start the process of restoring the settings stored in the EEPROM to the control registers. When the EEPROM\_SEL pin is set high, do any of the following to initiate an EEPROM read:

- Power up the AD9524.
- Perform a hardware chip reset by pulling the **RESET** pin low and then releasing **RESET**.
- Set the self clearing soft reset bit (Bit 5, Register 0x000) to 1.

When the EEPROM\_SEL pin is set low, set the self clearing Soft\_EEPROM bit (Bit 1, Register 0xB02) to 1. The AD9524 then starts to read the EEPROM and loads the values into the AD9524 registers. If the EEPROM\_SEL pin is low during reset or power-up, the EEPROM is not active, and the AD9524 default values are loaded instead.

When using the EEPROM to automatically load the AD9524 register values and lock the PLL, the calibrate VCO bit (Bit 1, Register 0x0F3) must be set to 1 when the register values are written to the EEPROM. This allows VCO calibration to start automatically after register loading. A valid input reference signal must be present during VCO calibration.

## EEPROM OPERATIONS

To ensure that the data transfer has completed correctly, verify that the EEPROM data error bit (Bit 0 in Register 0xB01) is set to 0. A value of 1 in this bit indicates a data transfer error.

### PROGRAMMING THE EEPROM BUFFER SEGMENT

The EEPROM buffer segment is a register space that allows the user to specify which groups of registers are stored to the EEPROM during EEPROM programming. Normally, this segment does not need to be programmed by the user. Instead, the default power-up values for the EEPROM buffer segment allow the user to store all of the register values from Register 0x000 to Register 0x234 to the EEPROM.

For example, if the user wants to load only the output driver settings from the EEPROM without disturbing the PLL register settings currently stored in the EEPROM, the EEPROM buffer segment can be modified to include only the registers that apply to the output drivers and exclude the registers that apply to the PLL configuration.

There are two parts to the EEPROM buffer segment: register section definition groups and operational codes. Each register section definition group contains the starting address and number of bytes to be written to the EEPROM.

If the AD9524 register map were continuous from Address 0x000 to Address 0x234, only one register section definition group would consist of a starting address of 0x000 and a length of 563 bytes. However, this is not the case. The AD9524 register map is noncontiguous, and the EEPROM is only 512 bytes long. Therefore, the register section definition group tells the EEPROM controller how the AD9524 register map is segmented.

There are three operational codes: IO\_Update, end-of-data, and pseudo-end-of-data. It is important that the EEPROM buffer segment always have either an end-of-data or a pseudo-end-of-data operational code and that an IO\_Update operation code appear at least once before the end-of-data operational code.

### Register Section Definition Group

The register section definition group is used to define a continuous register section for the EEPROM profile. It consists of three bytes. The first byte defines how many continuous register bytes are in this group. If the user puts 0x000 in the first byte, it means there is only one byte in this group. If the user puts 0x001, it means there are two bytes in this group. The maximum number of registers in one group is 128.

**Table 29. Example of an EEPROM Buffer Segment**

| Register Address (Hex)      | Bit 7 (MSB)                                          | Bit 6                                                        | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 (LSB) |
|-----------------------------|------------------------------------------------------|--------------------------------------------------------------|-------|-------|-------|-------|-------|-------------|
| Start EEPROM Buffer Segment |                                                      |                                                              |       |       |       |       |       |             |
| 0xA00                       | 0                                                    | Number of bytes of the first group of registers (Bits[6:0])  |       |       |       |       |       |             |
| 0xA01                       | Address of the first group of registers (Bits[15:8]) |                                                              |       |       |       |       |       |             |
| 0xA02                       | Address of the first group of registers (Bits[7:0])  |                                                              |       |       |       |       |       |             |
| 0xA03                       | 0                                                    | Number of bytes of the second group of registers (Bits[6:0]) |       |       |       |       |       |             |

The next two bytes are the high byte and low byte of the memory address (16 bits) of the first register in this group.

### IO\_Update (Operational Code 0x80)

The EEPROM controller uses this operational code to generate an IO\_Update signal to update the active control register bank from the buffer register bank during the download process.

At a minimum, there should be at least one IO\_Update operational code after the end of the final register section definition group. This is needed so that at least one IO\_Update occurs after all of the AD9524 registers are loaded when the EEPROM is read. If this operational code is absent during a write to the EEPROM, the register values loaded from the EEPROM are not transferred to the active register space, and these values do not take effect after they are loaded from the EEPROM to the AD9524.

### End-of-Data (Operational Code 0xFF)

The EEPROM controller uses this operational code to terminate the data transfer process between EEPROM and the control register during the upload and download process. The last item appearing in the EEPROM buffer segment should be either this operational code or the pseudo-end-of-data operational code.

### Pseudo-End-of-Data (Operational Code 0xFE)

The AD9524 EEPROM buffer segment has 23 bytes that can contain up to seven register section definition groups. If users want to define more than seven register section definition groups, the pseudo-end-of-data operational code can be used. During the upload process, when the EEPROM controller receives the pseudo-end-of-data operational code, it halts the data transfer process, clears the REG2EEPROM bit (Bit 0, Register 0xB03), and enables the AD9524 serial port. Users can then program the EEPROM buffer segment again and reinitiate the data transfer process by setting the REG2EEPROM bit to 1 and the IO\_Update bit (Bit 0, Register 0x234) to 1. The internal I<sup>2</sup>C main then begins writing to the EEPROM, starting from the EEPROM address held from the last writing.

This sequence enables more discrete instructions to be written to the EEPROM than would otherwise be possible due to the limited size of the EEPROM buffer segment. It also permits the user to write to the same register multiple times with a different value each time.

## EEPROM OPERATIONS

Table 29. Example of an EEPROM Buffer Segment (Continued)

| Register Address (Hex) | Bit 7 (MSB)                                           | Bit 6                                                       | Bit 5 | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0 (LSB) |
|------------------------|-------------------------------------------------------|-------------------------------------------------------------|-------|-------|-------|-------|-------|-------------|
| 0xA04                  | Address of the second group of registers (Bits[15:8]) |                                                             |       |       |       |       |       |             |
| 0xA05                  | Address of the second group of registers (Bits[7:0])  |                                                             |       |       |       |       |       |             |
| 0xA06                  | 0                                                     | Number of bytes of the third group of registers (Bits[6:0]) |       |       |       |       |       |             |
| 0xA07                  | Address of the third group of registers (Bits[15:8])  |                                                             |       |       |       |       |       |             |
| 0xA08                  | Address of the third group of registers (Bits[7:0])   |                                                             |       |       |       |       |       |             |
| 0xA09                  | IO_Update operational code (0x80)                     |                                                             |       |       |       |       |       |             |
| 0xA0A                  | End-of-data operational code (0xFF)                   |                                                             |       |       |       |       |       |             |

## POWER DISSIPATION AND THERMAL CONSIDERATIONS

The AD9524 is a multifunctional, high speed device that targets a wide variety of clock applications. The numerous innovative features contained in the device each consume incremental power. If all outputs are enabled in the maximum frequency and mode that have the highest power, the safe thermal operating conditions of the device may be exceeded. Careful analysis and consideration of power dissipation and thermal management are critical elements in the successful application of the AD9524 device.

The AD9524 device is specified to operate within the industrial ambient temperature range of  $-40^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$ . This specification is conditional, however, such that the absolute maximum junction temperature is not exceeded (as specified in Table 17). At high operating temperatures, extreme care must be taken when operating the device to avoid exceeding the junction temperature and potentially damaging the device.

A maximum junction temperature is listed in Table 1 with the ambient operating range. The ambient range and maximum junction temperature specifications ensure the performance of the device as guaranteed in the Specifications section.

Many variables contribute to the operating junction temperature within the device, including

- ▶ Selected driver mode of operation
- ▶ Output clock speed
- ▶ Supply voltage
- ▶ Ambient temperature

The combination of these variables determines the junction temperature within the AD9524 device for a given set of operating conditions.

The AD9524 is specified for an ambient temperature ( $T_A$ ). To ensure that  $T_A$  is not exceeded, an airflow source can be used.

Use the following equation to determine the junction temperature on the application PCB:

$$T_J = T_{CASE} + (\Psi_{JT} \times PD) \quad (2)$$

where:

$T_J$  is the junction temperature ( $^{\circ}\text{C}$ ).

$T_{CASE}$  is the case temperature ( $^{\circ}\text{C}$ ) measured by the user at the top center of the package.

$\Psi_{JT}$  is the value from Table 18.

$PD$  is the power dissipation of the AD9524.

Values of  $\theta_{JA}$  are provided for package comparison and PCB design considerations.  $\theta_{JA}$  can be used for a first-order approximation of  $T_J$  by the equation

$$T_J = T_A + (\theta_{JA} \times PD) \quad (3)$$

where  $T_A$  is the ambient temperature ( $^{\circ}\text{C}$ ).

Values of  $\theta_{JC}$  are provided for package comparison and PCB design considerations when an external heat sink is required.

Values of  $\Psi_{JB}$  are provided for package comparison and PCB design considerations.

## CLOCK SPEED AND DRIVER MODE

Clock speed directly and linearly influences the total power dissipation of the device and, therefore, the junction temperature. Two operating frequencies are listed under the incremental power dissipation parameter in Table 3. Using linear interpretation is a sufficient approximation for frequency not listed in the table. When calculating power dissipation for thermal consideration, the amount of power dissipated in the  $100\ \Omega$  resistor should be removed. If using the data in Table 2, this power is already removed. If using the current vs. frequency graphs provided in the Typical Performance Characteristics section, the power into the load must be subtracted, using the following equation:

$$\frac{\text{Differential Output Voltage Swing}^2}{100\ \Omega} \quad (4)$$

## EVALUATION OF OPERATING CONDITIONS

The first step in evaluating the operating conditions is to determine the maximum power consumption (PD) internal to the AD9524. The maximum PD excludes power dissipated in the load resistors of the drivers because such power is external to the device. Use the power dissipation specifications listed in Table 3 to calculate the total power dissipated for the desired configuration. The base typical configuration parameter in Table 3 lists a power of 428 mW, which includes one LVPECL output at 122.88 MHz. If the frequency of operation is not listed in Table 3, see the Typical Performance Characteristics section, current vs. frequency and driver mode, to calculate the power dissipation; then add 20% for maximum current draw. Remove the power dissipated in the load resistor to achieve the most accurate power dissipation internal to the AD9524. See Table 30 for a summary of the incremental power dissipation from the base power configuration for two different examples.

Table 30. Temperature Gradient Examples

| Description                | Mode       | Frequency (MHz) | Maximum Power (mW) |
|----------------------------|------------|-----------------|--------------------|
| Example 1                  |            |                 |                    |
| Base Typical Configuration |            |                 | 428                |
| Output Driver              | 5 × LVPECL | 122.88          | 275                |
| Total Power                |            |                 | 703                |
| Example 2                  |            |                 |                    |
| Base Typical Configuration |            |                 | 428                |
| Output Driver              | 5 × LVPECL | 983.04          | 795                |
| Total Power                |            |                 | 1223               |

The second step is to multiply the power dissipated by the thermal impedance to determine the maximum power gradient. For this example, a thermal impedance of  $\theta_{JA} = 20.1^{\circ}\text{C/W}$  was used.

**POWER DISSIPATION AND THERMAL CONSIDERATIONS****Example 1**

$$(703 \text{ mW} \times 20.1^\circ\text{C/W}) = 14.1^\circ\text{C}$$

With an ambient temperature of 85°C, the junction temperature is

$$T_J = 85^\circ\text{C} + 14.1^\circ\text{C} = 99^\circ\text{C} \quad (5)$$

This junction temperature is below the maximum allowable.

**Example 2**

$$(1223 \text{ mW} \times 20.1^\circ\text{C/W}) = 24.6^\circ\text{C}$$

With an ambient temperature of 85°C, the junction temperature is

$$T_J = 85^\circ\text{C} + 24.6^\circ\text{C} = 109^\circ\text{C} \quad (6)$$

This junction temperature is below the maximum allowable.

**THERMALLY ENHANCED PACKAGE MOUNTING GUIDELINES**

Refer to the [AN-772 Application Note](#), *A Design and Manufacturing Guide for the Lead Frame Chip Scale Package (LFCSP)*, for more information about mounting devices with an exposed paddle.

## CONTROL REGISTERS

## CONTROL REGISTER MAP

Register addresses that are not listed in Table 31 are not used, and writing to those registers has no effect. Registers that are marked as reserved should never have their values changed. When writing to registers with bits that are marked reserved, the user should take care to always write the default value for the reserved bits.

Table 31. Control Register Map

| Addr<br>(Hex)             | Register Name                                   | (MSB) Bit 7                             | Bit 6                             | Bit 5                             | Bit 4                                           | Bit 3                                               | Bit 2                                               | Bit 1                                                | (LSB) Bit 0                                        | Default<br>Value<br>(Hex) |
|---------------------------|-------------------------------------------------|-----------------------------------------|-----------------------------------|-----------------------------------|-------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------|------------------------------------------------------|----------------------------------------------------|---------------------------|
| Serial Port Configuration |                                                 |                                         |                                   |                                   |                                                 |                                                     |                                                     |                                                      |                                                    |                           |
| 0x000                     | SPI mode serial port configuration              | SDO active                              | LSB first/ address increment      | Soft reset                        | Reserved                                        | Reserved                                            | Soft reset                                          | LSB first/ address increment                         | SDO active                                         | 0x00                      |
|                           | I <sup>2</sup> C mode serial port configuration | Reserved                                | Reserved                          | Soft reset                        | Reserved                                        | Reserved                                            | Soft reset                                          | Reserved                                             | Reserved                                           | 0x00                      |
| 0x004                     | Readback control                                | Reserved                                | Reserved                          | Reserved                          | Reserved                                        | Reserved                                            | Reserved                                            | Reserved                                             | Read back active registers                         | 0x00                      |
| 0x005                     | EEPROM customer version ID                      | EEPROM customer version ID[7:0] (LSB)   |                                   |                                   |                                                 |                                                     |                                                     |                                                      |                                                    | 0x00                      |
| 0x006                     |                                                 | EEPROM customer version ID[15:8] (MSB)  |                                   |                                   |                                                 |                                                     |                                                     |                                                      |                                                    | 0x00                      |
| Input PLL (PLL1)          |                                                 |                                         |                                   |                                   |                                                 |                                                     |                                                     |                                                      |                                                    |                           |
| 0x010                     | PLL1 REFA R divider control                     | 10-bit REFA R divider[7:0] (LSB)        |                                   |                                   |                                                 |                                                     |                                                     |                                                      |                                                    | 0x00                      |
| 0x011                     |                                                 | Reserved                                |                                   |                                   |                                                 |                                                     |                                                     | 10-bit REFA R divider[9:8] (MSB)                     |                                                    | 0x00                      |
| 0x012                     | PLL1 REFB R divider control                     | 10-bit REFB R divider[7:0] (LSB)        |                                   |                                   |                                                 |                                                     |                                                     |                                                      |                                                    | 0x00                      |
| 0x013                     |                                                 | Reserved                                |                                   |                                   |                                                 |                                                     |                                                     | 10-bit REFB R divider[9:8] (MSB)                     |                                                    | 0x00                      |
| 0x014                     | PLL1 reference test divider                     | Reserved                                | Reserved                          | REF_TEST divider                  |                                                 |                                                     |                                                     |                                                      |                                                    | 0x00                      |
| 0x015                     | PLL1 reserved                                   | Reserved                                | Reserved                          | Reserved                          | Reserved                                        | Reserved                                            | Reserved                                            | Reserved                                             | Reserved                                           | 0x00                      |
| 0x016                     | PLL1 feedback N divider control                 | 10-bit PLL1 feedback divider[7:0] (LSB) |                                   |                                   |                                                 |                                                     |                                                     |                                                      |                                                    | 0x00                      |
| 0x017                     |                                                 | Reserved                                |                                   |                                   |                                                 |                                                     |                                                     | 10-bit PLL1 feedback divider[9:8] (MSB)              |                                                    | 0x00                      |
| 0x018                     | PLL1 charge pump control                        | PLL1 charge pump tristate               | PLL1 charge pump control          |                                   |                                                 |                                                     |                                                     |                                                      |                                                    | 0x0C                      |
| 0x019                     |                                                 | Reserved                                | Reserved                          | Reserved                          | Enable SPI control of antibracklash pulse width | Antibracklash pulse width control                   |                                                     | PLL1 charge pump mode                                |                                                    | 0x00                      |
| 0x01A                     | PLL1 input receiver control                     | REF_TEST input receiver enable          | REFB differential receiver enable | REFA differential receiver enable | REFB receiver enable                            | REFA receiver enable                                | Input REFA, REFB receiver power-down control enable | OSC_IN single-ended receiver mode enable (CMOS mode) | OSC_IN differential receiver mode enable           | 0x00                      |
| 0x01B                     | REF_TEST, REFA, REFB, and ZD_IN control         | Reserved                                | Reserved                          | Zero delay mode                   | OSC_IN signal feedback for PLL1                 | ZD_IN single-ended receiver mode enable (CMOS mode) | ZD_IN differen. receiver mode enable                | REFB single-ended receiver mode enable (CMOS mode)   | REFA single-ended receiver mode enable (CMOS mode) | 0x00                      |
| 0x01C                     | PLL1 miscellaneous control                      | Enable REFB R divider                   | OSC_CTRL control voltage to       | Reserved                          | Reference selection mode                        |                                                     |                                                     | Reserved                                             | Reserved                                           | 0x00                      |

## CONTROL REGISTERS

Table 31. Control Register Map (Continued)

| Addr<br>(Hex)      | Register Name                                | (MSB) Bit 7                           | Bit 6                         | Bit 5                              | Bit 4                                                             | Bit 3                               | Bit 2                                  | Bit 1                                    | (LSB) Bit 0                                   | Default<br>Value<br>(Hex) |
|--------------------|----------------------------------------------|---------------------------------------|-------------------------------|------------------------------------|-------------------------------------------------------------------|-------------------------------------|----------------------------------------|------------------------------------------|-----------------------------------------------|---------------------------|
|                    |                                              | independ.<br>division<br>control      | VCC/2 when<br>ref clock fails |                                    |                                                                   |                                     |                                        |                                          |                                               |                           |
| 0x01D              | PLL1 loop filter<br>zero resistor<br>control | Reserved                              | Reserved                      | Reserved                           | Reserved                                                          | PLL1 loop filter, R <sub>ZERO</sub> |                                        |                                          |                                               | 0x00                      |
| Output PLL (PLL2)  |                                              |                                       |                               |                                    |                                                                   |                                     |                                        |                                          |                                               |                           |
| 0x0F0              | PLL2 charge<br>pump control                  | PLL2 charge pump control              |                               |                                    |                                                                   |                                     |                                        |                                          |                                               | 0x00                      |
| 0x0F1              | PLL2 feedback<br>N divider control           | A counter                             |                               |                                    | B counter                                                         |                                     |                                        |                                          |                                               | 0x04                      |
| 0x0F2              | PLL2 control                                 | PLL2 lock<br>detector<br>power- down  | Reserved                      | Enable<br>frequency<br>doubler     | Enable SPI<br>control of<br>antibacklash<br>pulse width           | Antibacklash pulse width<br>control |                                        | PLL2 charge pump mode                    |                                               | 0x03                      |
| 0x0F3              | VCO control                                  | Reserved                              | Reserved                      | Reserved                           | Force release of<br>distribution sync<br>when PLL2 is<br>unlocked | Reserved                            | Force VCO<br>to midpoint<br>frequency  | Calibrate VCO<br>(not auto-<br>clearing) | Reserved                                      | 0x00                      |
| 0x0F4              | VCO divider<br>control                       | Reserved                              | Reserved                      | Reserved                           | Reserved                                                          | VCO<br>divider<br>power-<br>down    | VCO divider                            |                                          |                                               | 0x00                      |
| 0x0F5              | PLL2 loop filter<br>control (9 bits)         | Pole 2 resistor (R <sub>POLE2</sub> ) |                               | Zero resistor (R <sub>ZERO</sub> ) |                                                                   |                                     | Pole 1 capacitor (C <sub>POLE1</sub> ) |                                          |                                               | 0x00                      |
| 0x0F6              |                                              | Reserved                              | Reserved                      | Reserved                           | Reserved                                                          | Reserved                            | Reserved                               | Reserved                                 | Bypass internal<br>R <sub>ZERO</sub> resistor | 0x00                      |
| 0x0F9              | Reserved                                     | Reserved                              | Reserved                      | Reserved                           | Reserved                                                          | Reserved                            | Reserved                               | Reserved                                 | Reserved                                      | 0x00                      |
| Clock Distribution |                                              |                                       |                               |                                    |                                                                   |                                     |                                        |                                          |                                               |                           |
| 0x190              | Reserved                                     | Reserved                              |                               |                                    |                                                                   |                                     |                                        |                                          |                                               | 0x00                      |
| 0x196              | Channel 0<br>control                         | Invert divider<br>output              | Ignore sync                   | Power-down<br>channel              | Lower power<br>mode                                               | Driver mode                         |                                        |                                          |                                               | 0x00                      |
| 0x197              |                                              | 10-bit channel divider[7:0] (LSB)     |                               |                                    |                                                                   |                                     |                                        |                                          |                                               | 0x1F                      |
| 0x198              |                                              | Divider phase[5:0]                    |                               |                                    |                                                                   |                                     |                                        | 10-bit channel divider[9:8] (MSB)        |                                               | 0x04                      |
| 0x199              | Channel 1<br>control                         | Invert divider<br>output              | Ignore sync                   | Power-down<br>channel              | Lower power<br>mode                                               | Driver mode                         |                                        |                                          |                                               | 0x20                      |
| 0x19A              |                                              | 10-bit channel divider[7:0] (LSB)     |                               |                                    |                                                                   |                                     |                                        |                                          |                                               | 0x1F                      |
| 0x19B              |                                              | Divider phase[5:0]                    |                               |                                    |                                                                   |                                     |                                        | 10-bit channel divider[9:8] (MSB)        |                                               | 0x04                      |
| 0x19C              | Channel 2<br>control                         | Invert divider<br>output              | Ignore sync                   | Power-down<br>channel              | Lower power<br>mode                                               | Driver mode                         |                                        |                                          |                                               | 0x00                      |
| 0x19D              |                                              | 10-bit channel divider[7:0] (LSB)     |                               |                                    |                                                                   |                                     |                                        |                                          |                                               | 0x1F                      |
| 0x19E              |                                              | Divider phase[5:0]                    |                               |                                    |                                                                   |                                     |                                        | 10-bit channel divider[9:8] (MSB)        |                                               | 0x04                      |
| 0x19F              | Channel 3<br>control                         | Invert divider<br>output              | Ignore sync                   | Power-down<br>channel              | Lower power<br>mode                                               | Driver mode[3:0]                    |                                        |                                          |                                               | 0x20                      |
| 0x1A0              |                                              | 10-bit channel divider[7:0] (LSB)     |                               |                                    |                                                                   |                                     |                                        |                                          |                                               | 0x1F                      |
| 0x1A1              |                                              | Divider phase[5:0]                    |                               |                                    |                                                                   |                                     |                                        | 10-bit channel divider[9:8] (MSB)        |                                               | 0x04                      |
| 0x1AE              | Channel 4<br>control                         | Invert divider<br>output              | Ignore sync                   | Power-down<br>channel              | Lower power<br>mode                                               | Driver mode                         |                                        |                                          |                                               | 0x00                      |
| 0x1AF              |                                              | 10-bit channel divider[7:0] (LSB)     |                               |                                    |                                                                   |                                     |                                        |                                          |                                               | 0x1F                      |
| 0x1B0              |                                              | Divider phase[5:0]                    |                               |                                    |                                                                   |                                     |                                        | 10-bit channel divider[9:8] (MSB)        |                                               | 0x04                      |

## CONTROL REGISTERS

Table 31. Control Register Map (Continued)

| Addr (Hex)    | Register Name                                   | (MSB) Bit 7                       | Bit 6                      | Bit 5                    | Bit 4                               | Bit 3                      | Bit 2                             | Bit 1                                  | (LSB) Bit 0                                                                                                  | Default Value (Hex) |
|---------------|-------------------------------------------------|-----------------------------------|----------------------------|--------------------------|-------------------------------------|----------------------------|-----------------------------------|----------------------------------------|--------------------------------------------------------------------------------------------------------------|---------------------|
| 0x1B1         | Channel 5 control                               | Invert divider output             | Ignore sync                | Power-down channel       | Lower power mode                    | Driver mode                |                                   |                                        |                                                                                                              | 0x20                |
| 0x1B2         |                                                 | 10-bit channel divider[7:0] (LSB) |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x1F                |
| 0x1B3         |                                                 | Divider phase[5:0]                |                            |                          |                                     |                            |                                   |                                        | 10-bit channel divider[9:8] (MSB)                                                                            | 0x04                |
| 0x1BA         | PLL1 output control                             | Reserved                          | Reserved                   | Reserved                 | PLL1 output CMOS driver strength    | PLL1 output divider        |                                   |                                        |                                                                                                              | 0x00                |
| 0x1BB         | PLL1 output channel control                     | PLL1 output driver power-down     | Reserved                   | Reserved                 | Reserved                            | Reserved                   | Reserved                          | Route VCXO clock to Ch 1 divider input | Route VCXO clock to Ch 0 divider input                                                                       | 0x80                |
| Readback      |                                                 |                                   |                            |                          |                                     |                            |                                   |                                        |                                                                                                              |                     |
| 0x22C         | Readback 0                                      | Status PLL2 reference clock       | Status PLL1 feedback clock | Status VCXO              | Status REF_TEST                     | Status REFB                | Status REFA                       | Lock detect PLL2                       | Lock detect PLL1                                                                                             |                     |
| 0x22D         | Readback 1                                      | Reserved                          | Reserved                   | Reserved                 | Reserved                            | Holdover active            | Selected reference (in auto mode) | Reserved                               | VCO calibration in progress                                                                                  |                     |
| Other         |                                                 |                                   |                            |                          |                                     |                            |                                   |                                        |                                                                                                              |                     |
| 0x230         | Status signals                                  | Reserved                          | Reserved                   | Status Monitor 0 control |                                     |                            |                                   |                                        |                                                                                                              | 0x00                |
| 0x231         |                                                 | Reserved                          | Reserved                   | Status Monitor 1 control |                                     |                            |                                   |                                        |                                                                                                              | 0x00                |
| 0x232         |                                                 | Reserved                          | Reserved                   | Reserved                 | Enable Status_EEPROM on STATUS0 pin | STATUS1 pin divider enable | STATUS0 pin divider enable        | Reserved                               | Sync dividers (manual control)<br>0: sync signal inactive<br>1: dividers held in sync (same as SYNC pin low) | 0x00                |
| 0x233         | Power-down control                              | Reserved                          | Reserved                   | Reserved                 | Reserved                            | Reserved                   | PLL1 power-down                   | PLL2 power-down                        | Distribution power-down                                                                                      | 0x07                |
| 0x234         | Update all registers                            | Reserved                          |                            |                          |                                     |                            |                                   |                                        | IO_Update                                                                                                    | 0x00                |
| EEPROM Buffer |                                                 |                                   |                            |                          |                                     |                            |                                   |                                        |                                                                                                              |                     |
| 0xA00         | Serial port configuration                       | Size of transfer: one byte        |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x00                |
| 0xA01         |                                                 | Starting address: 0x0000          |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x00                |
| 0xA02         |                                                 |                                   |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x00                |
| 0xA03         | Readback control and EEPROM customer version ID | Size of transfer: three bytes     |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x02                |
| 0xA04         |                                                 | Starting address: 0x0004          |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x00                |
| 0xA05         |                                                 |                                   |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x04                |
| 0xA06         | PLL1                                            | Size of transfer: 15 bytes        |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x0E                |
| 0xA07         |                                                 | Starting address: 0x0010          |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x00                |
| 0xA08         |                                                 |                                   |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x10                |
| 0xA09         | PECL/CMOS output                                | Size of transfer: 15 bytes        |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x0E                |
| 0xA0A         |                                                 | Starting address: 0x00F0          |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x00                |
| 0xA0B         |                                                 |                                   |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0xF0                |
| 0xA0C         | Dividers                                        | Size of transfer: 44 bytes        |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x2B                |
| 0xA0D         |                                                 | Starting address: 0x0190          |                            |                          |                                     |                            |                                   |                                        |                                                                                                              | 0x01                |

## CONTROL REGISTERS

Table 31. Control Register Map (Continued)

| Addr<br>(Hex)  | Register Name                                       | (MSB) Bit 7                  | Bit 6    | Bit 5    | Bit 4    | Bit 3    | Bit 2    | Bit 1       | (LSB) Bit 0                      | Default<br>Value<br>(Hex) |
|----------------|-----------------------------------------------------|------------------------------|----------|----------|----------|----------|----------|-------------|----------------------------------|---------------------------|
| 0xA0E          |                                                     |                              |          |          |          |          |          |             |                                  | 0x90                      |
| 0xA0F          | Clock input and<br>REF                              | Size of transfer: two bytes  |          |          |          |          |          |             |                                  | 0x01                      |
| 0xA10          |                                                     | Starting address: 0x01E0     |          |          |          |          |          |             |                                  | 0x01                      |
| 0xA11          |                                                     |                              |          |          |          |          |          |             |                                  | 0xE0                      |
| 0xA12          | Other                                               | Size of transfer: four bytes |          |          |          |          |          |             |                                  | 0x03                      |
| 0xA13          |                                                     | Starting address: 0x0230     |          |          |          |          |          |             |                                  | 0x02                      |
| 0xA14          |                                                     |                              |          |          |          |          |          |             |                                  | 0x30                      |
| 0xA15          | IO_UPDATE                                           | Command: IO_UPDATE           |          |          |          |          |          |             |                                  | 0x80                      |
| 0xA16          | End of data                                         | Command: End of data         |          |          |          |          |          |             |                                  | 0xFF                      |
| EEPROM Control |                                                     |                              |          |          |          |          |          |             |                                  |                           |
| 0xB00          | Status_EEPRO<br>M (read only)                       | Reserved                     | Reserved | Reserved | Reserved | Reserved | Reserved | Reserved    | Status_<br>EEPROM (read<br>only) | 0x00                      |
| 0xB01          | EEPROM error<br>checking<br>readback (read<br>only) | Reserved                     | Reserved | Reserved | Reserved | Reserved | Reserved | Reserved    | EEPROM data<br>error (read only) | 0x00                      |
| 0xB02          | EEPROM<br>Control 1                                 | Reserved                     | Reserved | Reserved | Reserved | Reserved | Reserved | Soft_EEPROM | Enable<br>EEPROM write           | 0x00                      |
| 0xB03          | EEPROM<br>Control 2                                 | Reserved                     | Reserved | Reserved | Reserved | Reserved | Reserved | Reserved    | REG2EEPROM                       | 0x00                      |

## CONTROL REGISTER MAP BIT DESCRIPTIONS

## Serial Port Configuration (Address 0x000 to Address 0x006)

Table 32. SPI Mode Serial Port Configuration

| Address | Bits  | Bit Name                    | Description                                                                                                                                                                                                                                                                             |
|---------|-------|-----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x000   | 7     | SDO active                  | Selects unidirectional or bidirectional data transfer mode. This bit is ignored in I <sup>2</sup> C mode.<br>0: SDIO pin used for write and read; SDO is high impedance (default).<br>1: SDO used for read; SDIO used for write; unidirectional mode.                                   |
|         | 6     | LSB first/address increment | SPI MSB or LSB data orientation. This bit is ignored in I <sup>2</sup> C mode.<br>0: data-oriented MSB first; addressing decrements (default).<br>1: data-oriented LSB first; addressing increments.                                                                                    |
|         | 5     | Soft reset                  | Soft reset.<br>1 (self clearing): soft reset; restores default values to internal registers.                                                                                                                                                                                            |
|         | 4     | Reserved                    | Reserved.                                                                                                                                                                                                                                                                               |
|         | [3:0] | Mirror[7:4]                 | Bits[3:0] should always mirror Bits[7:4] so that it does not matter whether the part is in MSB first or LSB first mode (see Register 0x000, Bit 6). Set bits as follows:<br>Bit 0 = Bit 7.<br>Bit 1 = Bit 6.<br>Bit 2 = Bit 5.<br>Bit 3 = Bit 4.                                        |
| 0x004   | 0     | Read back active registers  | For buffered registers, serial port readback reads from actual (active) registers instead of from the buffer.<br>0 (default): reads values currently applied to the internal logic of the device.<br>1: reads buffered values that take effect on the next assertion of the I/O update. |

## CONTROL REGISTERS

Table 33. I<sup>2</sup>C Mode Serial Port Configuration

| Address | Bits  | Bit Name                   | Description                                                                                                                                                                                                                                                                             |
|---------|-------|----------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x000   | [7:6] | Reserved                   | Reserved.                                                                                                                                                                                                                                                                               |
|         | 5     | Soft reset                 | Soft reset.<br>1 (self clearing): soft reset; restores default values to internal registers.                                                                                                                                                                                            |
|         | 4     | Reserved                   | Reserved.                                                                                                                                                                                                                                                                               |
|         | [3:0] | Mirror[7:4]                | Bits[3:0] should always mirror Bits[7:4]. Set bits as follows:<br>Bit 0 = Bit 7.<br>Bit 1 = Bit 6.<br>Bit 2 = Bit 5.<br>Bit 3 = Bit 4.                                                                                                                                                  |
| 0x004   | 0     | Read back active registers | For buffered registers, serial port readback reads from actual (active) registers instead of from the buffer.<br>0 (default): reads values currently applied to the internal logic of the device.<br>1: reads buffered values that take effect on the next assertion of the I/O update. |

Table 34. EEPROM Customer Version ID

| Address | Bits  | Bit Name                         | Description                                                                                                                                                                                                                                                     |
|---------|-------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x005   | [7:0] | EEPROM customer version ID (LSB) | 16-bit EEPROM ID, Bits[7:0]. This register, along with Register 0x006, allows the user to store a unique ID to identify which version of the AD9524 register settings is stored in the EEPROM. It does not affect AD9524 operation in any way (default: 0x00).  |
| 0x006   | [7:0] | EEPROM customer version ID (MSB) | 16-bit EEPROM ID, Bits[15:8]. This register, along with Register 0x005, allows the user to store a unique ID to identify which version of the AD9524 register settings is stored in the EEPROM. It does not affect AD9524 operation in any way (default: 0x00). |

## Input PLL (PLL1) (Address 0x010 to Address 0x01D)

Table 35. PLL1 REFA R Divider Control

| Address | Bits  | Bit Name       | Description                                                                                             |
|---------|-------|----------------|---------------------------------------------------------------------------------------------------------|
| 0x010   | [7:0] | REFA R divider | 10-bit REFA R divider, Bits[7:0] (LSB). Divide-by-1 to divide-by-1023. 00000000, 00000001: divide-by-1. |
| 0x011   | [1:0] |                | 10-bit REFA R divider, Bits[9:8] (MSB)                                                                  |

Table 36. PLL1 REFB R Divider Control<sup>1</sup>

| Address | Bits  | Bit Name       | Description                                                                                             |
|---------|-------|----------------|---------------------------------------------------------------------------------------------------------|
| 0x012   | [7:0] | REFB R divider | 10-bit REFB R divider, Bits[7:0] (LSB). Divide-by-1 to divide-by-1023. 00000000, 00000001: divide-by-1. |
| 0x013   | [1:0] |                | 10-bit REFB R divider, Bits[9:8] (MSB)                                                                  |

<sup>1</sup> Requires Register 0x01C, Bit 7 = 1 for division that is independent of REFA division.

Table 37. PLL1 Reference Test Divider

| Address | Bits  | Bit Name         | Description                                                                             |
|---------|-------|------------------|-----------------------------------------------------------------------------------------|
| 0x014   | [7:6] | Reserved         | Reserved                                                                                |
|         | [5:0] | REF_TEST divider | 6-bit reference test divider. Divide-by-1 to divide-by-63. 000000, 000001: divide-by-1. |

Table 38. PLL1 Reserved

| Address | Bits  | Bit Name | Description |
|---------|-------|----------|-------------|
| 0x015   | [7:0] | Reserved | Reserved    |

Table 39. PLL1 Feedback N Divider Control

| Address | Bits  | Bit Name                                 | Description                                                                                               |
|---------|-------|------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| 0x016   | [7:0] | PLL1 feedback N divider control (N_PLL1) | 10-bit feedback divider, Bits[7:0] (LSB). Divide-by-1 to divide-by-1023. 00000000, 00000001: divide-by-1. |
| 0x017   | [1:0] |                                          | 10-bit feedback divider, Bits[1:0] (MSB)                                                                  |

## CONTROL REGISTERS

Table 40. PLL1 Charge Pump Control

| Address | Bits  | Bit Name                                      | Description                                                                                                                                                                                                                                                                                                                              |
|---------|-------|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x018   | 7     | PLL1 charge pump tristate                     | Tristates the PLL1 charge pump.                                                                                                                                                                                                                                                                                                          |
|         | [6:0] | PLL1 charge pump control                      | These bits set the magnitude of the PLL1 charge pump current. Granularity is ~0.5 $\mu$ A with a full-scale magnitude of ~63.5 $\mu$ A.                                                                                                                                                                                                  |
| 0x019   | [7:5] | Reserved                                      | Reserved.                                                                                                                                                                                                                                                                                                                                |
|         | 4     | Enable SPI control of antbacklash pulse width | Controls the functionality of Register 0x019, Bits[3:2].<br>0 (default): the device automatically controls the antbacklash period to high (equivalent to Register 0x019, Bits[3:2] = 10).<br>1: antbacklash period defined by Register 0x019, Bits[3:2].                                                                                 |
|         | [3:2] | Antbacklash pulse width control               | Controls the PFD antbacklash period. These bits default to the high setting unless reprogrammed using Register 0x019[4] = 1b. The high setting decreases the maximum allowable PLL1 PFD rate. See Table 7 for ranges.<br>00: minimum.<br>01: low.<br>10: high (initial state unless changed via Register 0x019[4] = 1b).<br>11: maximum. |
|         | [1:0] | PLL1 charge pump mode                         | Controls the mode of the PLL1 charge pump.<br>00: (default) tristate.<br>01: pump up.<br>10: pump down.<br>11: normal.                                                                                                                                                                                                                   |

Table 41. PLL1 Input Receiver Control

| Address | Bits | Bit Name                                               | Description                                                                                                                                                                                                                                                                                   |
|---------|------|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x01A   | 7    | REF_TEST input receiver enable                         | 1: enabled.<br>0: disabled (default).                                                                                                                                                                                                                                                         |
|         | 6    | REFB differential receiver enable                      | 1: differential receiver mode.<br>0: single-ended receiver mode (also depends on Register 0x01B, Bit 1) (default).                                                                                                                                                                            |
|         | 5    | REFA differential receiver enable                      | 1: differential receiver mode.<br>0: single-ended receiver mode (also depends on Register 0x01B, Bit 0) (default).                                                                                                                                                                            |
|         | 4    | REFB receiver enable                                   | REFB receiver power-down control mode only when Bit 2 = 1.<br>1: enable REFB receiver.<br>0: power-down (default).                                                                                                                                                                            |
|         | 3    | REFA receiver enable                                   | REFA receiver power-down control mode only when Bit 2 = 1.<br>1: enable REFA receiver.<br>0: power-down (default).                                                                                                                                                                            |
|         | 2    | Input REFA and REFB receiver power-down control enable | Enables power-down control of the input receivers, REFA and REFB.<br>1: power-down control enabled.<br>0: both receivers enabled (default).                                                                                                                                                   |
|         | 1    | OSC_IN single-ended receiver mode enable (CMOS mode)   | Selects which single-ended input pin is enabled when in the single-ended receiver mode (Register 0x01A, Bit 0 = 0).<br>1: negative receiver from oscillator input ( $\overline{\text{OSC\_IN}}$ pin) selected.<br>0: positive receiver from oscillator input (OSC_IN pin) selected (default). |
|         | 0    | OSC_IN differential receiver mode enable               | 1: differential receiver mode.<br>0: single-ended receiver mode (also depends on Bit 1) (default).                                                                                                                                                                                            |

Table 42. REF\_TEST, REFA, REFB, and ZD\_IN Control

| Address | Bits  | Bit Name        | Description                                                                                                                                                                                                                                                             |
|---------|-------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x01B   | [7:6] | Reserved        | 0: reserved (default).                                                                                                                                                                                                                                                  |
|         | 5     | Zero delay mode | Selects the zero delay mode used (via the ZD_IN pin) when Register 0x01B, Bit 4 = 0. Otherwise, this bit is ignored.<br>1: internal zero delay mode. The zero delay receiver is powered down. The internal zero delay path from Distribution Divider Channel 0 is used. |

## CONTROL REGISTERS

Table 42. REF\_TEST, REFA, REFB, and ZD\_IN Control (Continued)

| Address | Bits | Bit Name                                            | Description                                                                                                                                                                                                                                                                               |
|---------|------|-----------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|         |      |                                                     | 0: external zero delay mode. The ZD_IN receiver is enabled.                                                                                                                                                                                                                               |
|         | 4    | OSC_IN signal feedback for PLL1                     | Controls the input PLL feedback path, local feedback from the OSC_IN receiver or zero delay mode.<br>1: OSC_IN receiver input used for the input PLL feedback (non-zero delay mode).<br>0: zero delay mode enabled (also depends on Register 0x01B, Bit 4 to select the zero delay path). |
|         | 3    | ZD_IN single-ended receiver mode enable (CMOS mode) | Selects which single-ended input pin is enabled when in the single-ended receiver mode (Register 0x01B, Bit 2 = 0).<br>1: ZD_IN pin enabled.<br>0: ZD_IN pin enabled.                                                                                                                     |
|         | 2    | ZD_IN differential receiver mode enable             | 1: differential receiver mode.<br>0: single-ended receiver mode (also depends on Register 0x01B, Bit 3).                                                                                                                                                                                  |
|         | 1    | REFB single-ended receiver mode enable (CMOS mode)  | Selects which single-ended input pin is enabled when in single-ended receiver mode (Register 0x01A, Bit 6 = 0).<br>1: REFB pin enabled.<br>0: REFB pin enabled.                                                                                                                           |
|         | 0    | REFA single-ended receiver mode enable (CMOS mode)  | Selects which single-ended input pin is enabled when in single-ended receiver mode (Register 0x01A, Bit 5 = 0).<br>1: REFA pin enabled.<br>0: REFA pin enabled.                                                                                                                           |

Table 43. PLL1 Miscellaneous Control

| Address        | Bits           | Bit Name                                                     | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                               |                             |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
|----------------|----------------|--------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-----------------------------|-------|-------|-------------|----------------|---|---|---|-----------------------------|----------------|---|---|---|-----------------|----------------|---|---|---|--------------|----------------|---|---|---|--------------|---|---|----------------|----------------|------------------------------|---|---|----------------|----------------|-------------------------------|
| 0x01C          | 7              | Enable REFB R divider independent division control           | 1: REFB R divider is controlled by Register 0x012 and Register 0x013.<br>0: REFB R divider is set to the same setting as the REFA R divider (Register 0x010 and Register 0x011). This requires that, for the loop to stay locked, the REFA and REFB input frequencies must be the same.                                                                                                                                                                                                                                                                                                                                                                                                           |                               |                             |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
|                | 6              | OSC_CTRL control voltage to VCC/2 when reference clock fails | High permits the OSC_CTRL control voltage to be forced to midsupply when the feedback or input clocks fail. Low tristates the charge pump output.<br>1: OSC_CTRL control voltage goes to VCC/2.<br>0: OSC_CTRL control voltage tracks the tristated (high impedance) charge pump (through the buffer).                                                                                                                                                                                                                                                                                                                                                                                            |                               |                             |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
|                | 5              | Reserved                                                     | Reserved.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                               |                             |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
|                | [4:2]          | Reference selection mode                                     | Programs the REFA, REFB mode selection (default = 000).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                               |                             |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
|                |                |                                                              | <table><tr><th>REF_SEL Pin</th><th>Bit 4</th><th>Bit 3</th><th>Bit 2</th><th>Description</th></tr><tr><td>X<sup>1</sup></td><td>0</td><td>0</td><td>0</td><td>Nonrevertive: stay on REFB.</td></tr><tr><td>X<sup>1</sup></td><td>0</td><td>0</td><td>1</td><td>Revert to REFA.</td></tr><tr><td>X<sup>1</sup></td><td>0</td><td>1</td><td>0</td><td>Select REFA.</td></tr><tr><td>X<sup>1</sup></td><td>0</td><td>1</td><td>1</td><td>Select REFB.</td></tr><tr><td>0</td><td>1</td><td>X<sup>1</sup></td><td>X<sup>1</sup></td><td>REF_SEL pin = 0 (low): REFA.</td></tr><tr><td>1</td><td>1</td><td>X<sup>1</sup></td><td>X<sup>1</sup></td><td>REF_SEL pin = 1 (high): REFB.</td></tr></table> | REF_SEL Pin                   | Bit 4                       | Bit 3 | Bit 2 | Description | X <sup>1</sup> | 0 | 0 | 0 | Nonrevertive: stay on REFB. | X <sup>1</sup> | 0 | 0 | 1 | Revert to REFA. | X <sup>1</sup> | 0 | 1 | 0 | Select REFA. | X <sup>1</sup> | 0 | 1 | 1 | Select REFB. | 0 | 1 | X <sup>1</sup> | X <sup>1</sup> | REF_SEL pin = 0 (low): REFA. | 1 | 1 | X <sup>1</sup> | X <sup>1</sup> | REF_SEL pin = 1 (high): REFB. |
|                | REF_SEL Pin    | Bit 4                                                        | Bit 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | Bit 2                         | Description                 |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
|                | X <sup>1</sup> | 0                                                            | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 0                             | Nonrevertive: stay on REFB. |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
| X <sup>1</sup> | 0              | 0                                                            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Revert to REFA.               |                             |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
| X <sup>1</sup> | 0              | 1                                                            | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Select REFA.                  |                             |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
| X <sup>1</sup> | 0              | 1                                                            | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Select REFB.                  |                             |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
| 0              | 1              | X <sup>1</sup>                                               | X <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | REF_SEL pin = 0 (low): REFA.  |                             |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
| 1              | 1              | X <sup>1</sup>                                               | X <sup>1</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | REF_SEL pin = 1 (high): REFB. |                             |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |
| [1:0]          | Reserved       | 0: reserved (default).                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                               |                             |       |       |             |                |   |   |   |                             |                |   |   |   |                 |                |   |   |   |              |                |   |   |   |              |   |   |                |                |                              |   |   |                |                |                               |

<sup>1</sup> X = don't care.

Table 44. PLL1 Loop Filter Zero Resistor Control

| Address | Bits  | Bit Name                 | Description                                      |       |       |       |                   |
|---------|-------|--------------------------|--------------------------------------------------|-------|-------|-------|-------------------|
| 0x01D   | [7:4] | Reserved                 | Reserved.                                        |       |       |       |                   |
|         | [3:0] | PLL1 loop filter, R_ZERO | Programs the value of the zero resistor, R_ZERO. |       |       |       |                   |
|         |       |                          | Bit 3                                            | Bit 2 | Bit 1 | Bit 0 | R_ZERO Value (kΩ) |
|         |       |                          | 0                                                | 0     | 0     | 0     | 883               |
|         |       |                          | 0                                                | 0     | 0     | 1     | 677               |
|         |       |                          | 0                                                | 0     | 1     | 0     | 341               |
|         |       | 0                        | 0                                                | 1     | 1     | 135   |                   |

## CONTROL REGISTERS

Table 44. PLL1 Loop Filter Zero Resistor Control (Continued)

| Address | Bits | Bit Name | Description                   |
|---------|------|----------|-------------------------------|
|         |      |          | 0 1 0 0 10                    |
|         |      |          | 0 1 0 1 10                    |
|         |      |          | 0 1 1 0 10                    |
|         |      |          | 0 1 1 1 10                    |
|         |      |          | 1 0 0 0 Use external resistor |

## Output PLL (PLL2) (Address 0x0F0 to Address 0x0F9)

Table 45. PLL2 Charge Pump Control

| Address | Bits  | Bit Name                 | Description                                                                                                                            |
|---------|-------|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| 0x0F0   | [7:0] | PLL2 charge pump control | These bits set the magnitude of the PLL2 charge pump current. Granularity is ~3.5 $\mu$ A with a full-scale magnitude of ~900 $\mu$ A. |

Table 46. PLL2 Feedback N Divider Control

| Address | Bits                         | Bit Name  | Description                                                   |
|---------|------------------------------|-----------|---------------------------------------------------------------|
| 0x0F1   | [7:6]                        | A counter | A counter word                                                |
|         | [5:0]                        | B counter | B counter word                                                |
|         | Feedback Divider Constraints |           |                                                               |
|         | A Counter (Bits[7:6])        |           | B Counter (Bits[5:0]) Allowed N Division ( $4 \times B + A$ ) |
|         | A = 0 or A = 1               |           | B = 4 16, 17                                                  |
|         | A = 0 to A = 2               |           | B = 5 20, 21, 22                                              |
|         | A = 0 to A = 2               |           | B = 6 24, 25, 26                                              |
|         | A = 0 to A = 3               |           | B $\geq 7$ 28, 29 ... continuous to 255                       |

Table 47. PLL2 Control

| Address | Bits  | Bit Name                                       | Description                                                                                                                                                                                                                                                                                                                                                                                                              |
|---------|-------|------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x0F2   | 7     | PLL2 lock detector power-down                  | Controls power-down of the PLL2 lock detector.<br>1: lock detector powered down.<br>0: lock detector active.                                                                                                                                                                                                                                                                                                             |
|         | 6     | Reserved                                       | Default = 0; value must remain 0.                                                                                                                                                                                                                                                                                                                                                                                        |
|         | 5     | Enable frequency doubler                       | Enables doubling of the PLL2 reference input frequency.<br>1: enabled.<br>0: disabled.                                                                                                                                                                                                                                                                                                                                   |
|         | 4     | Enable SPI control of antibacklash pulse width | Controls the functionality of Register 0x0F2, Bits[3:2]. Set the antibacklash pulse width to the minimum setting. By setting Bit 4 to 1 from the default of 0, Bits[3:2] consequently default to 00.<br>0 (default): device automatically controls the antibacklash period to high (equivalent to Register 0x0F2, Bits[3:2] = 10).<br>1: antibacklash period defined by Register 0x0F2, Bits[2:1] (recommended setting). |
|         | [3:2] | Antibacklash pulse width control               | Controls the PFD antibacklash period. These bits default to the high setting unless reprogrammed using Register 0x0F2[4] = 1b. The high setting decreases the maximum allowable PLL2 PFD rate. See <a href="#">Table 12</a> for ranges.<br>00 minimum.<br>01: low.<br>10: high (initial state unless changed via Register 0x0F2[4] = 1b).<br>11: maximum.                                                                |
|         | [1:0] | PLL2 charge pump mode                          | Controls the mode of the PLL2 charge pump.<br>00: tristate.<br>01: pump up.<br>10: pump down.<br>11 (default): normal.                                                                                                                                                                                                                                                                                                   |

## CONTROL REGISTERS

Table 48. VCO Control

| Address | Bits  | Bit Name                                                 | Description                                                                                                                                                                                                                                            |
|---------|-------|----------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x0F3   | [7:5] | Reserved                                                 | Reserved.                                                                                                                                                                                                                                              |
|         | 4     | Force release of distribution sync when PLL2 is unlocked | 0 (default): distribution is held in sync (static) until the output PLL locks. Then it is automatically released from sync with all dividers synchronized.<br>1: overrides the PLL2 lock detector state; forces release of the distribution from sync. |
|         | 3     | Reserved                                                 | 0 (default): value must remain 0.                                                                                                                                                                                                                      |
|         | 2     | Force VCO to midpoint frequency                          | Selects VCO control voltage functionality.<br>0 (default): normal VCO operation.<br>1: forces VCO control voltage to midscale.                                                                                                                         |
|         | 1     | Calibrate VCO (not autoclearing)                         | 1: initiates VCO calibration (this is not an autoclearing bit).<br>0: resets the VCO calibration.                                                                                                                                                      |
|         | 0     | Reserved                                                 | Reserved.                                                                                                                                                                                                                                              |

Table 49. VCO Divider Control

| Address | Bits  | Bit Name               | Description                                                |
|---------|-------|------------------------|------------------------------------------------------------|
| 0x0F4   | [7:4] | Reserved               | Reserved.                                                  |
|         | 3     | VCO divider power-down | 1: powers down the divider.<br>0: normal operation.        |
|         | [2:0] | VCO divider            | Note that the VCO divider connects to all output channels. |
|         |       |                        | Bit 2    Bit 1    Bit 0    Divider Value                   |
|         |       |                        | 0        0        0        Divide-by-4                     |
|         |       |                        | 0        0        1        Divide-by-5                     |
|         |       |                        | 0        1        0        Divide-by-6                     |
|         |       |                        | 0        1        1        Divide-by-7                     |
|         |       |                        | 1        0        0        Divide-by-8                     |
|         |       |                        | 1        0        1        Divide-by-9                     |
|         |       |                        | 1        1        0        Divide-by-10                    |
|         |       |                        | 1        1        1        Divide-by-11                    |

Table 50. PLL2 Loop Filter Control

| Address | Bits  | Bit Name                         | Description                                     |
|---------|-------|----------------------------------|-------------------------------------------------|
| 0x0F5   | [7:6] | Pole 2 resistor ( $R_{POLE2}$ )  | Bit 7    Bit 6 $R_{POLE2}$ ( $\Omega$ )         |
|         |       |                                  | 0        0        900                           |
|         |       |                                  | 0        1        450                           |
|         |       |                                  | 1        0        300                           |
|         |       |                                  | 1        1        225                           |
|         | [5:3] | Zero resistor ( $R_{ZERO}$ )     | Bit 5    Bit 4    Bit 3 $R_{ZERO}$ ( $\Omega$ ) |
|         |       |                                  | 0        0        0        3250                 |
|         |       |                                  | 0        0        1        2750                 |
|         |       |                                  | 0        1        0        2250                 |
|         |       |                                  | 0        1        1        2100                 |
|         |       |                                  | 1        0        0        3000                 |
|         |       |                                  | 1        0        1        2500                 |
|         |       |                                  | 1        1        0        2000                 |
|         |       |                                  | 1        1        1        1850                 |
|         | [2:0] | Pole 1 capacitor ( $C_{POLE1}$ ) | Bit 2    Bit 1    Bit 0 $C_{POLE1}$ (pF)        |
|         |       |                                  | 0        0        0        0                    |
|         |       |                                  | 0        0        1        8                    |
|         |       |                                  | 0        1        0        16                   |

## CONTROL REGISTERS

Table 50. PLL2 Loop Filter Control (Continued)

| Address | Bits  | Bit Name                                   | Description                                                                                                                                                                                                                                                                     |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |
|---------|-------|--------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|---|---|----|---|---|---|----|---|---|---|----|---|---|---|----|---|---|---|----|
|         |       |                                            | <table> <tr><td>0</td><td>1</td><td>1</td><td>24</td></tr> <tr><td>1</td><td>0</td><td>0</td><td>24</td></tr> <tr><td>1</td><td>0</td><td>1</td><td>32</td></tr> <tr><td>1</td><td>1</td><td>0</td><td>40</td></tr> <tr><td>1</td><td>1</td><td>1</td><td>48</td></tr> </table> | 0 | 1 | 1 | 24 | 1 | 0 | 0 | 24 | 1 | 0 | 1 | 32 | 1 | 1 | 0 | 40 | 1 | 1 | 1 | 48 |
| 0       | 1     | 1                                          | 24                                                                                                                                                                                                                                                                              |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |
| 1       | 0     | 0                                          | 24                                                                                                                                                                                                                                                                              |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |
| 1       | 0     | 1                                          | 32                                                                                                                                                                                                                                                                              |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |
| 1       | 1     | 0                                          | 40                                                                                                                                                                                                                                                                              |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |
| 1       | 1     | 1                                          | 48                                                                                                                                                                                                                                                                              |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |
| 0x0F6   | [7:1] | Reserved                                   | Reserved.                                                                                                                                                                                                                                                                       |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |
|         | 0     | Bypass internal R <sub>ZERO</sub> resistor | Bypasses the internal R <sub>ZERO</sub> resistor (R <sub>ZERO</sub> = 0 Ω). Requires the use of a series external zero resistor. This bit is the MSB of the loop filter control register (Address 0x0F5 and Address 0x0F6).                                                     |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |   |   |   |    |

## Reserved (Address 0x190)

Table 51. Reserved Register

| Address | Bits  | Bit Name | Description                                                                                                         |
|---------|-------|----------|---------------------------------------------------------------------------------------------------------------------|
| 0x190   | [7:5] | Reserved | Reserved. The default value for this register is 0x00. It is recommended to write a value of 0x20 to this register. |

## Clock Distribution (Address 0x196 to Address 0x1A1, Address 0x1AE to Address 0x1B3, Address 0x1BA, and Address 0x1BB)

Table 52. Channel 0 to Channel 5 Control (This same map applies to all six channels.)

| Address | Bits  | Bit Name                                   | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                         |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
|---------|-------|--------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------------|---|---|---|---|-----------------|---|---|---|---|---------------|---|---|---|---|---------------|---|---|---|---|-------------|---|---|---|---|----------------|---|---|---|---|---------------|---|---|---|---|------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|-----------------------------------------------------------------------------------------------------------------------------------------|---|---|---|---|-----------------------------------------------------------------------|---|---|---|---|
| 0x196   | 7     | Invert divider output                      | Inverts the polarity of the divider's output clock.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                         |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
|         | 6     | Ignore sync                                | 0: obeys chip-level SYNC signal (default).<br>1: ignores chip-level SYNC signal.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                         |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
|         | 5     | Power-down channel                         | 1: powers down the entire channel.<br>0: normal operation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                         |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
|         | 4     | Lower power mode (differential modes only) | Reduces power used in the differential output modes (LVDS/LVPECL/HSTL). This reduction may result in power savings, but at the expense of performance. Note that this bit does not affect output swing and current, just the internal driver power.<br>1: low strength/lower power.<br>0: normal operation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                         |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
|         | [3:0] | Driver mode                                | Driver mode.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                         |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
|         |       |                                            | <table><tr><th>Bit 3</th><th>Bit 2</th><th>Bit 1</th><th>Bit 0</th><th>Driver Mode</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>Tristate output</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>LVPECL (8 mA)</td></tr><tr><td>0</td><td>0</td><td>1</td><td>0</td><td>LVDS (3.5 mA)</td></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>LVDS (7 mA)</td></tr><tr><td>0</td><td>1</td><td>0</td><td>0</td><td>HSTL-0 (16 mA)</td></tr><tr><td>0</td><td>1</td><td>0</td><td>1</td><td>HSTL-1 (8 mA)</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td><td>CMOS (both outputs in phase)<br/>+ Pin: true phase relative to divider output<br/>- Pin: true phase relative to divider output</td></tr><tr><td>0</td><td>1</td><td>1</td><td>1</td><td>CMOS (opposite phases on outputs)<br/>+ Pin: true phase relative to divider output<br/>- Pin: complement phase relative to divider output</td></tr><tr><td>1</td><td>0</td><td>0</td><td>0</td><td>CMOS<br/>+ Pin: true phase relative to divider output<br/>- Pin: high-Z</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>CMOS<br/>+ Pin: high-Z</td></tr></table> | Bit 3                                                                                                                                   | Bit 2 | Bit 1 | Bit 0 | Driver Mode | 0 | 0 | 0 | 0 | Tristate output | 0 | 0 | 0 | 1 | LVPECL (8 mA) | 0 | 0 | 1 | 0 | LVDS (3.5 mA) | 0 | 0 | 1 | 1 | LVDS (7 mA) | 0 | 1 | 0 | 0 | HSTL-0 (16 mA) | 0 | 1 | 0 | 1 | HSTL-1 (8 mA) | 0 | 1 | 1 | 0 | CMOS (both outputs in phase)<br>+ Pin: true phase relative to divider output<br>- Pin: true phase relative to divider output | 0 | 1 | 1 | 1 | CMOS (opposite phases on outputs)<br>+ Pin: true phase relative to divider output<br>- Pin: complement phase relative to divider output | 1 | 0 | 0 | 0 | CMOS<br>+ Pin: true phase relative to divider output<br>- Pin: high-Z | 1 | 0 | 0 | 1 |
| Bit 3   | Bit 2 | Bit 1                                      | Bit 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Driver Mode                                                                                                                             |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
| 0       | 0     | 0                                          | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Tristate output                                                                                                                         |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
| 0       | 0     | 0                                          | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | LVPECL (8 mA)                                                                                                                           |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
| 0       | 0     | 1                                          | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | LVDS (3.5 mA)                                                                                                                           |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
| 0       | 0     | 1                                          | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | LVDS (7 mA)                                                                                                                             |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
| 0       | 1     | 0                                          | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | HSTL-0 (16 mA)                                                                                                                          |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
| 0       | 1     | 0                                          | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | HSTL-1 (8 mA)                                                                                                                           |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
| 0       | 1     | 1                                          | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | CMOS (both outputs in phase)<br>+ Pin: true phase relative to divider output<br>- Pin: true phase relative to divider output            |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
| 0       | 1     | 1                                          | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | CMOS (opposite phases on outputs)<br>+ Pin: true phase relative to divider output<br>- Pin: complement phase relative to divider output |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
| 1       | 0     | 0                                          | 0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | CMOS<br>+ Pin: true phase relative to divider output<br>- Pin: high-Z                                                                   |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |
| 1       | 0     | 0                                          | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | CMOS<br>+ Pin: high-Z                                                                                                                   |       |       |       |             |   |   |   |   |                 |   |   |   |   |               |   |   |   |   |               |   |   |   |   |             |   |   |   |   |                |   |   |   |   |               |   |   |   |   |                                                                                                                              |   |   |   |   |                                                                                                                                         |   |   |   |   |                                                                       |   |   |   |   |

## CONTROL REGISTERS

Table 52. Channel 0 to Channel 5 Control (This same map applies to all six channels.) (Continued)

| Address | Bits  | Bit Name                         | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|---------|-------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|         |       |                                  | <div> <div>1010</div> <div>– Pin: true phase relative to divider output<br/>CMOS<br/>+ Pin: high-Z<br/>– Pin: high-Z</div> </div> <div> <div>1011</div> <div>CMOS (both outputs in phase)<br/>+ Pin: complement phase relative to divider output<br/>– Pin: complement phase relative to divider output</div> </div> <div> <div>1100</div> <div>CMOS (both outputs out of phase)<br/>+ Pin: complement phase relative to divider output<br/>– Pin: true phase relative to divider output</div> </div> <div> <div>1101</div> <div>CMOS<br/>+ Pin: complement phase relative to divider output<br/>– Pin: high-Z</div> </div> <div> <div>1110</div> <div>CMOS<br/>+ Pin: high-Z<br/>– Pin: complement phase relative to divider output</div> </div> <div> <div>1111</div> <div>Tristate output</div> </div> |
| 0x197   | [7:0] | Channel divider, Bits[7:0] (LSB) | Division = Channel Divider Bits[9:0] + 1. For example, [9:0] = 0 is divided by 1, [9:0] = 1 is divided by 2 ... [9:0] = 1023 is divided by 1024. 10-bit channel divider, Bits[7:0] (LSB).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| 0x198   | [7:2] | Divider phase                    | Divider initial phase after a sync is asserted relative to the divider input clock (from the VCO divider output).<br>LSB = ½ of a period of the divider input clock.<br>Phase = 0: no phase offset.<br>Phase = 1: ½ period offset, ...<br>Phase = 63: 31 period offset.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|         | [1:0] | Channel divider, Bits[9:8] (MSB) | 10-bit channel divider, Bits[9:8] (MSB).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

Table 53. PLL1 Output Control (PLL1\_OUT, Pin 46)

| Address | Bits  | Bit Name                         | Description                                                                                                                                   |
|---------|-------|----------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| 0x1BA   | [7:5] | Reserved                         | Reserved                                                                                                                                      |
|         | 4     | PLL1 output CMOS driver strength | CMOS driver strength<br>1: weak<br>0: strong                                                                                                  |
|         | [3:0] | PLL1 output divider              | 0000: divide-by-1000<br>1: divide-by-2 (default)<br>0010: divide-by-4<br>0100: divide-by-8<br>1000: divide-by-16<br>No other inputs permitted |

Table 54. PLL1 Output Channel Control

| Address | Bits  | Bit Name                                    | Description                                                                                                |
|---------|-------|---------------------------------------------|------------------------------------------------------------------------------------------------------------|
| 0x1BB   | 7     | PLL1 output driver power-down               | PLL1 output driver power-down                                                                              |
|         | [6:2] | Reserved                                    | Reserved                                                                                                   |
|         | 1     | Route VCXO clock to Channel 1 divider input | 1: channel uses VCXO clock. Routes VCXO clock to divider input<br>0: channel uses VCO divider output clock |
|         | 0     | Route VCXO clock to Channel 0 divider input | 1: channel uses VCXO clock. Routes VCXO clock to divider input<br>0: channel uses VCO divider output clock |

## CONTROL REGISTERS

## Readback (Address 0x22C to Address 0x22D)

Table 55. Readback Registers (Readback 0 and Readback 1)

| Address | Bits  | Bit Name                          | Description                                                                                                                                          |
|---------|-------|-----------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x22C   | 7     | Status PLL2 reference clock       | 1: OK<br>0: off/clocks are missing                                                                                                                   |
|         | 6     | Status PLL1 feedback clock        | 1: OK<br>0: off/clocks are missing                                                                                                                   |
|         | 5     | Status VCXO                       | 1: OK<br>0: off/clocks are missing                                                                                                                   |
|         | 4     | Status REF_TEST                   | 1: OK<br>0: off/clocks are missing                                                                                                                   |
|         | 3     | Status REFB                       | 1: OK<br>0: off/clocks are missing                                                                                                                   |
|         | 2     | Status REFA                       | 1: OK<br>0: off/clocks are missing                                                                                                                   |
|         | 1     | Lock detect PLL2                  | 1: locked<br>0: unlocked                                                                                                                             |
|         | 0     | Lock detect PLL1                  | 1: locked<br>0: unlocked                                                                                                                             |
| 0x22D   | [7:4] | Reserved                          | Reserved                                                                                                                                             |
|         | 3     | Holdover active                   | 1: holdover is active (both references are missing)<br>0: normal operation                                                                           |
|         | 2     | Selected reference (in auto mode) | Selected reference (applies only when the device automatically selects the reference; for example, not in manual control mode)<br>1: REFB<br>0: REFA |
|         | 1     | Reserved                          | Reserved                                                                                                                                             |
|         | 0     | VCO calibration in progress       | 1: VCO calibration in progress<br>0: VCO calibration not in progress                                                                                 |

## Other (Address 0x230 to Address 0x234)

Table 56. Status Signals

| Address | Bits  | Bit Name                 | Description                                                              |
|---------|-------|--------------------------|--------------------------------------------------------------------------|
| 0x230   | [7:6] | Reserved                 | Reserved                                                                 |
|         | [5:0] | Status Monitor 0 control | Bit 5   Bit 4   Bit 3   Bit 2   Bit 1   Bit 0   Muxout                   |
|         |       |                          | 0   0   0   0   0   0   GND                                              |
|         |       |                          | 0   0   0   0   0   1   PLL1 and PLL2 locked                             |
|         |       |                          | 0   0   0   0   1   0   PLL1 locked                                      |
|         |       |                          | 0   0   0   0   1   1   PLL2 locked                                      |
|         |       |                          | 0   0   0   1   0   0   Both references are missing (REFA and REFB)      |
|         |       |                          | 0   0   0   1   0   1   Both references are missing and PLL2 is locked   |
|         |       |                          | 0   0   0   1   1   0   REFB selected (applies only to auto select mode) |
|         |       |                          | 0   0   0   1   1   1   REFA is OK                                       |
|         |       |                          | 0   0   1   0   0   0   REFB is OK                                       |
|         |       |                          | 0   0   1   0   0   1   REF_TEST is OK                                   |
|         |       |                          | 0   0   1   0   1   0   VCXO is OK                                       |
|         |       |                          | 0   0   1   0   1   1   PLL1 feedback is OK                              |
|         |       |                          | 0   0   1   1   0   0   PLL2 reference clock is OK                       |
|         |       |                          | 0   0   1   1   0   1   Reserved                                         |
|         |       |                          | 0   0   1   1   1   0   REFA and REFB are OK                             |

## CONTROL REGISTERS

Table 56. Status Signals (Continued)

| Address | Bits                                                      | Bit Name                            | Description                                                                                                                                                                                                                                                                                                            |       |       |       |       |                                                  |                                     |
|---------|-----------------------------------------------------------|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|-------|-------|--------------------------------------------------|-------------------------------------|
|         |                                                           |                                     | 0                                                                                                                                                                                                                                                                                                                      | 0     | 1     | 1     | 1     | 1                                                | All clocks are OK (except REF_TEST) |
|         |                                                           |                                     | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 0     | 0     | 0                                                | PLL1 feedback is divide-by-2        |
|         |                                                           |                                     | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 0     | 0     | 1                                                | PLL1 PFD down divide-by-2           |
|         |                                                           |                                     | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 0     | 1     | 0                                                | PLL1 REF divide-by-2                |
|         |                                                           |                                     | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 0     | 1     | 1                                                | PLL1 PFD up divide-by-2             |
|         |                                                           |                                     | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 1     | 0     | 0                                                | GND                                 |
|         |                                                           |                                     | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 1     | 0     | 1                                                | GND                                 |
|         |                                                           |                                     | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 1     | 1     | 0                                                | GND                                 |
|         |                                                           |                                     | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 1     | 1     | 1                                                | GND                                 |
|         |                                                           |                                     | Note that all bit combinations after 010111 are reserved.                                                                                                                                                                                                                                                              |       |       |       |       |                                                  |                                     |
| 0x231   | [7:6]                                                     | Reserved                            | Reserved.                                                                                                                                                                                                                                                                                                              |       |       |       |       |                                                  |                                     |
|         | [5:0]                                                     | Status Monitor 1 control            | Bit 5                                                                                                                                                                                                                                                                                                                  | Bit 4 | Bit 3 | Bit 2 | Bit 1 | Bit 0                                            | Muxout                              |
|         | 0                                                         | 0                                   | 0                                                                                                                                                                                                                                                                                                                      | 0     | 0     | 0     | 0     | GND                                              |                                     |
|         | 0                                                         | 0                                   | 0                                                                                                                                                                                                                                                                                                                      | 0     | 0     | 0     | 1     | PLL1 and PLL2 locked                             |                                     |
|         | 0                                                         | 0                                   | 0                                                                                                                                                                                                                                                                                                                      | 0     | 0     | 1     | 0     | PLL1 locked                                      |                                     |
|         | 0                                                         | 0                                   | 0                                                                                                                                                                                                                                                                                                                      | 0     | 0     | 1     | 1     | PLL2 locked                                      |                                     |
|         | 0                                                         | 0                                   | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 0     |       | Both references are missing (REFA and REFB)      |                                     |
|         | 0                                                         | 0                                   | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 1     |       | Both references are missing and PLL2 is locked   |                                     |
|         | 0                                                         | 0                                   | 0                                                                                                                                                                                                                                                                                                                      | 1     | 1     | 0     |       | REFB selected (applies only to auto select mode) |                                     |
|         | 0                                                         | 0                                   | 0                                                                                                                                                                                                                                                                                                                      | 1     | 1     | 1     |       | REFA is OK                                       |                                     |
|         | 0                                                         | 0                                   | 1                                                                                                                                                                                                                                                                                                                      | 0     | 0     | 0     |       | REFB is OK                                       |                                     |
|         | 0                                                         | 0                                   | 1                                                                                                                                                                                                                                                                                                                      | 0     | 0     | 1     |       | REF_TEST is OK                                   |                                     |
|         | 0                                                         | 0                                   | 1                                                                                                                                                                                                                                                                                                                      | 0     | 1     | 0     |       | VCXO is OK                                       |                                     |
|         | 0                                                         | 0                                   | 1                                                                                                                                                                                                                                                                                                                      | 0     | 1     | 1     |       | PLL1 feedback is OK                              |                                     |
|         | 0                                                         | 0                                   | 1                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 0     |       | PLL2 reference clock is OK                       |                                     |
|         | 0                                                         | 0                                   | 1                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 1     |       | Reserved                                         |                                     |
|         | 0                                                         | 0                                   | 1                                                                                                                                                                                                                                                                                                                      | 1     | 1     | 0     |       | REFA and REFB are OK                             |                                     |
|         | 0                                                         | 0                                   | 1                                                                                                                                                                                                                                                                                                                      | 1     | 1     | 1     |       | All clocks are OK (except REF_TEST)              |                                     |
|         | 0                                                         | 1                                   | 0                                                                                                                                                                                                                                                                                                                      | 0     | 0     | 0     |       | GND                                              |                                     |
|         | 0                                                         | 1                                   | 0                                                                                                                                                                                                                                                                                                                      | 0     | 0     | 1     |       | GND                                              |                                     |
|         | 0                                                         | 1                                   | 0                                                                                                                                                                                                                                                                                                                      | 0     | 1     | 0     |       | GND                                              |                                     |
|         | 0                                                         | 1                                   | 0                                                                                                                                                                                                                                                                                                                      | 0     | 1     | 1     |       | GND                                              |                                     |
|         | 0                                                         | 1                                   | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 0     |       | PLL2 feedback is divide-by-2                     |                                     |
|         | 0                                                         | 1                                   | 0                                                                                                                                                                                                                                                                                                                      | 1     | 0     | 1     |       | PLL2 PFD down divide-by-2                        |                                     |
|         | 0                                                         | 1                                   | 0                                                                                                                                                                                                                                                                                                                      | 1     | 1     | 0     |       | PLL2 REF divide-by-2                             |                                     |
|         | 0                                                         | 1                                   | 0                                                                                                                                                                                                                                                                                                                      | 1     | 1     | 1     |       | PLL2 PFD up divide-by-2                          |                                     |
|         | Note that all bit combinations after 010111 are reserved. |                                     |                                                                                                                                                                                                                                                                                                                        |       |       |       |       |                                                  |                                     |
| 0x232   | [7:5]                                                     | Reserved                            | Reserved.                                                                                                                                                                                                                                                                                                              |       |       |       |       |                                                  |                                     |
|         | 4                                                         | Enable Status_EEPROM on STATUS0 pin | Enables the EEPROM status on the STATUS0 pin.<br>1: enable status.                                                                                                                                                                                                                                                     |       |       |       |       |                                                  |                                     |
|         | 3                                                         | STATUS1 pin divider enable          | Enables a divide-by-4 on the STATUS1 pin, allowing dynamic signals to be viewed at a lower frequency (such as the PFD input clocks). Not to be used with dc states on the status pins, which occur when the settings of Register 0x231, Bits[5:0] are in the range of 000000 to 001111.<br>1: enabled.<br>0: disabled. |       |       |       |       |                                                  |                                     |
|         | 2                                                         | STATUS0 pin divider enable          | Enables a divide-by-4 on the STATUS0 pin, allowing dynamic signals to be viewed at a lower frequency (such as the PFD input clocks). Not to be used with dc states on the status pins, which occur when the settings of Register 0x230, Bits[5:0] are in the range of 000000 to 001111.<br>1: enable.<br>0: disable.   |       |       |       |       |                                                  |                                     |

## CONTROL REGISTERS

Table 56. Status Signals (Continued)

| Address | Bits | Bit Name                       | Description                                                                                                   |
|---------|------|--------------------------------|---------------------------------------------------------------------------------------------------------------|
|         | 1    | Reserved                       | Reserved.                                                                                                     |
|         | 0    | Sync dividers (manual control) | Set bit to put dividers in sync; clear bit to release. Functions like SYNC pin low.<br>1: sync.<br>0: normal. |

Table 57. Power-Down Control

| Address | Bits  | Bit Name                | Description                                                                       |
|---------|-------|-------------------------|-----------------------------------------------------------------------------------|
| 0x233   | [7:3] | Reserved                | Reserved.                                                                         |
|         | 2     | PLL1 power-down         | 1: power-down (default).<br>0: normal operation.                                  |
|         | 1     | PLL2 power-down         | 1: power-down (default).<br>0: normal operation.                                  |
|         | 0     | Distribution power-down | Powers down the distribution.<br>1: power-down (default).<br>0: normal operation. |

Table 58. Update All Registers

| Address | Bits  | Bit Name  | Description                                                                                                                                                                                                                                                                                                            |
|---------|-------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0x234   | [7:1] | Reserved  | Reserved.                                                                                                                                                                                                                                                                                                              |
|         | 0     | IO_Update | This bit must be set to 1 to transfer the contents of the buffer registers into the active registers, which happens on the next SCLK rising edge. This bit is self clearing; that is, it does not have to be set back to 0.<br>1 (self clearing): update all active registers to the contents of the buffer registers. |

## EEPROM Buffer (Address 0xA00 to Address 0xA16)

Table 59. EEPROM Buffer Segment

| Address        | Bits  | Bit Name                                                              | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|----------------|-------|-----------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0xA00 to 0xA16 | [7:0] | EEPROM Buffer Segment Register 1 to EEPROM Buffer Segment Register 23 | The EEPROM buffer segment section stores the starting address and number of bytes that are to be stored and read back to and from the EEPROM. Because the register space is noncontiguous, the EEPROM controller needs to know the starting address and number of bytes in the register space to store and retrieve from the EEPROM. In addition, there are special instructions for the EEPROM controller: operational codes (that is, IO_Update and end-of-data) that are also stored in the EEPROM buffer segment. The on-chip default setting of the EEPROM buffer segment registers is designed such that all registers are transferred to/from the EEPROM, and an IO_Update is issued after the transfer (see the <a href="#">Programming the EEPROM Buffer Segment</a> section). |

## EEPROM Control (Address 0xB00 to Address 0xB03)

Table 60. Status\_EEPROM

| Address | Bits  | Bit Name                 | Description                                                                                                                                                                                                                                                                                                             |
|---------|-------|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0xB00   | [7:1] | Reserved                 | Reserved.                                                                                                                                                                                                                                                                                                               |
|         | 0     | Status_EEPROM(read only) | This read-only bit indicates the status of the data transferred between the EEPROM and the buffer register bank during the writing and reading of the EEPROM. This signal is also available at the STATUS0 pin when Register 0x232, Bit 4 is set.<br>0: data transfer is complete.<br>1: data transfer is not complete. |

Table 61. EEPROM Error Checking Readback

| Address | Bits  | Bit Name                      | Description                                                                                                                        |
|---------|-------|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| 0xB01   | [7:1] | Reserved                      | Reserved.                                                                                                                          |
|         | 0     | EEPROM data error (read only) | This read-only bit indicates an error during the data transfer between the EEPROM and the buffer.<br>0: no error; data is correct. |

## CONTROL REGISTERS

Table 61. EEPROM Error Checking Readback (Continued)

| Address | Bits | Bit Name | Description                 |
|---------|------|----------|-----------------------------|
|         |      |          | 1: incorrect data detected. |

Table 62. EEPROM Control 1

| Address | Bits  | Bit Name            | Description                                                                                                                                                                                    |
|---------|-------|---------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0xB02   | [7:2] | Reserved            | Reserved.                                                                                                                                                                                      |
|         | 1     | Soft_EEPROM         | When the EEPROM_SEL pin is tied low, setting the Soft_EEPROM bit resets the AD9524 using the settings saved in EEPROM.<br>1: soft reset with EEPROM settings (self clearing).                  |
|         | 0     | Enable EEPROM write | Enables the user to write to the EEPROM.<br>0: EEPROM write protection is enabled. User cannot write to EEPROM (default).<br>1: EEPROM write protection is disabled. User can write to EEPROM. |

Table 63. EEPROM Control 2

| Address | Bits  | Bit Name   | Description                                                                                                                                                                                                                                                   |
|---------|-------|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0xB03   | [7:1] | Reserved   | Reserved.                                                                                                                                                                                                                                                     |
|         | 0     | REG2EEPROM | Transfers data from the buffer register to the EEPROM (self clearing).<br>1: setting this bit initiates the data transfer from the buffer register to the EEPROM (writing process); it is reset by the I <sup>2</sup> C main after the data transfer is done. |

## OUTLINE DIMENSIONS

| Package Drawing (Option) | Package Type | Package Description                   |
|--------------------------|--------------|---------------------------------------|
| CP-48-1                  | LFCSP        | 48-Lead Lead Frame Chip Scale Package |

For the latest package outline information and land patterns (footprints), go to [Package Index](#).

## ORDERING GUIDE

| Model <sup>1</sup> | Temperature Range | Package Description                            | Packing Quantity | Package Option |
|--------------------|-------------------|------------------------------------------------|------------------|----------------|
| AD9524BCPZ         | -40°C to +85°C    | 48 -Lead Lead Frame Chip Scale Package [LFCSP] | Tray, 260        | CP-48-1        |
| AD9524BCPZ-REEL7   | -40°C to +85°C    | 48-Lead Lead Frame Chip Scale Package [LFCSP]  | Reel, 750        | CP-48-1        |

<sup>1</sup> Z = RoHS Compliant Part.

## EVALUATION BOARDS

| Model <sup>1</sup> | Description      |
|--------------------|------------------|
| AD9524/PCBZ        | Evaluation Board |

<sup>1</sup> Z = RoHS Compliant Part.

I<sup>2</sup>C refers to a communications protocol originally developed by Philips Semiconductors (now NXP Semiconductors).

# Mouser Electronics

Authorized Distributor

Click to View Pricing, Inventory, Delivery & Lifecycle Information:

[Analog Devices Inc.:](#)

[AD9524/PCBZ](#) [AD9524BCPZ](#) [AD9524BCPZ-REEL7](#)