

# ADC32RF52 Dual Channel 14-bit 1.5-GSPS RF Sampling Data Converter

## 1 Features

- 14-Bit, dual channel 1.5-GSPS ADC
- Noise spectral density:
  - NSD = -153 dBFS/Hz (no AVG)
  - NSD = -156 dBFS/Hz (2x AVG)
  - NSD = -159 dBFS/Hz (4x AVG)
- Single core (non-interleaved) ADC architecture
- Aperture jitter: 50 fs
- Low close-in residual phase noise:
  - -133 dBc/Hz at 10 kHz offset
- Spectral performance ( $f_{IN} = 900$  MHz, -4 dBFS):
  - 2x internal averaging
  - SNR: 66.8 dBFS
  - SFDR HD2,3: 74 dBc
  - SFDR worst spur: 90 dBFS
- Input fullscale: 1.0/1.1 V<sub>pp</sub> (1/1.8 dBm)
- Code error rate (CER):  $10^{-15}$
- Full power input bandwidth (-3 dB): 1.6 GHz
- JESD204B serial data interface
  - Maximum lane rate: 13 Gbps
  - Supports subclass 1 deterministic latency
- Digital down-converters
  - Up to four DDC per ADC channel
  - Complex output: 4x, 16x to 128x decimation
  - 48-bit NCO phase coherent frequency hopping
  - Fast frequency hopping: < 1  $\mu$ s
- Power consumption: 1.8 W/channel (2x AVG)
- Power supplies: 1.8 V, 1.2 V

## 2 Applications

- Phased array radar
- Spectrum analyzer
- Software defined radio (SDR)
- [Electronic warfare](#)
- High-speed digitizer
- Cable infrastructure
- Communications infrastructure

## 3 Description

The ADC32RF52 is a single core 14-bit, 1.5 GSPS, dual channel analog to digital converter (ADC) that supports RF sampling with input frequencies up to 2 GHz. The design maximizes signal-to-noise ratio (SNR) and delivers a noise spectral density of -153 dBFS/Hz. Using additional internal ADCs along with on-chip signal averaging, the noise density improves to -156 dBFS/Hz (2x AVG) and -159 dBFS/Hz (4x AVG).

Each ADC channel can be connected to a quad-band digital down-converter (DDC) using a 48-bit NCO which supports phase coherent frequency hopping. Using the GPIO pins for NCO frequency control, frequency hopping can be achieved in less than 1  $\mu$ s.

The ADC32RF52 supports the JESD204B serial data interface with subclass 1 deterministic latency using data rates up to 13 Gbps.

The power efficient ADC architecture consumes 1.4 W/ch at 1.5 Gsps and provides power scaling with lower sampling rates.

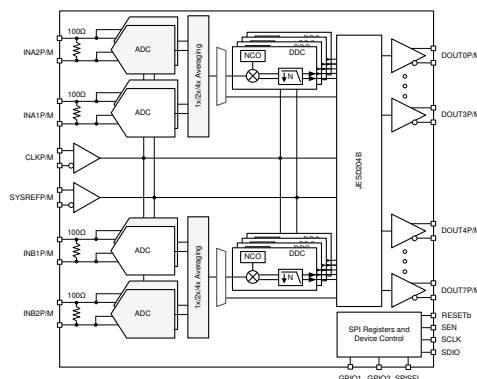
### Package Information

| PART NUMBER | PCKAGE <sup>(1)</sup> | PACKAGE SIZE <sup>(2)</sup> |
|-------------|-----------------------|-----------------------------|
| ADC32RF52   | QFN (64)              | 9 mm × 9 mm                 |

- (1) For all available packages, see the package option addendum at the end of the data sheet.
- (2) The package size (length × width) is a nominal value and includes pins, where applicable.

**Table 3-1. Device Comparison**

| PART NUMBER | SAMPLING RATE |
|-------------|---------------|
| ADC32RF55   | 3 GSPS        |
| ADC32RF54   | 2.6 GSPS      |
| ADC32RF52   | 1.5 GSPS      |



**Block Diagram**



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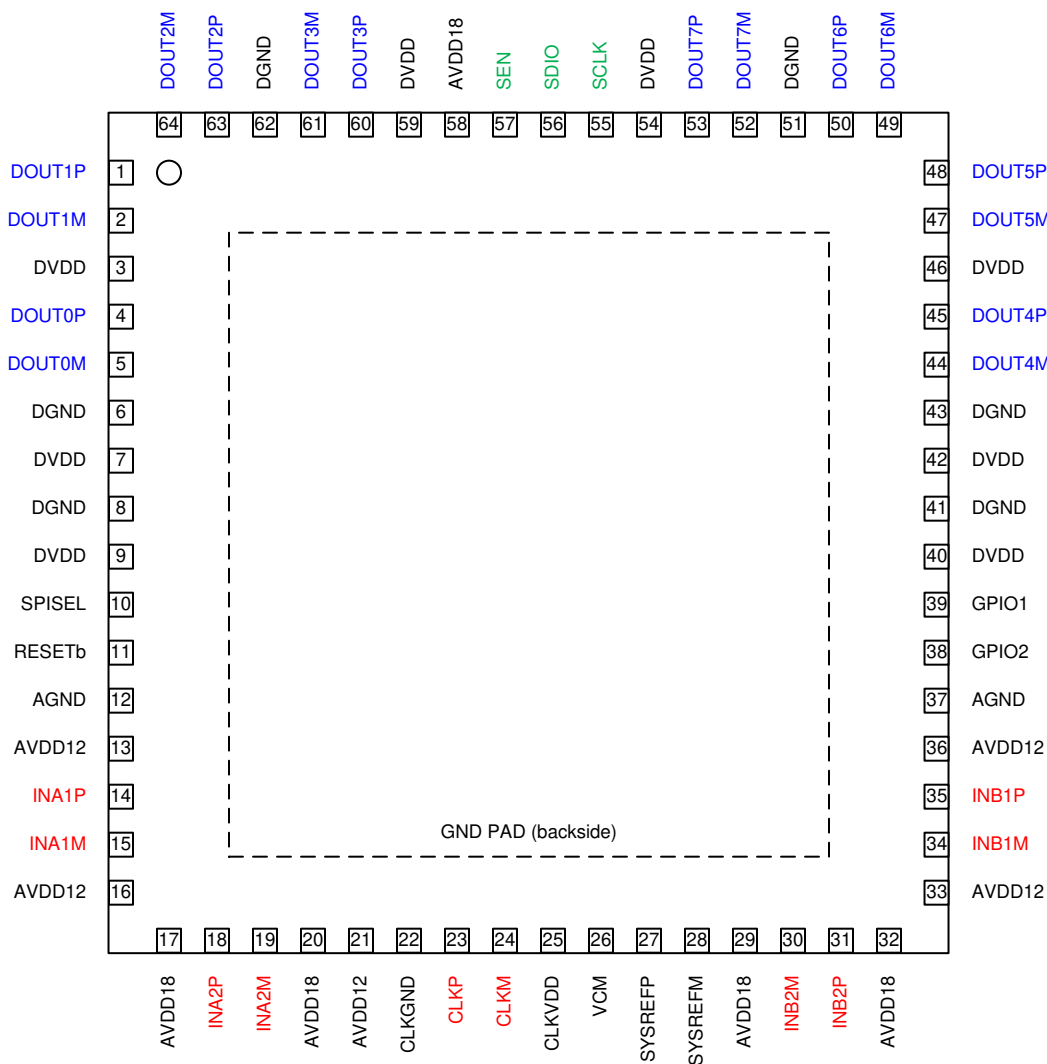
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## 4 Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

| DATE           | REVISION | NOTES           |
|----------------|----------|-----------------|
| September 2023 | *        | Initial Release |

## 5 Pin Configuration and Functions



**Figure 5-1. RTD (VQFNP) Package, 64 Pin  
(Top View)**

**Table 5-1. Pin Functions**

| PIN           |     | TYPE | DESCRIPTION                                                                                                                                                                                                                            |
|---------------|-----|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME          | NO. |      |                                                                                                                                                                                                                                        |
| Analog Inputs |     |      |                                                                                                                                                                                                                                        |
| INA1P         | 14  | I    | Differential analog input for channel A. 100 $\Omega$ (default) or 50 $\Omega$ differential internal termination.                                                                                                                      |
| INA1M         | 15  |      |                                                                                                                                                                                                                                        |
| INA2P         | 18  | I    | Differential analog input for alternate channel A input. This input is used for additional ADC averaging for channel A. 100 $\Omega$ (default) or 50 $\Omega$ differential internal termination. Should be connected to GND if unused. |
| INA2M         | 19  |      |                                                                                                                                                                                                                                        |
| INB1P         | 35  | I    | Differential analog input for channel B. 100 $\Omega$ (default) or 50 $\Omega$ differential internal termination.                                                                                                                      |
| INB1M         | 34  |      |                                                                                                                                                                                                                                        |
| INB2P         | 31  | I    | Differential analog input for alternate channel B input. This input is used for additional ADC averaging for channel B. 100 $\Omega$ (default) or 50 $\Omega$ differential internal termination. Should be connected to GND if unused. |
| INB2M         | 30  |      |                                                                                                                                                                                                                                        |

**Table 5-1. Pin Functions (continued)**

| PIN                    |                       | TYPE | DESCRIPTION                                                                                                                    |
|------------------------|-----------------------|------|--------------------------------------------------------------------------------------------------------------------------------|
| NAME                   | NO.                   |      |                                                                                                                                |
| VCM                    | 26                    | O    | Common-mode voltage output for the analog inputs.                                                                              |
| Clock, Synchronization |                       |      |                                                                                                                                |
| CLKP                   | 23                    | I    | Differential sampling clock input. 100 Ω differential internal termination.                                                    |
| CLKM                   | 24                    |      |                                                                                                                                |
| SYSREFP                | 27                    | I    | Differential external synchronization input.                                                                                   |
| SYSREFM                | 28                    |      |                                                                                                                                |
| Control                |                       |      |                                                                                                                                |
| RESETb                 | 11                    | I    | Hardware reset. Active low. This pin has an internal 21 kΩ pullup resistor to AVDD18.                                          |
| SEN                    | 57                    | I    | Serial interface enable. Active low. This pin has an internal 21 kΩ pull-up resistor to AVDD18.                                |
| SCLK                   | 55                    | I    | Serial interface clock input. This pin has an internal 21 kΩ pull-down resistor.                                               |
| SDIO                   | 56                    | I/O  | Serial interface data input and output. This pin has an internal 21 kΩ pull-down resistor.                                     |
| GPIO1                  | 39                    | I    | GPIO control pin. This pin is configured through SPI interface for power down or NCO control function.                         |
| GPIO2                  | 38                    | I    | GPIO control pin. This pin is configured through SPI interface for power down or NCO control function.                         |
| SPISEL                 | 10                    | I    | Determines SPI control: either normal SPI for register writes or fast access to NCO selection only for fast frequency hopping. |
| Digital Data Interface |                       |      |                                                                                                                                |
| DOUT0P                 | 4                     | O    | JESD204B high-speed serial data output interface pins for channel A.                                                           |
| DOUT0M                 | 5                     |      |                                                                                                                                |
| DOUT1P                 | 1                     |      |                                                                                                                                |
| DOUT1M                 | 2                     |      |                                                                                                                                |
| DOUT2P                 | 63                    |      |                                                                                                                                |
| DOUT2M                 | 64                    |      |                                                                                                                                |
| DOUT3P                 | 60                    |      |                                                                                                                                |
| DOUT3M                 | 61                    |      |                                                                                                                                |
| DOUT4P                 | 45                    | O    | JESD204B high-speed serial data output interface pins for channel B.                                                           |
| DOUT4M                 | 44                    |      |                                                                                                                                |
| DOUT5P                 | 48                    |      |                                                                                                                                |
| DOUT5M                 | 47                    |      |                                                                                                                                |
| DOUT6P                 | 50                    |      |                                                                                                                                |
| DOUT6M                 | 49                    |      |                                                                                                                                |
| DOUT7P                 | 53                    |      |                                                                                                                                |
| DOUT7M                 | 52                    |      |                                                                                                                                |
| Power Supply           |                       |      |                                                                                                                                |
| AVDD18                 | 17,20,29,32, 58       | I    | Analog 1.8-V power supply                                                                                                      |
| AVDD12                 | 13,16,21,33, 36       | I    | Analog 1.2-V power supply                                                                                                      |
| CLKVDD                 | 25                    | I    | Clock 1.2-V power supply. Very sensitive to power supply noise. Directly impacts close in aperture phase noise.                |
| DVDD                   | 3,7,9,40,42, 46,54,59 | I    | Digital 1.2-V power supply                                                                                                     |
| AGND                   | 12,37                 | I    | Analog ground, shorted to thermal pad.                                                                                         |
| CLKGND                 | 22                    | I    | Clock ground.                                                                                                                  |
| DGND                   | 6,8,41,43,51,62       | I    | Digital ground.                                                                                                                |

## 6 Specifications

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

| PARAMETER                                | TEST CONDITIONS                              | MIN  | MAX          | UNIT |
|------------------------------------------|----------------------------------------------|------|--------------|------|
| Supply voltage range, AVDD18             |                                              | −0.3 | 2.1          | V    |
| Supply voltage range, AVDD12/CLKVDD/DVDD |                                              | −0.3 | 1.4          | V    |
| Voltage applied to input pins            | INA1P/M, INB1P/M, INA2P/M, INB2P/M           | −0.6 | 1.2          | V    |
|                                          | CLKP/M                                       | −0.3 | VDDCLK + 0.3 |      |
|                                          | SYSREFP/M                                    | −0.3 | AVDD12 + 0.6 |      |
|                                          | GPIO1/2, PDN, RESET, SCLK, SEN, SDIO, SPISEL | −0.3 | AVDD18 + 0.2 |      |
| Peak RF input power (INx1P/M, INx2P/M)   | Differential 100 Ω termination.              |      | 12           | dBm  |
| Junction temperature, T <sub>J</sub>     |                                              |      | 125          | °C   |
| Storage temperature, T <sub>stg</sub>    |                                              | −65  | 150          | °C   |

- (1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

### 6.2 ESD Ratings

|                    |                         |                                                                       | VALUE  | UNIT |
|--------------------|-------------------------|-----------------------------------------------------------------------|--------|------|
| V <sub>(ESD)</sub> | Electrostatic discharge | Human body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>     | ± 1000 | V    |
|                    |                         | Charged device model (CDM), per ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup> | ± 500  |      |

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.  
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

|                |                                | MIN   | NOM | MAX                | UNIT |
|----------------|--------------------------------|-------|-----|--------------------|------|
| AVDD18         | 1.8 V analog supply            | 1.75  | 1.8 | 1.85               | V    |
| AVDD12         | 1.2 V analog supply            | 1.15  | 1.2 | 1.225              |      |
| CLKVDD         | 1.2 V clock supply             | 1.175 | 1.2 | 1.225              |      |
| DVDD           | 1.2 V digital supply           | 1.15  | 1.2 | 1.225              |      |
| T <sub>A</sub> | Operating free-air temperature | −40   |     | 85                 | °C   |
| T <sub>J</sub> | Operating junction temperature |       |     | 105 <sup>(1)</sup> | °C   |

- (1) Prolonged use above this junction temperature may increase the device failure-in-time (FIT) rate.

## 6.4 Thermal Information

| THERMAL METRIC <sup>(1)</sup> |                                              | ADC32RF52 | UNIT |
|-------------------------------|----------------------------------------------|-----------|------|
|                               |                                              | RTD (QFN) |      |
|                               |                                              | 64 Pins   |      |
| R <sub>ΘJA</sub>              | Junction-to-ambient thermal resistance       | 20.1      | °C/W |
| R <sub>ΘJC(top)</sub>         | Junction-to-case (top) thermal resistance    | 6.8       | °C/W |
| R <sub>ΘJB</sub>              | Junction-to-board thermal resistance         | 5.2       | °C/W |
| Ψ <sub>JT</sub>               | Junction-to-top characterization parameter   | 0.1       | °C/W |
| Ψ <sub>JB</sub>               | Junction-to-board characterization parameter | 5.1       | °C/W |
| R <sub>ΘJC(bot)</sub>         | Junction-to-case (bottom) thermal resistance | 0.5       | °C/W |

(1) For more information about thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report, SPRA953.

## 6.5 Electrical Characteristics - Power Consumption

Maximum and minimum values are specified over the operating free-air temperature range and nominal supply voltages. Typical values are specified at T<sub>A</sub> = 25°C, ADC sampling rate = 1.5 GSPS, Bypass mode, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, AVDDCLK, DVDD = 1.2 V and –1-dBFS differential input, unless otherwise noted

| PARAMETER           |                                      | TEST CONDITIONS           | MIN | TYP  | MAX  | UNIT |
|---------------------|--------------------------------------|---------------------------|-----|------|------|------|
| FS = 1.5 GSPS       |                                      |                           |     |      |      |      |
| I <sub>AVDD18</sub> | Supply current, 1.8 V analog supply  | Bypass mode, LMFS = 8224  |     | 240  |      | mA   |
| I <sub>AVDD12</sub> | Supply current, 1.2 V analog supply  |                           |     | 700  |      |      |
| I <sub>CLKVDD</sub> | Supply current, 1.2 V clock supply   |                           |     | 100  |      |      |
| I <sub>DVDD</sub>   | Supply current, 1.2 V digital supply |                           |     | 1200 |      |      |
| P <sub>DIS</sub>    | Power dissipation                    |                           |     | 2.8  |      | W    |
| I <sub>AVDD18</sub> | Supply current, 1.8 V analog supply  | 2x averaging, LMFS = 8224 |     | 320  |      | mA   |
| I <sub>AVDD12</sub> | Supply current, 1.2 V analog supply  |                           |     | 900  |      |      |
| I <sub>CLKVDD</sub> | Supply current, 1.2 V clock supply   |                           |     | 100  |      |      |
| I <sub>DVDD</sub>   | Supply current, 1.2 V digital supply |                           |     | 1400 |      |      |
| P <sub>DIS</sub>    | Power dissipation                    |                           |     | 3.55 |      | W    |
| I <sub>AVDD18</sub> | Supply current, 1.8 V analog supply  | 4x averaging, LMFS = 8224 |     | 500  | 600  | mA   |
| I <sub>AVDD12</sub> | Supply current, 1.2 V analog supply  |                           |     | 1300 | 1700 |      |
| I <sub>CLKVDD</sub> | Supply current, 1.2 V clock supply   |                           |     | 120  | 150  |      |
| I <sub>DVDD</sub>   | Supply current, 1.2 V digital supply |                           |     | 1800 | 2900 |      |
| P <sub>DIS</sub>    | Power dissipation                    |                           |     | 4.85 |      | W    |
| POWER DOWN MODES    |                                      |                           |     |      |      |      |
| P <sub>DIS</sub>    | Power down mode power consumption    |                           |     | 190  |      | mW   |

## 6.6 Electrical Characteristics - DC Specifications

Maximum and minimum values are specified over the operating free-air temperature range and nominal supply voltages. Typical values are specified at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, Bypass mode, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, AVDDCLK, DVDD = 1.2 V and –1-dBFS differential input, unless otherwise noted

| PARAMETER                                                     |                                                       | TEST CONDITIONS                                                    | MIN                    | TYP  | MAX  | UNIT             |
|---------------------------------------------------------------|-------------------------------------------------------|--------------------------------------------------------------------|------------------------|------|------|------------------|
| DC ACCURACY                                                   |                                                       |                                                                    |                        |      |      |                  |
| DNL                                                           | Differential nonlinearity                             | F <sub>IN</sub> = 10 MHz                                           | ±1                     |      |      | LSB              |
| INL                                                           | Integral nonlinearity                                 | F <sub>IN</sub> = 10 MHz                                           | ±8                     |      |      | LSB              |
| V <sub>OS_ERR</sub>                                           | Offset error                                          |                                                                    | ±0.2                   |      |      | %FSR             |
| GAIN <sub>ERR</sub>                                           | Gain error                                            |                                                                    | ±0.2                   |      |      | %FSR             |
| GAIN <sub>Match</sub>                                         | Gain matching across channels                         |                                                                    | ±0.2                   |      |      | dB               |
| ADC ANALOG INPUTS (INA1P/M, INB1P/M, INA2P/M, INB2P/M)        |                                                       |                                                                    |                        |      |      |                  |
| FS                                                            | Input full scale (differential)                       | 1x or 2x AVG, RSW = 0                                              | 0.95                   |      |      | V <sub>pp</sub>  |
|                                                               |                                                       | 1x AVG, RSW = 1                                                    | 1.0                    |      |      |                  |
|                                                               |                                                       | 2x AVG, RSW = 1                                                    | 1.1                    |      |      |                  |
| V <sub>ICM</sub>                                              | Input common model voltage                            |                                                                    | 250                    | 350  | 450  | mV               |
| Z <sub>IN</sub>                                               | Differential input impedance                          | Differential at 100 MHz                                            | 100                    |      |      | Ω                |
| V <sub>OCM</sub>                                              | Output common mode voltage                            |                                                                    | 350                    |      |      | mV               |
| BW                                                            | Analog Input Bandwidth (-3 dB)                        | No averaging, RSW = 1                                              | 1.6                    |      |      | GHz              |
|                                                               |                                                       | 2x or 4x averaging, RSW = 1                                        | 1.5                    |      |      |                  |
| Phase imbalance, analog input                                 |                                                       |                                                                    | ±2                     |      |      | deg              |
| Amplitude imabalance, analog input                            |                                                       |                                                                    | ±0.5                   |      |      | dB               |
| CLOCK INPUT (CLKP/M)                                          |                                                       |                                                                    |                        |      |      |                  |
| Input clock frequency                                         |                                                       |                                                                    | 500                    | 1500 |      | MHz              |
| V <sub>ID</sub>                                               | Differential input voltage                            |                                                                    | 1                      |      | 2.4  | V <sub>pp</sub>  |
| V <sub>ICM</sub>                                              | Input common mode voltage                             |                                                                    | 0.65                   | 0.75 | 0.85 | V                |
| Z <sub>IN</sub>                                               | Differential input impedance                          | Differential at 2.6 GHz                                            | 100                    |      |      | Ω                |
| Clock duty cycle                                              |                                                       |                                                                    | 45                     | 50   | 55   | %                |
| SYSREF INPUT (SYSREFP/M)                                      |                                                       |                                                                    |                        |      |      |                  |
| V <sub>ID</sub>                                               | Differential input voltage                            |                                                                    | 600                    | 800  | 1000 | mV <sub>pp</sub> |
| V <sub>ICM</sub>                                              | Input common mode voltage                             | Input common mode voltage                                          | 1.05                   | 1.2  | 1.4  | V                |
| Z <sub>IN</sub>                                               | Differential input impedance                          |                                                                    | 100                    |      |      | Ω                |
| DIGITAL INPUTS (RESET, PDN, SCLK, SEN, SDIO, GPIO1/2, SPISEL) |                                                       |                                                                    |                        |      |      |                  |
| V <sub>IH</sub>                                               | High-level input voltage                              |                                                                    | 0.8                    |      |      | V                |
| V <sub>IL</sub>                                               | Low-level input voltage                               |                                                                    | 0.4                    |      |      | V                |
| C <sub>I</sub>                                                | Input capacitance                                     |                                                                    | 0.6                    |      |      | pF               |
| DIGITAL OUTPUT (SDIO)                                         |                                                       |                                                                    |                        |      |      |                  |
| V <sub>OH</sub>                                               | High-level output voltage                             | I <sub>LOAD</sub> = -400 uA                                        | AVDD18<br>– 0.1 AVDD18 |      |      | V                |
| V <sub>OL</sub>                                               | Low-level output voltage                              | I <sub>LOAD</sub> = 400 uA                                         | 0.1                    |      |      | V                |
| CML SERDES OUTPUTS: DOUT[0:7]P/M                              |                                                       |                                                                    |                        |      |      |                  |
| V <sub>OD</sub>                                               | Serdes transmitter output amplitude                   | differential peak-peak                                             | 700                    |      |      | mV <sub>pp</sub> |
| V <sub>OCM</sub>                                              | Serdes transmitter output common mode                 |                                                                    | 425                    |      |      | mV               |
| Z <sub>TX</sub>                                               | Serdes transmitter single ended termination impedance |                                                                    | 50                     |      |      | Ω                |
|                                                               | Transmitter short-circuit current                     | Transmitter pins shorted to any voltage between –0.25 V and 1.45 V | –100                   |      | 100  | mA               |

## 6.7 Electrical Characteristics - AC Specifications (Dither DISABLED)

Maximum and minimum values are specified over the operating free-air temperature range and nominal supply voltages. Typical values are specified at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, Bypass mode, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, AVDDCLK, DVDD = 1.2 V, -1-dBFS differential input and dither DISABLED, unless otherwise noted

| PARAMETER |                                                     | TEST CONDITIONS                                                        | MIN  | TYP    | MAX | UNIT    |
|-----------|-----------------------------------------------------|------------------------------------------------------------------------|------|--------|-----|---------|
| NSD       | Noise Spectral Density                              | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>no averaging |      | -153.2 |     | dBFS/Hz |
|           |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>2x averaging |      | -156.0 |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>4x averaging |      | -158.6 |     |         |
| NF        | Noise Figure                                        | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>no averaging |      | 22.1   |     | dB      |
|           |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>2x averaging |      | 21.0   |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>4x averaging |      | 20.2   |     |         |
| SNR       | Signal-to-noise ratio<br>no averaging               | $f_{IN} = 100\text{ MHz}$                                              |      | 64.1   |     | dBFS    |
|           |                                                     | $f_{IN} = 600\text{ MHz}$                                              |      | 64.1   |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$                                              | 61.5 | 63.9   |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 |      | 65.1   |     |         |
|           |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |      | 63.6   |     |         |
|           | Signal-to-noise ratio<br>2x averaging               | $f_{IN} = 100\text{ MHz}$                                              |      | 66.5   |     |         |
|           |                                                     | $f_{IN} = 600\text{ MHz}$                                              |      | 66.6   |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$                                              |      | 66.3   |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 |      | 67.9   |     |         |
|           |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |      | 65.9   |     |         |
|           | Signal-to-noise ratio<br>4x averaging               | $f_{IN} = 100\text{ MHz}$                                              |      | 69.3   |     |         |
|           |                                                     | $f_{IN} = 600\text{ MHz}$                                              |      | 69.2   |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$                                              |      | 68.5   |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 |      | 69.9   |     |         |
|           |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |      | 65.9   |     |         |
| SINAD     | Signal to noise and distortion<br>ratio             | $f_{IN} = 100\text{ MHz}$                                              |      | 60.6   |     | dBFS    |
|           |                                                     | $f_{IN} = 600\text{ MHz}$                                              |      | 62.2   |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$                                              |      | 62.1   |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 |      | 62.1   |     |         |
|           |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |      | 62.0   |     |         |
| ENOB      | Effective number of bits                            | $f_{IN} = 100\text{ MHz}$                                              |      | 10.4   |     | Bits    |
|           |                                                     | $f_{IN} = 600\text{ MHz}$                                              |      | 10.4   |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$                                              |      | 10.3   |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 |      | 10.5   |     |         |
|           |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |      | 10.3   |     |         |
| THD       | Total Harmonic Distortion (First<br>five harmonics) | $f_{IN} = 100\text{ MHz}$                                              |      | 64     |     | dBc     |
|           |                                                     | $f_{IN} = 600\text{ MHz}$                                              |      | 67     |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$                                              |      | 67     |     |         |
|           |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 |      | 65     |     |         |
|           |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |      | 68     |     |         |

## 6.7 Electrical Characteristics - AC Specifications (Dither DISABLED) (continued)

Maximum and minimum values are specified over the operating free-air temperature range and nominal supply voltages. Typical values are specified at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, Bypass mode, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, AVDDCLK, DVDD = 1.2 V, -1-dBFS differential input and dither DISABLED, unless otherwise noted

| PARAMETER    |                                                    | TEST CONDITIONS                                                              | MIN | TYP | MAX | UNIT |
|--------------|----------------------------------------------------|------------------------------------------------------------------------------|-----|-----|-----|------|
| HD2          | Second Harmonic Distortion                         | $f_{IN} = 100\text{ MHz}$                                                    |     | 72  |     | dBFS |
|              |                                                    | $f_{IN} = 600\text{ MHz}$                                                    |     | 70  |     |      |
|              |                                                    | $f_{IN} = 900\text{ MHz}$                                                    |     | 71  |     |      |
|              |                                                    | $f_{IN} = 900\text{ MHz}, A_{IN} = -20\text{ dBFS}$                          |     | 69  |     |      |
|              |                                                    | $f_{IN} = 1.4\text{ GHz}$                                                    |     | 69  |     |      |
| HD3          | Third Harmonic Distortion                          | $f_{IN} = 100\text{ MHz}$                                                    |     | 65  |     | dBFS |
|              |                                                    | $f_{IN} = 600\text{ MHz}$                                                    |     | 73  |     |      |
|              |                                                    | $f_{IN} = 900\text{ MHz}$                                                    |     | 71  |     |      |
|              |                                                    | $f_{IN} = 900\text{ MHz}, A_{IN} = -20\text{ dBFS}$                          |     | 70  |     |      |
|              |                                                    | $f_{IN} = 1.4\text{ GHz}$                                                    |     | 81  |     |      |
| Non<br>HD2,3 | Spur free dynamic range<br>(excluding HD2 and HD3) | $f_{IN} = 100\text{ MHz}$                                                    |     | 82  |     | dBFS |
|              |                                                    | $f_{IN} = 600\text{ MHz}$                                                    |     | 83  |     |      |
|              |                                                    | $f_{IN} = 900\text{ MHz}$                                                    |     | 83  |     |      |
|              |                                                    | $f_{IN} = 900\text{ MHz}, A_{IN} = -20\text{ dBFS}$                          |     | 93  |     |      |
|              |                                                    | $f_{IN} = 1.4\text{ GHz}$                                                    |     | 81  |     |      |
| IMD3         | Two tone inter-modulation distortion               | $f_1 = 900\text{ MHz}, f_2 = 1000\text{ MHz}, A_{IN} = -7\text{ dBFS/ tone}$ |     | 71  |     | dBc  |

## 6.8 Electrical Characteristics - AC Specifications (Dither ENABLED)

Maximum and minimum values are specified over the operating free-air temperature range and nominal supply voltages. Typical values are specified at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, Bypass mode, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, AVDDCLK, DVDD = 1.2 V, -4-dBFS differential input and dither ENABLED, unless otherwise noted

| PARAMETER            |                                                     | TEST CONDITIONS                                                        | MIN <sup>(2)</sup> | TYP    | MAX | UNIT    |
|----------------------|-----------------------------------------------------|------------------------------------------------------------------------|--------------------|--------|-----|---------|
| NSD <sup>(1)</sup>   | Noise Spectral Density                              | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>no averaging |                    | -153.4 |     | dBFS/Hz |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>2x averaging |                    | -156.1 |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>4x averaging |                    | -158.7 |     |         |
| NF <sup>(1)</sup>    | Noise Figure                                        | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>no averaging |                    | 22.2   |     | dB      |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>2x averaging |                    | 20.9   |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$<br>4x averaging |                    | 20.5   |     |         |
| SNR <sup>(1)</sup>   | Signal-to-noise ratio<br>no averaging               | $f_{IN} = 100\text{ MHz}$                                              |                    | 63.6   |     | dBFS    |
|                      |                                                     | $f_{IN} = 600\text{ MHz}$                                              |                    | 64.5   |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$                                              | 62.0               | 64.4   |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 | 62.3               | 65.2   |     |         |
|                      |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |                    | 63.8   |     |         |
|                      | Signal-to-noise ratio<br>2x averaging               | $f_{IN} = 100\text{ MHz}$                                              |                    | 66.3   |     |         |
|                      |                                                     | $f_{IN} = 600\text{ MHz}$                                              |                    | 66.9   |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$                                              |                    | 66.8   |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 |                    | 68.0   |     |         |
|                      |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |                    | 66.1   |     |         |
|                      | Signal-to-noise ratio<br>4x averaging               | $f_{IN} = 100\text{ MHz}$                                              |                    | 69.2   |     |         |
|                      |                                                     | $f_{IN} = 600\text{ MHz}$                                              |                    | 69.1   |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$                                              | 67.0               | 68.8   |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 | 67.7               | 69.5   |     |         |
|                      |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |                    | 67.0   |     |         |
| SINAD <sup>(1)</sup> | Signal to noise and distortion<br>ratio             | $f_{IN} = 100\text{ MHz}$                                              |                    | 62.2   |     | dBFS    |
|                      |                                                     | $f_{IN} = 600\text{ MHz}$                                              |                    | 63.4   |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$                                              |                    | 63.6   |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 |                    | 64.3   |     |         |
|                      |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |                    | 62.8   |     |         |
| ENOB <sup>(1)</sup>  | Effective number of bits                            | $f_{IN} = 100\text{ MHz}$                                              |                    | 10.3   |     | Bits    |
|                      |                                                     | $f_{IN} = 600\text{ MHz}$                                              |                    | 10.4   |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$                                              |                    | 10.4   |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 |                    | 10.5   |     |         |
|                      |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |                    | 10.3   |     |         |
| THD                  | Total Harmonic Distortion (First<br>five harmonics) | $f_{IN} = 100\text{ MHz}$                                              |                    | 68     |     | dBc     |
|                      |                                                     | $f_{IN} = 600\text{ MHz}$                                              |                    | 72     |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                 |                    | 72     |     |         |
|                      |                                                     | $f_{IN} = 900\text{ MHz}$                                              |                    | 72     |     |         |
|                      |                                                     | $f_{IN} = 1.4\text{ GHz}$                                              |                    | 71     |     |         |

## 6.8 Electrical Characteristics - AC Specifications (Dither ENABLED) (continued)

Maximum and minimum values are specified over the operating free-air temperature range and nominal supply voltages. Typical values are specified at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, Bypass mode, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, AVDDCLK, DVDD = 1.2 V, -4-dBFS differential input and dither ENABLED, unless otherwise noted

| PARAMETER |                                                 | TEST CONDITIONS                                                                     | MIN <sup>(2)</sup> | TYP | MAX | UNIT |
|-----------|-------------------------------------------------|-------------------------------------------------------------------------------------|--------------------|-----|-----|------|
| HD2       | Second Harmonic Distortion                      | $f_{IN} = 100\text{ MHz}$                                                           |                    | 75  |     | dBFS |
|           |                                                 | $f_{IN} = 600\text{ MHz}$                                                           |                    | 75  |     |      |
|           |                                                 | $f_{IN} = 900\text{ MHz}$                                                           | 70                 | 74  |     |      |
|           |                                                 | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                              |                    | 84  |     |      |
|           |                                                 | $f_{IN} = 1.4\text{ GHz}$                                                           |                    | 72  |     |      |
| HD3       | Third Harmonic Distortion                       | $f_{IN} = 100\text{ MHz}$                                                           |                    | 70  |     | dBFS |
|           |                                                 | $f_{IN} = 600\text{ MHz}$                                                           |                    | 77  |     |      |
|           |                                                 | $f_{IN} = 900\text{ MHz}$                                                           | 71                 | 79  |     |      |
|           |                                                 | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                              |                    | 75  |     |      |
|           |                                                 | $f_{IN} = 1.4\text{ GHz}$                                                           |                    | 81  |     |      |
| Non HD2,3 | Spur free dynamic range (excluding HD2 and HD3) | $f_{IN} = 100\text{ MHz}$                                                           |                    | 92  |     | dBFS |
|           |                                                 | $f_{IN} = 600\text{ MHz}$                                                           |                    | 89  |     |      |
|           |                                                 | $f_{IN} = 900\text{ MHz}$                                                           | 85                 | 90  |     |      |
|           |                                                 | $f_{IN} = 900\text{ MHz}$ , $A_{IN} = -20\text{ dBFS}$                              |                    | 98  |     |      |
|           |                                                 | $f_{IN} = 1.4\text{ GHz}$                                                           |                    | 94  |     |      |
| IMD3      | Two tone inter-modulation distortion            | $f_1 = 900\text{ MHz}$ , $f_2 = 1000\text{ MHz}$ , $A_{IN} = -10\text{ dBFS/ tone}$ | 74                 | 84  |     | dBFS |

(1) Measured from 60 MHz to Nyquist ( $F_S/2$ ) excluding dither

(2) SNR, HD3 minimum values are specified by ATE, HD2 and Non HD23 are specified by bench characterization.

## 6.9 Timing Requirements

Maximum and minimum values are specified over the operating free-air temperature range and nominal supply voltages. Typical values are specified at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, Bypass mode, 50% clock duty cycle, AVDD18 = 1.8V, AVDD12, AVDDCLK, DVDD = 1.2V and –1-dBFS differential input, unless otherwise noted

| PARAMETER                                              |                                                                           | TEST CONDITIONS                         | MIN | TYP  | MAX | UNIT         |
|--------------------------------------------------------|---------------------------------------------------------------------------|-----------------------------------------|-----|------|-----|--------------|
| ADC TIMING SPECIFICATIONS                              |                                                                           |                                         |     |      |     |              |
| T <sub>AD</sub>                                        | Aperture Delay                                                            |                                         |     | 0.17 |     | ns           |
|                                                        | Aperure Delay variation                                                   |                                         |     | 0.07 |     | ns           |
| T <sub>A</sub>                                         | Aperture Jitter                                                           |                                         |     | 50   |     | fs           |
| Overload recovery time                                 |                                                                           | 3-dB overload condition                 |     | 10   |     | clock cycles |
|                                                        |                                                                           | 6-dB overload condition                 |     | 50   |     |              |
| t <sub>ADC</sub>                                       | ADC latency from sampling instant to internal hand-off to digital         |                                         |     | 68   |     | clock cycles |
|                                                        | Internal propagation delay                                                |                                         |     | 5    |     | ns           |
|                                                        | Latency adder for 2x or 4x averaging                                      |                                         |     | 4    |     | clock cycles |
|                                                        | Deterministic delay from digital block (DDC (if used) and JESD interface) | LMFS = 8-2-8-20                         |     | 260  |     | clock cycles |
|                                                        |                                                                           | LMFS = 8-2-2-4                          |     | 280  |     |              |
|                                                        |                                                                           | 4x complex decimation, LMFS = 8-4-2-2   |     | 456  |     |              |
|                                                        |                                                                           | 4x real decimation, LMFS = 4-2-2-2      |     | 456  |     |              |
|                                                        |                                                                           | 4x decimation, F (number of octets) = 2 |     | 394  |     |              |
|                                                        |                                                                           | 4x decimation, F = 4                    |     | 374  |     |              |
|                                                        |                                                                           | 4x decimation, F = 8                    |     | 367  |     |              |
|                                                        |                                                                           | 8x decimation, F = 2                    |     | 560  |     |              |
|                                                        |                                                                           | 8x decimation, F = 4                    |     | 520  |     |              |
|                                                        |                                                                           | 8x decimation, F = 8                    |     | 506  |     |              |
|                                                        |                                                                           | 8x decimation, F = 16                   |     | 491  |     |              |
|                                                        |                                                                           | 16x decimation, F = 2                   |     | 900  |     |              |
|                                                        |                                                                           | 16x decimation, F = 4                   |     | 820  |     |              |
|                                                        |                                                                           | 16x decimation, F = 8                   |     | 792  |     |              |
|                                                        |                                                                           | 16x decimation, F = 16                  |     | 762  |     |              |
|                                                        |                                                                           | 16x decimation, F = 32                  |     | 748  |     |              |
|                                                        |                                                                           | 32x decimation, F = 2                   |     | 1596 |     |              |
|                                                        |                                                                           | 32x decimation, F = 4                   |     | 1436 |     |              |
|                                                        |                                                                           | 32x decimation, F = 8                   |     | 1380 |     |              |
|                                                        |                                                                           | 32x decimation, F = 16                  |     | 1320 |     |              |
|                                                        |                                                                           | 32x decimation, F = 32                  |     | 1292 |     |              |
|                                                        |                                                                           | 64x decimation, F = 2                   |     | 2940 |     |              |
|                                                        |                                                                           | 64x decimation, F = 4                   |     | 2620 |     |              |
|                                                        |                                                                           | 64x decimation, F = 8                   |     | 2508 |     |              |
|                                                        |                                                                           | 64x decimation, F = 16                  |     | 2388 |     |              |
|                                                        |                                                                           | 64x decimation, F = 32                  |     | 2332 |     |              |
|                                                        |                                                                           | 128x decimation, F = 2                  |     | 5668 |     |              |
|                                                        |                                                                           | 128x decimation, F = 4                  |     | 5028 |     |              |
|                                                        |                                                                           | 128x decimation, F = 8                  |     | 4804 |     |              |
|                                                        |                                                                           | 128x decimation, F = 16                 |     | 4564 |     |              |
|                                                        |                                                                           | 128x decimation, F = 32                 |     | 4452 |     |              |
| SERIAL PROGRAMMING INTERFACE (SCLK, SEN, SDIO) - Input |                                                                           |                                         |     |      |     |              |

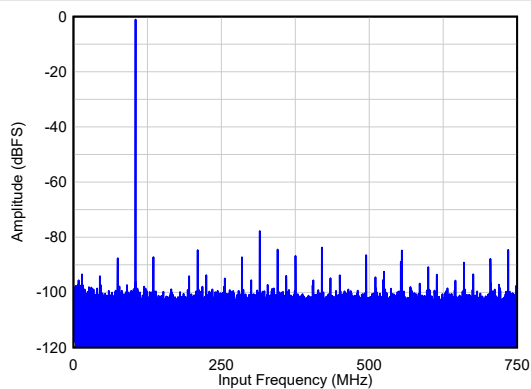
## 6.9 Timing Requirements (continued)

Maximum and minimum values are specified over the operating free-air temperature range and nominal supply voltages. Typical values are specified at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, Bypass mode, 50% clock duty cycle, AVDD18 = 1.8V, AVDD12, AVDDCLK, DVDD = 1.2V and –1-dBFS differential input, unless otherwise noted

| PARAMETER                                    |                                                      | TEST CONDITIONS | MIN  | TYP  | MAX  | UNIT |
|----------------------------------------------|------------------------------------------------------|-----------------|------|------|------|------|
| f <sub>CLK(SCLK)</sub>                       | Serial clock frequency                               |                 | 1    |      | 20   | MHz  |
| t <sub>SU(SEN)</sub>                         | SEN to rising edge of SCLK                           |                 | 10   |      |      | ns   |
| t <sub>H(SEN)</sub>                          | SEN from rising edge of SCLK                         |                 | 10   |      |      | ns   |
| t <sub>SU(SDIO)</sub>                        | SDIO to rising edge of SCLK                          |                 | 10   |      |      | ns   |
| t <sub>H(SDIO)</sub>                         | SDIO from rising edge of SCLK                        |                 | 10   |      |      | ns   |
| SERIAL PROGRAMMING INTERFACE (SDIO) - Output |                                                      |                 |      |      |      |      |
| t <sub>(OZD)</sub>                           | SDIO tri-state to driven                             |                 |      |      | 10   | ns   |
| t <sub>(ODZ)</sub>                           | SDIO data to tri-state                               |                 |      |      | 14   | ns   |
| t <sub>(OD)</sub>                            | SDIO valid from falling edge of SCLK                 |                 |      |      | 10   | ns   |
| TIMING: SYSREFP/M                            |                                                      |                 |      |      |      |      |
| t <sub>s(SYSREF)</sub>                       | Setup time, SYSREFP/M valid to rising edge of CLKP/M |                 | 50   |      |      | ps   |
| t <sub>h(SYSREF)</sub>                       | Hold time, SYSREFP/M valid to rising edge of CLKP/M  |                 | 50   |      |      | ps   |
| CML SERDES OUTPUTS: DA[0:3]P/M, DB[0:3]P/M   |                                                      |                 |      |      |      |      |
| f <sub>Serdes</sub>                          | Serdes bit rate                                      |                 | 0.5  | 12.8 | 13.0 | Gbps |
| R <sub>J</sub>                               | Random jitter, RMS                                   | RPAT, 6.4 Gbps  | 0.7  |      |      | ps   |
|                                              |                                                      | RPAT, 12.8 Gbps | 0.6  |      |      |      |
| D <sub>J</sub>                               | Deterministic jitter, peak to peak                   | RPAT, 6.4 Gbps  | 8.9  |      |      | ps   |
|                                              |                                                      | RPAT, 12.8 Gbps | 14.7 |      |      |      |
| T <sub>J</sub>                               | Total jitter, peak to peak                           | RPAT, 6.4 Gbps  | 19.5 |      |      | ps   |
|                                              |                                                      | RPAT, 12.8 Gbps | 24   |      |      |      |

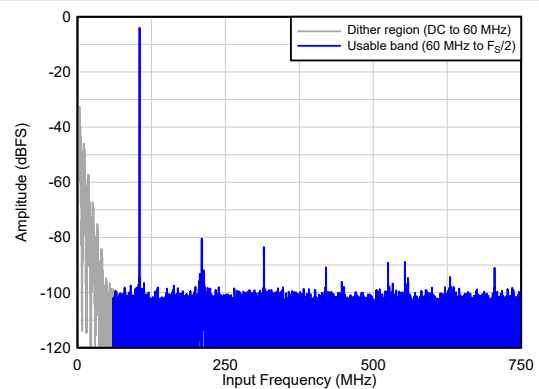
## 6.10 Typical Characteristics

Typical values are at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, 50% clock duty cycle,  $AVDD18 = 1.8\text{ V}$ ,  $AVDD12$ ,  $CLKVDD$ ,  $DVDD = 1.2\text{ V}$  and  $-1\text{ dBFS}$  differential input, Dither = DIS, unless otherwise noted



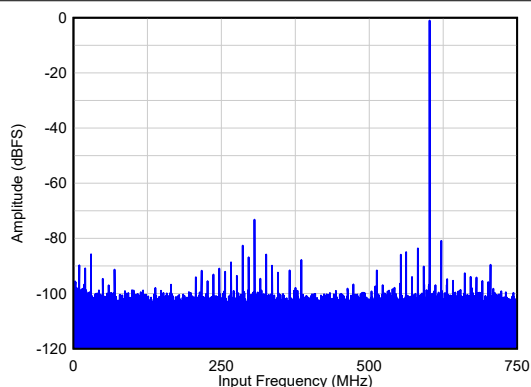
SNR = 64.5 dBFS, HD23 = 77 dBc, Non HD23 = 84 dBFS  
 $A_{IN} = -1\text{ dBFS}$ , 1x AVG, Dither = DIS

**Figure 6-1. Single Tone FFT at  $F_{IN} = 100\text{ MHz}$**



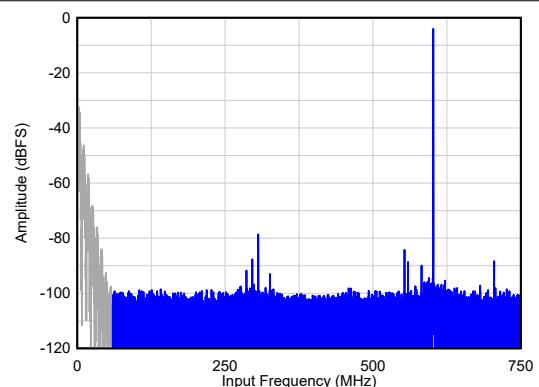
SNR = 64.3 dBFS<sup>1</sup>, HD23 = 76 dBc, Non HD23 = 89 dBFS  
 $A_{IN} = -4\text{ dBFS}$ , 1x AVG, Dither = EN

**Figure 6-2. Single Tone FFT at  $F_{IN} = 100\text{ MHz}$**



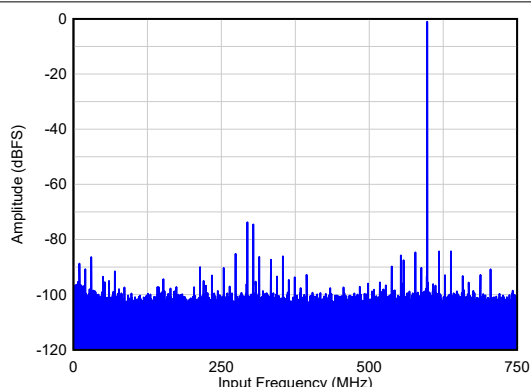
SNR = 64.4 dBFS, HD23 = 72 dBc, Non HD23 = 81 dBFS  
 $A_{IN} = -1\text{ dBFS}$ , 1x AVG, Dither = DIS

**Figure 6-3. Single Tone FFT at  $F_{IN} = 600\text{ MHz}$**



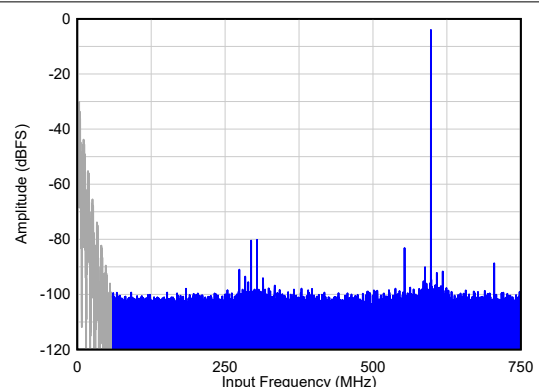
SNR = 64.4 dBFS<sup>1</sup>, HD23 = 75 dBc, Non HD23 = 84 dBFS  
 $A_{IN} = -4\text{ dBFS}$ , 1x AVG, Dither = EN

**Figure 6-4. Single Tone FFT at  $F_{IN} = 600\text{ MHz}$**



SNR = 64.3 dBFS, HD23 = 72 dBc, Non HD23 = 84 dBFS  
 $A_{IN} = -1\text{ dBFS}$ , 1x AVG, Dither = DIS

**Figure 6-5. Single Tone FFT at  $F_{IN} = 900\text{ MHz}$**



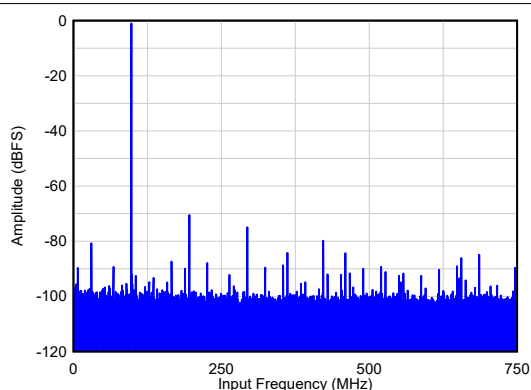
SNR = 64.4 dBFS<sup>1</sup>, HD23 = 76 dBc, Non HD23 = 83 dBFS  
 $A_{IN} = -4\text{ dBFS}$ , 1x AVG, Dither = EN

**Figure 6-6. Single Tone FFT at  $F_{IN} = 900\text{ MHz}$**

<sup>1</sup> Measured from 60 MHz to  $F_S/2$

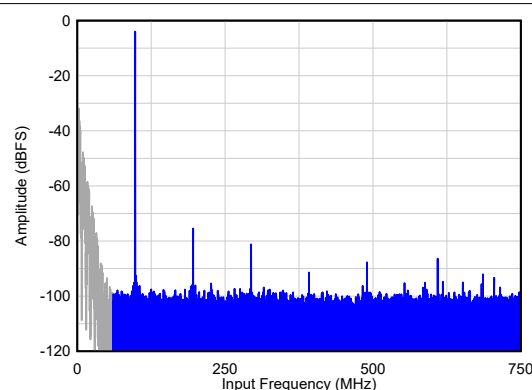
## 6.10 Typical Characteristics (continued)

Typical values are at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, CLKVDD, DVDD = 1.2 V and -1-dBFS differential input, Dither = DIS, unless otherwise noted



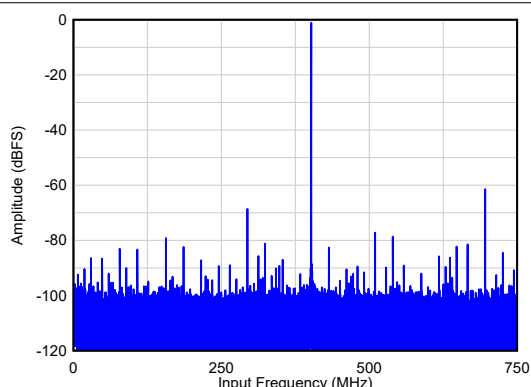
SNR = 63.8 dBFS, HD23 = 69 dBc, Non HD23 = 80 dBFS  
 $A_{IN} = -1$  dBFS, 1x AVG, Dither = DIS

**Figure 6-7. Single Tone FFT at  $F_{IN} = 1400$  MHz**



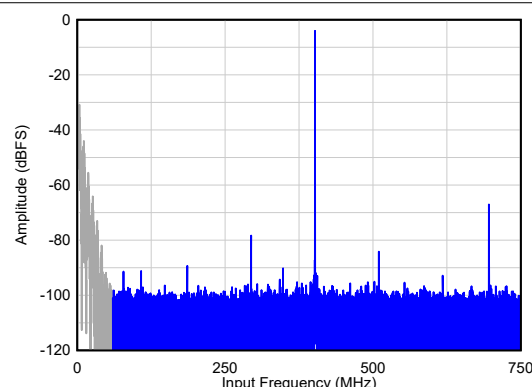
SNR = 64.1 dBFS<sup>1</sup>, HD23 = 71 dBc, Non HD23 = 86 dBFS  
 $A_{IN} = -4$  dBFS, 1x AVG, Dither = EN

**Figure 6-8. Single Tone FFT at  $F_{IN} = 1400$  MHz**



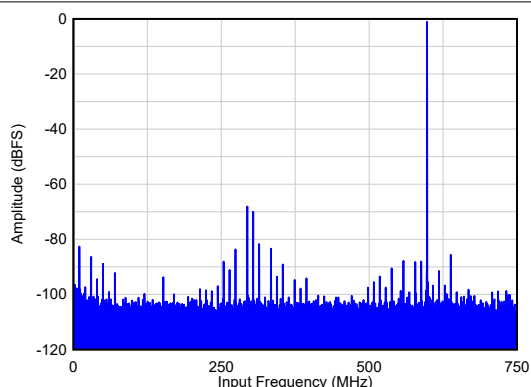
SNR = 62.6 dBFS, HD23 = 60 dBc, Non HD23 = 79 dBFS  
 $A_{IN} = -1$  dBFS, 1x AVG, Dither = DIS

**Figure 6-9. Single Tone FFT at  $F_{IN} = 1900$  MHz**



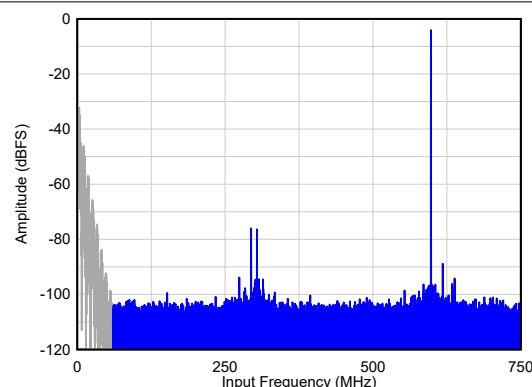
SNR = 63.4 dBFS<sup>1</sup>, HD23 = 63 dBc, Non HD23 = 89 dBFS  
 $A_{IN} = -4$  dBFS, 1x AVG, Dither = EN

**Figure 6-10. Single Tone FFT at  $F_{IN} = 1900$  MHz**



SNR = 66.8 dBFS, HD23 = 67 dBc, Non HD23 = 82 dBFS  
 $A_{IN} = -1$  dBFS, 2x AVG, Dither = DIS

**Figure 6-11. Single Tone FFT at  $F_{IN} = 900$  MHz**

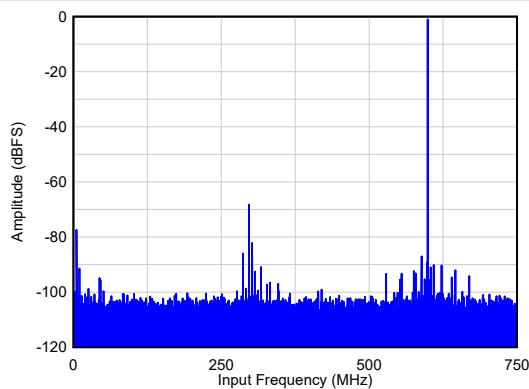


SNR = 67.0 dBFS<sup>1</sup>, HD23 = 72 dBc, Non HD23 = 89 dBFS  
 $A_{IN} = -4$  dBFS, 2x AVG, Dither = EN

**Figure 6-12. Single Tone FFT at  $F_{IN} = 900$  MHz**

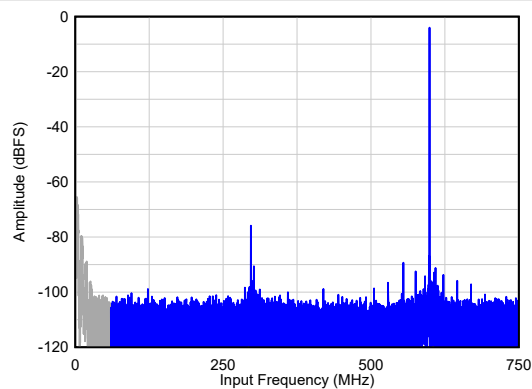
## 6.10 Typical Characteristics (continued)

Typical values are at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, CLKVDD, DVDD = 1.2 V and  $-1\text{ dBFS}$  differential input, Dither = DIS, unless otherwise noted



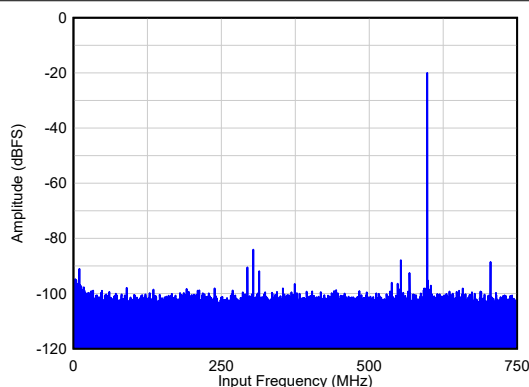
SNR = 66.8 dBFS, HD23 = 67 dBc, Non HD23 = 82 dBFS  
 $A_{IN} = -1\text{ dBFS}$ , 4x AVG, Dither = DIS

**Figure 6-13. Single Tone FFT at  $F_{IN} = 900\text{ MHz}$**



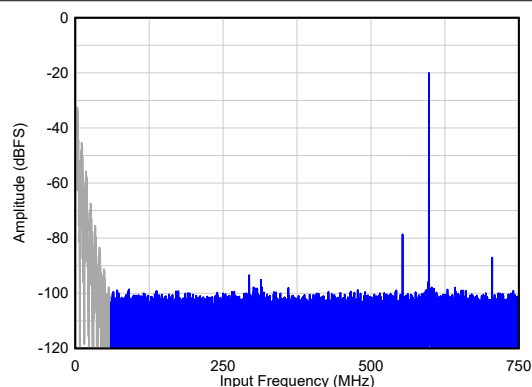
SNR = 67.0 dBFS<sup>1</sup>, HD23 = 75 dBc, Non HD23 = 89 dBFS  
 $A_{IN} = -4\text{ dBFS}$ , 4x AVG, Dither = EN

**Figure 6-14. Single Tone FFT at  $F_{IN} = 900\text{ MHz}$**



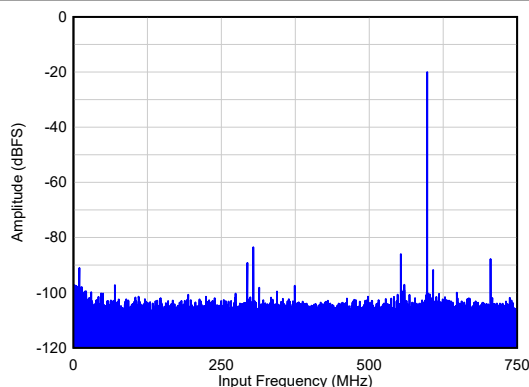
SNR = 65.2 dBFS, HD23 = 64 dBc, Non HD23 = 88 dBFS  
 $A_{IN} = -20\text{ dBFS}$ , 1x AVG, Dither = DIS

**Figure 6-15. Single Tone FFT at  $F_{IN} = 900\text{ MHz}$**



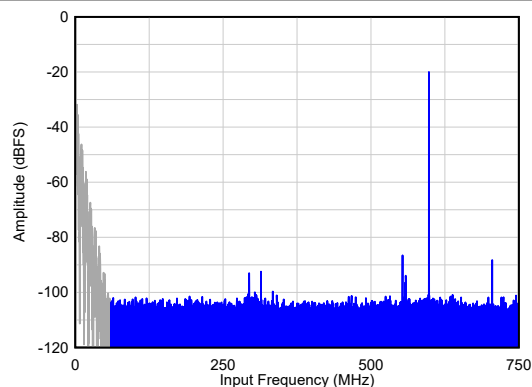
SNR = 64.8 dBFS<sup>1</sup>, HD23 = 59 dBc, Non HD23 = 79 dBFS  
 $A_{IN} = -20\text{ dBFS}$ , 1x AVG, Dither = EN

**Figure 6-16. Single Tone FFT at  $F_{IN} = 900\text{ MHz}$**



SNR = 67.9 dBFS, HD23 = 64 dBc, Non HD23 = 86 dBFS  
 $A_{IN} = -20\text{ dBFS}$ , 2x AVG, Dither = DIS

**Figure 6-17. Single Tone FFT at  $F_{IN} = 900\text{ MHz}$**

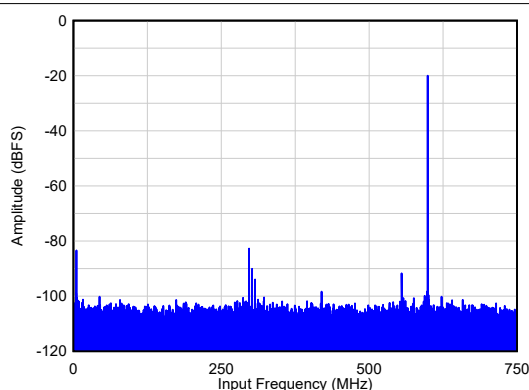


SNR = 67.6 dBFS<sup>1</sup>, HD23 = 67 dBc, Non HD23 = 87 dBFS  
 $A_{IN} = -20\text{ dBFS}$ , 2x AVG, Dither = EN

**Figure 6-18. Single Tone FFT at  $F_{IN} = 900\text{ MHz}$**

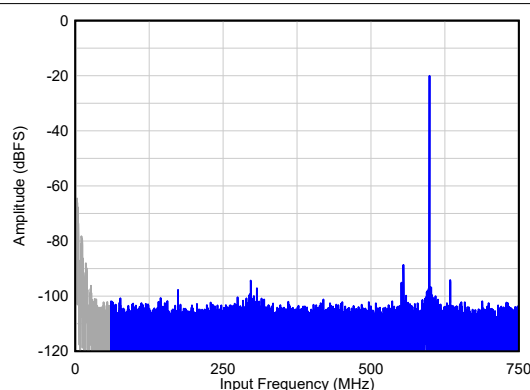
## 6.10 Typical Characteristics (continued)

Typical values are at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, CLKVDD, DVDD = 1.2 V and -1-dBFS differential input, Dither = DIS, unless otherwise noted



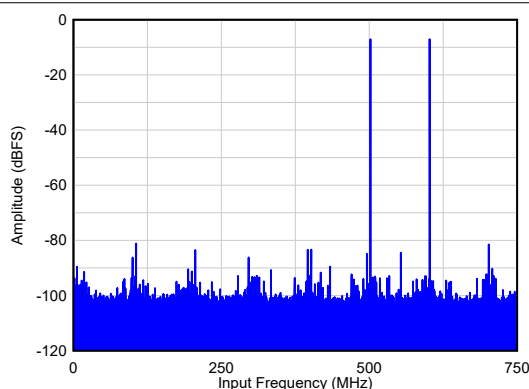
SNR = 67.9 dBFS, HD23 = 64 dBc, Non HD23 = 86 dBFS  
 $A_{IN} = -20$  dBFS, 4x AVG, Dither = DIS

**Figure 6-19. Single Tone FFT at  $F_{IN} = 900$  MHz**



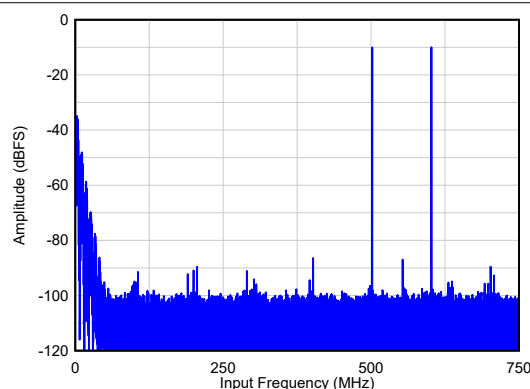
SNR = 67.6 dBFS<sup>1</sup>, HD23 = 67 dBc, Non HD23 = 87 dBFS  
 $A_{IN} = -20$  dBFS, 4x AVG, Dither = EN

**Figure 6-20. Single Tone FFT at  $F_{IN} = 900$  MHz**



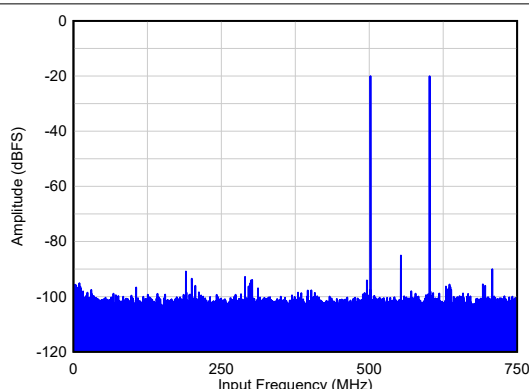
IMD3 = 73 dBc  
 $A_{IN} = -7$  dBFS/tone, 1x AVG, Dither = DIS

**Figure 6-21. Two Tone FFT at  $F_{IN} = 900, 1000$  MHz**



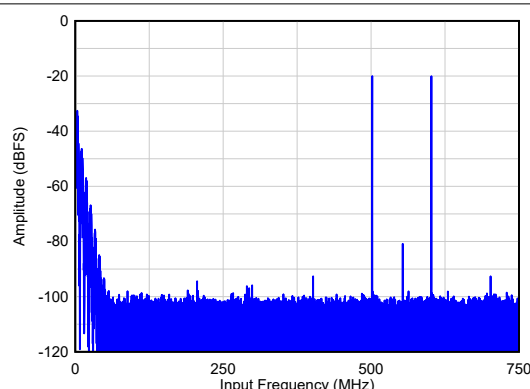
IMD3 = 75 dBc  
 $A_{IN} = -10$  dBFS/tone, 1x AVG, Dither = EN

**Figure 6-22. Two Tone FFT at  $F_{IN} = 900, 1000$  MHz**



IMD3 = 70 dBc  
 $A_{IN} = -20$  dBFS/tone, 1x AVG, Dither = DIS

**Figure 6-23. Two Tone FFT at  $F_{IN} = 900, 1000$  MHz**

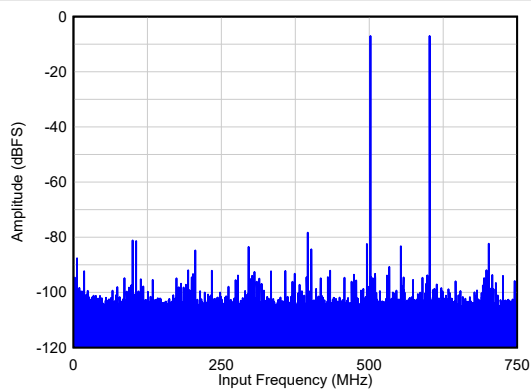


IMD3 = 72 dBc  
 $A_{IN} = -20$  dBFS/tone, 1x AVG, Dither = EN

**Figure 6-24. Two Tone FFT at  $F_{IN} = 900, 1000$  MHz**

## 6.10 Typical Characteristics (continued)

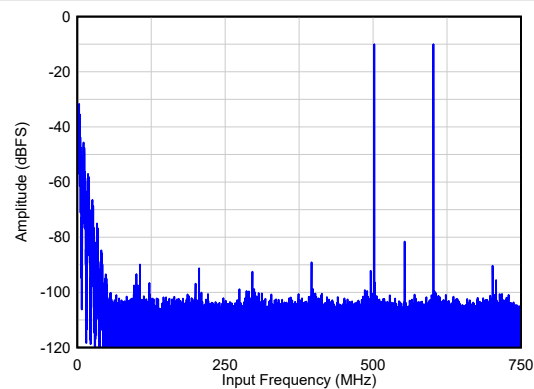
Typical values are at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, 50% clock duty cycle,  $AVDD18 = 1.8\text{ V}$ ,  $AVDD12$ ,  $CLKVDD$ ,  $DVDD = 1.2\text{ V}$  and  $-1\text{-dBFS}$  differential input, Dither = DIS, unless otherwise noted



IMD3 = 72 dBc

$A_{IN} = -7\text{ dBFS/tone}$ , 2x AVG, Dither = DIS

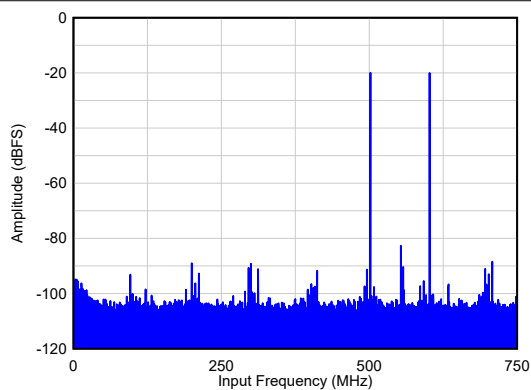
**Figure 6-25. Two Tone FFT at  $F_{IN} = 900, 1000\text{ MHz}$**



IMD3 = 79 dBc

$A_{IN} = -10\text{ dBFS/tone}$ , 2x AVG, Dither = EN

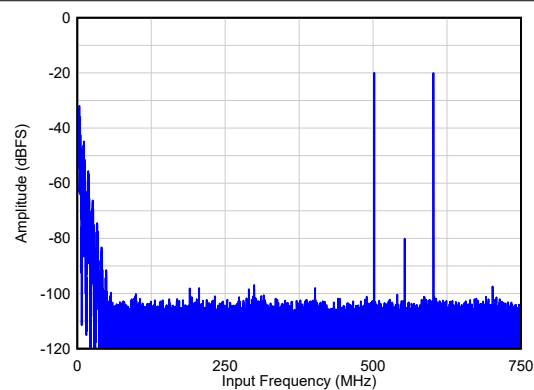
**Figure 6-26. Two Tone FFT at  $F_{IN} = 900, 1000\text{ MHz}$**



IMD3 = 63 dBc

$A_{IN} = -20\text{ dBFS/tone}$ , 2x AVG, Dither = DIS

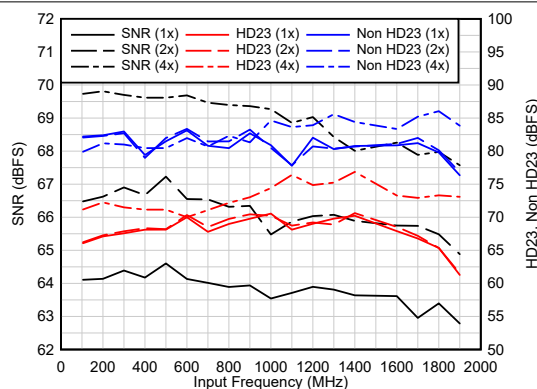
**Figure 6-27. Two Tone FFT at  $F_{IN} = 900, 1000\text{ MHz}$**



IMD3 = 77 dBc

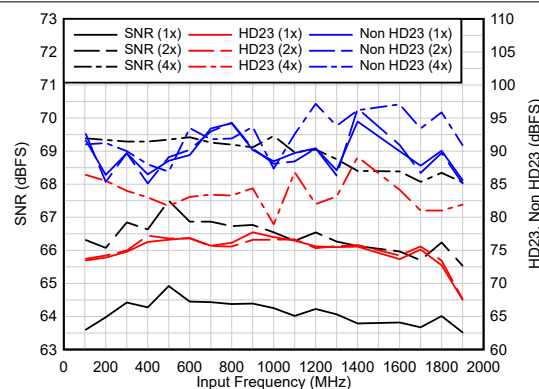
$A_{IN} = -20\text{ dBFS/tone}$ , 2x AVG, Dither = EN

**Figure 6-28. Two Tone FFT at  $F_{IN} = 900, 1000\text{ MHz}$**



$A_{IN} = -1\text{ dBFS}$ , Dither = DIS

**Figure 6-29. AC Performance vs  $F_{IN}$**

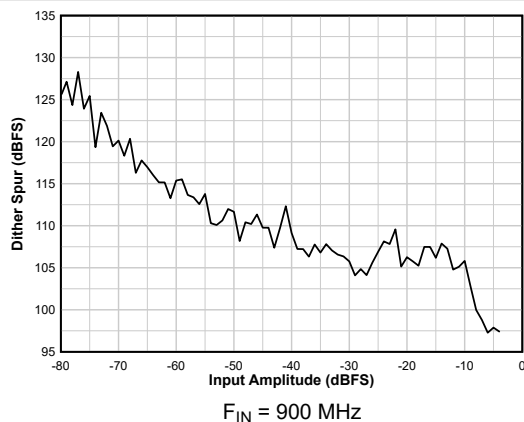


$A_{IN} = -4\text{ dBFS}$ , Dither = EN

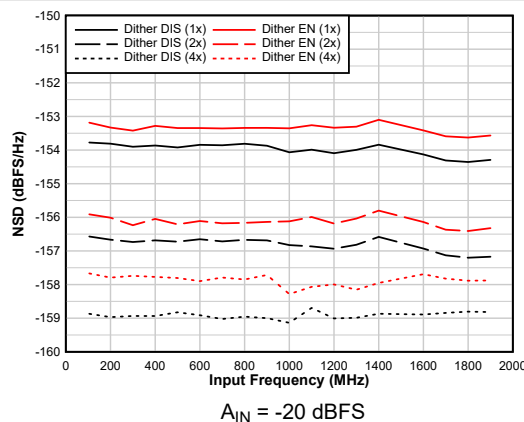
**Figure 6-30. AC Performance vs  $F_{IN}$**

## 6.10 Typical Characteristics (continued)

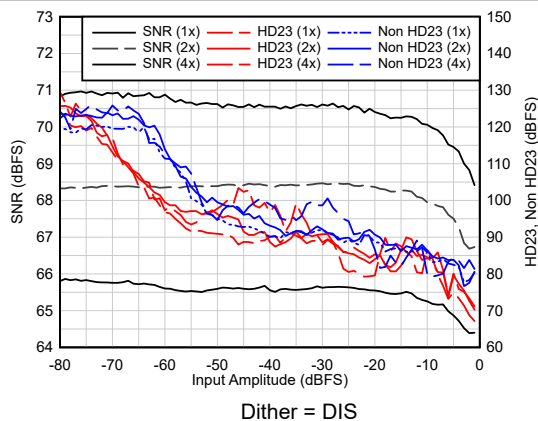
Typical values are at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, 50% clock duty cycle,  $AVDD18 = 1.8\text{ V}$ ,  $AVDD12, CLKVDD, DVDD = 1.2\text{ V}$  and  $-1\text{ dBFS}$  differential input, Dither = DIS, unless otherwise noted



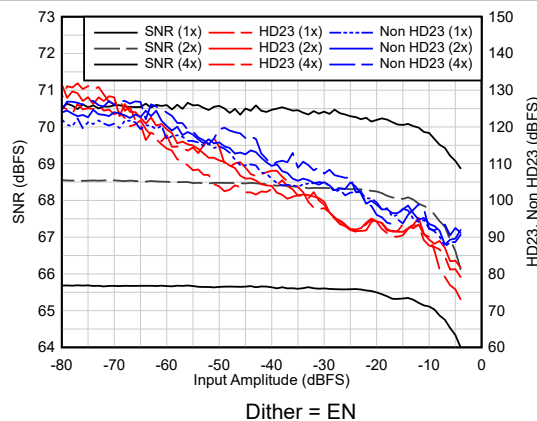
**Figure 6-31. Dither Spur vs  $A_{IN}$**



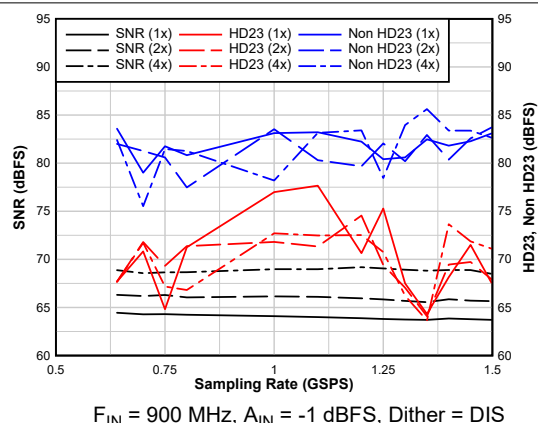
**Figure 6-32. NSD Performance vs  $F_{IN}$**



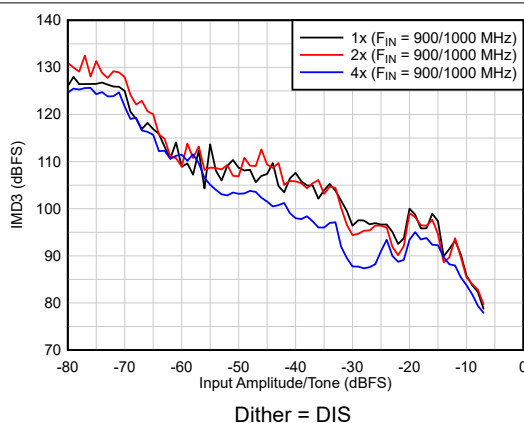
**Figure 6-33. AC Performance vs  $A_{IN}$**



**Figure 6-34. AC Performance vs  $A_{IN}$**



**Figure 6-35. AC Performance vs  $F_S$**



**Figure 6-36. IMD3 Performance vs  $A_{IN}$**

## 6.10 Typical Characteristics (continued)

Typical values are at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, CLKVDD, DVDD = 1.2 V and  $-1\text{-dBFS}$  differential input, Dither = DIS, unless otherwise noted

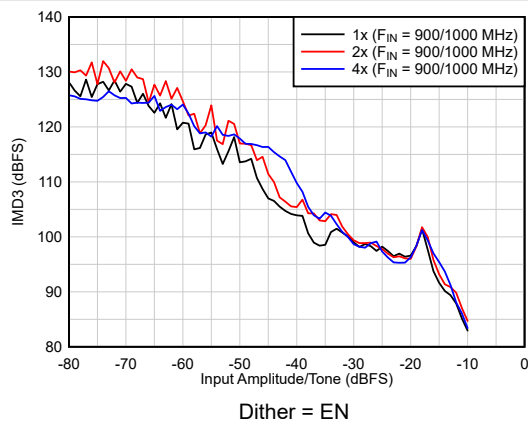


Figure 6-37. IMD3 Performance vs  $A_{IN}$

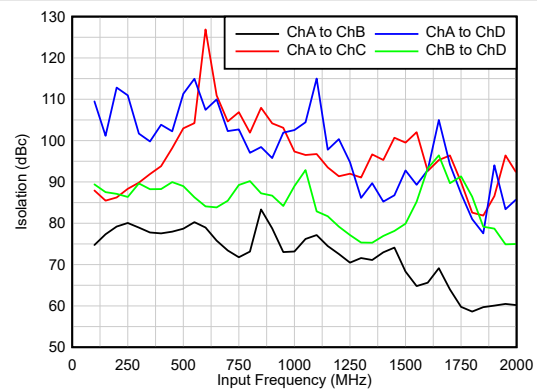


Figure 6-38. Isolation vs Input Frequency

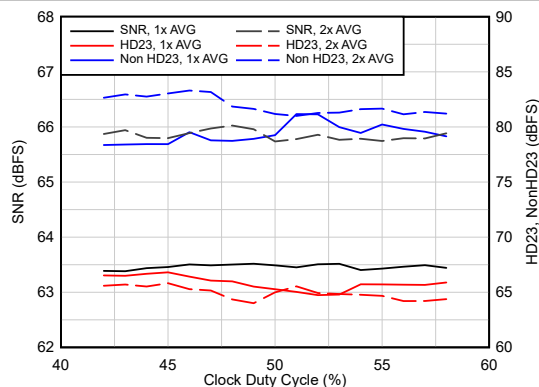


Figure 6-39. AC Performance vs Clock Duty Cycle

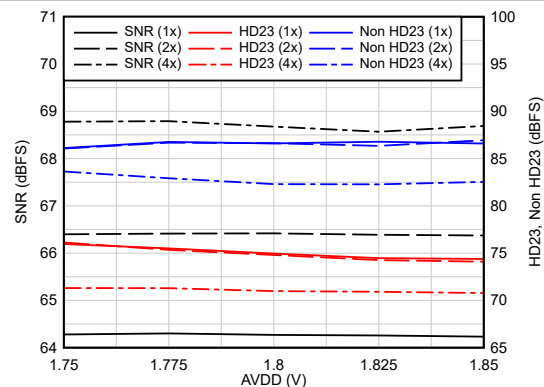


Figure 6-40. AC Performance vs AVDD18

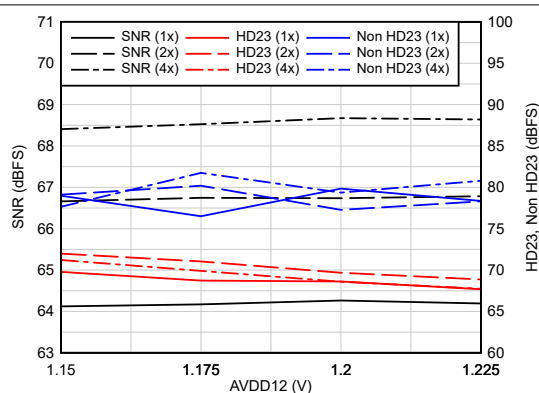


Figure 6-41. AC Performance vs AVDD12

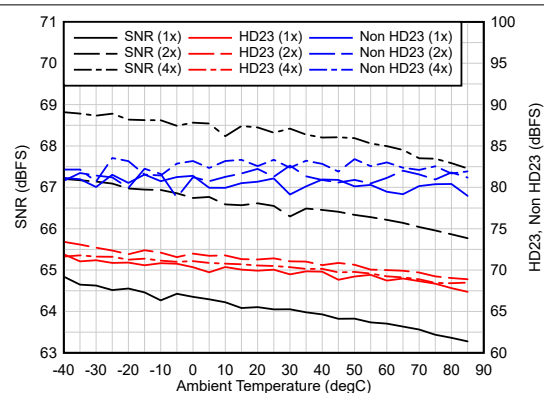
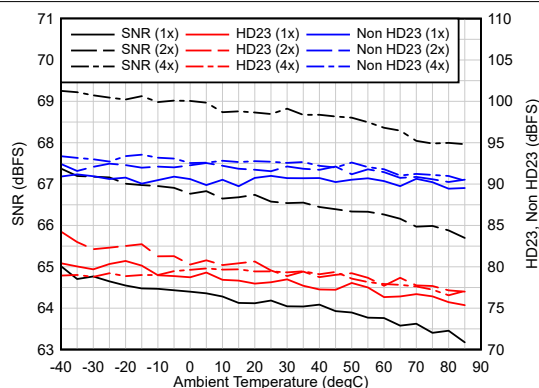


Figure 6-42. AC Performance vs Temperature

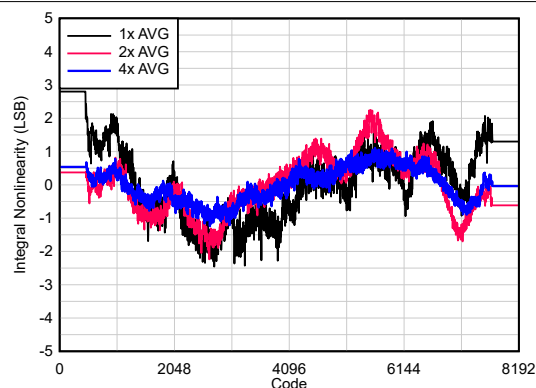
## 6.10 Typical Characteristics (continued)

Typical values are at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, CLKVDD, DVDD = 1.2 V and -1-dBFS differential input, Dither = DIS, unless otherwise noted



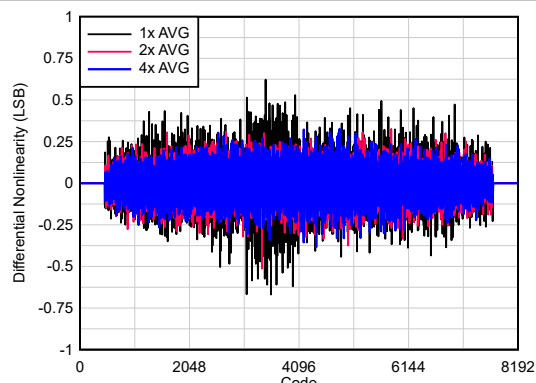
$F_{IN} = 900\text{ MHz}$ ,  $A_{IN} = -1\text{ dBFS}$ , Dither = EN

**Figure 6-43. AC Performance vs Temperature**



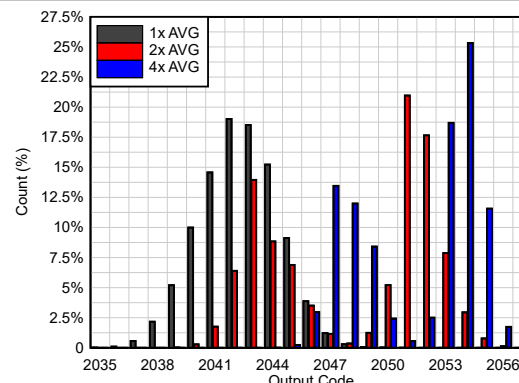
$F_{IN} = 900\text{ MHz}$ , Dither = DIS, 13-bit output

**Figure 6-44. INL vs Code**



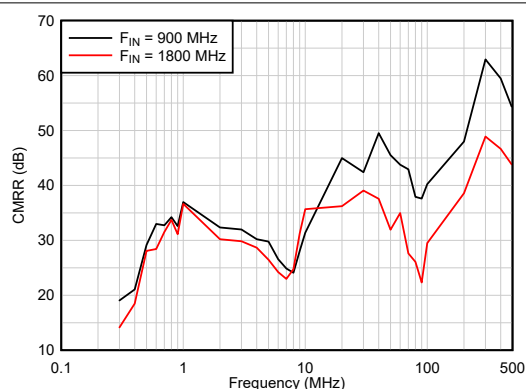
$F_{IN} = 900\text{ MHz}$ , Dither = DIS, 13-bit output

**Figure 6-45. DNL vs Code**



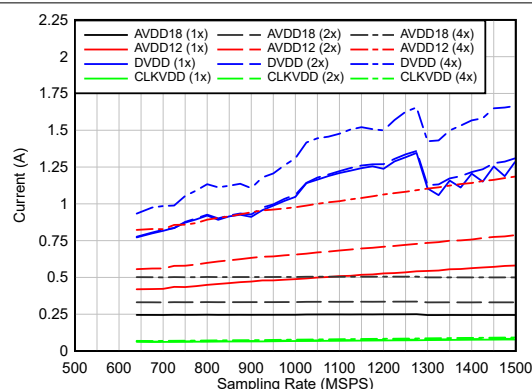
Dither = DIS

**Figure 6-46. DC Offset Histogram**



$A_{IN} = -1\text{ dBFS}$ , 1x AVG, Dither = DIS

**Figure 6-47. CMRR**

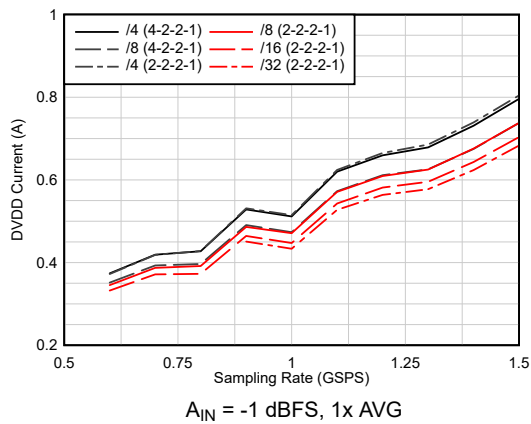


DDC Bypass

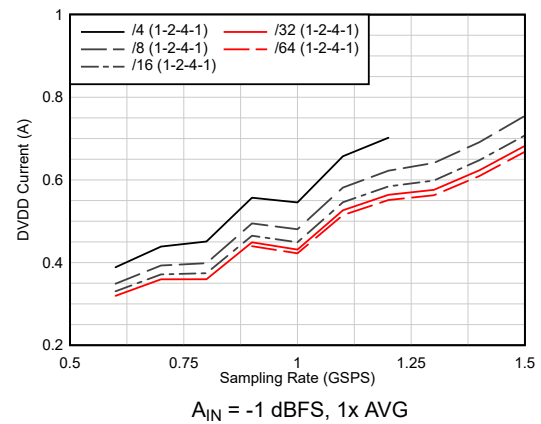
**Figure 6-48. Current vs Sampling Rate vs Averaging**

## 6.10 Typical Characteristics (continued)

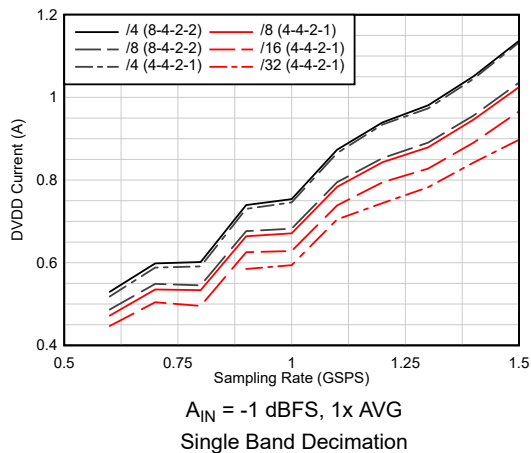
Typical values are at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, 50% clock duty cycle,  $AVDD18 = 1.8\text{ V}$ ,  $AVDD12$ ,  $CLKVDD$ ,  $DVDD = 1.2\text{ V}$  and  $-1\text{-dBFS}$  differential input, Dither = DIS, unless otherwise noted



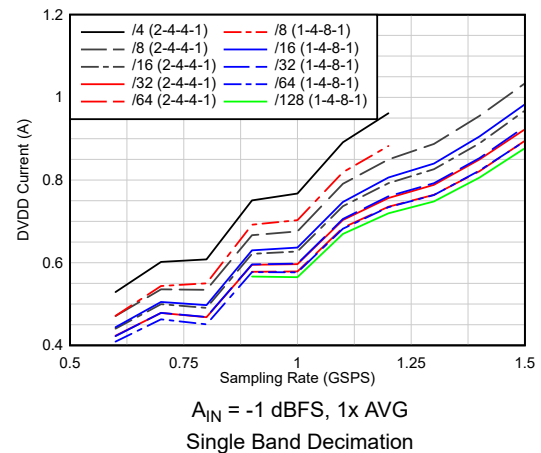
**Figure 6-49. Current vs Sampling Rate vs Real Decimation**



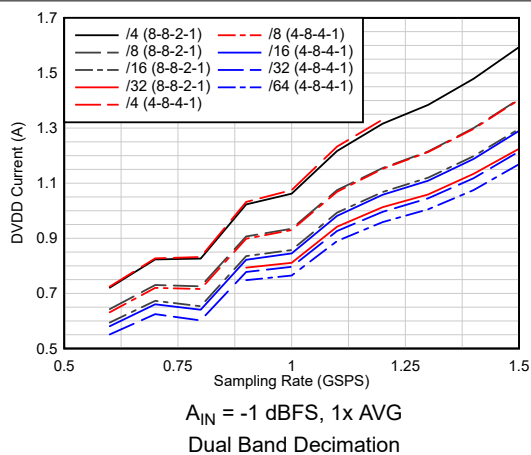
**Figure 6-50. Current vs Sampling Rate vs Real Decimation**



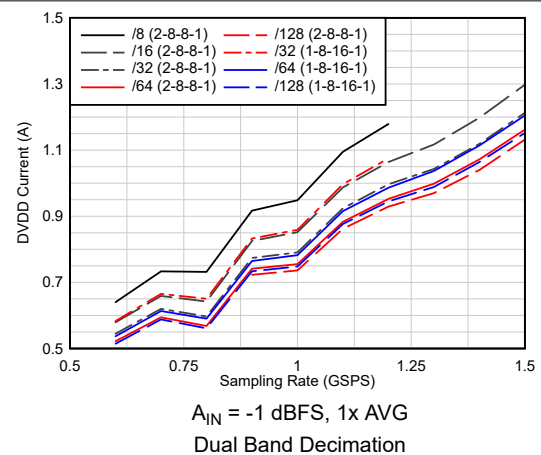
**Figure 6-51. Current vs Sampling Rate vs Complex Decimation**



**Figure 6-52. Current vs Sampling Rate vs Complex Decimation**



**Figure 6-53. Current vs Sampling Rate vs Complex Decimation**



**Figure 6-54. Current vs Sampling Rate vs Complex Decimation**

## 6.10 Typical Characteristics (continued)

Typical values are at  $T_A = 25^\circ\text{C}$ , ADC sampling rate = 1.5 GSPS, 50% clock duty cycle, AVDD18 = 1.8 V, AVDD12, CLKVDD, DVDD = 1.2 V and -1-dBFS differential input, Dither = DIS, unless otherwise noted

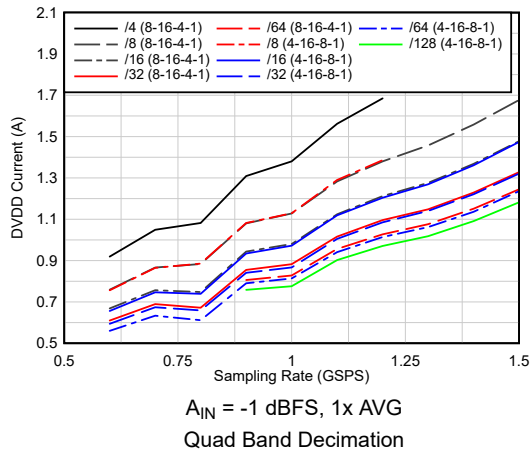


Figure 6-55. Current vs Sampling Rate vs Complex Decimation

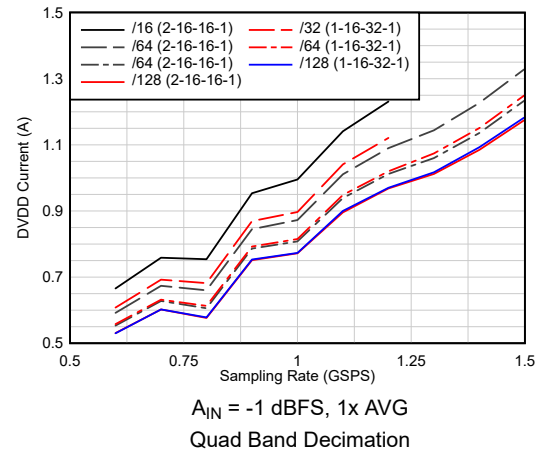


Figure 6-56. Current vs Sampling Rate vs Complex Decimation

## 7 Detailed Description

### 7.1 Overview

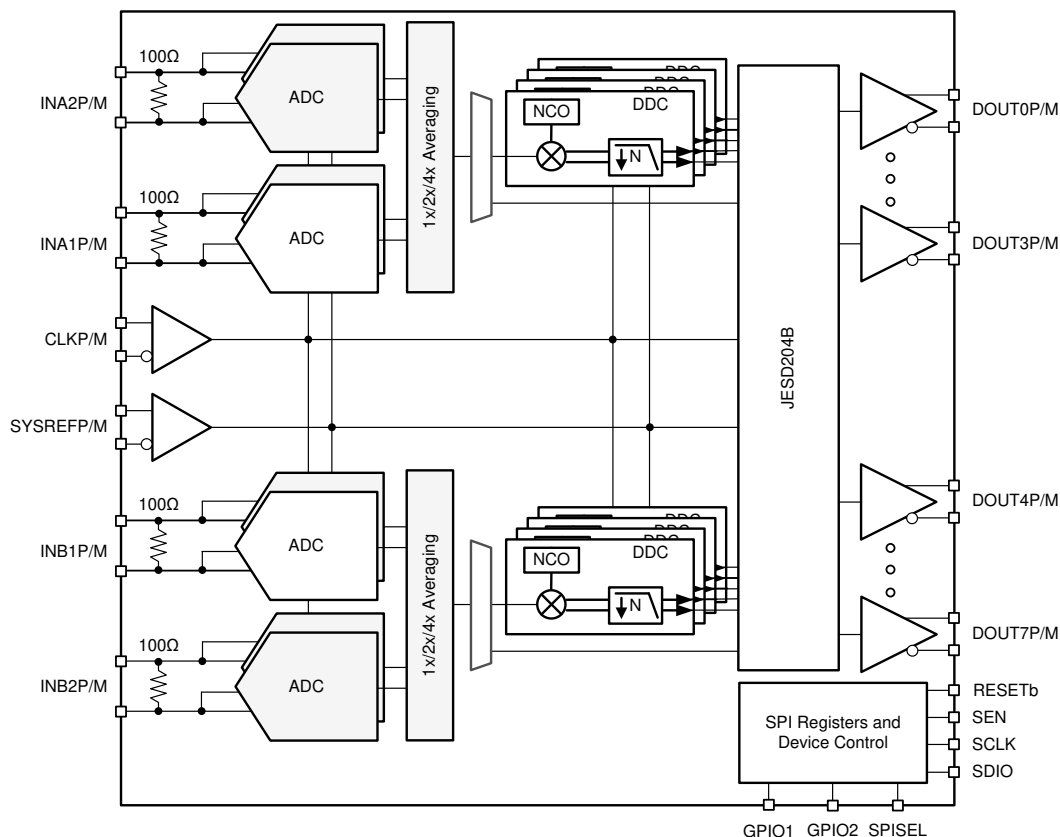
The ADC32RF52 is a single core (non-interleaved) 14-bit, 1.5 GSPS, dual channel analog to digital converter (ADC). The design maximizes signal-to-noise ratio (SNR) and delivers a noise spectral density of -151 dBFS/Hz. Additional internal ADCs can be used for on-chip averaging (2x and 4x) to further improve the noise density to as low as -156 dBFS/Hz.

The analog signal input is non-buffered to save power consumption with a nominal differential input impedance of 100  $\Omega$ . The full power input bandwidth is 2.3 GHz (-3 dB) and the device supports direct RF sampling with input frequencies in the through the L-band. The device is designed for low residual phase noise to support high performance radar applications. The sampling clock input has a dedicated power supply input which requires a very clean power supply.

Each ADC channel can be connected to a quad-band digital down-converter (DDC) using a 48-bit NCO which supports phase coherent frequency hopping. Using the GPIO pins for NCO frequency control, frequency hopping can be achieved in less than 1  $\mu$ s. The digital down converters support a wide range of instantaneous bandwidth (IBW) coverage - from single wide band mode with 4x complex decimation to up to four narrow bandwidth channels with as high as 128x complex decimation.

The ADC32RF52 supports the JESD204B serial data interface with subclass 1 deterministic latency using data rates up to 13.0 Gbps.

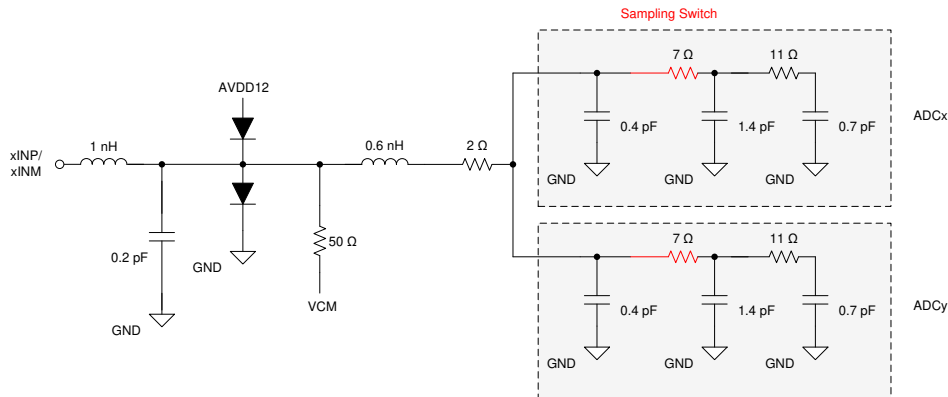
### 7.2 Functional Block Diagram



## 7.3 Feature Description

### 7.3.1 Analog Inputs

The ADC32RF52 provides up to four internal ADCs per channel for purpose of averaging to improve the noise performance. Two ADCs internally are connected to the same differential input pins as shown in the equivalent input schematic (see [Figure 7-1](#)). The analog inputs have a differential 100  $\Omega$  split termination with internal biasing. This can be changed to differential 50  $\Omega$  termination via SPI register write. When only a single ADC is used, there is a minor parasitic capacitance remaining from the unused ADC.



**Figure 7-1. Equivalent Input Schematic**

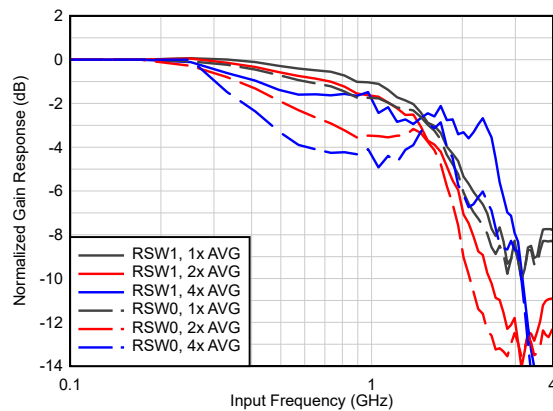
#### 7.3.1.1 Input Bandwidth and Full-Scale

The input bandwidth (-3 dB) and input fullscale are dependent on what input termination and averaging mode are chosen as shown in the summary in [Table 7-1](#). With 2x averaging enabled, the -3 dB bandwidth reduces to ~ 1.5 GHz and 100  $\Omega$  differential termination - the bandwidth can be increased by changing the input termination to 50  $\Omega$  differential.

**Table 7-1. Digital averaging vs Full Power Input Bandwidth (-3 dB)**

| # of ADCs averaged | Input Bandwidth (-3 dB) | Reset Switch | Selected differential input termination | Input Full-scale |
|--------------------|-------------------------|--------------|-----------------------------------------|------------------|
| 1 (Default)        | 1.6 GHz                 | 1            | 100 $\Omega$                            | + 1 dBm          |
| 2                  | 1.5 GHz                 | 1            |                                         | + 1.8 dBm        |
| 4                  | 1.5 GHz                 | 1            |                                         | +1.8 dBm         |
| 1                  | 1.5 GHz                 | 0            |                                         | + 0.5 dBm        |
| 2                  | 0.8 GHz                 | 0            |                                         |                  |
| 4                  | 0.4 GHz                 | 0            |                                         |                  |

There is an internal RESET switch which resets the sampling capacitor to VCM in between samples when enabled. The full power input bandwidth plots with input RESET switch disabled (RSW0) and enabled (RSW1) are shown in [Figure 7-2](#).



**Figure 7-2. Full power input bandwidth**

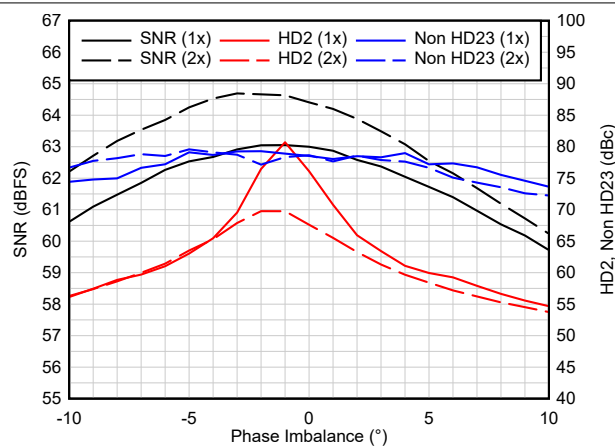
The RESET switch is enabled by default and can be disabled with the following register writes:

**Table 7-2. Register Write Example for Configuring the RESET Switch**

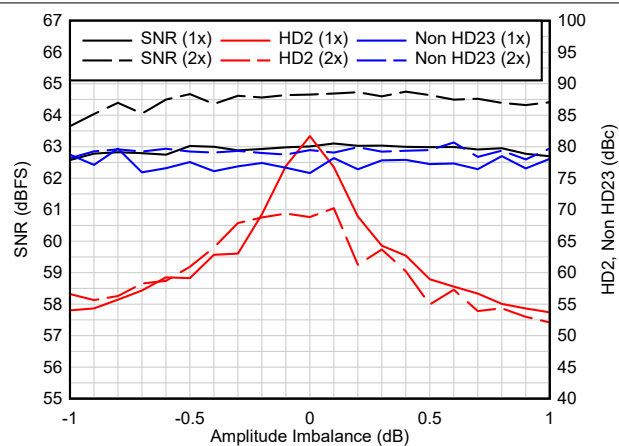
| ADDR | DATA | DESCRIPTION                            |
|------|------|----------------------------------------|
| 0x05 | 0x40 | Select ANALOG page                     |
| 0x6D | 0xC0 | Disable RESET Switch (to enable: 0x00) |
| 0x6E | 0x08 | Disable RESET Switch (to enable: 0x00) |

### 7.3.1.2 Input Imbalance

The AC performance is sensitive to amplitude and phase imbalance of the analog inputs, as shown in [Figure 7-3](#) and [Figure 7-4](#) for 1x and 2x internal averaging ( $F_S = 1.5$  GSPS,  $F_{IN} = 0.9$  GHz,  $A_{IN} = -1$  dBFS, dither = DIS).



**Figure 7-3. Amplitude Imbalance vs SNR**



**Figure 7-4. Phase Imbalance vs SNR**

### 7.3.1.3 Overrange Indication

The ADC provides two options (configured using SPI) to indicate if input fullscale overrange occurred:

- Fast Overrange on GPIO1/2 pins: indication is available after ~ 6 clock cycles and the overrange indication flag stays high (sticky) until it is cleared via SPI register writes. Note: OVRA and OVRB or OR-ed together and given on GPIO1 and 2.
- Overrange embedded in JESD stream: in this configuration the overrange indicator replaces the LSB of the output data of the corresponding channel. The indicator is output ahead of the data and is updated every clock cycle.

**Table 7-3. JESD OVR Latency**

| Decimation | # of Bands                      | OVR Latency (incl JESD, in sampling clock cycles) |
|------------|---------------------------------|---------------------------------------------------|
| DDC Bypass | -                               | 140-144                                           |
| 8          | Single (real and complex), dual | 44                                                |
|            | Quad                            | 33                                                |
| 16         | Single (real and complex), dual | 80                                                |
|            | Quad                            | 58                                                |
| 32         | Single (real and complex), dual | 152                                               |
|            | Quad                            | 108                                               |
| 64         | Single (real and complex), dual | 296                                               |
|            | Quad                            | 208                                               |
| 128        | Single (real and complex), dual | 584                                               |
|            | Quad                            | 408                                               |

The overrange output flag (GPIO or JESD) is the output of individual overrange flags of all ADCs per channel being used. For example, in non-averaged mode the overrange indication per channel is for a single ADC while in 4x average mode the overrange flag of all 4 ADCs are OR-ed together. [Table 7-4](#) shows how to configure the OVR using SPI registers.

**Table 7-4. Programming example to configure the OVR to GPIO or JESD**

| ADDR                                              | DATA | DESCRIPTION                   | ADDR                                                | DATA | DESCRIPTION                          |
|---------------------------------------------------|------|-------------------------------|-----------------------------------------------------|------|--------------------------------------|
| OVRA on GPIO1 and OVRB on GPIO2, OVR sticky       |      |                               | OVR on JESD                                         |      |                                      |
| 0x05                                              | 0x02 | Select DIGITAL page           | 0x05                                                | 0x02 | Select DIGITAL page                  |
| 0x238                                             | 0xF0 |                               | 0x2E                                                | D0   | Set D0 = 1 to enable OVR on JESD     |
| 0x383                                             | 0x02 | Enable individual OVR on GPIO | 0x05                                                | 0x00 |                                      |
| Clear OVR                                         |      |                               | These extra writes are only needed using decimation |      |                                      |
| 0x05                                              | 0x40 | Select ANALOG page            | 0x05                                                | 0x18 | Select DDCA & DDCB page at same time |
| 0x74                                              | 0x04 | Clear OVR flag chA            | 0x20                                                | 0x06 | Enable OVR on JESD                   |
| 0x74                                              | 0x00 |                               |                                                     |      |                                      |
| 0x84                                              | 0x04 | Clear OVR flag chB            |                                                     |      |                                      |
| 0x84                                              | 0x00 |                               |                                                     |      |                                      |
| Change OVR from sticky to non sticky (self clear) |      |                               |                                                     |      |                                      |
| 0x05                                              | 0x40 | Select ANALOG page            |                                                     |      |                                      |
| 0x31                                              | 0x06 | Set OVR to non-sticky         |                                                     |      |                                      |

### 7.3.1.4 Analog out-of-band dither

The ADC32RF52 provides optional (enabled via SPI writes) analog out-of-band, large amplitude dither. It has a bandwidth of  $\sim 20$  MHz located at DC and an adjustable amplitude with a maximum dither power of  $\sim -20$  dBFS (PAR  $\sim 9$  dB). The dither is completely rolled-off into the noise floor within  $\sim 100$  MHz as illustrated in Figure 7-5. Since the dither is large amplitude it is recommended for the signal input not to exceed  $-2.5$  dBFS to avoid input saturation. The dither signal also couples to the input signal and, depending on input frequency, can degrade the close in phase noise for offsets  $> 1$  MHz.

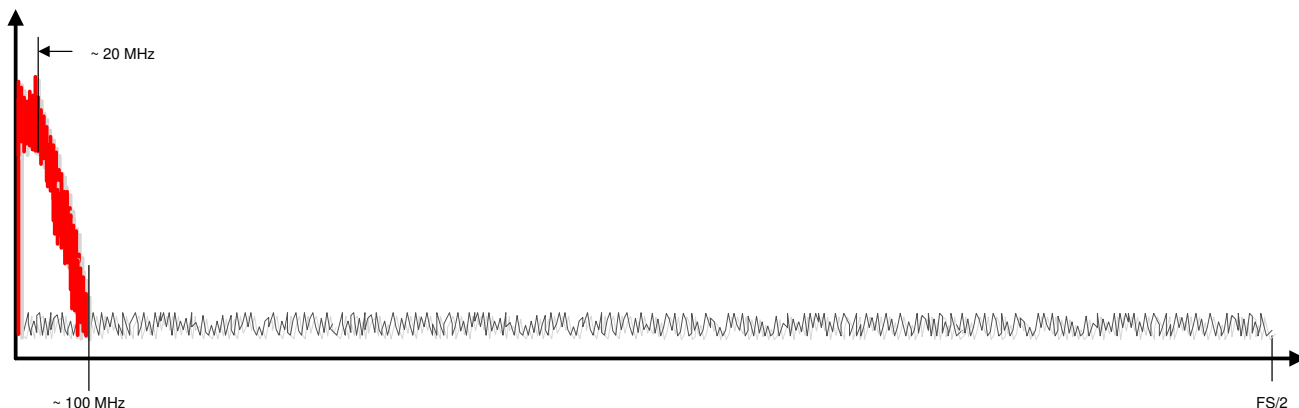


Figure 7-5. Analog out-of-band dither

In the frequency domain the dither signal shows up like individual tones as shown in #none#. The dither update frequency can be adjusted with the dither divider setting. The dither update frequency is:  $F_S / 4 / 2047 / \text{'Dither Divider'}$ . In the frequency spectrum there will be 2 larger dither spurs at  $F_{IN} \pm F_S / 4 / \text{'Dither Divider'}$ .

By default, the divider is set to 50, which translates to a dither spur spacing of  $\sim 7$  kHz. A divider setting of 32 translates to a dither spacing of  $\sim 11$  kHz as shown in #none#. The lower the divider setting, the higher the dither tone frequency. #none# also shows that the dither energy reduces as the offset frequency increases - less dither energy reduces the higher harmonic spur improvement.

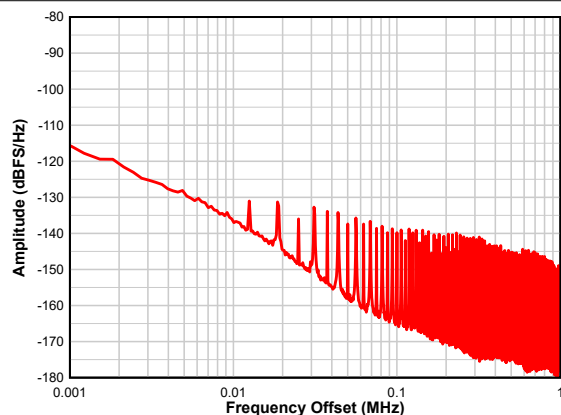


Figure 7-6. Dither Close-Up

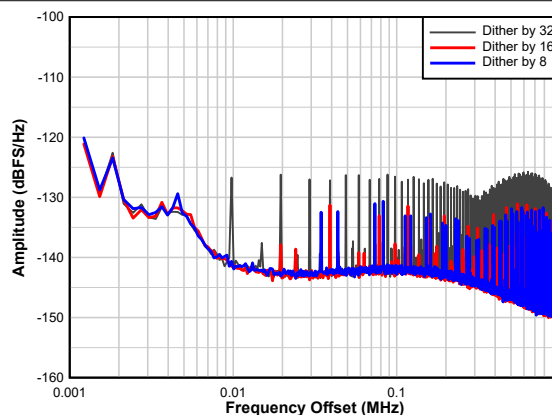


Figure 7-7. Dither vs Dither Divider Setting

The analog dither needs to be enabled in multiple locations. Different dither amplitudes should be used depending on internal averaging used as shown in [Table 7-5](#).

**Table 7-5. Recommended Dither Amplitude Settings**

| Mode      | Amplitude     | Dither Amp1 | Dither Amp2 |
|-----------|---------------|-------------|-------------|
| 1x AVG    | +/-1024 codes | 0           | 0           |
| 1x AVG    | +/-768 codes  | 0           | -4          |
| 2x/4x AVG | +/-1024 codes | 3           | 0           |
| 2x/4x AVG | +/-768 codes  | 0           | 0           |

The internal analog dither can be enabled via the following register writes. The dither divider is set in register 0xB1 as actual -1 (e.g. a divider of 48 would be programmed as 47, default is 0x00 which is divider = 50). See [Table 7-6](#).

**Table 7-6. Register Write Example for Configuring the Internal Dither**

| ADDR | DATA | DESCRIPTION                      | ADDR | DATA | DESCRIPTION                                   |
|------|------|----------------------------------|------|------|-----------------------------------------------|
| 0x05 | 0x40 | Select ANALOG page               | 0xB1 | 0x00 | Sets dither divider. 0x00 = /50               |
| 0xA8 | 0x00 | DITHER AMP1: 3 = 0x80, 0 = 0x00  | 0xB2 | 0x00 |                                               |
| 0xCD | 0x00 | DITHER AMP2: -4 = 0x40, 0 = 0x00 | 0xAF | 0x18 |                                               |
| 0x04 | 0x01 |                                  | 0xAF | 0x10 | 0x10 = dither ENABLED, 0x90 = dither DISABLED |
| 0x20 | 0x04 |                                  | 0x04 | 0x01 |                                               |
| 0x91 | 0x40 |                                  | 0x20 | 0x00 |                                               |
| 0xAF | 0x10 |                                  | 0x04 | 0x00 |                                               |

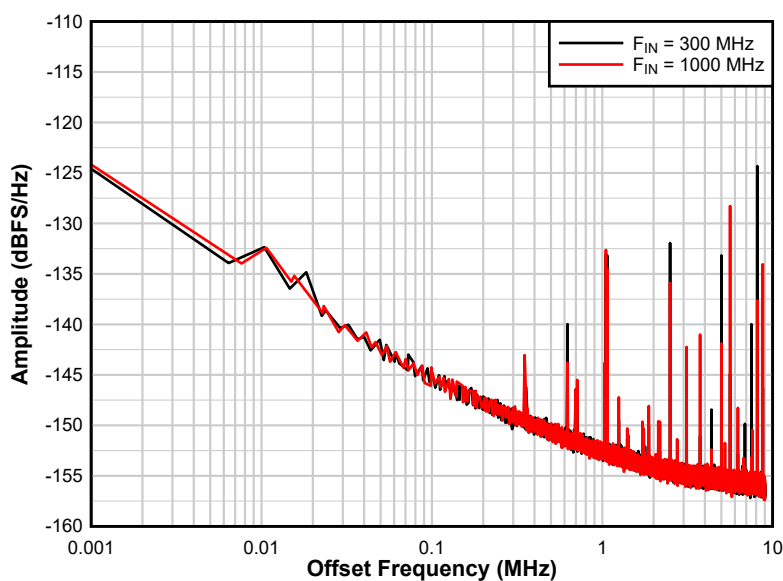
### 7.3.2 Sampling Clock Input

The internal sampling clock path was designed for lowest residual phase noise contribution. The sampling clock circuitry requires a dedicated low noise power supply for best performance. The internal residual clock phase noise is also sensitive to clock amplitude and for best performance the clock amplitude should be larger than  $1 V_{PP}$ .

**Table 7-7. Internal Aperture Clock Phase Noise**  
( $F_S = 1.5$  Gsps,  $V_{IN} = 1 V_{PP}$ )

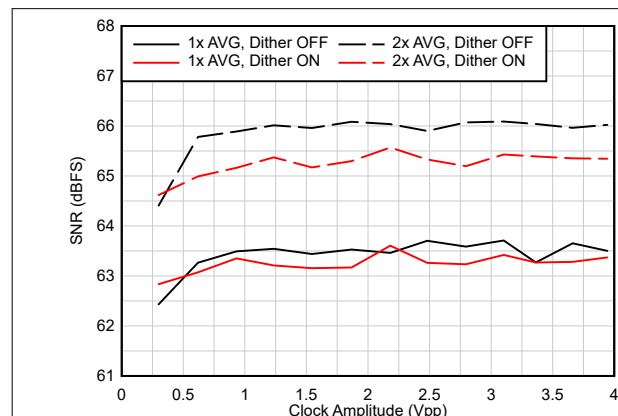
| Frequency Offset (MHz) | Amplitude (dBc/Hz) |
|------------------------|--------------------|
| 0.001                  | -123               |
| 0.01                   | -133               |
| 0.1                    | -143               |
| 1                      | -152               |
| 10                     | -157               |
| 250                    | -160               |

The clock input and ADC sampling circuitry also have an amplitude noise component which modulates on to the sampled input signal. Unlike phase noise, the amplitude noise does not scale with input frequency as shown in [Figure 7-8](#). This noise component can dominate the close in noise performance at lower input frequencies.

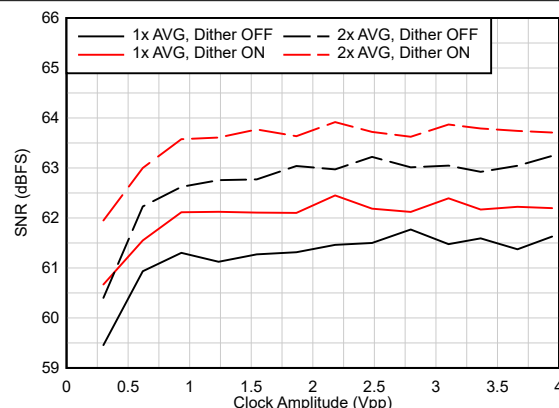


**Figure 7-8. Amplitude Noise**

The internal aperture jitter is also dependent on the amplitude of the external clock input signal. [Figure 7-9](#) and [Figure 7-10](#) show the expected SNR performance with dither on/off across clock amplitude.

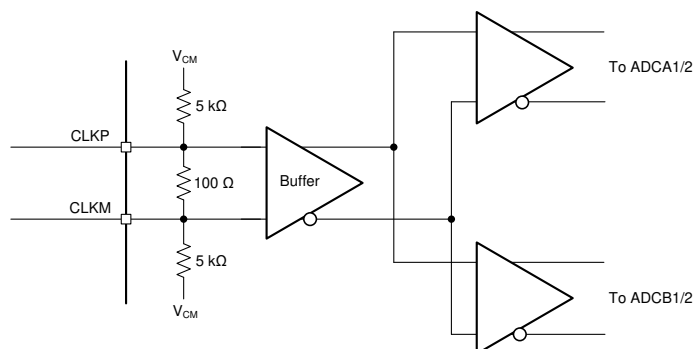


**Figure 7-9. SNR vs Clock Amplitude ( $F_{IN} = 900$  MHz)**



**Figure 7-10. SNR vs Clock Amplitude ( $F_{IN} = 1800$  MHz)**

The sampling clock input is internally terminated to  $100\ \Omega$  differentially and provides a return loss better than 10 dB (see [Figure 7-11](#)). The clock input consists of a single clock input buffer followed by a dedicated clock buffer for ADCA1/2 as well as ADCB1/2. When averaging multiple ADCs, there are some close in clock buffer noise which is correlated; and thus, does not improve with averaging.



**Figure 7-11. Clock Input Internal Circuitry**

### 7.3.3 SYSREF

The SYSREF input signal is used to reset internal digital blocks and align them to the internal multi-frame clock to achieve deterministic latency subclass 1. The SYSREF input signal can be AC or DC coupled (selected via SPI register option) as shown in Figure 7-12. The ADC32RF5x has internal 100-Ω termination for DC coupling and internal biasing when using AC coupling.

A register mask can be used to only give SYSREF to the NCO (see NCO section) in the decimation filter block and leave all other blocks such as JESD interface unaffected.

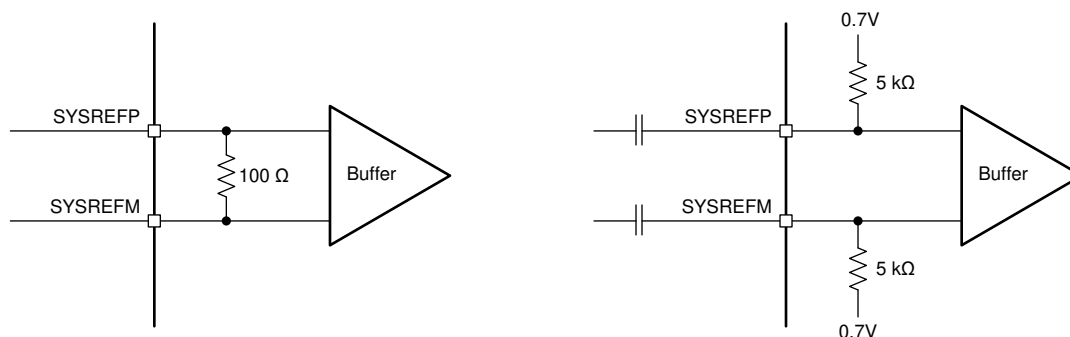
When giving a periodic SYSREF signal, the frequency must be a sub-harmonic of the internal local multi-frame clock (LMFC). The LMFC frequency is determined by the selected decimation: frames per multi-frame setting (K), samples per frame (S), and the device sampling frequency (FS).

**Table 7-8. LMFC and SYSREF settings for different operating modes**

| Operating Mode  | LMFS Mode | LMFC Clock Frequency         | SYSREF Frequency                      |
|-----------------|-----------|------------------------------|---------------------------------------|
| DDC Bypass Mode | 82820     | $FS / (20 \times K)$         | $FS / (N \times 20 \times K)$         |
|                 | 8224      | $FS / (4 \times K)$          | $FS / (N \times 4 \times K)$          |
| Decimation      | Various   | $FS / (D \times S \times K)$ | $FS / (N \times D \times S \times K)$ |

Where N is an integer value (1, 2, 3...).

After enabling SYSREF input, the internal SYSREF input ignores any incoming SYSREF pulse after the first 16 pulses.



**Figure 7-12. SYSREF Input Circuitry and Edge Alignment**

The internal synchronization using the external SYSREF signal can be enabled with the following register writes (see Table 7-9)

**Table 7-9. Register write example for enabling SYSREF synchronization**

| ADDR  | DATA | DESCRIPTION                                                 |
|-------|------|-------------------------------------------------------------|
| 0x05  | 0x02 | Select DIGITAL page                                         |
| 0x236 | 0x02 | Enable internal SYSREF input and clear SYSREF pulse counter |
| 0x236 | 0x03 | Starts internal SYSREF counter                              |

AC coupling with internal biasing of the SYSREF input can be enabled with the following SPI register writes (see Table 7-10)

**Table 7-10. Register write example for enabling SYSREF AC coupling**

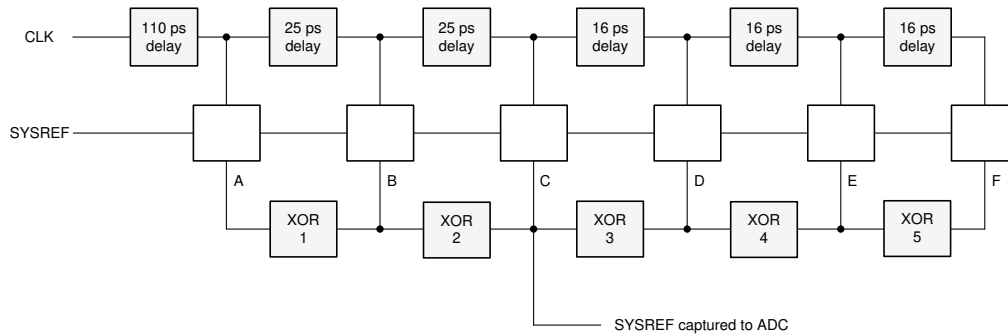
| ADDR | DATA | DESCRIPTION                                                 |
|------|------|-------------------------------------------------------------|
| 0x05 | 0x40 | Select ANALOG page                                          |
| 0xB4 | 0x01 | Enable external AC coupling with internal biasing on SYSREF |

### 7.3.3.1 SYSREF Capture Detection

The SYSREF input signal rising edge should be edge aligned with the rising edge of the sampling clock to maximize the setup and hold times. The ADC32RF52 includes an internal SYSREF monitoring circuitry to detect possible metastability resulting in a clock cycle slip; and thus, misalignment across devices.

The sampling clock gets delayed by ~160 ps and then captures the SYSREF signal. The SYSREF monitoring circuitry captures the SYSREF signal  $\pm 50$  ps (-50, -25, +16, +32, +48 ps) around the main SYSREF capture. In ideal conditions no SYSREF transition happens within the 100 ps SYSREF capture window and all XOR flags show "0". If a SYSREF/clock misalignment happens and the SYSREF transition falls within the SYSREF monitoring window, then one of the XOR flags (which monitor adjacent SYSREF captures within the window) shows a "1" and the SYSREF can be adjusted externally.

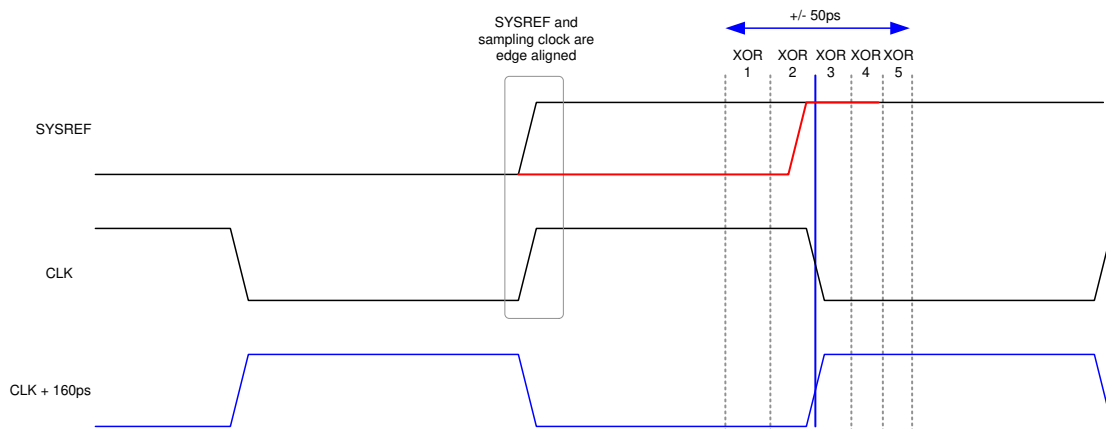
The SYSREF monitor registers are not 'sticky' registers - they get updated at every rising edge of SYSREF.



**Figure 7-13. SYSREF Detection Circuitry**

The example in [Figure 7-14](#) shows a misaligned SYSREF signal where the SYSREF signal arrives much later than the sampling clock rising edge. The SYSREF window feature checks if the SYSREF transition is within  $\pm 50$  ps of the instant when the SYSREF signal gets captured by the sampling clock.

In this example, the delayed SYSREF signal transitions between the "B" and "C" flip flop which raises the XOR2 flag. The XOR flags get reported in register 0x22F in the digital page. In this example, Register 0x22F reads back 0x8B, as shown in [Table 7-11](#).



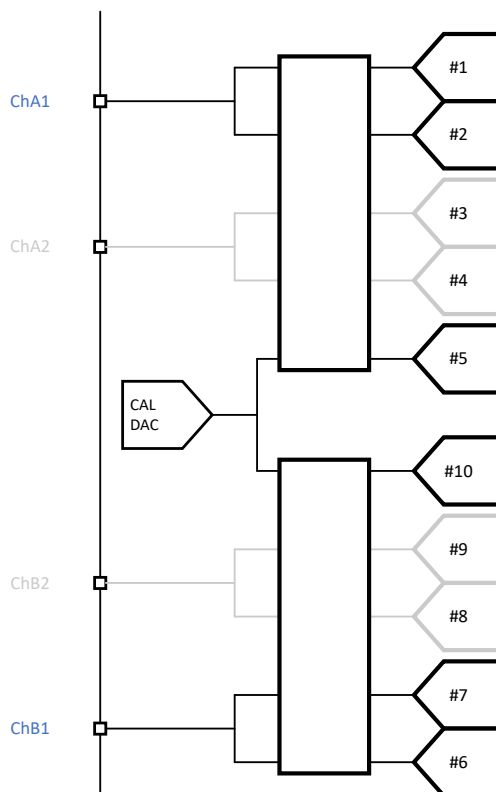
**Figure 7-14. Detection of SYSREF Transition within Capture Window**

**Table 7-11. SYSREF Window Register Example (0x22F)**

| ADDR  | D7 | D6        | D5        | D4        | D3        | D2        | D1        | D0 |
|-------|----|-----------|-----------|-----------|-----------|-----------|-----------|----|
| 0x22F | 1  | SYSREF X5 | SYSREF X4 | SYSREF X3 | SYSREF X2 | SYSREF X1 | SYSREF OR | 1  |
|       | 1  | 0         | 0         | 0         | 1         | 0         | 1         | 1  |

### 7.3.4 ADC Foreground Calibration

The internal ADC architecture is sensitive to temperature changes. The ADC32RF52 contains two additional internal ADC cores (one for channel A1/2 and one for channel B1/2) which are used whenever one of the ADCs is in calibration. ADCs are calibrated as pairs where one ADC at a time is connected to the internal calibration DAC. The calibration is configured via SPI register writes and can be executed using SPI register writes or using the GPIO1 pin. When executed, the calibration takes  $\sim 46 \text{ ms} \times 1.5 \text{ GSPS} / F_S$  per ADC pair ( $\sim 23 \text{ ms} \times 1.5 \text{ GSPS} / F_S$  per ADC). The example in [Figure 7-15](#) shows 2x internal averaging where 4 ADC cores (#1, #2 for chA1 and #6, #7 for chB1) are used in operation and ADCs #5 and #10 for calibration.



**Figure 7-15. Internal ADC setup for 2x averaging mode**

### 7.3.4.1 Calibration Control

Figure 7-16 shows a timing diagram of the calibration control using GPIO1 pin.

When GPIO1 transitions to LOW logic state:

- an ADC pair gets swapped out within ~ 120 ns
- a new calibration gets triggered immediately

If GPIO1 is being held low when the calibration of an ADC pair is completed, the next ADC pair is switched and a new calibration is triggered. The order in which ADC pair gets calibrated can be configured via SPI to serial or random.

When using 2x averaging for example, the calibration is executed for 3 ADC pairs to make sure all ADCs in use have been recently calibrated.

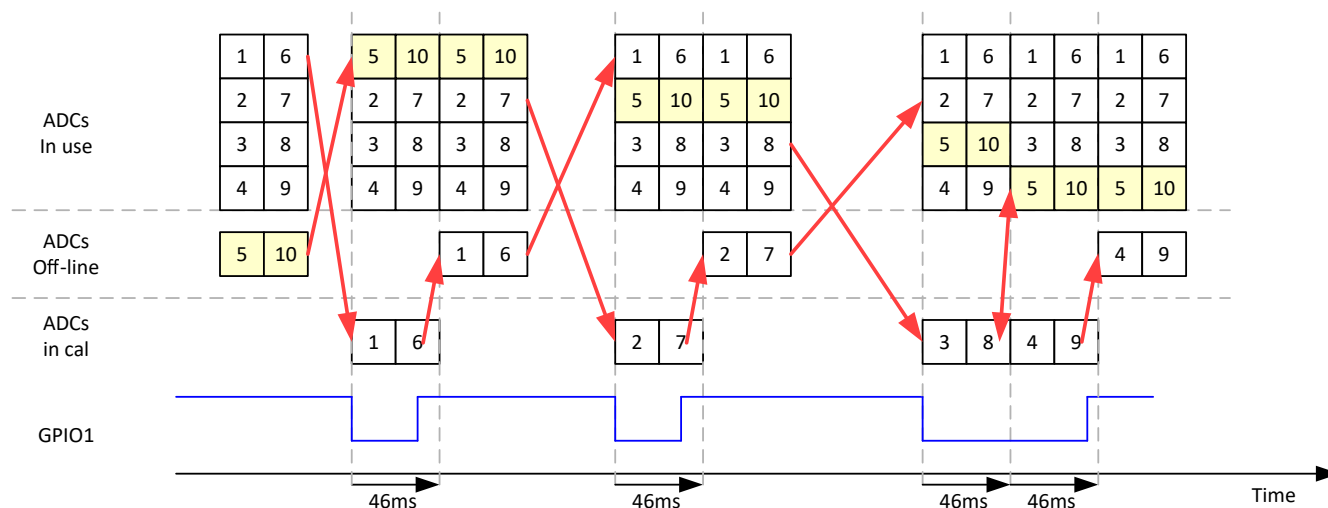


Figure 7-16. Timing diagram - calibration (4x AVG example)

Figure 7-17 shows the ADC switch happens approximate 120 ns after the logic level change on GPIO1 is detected.

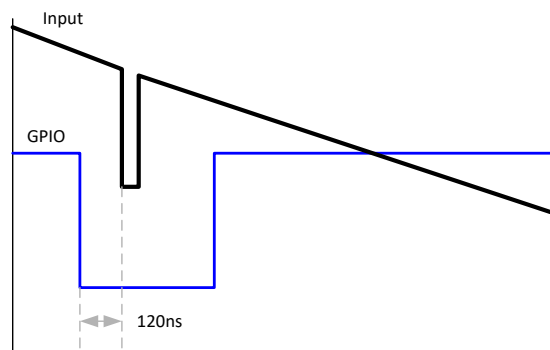
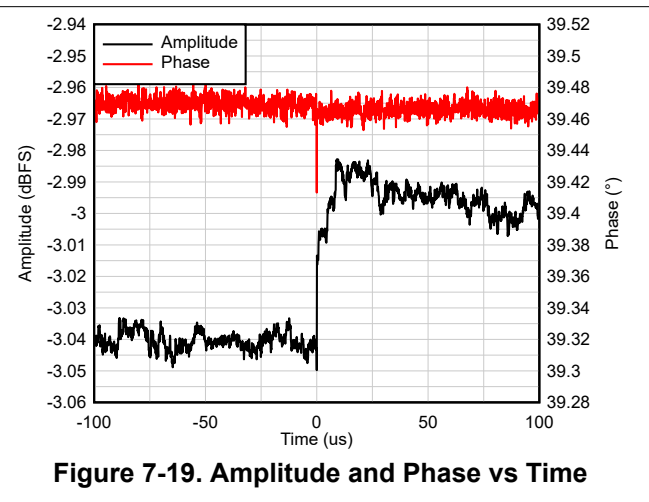
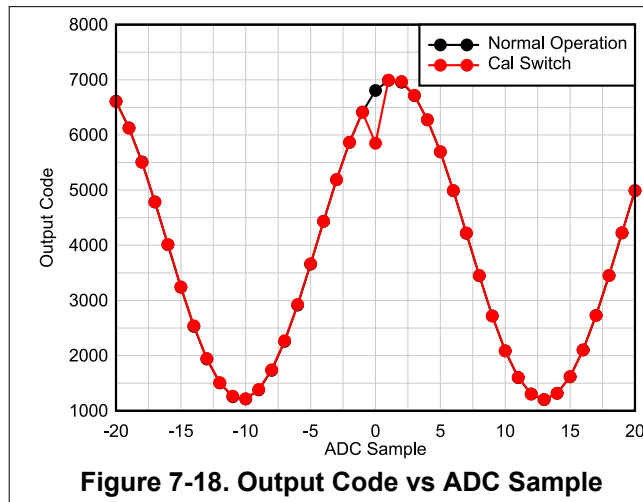


Figure 7-17. Timing diagram shows the ADC switch

### 7.3.4.2 ADC Switch

During the ADC transition, the amplitude drops for 1-2 samples as shown in [Figure 7-18](#). The gain variation from one ADC to the next is  $\sim < 0.05$  dB while the phase change is less 0.01 deg as shown in [Figure 7-19](#).



### 7.3.4.3 Calibration Configuration

The ADC32RF5x provides 3 different options to configure the internal foreground calibration:

- Calibrate all ADCs one time using SPI trigger (after initial power up or during operation) - see [Table 7-12](#)
- Continuous calibration - see [Table 7-13](#)
- Calibrate 2 ADC pairs at a time using GPIO trigger - see [Table 7-14](#)

The status of the calibration can be read back from register 0x298 (CALIBRATION page). Successful calibration reads back 0x0E on the 4 LSB of that register.

**Table 7-12. Register Writes for power up calibration or SINGLE calibration of all ADCs Using SPI**

| ADDR | DATA | DESCRIPTION                             |
|------|------|-----------------------------------------|
| 0x05 | 0x20 | Select CALIBRATION page                 |
| 0x46 | 0x02 |                                         |
| 0x45 | 0x8A | Toggle calibration start                |
| 0x45 | 0x0A |                                         |
| wait |      | 2.6 seconds x 1.5 GSPS / F <sub>S</sub> |

**Table 7-13. Register Writes to Trigger CONTINUOUS Calibration of all ADCs Using SPI**

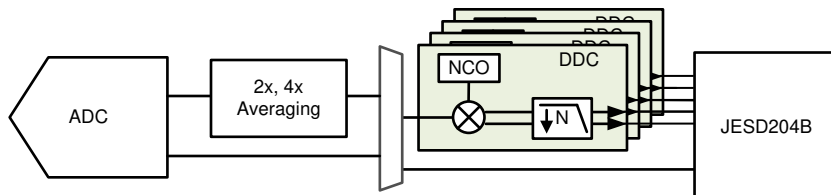
| ADDR | DATA | DESCRIPTION             |
|------|------|-------------------------|
| 0x05 | 0x20 | Select CALIBRATION page |
| 0x46 | 0x03 |                         |
| 0x45 | 0x0A |                         |

**Table 7-14. Register Writes to Trigger ADC Pair Calibration Using the GPIO Pin**

| ADDR  | DATA | DESCRIPTION                                |
|-------|------|--------------------------------------------|
| 0x05  | 0x20 | Select CALIBRATION page                    |
| 0x46  | 0x02 |                                            |
| 0x45  | 0x4A |                                            |
| 0x05  | 0x02 | Select DIGITAL page                        |
| 0x234 | 0x04 | Use GPIO1 pin to freeze calibration switch |

### 7.3.5 Decimation Filter

The ADC32RF52 provides up to four digital down converters per ADC channel (see [Figure 7-20](#)). The decimation filters provide a flexible option to cover a wide range of instantaneous bandwidths (IBW) as shown in [Table 7-15](#). Single band decimation supports a wide bandwidth up to complex decimation by 4x while up to four narrow band channels with up to 128x complex decimation are supported in quad band decimation mode.



**Figure 7-20. Digital Decimation Filter Options**

**Table 7-15. Summary of Different Decimation Filter Band Options**

| # of DDCs | Minimum Complex Decimation | Maximum Complex Decimation |
|-----------|----------------------------|----------------------------|
| 1         | 4                          | 128                        |
| 2         | 8                          | 128                        |
| 4         | 16                         | 128                        |

The decimation filter can be configured to two different operating modes:

- **Complex Decimation:** This mode provides complex output with ~ 80% passband bandwidth using a 48-bit phase coherent NCO.  
During the complex mixing operation the digital output is reduced by 6-dB. This reduces the fullscale from 0-dBFS to -6-dBFS. This 6-dB change applies to signals and noise and thus no dynamic range is lost.
- **Real Decimation:** In real decimation mode, the complex mixer is bypassed (NCO is set to 0 for lowest power consumption), and the digital filter acts as a low pass filter. There is no frequency shifting and the output passband bandwidth is ~ 40%.

Since the JESD204B interface is common across ADC channel A and B, the decimation ratio as well as the # of DDCs/ADC has to be the same across channels A and B.

By default, the output of values of the decimation filter are rounded to 16-bit resolution. To avoid quantization noise limitation when using high order of decimation (that is /64 or /128), a special 20-bit output mode can be enabled (see [20-bit mode](#)).

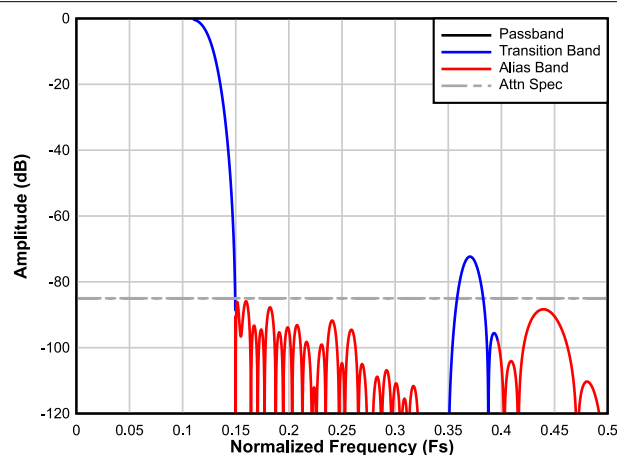
[Table 7-16](#) provides an overview of the available complex decimation settings and resulting complex and real output bandwidths.

**Table 7-16. Complex Decimation Setting vs Output Bandwidth**

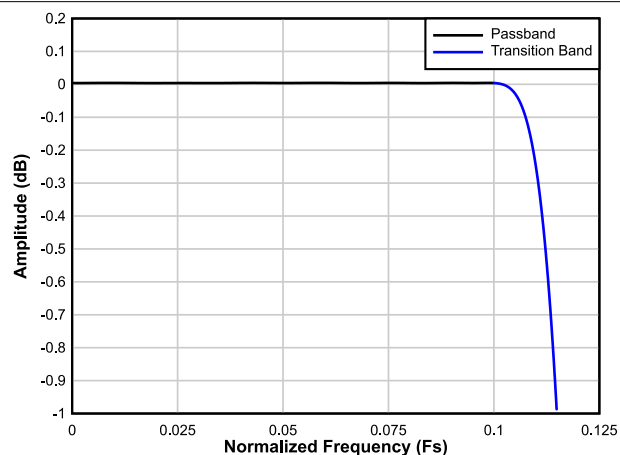
| Decimation Factor N (complex) | Complex Output Bandwidth per DDC | $F_S = 1.5 \text{ Gsps}$    |                                  | Real Output Bandwidth per DDC | $F_S = 1.5 \text{ Gsps}$ |                               |
|-------------------------------|----------------------------------|-----------------------------|----------------------------------|-------------------------------|--------------------------|-------------------------------|
|                               |                                  | Complex Output Rate per DDC | Complex Output Bandwidth per DDC |                               | Real Output Rate per DDC | Real Output Bandwidth per DDC |
| 4                             | $0.8 \times F_S / 4$             | 375 Msps                    | 300 MHz                          | $0.4 \times F_S / 4$          | 375 Msps                 | 150 MHz                       |
| 8                             | $0.8 \times F_S / 8$             | 187.5 Msps                  | 150 MHz                          | $0.4 \times F_S / 8$          | 187.5 Msps               | 75 MHz                        |
| 16                            | $0.8 \times F_S / 16$            | 93.75 Msps                  | 75 MHz                           | $0.4 \times F_S / 16$         | 93.75 Msps               | 37.5 MHz                      |
| 32                            | $0.8 \times F_S / 32$            | 46.875 Msps                 | 37.5 MHz                         | $0.4 \times F_S / 32$         | 46.875 Msps              | 18.75 MHz                     |
| 64                            | $0.8 \times F_S / 64$            | 23.4375 Msps                | 18.75 MHz                        | $0.4 \times F_S / 64$         | 23.4375 Msps             | 9.375 MHz                     |
| 128                           | $0.8 \times F_S / 128$           | 11.71875 Msps               | 9.375 MHz                        | $0.4 \times F_S / 128$        | 11.71875 Msps            | 4.6875 MHz                    |

### 7.3.5.1 Decimation Filter Response

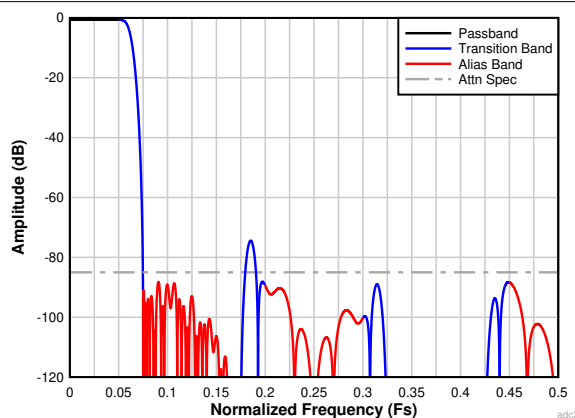
This section provides the different decimation filter responses with a normalized ADC sampling rate. The complex filter pass band is  $\sim 80\%$  ( $-1$  dB) with a minimum of 85 dB stop band rejection.



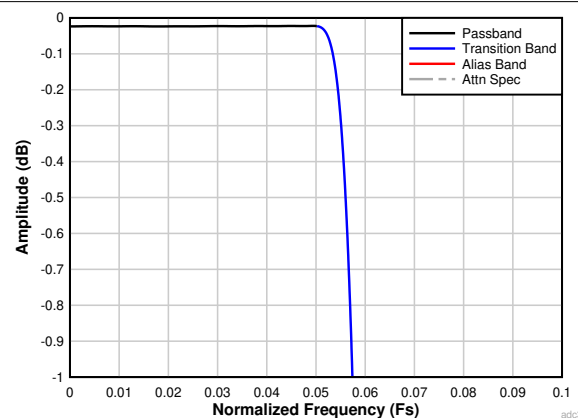
**Figure 7-21. Complex Decimation by 4 Filter Response**



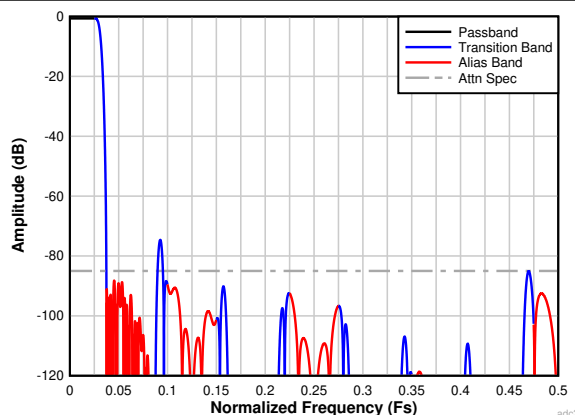
**Figure 7-22. Decimation by 4 Passband Ripple Response**



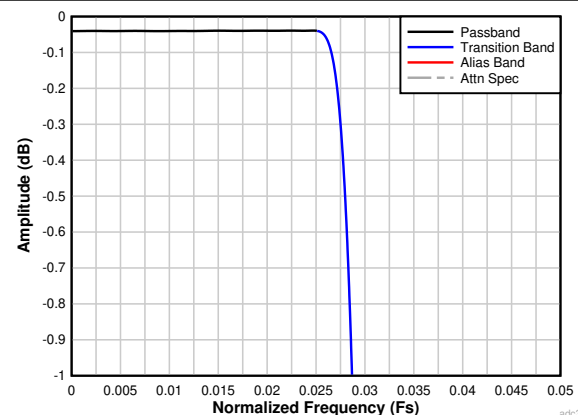
**Figure 7-23. Complex Decimation by 8 Filter Response**



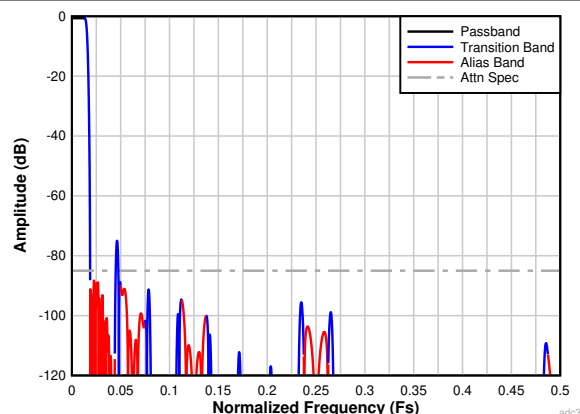
**Figure 7-24. Decimation by 8 Passband Ripple Response**



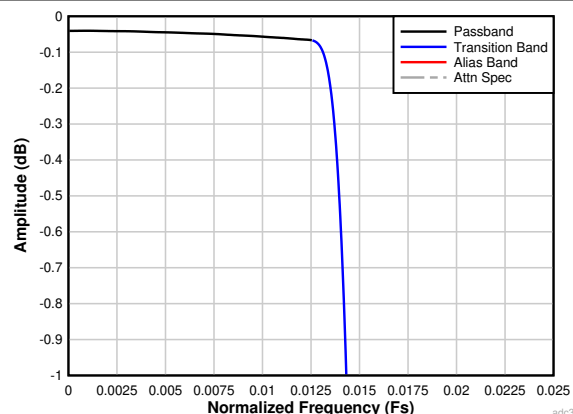
**Figure 7-25. Complex Decimation by 16 Filter Response**



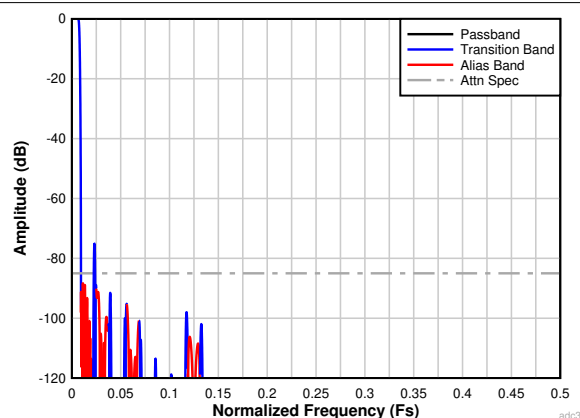
**Figure 7-26. Decimation by 16 Passband Ripple Response**



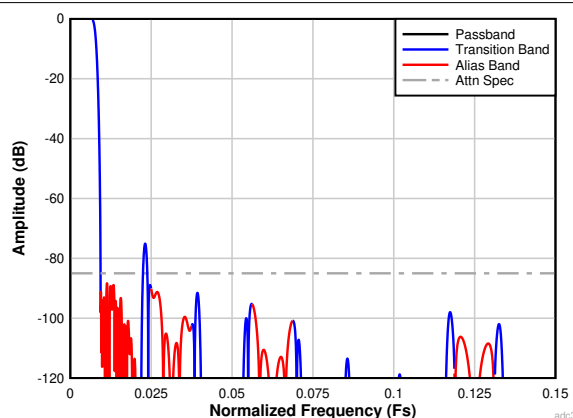
**Figure 7-27. Complex Decimation by 32 Filter Response**



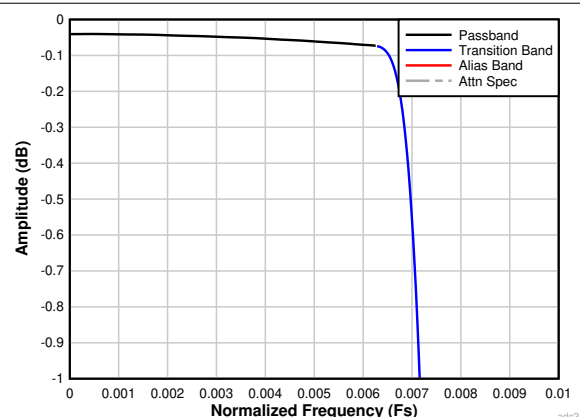
**Figure 7-28. Decimation by 32 Passband Ripple Response**



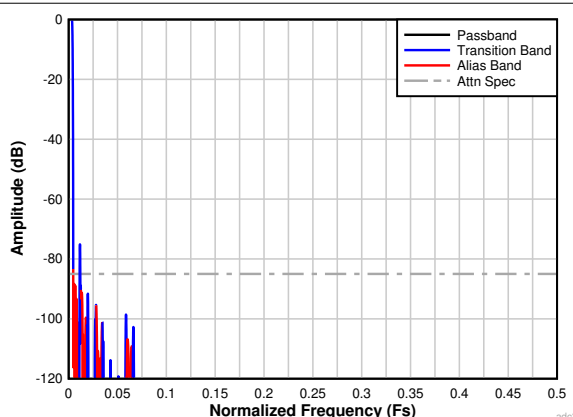
**Figure 7-29. Complex Decimation by 64 Filter Response**



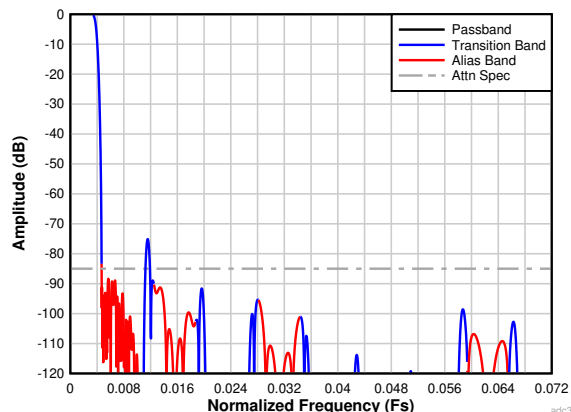
**Figure 7-30. Complex Decimation by 64 Filter Response**



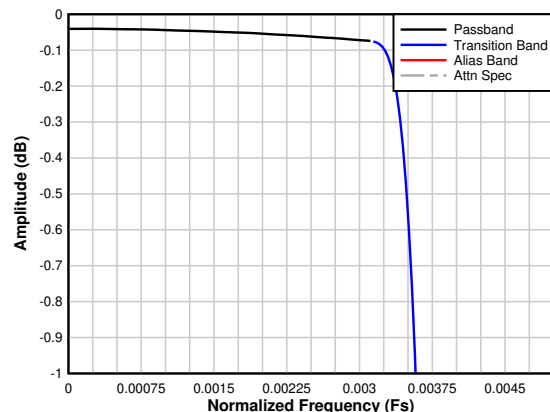
**Figure 7-31. Decimation by 64 Passband Ripple Response**



**Figure 7-32. Complex Decimation by 128 Filter Response**



**Figure 7-33. Complex Decimation by 128 Filter Response**



**Figure 7-34. Decimation by 128 Passband Ripple Response**

### 7.3.5.2 Decimation Filter Configuration

The decimation filter is configured with these register writes.

**Table 7-17. Register writes to enable the internal decimation filter**

| ADDR | DATA | DESCRIPTION                     |
|------|------|---------------------------------|
| 0x05 | 0x02 | Select DIGITAL page             |
| 0x2C |      | Select single/dual/quad band    |
| 0x2D |      | Select decimation               |
| 0x05 | 0x04 | Select JESD page                |
| 0x22 |      | Select LMFS mode                |
| 0x24 |      | Select DDC CLK setting          |
| 0x25 |      | Select JESD TX CLK DIV setting  |
| 0x9F |      | Select JESD PLL 1/2 settings    |
| 0xA0 |      | Select JESD PLL INPUT1 setting  |
| 0xA1 |      | Select JESD PLL INPUT2 settings |
| 0xA2 |      | Select JESD PLL INPUT3 settings |

### 7.3.5.3 20-bit Output Mode

The device includes a 20-bit output resolution mode which can be used for high order decimation (e.g. 64x, 128x) to avoid SNR degradation due to quantization noise limitation. In this mode the output data is transmitted at 2x the output rate. The 20-bit sample from the DDC gets expanded to 32-bit by adding 12x 0s, and occupies 2 consecutive 16-bit samples. This doubles the number of octets 'F' and the proper LMFS mode and JESD PLL settings have to be selected.

So for example a single band complex decimation would go from LMFS = 2441 (16-bit output mode) to LMFS = 2481 (20-bit output mode) as illustrated in Table 7-18.

**Table 7-18. JESD Frame Assembly Comparison between 16-bit and 20-bit Output Mode**

| LMFS = 2441            |                       |                        |                       | LMFS = 2481             |                         |                        |                       |                         |                         |                        |                       |
|------------------------|-----------------------|------------------------|-----------------------|-------------------------|-------------------------|------------------------|-----------------------|-------------------------|-------------------------|------------------------|-----------------------|
| xI <sub>0</sub> [15:8] | xI <sub>0</sub> [7:0] | xQ <sub>0</sub> [15:8] | xQ <sub>0</sub> [7:0] | xI <sub>0</sub> [31:24] | xI <sub>0</sub> [23:16] | xI <sub>0</sub> [15:8] | xI <sub>0</sub> [7:0] | xQ <sub>0</sub> [31:24] | xQ <sub>0</sub> [23:16] | xQ <sub>0</sub> [15:8] | xQ <sub>0</sub> [7:0] |
|                        |                       |                        |                       | 20-bit sample I         |                         |                        |                       | 20-bit sample Q         |                         |                        |                       |
|                        |                       |                        |                       | 0000 000000             |                         |                        |                       | 0000 000000             |                         |                        |                       |

The 20-bit output mode is enabled by setting D7 in 0x2C (DIGITAL page) and selecting viable decimation and LMFS mode.

### 7.3.5.4 Dynamic Switching

The ADC32RF52 supports a dynamic switch mode between two decimation filter configurations without the need to resynchronize the JESD204B interface. This enables support for single, wideband DDC and 4 narrow band DDCs that can be switched in between with minimum impact on latency.

Two different configurations are supported in the dynamic switching mode. Each configuration maintains the # of serdes lanes and serdes output rate during the switch. Table 7-19 shows the specific supported configurations for LMFS and decimation settings for a 2 lane and a 1 lane setup. Since the amount of output data in quad band mode is four times larger compared to single band, the decimation factor in quad band mode needs to be reduced by a factor of four compared to the single band case.

**Table 7-19. Dynamic switch configuration modes**

|         | Single Band DDC |                    | Quad Band DDC |                    |
|---------|-----------------|--------------------|---------------|--------------------|
|         | LMFS            | Complex Decimation | LMFS          | Complex Decimation |
| 2 lanes | 2-4-16-4        | /16                | 2-16-16-1     | /64                |
| 1 lane  | 1-4-32-4        | /32                | 1-16-32-1     | /128               |

There is no information in the JESD204B output data stream indicating if the output data is quad band or single band. The JESD204B receiving device controls the switching and thus needs to decode the incoming data for quad band or single band mode. The LMFS value transmitted ILA when the JESD204B link is established is always from the quad band mode to avoid ILA errors at the start of the link.

#### 7.3.5.4.1 2 Lane Mode

JESD transmit (TX) will operate in LMFS = 2-16-16-1 in both the quad and single band modes. The JESD receiver should be configured to and switched between 2-4-16-4 and 2-16-16-1.

**Table 7-20. 2 lane dynamic switch frame assembly**

| LMFS      | FRAME ASSEMBLY             |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
|-----------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|
| 2-16-16-1 | A1I <sub>0</sub><br>[15:8] | A1I <sub>0</sub><br>[7:0] | A1Q <sub>0</sub><br>[15:8] | A1Q <sub>0</sub><br>[7:0] | A2I <sub>0</sub><br>[15:8] | A2I <sub>0</sub><br>[7:0] | A2Q <sub>0</sub><br>[15:8] | A2Q <sub>0</sub><br>[7:0] | A3I <sub>0</sub><br>[15:8] | A3I <sub>0</sub><br>[7:0] | A3Q <sub>0</sub><br>[15:8] | A3Q <sub>0</sub><br>[7:0] | A4I <sub>0</sub><br>[15:8] | A4I <sub>0</sub><br>[7:0] | A4Q <sub>0</sub><br>[15:8] | A4Q <sub>0</sub><br>[7:0] |
|           | B1I <sub>0</sub><br>[15:8] | B1I <sub>0</sub><br>[7:0] | B1Q <sub>0</sub><br>[15:8] | B1Q <sub>0</sub><br>[7:0] | B2I <sub>0</sub><br>[15:8] | B2I <sub>0</sub><br>[7:0] | B2Q <sub>0</sub><br>[15:8] | B2Q <sub>0</sub><br>[7:0] | B3I <sub>0</sub><br>[15:8] | B3I <sub>0</sub><br>[7:0] | B3Q <sub>0</sub><br>[15:8] | B3Q <sub>0</sub><br>[7:0] | B4I <sub>0</sub><br>[15:8] | B4I <sub>0</sub><br>[7:0] | B4Q <sub>0</sub><br>[15:8] | B4Q <sub>0</sub><br>[7:0] |
| 2-4-16-4  | AI <sub>0</sub><br>[15:8]  | AI <sub>0</sub><br>[7:0]  | AI <sub>1</sub><br>[15:8]  | AI <sub>1</sub><br>[7:0]  | AI <sub>2</sub><br>[15:8]  | AI <sub>2</sub><br>[7:0]  | AI <sub>3</sub><br>[15:8]  | AI <sub>3</sub><br>[7:0]  | AQ <sub>0</sub><br>[15:8]  | AQ <sub>0</sub><br>[7:0]  | AQ <sub>1</sub><br>[15:8]  | AQ <sub>1</sub><br>[7:0]  | AQ <sub>2</sub><br>[15:8]  | AQ <sub>2</sub><br>[7:0]  | AQ <sub>3</sub><br>[15:8]  | AQ <sub>3</sub><br>[7:0]  |
|           | BI <sub>0</sub><br>[15:8]  | BI <sub>0</sub><br>[7:0]  | BI <sub>1</sub><br>[15:8]  | BI <sub>1</sub><br>[7:0]  | BI <sub>2</sub><br>[15:8]  | BI <sub>2</sub><br>[7:0]  | BI <sub>3</sub><br>[15:8]  | BI <sub>3</sub><br>[7:0]  | BQ <sub>0</sub><br>[15:8]  | BQ <sub>0</sub><br>[7:0]  | BQ <sub>1</sub><br>[15:8]  | BQ <sub>1</sub><br>[7:0]  | BQ <sub>2</sub><br>[15:8]  | BQ <sub>2</sub><br>[7:0]  | BQ <sub>3</sub><br>[15:8]  | BQ <sub>3</sub><br>[7:0]  |

#### 7.3.5.4.2 1 Lane Mode

JESD transmit (TX) will operate in LMFS = 1-16-32-1 in both the quad and single band modes. The JESD receiver should be configured to and switched between 1-4-32-4 and 1-16-32-1.

**Table 7-21. 2 lane dynamic switch frame assembly**

| LMFS      | FRAME ASSEMBLY             |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |
|-----------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|
| 1-16-32-1 | A1I <sub>0</sub><br>[15:8] | A1I <sub>0</sub><br>[7:0]  | A1Q <sub>0</sub><br>[15:8] | A1Q <sub>0</sub><br>[7:0]  | A2I <sub>0</sub><br>[15:8] | A2I <sub>0</sub><br>[7:0]  | A2Q <sub>0</sub><br>[15:8] | A2Q <sub>0</sub><br>[7:0]  | A3I <sub>0</sub><br>[15:8] | A3I <sub>0</sub><br>[7:0]  | A3Q <sub>0</sub><br>[15:8] | A3Q <sub>0</sub><br>[7:0]  | A4I <sub>0</sub><br>[15:8] | A4I <sub>0</sub><br>[7:0]  | A4Q <sub>0</sub><br>[15:8] | A4Q <sub>0</sub><br>[7:0]  |
|           | ...                        | B1I <sub>0</sub><br>[15:8] | B1I <sub>0</sub><br>[7:0]  | B1Q <sub>0</sub><br>[15:8] | B1Q <sub>0</sub><br>[7:0]  | B2I <sub>0</sub><br>[15:8] | B2I <sub>0</sub><br>[7:0]  | B2Q <sub>0</sub><br>[15:8] | B2Q <sub>0</sub><br>[7:0]  | B3I <sub>0</sub><br>[15:8] | B3I <sub>0</sub><br>[7:0]  | B3Q <sub>0</sub><br>[15:8] | B3Q <sub>0</sub><br>[7:0]  | B4I <sub>0</sub><br>[15:8] | B4I <sub>0</sub><br>[7:0]  | B4Q <sub>0</sub><br>[15:8] |
| 1-4-32-4  | AI <sub>0</sub><br>[15:8]  | AI <sub>0</sub><br>[7:0]   | AI <sub>1</sub><br>[15:8]  | AI <sub>1</sub><br>[7:0]   | AI <sub>2</sub><br>[15:8]  | AI <sub>2</sub><br>[7:0]   | AI <sub>3</sub><br>[15:8]  | AI <sub>3</sub><br>[7:0]   | AQ <sub>0</sub><br>[15:8]  | AQ <sub>0</sub><br>[7:0]   | AQ <sub>1</sub><br>[15:8]  | AQ <sub>1</sub><br>[7:0]   | AQ <sub>2</sub><br>[15:8]  | AQ <sub>2</sub><br>[7:0]   | AQ <sub>3</sub><br>[15:8]  | AQ <sub>3</sub><br>[7:0]   |
|           | ...                        | BI <sub>0</sub><br>[15:8]  | BI <sub>0</sub><br>[7:0]   | BI <sub>1</sub><br>[15:8]  | BI <sub>1</sub><br>[7:0]   | BI <sub>2</sub><br>[15:8]  | BI <sub>2</sub><br>[7:0]   | BI <sub>3</sub><br>[15:8]  | BI <sub>3</sub><br>[7:0]   | BQ <sub>0</sub><br>[15:8]  | BQ <sub>0</sub><br>[7:0]   | BQ <sub>1</sub><br>[15:8]  | BQ <sub>1</sub><br>[7:0]   | BQ <sub>2</sub><br>[15:8]  | BQ <sub>2</sub><br>[7:0]   | BQ <sub>3</sub><br>[15:8]  |

### 7.3.5.5 Numerically Controlled Oscillator (NCO)

Each digital down-converter (DDC) uses a 48-bit numerically controlled oscillator (NCO) to fine tune the frequency placement prior to the digital filtering. Different NCO frequencies for each DDC are programmed using SPI register writes and the desired NCO frequency can be selected using SPI or the GPIO pins. When using the GPIO pins for NCO frequency control, frequency hopping can be achieved in less than 1  $\mu$ s. The digital NCO is designed to have a SFDR of at least 100 dB. The number of available, programmable NCO frequencies depends on # of DDC bands used as illustrated in Table 7-22.

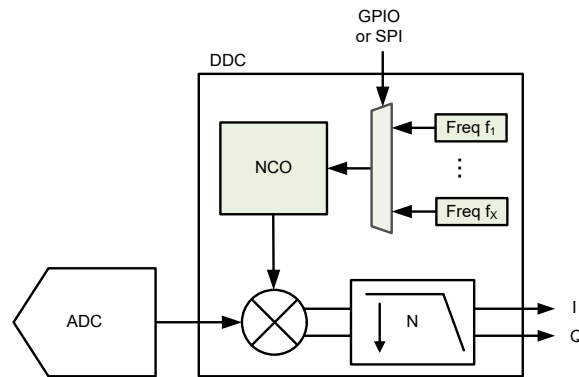


Figure 7-35. NCO Block Diagram

Table 7-22. Available # of Frequencies per NCO depending on # of DDCs used

| # of DDCs used | # of Frequencies per NCO |
|----------------|--------------------------|
| 1              | 8                        |
| 2              | 4                        |
| 4              | 4                        |

There are two different NCO operating modes available - phase continuous and infinite phase coherent.

**Phase Continuous NCO:** During a NCO frequency change, the NCO phase gradually adjusts to the new frequency as shown in Figure 7-36. The 'dashed' line shows the phase of original  $f_1$  frequency.

**Infinite Phase Coherent NCO:** With a phase coherent NCO, all frequencies are synchronized to a single event using SYSREF. This enables an infinite amount of frequency hops without the need to reset the NCO as phase coherency is maintained between frequency hops. This is illustrated in Figure 7-36 (right). When returning to the original frequency  $f_1$  the NCO phase appears as if the NCO had never changed frequencies.

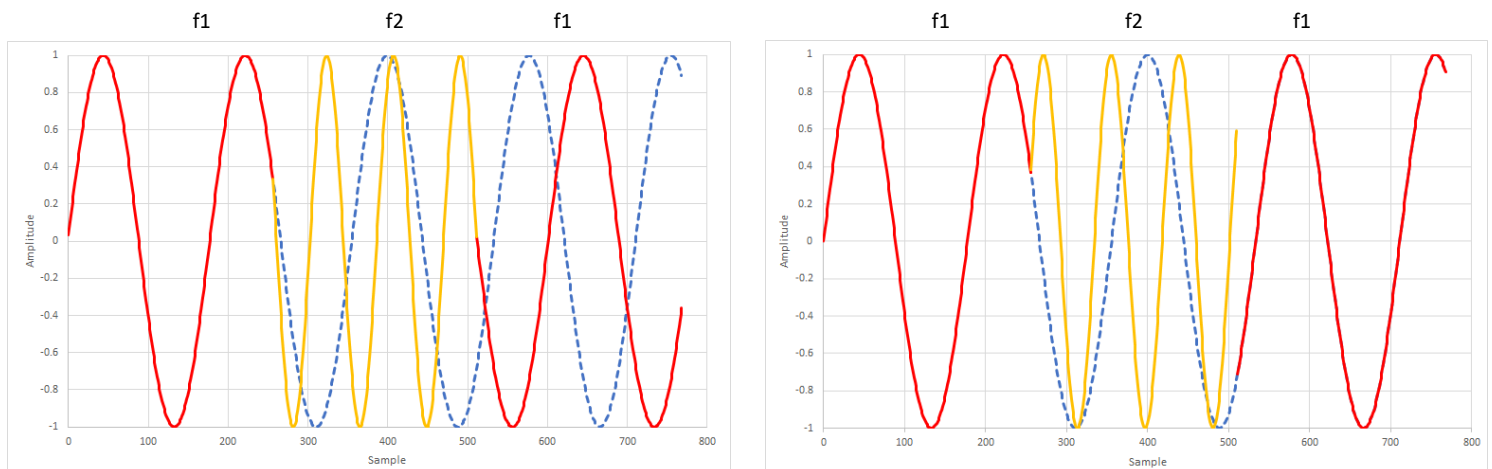


Figure 7-36. Phase Continuous (left) and Infinite Phase Coherent (right) NCO Frequency Switching

The oscillator generates a complex exponential sequence of:

$$e^{j\omega n} \text{ (default) or } e^{-j\omega n} \quad (1)$$

where: frequency ( $\omega$ ) is specified as a signed number by the 48-bit register setting

The complex exponential sequence is multiplied with the real input from the ADC to mix the desired carrier to a frequency equal to  $f_{IN} + f_{NCO}$ . The NCO frequency can be tuned from  $-F_S/2$  to  $+F_S/2$  and is processed as a signed, 2s complement number.

The NCO frequency setting is set by the 48-bit register value given and calculated as:

$$\text{NCO frequency (0 to } +F_S/2\text{): } NCO = f_{NCO} \times 2^{48} / F_S \quad (2)$$

$$\text{NCO frequency } (-F_S/2 \text{ to } 0\text{): } NCO = (f_{NCO} + F_S) \times 2^{48} / F_S \quad (3)$$

where:

- $NCO$  = NCO register setting (decimal value)
- $f_{NCO}$  = Desired NCO frequency (MHz)
- $F_S$  = ADC sampling rate (MSPS)

The NCO programming is illustrated with this example:

- ADC sampling rate  $F_S = 1300$  MSPS
- Desired NCO frequency = 460 MHz

$$\text{NCO frequency setting} = f_{NCO} \times 2^{48} / F_S = 460 \text{ MHz} \times 2^{48} / 1300 \text{ MSPS} = 99,598,837,913,001 \quad (4)$$

Table 7-23 shows the register writes to set frequency 1 of NCO1 of DDCA to that frequency:

**Table 7-23. Example register writes to change NCO frequency**

| ADDR  | DATA | DESCRIPTION                                                                                                                                  |
|-------|------|----------------------------------------------------------------------------------------------------------------------------------------------|
| 0x05  | 0x08 | Select DDCA page                                                                                                                             |
| 0x105 | 0x5A | Frequency = 460 MHz with $F_S = 1.3$ GSPS<br>$99,598,837,913,001 = 0x5A95A95A95A9$ where the MSB goes to address 0x105 and the LSB to 0x100. |
| 0x104 | 0x95 |                                                                                                                                              |
| 0x103 | 0xA9 |                                                                                                                                              |
| 0x102 | 0x5A |                                                                                                                                              |
| 0x101 | 0x95 |                                                                                                                                              |
| 0x100 | 0xA9 |                                                                                                                                              |
| 0x181 | 0x00 | Load and update NCO1 with the new frequency.                                                                                                 |
| 0x181 | 0x30 | 0x30 updates the NCO values, 0x00 clears the register for the next update.                                                                   |

### 7.3.5.6 NCO Frequency Programming

There are 4 separate NCOs per channel - one for each band (e.g. NCO1 = band 1) and 4 different frequencies can be programmed per NCO as shown in [Figure 7-37](#). The NCO frequencies are located in the DDCA/B pages (0x05 0x08 for channel A and 0x05 0x10 for channel B) in registers 0x100 to 0x17D. Depending on # of bands used, the frequencies for each NCO are selected in registers 0x3B and 0x41 (DIGITAL page) as shown in [Table 7-24](#). If the NCO frequencies are the same for channel A and channel B they can be written to both DDCA and DDCB pages simultaneously by selecting both pages (0x05 0x18).

| Channel A       |                 | Channel B       |                 |
|-----------------|-----------------|-----------------|-----------------|
| NCO1            | NCO3            | NCO1            | NCO3            |
| 1: 0x100..0x105 | 1: 0x140..0x145 | 1: 0x100..0x105 | 1: 0x140..0x145 |
| 2: 0x108..0x10D | 2: 0x148..0x14D | 2: 0x108..0x10D | 2: 0x148..0x14D |
| 3: 0x110..0x115 | 3: 0x150..0x155 | 3: 0x110..0x115 | 3: 0x150..0x155 |
| 4: 0x118..0x11D | 4: 0x158..0x15D | 4: 0x118..0x11D | 4: 0x158..0x15D |
| NCO2            | NCO4            | NCO2            | NCO4            |
| 1: 0x120..0x125 | 1: 0x160..0x165 | 1: 0x120..0x125 | 1: 0x160..0x165 |
| 2: 0x128..0x12D | 2: 0x168..0x16D | 2: 0x128..0x12D | 2: 0x168..0x16D |
| 3: 0x130..0x135 | 3: 0x170..0x175 | 3: 0x130..0x135 | 3: 0x170..0x175 |
| 4: 0x138..0x13D | 4: 0x178..0x17D | 4: 0x138..0x13D | 4: 0x178..0x17D |

**Figure 7-37. Multi-Band NCO**

Single band DDC uses the frequencies of both NCO1 and NCO2 for a combined 8 different frequencies for NCO1 using 3 bit control (NCO2 CHx [1] and NCO1 CHx [1:0]). The NCO2 selection bit (D3) decides if frequencies from NCO1 or NCO2 are being used. In dual and quad band DDC operating mode there are 4 frequencies per NCO available and selected using 2 register bits (NCOx CHx [1:0]). The NCO frequency selection registers are shown in [Table 7-24](#).

**Table 7-24. NCO Frequency Selection SPI Interface Registers**

| # OF BANDS | ADDR | D7             | D6 | D5             | D4 | D3             | D2 | D1             | D0 |
|------------|------|----------------|----|----------------|----|----------------|----|----------------|----|
| SINGLE     | 0x3B | 0              | 0  | 0              | 0  | NCO2 CHA [1]   | 0  | NCO1 CHA [1:0] |    |
|            | 0x41 | 0              | 0  | 0              | 0  | NCO2 CHB [1]   | 0  | NCO1 CHB [1:0] |    |
| DUAL       | 0x3B | 0              | 0  | 0              | 0  | NCO2 CHA [1:0] |    | NCO1 CHA [1:0] |    |
|            | 0x41 | 0              | 0  | 0              | 0  | NCO2 CHB [1:0] |    | NCO1 CHB [1:0] |    |
| QUAD       | 0x3B | NCO4 CHA [1:0] |    | NCO3 CHA [1:0] |    | NCO2 CHA [1:0] |    | NCO1 CHA [1:0] |    |
|            | 0x41 | NCO4 CHB [1:0] |    | NCO3 CHB [1:0] |    | NCO2 CHB [1:0] |    | NCO1 CHB [1:0] |    |

To select a different frequency for the NCO, two registers (0x3B and 0x41) in the DIGITAL page have to be updated. Assuming a SPI clock frequency of 10 MHz (100 ns period), programming two registers (2x (16 bit address and 8 bit data) = 48 bit) means that the NCO frequency would be updated in ~ 5 us.

When updating the currently being used NCO frequency to a new frequency, the following command has to be written to load the new frequency into the NCO - 0x181 0x00/0x30 in each of the DDCA/B pages.

**Table 7-25. Example Register Writes**

| ADDR          | DATA | DESCRIPTION                                                |
|---------------|------|------------------------------------------------------------|
| 0x05          | 0x02 | Select DIGITAL page                                        |
| 0x3B          | 0x01 | Select frequency 2 for NCO1 of channel A.                  |
| 0x05          | 0x08 | Select DDCA page                                           |
| 0x10D...0x108 | 0x.. | Write new frequency in frequency 2 of NCO1 of channel A    |
| 0x181         | 0x00 | Update NCO with current frequencies from the register map. |
| 0x181         | 0x30 |                                                            |

The NCO phase accumulators can be reset using the external SYSREF signal. A SYSREF mask can be setup such the SYSREF signal only goes to the NCO and the remaining device remains unaffected. The following register writes configure the SYSREF mask to only affect the NCO. After completion the SYSREF mask should be set back to default.

**Table 7-26. Example Register Writes to configure the SYSREF MASK**

| ADDR  | DATA | DESCRIPTION                                 |
|-------|------|---------------------------------------------|
| 0x05  | 0x18 | Select DDCAB/CD page                        |
| 0x181 | 0x40 | Reset NCO phases with SYSREF toggle         |
| 0x05  | 0x02 | Select Digital Page                         |
| 0x357 | 0xA2 | SYSREF mask settings (0x00 is mask default) |
| 0x358 | 0x02 | SYSREF mask settings (0x00 is mask default) |

### 7.3.5.7 Fast Frequency Hopping

The ADC32RF52 supports several different options to update the NCO frequencies. Fast frequency hopping can be achieved in one of the following ways:

- Using the GPIO1/2 pins to select the NCO frequency
- Using the GPIO1/2, SPISEL and SCLK/SDIO pins to select the NCO frequency
- Using the GPIO1/2 pins to program the NCO frequency selection (Fast SPI)

| NCO CONTROL                 | SCLK          | SDATA | SPISEL | GPIO1                  | GPIO2 | NCO SEL MODE |
|-----------------------------|---------------|-------|--------|------------------------|-------|--------------|
| Regular SPI (default)       | SPI Interface |       | 0      | used for other purpose |       | 00           |
| GPIO1/2                     | SPI Interface |       | 0      | used for NCO control   |       | 00           |
| GPIO1/2, SPISEL, SCLK/SDATA | NCO CONTROL   |       | 1      | used for NCO control   |       | 00           |
| FAST SPI                    | SPI Interface |       | 1      | SDATA                  | SCLK  | 10           |

The internal NCO is switched very quickly however the switching time depends primarily on the time it takes to flush out the decimation filter as shown in [Table 7-27](#).

**Table 7-27. NCO switching time ( $F_s = 1.5$  GSPS) vs decimation setting**

| Decimation Setting | NCO Switching Time |
|--------------------|--------------------|
| /4                 | ~ 500 ns           |
| /8                 | ~ 700 ns           |
| /16                | ~ 1.2 us           |
| /32                | ~ 2 us             |
| /64                | ~ 4 us             |
| /128               | ~ 8 us             |

#### 7.3.5.7.1 Fast frequency hopping using the GPIO1/2 pins

The NCO frequency is selected as shown in [Table 7-28](#). This mode is enabled with the following register writes:

1. Set 0x234 to 0x03 (NCO SEL MODE = 0, GPIO MODE = 3)

**Table 7-28. NCO Frequency Selection using GPIO1/2 Pins**

| # OF BANDS | GPIO2          | GPIO1 | GPIO2          | GPIO1 | GPIO2          | GPIO1 | GPIO2          | GPIO1 |
|------------|----------------|-------|----------------|-------|----------------|-------|----------------|-------|
| SINGLE     | 0              | 0     | 0              | 0     | 0              | 0     | NCO1 CHA [1:0] |       |
|            | 0              | 0     | 0              | 0     | 0              | 0     | NCO1 CHB [1:0] |       |
| DUAL       | 0              | 0     | 0              | 0     | NCO2 CHA [1:0] |       | NCO1 CHA [1:0] |       |
|            | 0              | 0     | 0              | 0     | NCO2 CHB [1:0] |       | NCO1 CHB [1:0] |       |
| QUAD       | NCO4 CHA [1:0] |       | NCO3 CHA [1:0] |       | NCO2 CHA [1:0] |       | NCO1 CHA [1:0] |       |
|            | NCO4 CHB [1:0] |       | NCO3 CHB [1:0] |       | NCO2 CHB [1:0] |       | NCO1 CHB [1:0] |       |

### 7.3.5.7.2 Fast frequency hopping using GPIO1/2, SEN and SDATA pins

2 pins for channel A and 2 for channel B?

This mode is enabled by setting the SPISEL to logic high and using the following register writes:

1. Set 0x234 to 0x63 (NCO SEL MODE = 3, GPIO MODE = 3)

**Table 7-29. NCO Frequency Selection SPI Interface Registers**

| # OF BANDS | SDATA          | SEN | GPIO2          | GPIO1 | SDATA          | SEN | GPIO2          | GPIO1 |
|------------|----------------|-----|----------------|-------|----------------|-----|----------------|-------|
| SINGLE     | 0              | 0   | 0              | 0     | NCO2 CHA [1]   | 0   | NCO1 CHA [1:0] |       |
|            | 0              | 0   | 0              | 0     | NCO2 CHB [1]   | 0   | NCO1 CHB [1:0] |       |
| DUAL       | 0              | 0   | 0              | 0     | NCO2 CHA [1:0] |     | NCO1 CHA [1:0] |       |
|            | 0              | 0   | 0              | 0     | NCO2 CHB [1:0] |     | NCO1 CHB [1:0] |       |
| QUAD       | NCO4 CHA [1:0] |     | NCO3 CHA [1:0] |       | NCO2 CHA [1:0] |     | NCO1 CHA [1:0] |       |
|            | NCO4 CHB [1:0] |     | NCO3 CHB [1:0] |       | NCO2 CHB [1:0] |     | NCO1 CHB [1:0] |       |

### 7.3.5.7.3 Fast frequency hopping using the fast SPI

In this mode the GPIO1/2 pins are used as a "fast SPI" input which only updates the NCO selection registers. No register address information needs to be sent. GPIO1 pin is SDATA and GPIO2 pin is SCLK.

This mode is enabled by setting the SPISEL to logic high and using the following register write:

1. Set 0x234 to 0x43 (NCO SEL MODE = 2, GPIO MODE = 3)

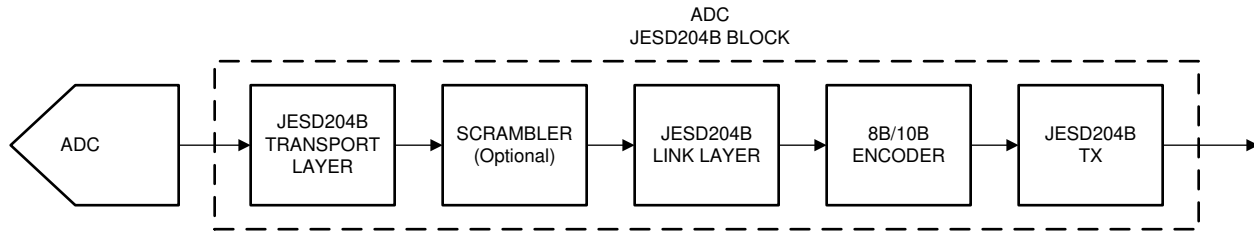
The NCO frequencies are selected as shown in [Table 7-30](#).

**Table 7-30. NCO Frequency Programming using FAST SPI**

| # OF BANDS | D15            | D14 | D13            | D12 | D11            | D10 | D9             | D8 | D7             | D6 | D5             | D4 | D3             | D2 | D1             | D0 |
|------------|----------------|-----|----------------|-----|----------------|-----|----------------|----|----------------|----|----------------|----|----------------|----|----------------|----|
| SINGLE     | 0              | 0   | 0              | 0   | NCO1 CHB [2]   | 0   | NCO1 CHB [1:0] |    | 0              | 0  | 0              | 0  | NCO1 CHA [2]   | 0  | NCO1 CHA [1:0] |    |
| DUAL       | 0              | 0   | 0              | 0   | NCO2 CHB [1:0] |     | NCO1 CHB [1:0] |    | 0              | 0  | 0              | 0  | NCO2 CHA [1:0] |    | NCO1 CHA [1:0] |    |
| QUAD       | NCO4 CHB [1:0] |     | NCO3 CHB [1:0] |     | NCO2 CHB [1:0] |     | NCO1 CHB [1:0] |    | NCO4 CHA [1:0] |    | NCO3 CHA [1:0] |    | NCO2 CHA [1:0] |    | NCO1 CHA [1:0] |    |

### 7.3.6 JESD204B Interface

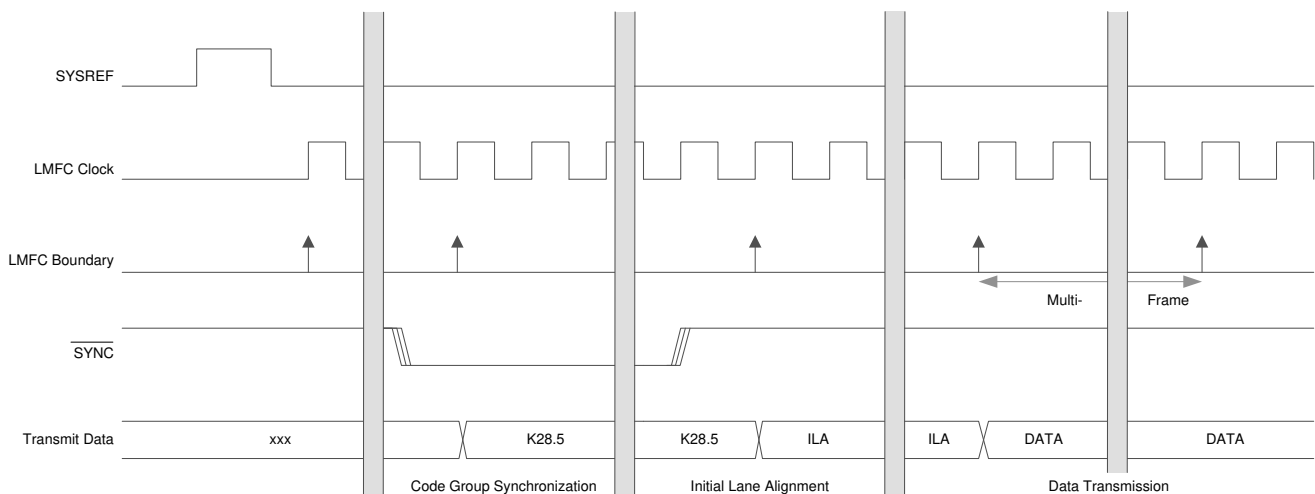
The ADC32RF52 uses the JESD204B high-speed serial interface to transfer data from the ADC to the receiving logic device. ADC32RF5x serialized lanes are capable of operating up to 13.0 Gbps, slightly above the JESD204B max lane rate. A maximum of 8 lanes can be used to allow lower lane rates for interfacing with speed limited logic devices. Figure 7-38 shows a simplified block diagram of the JESD204B interface.



**Figure 7-38. JESD204B Block Diagram**

#### 7.3.6.1 JESD204B Initial Lane Alignment (ILA)

The receiving device starts the initial lane alignment process by deasserting the  $\overline{\text{SYNC}}$  signal. When a logic low state is detected on the  $\overline{\text{SYNC}}$  input, the ADC starts transmitting comma characters (K28.5) to establish the code group synchronization, as shown in Figure 7-39. When synchronization is completed, the receiving device reasserts the  $\overline{\text{SYNC}}$  signal and the ADC starts the initial lane alignment sequence with the next local multi-frame clock (LMFC) boundary. The ADC transmits four multi-frames, each containing K frame (K is SPI programmable). Each of the multi-frames contains the frame start and frame end symbols. The second multi-frame also contains the JESD204B link configuration data.



**Figure 7-39. JESD204B Internal Timing Diagram**

##### 7.3.6.1.1 $\overline{\text{SYNC}}$ Signal

The  $\overline{\text{SYNC}}$  signal can be issued using one of two different methods:

- One of the GPIO1/2 pins can be configured via SPI to become the  $\overline{\text{SYNC}}$  input pin (address 0x234 in the digital page)
- The synchronization command can be issued via SPI register write (address 0x21 in the JESD page)

When using the GPIO1/2 pins for the  $\overline{\text{SYNC}}$  signal input, the device also supports the option to invert the signal polarity (address 0x236 in the digital page).

### 7.3.6.2 JESD204B Frame Assembly

The JESD204B standard defines the following parameters:

- L: number of lanes per link
- M: number of converters per device
- F: number of octets per frame clock period
- S: number of samples per frame

### 7.3.6.3 JESD204B Frame Assembly in Bypass Mode

Table 7-31 lists the available JESD204B formats and corresponding valid sampling rate ranges for the ADC32RF5x. The sampling rates are limited by the minimum and maximum SERDES line rate as well as ADC sampling clock frequencies. The JESD204B frame assembly for the different lanes is shown in Table 7-32.

When internal digital averaging is used, the output resolution is automatically adjusted from 14-bit to 16-bit to avoid quantization noise limitation.

**Table 7-31. JESD Mode Options: Bypass Mode**

| DECIMATION<br>SETTING D<br>(complex) | OUTPUT<br>RESOLUTION<br>(Bits) | L | M | F | S  | MIN F <sub>S</sub><br>(Gbps) | MAX F <sub>S</sub><br>(Gbps) | RATIO<br>[f <sub>SERDES</sub> /F <sub>S</sub> ] |
|--------------------------------------|--------------------------------|---|---|---|----|------------------------------|------------------------------|-------------------------------------------------|
| Bypass                               | 12 <sup>(1)</sup>              | 8 | 2 | 8 | 20 | 0.5                          | 1.5                          | 4                                               |
|                                      | 14/16 <sup>(2)</sup>           | 8 | 2 | 2 | 4  | 0.5                          | 1.5                          | 5                                               |
|                                      |                                | 4 | 2 | 2 | 2  | 0.5                          | 1.5                          | 10                                              |

(1) In this output mode, two LSBs are truncated to a 12-bit output.

(2) When using digital averaging the output resolution changes to 16-bit.

**Table 7-32. JESD Sample Frame Assembly: Bypass Mode**

| OUTPUT LANE | LMFS = 82820           |                                                  |                       |                        |                                                  |                       |                        |                                | LMFS = 8224           |                             | LMFS = 4222           |                             |
|-------------|------------------------|--------------------------------------------------|-----------------------|------------------------|--------------------------------------------------|-----------------------|------------------------|--------------------------------|-----------------------|-----------------------------|-----------------------|-----------------------------|
| DOUT0       | A <sub>0</sub> [11:4]  | A <sub>0</sub> [3:0],<br>A <sub>1</sub> [11:8]   | A <sub>1</sub> [7:0]  | A <sub>2</sub> [11:4]  | A <sub>2</sub> [3:0],<br>A <sub>3</sub> [11:8]   | A <sub>3</sub> [7:0]  | A <sub>4</sub> [11:4]  | A <sub>4</sub> [3:0],<br>0000  | A <sub>0</sub> [13:6] | A <sub>0</sub> [5:0],<br>00 | A <sub>0</sub> [13:6] | A <sub>0</sub> [5:0],<br>00 |
| DOUT1       | A <sub>5</sub> [11:4]  | A <sub>5</sub> [3:0],<br>A <sub>6</sub> [11:8]   | A <sub>6</sub> [7:0]  | A <sub>7</sub> [11:4]  | A <sub>7</sub> [3:0],<br>A <sub>8</sub> [11:8]   | A <sub>8</sub> [7:0]  | A <sub>9</sub> [11:4]  | A <sub>9</sub> [3:0],<br>0000  | A <sub>1</sub> [13:6] | A <sub>1</sub> [5:0],<br>00 | A <sub>1</sub> [13:6] | A <sub>1</sub> [5:0],<br>00 |
| DOUT2       | A <sub>10</sub> [11:4] | A <sub>10</sub> [3:0],<br>A <sub>11</sub> [11:8] | A <sub>11</sub> [7:0] | A <sub>12</sub> [11:4] | A <sub>12</sub> [3:0],<br>A <sub>13</sub> [11:8] | A <sub>13</sub> [7:0] | A <sub>14</sub> [11:4] | A <sub>14</sub> [3:0],<br>0000 | A <sub>2</sub> [13:6] | A <sub>2</sub> [5:0],<br>00 | B <sub>0</sub> [13:6] | B <sub>0</sub> [5:0],<br>00 |
| DOUT3       | A <sub>15</sub> [11:4] | A <sub>15</sub> [3:0],<br>A <sub>16</sub> [11:8] | A <sub>16</sub> [7:0] | A <sub>17</sub> [11:4] | A <sub>17</sub> [3:0],<br>A <sub>18</sub> [11:8] | A <sub>18</sub> [7:0] | A <sub>19</sub> [11:4] | A <sub>19</sub> [3:0],<br>0000 | A <sub>3</sub> [13:6] | A <sub>3</sub> [5:0],<br>00 | B <sub>1</sub> [13:6] | B <sub>1</sub> [5:0],<br>00 |
| DOUT4       | B <sub>0</sub> [11:4]  | B <sub>0</sub> [3:0],<br>B <sub>1</sub> [11:8]   | B <sub>1</sub> [7:0]  | B <sub>2</sub> [11:4]  | B <sub>2</sub> [3:0],<br>B <sub>3</sub> [11:8]   | B <sub>3</sub> [7:0]  | B <sub>4</sub> [11:4]  | B <sub>4</sub> [3:0],<br>0000  | B <sub>0</sub> [13:6] | B <sub>0</sub> [5:0],<br>00 |                       |                             |
| DOUT5       | B <sub>5</sub> [11:4]  | B <sub>5</sub> [3:0],<br>B <sub>6</sub> [11:8]   | B <sub>6</sub> [7:0]  | B <sub>7</sub> [11:4]  | B <sub>7</sub> [3:0],<br>B <sub>8</sub> [11:8]   | B <sub>8</sub> [7:0]  | B <sub>9</sub> [11:4]  | B <sub>9</sub> [3:0],<br>0000  | B <sub>1</sub> [13:6] | B <sub>1</sub> [5:0],<br>00 |                       |                             |
| DOUT6       | B <sub>10</sub> [11:4] | B <sub>10</sub> [3:0],<br>B <sub>11</sub> [11:8] | B <sub>11</sub> [7:0] | B <sub>12</sub> [11:4] | B <sub>12</sub> [3:0],<br>B <sub>13</sub> [11:8] | B <sub>13</sub> [7:0] | B <sub>14</sub> [11:4] | B <sub>14</sub> [3:0],<br>0000 | B <sub>2</sub> [13:6] | B <sub>2</sub> [5:0],<br>00 |                       |                             |
| DOUT7       | B <sub>15</sub> [11:4] | B <sub>15</sub> [3:0],<br>B <sub>16</sub> [11:8] | B <sub>16</sub> [7:0] | B <sub>17</sub> [11:4] | B <sub>17</sub> [3:0],<br>B <sub>18</sub> [11:8] | B <sub>18</sub> [7:0] | B <sub>19</sub> [11:4] | B <sub>19</sub> [3:0],<br>0000 | B <sub>3</sub> [13:6] | B <sub>3</sub> [5:0],<br>00 |                       |                             |

### 7.3.6.4 JESD204B Frame Assembly with Complex Decimation - Single Band

Table 7-33 lists the available JESD204B interface formats and corresponding valid sampling rate ranges for the ADC32RF5x with complex decimation (single band). The sampling rates are limited by the minimum and maximum SERDES line rate as well as ADC sampling clock frequencies. The JESD204B frame assembly for the different lanes is shown in Table 7-32.

**Table 7-33. JESD Mode Options: Complex Decimation - Single Band**

| DECIMATION<br>SETTING D<br>(complex) | L | M | F | S | MIN F <sub>S</sub><br>(Gsp/s) | MAX F <sub>S</sub><br>(Gsp/s) | RATIO<br>[f <sub>SERDES</sub> /(F <sub>S</sub> /D)] |
|--------------------------------------|---|---|---|---|-------------------------------|-------------------------------|-----------------------------------------------------|
| /4                                   | 4 | 4 | 2 | 1 | 0.5                           | 1.5                           | 20                                                  |
| /8                                   |   |   |   |   |                               |                               |                                                     |
| /16                                  |   |   |   |   |                               |                               |                                                     |
| /32                                  |   |   |   |   |                               |                               |                                                     |
| /8                                   | 2 | 4 | 4 | 1 | 0.5                           | 1.5                           | 40                                                  |
| /16                                  |   |   |   |   |                               |                               |                                                     |
| /32                                  |   |   |   |   |                               |                               |                                                     |
| /64                                  |   |   |   |   |                               |                               |                                                     |
| /8                                   | 1 | 4 | 8 | 1 | 0.5                           | 1.3                           | 80                                                  |
| /16                                  |   |   |   |   |                               | 1.5                           |                                                     |
| /32                                  |   |   |   |   |                               |                               |                                                     |
| /64                                  |   |   |   |   |                               |                               |                                                     |
| /128                                 |   |   |   |   | 0.8                           |                               |                                                     |

**Table 7-34. JESD Sample Frame Assembly: Complex Decimation - Single Band**

| OUTPUT<br>LANE | LMFS = 4421               |                          | LMFS = 2441               |                          |                           |                          | LMFS = 1481               |                          |                           |                          |                           |                          |                           |                          |
|----------------|---------------------------|--------------------------|---------------------------|--------------------------|---------------------------|--------------------------|---------------------------|--------------------------|---------------------------|--------------------------|---------------------------|--------------------------|---------------------------|--------------------------|
| DOUT0          | AI <sub>0</sub><br>[15:8] | AI <sub>0</sub><br>[7:0] | AI <sub>0</sub><br>[15:8] | AI <sub>0</sub><br>[7:0] | AQ <sub>0</sub><br>[15:8] | AQ <sub>0</sub><br>[7:0] | AI <sub>0</sub><br>[15:8] | AI <sub>0</sub><br>[7:0] | AQ <sub>0</sub><br>[15:8] | AQ <sub>0</sub><br>[7:0] | BI <sub>0</sub><br>[15:8] | BI <sub>0</sub><br>[7:0] | BQ <sub>0</sub><br>[15:8] | BQ <sub>0</sub><br>[7:0] |
| DOUT1          | AQ <sub>0</sub><br>[15:8] | AQ <sub>0</sub><br>[7:0] | BI <sub>0</sub><br>[15:8] | BI <sub>0</sub><br>[7:0] | BQ <sub>0</sub><br>[15:8] | BQ <sub>0</sub><br>[7:0] |                           |                          |                           |                          |                           |                          |                           |                          |
| DOUT2          | BI <sub>0</sub><br>[15:8] | BI <sub>0</sub><br>[7:0] |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |
| DOUT3          | BQ <sub>0</sub><br>[15:8] | BQ <sub>0</sub><br>[7:0] |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |
| DOUT4          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |
| DOUT5          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |
| DOUT6          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |
| DOUT7          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |                           |                          |

### 7.3.6.5 JESD204B Frame Assembly with Complex Decimation - Dual Band

Table 7-35 lists the available JESD204B interface formats and corresponding valid sampling rate ranges for the ADC32RF5x with complex decimation (dual band). The sampling rates are limited by the minimum and maximum SERDES line rate as well as ADC sampling clock frequencies. The JESD204B frame assembly for the different lanes are shown in Table 7-36 and Table 7-37.

**Table 7-35. JESD Mode Options: Complex Decimation - Dual Band**

| DECIMATION<br>SETTING D<br>(complex) | L | M | F  | S | MIN F <sub>S</sub><br>(Gbps) | MAX F <sub>S</sub><br>(Gbps) | RATIO<br>[f <sub>SERDES</sub> /(F <sub>S</sub> /D)] |
|--------------------------------------|---|---|----|---|------------------------------|------------------------------|-----------------------------------------------------|
| /8                                   | 8 | 8 | 2  | 1 | 0.5                          | 1.5                          | 20                                                  |
| /16                                  |   |   |    |   | 0.8                          |                              |                                                     |
| /32                                  |   |   |    |   |                              |                              |                                                     |
| /8                                   | 4 | 8 | 4  | 1 | 0.5                          | 1.5                          | 40                                                  |
| /16                                  |   |   |    |   | 0.8                          |                              |                                                     |
| /32                                  |   |   |    |   |                              |                              |                                                     |
| /64                                  |   |   |    |   |                              |                              |                                                     |
| /8                                   | 2 | 8 | 8  | 1 | 0.5                          | 1.3                          | 80                                                  |
| /16                                  |   |   |    |   |                              | 1.5                          |                                                     |
| /32                                  |   |   |    |   |                              |                              |                                                     |
| /64                                  |   |   |    |   |                              |                              |                                                     |
| /128                                 |   |   |    |   | 0.8                          |                              |                                                     |
| /16                                  | 1 | 8 | 16 | 1 | 0.5                          | 1.3                          | 160                                                 |
| /32                                  |   |   |    |   |                              | 1.5                          |                                                     |
| /64                                  |   |   |    |   |                              |                              |                                                     |
| /128                                 |   |   |    |   |                              |                              |                                                     |

**Table 7-36. JESD Sample Frame Assembly: Complex Decimation - Dual Band**

| OUTPUT<br>T<br>LANE | LMFS = 8821                |                           | LMFS = 4841                |                           |                            |                           | LMFS = 2881                |                           |                            |                           |                            |                           |                            |                           |
|---------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|
| DOUT0               | A1I <sub>0</sub><br>[15:8] | A1I <sub>0</sub><br>[7:0] | A1I <sub>0</sub><br>[15:8] | A1I <sub>0</sub><br>[7:0] | A1Q <sub>0</sub><br>[15:8] | A1Q <sub>0</sub><br>[7:0] | A1I <sub>0</sub><br>[15:8] | A1I <sub>0</sub><br>[7:0] | A1Q <sub>0</sub><br>[15:8] | A1Q <sub>0</sub><br>[7:0] | A2I <sub>0</sub><br>[15:8] | A2I <sub>0</sub><br>[7:0] | A2Q <sub>0</sub><br>[15:8] | A2Q <sub>0</sub><br>[7:0] |
| DOUT1               | A1Q <sub>0</sub><br>[15:8] | A1Q <sub>0</sub><br>[7:0] | A2I <sub>0</sub><br>[15:8] | A2I <sub>0</sub><br>[7:0] | A2Q <sub>0</sub><br>[15:8] | A2Q <sub>0</sub><br>[7:0] | B1I <sub>0</sub><br>[15:8] | B1I <sub>0</sub><br>[7:0] | B1Q <sub>0</sub><br>[15:8] | B1Q <sub>0</sub><br>[7:0] | B2I <sub>0</sub><br>[15:8] | B2I <sub>0</sub><br>[7:0] | B2Q <sub>0</sub><br>[15:8] | B2Q <sub>0</sub><br>[7:0] |
| DOUT2               | A2I <sub>0</sub><br>[15:8] | A2I <sub>0</sub><br>[7:0] | B1I <sub>0</sub><br>[15:8] | B1I <sub>0</sub><br>[7:0] | B1Q <sub>0</sub><br>[15:8] | B1Q <sub>0</sub><br>[7:0] |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT3               | A2Q <sub>0</sub><br>[15:8] | A2Q <sub>0</sub><br>[7:0] | B2I <sub>0</sub><br>[15:8] | B2I <sub>0</sub><br>[7:0] | B2Q <sub>0</sub><br>[15:8] | B2Q <sub>0</sub><br>[7:0] |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT4               | B1I <sub>0</sub><br>[15:8] | B1I <sub>0</sub><br>[7:0] |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT5               | B1Q <sub>0</sub><br>[15:8] | B1Q <sub>0</sub><br>[7:0] |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT6               | B2I <sub>0</sub><br>[15:8] | B2I <sub>0</sub><br>[7:0] |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT7               | B2Q <sub>0</sub><br>[15:8] | B2Q <sub>0</sub><br>[7:0] |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |

**Table 7-37. JESD Sample Frame Assembly: Complex Decimation - Dual Band**

| OUTP<br>UT<br>LANE | LMFS = 1-8-16-1            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
|--------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|
|                    | A1I <sub>0</sub><br>[15:8] | A1I <sub>0</sub><br>[7:0] | A1Q <sub>0</sub><br>[15:8] | A1Q <sub>0</sub><br>[7:0] | A2I <sub>0</sub><br>[15:8] | A2I <sub>0</sub><br>[7:0] | A2Q <sub>0</sub><br>[15:8] | A2Q <sub>0</sub><br>[7:0] | B1I <sub>0</sub><br>[15:8] | B1I <sub>0</sub><br>[7:0] | B1Q <sub>0</sub><br>[15:8] | B1Q <sub>0</sub><br>[7:0] | B2I <sub>0</sub><br>[15:8] | B2I <sub>0</sub><br>[7:0] | B2Q <sub>0</sub><br>[15:8] | B2Q <sub>0</sub><br>[7:0] |
| DOUT 0             |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT 1             |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT 2             |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT 3             |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT 4             |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT 5             |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT 6             |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT 7             |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |

### 7.3.6.6 JESD204B Frame Assembly with Complex Decimation - Quad Band

Table 7-38 lists the available JESD204B interface formats and corresponding valid sampling rate ranges for the ADC32RF5x with complex decimation (quad band). The sampling rates are limited by the minimum and maximum SERDES line rate as well as ADC sampling clock frequencies. The JESD204B frame assembly for the different lanes are shown in Table 7-39, Table 7-40 and Table 7-41.

**Table 7-38. JESD Mode Options: Complex Decimation - Quad Band**

| DECIMATION<br>SETTING D<br>(complex) | L | M  | F  | S | MIN F <sub>S</sub><br>(Gsp/s) | MAX F <sub>S</sub><br>(Gsp/s) | RATIO<br>[f <sub>SERDES</sub> /(F <sub>S</sub> /D)] |
|--------------------------------------|---|----|----|---|-------------------------------|-------------------------------|-----------------------------------------------------|
| /16                                  | 8 | 16 | 4  | 1 | 0.5                           | 1.5                           | 40                                                  |
| /32                                  |   |    |    |   | 0.8                           |                               |                                                     |
| /64                                  |   |    |    |   |                               |                               |                                                     |
| /16                                  | 4 | 16 | 8  | 1 | 0.5                           | 1.5                           | 80                                                  |
| /32                                  |   |    |    |   | 0.8                           |                               |                                                     |
| /64                                  |   |    |    |   |                               |                               |                                                     |
| /128                                 |   |    |    |   |                               |                               |                                                     |
| /16                                  | 2 | 16 | 16 | 1 | 0.5                           | 1.3                           | 160                                                 |
| /32                                  |   |    |    |   |                               | 1.5                           |                                                     |
| /64                                  |   |    |    |   |                               |                               |                                                     |
| /128                                 |   |    |    |   |                               |                               |                                                     |
| /16                                  | 1 | 16 | 32 | 1 | 0.5                           | 0.65                          | 320                                                 |
| /32                                  |   |    |    |   |                               | 1.3                           |                                                     |
| /64                                  |   |    |    |   |                               | 1.5                           |                                                     |
| /128                                 |   |    |    |   |                               |                               |                                                     |

**Table 7-39. JESD Sample Frame Assembly: Complex Decimation - Quad Band**

| OUTPUT<br>LANE | LMFS = 8-16-4-1            |                           |                            |                           | LMFS = 4-16-8-1            |                           |                            |                           |                            |                           |                            |                           |
|----------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|
| DOUT0          | A1I <sub>0</sub><br>[15:8] | A1I <sub>0</sub><br>[7:0] | A1Q <sub>0</sub><br>[15:8] | A1Q <sub>0</sub><br>[7:0] | A1I <sub>0</sub><br>[15:8] | A1I <sub>0</sub><br>[7:0] | A1Q <sub>0</sub><br>[15:8] | A1Q <sub>0</sub><br>[7:0] | A2I <sub>0</sub><br>[15:8] | A2I <sub>0</sub><br>[7:0] | A2Q <sub>0</sub><br>[15:8] | A2Q <sub>0</sub><br>[7:0] |
| DOUT1          | A2I <sub>0</sub><br>[15:8] | A2I <sub>0</sub><br>[7:0] | A2Q <sub>0</sub><br>[15:8] | A2Q <sub>0</sub><br>[7:0] | A3I <sub>0</sub><br>[15:8] | A3I <sub>0</sub><br>[7:0] | A3Q <sub>0</sub><br>[15:8] | A3Q <sub>0</sub><br>[7:0] | A4I <sub>0</sub><br>[15:8] | A4I <sub>0</sub><br>[7:0] | A4Q <sub>0</sub><br>[15:8] | A4Q <sub>0</sub><br>[7:0] |
| DOUT2          | A3I <sub>0</sub><br>[15:8] | A3I <sub>0</sub><br>[7:0] | A3Q <sub>0</sub><br>[15:8] | A3Q <sub>0</sub><br>[7:0] | B1I <sub>0</sub><br>[15:8] | B1I <sub>0</sub><br>[7:0] | B1Q <sub>0</sub><br>[15:8] | B1Q <sub>0</sub><br>[7:0] | B2I <sub>0</sub><br>[15:8] | B2I <sub>0</sub><br>[7:0] | B2Q <sub>0</sub><br>[15:8] | B2Q <sub>0</sub><br>[7:0] |
| DOUT3          | A4I <sub>0</sub><br>[15:8] | A4I <sub>0</sub><br>[7:0] | A4Q <sub>0</sub><br>[15:8] | A4Q <sub>0</sub><br>[7:0] | B3I <sub>0</sub><br>[15:8] | B3I <sub>0</sub><br>[7:0] | B3Q <sub>0</sub><br>[15:8] | B3Q <sub>0</sub><br>[7:0] | B4I <sub>0</sub><br>[15:8] | B4I <sub>0</sub><br>[7:0] | B4Q <sub>0</sub><br>[15:8] | B4Q <sub>0</sub><br>[7:0] |
| DOUT4          | B1I <sub>0</sub><br>[15:8] | B1I <sub>0</sub><br>[7:0] | B1Q <sub>0</sub><br>[15:8] | B1Q <sub>0</sub><br>[7:0] |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT5          | B2I <sub>0</sub><br>[15:8] | B2I <sub>0</sub><br>[7:0] | B2Q <sub>0</sub><br>[15:8] | B2Q <sub>0</sub><br>[7:0] |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT6          | B3I <sub>0</sub><br>[15:8] | B3I <sub>0</sub><br>[7:0] | B3Q <sub>0</sub><br>[15:8] | B3Q <sub>0</sub><br>[7:0] |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT7          | B4I <sub>0</sub><br>[15:8] | B4I <sub>0</sub><br>[7:0] | B4Q <sub>0</sub><br>[15:8] | B4Q <sub>0</sub><br>[7:0] |                            |                           |                            |                           |                            |                           |                            |                           |

**Table 7-40. JESD Sample Frame Assembly: Complex Decimation - Quad Band**

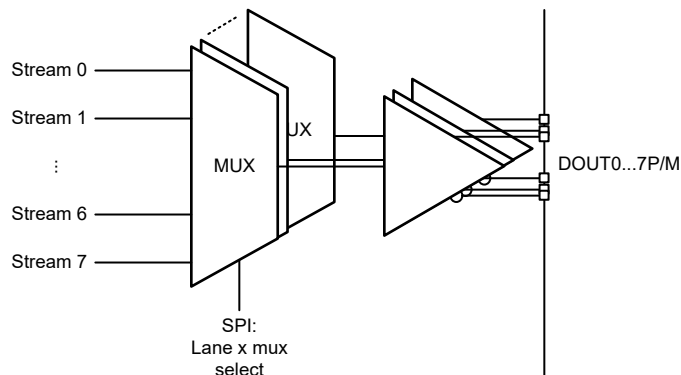
| OUTP<br>UT<br>LANE | LMFS = 2-16-16-1           |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
|--------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|----------------------------|---------------------------|
| DOUT<br>0          | A1I <sub>0</sub><br>[15:8] | A1I <sub>0</sub><br>[7:0] | A1Q <sub>0</sub><br>[15:8] | A1Q <sub>0</sub><br>[7:0] | A2I <sub>0</sub><br>[15:8] | A2I <sub>0</sub><br>[7:0] | A2Q <sub>0</sub><br>[15:8] | A2Q <sub>0</sub><br>[7:0] | A3I <sub>0</sub><br>[15:8] | A3I <sub>0</sub><br>[7:0] | A3Q <sub>0</sub><br>[15:8] | A3Q <sub>0</sub><br>[7:0] | A4I <sub>0</sub><br>[15:8] | A4I <sub>0</sub><br>[7:0] | A4Q <sub>0</sub><br>[15:8] | A4Q <sub>0</sub><br>[7:0] |
| DOUT<br>1          | B1I <sub>0</sub><br>[15:8] | B1I <sub>0</sub><br>[7:0] | B1Q <sub>0</sub><br>[15:8] | B1Q <sub>0</sub><br>[7:0] | B2I <sub>0</sub><br>[15:8] | B2I <sub>0</sub><br>[7:0] | B2Q <sub>0</sub><br>[15:8] | B2Q <sub>0</sub><br>[7:0] | B3I <sub>0</sub><br>[15:8] | B3I <sub>0</sub><br>[7:0] | B3Q <sub>0</sub><br>[15:8] | B3Q <sub>0</sub><br>[7:0] | B4I <sub>0</sub><br>[15:8] | B4I <sub>0</sub><br>[7:0] | B4Q <sub>0</sub><br>[15:8] | B4Q <sub>0</sub><br>[7:0] |
| DOUT<br>2          |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT<br>3          |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT<br>4          |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT<br>5          |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT<br>6          |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |
| DOUT<br>7          |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |                            |                           |

**Table 7-41. JESD Sample Frame Assembly: Complex Decimation - Quad Band**

| OUTP<br>UT<br>LANE | LMFS = 1-16-32-1           |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                           |
|--------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|----------------------------|---------------------------|
| DOUT<br>0          | A1I <sub>0</sub><br>[15:8] | A1I <sub>0</sub><br>[7:0]  | A1Q <sub>0</sub><br>[15:8] | A1Q <sub>0</sub><br>[7:0]  | A2I <sub>0</sub><br>[15:8] | A2I <sub>0</sub><br>[7:0]  | A2Q <sub>0</sub><br>[15:8] | A2Q <sub>0</sub><br>[7:0]  | A3I <sub>0</sub><br>[15:8] | A3I <sub>0</sub><br>[7:0]  | A3Q <sub>0</sub><br>[15:8] | A3Q <sub>0</sub><br>[7:0]  | A4I <sub>0</sub><br>[15:8] | A4I <sub>0</sub><br>[7:0]  | A4Q <sub>0</sub><br>[15:8] | A4Q <sub>0</sub><br>[7:0]  | ...                       |
|                    | ...                        | B1I <sub>0</sub><br>[15:8] | B1I <sub>0</sub><br>[7:0]  | B1Q <sub>0</sub><br>[15:8] | B1Q <sub>0</sub><br>[7:0]  | B2I <sub>0</sub><br>[15:8] | B2I <sub>0</sub><br>[7:0]  | B2Q <sub>0</sub><br>[15:8] | B2Q <sub>0</sub><br>[7:0]  | B3I <sub>0</sub><br>[15:8] | B3I <sub>0</sub><br>[7:0]  | B3Q <sub>0</sub><br>[15:8] | B3Q <sub>0</sub><br>[7:0]  | B4I <sub>0</sub><br>[15:8] | B4I <sub>0</sub><br>[7:0]  | B4Q <sub>0</sub><br>[15:8] | B4Q <sub>0</sub><br>[7:0] |
| DOUT<br>1          |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                           |
| DOUT<br>2          |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                           |
| DOUT<br>3          |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                           |
| DOUT<br>4          |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                           |
| DOUT<br>5          |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                           |
| DOUT<br>6          |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                           |
| DOUT<br>7          |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                            |                           |

### 7.3.7 SERDES Output MUX

The SERDES output block contains one digital mux per SERDES output lane with a 3-bit register. This allows routing any of the 8 digital streams to any output serdes transmitter as shown in the example in [Figure 7-40](#). The MUX can be used to reorder lanes as well as duplicate lane outputs (for example in LMFS = 1-4-8-1 mode the same output stream could be duplicated on all 8 lanes).



**Figure 7-40. SERDES output mux for DOUT0**

By default after power the active SERDES lanes start on lane DOUT0 as shown for the complex decimation dual band example in [Table 7-42](#). After power up the output is transmitted on lanes DOUT0..3. Using the digital output muxes, the output data for channel B is shifted from lanes DOUT2,3 to DOUT4,5. All SERDES transmitters are powered up and enabled by default. After configuring the output mux unused lanes can be powered down to save power consumption.

**Table 7-42. JESD Sample Frame Assembly: Complex Decimation - Dual Band with LMFS = 4841**

| OUTPUT LANE | Default                 |                        |                         |                        | Using MUX               |                        |                         |                        |
|-------------|-------------------------|------------------------|-------------------------|------------------------|-------------------------|------------------------|-------------------------|------------------------|
| DOUT0       | A1I <sub>0</sub> [15:8] | A1I <sub>0</sub> [7:0] | A1Q <sub>0</sub> [15:8] | A1Q <sub>0</sub> [7:0] | A1I <sub>0</sub> [15:8] | A1I <sub>0</sub> [7:0] | A1Q <sub>0</sub> [15:8] | A1Q <sub>0</sub> [7:0] |
| DOUT1       | A2I <sub>0</sub> [15:8] | A2I <sub>0</sub> [7:0] | A2Q <sub>0</sub> [15:8] | A2Q <sub>0</sub> [7:0] | A2I <sub>0</sub> [15:8] | A2I <sub>0</sub> [7:0] | A2Q <sub>0</sub> [15:8] | A2Q <sub>0</sub> [7:0] |
| DOUT2       | B1I <sub>0</sub> [15:8] | B1I <sub>0</sub> [7:0] | B1Q <sub>0</sub> [15:8] | B1Q <sub>0</sub> [7:0] |                         |                        |                         |                        |
| DOUT3       | B2I <sub>0</sub> [15:8] | B2I <sub>0</sub> [7:0] | B2Q <sub>0</sub> [15:8] | B2Q <sub>0</sub> [7:0] |                         |                        |                         |                        |
| DOUT4       |                         |                        |                         |                        | B1I <sub>0</sub> [15:8] | B1I <sub>0</sub> [7:0] | B1Q <sub>0</sub> [15:8] | B1Q <sub>0</sub> [7:0] |
| DOUT5       |                         |                        |                         |                        | B2I <sub>0</sub> [15:8] | B2I <sub>0</sub> [7:0] | B2Q <sub>0</sub> [15:8] | B2Q <sub>0</sub> [7:0] |
| DOUT6       |                         |                        |                         |                        |                         |                        |                         |                        |
| DOUT7       |                         |                        |                         |                        |                         |                        |                         |                        |

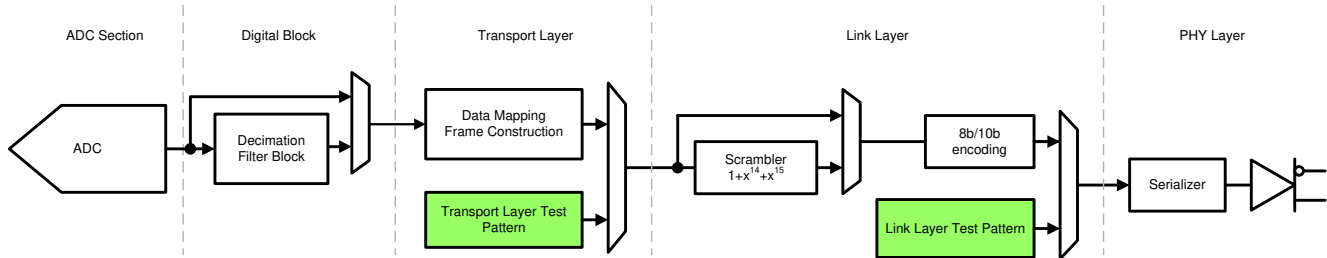
[Table 7-43](#) shows the register writes to shift the output lanes from default as illustrated in [Table 7-42](#).

**Table 7-43. Example register writes to shift the output serdes lanes using the SERDES Output MUX**

| ADDR | DATA | DESCRIPTION                                                   |
|------|------|---------------------------------------------------------------|
| 0x05 | 0x04 | Select JESD page                                              |
| 0x81 | 0x54 | Select internal JESD streams 4 and 5 to lanes DOUT2 and DOUT3 |
| 0x82 | 0x32 | Select internal JESD streams 2 and 3 to lanes DOUT4 and DOUT5 |

### 7.3.8 Test Pattern

The ADC32RF5x provides two different options to output test patterns instead of the actual output data of the ADC to simplify the serial interface and system debug of the JESD204B digital interface link. The output data path is shown in [Figure 7-41](#).



**Figure 7-41. Test Pattern Options**

The available test patterns in each block are described in [Table 7-44](#). Both test pattern blocks replace output data from the digital block (and not from the ADC) and therefore are available in decimation or decimation bypass mode. The test patterns are synchronized with the SYSREF signal.

**Table 7-44. Test Pattern Overview**

| TEST PATTERN LOCATION | TYPE                                | 8b/10b encoded | REGISTER PAGE     | REGISTER    |
|-----------------------|-------------------------------------|----------------|-------------------|-------------|
| TRANSPORT LAYER       | CUSTOM PATTERN                      | Yes            | JESD<br>0x05 0x04 | 0x2E, D0    |
|                       | TOGGLE 1010 PATTERN                 | Yes            |                   | 0x2E, D1    |
|                       | RAMP PATTERN                        | Yes            |                   | 0x2E, D2    |
|                       | PRBS PATTERN ( $2^7 \dots 2^{31}$ ) | Yes            |                   | 0x2F, D0    |
| LINK LAYER            | JESD204B TEST PATTERNS              | Depends        |                   | 0x2D, D2-D0 |
|                       | PRBS PATTERN ( $2^7 \dots 2^{31}$ ) | No             |                   | 0x2F, D4    |

The RAMP pattern provides two different output options. Internally each ADC data bus consists of parallel data streams. The RAMP pattern is generated for each stream and a different starting value can be set for each stream. By default all starting values are 0 and increment = 1. For example, DDC bypass mode uses 4 internal data streams per ADC channel. Enabling a RAMP pattern would show a 'slow' ramp which increments once every 4 clock cycles with starting values set to 0 and ramp increment = 1.

On other hand a RAMP pattern which increments every clock cycle can be set using different starting values (e.g. 0/1/2/3) for the 4 streams and setting the RAMP increment to 4. [Table 7-45](#) shows the register addresses for the different digital streams being used for each operating mode.

**Table 7-45. Register address for RAMP starting values based on operating mode**

| Address<br>(JESD Page) | Bypass Mode<br>LMFS = 8224 | Complex Decimation<br>Single Band | Complex Decimation<br>Dual Band | Complex Decimation<br>Quad Band |
|------------------------|----------------------------|-----------------------------------|---------------------------------|---------------------------------|
| 0xA4/A5/A6             | A <sub>0</sub>             | A1I <sub>0</sub>                  | A1I <sub>0</sub>                | A1I <sub>0</sub>                |
| 0xA8/A9/AA             | A <sub>1</sub>             | A1Q <sub>0</sub>                  | A1Q <sub>0</sub>                | A1Q <sub>0</sub>                |
| 0xAC/AD/AE             | A <sub>2</sub>             |                                   | A2I <sub>0</sub>                | A2I <sub>0</sub>                |
| 0xB0/B1/B2             | A <sub>3</sub>             |                                   | A2Q <sub>0</sub>                | A2Q <sub>0</sub>                |
| 0xB4/B5/B6             |                            |                                   |                                 | A3I <sub>0</sub>                |
| 0xB8/B9/BA             |                            |                                   |                                 | A3Q <sub>0</sub>                |
| 0xBC/BD/BE             |                            |                                   |                                 | A4I <sub>0</sub>                |
| 0xC0/C1/C2             |                            |                                   |                                 | A4Q <sub>0</sub>                |
| 0xC4/C5/C6             | B <sub>0</sub>             | B1I <sub>0</sub>                  | B1I <sub>0</sub>                | B1I <sub>0</sub>                |
| 0xC8/C9/CA             | B <sub>1</sub>             | B1Q <sub>0</sub>                  | B1Q <sub>0</sub>                | B1Q <sub>0</sub>                |
| 0xCC/CD/CE             | B <sub>2</sub>             |                                   | B2I <sub>0</sub>                | B2I <sub>0</sub>                |

**Table 7-45. Register address for RAMP starting values based on operating mode (continued)**

| Address<br>(JESD Page) | Bypass Mode<br>LMFS = 8224 | Complex Decimation<br>Single Band | Complex Decimation<br>Dual Band | Complex Decimation<br>Quad Band |
|------------------------|----------------------------|-----------------------------------|---------------------------------|---------------------------------|
| 0xD0/D1/D2             | B <sub>3</sub>             |                                   | B2Q <sub>0</sub>                | B2Q <sub>0</sub>                |
| 0xD4/D5/D6             |                            |                                   |                                 | B3I <sub>0</sub>                |
| 0xD8/D9/DA             |                            |                                   |                                 | B3Q <sub>0</sub>                |
| 0xDC/DD/DE             |                            |                                   |                                 | B4I <sub>0</sub>                |
| 0xE0/E1/E2             |                            |                                   |                                 | B4Q <sub>0</sub>                |

**7.3.8.1 Transport Layer**

The transport layer maps the ADC output data into 8-bit octets and constructs the JESD204B frames using the LMFS parameters. Tail bits or 0's are added when needed. Alternatively, test patterns can be substituted instead of the ADC data with the JESD frame, as shown in [Table 7-44](#).

**7.3.8.2 Link Layer**

The link layer contains the scrambler and the 8b/10b encoding of any data passed on from the transport layer. Additionally, the link layer also handles the initial lane alignment sequence that can be manually restarted. The link layer test patterns are intended for testing the quality of the link (jitter testing and so forth). The test patterns do not pass through the 8b/10b encoder and contain the options listed in [Table 7-44](#).

**7.3.8.3 Internal Capture Memory Buffer**

The ADC includes a small internal capture memory buffer which can store up to 64 samples. Once a strobe is given to the memory using SPI register write, the memory will store the next continuous 64 samples of one ADC channel (selected via SPI register write) and stop. The samples are captured from the ADC cores (prior to averaging or decimation). These samples can be read back using the SPI interface without involving the JESD204B interface at all.

This mode allows debug of the analog front end during the initial bring-up phase even if the JESD204B interface is not operational yet.

**Table 7-46. Register writes to enable the internal sample capture buffer**

| ADDR | DATA | DESCRIPTION                                                                                                         |
|------|------|---------------------------------------------------------------------------------------------------------------------|
| 0x05 | 0x02 | Select DIGITAL page                                                                                                 |
| 0x34 |      | Select ADC channel (D5/D4) and give strobe (D6).<br>The 64 samples are stored in 0x800 to 0x87F in the digital page |

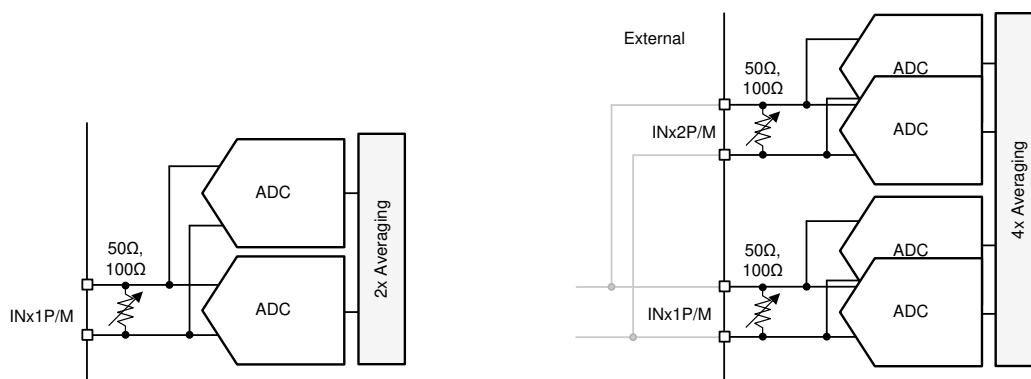
## 7.4 Device Functional Modes

The device offers two different operating modes: bypass mode (1x AVG) and digital averaging (2x/4x AVG). Both operating modes use the same digital back end and JESD204B output configurations.

### 7.4.1 Digital Averaging

The ADC32RF52 provides a total of eight internal single core 1.5 Gsps ADCs. Normal bypass mode uses only two ADC cores (one ADC per channel). However the additional six ADCs can be used to trade off further noise density improvement against additional power consumption. Figure 7-42 shows the internal block diagrams for the digital averaging modes. In averaging mode the output resolution is increased to 16-bit to avoid quantization noise limitation.

In 2x averaging mode (left) one external input is connected to the INx1 input where two ADC cores internally average the input signal. In 4x averaging (right) the signal has to be split externally and connected to both the INx1 and INx2 inputs where four ADC cores internally average the signal.



**Figure 7-42. Internal digital averaging (left: 2x, right: 4x)**

Table 7-47 provides a trade-off comparison of the 3 different averaging mode options vs the default, non-averaged mode.

**Table 7-47. Digital averaging vs full power input bandwidth (–3 dB)**

| # of ADCs averaged | ADC inputs used for averaging | Input Bandwidth (–3 dB) | Selected differential input termination | Noise density |
|--------------------|-------------------------------|-------------------------|-----------------------------------------|---------------|
| Default            | INx1                          | 1.6 GHz                 | 100 Ω                                   | –153 dBFS/Hz  |
| 2                  | INx1                          | 1.5 GHz                 | 100 Ω                                   | –156 dBFS/Hz  |
| 4                  | INx1, INx2                    | 1.5 GHz                 | 100 Ω                                   | –159 dBFS/Hz  |

Digital averaging improves decorrelated noise contributions by 3 dB per 2x AVG (ideal) while correlated noise does not improve with averaging. Some of the dominant noise sources are correlated (e.g. clock jitter (external or first clock input buffer) or power supply noise) while others (e.g. ADC thermal noise, clock distribution buffers) are decorrelated. illustrates a performance example comparison across averaging options.

**SNR:** When operating close to ADC fullscale, some of the SNR limitation is due to jitter and hence the SNR improvement won't reach 3 dB (2x AVG) or 6 dB (4x AVG). As the input fullscale is reduced, the clock jitter contribution to SNR becomes less and the SNR improvement is approaching the ideal 3 dB per 2x AVG. The same phenomenon can be observed when using digital decimation. As the decimation factor increases, the close-in (correlated noise) becomes the more dominating noise unless the input signal amplitude is reduced.

**SFDR:** The amplitude of low order harmonics (HD2-HD5) and IMD3 typically is very similar across ADCs and thus the improvement with averaging is very small.

## 7.5 Programming

The device is primarily configured and controlled using the serial programming interface (SPI) however it can operate in a default configuration without requiring the SPI interface. Furthermore the power down function as well as NCO frequency hopping or JESD synchronization are possible via pin control (GPIO1/2 pins).

### 7.5.1 GPIO Pin Control

There are several commands which can be executed using SPI programming or GPIO pins. [Table 7-48](#) provides an overview of the commands available using GPIO pins.

**Table 7-48. GPIO Pin Command Options**

| FEATURE            | DESCRIPTION                                                                                                                                                                      |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| JESD SYNC          | Support for single ended CMOS or differential LVDS                                                                                                                               |
| NCO Control        | Fast frequency hopping with 3 different control options                                                                                                                          |
| Fast Overrange     | GPIO1 indicates overrange for channel B and GPIO2 for channel B. In this mode the overrange indication is 'sticky' - the flag stays high until it is cleared using SPI commands. |
| Calibration Freeze | Freezes swapping of calibration ADC                                                                                                                                              |

### 7.5.2 Configuration using the SPI interface

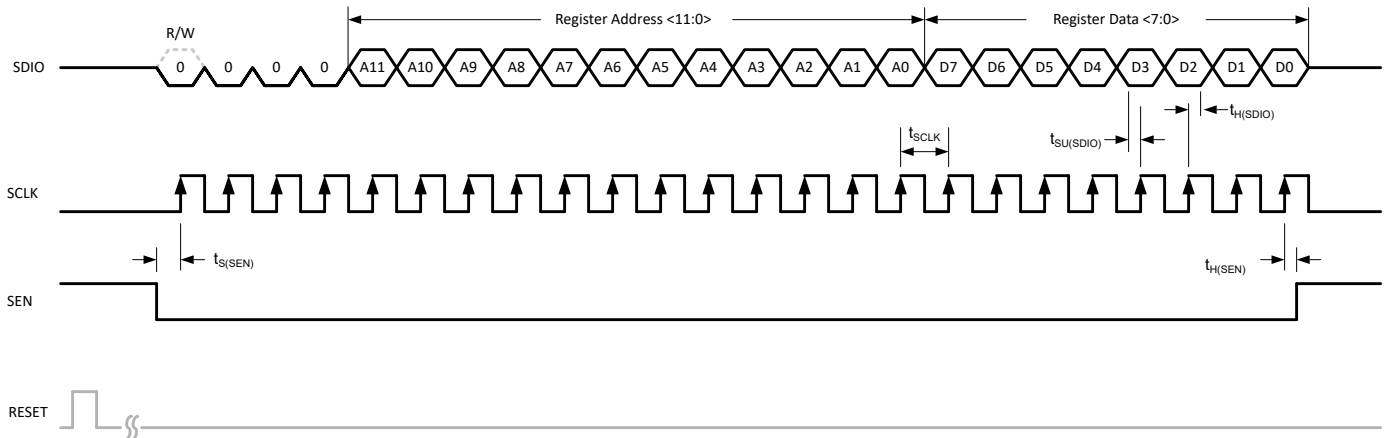
The device has a set of internal registers that can be accessed by the serial interface formed by the SEN (serial interface enable), SCLK (serial interface clock) and SDIO (serial interface data input/output) pins. Serially shifting bits into the device is enabled when SEN is low. Serial data input are latched at every SCLK rising edge when SEN is active (low). The serial data are loaded into the register at every 24th SCLK rising edge when SEN is low. When the word length exceeds a multiple of 24 bits, the excess bits are ignored. Data can be loaded in multiples of 24-bit words within a single active SEN pulse. The interface can function with SCLK frequencies from 20 MHz down to ~ 1 MHz and also with a non-50% SCLK duty cycle.

### 7.5.2.1 Register Write

The internal registers can be programmed following these steps:

1. Drive the SEN pin low
2. Set the R/W bit to 0 (bit A15 of the 16-bit address) and bits A[14:12] in address field to 0.
3. Initiate a serial interface cycle by specifying the address of the register (A[11:0]) whose content is written and
4. Write the 8-bit data that are latched in on the SCLK rising edges

Figure 7-43 shows the timing requirements for the serial register write operation.

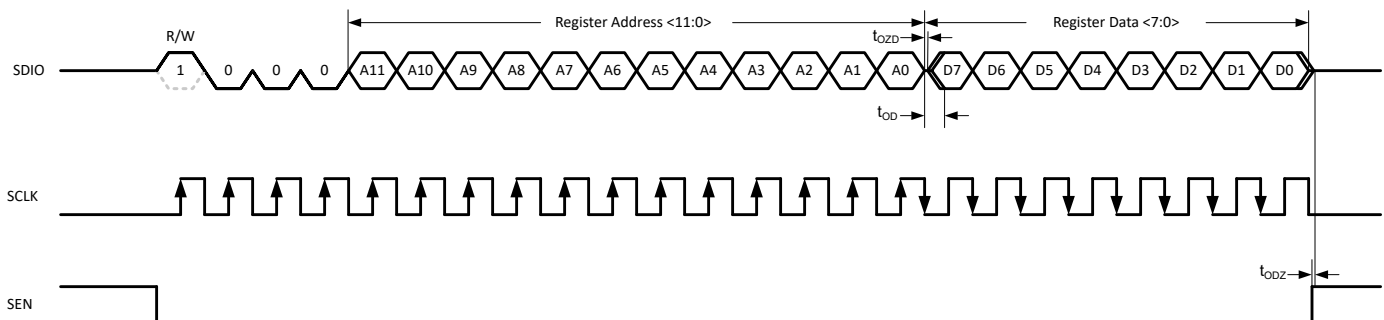


**Figure 7-43. Serial Register Write Timing Diagram**

### 7.5.2.2 Register Read

The device includes a mode where the contents of the internal registers can be read back using the SDIO pin. This readback mode can be useful as a diagnostic check to verify the serial interface communication between the external controller and the ADC. The procedure to read the contents of the serial registers is as follows:

1. Drive the SEN pin low
2. Set the R/W bit (A15) to 1. This setting disables any further writes to the registers. Set A[14:12] in address field to 0.
3. Initiate a serial interface cycle specifying the address of the register (A[11:0]) whose content must be read
4. The device outputs the contents (D[7:0]) of the selected register on the SDIO pin
5. The external controller can latch the contents at the SCLK falling edge



**Figure 7-44. Serial Register Read Timing Diagram**

## 7.6 Register Maps

**Table 7-49. Register Map Summary**

| PAGE    | REGISTER ADDRESS | REGISTER DATA   |              |                |           |                |              |                |             |
|---------|------------------|-----------------|--------------|----------------|-----------|----------------|--------------|----------------|-------------|
|         | A[11:0]          | D7              | D6           | D5             | D4        | D3             | D2           | D1             | D0          |
| GLOBAL  | 0x00             | 0               | 0            | 0              | 0         | 0              | 0            | 0              | RESET       |
|         | 0x05             | MEM PAGE        | ANALOG PAGE  | CALIB PAGE     | DDCB PAGE | DDCA PAGE      | JESD PAGE    | DIGITAL PAGE   | 0           |
| DIGITAL | 0x2C             | 20-BIT OUT      | DDC BAND SEL |                | 0         | 0              | 0            | DDC REAL       | BYP EN      |
|         | 0x2D             | 0               | DECIMATION   |                |           | 0              | 0            | 0              | 0           |
|         | 0x2E             | 0               | 0            | 0              | 0         | AVG EN         | AVG SEL(1)   |                | OVR ON JESD |
|         | 0x33             | 0               | 0            | 0              | 1         | FORMAT         | 0            | GBL PDN        | 0           |
|         | 0x34             | 0               | MEM STROBE   | MEM CH SEL     |           | 0              | 0            | 0              | 0           |
|         | 0x3B             | NCO4 CHA [1:0]  |              | NCO3 CHA [1:0] |           | NCO2 CHA [1:0] |              | NCO1 CHA [1:0] |             |
|         | 0x41             | NCO4 CHB [1:0]  |              | NCO3 CHB [1:0] |           | NCO2 CHB [1:0] |              | NCO1 CHB [1:0] |             |
|         | 0x22F            | 1               | SYSREF X5    | SYSREF X4      | SYSREF X3 | SYSREF X2      | SYSREF X1    | SYSREF OR      | 1           |
|         | 0x234            | 0               | NCO SEL MODE |                | 0         | 0              | GPIO MODE    |                |             |
|         | 0x235            | NCO SEL SOURCE  |              |                |           |                |              |                |             |
|         | 0x236            | 0               | GPIO2 INV    | GPIO1 INV      | GPIO SWAP | 0              | 0            | SYSREF RESET   | SYSREF EN   |
|         | 0x237            | 0               | 0            | 0              | 0         | 0              | GPIO2 CFG    | 0              | GPIO1 CFG   |
|         | 0x238            | OVR OUTPUT CFG  |              |                |           | 0              | 0            | 0              | 0           |
| JESD    | 0x20             | K               |              |                |           |                |              |                |             |
|         | 0x21             | 0               | SYNC SPI EN  | SYNC SPI       | 0         | 0              | SYSREF MODE  |                |             |
|         | 0x22             | LMFS MODE       |              |                |           |                |              |                |             |
|         | 0x24             | DDC CLK DIV     |              |                |           |                |              |                |             |
|         | 0x25             | JESD TX CLK DIV |              |                |           |                |              |                |             |
|         | 0x27             | 0               | 0            | DROP LSB       | 0         | 0              | 0            | CLK BAL EN     | 0           |
|         | 0x28             | JESD TX LANE EN |              |                |           |                |              |                |             |
|         | 0x2B             | 0               | 0            | 0              | 0         | 0              | 0            | 0              | SYNC INV    |
|         | 0x2D             | 0               | 0            | 0              | 0         | 0              | TEST SEQ SEL |                |             |
|         | 0x2E             | RAMP INCR       |              |                |           | 0              | RAMP EN      | ALT PAT        | 0           |
|         | 0x2F             | 0               | PRBS PAT     |                | PRBS EN   | 0              | 0            | 0              | 0           |

**Table 7-49. Register Map Summary (continued)**

| PAGE | REGISTER ADDRESS | REGISTER DATA                |                     |              |                     |                 |                |                 |              |   |
|------|------------------|------------------------------|---------------------|--------------|---------------------|-----------------|----------------|-----------------|--------------|---|
|      | A[11:0]          | D7                           | D6                  | D5           | D4                  | D3              | D2             | D1              | D0           |   |
| JESD | 0x53             | SCR EN                       | 0                   | 0            | 0                   | 0               | 0              | 0               | 0            |   |
|      | 0x7A             | JESD LANE POL INV            |                     |              |                     |                 |                |                 |              |   |
|      | 0x80             | 0                            | LANE DOUT1 SEL      |              |                     | 0               | LANE DOUT0 SEL |                 |              |   |
|      | 0x81             | 0                            | LANE DOUT3 SEL      |              |                     | 0               | LANE DOUT2 SEL |                 |              |   |
|      | 0x82             | 0                            | LANE DOUT5 SEL      |              |                     | 0               | LANE DOUT4 SEL |                 |              |   |
|      | 0x83             | 0                            | LANE DOUT7 SEL      |              |                     | 0               | LANE DOUT6 SEL |                 |              |   |
|      | 0x84             | 0                            | 0                   | 0            | 0                   | 0               | 0              | JESD PLL FACTOR |              |   |
|      | 0x89             | TX EMPH DOUT1 [0]            | TX EMPH DOUT0 [5:0] |              |                     |                 |                |                 |              | 0 |
|      | 0x8A             | 0                            | 0                   | 0            | TX EMPH DOUT1 [5:1] |                 |                |                 |              |   |
|      | 0x8B             | TX EMPH DOUT3 [0]            | TX EMPH DOUT2 [5:0] |              |                     |                 |                |                 |              | 0 |
|      | 0x8C             | 0                            | 0                   | 0            | TX EMPH DOUT3 [5:1] |                 |                |                 |              |   |
|      | 0x8D             | TX EMPH DOUT5 [0]            | TX EMPH DOUT4 [5:0] |              |                     |                 |                |                 |              | 0 |
|      | 0x8E             | 0                            | 0                   | 0            | TX EMPH DOUT5 [5:1] |                 |                |                 |              |   |
|      | 0x8F             | TX EMPH DOUT7 [0]            | TX EMPH DOUT6 [5:0] |              |                     |                 |                |                 |              | 0 |
|      | 0x90             | 0                            | 0                   | 0            | TX EMPH DOUT7 [5:1] |                 |                |                 |              |   |
|      | 0x9D             | PD DOUT7 [0]                 | PD DOUT6 [0]        | PD DOUT5 [0] | PD DOUT4 [0]        | PD DOUT3 [0]    | PD DOUT2 [0]   | PD DOUT1 [0]    | PD DOUT0 [0] |   |
|      | 0x9E             | PD DOUT7 [1]                 | PD DOUT6 [1]        | PD DOUT5 [1] | PD DOUT4 [1]        | PD DOUT3 [1]    | PD DOUT2 [1]   | PD DOUT1 [1]    | PD DOUT0 [1] |   |
|      | 0x9F             | 0                            | JESD PLL1           |              |                     | 0               | JESD PLL2      |                 |              |   |
|      | 0xA0             | 0                            | JESD PLL INPUT1     |              |                     | 0               | 0              | 0               | 0            |   |
|      | 0xA1             | 0                            | JESD PLL INPUT2     |              |                     | 0               | 0              | 0               | 0            |   |
|      | 0xA2             | 0                            | 0                   | 0            | 0                   | JESD PLL INPUT3 |                |                 | 0            |   |
|      | 0xA4..A6         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xA8..AA         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xAC..AE         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xB0..B2         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xB4..B6         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xB8..BA         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xBC..BE         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xC0..C2         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xC4..C6         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xC8..CA         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xCC..CE         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xD0..D2         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xD4..D6         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xD8..DA         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xDC..DE         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |
|      | 0xE0..E2         | START VALUE JESD RAMP [19:0] |                     |              |                     |                 |                |                 |              |   |

Table 7-49. Register Map Summary (continued)

| PAGE        | REGISTER ADDRESS | REGISTER DATA                                                |             |          |              |            |            |                |              |
|-------------|------------------|--------------------------------------------------------------|-------------|----------|--------------|------------|------------|----------------|--------------|
|             |                  | D7                                                           | D6          | D5       | D4           | D3         | D2         | D1             | D0           |
| DDCA/B      | 0x100..0x105     | NCO1 FREQUENCY1 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x108..0x10D     | NCO1 FREQUENCY2 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x110..0x115     | NCO1 FREQUENCY3 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x118..0x11D     | NCO1 FREQUENCY4 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x120..0x125     | NCO2 FREQUENCY1 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x128..0x12D     | NCO2 FREQUENCY2 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x130..0x135     | NCO2 FREQUENCY3 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x138..0x13D     | NCO2 FREQUENCY4 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x140..0x145     | NCO3 FREQUENCY1 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x148..0x14D     | NCO3 FREQUENCY2 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x150..0x155     | NCO3 FREQUENCY3 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x158..0x15D     | NCO3 FREQUENCY4 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x160..0x165     | NCO4 FREQUENCY1 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x168..0x16D     | NCO4 FREQUENCY2 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x170..0x175     | NCO4 FREQUENCY3 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x178..0x17D     | NCO4 FREQUENCY4 [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |             |          |              |            |            |                |              |
|             | 0x180            | 0                                                            | 0           | DDC PDN  | DDC DITH PDN | REAL DDC   | DB/QB DDC  | 0              | NCO MODE     |
|             | 0x181            | 0                                                            | 0           | LOAD NCO |              | 0          | 0          | 0              | 0            |
| CALIBRATION | 0x34             | 0                                                            | 0           | 0        | 0            | 0          | AVG SEL(2) |                | 1            |
|             | 0x45             | CAL SPI                                                      | CAL GPIO    | 0        | 0            | 1          | 0          | 1              | 0            |
|             | 0x298            | 0                                                            | 0           | 0        | 0            | CAL STATUS |            |                |              |
| ANALOG      | 0x6D             | RESET SW [1:0]                                               |             | 0        | 0            | 0          | 0          | 0              | 0            |
|             | 0x6E             | 0                                                            | 0           | 0        | 0            | 0          | 0          | RESET SW [3:2] |              |
|             | 0x7B             | 0                                                            | 0           | TERM A   | 0            | 0          | 0          | 0              | TERM A       |
|             | 0x8B             | 0                                                            | 0           | TERM B   | 0            | 0          | 0          | 0              | TERM B       |
|             | 0xA8             | 0                                                            | DITHER AMP1 |          |              |            | 0          | 0              | 0            |
|             | 0xAF             | DITHER DIS                                                   | 0           | 0        | 1            | 0          | 0          | 0              | 0            |
|             | 0xB1             | DITHER DIVIDER                                               |             |          |              |            |            |                |              |
|             | 0xB4             | 0                                                            | 0           | 0        | 0            | 0          | 0          | 0              | SYSREF AC EN |
|             | 0xCD             | 0                                                            | DITH AMP2   |          |              | 0          | 0          | 0              | 0            |
|             | 0xE6             | TX SWING [0]                                                 | 0           | 0        | 0            | 0          | 0          | 0              | 0            |
|             | 0xE7             | 0                                                            | 0           | 0        | 0            | 0          | 0          | TX SWING [2:1] |              |

## 7.6.1 Detailed Register Description

**Figure 7-45. Register 0x00**

| 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|-------|-------|-------|-------|-------|-------|-------|-------|
| 0     | 0     | 0     | 0     | 0     | 0     | 0     | RESET |
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-50. Register 0x00 Field Descriptions**

| Bit | Field | Type | Reset | Description                                                                             |
|-----|-------|------|-------|-----------------------------------------------------------------------------------------|
| 7-1 | 0     | R/W  | 0     | Must write 0                                                                            |
| 0   | RESET | R/W  | 0     | This bit resets all internal registers to the default values. Does not self clear to 0. |

**Figure 7-46. Register 0x05**

| 7        | 6           | 5          | 4         | 3         | 2         | 1            | 0     |
|----------|-------------|------------|-----------|-----------|-----------|--------------|-------|
| MEM PAGE | ANALOG PAGE | CALIB PAGE | DDCB PAGE | DDCA PAGE | JESD PAGE | DIGITAL PAGE | 0     |
| R/W-0    | R/W-0       | R/W-0      | R/W-0     | R/W-0     | R/W-0     | R/W-0        | R/W-0 |

**Table 7-51. Register 0x05 Field Descriptions**

| Bit | Field        | Type | Reset | Description                                                                                                                                                                                |
|-----|--------------|------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7   | MEM PAGE     | R/W  | 0     | This bit enables access to the MEMORY page<br>0: MEMORY page access disabled<br>1: MEMORY page access enabled                                                                              |
| 6   | ANALOG PAGE  | R/W  | 0     | This bit enables access to the ANALOG page<br>0: ANALOG page access disabled<br>1: ANALOG page access enabled                                                                              |
| 5   | CALIB PAGE   | R/W  | 0     | This bit enables access to the CALIBRATION page<br>0: CALIBRATION page access disabled<br>1: CALIBRATION page access enabled                                                               |
| 4   | DDCB PAGE    | R/W  | 0     | This bit enables access to the DDCB page. Contents can be written to DDCA and DDCB page simultaneously if it is identical.<br>0: DDCB page access disabled<br>1: DDCB page access enabled. |
| 3   | DDCA PAGE    | R/W  | 0     | This bit enables access to the DDCA page. Contents can be written to DDCA and DDCB page simultaneously if it is identical.<br>0: DDCA page access disabled<br>1: DDCA page access enabled  |
| 2   | JESD PAGE    | R/W  | 0     | This bit enables access to the JESD page<br>0: JESD page access disabled<br>1: JESD page access enabled                                                                                    |
| 1   | DIGITAL PAGE | R/W  | 0     | This bit enables access to the DIGITAL page<br>0: DIGITAL page access disabled<br>1: DIGITAL page access enabled                                                                           |
| 0   | 0            | R/W  | 0     | Must write 0                                                                                                                                                                               |

**Figure 7-47. Register 0x2C (DIGITAL page)**

| 7          | 6            | 5     | 4     | 3     | 2     | 1        | 0      |
|------------|--------------|-------|-------|-------|-------|----------|--------|
| 20-BIT OUT | DDC BAND SEL |       | 0     | 0     | 0     | DDC REAL | BYP EN |
| R/W-0      | R/W-0        | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0    | R/W-0  |

**Table 7-52. Register 0x2C Field Descriptions**

| Bit | Field        | Type | Reset | Description                                                                                                                                                                                                              |
|-----|--------------|------|-------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7   | 20-BIT OUT   | R/W  | 0     | This bit enables the 20-bit output mode. It carries the output sample with 20-bit output resolution from the DDC and the sample is filled to 32-bit with 12 trailing 0s.<br>0: Normal operation<br>1: 20-bit output mode |
| 6-5 | DDC BAND SEL | R/W  | 00    | Selects 1, 2 or 4 DDC per ADC when complex decimation is enabled<br>0: Single band<br>1: Dual band<br>2: Quad band<br>3: not used                                                                                        |
| 4-2 | 0            | R    | 0     | Must write 0                                                                                                                                                                                                             |
| 1   | DDC REAL     | R/W  | 0     | This bit enables real decimation filter (NCO = 0). BYP EN (D0) must be set to 0.<br>0: Complex decimation<br>1: Real decimation                                                                                          |
| 0   | BYP EN       | R/W  | 0     | This bit enables DDC bypass mode<br>0: Decimation filter enabled. Complex decimation by default unless D1 is set<br>1: Decimation filter bypass                                                                          |

**Figure 7-48. Register 0x2D (DIGITAL page)**

| 7     | 6          | 5     | 4     | 3     | 2     | 1     | 0     |
|-------|------------|-------|-------|-------|-------|-------|-------|
| 0     | DECIMATION |       |       | 0     | 0     | 0     | 0     |
| R/W-0 | R/W-0      | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-53. Register 0x2D Field Descriptions**

| Bit | Field      | Type | Reset | Description                                                                                                                                                                   |
|-----|------------|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7   | 0          | R/W  | 0     | Must write 0                                                                                                                                                                  |
| 6-4 | DECIMATION | R/W  | 0     | Selects decimation.<br>0,1: not used<br>2: Decimation by 4<br>3: Decimation by 8<br>4: Decimation by 16<br>5: Decimation by 32<br>6: Decimation by 64<br>7: Decimation by 128 |
| 3-0 | 0          | R/W  | 0     | Must write 0                                                                                                                                                                  |

**Figure 7-49. Register 0x2E (DIGITAL page)**

| 7     | 6     | 5     | 4     | 3      | 2           | 1     | 0           |
|-------|-------|-------|-------|--------|-------------|-------|-------------|
| 0     | 0     | 0     | 0     | AVG EN | AVG SEL (1) |       | OVR ON JESD |
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0  | R/W-0       | R/W-0 | R/W-0       |

**Table 7-54. Register 0x2E Field Descriptions**

| Bit | Field       | Type | Reset | Description                                                                                                                              |
|-----|-------------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------|
| 7-4 | 0           | R/W  | 0     | Must write 0                                                                                                                             |
| 3   | AVG EN      | R/W  | 0     | This bit enables averaging<br>0: no average<br>1: ADC averaging enabled                                                                  |
| 2-1 | AVG SEL (1) | R/W  | 00    | Selects ADC averaging. Also AVG SEL (2) in CALIBRATION page needs to be set.<br>0: no average<br>1: 2 ADC average<br>2: 4 ADC average    |
| 0   | OVR ON JESD | R/W  | 0     | This bit enables to output OVR flag to replace the LSB in the JESD output stream<br>0: OVR on GPIO<br>1: OVR replaces LSB on JESD stream |

**Figure 7-50. Register 0x33 (DIGITAL page)**

| 7     | 6     | 5     | 4     | 3      | 2     | 1       | 0     |
|-------|-------|-------|-------|--------|-------|---------|-------|
| 0     | 0     | 0     | 1     | FORMAT | 0     | GBL PDN | 0     |
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0  | R/W-0 | R/W-0   | R/W-0 |

**Table 7-55. Register 0x33 Field Descriptions**

| Bit | Field   | Type | Reset | Description                                                                                                                                                                 |
|-----|---------|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-5 | 0       | R/W  | 0     | Must write 0                                                                                                                                                                |
| 4   | 1       | R/W  | 0     | Must write 1                                                                                                                                                                |
| 3   | FORMAT  | R/W  | 0     | This register bit determines the output data format in DDC bypass mode only.<br>0: Offset Binary<br>1: 2s Complement<br>DDC mode only supports 2s complement output format. |
| 2   | 0       | R/W  | 0     | Must write 0                                                                                                                                                                |
| 1   | GBL PDN | R/W  | 0     | This register bit enables global power down mode<br>0: normal operation<br>1: global power down mode enabled                                                                |
| 0   | 0       | R/W  | 0     | Must write 0                                                                                                                                                                |

**Figure 7-51. Register 0x34 (DIGITAL page)**

| 7     | 6          | 5          | 4     | 3     | 2     | 1     | 0     |
|-------|------------|------------|-------|-------|-------|-------|-------|
| 0     | MEM STROBE | MEM CH SEL |       | 0     | 0     | 0     | 0     |
| R/W-0 | R/W-0      | R/W-0      | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-56. Register 0x34 Field Descriptions**

| Bit | Field      | Type | Reset | Description                                                                                          |
|-----|------------|------|-------|------------------------------------------------------------------------------------------------------|
| 7   | 0          | R/W  | 0     | Must write 0                                                                                         |
| 6   | MEM STROBE | R/W  | 0     | This register enables fast power down mode<br>0: normal operation<br>1: fast power down mode enabled |

**Table 7-56. Register 0x34 Field Descriptions (continued)**

| Bit | Field      | Type | Reset | Description                                                                                                                                                                                                                                                                                                                                                                                                    |
|-----|------------|------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5-4 | MEM CH SEL | R/W  | 0     | This register selects which ADC channel is used to fill up the capture sample buffer. Only 1 channel can be selected at a time and the samples are captured from the ADC core without averaging or decimation.<br>00: capture memory is filled from chA1 input<br>01: capture memory is filled from chA2 input<br>10: capture memory is filled from chB1 input<br>11: capture memory is filled from chB2 input |
| 0   | 0          | R/W  | 0     | Must write 0                                                                                                                                                                                                                                                                                                                                                                                                   |

**Figure 7-52. Register 0x3B (DIGITAL page)**

|                |       |                |       |                |       |                |       |
|----------------|-------|----------------|-------|----------------|-------|----------------|-------|
| 7              | 6     | 5              | 4     | 3              | 2     | 1              | 0     |
| NCO4 CHA [1:0] |       | NCO3 CHA [1:0] |       | NCO2 CHA [1:0] |       | NCO1 CHA [1:0] |       |
| R/W-0          | R/W-0 | R/W-0          | R/W-0 | R/W-0          | R/W-0 | R/W-0          | R/W-0 |

**Table 7-57. Register 0x3B Field Descriptions**

| Bit | Field          | Type | Reset | Description                                                                                                                                                                                                                                   |
|-----|----------------|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-6 | NCO4 CHA [1:0] | R/W  | 00    | This register is used when selecting the NCO frequency for channel A, band 4 with the SPI interface in quad DDC mode.                                                                                                                         |
| 5-4 | NCO3 CHA [1:0] | R/W  | 00    | This register is used when selecting the NCO frequency for channel A, band 3 with the SPI interface in quad DDC mode.                                                                                                                         |
| 3-2 | NCO2 CHA [1:0] | R/W  | 00    | In single band DDC mode this register is used to select between NCO bank 1 or 2.<br>00: NCO bank 1<br>01: NCO bank 2<br>In dual band DDC mode this register is used to select the NCO frequency for channel A, band 2 with the SPI interface. |
| 1-0 | NCO1 CHA [1:0] | R/W  | 00    | This register is used when selecting the NCO1 of channel A with the SPI interface.                                                                                                                                                            |

**Figure 7-53. Register 0x41 (DIGITAL page)**

|                |       |                |       |                |       |                |       |
|----------------|-------|----------------|-------|----------------|-------|----------------|-------|
| 7              | 6     | 5              | 4     | 3              | 2     | 1              | 0     |
| NCO4 CHB [1:0] |       | NCO3 CHB [1:0] |       | NCO2 CHB [1:0] |       | NCO1 CHB [1:0] |       |
| R/W-0          | R/W-0 | R/W-0          | R/W-0 | R/W-0          | R/W-0 | R/W-0          | R/W-0 |

**Table 7-58. Register 0x41 Field Descriptions**

| Bit | Field          | Type | Reset | Description                                                                                                                                                                                                                                                |
|-----|----------------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-6 | NCO4 CHB [1:0] | R/W  | 00    | This register is used when selecting the NCO frequency for channel B, band 4 with the SPI interface in quad DDC mode.                                                                                                                                      |
| 5-4 | NCO3 CHB [1:0] | R/W  | 00    | This register is used when selecting the NCO frequency for channel B, band 3 with the SPI interface in quad DDC mode.                                                                                                                                      |
| 3-2 | NCO2 CHB [1:0] | R/W  | 00    | In single band DDC mode this register is used to select between NCO bank 1 or 2 of channel B.<br>00: NCO bank 1<br>01: NCO bank 2<br>In dual band DDC mode this register is used to select the NCO frequency for channel B, band 2 with the SPI interface. |
| 1-0 | NCO1 CHB [1:0] | R/W  | 00    | This register is used when selecting the NCO1 of channel B with the SPI interface.                                                                                                                                                                         |

**Figure 7-54. Register 0x22F (DIGITAL page)**

| 7     | 6         | 5         | 4         | 3         | 2         | 1         | 0     |
|-------|-----------|-----------|-----------|-----------|-----------|-----------|-------|
| 1     | SYSREF X5 | SYSREF X4 | SYSREF X3 | SYSREF X2 | SYSREF X1 | SYSREF OR | 1     |
| R/W-0 | R/W-0     | R/W-0     | R/W-0     | R/W-0     | R/W-0     | R/W-0     | R/W-0 |

**Table 7-59. Register 0x22F Field Descriptions**

| Bit | Field        | Type | Reset | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-----|--------------|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7   | 1            | R/W  | 1     | Must write 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| 6-2 | SYSREF X1..5 | R/W  | 0     | These bits are the XOR flags from the SYSREF window monitoring circuitry. The sampling clock gets delayed internally by ~ 160 ps and used to capture the SYSREF signal. If a SYSREF signal transition happens within +/- 50 ps of the SYSREF capture the appropriate XOR flag gets raised. These bits are not sticky - they get overwritten with the next SYSREF rising edge.<br>X1: Window from 110 ps to 135 ps after the rising sampling clock edge<br>X2: Window from 135 ps to 160 ps after the rising sampling clock edge<br>X3: Window from 160 ps to 176 ps after the rising sampling clock edge<br>X4: Window from 176 ps to 192 ps after the rising sampling clock edge<br>X5: Window from 192 ps to 208 ps after the rising sampling clock edge<br>0: No SYSREF transition detected<br>1: SYSREF transition detected within given window |
| 1   | SYSREF OR    | R/W  | 0     | This bit is the output of the five SYSREF XOR flags logically OR'ed together.<br>0: no SYSREF flag raised<br>1: one of the five SYSREF XOR flags is raised.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| 0   | 1            | R/W  | 1     | Must write 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

**Figure 7-55. Register 0x234 (DIGITAL page)**

| 7     | 6            | 5     | 4     | 3     | 2     | 1         | 0     |
|-------|--------------|-------|-------|-------|-------|-----------|-------|
| 0     | NCO SEL MODE |       |       | 0     | 0     | GPIO MODE |       |
| R/W-0 | R/W-0        | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0     | R/W-0 |

**Table 7-60. Register 0x234 Field Descriptions**

| Bit | Field        | Type | Reset | Description                                                                                                                                                                                                                                                                                                                                                                                     |
|-----|--------------|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7   | 0            | R/W  | 0     | Must write 0                                                                                                                                                                                                                                                                                                                                                                                    |
| 6-5 | NCO SEL MODE | R/W  | 00    | These bits select control of the NCO selection in complex decimation.<br>0: NCO selection using GPIO pins (GPIO MODE (D2-D0) needs to be set accordingly)<br>2: GPIO1/2 pins are used as a fast serial interface only for the NCO selection for each digital mixer<br>3: GPIO1/2, SCLK, SDIO pins are used for NCO selection.<br>others: not used<br>Register 0x235 may need to be set as well. |
| 4-3 | 0            | R/W  | 0     | Must write 0                                                                                                                                                                                                                                                                                                                                                                                    |
| 2-0 | GPIO MODE    | R/W  | 000   | This register sets the functionality of the two GPIO pins<br>0: GPIO pins are used as SYNC input (LVDS), GPIO1 = SYNC, GPIO2 = SYNCM<br>1: GPIO1 is used as SYNC input (CMOS)<br>3: Both GPIO pins are used to select NCOs for the decimation filters<br>4: GPIO1 is used to disable the calibration<br>5: GPIO1 is used as start of SYSREF counter<br>others: not used                         |

**Figure 7-56. Register 0x235 (DIGITAL page)**

| 7              | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|----------------|-------|-------|-------|-------|-------|-------|-------|
| NCO SEL SOURCE |       |       |       |       |       |       |       |
| R/W-0          | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-61. Register 0x235 Field Descriptions**

| Bit | Field          | Type | Reset | Description                                                                                                                                                                                       |
|-----|----------------|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-0 | NCO SEL SOURCE | R/W  | 0     | This register works in conjunction with NCO SEL MODE (0x234).<br>0x00: NCO selection other than regular SPI (GPIO, Fast SPI etc)<br>0xFF: NCO selection using regular SPI with addresses 0x3B/41. |

**Figure 7-57. Register 0x236 (DIGITAL page)**

| 7     | 6         | 5         | 4         | 3     | 2     | 1            | 0         |
|-------|-----------|-----------|-----------|-------|-------|--------------|-----------|
| 0     | GPIO2 INV | GPIO1 INV | GPIO SWAP | 0     | 0     | SYSREF RESET | SYSREF EN |
| R/W-0 | R/W-0     | R/W-0     | R/W-0     | R/W-0 | R/W-0 | R/W-0        | R/W-0     |

**Table 7-62. Register 0x236 Field Descriptions**

| Bit | Field        | Type | Reset | Description                                                                                                                          |
|-----|--------------|------|-------|--------------------------------------------------------------------------------------------------------------------------------------|
| 7   | 0            | R/W  | 0     | Must write 0                                                                                                                         |
| 6   | GPIO2 INV    | R/W  | 0     | This bit inverts polarity of the GPIO2 pin<br>0: Polarity as is<br>1: Polarity inverted                                              |
| 5   | GPIO1 INV    | R/W  | 0     | This bit inverts polarity of the GPIO1 pin<br>0: Polarity as is<br>1: Polarity inverted                                              |
| 4   | GPIO SWAP    | R/W  | 0     | This bit swaps GPIO1 and GPIO2 pins internally.<br>0: Normal operation<br>1: GPIO1 and GPIO2 are swapped                             |
| 3-2 | 0            | R/W  | 0     | Must write 0                                                                                                                         |
| 1   | SYSREF RESET | R/W  | 0     | This bit enables and clears the internal SYSREF counter:<br>0: Normal operation<br>1: Enables SYSREF and clears the internal counter |
| 0   | SYSREF EN    | R/W  | 0     | This bit starts the internal SYSREF counter:<br>0: Normal operation<br>1: Starts SYSREF counter                                      |

**Figure 7-58. Register 0x237 (DIGITAL page)**

| 7     | 6     | 5     | 4     | 3     | 2         | 1     | 0         |
|-------|-------|-------|-------|-------|-----------|-------|-----------|
| 0     | 0     | 0     | 0     | 0     | GPIO2 CFG | 0     | GPIO1 CFG |
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0     | R/W-0 | R/W-0     |

**Table 7-63. Register 0x237 Field Descriptions**

| Bit | Field     | Type | Reset | Description                                                                                                 |
|-----|-----------|------|-------|-------------------------------------------------------------------------------------------------------------|
| 7-3 | 0         | R/W  | 0     | Must write 0                                                                                                |
| 2   | GPIO2 CFG | R/W  | 0     | This bit configures GPIO2 pin either as input or output.<br>0: GPIO2 pin is input<br>1: GPIO2 pin is output |
| 1   | 0         | R/W  | 0     | Must write 0                                                                                                |
| 0   | GPIO1 CFG | R/W  | 0     | This bit configures GPIO1 pin either as input or output.<br>0: GPIO1 pin is input<br>1: GPIO1 pin is output |

**Figure 7-59. Register 0x238 (DIGITAL page)**

| 7              | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|----------------|-------|-------|-------|-------|-------|-------|-------|
| OVR OUTPUT CFG |       |       |       | 0     | 0     | 0     | 0     |
| R/W-0          | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-64. Register 0x238 Field Descriptions**

| Bit | Field          | Type | Reset | Description                                                                                                                                     |
|-----|----------------|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-4 | OVR OUTPUT CFG | R/W  | 0000  | This bit configures if the overrange indication (OVR) is output on JESD output stream or on GPIO pins<br>0000: OVR on JESD<br>1111: OVR on GPIO |
| 3-0 | 0              | R/W  | 0     | Must write 0                                                                                                                                    |

**Figure 7-60. Register 0x20 (JESD page)**

| 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|-------|-------|-------|-------|-------|-------|-------|-------|
| K     |       |       |       |       |       |       |       |
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-65. Register 0x20 Field Descriptions**

| Bit | Field | Type | Reset    | Description                                                                                               |
|-----|-------|------|----------|-----------------------------------------------------------------------------------------------------------|
| 7-0 | K     | R/W  | 00000000 | This is JESD204B parameter K which sets number of frames in a multi-frame. Bit value is set as K minus 1. |

**Figure 7-61. Register 0x21 (JESD page)**

| 7     | 6           | 5        | 4     | 3     | 2           | 1     | 0     |
|-------|-------------|----------|-------|-------|-------------|-------|-------|
| 0     | SYNC SPI EN | SYNC SPI | 0     | 0     | SYSREF MODE |       |       |
| R/W-0 | R/W-0       | R/W-0    | R/W-0 | R/W-0 | R/W-0       | R/W-0 | R/W-0 |

**Table 7-66. Register 0x21 Field Descriptions**

| Bit | Field       | Type | Reset | Description                                                                                                                                                                                                                                                                                                                                                      |
|-----|-------------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7   | 0           | R/W  | 0     | Must write 0                                                                                                                                                                                                                                                                                                                                                     |
| 6   | SYNC SPI EN | R/W  | 0     | This bit enables JESD SYNC control using SPI (ignoring SYNC using GPIO1/2 pins) using bit D5 (SYNC SPI).<br>0: SPI SYNC disabled<br>1: SPI SYNC (using register bit D5) enabled                                                                                                                                                                                  |
| 5   | SYNC SPI    | R/W  | 0     | This bit enables JESD SYNC. SYNC control via SPI must be enabled also (D6).<br>0: ADC outputs data (SYNC disabled)<br>1: SYNC enabled (ADC outputs K28.5 characters for JESD interface synchronization)                                                                                                                                                          |
| 4-3 | 0           | R/W  | 0     | Must write 0                                                                                                                                                                                                                                                                                                                                                     |
| 2-0 | SYSREF MODE | R/W  | 000   | This register controls how the ADC processes incoming SYSREF pulses.<br>0: Ignore all SYSREF pulses<br>1: Use all SYSREF pulses<br>2: Don't use SYSREF pulses<br>3: Skip one SYSREF pulse then use only the next one<br>4: Skip one SYSREF pulse then use all pulses<br>5: Skip two SYSREF pulses and then use one<br>6: Skip two SYSREF pulses and then use all |

**Figure 7-62. Register 0x22 (JESD page)**

| 7         | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|-----------|-------|-------|-------|-------|-------|-------|-------|
| JESD MODE |       |       |       |       |       |       |       |
| R/W-0     | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-67. Register 0x22 Field Descriptions**

| Bit | Field     | Type | Reset    | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----|-----------|------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7:0 | JESD MODE | R/W  | 00000000 | This register sets the LMFS configuration<br>0: LMFS = 8-2-8-20 (also bit DROP LSB in 0x27 needs to be set)<br>1: LMFS = 8-2-2-4<br>3: LMFS = 8-4-2-2<br>4: LMFS = 8-16-4-1<br>5: LMFS = 4-16-8-1<br>6: LMFS = 2-16-16-1<br>7: LMFS = 1-16-32-1<br>8: LMFS = 8-8-2-1<br>9: LMFS = 4-8-4-1<br>10: LMFS = 2-8-8-1<br>11: LMFS = 1-8-16-1<br>12: LMFS = 4-4-2-1<br>13: LMFS = 2-4-4-1<br>14: LMFS = 1-4-8-1<br>15: LMFS = 2-2-2-1<br>16: LMFS = 1-2-4-1<br>others: not used |

**Figure 7-63. Register 0x24 (JESD page)**

| 7           | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|-------------|-------|-------|-------|-------|-------|-------|-------|
| DDC CLK DIV |       |       |       |       |       |       |       |
| R/W-0       | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-68. Register 0x24 Field Descriptions**

| Bit | Field       | Type | Reset    | Description                                                                                                      |
|-----|-------------|------|----------|------------------------------------------------------------------------------------------------------------------|
| 7:0 | DDC CLK DIV | R/W  | 00000000 | This register sets the internal clock divider when using the decimation filter. See <a href="#">Table 7-70</a> . |

**Figure 7-64. Register 0x25 (JESD page)**

| 7               | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|-----------------|-------|-------|-------|-------|-------|-------|-------|
| JESD TX CLK DIV |       |       |       |       |       |       |       |
| R/W-0           | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-69. Register 0x25 Field Descriptions**

| Bit | Field           | Type | Reset    | Description                                                                                                                                                                  |
|-----|-----------------|------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7:0 | JESD TX CLK DIV | R/W  | 00000000 | This register sets the internal clock divider for the selected LMFS output mode. See <a href="#">Table 7-70</a> for 16-bit and <a href="#">Table 7-71</a> for 20-bit output. |

**Table 7-70. Register Settings for 0x24/0x25 Based on Bypass/Decimation and LMFS Mode (16-bit Output)**

| LMFS      | 0x24 (DDC CLK DIV) |    |    |     |     |     |      | 0x25 (JESD TX CLK DIV) |    |    |     |     |     |      |
|-----------|--------------------|----|----|-----|-----|-----|------|------------------------|----|----|-----|-----|-----|------|
|           | BYP                | /4 | /8 | /16 | /32 | /64 | /128 | BYP                    | /4 | /8 | /16 | /32 | /64 | /128 |
| 8-2-2-4   | 0                  |    |    |     |     |     |      | 0                      |    |    |     |     |     |      |
| 8-2-8-20  | 0                  |    |    |     |     |     |      | 4                      |    |    |     |     |     |      |
| 8-4-8-10  | 1                  |    |    |     |     |     |      | 4                      |    |    |     |     |     |      |
| 8-4-2-2   | 1                  | 0  | 0  | 0   | 0   |     |      | 0                      | 1  | 1  | 1   | 1   |     |      |
| 8-8-2-1   |                    | 0  | 0  | 0   | 0   | 0   |      |                        | 0  | 0  | 0   | 0   | 0   |      |
| 8-16-4-1  |                    | 1  | 1  | 1   | 1   | 1   | 1    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 4-2-2-2   |                    | 0  | 0  | 0   | 0   | 0   | 0    |                        | 1  | 1  | 1   | 1   | 1   | 1    |
| 4-4-2-1   |                    | 0  | 0  | 0   | 0   | 0   |      |                        | 0  | 0  | 0   | 0   | 0   |      |
| 4-8-4-1   |                    | 1  | 1  | 1   | 1   | 1   | 1    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 4-16-8-1  |                    | 3  | 3  | 3   | 3   | 3   | 3    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 2-2-2-1   |                    | 0  | 0  | 0   | 0   | 0   |      |                        | 0  | 0  | 0   | 0   | 0   |      |
| 2-4-4-1   |                    | 1  | 1  | 1   | 1   | 1   | 1    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 2-8-8-1   |                    | 3  | 3  | 3   | 3   | 3   | 3    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 2-16-16-1 |                    |    | 7  | 7   | 7   | 7   | 7    |                        |    | 0  | 0   | 0   | 0   | 0    |
| 1-2-4-1   |                    | 1  | 1  | 1   | 1   | 1   | 1    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 1-4-8-1   |                    | 3  | 3  | 3   | 3   | 3   | 3    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 1-8-16-1  |                    |    | 7  | 7   | 7   | 7   | 7    |                        |    | 0  | 0   | 0   | 0   | 0    |
| 1-16-32-1 |                    |    |    | 15  | 15  | 15  | 15   |                        |    |    | 0   | 0   | 0   | 0    |

**Table 7-71. Register Settings for 0x24/0x25 Based on Decimation and LMFS Mode (20-bit Output).**

| LMFS      | 0x24 (DDC CLK DIV) |    |    |     |     |     |      | 0x25 (JESD TX CLK DIV) |    |    |     |     |     |      |
|-----------|--------------------|----|----|-----|-----|-----|------|------------------------|----|----|-----|-----|-----|------|
|           | BYP                | /4 | /8 | /16 | /32 | /64 | /128 | BYP                    | /4 | /8 | /16 | /32 | /64 | /128 |
| 8-8-4-1   |                    | 1  | 1  | 1   | 1   | 1   | 1    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 8-16-8-1  |                    | 3  | 3  | 3   | 3   | 3   | 3    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 4-4-4-1   |                    | 1  | 1  | 1   | 1   | 1   | 1    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 4-8-8-1   |                    | 3  | 3  | 3   | 3   | 3   | 3    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 4-16-16-1 |                    |    | 7  | 7   | 7   | 7   | 7    |                        |    | 0  | 0   | 0   | 0   | 0    |
| 2-2-4-1   |                    | 1  | 1  | 1   | 1   | 1   | 1    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 2-4-8-1   |                    | 3  | 3  | 3   | 3   | 3   | 3    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 2-8-16-1  |                    |    | 7  | 7   | 7   | 7   | 7    |                        |    | 0  | 0   | 0   | 0   | 0    |
| 2-16-32-1 |                    |    |    | 15  | 15  | 15  | 15   |                        |    |    | 0   | 0   | 0   | 0    |
| 1-2-8-1   |                    | 3  | 3  | 3   | 3   | 3   | 3    |                        | 0  | 0  | 0   | 0   | 0   | 0    |
| 1-4-16-1  |                    |    | 7  | 7   | 7   | 7   | 7    |                        |    | 0  | 0   | 0   | 0   | 0    |
| 1-8-32-1  |                    |    |    | 15  | 15  | 15  | 15   |                        |    |    | 0   | 0   | 0   | 0    |
| 1-16-64-1 |                    |    |    |     | 31  | 31  | 31   |                        |    |    |     | 0   | 0   | 0    |

**Figure 7-65. Register 0x27 (JESD page)**

| 7     | 6     | 5        | 4     | 3     | 2     | 1          | 0     |
|-------|-------|----------|-------|-------|-------|------------|-------|
| 0     | 0     | DROP LSB | 0     | 0     | 0     | CLK BAL EN | 0     |
| R/W-0 | R/W-0 | R/W-0    | R/W-0 | R/W-0 | R/W-0 | R/W-0      | R/W-0 |

**Table 7-72. Register 0x27 Field Descriptions**

| Bit | Field      | Type | Reset | Description                                                                                                                                                                        |
|-----|------------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-6 | 0          | R/W  | 0     | Must write 0                                                                                                                                                                       |
| 5   | DROP LSB   | R/W  | 0     | This register needs to be set when using the 12-bit output LMFS mode.<br>0: Drop LSB disabled<br>1: Drop LSB enabled when using LMFS = 8-2-8-2-20                                  |
| 4-2 | 0          | R/W  | 0     | Must write 0                                                                                                                                                                       |
| 1   | CLK BAL EN | R/W  | 0     | This register bit needs to be enabled in bypass mode LMFS = 8-2-2-4 only to improve some internal clock balancing.<br>0: CLK BAL disabled<br>1: CLK BAL EN. Set for LMFS = 8-2-2-4 |
| 0   | 0          | R/W  | 0     | Must write 0                                                                                                                                                                       |

**Figure 7-66. Register 0x28 (JESD page)**

| 7            | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|--------------|-------|-------|-------|-------|-------|-------|-------|
| JESD LANE EN |       |       |       |       |       |       |       |
| R/W-0        | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-73. Register 0x28 Field Descriptions**

| Bit | Field        | Type | Reset    | Description                                                                                                                                                   |
|-----|--------------|------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-0 | JESD LANE EN | R/W  | 11111111 | This register turns on individual output lanes<br>0: Lane powered down<br>1: Serdes lane enabled<br>D0: Lane DOUT0<br>D1: Lane DOUT1<br>...<br>D7: Lane DOUT7 |

**Figure 7-67. Register 0x2B**

| 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0        |
|-------|-------|-------|-------|-------|-------|-------|----------|
| 0     | 0     | 0     | 0     | 0     | 0     | 0     | SYNC INV |
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0    |

**Table 7-74. Register 0x2B Field Descriptions**

| Bit | Field    | Type | Reset | Description                                                                                            |
|-----|----------|------|-------|--------------------------------------------------------------------------------------------------------|
| 7-1 | 0        | R/W  | 0     | Must write 0                                                                                           |
| 0   | SYNC INV | R/W  | 0     | This register inverts the polarity from external SYNC pin<br>0: Polarity as is<br>1: Polarity inverted |

**Figure 7-68. Register 0x2D (JESD page)**

| 7     | 6     | 5     | 4     | 3     | 2            | 1     | 0     |
|-------|-------|-------|-------|-------|--------------|-------|-------|
| 0     | 0     | 0     | 0     | 0     | JESD SEQ SEL |       |       |
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0        | R/W-0 | R/W-0 |

**Table 7-75. Register 0x2D Field Descriptions**

| Bit | Field        | Type | Reset | Description                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----|--------------|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-3 | 0            | R/W  | 0     | Must write 0                                                                                                                                                                                                                                                                                                                                                                                                  |
| 2-0 | JESD SEQ SEL | R/W  | 000   | This register selects the JESD test pattern sequence<br>0: Test sequence disabled<br>1: Repeat D21.5 high frequency pattern for random jitter (RJ)<br>2: Repeat K28.5 mixed frequency pattern for deterministic jitter (DJ)<br>3: Repeat initial lane alignment (ILA) sequence<br>4: Modified random pattern<br>5: Scrambled jitter pattern<br>6: Repeat K28.7 low frequency pattern<br>7: Short test pattern |

**Figure 7-69. Register 0x2E (JESD page)**

| 7         | 6     | 5     | 4     | 3     | 2       | 1       | 0     |
|-----------|-------|-------|-------|-------|---------|---------|-------|
| RAMP INCR |       |       |       | 0     | RAMP EN | ALT PAT | 0     |
| R/W-0     | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0   | R/W-0   | R/W-0 |

**Table 7-76. Register 0x2E Field Descriptions**

| Bit | Field     | Type | Reset | Description                                                                                                                |
|-----|-----------|------|-------|----------------------------------------------------------------------------------------------------------------------------|
| 7-4 | RAMP INCR | R/W  | 0000  | This register value sets the increment step size for the ramp pattern on 16-bit output. The step size is RAMP INCR plus 1. |
| 3   | 0         | R/W  | 0     | Must write 0                                                                                                               |
| 2   | RAMP EN   | R/W  | 0     | Enables RAMP output pattern in the TRANSPORT LAYER.                                                                        |
| 1   | ALT PAT   | R/W  | 0     | Enables a toggle pattern switching between 0x0000 and 0xFFFF in the TRANSPORT LAYER                                        |
| 0   | 0         | R/W  | 0     | Must write 0                                                                                                               |

**Figure 7-70. Register 0x2F (JESD page)**

| 7     | 6           | 5     | 4              | 3     | 2     | 1     | 0     |
|-------|-------------|-------|----------------|-------|-------|-------|-------|
| 0     | SERDES PRBS |       | SERDES PRBS EN | 0     | 0     | 0     | 0     |
| R/W-0 | R/W-0       | R/W-0 | R/W-0          | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-77. Register 0x2F Field Descriptions**

| Bit | Field          | Type | Reset | Description                                                                                                                                                                                                                              |
|-----|----------------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7   | 0              | R/W  | 0     | Must write 0                                                                                                                                                                                                                             |
| 6-5 | SERDES PRBS    | R/W  | 0     | This register selects the PRBS pattern in the LINK LAYER (no 8b/10b encoding). PRBS pattern must be enabled (D4).<br>0: PRBS 2 <sup>7</sup> -1<br>1: PRBS 2 <sup>15</sup> -1<br>2: PRBS 2 <sup>23</sup> -1<br>3: PRBS 2 <sup>31</sup> -1 |
| 4   | SERDES PRBS EN | R/W  | 0     | This register enables PRBS test pattern in the LINK LAYER<br>0: Test pattern mode disabled<br>1: PRBS test pattern mode enabled                                                                                                          |
| 3-0 | 0              | R/W  | 0     | Must write 0                                                                                                                                                                                                                             |

**Figure 7-71. Register 0x53 (JESD page)**

| 7      | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|--------|-------|-------|-------|-------|-------|-------|-------|
| SCR EN | 0     | 0     | 0     | 0     | 0     | 0     | 0     |
| R/W-0  | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-78. Register 0x53 Field Descriptions**

| Bit | Field  | Type | Reset | Description                                                                                                 |
|-----|--------|------|-------|-------------------------------------------------------------------------------------------------------------|
| 7   | SCR EN | R/W  | 0     | Enables scrambling of the JESD output data<br>0: Output scrambling disabled<br>1: Output scrambling enabled |
| 6-0 | 0      | R/W  | 0     | Must write 0                                                                                                |

**Figure 7-72. Register 0x7A (JESD page)**

| 7                 | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|-------------------|-------|-------|-------|-------|-------|-------|-------|
| JESD LANE POL INV |       |       |       |       |       |       |       |
| R/W-0             | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-79. Register 0x7A Field Descriptions**

| Bit | Field             | Type | Reset    | Description                                                                                                                                                                                            |
|-----|-------------------|------|----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-0 | JESD LANE POL INV | R/W  | 00000000 | This register inverts the polarity of the individual SERDES output lanes. Register bit D0 corresponds to SERDES lane DOUT0, D1 to DOUT1 etc<br>0: Output polarity as is<br>1: Output polarity inverted |

**Figure 7-73. Register 0x80/81/82/83 (JESD page)**

| ADDR | 7     | 6              | 5     | 4     | 3     | 2              | 1     | 0     |
|------|-------|----------------|-------|-------|-------|----------------|-------|-------|
| 0x80 | 0     | LANE DOUT1 SEL |       |       | 0     | LANE DOUT0 SEL |       |       |
| 0x81 | 0     | LANE DOUT3 SEL |       |       | 0     | LANE DOUT2 SEL |       |       |
| 0x82 | 0     | LANE DOUT5 SEL |       |       | 0     | LANE DOUT4 SEL |       |       |
| 0x83 | 0     | LANE DOUT7 SEL |       |       | 0     | LANE DOUT6 SEL |       |       |
|      | R/W-0 | R/W-0          | R/W-0 | R/W-0 | R/W-0 | R/W-0          | R/W-0 | R/W-0 |

**Table 7-80. Register 0x80/81/82/83 Field Descriptions**

| Bit | Field                | Type | Reset | Description                                                                                                                                                                                                                                                                               |
|-----|----------------------|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7,3 | 0                    | R/W  | 0     | Must write 0                                                                                                                                                                                                                                                                              |
| 6-4 | LANE DOUT1/3/5/7 SEL | R/W  | 000   | These register bits control the output mux. Any physical serdes output lane (DOUTx) can be connected to any JESD digital stream. By default lane DOUT0 is connected to JESD stream 0, lane DOUT1 to JESD stream 1 etc.<br>0: JESD stream 0<br>1: JESD stream 1<br>...<br>7: JESD stream 7 |
| 2-0 | LANE DOUT0/2/4/6 SEL | R/W  | 000   |                                                                                                                                                                                                                                                                                           |

**Figure 7-74. Register 0x84 (JESD page)**

| 7     | 6     | 5     | 4     | 3     | 2     | 1               | 0     |
|-------|-------|-------|-------|-------|-------|-----------------|-------|
| 0     | 0     | 0     | 0     | 0     | 0     | JESD PLL FACTOR |       |
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0           | R/W-0 |

**Table 7-81. Register 0x84 Field Descriptions**

| Bit | Field           | Type | Reset | Description                                                                                                                         |
|-----|-----------------|------|-------|-------------------------------------------------------------------------------------------------------------------------------------|
| 7-2 | 0               | R/W  | 0     | Must write 0                                                                                                                        |
| 1-0 | JESD PLL FACTOR | R/W  | 00    | This register bit must be set for 12-bit output LMFS = 8-2-8-20 only.<br>0: all other JESD LMFS modes<br>1: Set for LMFS = 8-2-8-20 |

**Figure 7-75. Register 0x89/8A/8B/8C/8D/8E/8F/90 (JESD page)**

| ADDR | 7                 | 6                   | 5     | 4                   | 3     | 2     | 1     | 0     |
|------|-------------------|---------------------|-------|---------------------|-------|-------|-------|-------|
| 0x89 | TX EMPH DOUT1 [0] | TX EMPH DOUT0 [5:0] |       |                     |       |       |       | 0     |
| 0x8A | 0                 | 0                   | 0     | TX EMPH DOUT1 [5:1] |       |       |       |       |
| 0x8B | TX EMPH DOUT3 [0] | TX EMPH DOUT2 [5:0] |       |                     |       |       |       | 0     |
| 0x8C | 0                 | 0                   | 0     | TX EMPH DOUT3 [5:1] |       |       |       |       |
| 0x8D | TX EMPH DOUT5 [0] | TX EMPH DOUT4 [5:0] |       |                     |       |       |       | 0     |
| 0x8E | 0                 | 0                   | 0     | TX EMPH DOUT5 [5:1] |       |       |       |       |
| 0x8F | TX EMPH DOUT7 [0] | TX EMPH DOUT6 [5:0] |       |                     |       |       |       | 0     |
| 0x90 | 0                 | 0                   | 0     | TX EMPH DOUT7 [5:1] |       |       |       |       |
|      | R/W-0             | R/W-0               | R/W-0 | R/W-0               | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-82. Register 0x89/8A/8B/8C/8D/8E/8F/90 Field Descriptions**

| Bit   | Field                     | Type | Reset  | Description                                                                                                                                                                                                                                                                                                                                |
|-------|---------------------------|------|--------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-5,0 | 0                         | R/W  | 0      | Must write 0                                                                                                                                                                                                                                                                                                                               |
| 6-1   | TX EMPH DOUT0/2/4/6 [5:0] | R/W  | 000000 | These bits select the amount of de-emphasis for the JESD output transmitter. The de-emphasis value in dB is measured as the ratio between the peak value after the signal transition to the settled value of the voltage in one bit period.<br>0: 0 dB<br>1: –1 dB<br>3: –2 dB<br>7: –4.1 dB<br>15: –6.2 dB<br>31: –8.2 dB<br>63: –11.5 dB |
| 4-0,7 | TX EMPH DOUT1/3/5/7 [5:0] | R/W  | 000000 |                                                                                                                                                                                                                                                                                                                                            |

**Figure 7-76. Register 0x9D/9E (JESD page)**

| 7              | 6              | 5              | 4              | 3              | 2              | 1              | 0              |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| PD DOUT7 [0,1] | PD DOUT6 [0,1] | PD DOUT5 [0,1] | PD DOUT4 [0,1] | PD DOUT3 [0,1] | PD DOUT2 [0,1] | PD DOUT1 [0,1] | PD DOUT0 [0,1] |
| R/W-0          | R/W-0          | R/W-0          | R/W-0          | R/W-0          | R/W-0          | R/W-0          | R/W-0          |

**Table 7-83. Register 0x9D/9E Field Descriptions**

| Bit | Field          | Type | Reset | Description                                                                                                                                                                                                                                                          |
|-----|----------------|------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-0 | PD DOUTx [0,1] | R/W  | 0     | Register 0x9D and 0x9E allow power down of individual serdes output lanes. Register 0x9D (PD DOUTx [0]) covers the output driver, 0x9E (PD DOUTx [1]) covers the associated internal high-speed data clock.<br>0: Output lane enabled<br>1: Output lane powered down |

**Figure 7-77. Register 0x9F (JESD page)**

| 7     | 6         | 5     | 4     | 3     | 2         | 1     | 0     |
|-------|-----------|-------|-------|-------|-----------|-------|-------|
| 0     | JESD PLL1 |       |       | 0     | JESD PLL2 |       |       |
| R/W-0 | R/W-0     | R/W-0 | R/W-0 | R/W-0 | R/W-0     | R/W-0 | R/W-0 |

**Table 7-84. Register 0x9F Field Descriptions**

| Bit | Field     | Type | Reset | Description                                                                                                                                 |
|-----|-----------|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------|
| 7   | 0         | R/W  | 0     | Must write 0                                                                                                                                |
| 6-4 | JESD PLL1 | R/W  | 000   | Internal JESD PLL input divider setting. See <a href="#">Table 7-86</a> how to configure it for the different decimation and LMFS settings. |
| 3   | 0         | R/W  | 0     | Must write 0                                                                                                                                |
| 2-0 | JESD PLL2 | R/W  | 000   | Internal JESD PLL input divider setting. See <a href="#">Table 7-86</a> how to configure it for the different decimation and LMFS settings. |

**Figure 7-78. Register 0xA0/A1/A2 (JESD page)**

| ADDR | 7     | 6               | 5     | 4     | 3               | 2     | 1     | 0     |
|------|-------|-----------------|-------|-------|-----------------|-------|-------|-------|
| 0xA0 | 0     | JESD PLL INPUT1 |       |       | 0               | 0     | 0     | 0     |
| 0xA1 | 0     | JESD PLL INPUT2 |       |       | 0               | 0     | 0     | 0     |
| 0xA2 | 0     | 0               | 0     | 0     | JESD PLL INPUT3 |       |       | 0     |
|      | R/W-0 | R/W-0           | R/W-0 | R/W-0 | R/W-0           | R/W-0 | R/W-0 | R/W-0 |

**Table 7-85. Register 0xA0/A1/A2 Field Descriptions**

| Bit | Field             | Type | Reset | Description                                                                                                                                                                                                |
|-----|-------------------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-0 | 0                 | R/W  | 0     | Must write 0                                                                                                                                                                                               |
| 6-4 | JESD PLL INPUT1/2 | R/W  | 000   | Internal JESD PLL input divider setting. See <a href="#">Table 7-86</a> (16-bit output) and <a href="#">Table 7-87</a> (20-bit output) how to configure it for the different decimation and LMFS settings. |
| 3-1 | JESD PLL INPUT3   | R/W  | 000   | Internal JESD PLL input divider setting. See <a href="#">Table 7-86</a> (16-bit output) and <a href="#">Table 7-87</a> (20-bit output) how to configure it for the different decimation and LMFS settings. |

**Table 7-86. Register settings for 0x9F/A0/A1/A2 based on bypass/decimation and LMFS mode (16-bit output)**

|          | JESD PLL1/2, JESD PLL INPUT 1/2 |    |    |     |     |     |      | JESD PLL INPUT 3 |    |    |     |     |     |      |
|----------|---------------------------------|----|----|-----|-----|-----|------|------------------|----|----|-----|-----|-----|------|
| LMFS     | BYP                             | /4 | /8 | /16 | /32 | /64 | /128 | BYP              | /4 | /8 | /16 | /32 | /64 | /128 |
| 8-2-2-4  | 0                               |    |    |     |     |     |      | 0                |    |    |     |     |     |      |
| 8-2-8-20 | 0                               |    |    |     |     |     |      | 0                |    |    |     |     |     |      |
| 8-4-8-10 | 0                               |    |    |     |     |     |      | 1                |    |    |     |     |     |      |
| 8-4-2-2  | 0                               | 1  | 2  | 3   | 3   |     |      | 1                | 0  | 0  | 0   | 2   |     |      |

**Table 7-86. Register settings for 0x9F/A0/A1/A2 based on bypass/decimation and LMFS mode (16-bit output) (continued)**

|           | JESD PLL1/2, JESD PLL INPUT 1/2 |   |   |   |   |   |   | JESD PLL INPUT 3 |   |   |   |   |   |   |
|-----------|---------------------------------|---|---|---|---|---|---|------------------|---|---|---|---|---|---|
| 8-8-2-1   |                                 | 0 | 1 | 2 | 3 | 4 |   |                  | 0 | 0 | 0 | 0 | 0 |   |
| 8-16-4-1  |                                 | 0 | 0 | 1 | 2 | 3 | 4 |                  | 1 | 0 | 0 | 0 | 0 | 0 |
| 4-2-2-2   |                                 | 1 | 2 | 3 |   |   |   |                  | 0 | 0 | 0 |   |   |   |
| 4-4-2-1   |                                 | 0 | 1 | 2 | 3 | 4 |   |                  | 0 | 0 | 0 | 0 | 0 |   |
| 4-8-4-1   |                                 | 0 | 0 | 1 | 2 | 3 | 4 |                  | 1 | 0 | 0 | 0 | 0 | 0 |
| 4-16-8-1  |                                 | 0 | 0 | 0 | 1 | 2 | 3 |                  | 3 | 1 | 0 | 0 | 0 | 0 |
| 2-2-2-1   |                                 | 0 | 1 | 2 | 3 | 4 |   |                  | 0 | 0 | 0 | 0 | 0 |   |
| 2-4-4-1   |                                 | 0 | 0 | 1 | 2 | 3 | 4 |                  | 0 | 0 | 0 | 0 | 0 | 0 |
| 2-8-8-1   |                                 | 0 | 0 | 0 | 1 | 2 | 3 |                  | 3 | 1 | 0 | 0 | 0 | 0 |
| 2-16-16-1 |                                 |   | 0 | 0 | 0 | 1 | 2 |                  |   | 3 | 1 | 0 | 0 | 0 |
| 1-2-4-1   |                                 | 0 | 0 | 1 | 2 | 3 | 4 |                  | 1 | 0 | 0 | 0 | 0 | 0 |
| 1-4-8-1   |                                 | 0 | 0 | 0 | 1 | 2 | 3 |                  | 3 | 1 | 0 | 0 | 0 | 0 |
| 1-8-16-1  |                                 |   | 0 | 0 | 0 | 1 | 2 |                  |   | 3 | 1 | 0 | 0 | 0 |
| 1-16-32-1 |                                 |   |   | 0 | 0 | 0 | 1 |                  |   |   | 3 | 1 | 0 | 0 |

**Table 7-87. Register settings for 0x9F/A0/A1/A2 based on decimation and LMFS mode (20-bit output)**

|           | JESD PLL1/2, JESD PLL INPUT 1/2 |    |     |     |     |      | JESD PLL INPUT 3 |    |     |     |     |      |
|-----------|---------------------------------|----|-----|-----|-----|------|------------------|----|-----|-----|-----|------|
| LMFS      | /4                              | /8 | /16 | /32 | /64 | /128 | /4               | /8 | /16 | /32 | /64 | /128 |
| 8-8-4-1   | 0                               | 0  | 1   | 2   | 3   | 4    | 1                | 0  | 0   | 0   | 0   | 0    |
| 8-16-8-1  | 0                               | 0  | 0   | 1   | 2   | 3    | 3                | 1  | 0   | 0   | 0   | 0    |
| 4-4-4-1   | 0                               | 0  | 1   | 2   | 3   | 4    | 1                | 0  | 0   | 0   | 0   | 0    |
| 4-8-8-1   | 0                               | 0  | 0   | 1   | 2   | 3    | 3                | 1  | 0   | 0   | 0   | 0    |
| 4-16-16-1 |                                 | 0  | 0   | 0   | 1   | 2    |                  | 3  | 1   | 0   | 0   | 0    |
| 2-2-4-1   | 0                               | 0  | 1   | 2   | 3   | 4    | 1                | 0  | 0   | 0   | 0   | 0    |
| 2-4-8-1   | 0                               | 0  | 0   | 1   | 2   | 3    | 3                | 1  | 0   | 0   | 0   | 0    |
| 2-8-16-1  |                                 | 0  | 0   | 0   | 1   | 2    |                  | 3  | 1   | 0   | 0   | 0    |
| 2-16-32-1 |                                 |    | 0   | 0   | 0   | 1    |                  |    | 3   | 1   | 0   | 0    |
| 1-2-8-1   | 0                               | 0  | 0   | 1   | 2   | 3    | 3                | 1  | 0   | 0   | 0   | 0    |
| 1-4-16-1  |                                 | 0  | 0   | 0   | 1   | 2    |                  | 3  | 1   | 0   | 0   | 0    |
| 1-8-32-1  |                                 |    | 0   | 0   | 0   | 1    |                  |    | 3   | 1   | 0   | 0    |
| 1-16-64-1 |                                 |    |     | 0   | 0   | 0    |                  |    |     | 3   | 1   | 0    |

**Figure 7-79. Register 0xA4..0xE2 (JESD page)**

|                              |       |       |       |       |       |       |       |
|------------------------------|-------|-------|-------|-------|-------|-------|-------|
| 7                            | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
| START VALUE JESD RAMP [19:0] |       |       |       |       |       |       |       |
| R/W-0                        | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-88. Register 0xA4..0xE2 Field Descriptions**

| Bit | Field                        | Type | Reset    | Description                                                                                                                                                                                                                                                |
|-----|------------------------------|------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-0 | START VALUE JESD RAMP [19:0] | R/W  | 00000000 | The JESD RAMP test pattern is designed to act as an individual RAMP pattern on each digital stream. See <a href="#">Section 7.3.8</a> for detailed examples. Different registers are being used to set RAMP starting values for different operating modes. |

**Figure 7-80. Register 0x100..0x17D (DDCA/B page)**

| 7                                                            | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|--------------------------------------------------------------|-------|-------|-------|-------|-------|-------|-------|
| NCOx FREQUENCYx [7:0],[15:8],[23:16],[31:24],[39:32],[47:40] |       |       |       |       |       |       |       |
| R/W-0                                                        | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-89. Register 0x100..0x17D Field Descriptions**

| Bit  | Field           | Type | Reset | Description                                                                                                                                                                               |
|------|-----------------|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 47:0 | NCOx FREQUENCYx | R/W  | 0     | The frequencies for NCOs are located in addresses 0x100 to 0x17D. Each frequency is 48-bit and the MSB starts on the highest address as illustrated in <i>NCO Frequency Programming</i> . |

**Figure 7-81. Register 0x180 (DDCA/B page)**

| 7     | 6     | 5       | 4            | 3        | 2         | 1     | 0        |
|-------|-------|---------|--------------|----------|-----------|-------|----------|
| 0     | 0     | DDC PDN | DDC DITH PDN | REAL DDC | DB/QB DDC | 0     | NCO MODE |
| R/W-0 | R/W-0 | R/W-0   | R/W-0        | R/W-0    | R/W-0     | R/W-0 | R/W-0    |

**Table 7-90. Register 0x180 Field Descriptions**

| Bit | Field        | Type | Reset | Description                                                                                                                |
|-----|--------------|------|-------|----------------------------------------------------------------------------------------------------------------------------|
| 7-6 | 0            | R/W  | 0     | Must write 0                                                                                                               |
| 5   | DDC PDN      | R/W  | 0     | This bit powers down the DDC mixer and NCO<br>0: DDC block enabled<br>1: DDC block powered down                            |
| 4   | DDC DITH PDN | R/W  | 0     | This bit powers down the dither in the DDC digital block<br>0: DDC dither enabled<br>1: DDC dither powered down            |
| 3   | REAL DDC     | R/W  | 0     | Set this bit to 1 in real decimation mode to disable the NCO.<br>0: Complex Decimation<br>1: Real Decimation               |
| 2   | DB/QB DDC    | R/W  | 0     | This register splits the NCOs for dual or quad band operation.<br>0: Dual Band<br>1: Quad Band                             |
| 1   | 0            | R/W  | 0     | Must write 0                                                                                                               |
| 0   | NCO MODE     | R/W  | 0     | This register selects phase coherent or phase continuous operation of the NCO.<br>0: Phase continuous<br>1: Phase coherent |

**Figure 7-82. Register 0x181 (DDCA/B page)**

| 7     | 6     | 5        | 4     | 3     | 2     | 1     | 0     |
|-------|-------|----------|-------|-------|-------|-------|-------|
| 0     | 0     | LOAD NCO |       | 0     | 0     | 0     | 0     |
| R/W-0 | R/W-0 | R/W-0    | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-91. Register 0x181 Field Descriptions**

| Bit | Field    | Type | Reset | Description                                                                                                                                                                              |
|-----|----------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-6 | 0        | R/W  | 0     | Must write 0                                                                                                                                                                             |
| 5-4 | LOAD NCO | R/W  | 00    | This register loads all the NCO frequencies from the memory to the NCOs. To update the NCO this register has to be set to 3 and back to 0 as shown in <i>NCO Frequency Programming</i> . |
| 3-0 | 0        | R/W  | 0     | Must write 0                                                                                                                                                                             |

**Table 7-92. NCO frequency programming example**

| ADDR  | DATA | DESCRIPTION                                                                                                                                |
|-------|------|--------------------------------------------------------------------------------------------------------------------------------------------|
| 0x105 | 0x4E | Frequency = 460 MHz with $F_S = 1.3$ GSPS<br>99,598,837,913,001 = 0x5A95A95A95A9 where the MSB goes to address 0x105 and the LSB to 0x100. |
| 0x104 | 0x81 |                                                                                                                                            |
| 0x103 | 0xB4 |                                                                                                                                            |
| 0x102 | 0xE8 |                                                                                                                                            |
| 0x101 | 0x1B |                                                                                                                                            |
| 0x100 | 0x4E |                                                                                                                                            |
| 0x181 | 0x00 | Load and update all NCO frequencies                                                                                                        |
| 0x181 | 0x30 |                                                                                                                                            |

**Figure 7-83. Register 0x34 (CALIBRATION page)**

| 7     | 6     | 5     | 4     | 3     | 2           | 1     | 0     |
|-------|-------|-------|-------|-------|-------------|-------|-------|
| 0     | 0     | 0     | 0     | 0     | AVG SEL (2) |       | 1     |
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0       | R/W-0 | R/W-0 |

**Table 7-93. Register 0x34 Field Descriptions**

| Bit | Field       | Type | Reset | Description                                                                                                                                         |
|-----|-------------|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-3 | 0           | R/W  | 0     | Must write 0                                                                                                                                        |
| 2-1 | AVG SEL (2) | R/W  | 00    | Selects ADC averaging. Also AVG SEL (1) in DIGITAL page needs to be set.<br>0: no average<br>01: 2 ADC average<br>10: not used<br>11: 4 ADC average |
| 0   | 1           | R/W  | 1     | Must write 1                                                                                                                                        |

**Figure 7-84. Register 0x45 (CALIBRATION page)**

| 7       | 6        | 5     | 4     | 3     | 2     | 1     | 0     |
|---------|----------|-------|-------|-------|-------|-------|-------|
| CAL SPI | CAL GPIO | 0     | 0     | 1     | 0     | 1     | 0     |
| R/W-0   | R/W-0    | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-94. Register 0x45 Field Descriptions**

| Bit | Field    | Type | Reset | Description                                                                               |
|-----|----------|------|-------|-------------------------------------------------------------------------------------------|
| 7   | CAL SPI  | R/W  | 0     | This register triggers the calibration using SPI write. It needs to be toggled (0=>1=>0). |
| 6   | CAL GPIO | R/W  | 0     | This register triggers the calibration using the GPIO1 pin.                               |
| 5-4 | 0        | R/W  | 0     | Must write 0                                                                              |
| 3   | 1        | R/W  | 1     | Must write 1                                                                              |
| 2   | 0        | R/W  | 0     | Must write 0                                                                              |
| 1   | 1        | R/W  | 1     | Must write 1                                                                              |
| 0   | 0        | R/W  | 0     | Must write 0                                                                              |

**Figure 7-85. Register 0x298 (CALIBRATION page)**

| 7     | 6     | 5     | 4     | 3          | 2     | 1     | 0     |
|-------|-------|-------|-------|------------|-------|-------|-------|
| 0     | 0     | 0     | 0     | CAL STATUS |       |       |       |
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0      | R/W-0 | R/W-0 | R/W-0 |

**Table 7-95. Register 0x298 Field Descriptions**

| Bit | Field      | Type | Reset | Description                                                                                                                                       |
|-----|------------|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-4 | 0          | R/W  | 0     | Must write 0                                                                                                                                      |
| 3-0 | CAL STATUS | R/W  | 0000  | This register can be used to check if calibration state machine has finished without any errors. A value of 0xE indicates successful calibration. |

**Figure 7-86. Register 0x6D/6E (ANALOG page)**

| 7              | 6     | 5     | 4     | 3     | 2     | 1              | 0     |
|----------------|-------|-------|-------|-------|-------|----------------|-------|
| RESET SW [1:0] |       | 0     | 0     | 0     | 0     | 0              | 0     |
| 0              | 0     | 0     | 0     | 0     | 0     | RESET SW [3:2] |       |
| R/W-0          | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0          | R/W-0 |

**Table 7-96. Register 0x6D/6E Field Descriptions**

| Bit | Field          | Type | Reset | Description                                                                                                                 |
|-----|----------------|------|-------|-----------------------------------------------------------------------------------------------------------------------------|
| 7-6 | RESET SW [1:0] | R/W  | 00    | This register disables the sampling reset switch.<br>00: Sampling reset switch enabled<br>1: Sampling reset switch disabled |
| 5-0 | 0              | R/W  | 0     | Must write 0                                                                                                                |
| 1-0 | RESET SW [3:2] | R/W  | 00    | This register disables the sampling reset switch.<br>00: Sampling reset switch enabled<br>1: Sampling reset switch disabled |
| 7-2 | 0              | R/W  | 0     | Must write 0                                                                                                                |

**Figure 7-87. Register 0x7B (ANALOG page)**

| 7     | 6     | 5      | 4     | 3     | 2     | 1     | 0      |
|-------|-------|--------|-------|-------|-------|-------|--------|
| 0     | 0     | TERM A | 0     | 0     | 0     | 0     | TERM A |
| R/W-0 | R/W-0 | R/W-0  | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0  |

**Table 7-97. Register 0x7B Field Descriptions**

| Bit | Field  | Type | Reset | Description                                                                                                                                                                                                                     |
|-----|--------|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-6 | 0      | R/W  | 0     | Must write 0                                                                                                                                                                                                                    |
| 5,0 | TERM A | R/W  | 00    | These registers set the internal termination resistor at the analog inputs for channel A1 and A2. Both registers need to be set to the same value.<br>0: 100 ohm differential termination<br>1: 50 ohm differential termination |
| 4-1 | 0      | R/W  | 0     | Must write 0                                                                                                                                                                                                                    |

**Figure 7-88. Register 0x8B (ANALOG page)**

| 7     | 6     | 5      | 4     | 3     | 2     | 1     | 0      |
|-------|-------|--------|-------|-------|-------|-------|--------|
| 0     | 0     | TERM B | 0     | 0     | 0     | 0     | TERM B |
| R/W-0 | R/W-0 | R/W-0  | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0  |

**Table 7-98. Register 0x8B Field Descriptions**

| Bit | Field  | Type | Reset | Description                                                                                                                                                                                                                     |
|-----|--------|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-6 | 0      | R/W  | 0     | Must write 0                                                                                                                                                                                                                    |
| 5,0 | TERM B | R/W  | 00    | These registers set the internal termination resistor at the analog inputs for channel B1 and B2. Both registers need to be set to the same value.<br>0: 100 ohm differential termination<br>1: 50 ohm differential termination |
| 4-1 | 0      | R/W  | 0     | Must write 0                                                                                                                                                                                                                    |

**Figure 7-89. Register 0xA8 (ANALOG page)**

| 7     | 6         | 5     | 4     | 3     | 2     | 1     | 0     |
|-------|-----------|-------|-------|-------|-------|-------|-------|
| 0     | DITH AMP1 |       |       |       | 0     | 0     | 0     |
| R/W-0 | R/W-0     | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-99. Register 0xA8 Field Descriptions**

| Bit | Field     | Type | Reset | Description                                                                                                                                                                                                                                                                                         |
|-----|-----------|------|-------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7   | 0         | R/W  | 0     | Must write 0                                                                                                                                                                                                                                                                                        |
| 6-3 | DITH AMP1 | R/W  | 0000  | This register sets dither amplitude coarse gain. There are two recommended settings:<br>0000: Amplitude = 0<br>0011: Amplitude = 3<br>Here is a list of all the settings:<br>0000: Amplitude = 0 (smallest)<br>0001: Amplitude = 1<br>...<br>1110: Amplitude = 14<br>1111: Amplitude = 15 (largest) |
| 2-0 | 0         | R/W  | 0     | Must write 0                                                                                                                                                                                                                                                                                        |

**Figure 7-90. Register 0xAF (ANALOG page)**

| 7          | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|------------|-------|-------|-------|-------|-------|-------|-------|
| DITHER DIS | 0     | 0     | 1     | 0     | 0     | 0     | 0     |
| R/W-0      | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-100. Register 0xAF Field Descriptions**

| Bit | Field      | Type | Reset | Description                                                                        |
|-----|------------|------|-------|------------------------------------------------------------------------------------|
| 7   | DITHER DIS | R/W  | 0     | This register disables internal dither.<br>0: Dither enabled<br>1: Dither disabled |
| 6-5 | 0          | R/W  | 0     | Must write 0                                                                       |
| 4   | 1          | R/W  | 0     | Must write 1                                                                       |
| 3-0 | 0          | R/W  | 0     | Must write 0                                                                       |

**Figure 7-91. Register 0xB1 (ANALOG page)**

| 7              | 6     | 5     | 4     | 3     | 2     | 1     | 0     |
|----------------|-------|-------|-------|-------|-------|-------|-------|
| DITHER DIVIDER |       |       |       |       |       |       |       |
| R/W-0          | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-101. Register 0xB1 Field Descriptions**

| Bit | Field          | Type | Reset | Description                                                                                                                                          |
|-----|----------------|------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-0 | DITHER DIVIDER | R/W  | 0     | This register sets the dither divider frequency. SPI write is actual -1. For example a divider of 48 is 47 (0x2F).<br>0x00 (default) is a divide /50 |

**Figure 7-92. Register 0xB4 (ANALOG page)**

| 7     | 6     | 5     | 4     | 3     | 2     | 1     | 0         |
|-------|-------|-------|-------|-------|-------|-------|-----------|
| 0     | 0     | 0     | 0     | 0     | 0     | 0     | SYSREF AC |
| R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0     |

**Table 7-102. Register 0xB4 Field Descriptions**

| Bit | Field     | Type | Reset | Description                                                                                                                                                                                              |
|-----|-----------|------|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-1 | 0         | R/W  | 0     | Must write 0                                                                                                                                                                                             |
| 0   | SYSREF AC | R/W  | 0     | This register enables external AC coupling of the SYSREF input with internal biasing.<br>0: External DC coupling with internal 100 $\Omega$ termination<br>1: External AC coupling with internal biasing |

**Figure 7-93. Register 0xCD (ANALOG page)**

| 7     | 6         | 5     | 4     | 3     | 2     | 1     | 0     |
|-------|-----------|-------|-------|-------|-------|-------|-------|
| 0     | DITH AMP2 |       |       | 0     | 0     | 0     | 0     |
| R/W-0 | R/W-0     | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 |

**Table 7-103. Register 0xCD Field Descriptions**

| Bit | Field     | Type | Reset | Description                                                                                                                                                                                                                                                                                                                                                                     |
|-----|-----------|------|-------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7   | 0         | R/W  | 0     | Must write 0                                                                                                                                                                                                                                                                                                                                                                    |
| 6-4 | DITH AMP2 | R/W  | 0     | This register sets dither amplitude fine gain. There are two recommended settings:<br>000: Amplitude = 0<br>100: Amplitude = -4<br>Here is a list of all the settings:<br>000: Amplitude = 0<br>001: Amplitude = 1<br>010: Amplitude = 2<br>011: Amplitude = 3 (largest)<br>100: Amplitude = -4 (smallest)<br>101: Amplitude = -3<br>110: Amplitude = -2<br>111: Amplitude = -1 |
| 3-0 | 0         | R/W  | 0     | Must write 0                                                                                                                                                                                                                                                                                                                                                                    |

**Figure 7-94. Register 0xE6/E7 (ANALOG page)**

| ADDR | 7            | 6     | 5     | 4     | 3     | 2     | 1              | 0     |
|------|--------------|-------|-------|-------|-------|-------|----------------|-------|
| 0xE6 | TX SWING [0] | 0     | 0     | 0     | 0     | 0     | 0              | 0     |
| 0xE7 | 0            | 0     | 0     | 0     | 0     | 0     | TX SWING [2:1] |       |
|      | R/W-0        | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0 | R/W-0          | R/W-0 |

**Table 7-104. Register 0xE6/E7 Field Descriptions**

| Bit   | Field          | Type | Reset | Description                                                                                                                                                                               |
|-------|----------------|------|-------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 7-0   | 0              | R/W  | 0     | Must write 0                                                                                                                                                                              |
| 1,0,7 | TX SWING [2:0] | R/W  | 000   | This register adjusts the output amplitude on all 8 serdes lanes.<br>0: 850 mVpp<br>1: 825 mVpp<br>2: 800 mVpp<br>3: 775 mVpp<br>4: 950 mVpp<br>5: 925 mVpp<br>6: 900 mVpp<br>7: 875 mVpp |

## 8 Application and Implementation

### Note

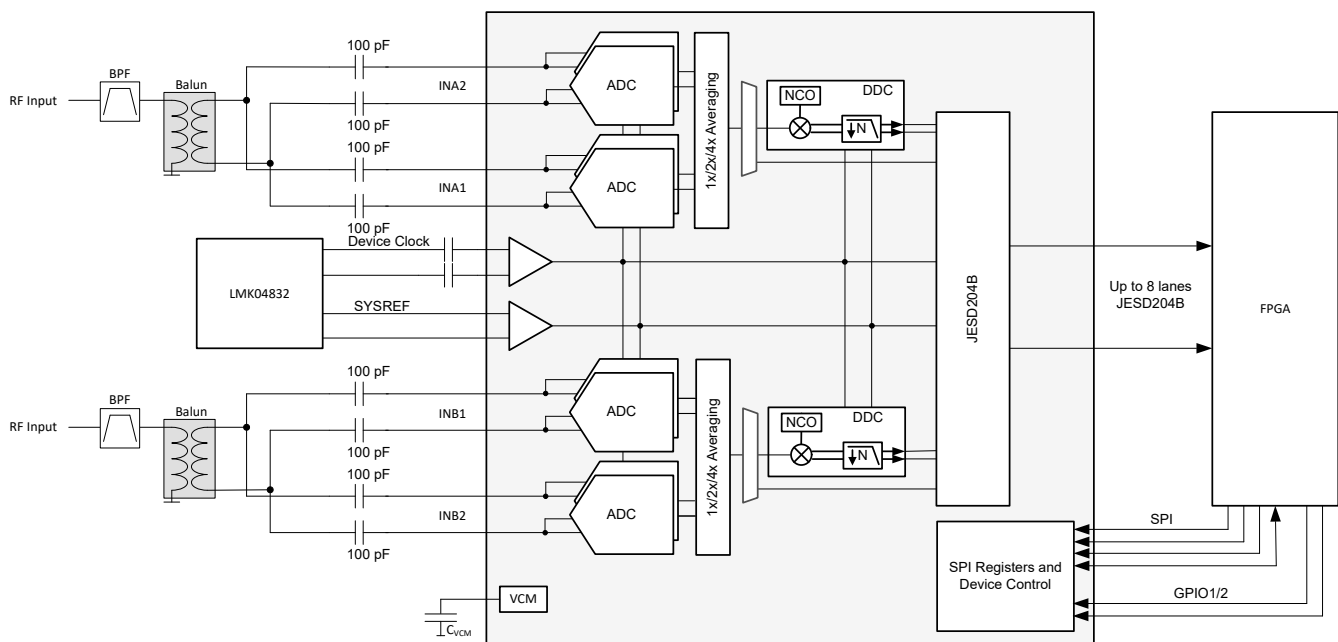
Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

### 8.1 Application Information

The ADC32RF5x can be used in a wide range of applications including radar, frequency domain digitizer and spectrum analyzer, test and communications equipment and software-defined radios (SDRs). The Typical Applications section describe one configuration that meets the needs of a number of these applications.

### 8.2 Typical Applications

#### 8.2.1 Wideband RF Sampling Receiver



**Figure 8-1. Typical Configuration for Wideband RF Sampling**

#### 8.2.1.1 Design Requirements

##### 8.2.1.1.1 Input Signal Path

Appropriate band limiting filters should be used to reject unwanted frequencies in the receive signal path.

A 1:2 (for 100 ohm effective termination impedance) or a 1:1 (for 50 ohm effective termination impedance) balun transformer is needed to convert the single ended RF input to differential for input to the ADC. The balun outputs should be AC coupled with 100 pF capacitors. The balun should have good amplitude (< 0.5 dB) and phase balance (less than 2 deg) within the frequency range of interest. A back-to-back balun configuration often times gives better SFDR performance. [Table 8-1](#) lists a number of recommended baluns for different impedance ratios and frequency ranges.

The S-parameters of the ADC input can be used to design the front end matching network.

**Table 8-1. Recommended Baluns**

| PART NUMBER | MANUFACTURER    | IMPEDANCE RATIO | AMPLITUDE BALANCE (dB) | PHASE BALANCE (°) | FREQUENCY RANGE  |
|-------------|-----------------|-----------------|------------------------|-------------------|------------------|
| BAL-0009SMG | Marki Microwave | 1:2             | 0.6                    | 5                 | 0.5 MHz to 9 GHz |
| TCM2-43X+   | Minicircuits    | 1:2             | 0.5                    | 7                 | 10 MHz to 4 GHz  |
| TCM2-33WX+  | Minicircuits    | 1:2             | 0.7                    | 4                 | 10 MHz to 3 GHz  |
| TC1-1-13M+  | Minicircuits    | 1:1             | 0.5                    | 2-3               | 10 MHz to 3 GHz  |

#### 8.2.1.1.2 Clocking

The ADC32RF52 clock inputs must be AC-coupled to the device to provide the rated performance. The clock source must have low jitter (integrated phase noise) for the ADC to meet the stated SNR performance, especially when operating at higher input frequencies. The clock signal may need to be filtered with a band pass filter to remove some of the broad band clock noise.

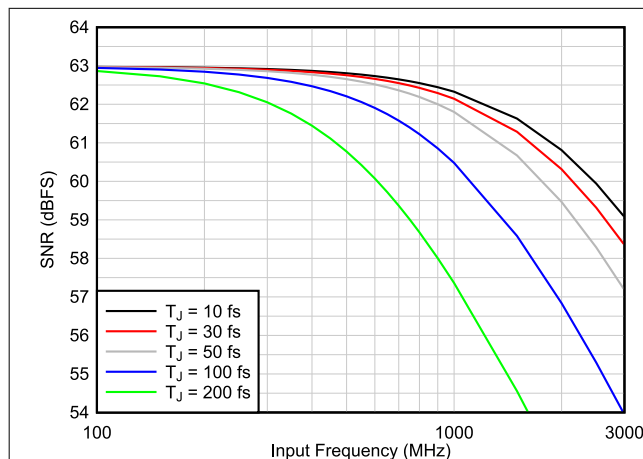
The JESD204B data converter system (ADC and FPGA) requires additional SYSREF and device clocks. The LMK04828 or LMK04832 devices are suitable to generate these clocks. Depending on the ADC clock frequency and jitter requirements, this device may also be used as a system clock synthesizer or as a device clock and SYSREF distribution device when using multiple ADC32RF52 devices in a system.

#### 8.2.1.2 Detailed Design Procedure

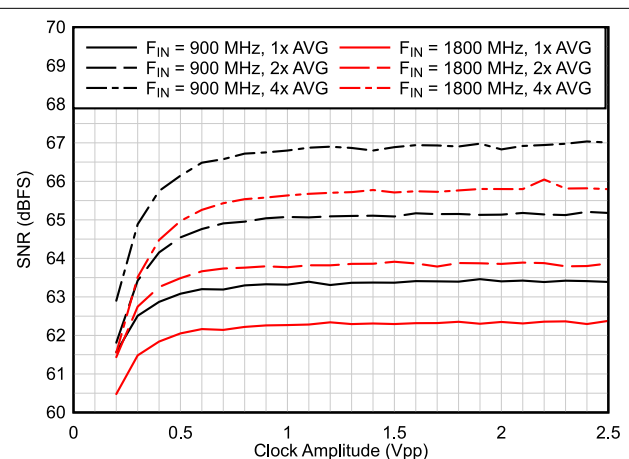
##### 8.2.1.2.1 Sampling Clock

To maximize the SNR performance of the ADC a very low jitter (< 50 fs) sampling clock is required. Figure 8-2 shows the estimated SNR performance vs input frequency vs external clock jitter. The internal ADC aperture jitter also has some dependency to the clock amplitude (gets more sensitive with higher input frequency) as shown in Figure 8-3.

When using averaging and/or decimation, the SNR for a single ADC core should be estimated first before adding the SNR improvement from internal averaging and/or decimation.



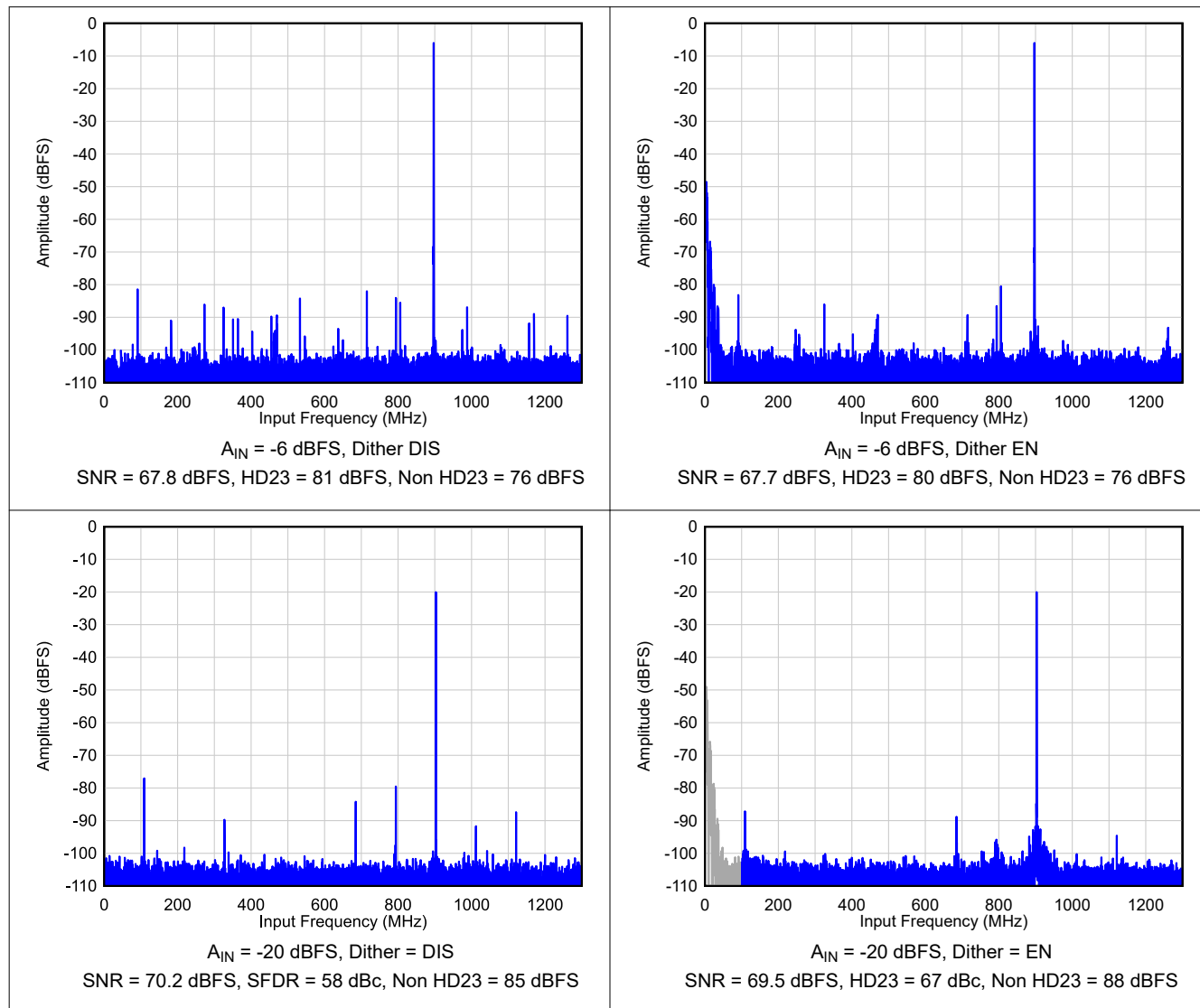
**Figure 8-2. SNR vs  $T_{Jitter}$  vs  $F_{IN}$  (1x AVG)**



**Figure 8-3. SNR vs Clock Amplitude (dither off)**

### 8.2.1.3 Application Curves

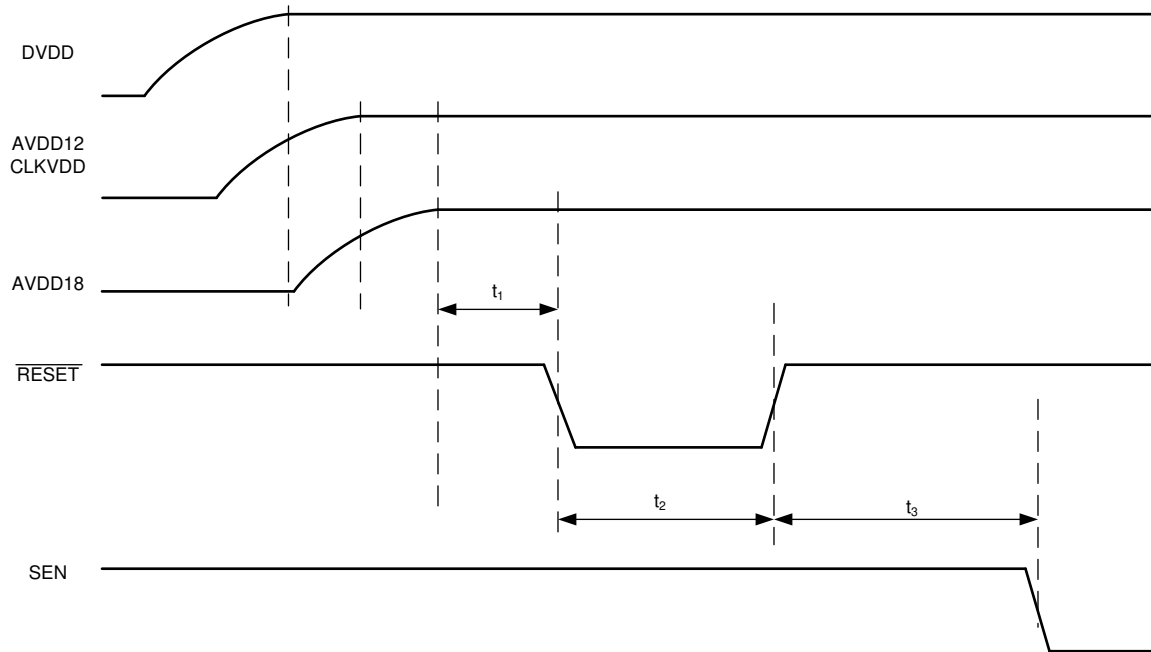
The following application curves demonstrate performance and results only of the ADC using a balun front end and configured to 4x internal averaging. The input frequency is 900 MHz ( $F_S = 2.6$  GSPS) and input amplitudes of -6 and -20 dBFS are shown with dither enabled/disabled.



### 8.3 Initialization Set Up

After power-up, the internal registers must be initialized to their default values through a hardware reset by applying a low pulse on the RESET pin, as shown in Figure 8-4.

1. Apply 1.2 V DVDD digital power supply
2. Apply remaining 1.2 V power supplies (AVDD12, CLKVDD), in no specific order
3. Apply 1.8 V AVDD18 power supply
4. Apply hardware reset. After hardware reset is released, the default registers are loaded from internal fuses.
5. Begin programming the internal registers using the SPI interface.



**Figure 8-4. Initialization of serial registers after power up**

**Table 8-2. Power-up timing**

|                |                                                                | MIN | TYP | MAX | UNIT         |
|----------------|----------------------------------------------------------------|-----|-----|-----|--------------|
| t <sub>1</sub> | Power-on delay: delay from power up to active high RESET pulse | 1   |     |     | ms           |
| t <sub>2</sub> | Reset pulse width: active low RESET pulse width                | 100 |     |     | ns           |
| t <sub>3</sub> | Register write delay: delay from RESET disable to SEN active   | 45k |     |     | Clock cycles |

### 8.3.1 Initial Device Configuration After Power-Up

The following section outlines the sequence of register writes for the device configuration after initial power up.

**Table 8-3. Summary of programming steps after initial power up**

| Step | Section       | Description                                                                                                                    |
|------|---------------|--------------------------------------------------------------------------------------------------------------------------------|
| 1    | RESET         | Hardware and software RESET to reset all registers to known state                                                              |
| 2    | DEVICE CONFIG | Configures the digital operating modes like averaging, test pattern output, input termination, internal dither and decimation. |
| 3    | JESD          | Configures the JESD204B interface                                                                                              |
| 4    | SYSREF        | Enables SYSREF input and resets internal circuits based on external SYSREF signal.                                             |
| 5    | JESD          | Clears and configures some of the JESD registers                                                                               |
| 6    | TRIM          | Set trim settings for best analog performance                                                                                  |
| 7    | CALIB CONFIG  | Configure the calibration settings                                                                                             |
| 8    | SYSREF        | Issue SYSREF for trim settings to go into effect                                                                               |
| 9    | RUN CALIB     | Run power up calibration                                                                                                       |
| 10   | JESD          | Synchronize the JESD interface with the receiver                                                                               |

The following section outlines the detailed register writes for the device configuration after initial power up. This includes all the register writes (fields in grey) which are not documented in the register summary table. The register examples are given for 2x internal averaging, DDC bypass mode (LMFS = 8224).

#### 8.3.1.1 STEP 1: RESET

After the initial power up, both hardware and software reset are required.

**Table 8-4. Register Programming Sequence for Software RESET**

| ADDRESS | DATA | DESCRIPTION                                                                 |
|---------|------|-----------------------------------------------------------------------------|
| 0x00    | 0x01 | Software set and reset                                                      |
| 0x00    | 0x00 |                                                                             |
| 0x01    | 0x00 | These two resets are staggered to minimize strain on external power supply. |
| 0x09    | 0x20 |                                                                             |
| 0x09    | 0x80 |                                                                             |
| 0x09    | 0x00 |                                                                             |
| 0x08    | 0x01 | Internal memory reset (set and reset)                                       |
| 0x08    | 0x00 |                                                                             |
| 0x05    | 0x40 | Select ANALOG page                                                          |
| 0x47    | 0x80 | Analog reset (set and reset)                                                |
| 0x47    | 0x00 |                                                                             |

### 8.3.1.2 STEP 2: Device Configuration

In this step, the operating mode and digital features (DDC, test pattern) are configured.

**Table 8-5. Register Programming Sequence for Device Configuration**

| ADDRESS | DATA | DESCRIPTION                                                           |
|---------|------|-----------------------------------------------------------------------|
| 0x05    | 0x20 | Select CALIBRATION page                                               |
| 0x34    | 0x03 | Select 2x averaging (1x AVG: 0x01, 4x AVG: 0x07)                      |
| 0x05    | 0x02 | Select DIGITAL page                                                   |
| 0x2C    | 0x01 | Select DDC Bypass mode                                                |
| 0x2D    | 0x00 | No decimation, step can be skipped                                    |
| 0x2E    | 0x0B | Select 2x averaging (1x: 0x09, 2x: 0x0B, 4x: 0x0D), OVR on JESD       |
| 0x23C   | 0x07 | Set register to 0x07                                                  |
| 0x33    | 0x10 | Set register to 0x10                                                  |
| 0x2F    | 0x11 | Set register to 0x11 (1x: 0x55, 2x: 0x11, 4x: 0xE1)                   |
| 0x30    | 0x11 | Set register to 0x11 (1x: 0x55, 2x: 0x11, 4x: 0xE1)                   |
| 0x05    | 0x40 | Select ANALOG page                                                    |
| 0x7B/8B | 0x00 | Select internal input termination (0x00 = 100 $\Omega$ )              |
| 0xA8    | 0x00 | DITHER AMP1: 3 = 0x80, 0 = 0x00                                       |
| 0xCD    | 0x00 | DITHER AMP2: -4 = 0x40, 0 = 0x00                                      |
| 0x04    | 0x01 |                                                                       |
| 0x20    | 0x04 |                                                                       |
| 0x91    | 0x40 |                                                                       |
| 0xAF    | 0x10 |                                                                       |
| 0xB1    | 0x00 | Sets dither divider. 0x00 = /50                                       |
| 0xB2    | 0x00 |                                                                       |
| 0xAF    | 0x18 |                                                                       |
| 0xAF    | 0x10 | 0x10 = dither ENABLED, 0x90 = dither DISABLED                         |
| 0x04    | 0x01 |                                                                       |
| 0x20    | 0x00 |                                                                       |
| 0x04    | 0x00 |                                                                       |
| 0x05    | 0x02 |                                                                       |
| 0x363   | 0x01 |                                                                       |
| 0x05    | 0x18 | Select DDCA and DDCB pages, load non linearity correction (NLC) trims |
| 0x21D   | 0x00 |                                                                       |
| 0x21E   | 0x01 |                                                                       |
| 0x205   | 0x03 |                                                                       |
| 0x204   | 0xFF |                                                                       |
| 0x31D   | 0x00 |                                                                       |
| 0x31E   | 0x01 |                                                                       |
| 0x305   | 0x03 |                                                                       |
| 0x304   | 0xFF |                                                                       |
| 0x31C   | 0x3E |                                                                       |
| 0x325   | 0x00 | Load NLC                                                              |
| 0x325   | 0x01 |                                                                       |
| 0x325   | 0x00 |                                                                       |

**Table 8-5. Register Programming Sequence for Device Configuration (continued)**

| ADDRESS       | DATA            | DESCRIPTION |
|---------------|-----------------|-------------|
| Sampling Rate | 640 - 1500 MSPS |             |
| Nyquist Zone  | 1st             | 2nd         |
| 0x206         | 0x0E            | 0x0F        |
| 0x207         | 0x00            | 0x00        |
| 0x208         | 0x00            | 0x00        |
| 0x209         | 0x00            | 0x00        |
| 0x20A         | 0xF5            | 0xF4        |
| 0x20B         | 0x03            | 0x03        |
| 0x20C         | 0x27            | 0x28        |
| 0x20D         | 0x00            | 0x00        |
| 0x210         | 0xFC            | 0F9         |
| 0x211         | 0x03            | 0x03        |
| 0x212         | 0x5F            | 0xFD        |
| 0x213         | 0x03            | 0x03        |
| 0x21A         | 0x3C            | 0x3D        |
| 0x21C         | 0x00            | 0x00        |
| 0x223         | 0xFF            | 0xFF        |
| 0x224         | 0xFF            | 0xFF        |
| 0x225         | 0x00            | Load NLC    |
| 0x225         | 0x01            |             |
| 0x225         | 0x00            |             |
| 0x20          | 0x02            | OVR MUX EN  |
| 0x203         | 0x30            |             |
| 0x303         | 0x30            |             |
| 0x180         | 0x30            |             |

**8.3.1.3 STEP 3: JESD Interface Configuration (1)**

In this step, the JESD204B digital interface and the parameters are configured.

**Table 8-6. Register Programming Sequence for JESD204B Interface Configuration**

| ADDRESS | DATA | DESCRIPTION           |
|---------|------|-----------------------|
| 0x05    | 0x02 | Select DIGITAL page   |
| 0x81    | 0x00 | Set register to 0x00  |
| 0x80    | 0xF0 | Set register to 0xF0  |
| 0x7F    | 0xFF | Set register to 0xFF  |
| 0x7E    | 0xFF | Set register to 0xFF  |
| 0x7D    | 0xFF | Set register to 0xFF  |
| 0x7C    | 0xFF | Set register to 0xFF  |
| 0x7B    | 0x3B | Set register to 0x3B  |
| 0x7A    | 0x28 | Set register to 0x28  |
| 0x79    | 0x51 | Set register to 0x51  |
| 0x78    | 0x40 | Set register to 0x40  |
| 0x05    | 0x04 | Select JESD page      |
| 0x23    | 0x03 | Set register to 0x03  |
| 0x29    | 0xFF | Set register to 0xFF  |
| 0x20    | 0x0F | Select K (0x0F: K=15) |

**Table 8-6. Register Programming Sequence for JESD204B Interface Configuration (continued)**

| ADDRESS | DATA | DESCRIPTION                                |
|---------|------|--------------------------------------------|
| 0x21    | 0x01 | SYSREF mode                                |
| 0x22    | 0x01 | Select LMFS configuration (LMFS = 8-2-2-4) |
| 0x24    | 0x00 | Select DDC CLK DIV                         |
| 0x25    | 0x00 | Select JESD TX CLK DIV                     |
| 0x26    | 0x00 |                                            |
| 0x27    | 0x02 | Select CLK BAL EN for LMFS = 8-2-2-4       |
| 0x53    | 0x80 | Output scrambler EN/DIS (SCR EN)           |
| 0x5C    | 0x01 | F-1 in ILA (F=2)                           |
| 0x5D    | 0x0F | K-1 in ILA (K=15)                          |
| 0x6E    | 0x11 |                                            |
| 0xA0    | 0x00 | Select JESD PLL INPUT divider 1/2/3        |
| 0xA1    | 0x00 |                                            |
| 0xA2    | 0x00 |                                            |
| 0x9F    | 0x00 | Select JESD PLL setting                    |
| 0x2A    | 0x0C |                                            |
| 0x23    | 0x02 | JESD INIT toggle                           |
| 0x23    | 0x00 |                                            |

#### 8.3.1.4 STEP 4: SYSREF Synchronization

After device and JESD204B interface configuration a synchronization using external SYSREF is necessary.

**Table 8-7. Device Synchronization Using External SYSREF**

| ADDRESS | DATA | DESCRIPTION                                                 |
|---------|------|-------------------------------------------------------------|
| 0x05    | 0x02 | Select DIGITAL page                                         |
| 0x236   | 0x02 | Enable internal SYSREF input and clear SYSREF pulse counter |
| 0x236   | 0x03 | Starts SYSREF counter                                       |

#### 8.3.1.5 STEP 5: JESD Interface Configuration (2)

Some registers of the JESD204B interface need to be set after the first SYSREF.

**Table 8-8. Register Programming Sequence for JESD204B Interface Configuration**

| ADDRESS | DATA | DESCRIPTION      |
|---------|------|------------------|
| 0x05    | 0x04 | Select JESD page |
| 0x29    | 0x00 |                  |
| 0x84    | 0x00 | JESD PLL factor  |

### 8.3.1.6 STEP 6: Analog Trim Settings

The following registers need to be set for best analog performance. The register write order is all writes in first 2 columns before moving to the next set of address/data in middle columns, and so on.

**Table 8-9. Analog Trim Setting Registers**

| ADDR  | DATA | ADDR  | DATA                                                                                               | ADDR  | DATA |
|-------|------|-------|----------------------------------------------------------------------------------------------------|-------|------|
| 0x05  | 0x40 | 0xA8  | 1x AVG: 0x18<br>2x/4x AVG:<br>F <sub>S</sub> <1.1 GSPS: 0x00<br>F <sub>S</sub> =1.1-1.5 GSPS: 0x08 | 0x56  | 0x0F |
| 0xE8  | 0xF0 |       |                                                                                                    | 0x6E  | 0x08 |
| 0xE9  | 0x01 |       |                                                                                                    | 0x102 | 0x02 |
| 0x4B  | 0x1F | 0xCD  | 0x00                                                                                               | 0x103 | 0xD9 |
| 0x5B  | 0x01 | 0xCE  | 0x00                                                                                               | 0xA7  | 0x00 |
| 0xEA  | 0x00 | 0x100 | See <a href="#">Table 8-10</a> for<br>sample rate dependent<br>trim registers                      | 0xA6  | 0x08 |
| 0xEB  | 0x03 | 0x101 |                                                                                                    | 0x05  | 0x20 |
| 0x95  | 0x00 | 0x104 |                                                                                                    | 0xC9  | 0x09 |
| 0xFC  | 0x28 | 0x105 |                                                                                                    | 0x102 | 0xFE |
| 0xE0  | 0x8E | 0x107 | 0x10                                                                                               | 0x103 | 0x03 |
| 0xE1  | 0x03 | 0x05  | 0x20                                                                                               | 0x104 | 0xD4 |
| 0x4C  | 0x40 | 0x30  | 0xE8                                                                                               | 0x105 | 0x03 |
| 0x4E  | 0x01 | 0x31  | 0xFF                                                                                               | 0x106 | 0xFE |
| 0x4E  | 0x00 | 0x30  | 0x08                                                                                               | 0x107 | 0x03 |
| 0xA1  | 0x01 | 0x31  | 0x80                                                                                               | 0x108 | 0xBC |
| 0xF8  | 0x00 | 0x32  | 0x03                                                                                               | 0x109 | 0x1A |
| 0x31  | 0x20 | 0x05  | 0x02                                                                                               | 0x101 | 0x01 |
| 0xFD  | 0x1C | 0x243 | 0x02                                                                                               | 0x159 | 0x63 |
| 0xAA  | 0x02 | 0x05  | 0x20                                                                                               | 0x05  | 0x40 |
| 0x4D  | 0x80 | 0x36  | 0x04                                                                                               | 0x31  | 0x00 |
| 0xB3  | 0x30 | 0x1F8 | 0x01                                                                                               | 0x4D  | 0x00 |
| 0x64  | 0x10 | 0x1FC | 0x0A                                                                                               | 0x62  | 0x10 |
| 0x62  | 0x12 | 0x1F0 | 0x20                                                                                               | 0x56  | 0x0E |
| 0xFE  | 0x80 | 0x1F1 | 0x0C                                                                                               | 0x56  | 0x0C |
| 0xFC  | 0x28 | 0x05  | 0x40                                                                                               | 0x56  | 0x08 |
| 0xFF  | 0x14 | 0x39  | 0x40                                                                                               | 0x56  | 0x00 |
| 0x106 | 0x00 | 0x56  | 0x01                                                                                               | 0x6E  | 0x00 |
| 0x107 | 0x00 | 0x56  | 0x03                                                                                               | 0xF8  | 0x06 |
| 0x3B  | 0x0C | 0x56  | 0x07                                                                                               |       |      |

**Table 8-10. Sample rate dependent trim registers**

| F <sub>S</sub> (GSPS) | 0x100 | 0x101 | 0x104 | 0x105 |
|-----------------------|-------|-------|-------|-------|
| 0.6-0.7               | 0x48  | 0x00  | 0x01  | 0x01  |
| 0.7-0.9               | 0xC8  | 0x01  | 0x81  | 0x00  |
| 0.9-1.1               | 0x48  | 0x01  | 0x81  | 0x00  |
| 1.1-1.3               | 0xC8  | 0x00  | 0x81  | 0x00  |
| 1.3-1.5               | 0x48  | 0x00  | 0x81  | 0x00  |

### 8.3.1.7 STEP 7: Calibration Configuration

The following registers configure the internal foreground calibration. The register write order is all writes in first 2 columns before moving to the next set of address/data in middle columns, and so on.

**Table 8-11. Calibration Register Settings**

| ADDRESS | DATA | ADDRESS | DATA | ADDRESS | DATA |
|---------|------|---------|------|---------|------|
| 0x05    | 0x40 | 0xFC    | 0x13 | 0x47    | 0xC7 |
| 0x68    | 0xC0 | 0xFD    | 0x08 | 0x46    | 0x13 |
| 0x69    | 0xFF | 0x36    | 0x04 | 0xFC    | 0x13 |
| 0x05    | 0x20 | 0x36    | 0x05 | 0xFD    | 0x00 |
| 0x46    | 0x03 | 0x36    | 0x04 | 0x36    | 0x04 |
| 0x47    | 0xC2 | 0xFC    | 0x13 | 0x36    | 0x05 |
| 0x46    | 0x13 | 0xFD    | 0x0A | 0x36    | 0x04 |
| 0x1AE   | 0x00 | 0x36    | 0x04 | 0xFC    | 0x13 |
| 0x1E6   | 0x1C | 0x36    | 0x05 | 0xFD    | 0x02 |
| 0x1AE   | 0x00 | 0x36    | 0x04 | 0x36    | 0x04 |
| 0x1E6   | 0x1C | 0xFC    | 0x13 | 0x36    | 0x05 |
| 0x1E9   | 0x08 | 0xFD    | 0x0C | 0x36    | 0x04 |
| 0x1E9   | 0xA8 | 0x36    | 0x04 | 0xFC    | 0x13 |
| 0x1E8   | 0x02 | 0x36    | 0x05 | 0xFD    | 0x04 |
| 0x1E8   | 0x06 | 0x36    | 0x04 | 0x36    | 0x04 |
| 0x1E8   | 0x04 | 0xFC    | 0x13 | 0x36    | 0x05 |
| 0x1E8   | 0x00 | 0xFD    | 0x0E | 0x36    | 0x04 |
| 0x1E9   | 0xA0 | 0x36    | 0x04 | 0xFC    | 0x13 |
| 0x1F0   | 0x28 | 0x36    | 0x05 | 0xFD    | 0x06 |
| 0x1F1   | 0x0C | 0x36    | 0x04 | 0x36    | 0x04 |
| 0x1F0   | 0x2A | 0xFC    | 0x03 | 0x36    | 0x05 |
| 0x1F0   | 0x2E | 0x36    | 0x04 | 0x36    | 0x04 |
| 0x1F0   | 0x2C | 0x46    | 0x03 | 0xFC    | 0x13 |
| 0x1F0   | 0x28 | 0x47    | 0xC0 | 0xFD    | 0x08 |
| 0x1F0   | 0x08 | 0x46    | 0x13 | 0x36    | 0x04 |
| 0x1F0   | 0x18 | 0x46    | 0x03 | 0x36    | 0x05 |
| 0x1F0   | 0x38 | 0x47    | 0xC7 | 0x36    | 0x04 |
| 0x1F1   | 0x0C | 0x46    | 0x13 | 0xFC    | 0x13 |
| 0x1F0   | 0x3A | 0x1AE   | 0x00 | 0xFD    | 0x0A |
| 0x1F0   | 0x3E | 0x1E6   | 0x1C | 0x36    | 0x04 |
| 0x1F0   | 0x3C | 0x1AE   | 0x00 | 0x36    | 0x05 |
| 0x1F0   | 0x38 | 0x1E6   | 0x1C | 0x36    | 0x04 |
| 0x1F0   | 0x18 | 0x1E9   | 0xA8 | 0xFC    | 0x13 |
| 0x1F0   | 0x10 | 0x1E8   | 0x02 | 0xFD    | 0x0C |
| 0x1AE   | 0x00 | 0x1E8   | 0x06 | 0x36    | 0x04 |
| 0x1E6   | 0x1C | 0x1E8   | 0x04 | 0x36    | 0x05 |
| 0x1AE   | 0x00 | 0x1E8   | 0x00 | 0x36    | 0x04 |
| 0x1E6   | 0x1C | 0x1E9   | 0xA0 | 0xFC    | 0x13 |
| 0x47    | 0xC0 | 0x1F0   | 0x18 | 0xFD    | 0x0E |
| 0x46    | 0x03 | 0x1F0   | 0x08 | 0x36    | 0x04 |
| 0x47    | 0xC2 | 0x1F0   | 0x28 | 0x36    | 0x05 |
| 0x46    | 0x13 | 0x1F1   | 0x0C | 0x36    | 0x04 |

**Table 8-11. Calibration Register Settings (continued)**

| ADDRESS | DATA | ADDRESS | DATA | ADDRESS | DATA |
|---------|------|---------|------|---------|------|
| 0xFC    | 0x13 | 0x1F0   | 0x2A | 0xFC    | 0x03 |
| 0xFD    | 0x00 | 0x1F0   | 0x2E | 0x36    | 0x04 |
| 0x36    | 0x04 | 0x1F0   | 0x2C | 0x46    | 0x03 |
| 0x36    | 0x05 | 0x1F0   | 0x28 | 0x47    | 0xC0 |
| 0x36    | 0x04 | 0x1F0   | 0x08 | 0x46    | 0x13 |
| 0xFC    | 0x13 | 0x1F0   | 0x18 | 0x05    | 0x40 |
| 0xFD    | 0x02 | 0x1F0   | 0x38 | 0x68    | 0x40 |
| 0x36    | 0x04 | 0x1F1   | 0x0C | 0x69    | 0xFD |
| 0x36    | 0x05 | 0x1F0   | 0x3A | 0x69    | 0xF5 |
| 0x36    | 0x04 | 0x1F0   | 0x3E | 0x69    | 0xD5 |
| 0xFC    | 0x13 | 0x1F0   | 0x3C | 0x69    | 0x55 |
| 0xFD    | 0x04 | 0x1F0   | 0x38 | 0x68    | 0x00 |
| 0x36    | 0x04 | 0x1F0   | 0x18 | 0x69    | 0x54 |
| 0x36    | 0x05 | 0x1F0   | 0x10 | 0x69    | 0x50 |
| 0x36    | 0x04 | 0x1AE   | 0x00 | 0x69    | 0x40 |
| 0xFC    | 0x13 | 0x1E6   | 0x1C | 0x69    | 0x00 |
| 0xFD    | 0x06 | 0x1AE   | 0x00 | 0x93    | 0x0E |
| 0x36    | 0x04 | 0x1E6   | 0x1C | 0x94    | 0x70 |
| 0x36    | 0x05 | 0x47    | 0xC0 | 0x94    | 0x77 |
| 0x36    | 0x04 | 0x46    | 0x03 |         |      |

**8.3.1.8 STEP 8: SYSREF Synchronization**

After setting the analog trim registers, a synchronization using external SYSREF is necessary.

**Table 8-12. Device Synchronization Using External SYSREF**

| ADDRESS | DATA | DESCRIPTION                                                 |
|---------|------|-------------------------------------------------------------|
| 0x05    | 0x18 | Select DDCA and DDCB pages                                  |
| 0x181   | 0x34 | Resets the NCO using a single SYSREF pulse                  |
| 0x181   | 0x30 |                                                             |
| 0x05    | 0x02 | Select DIGITAL page                                         |
| 0x236   | 0x02 | Enable internal SYSREF input and clear SYSREF pulse counter |
| 0x236   | 0x03 | Starts SYSREF counter                                       |

**8.3.1.9 STEP 9: Run Power up Calibration**

The following registers start the power up foreground calibration. The register write order is all writes in first 2 columns before moving to the next set of address and/or data in middle columns, and so on.

**Table 8-13. Calibration Register Settings**

| ADDRESS | DATA | ADDRESS | DATA | ADDRESS | DATA |
|---------|------|---------|------|---------|------|
| 0x05    | 0x20 | 0x05    | 0x00 | 0x95    | 0x00 |
| 0xE7    | 0x01 | 0x04    | 0x01 | 0x96    | 0x00 |
| 0x174   | 0x02 | 0x20    | 0x1F | 0x97    | 0x10 |
| 0x178   | 0x00 | 0x93    | 0x20 | 0x9C    | 0x00 |
| 0x17C   | 0x22 | 0x04    | 0x01 | 0x57    | 0x1E |
| 0x3C    | 0x00 | 0x20    | 0x00 | 0xFE    | 0x10 |
| 0xFC    | 0x03 | 0x04    | 0x00 | 0xFF    | 0x19 |
| 0xFD    | 0x00 | 0x05    | 0x20 | 0x46    | 0x02 |

**Table 8-13. Calibration Register Settings (continued)**

| ADDRESS | DATA | ADDRESS | DATA | ADDRESS                                      | DATA |
|---------|------|---------|------|----------------------------------------------|------|
| 0x154   | 0x1C | 0xC0    | 0x7C | 0x45                                         | 0x8A |
| 0x155   | 0x03 | 0xBC    | 0x3C | 0x45                                         | 0x0A |
| 0xFC    | 0x03 | 0xC9    | 0x01 | Delay 2.6 x 1.5 GSPS/ F <sub>S</sub> seconds |      |
| 0xEE    | 0x26 | 0xC9    | 0x00 | 0xFE                                         | 0x00 |
| 0xEF    | 0x02 | 0xC9    | 0x06 | 0xFF                                         | 0x00 |
| 0x18C   | 0x88 | 0x38    | 0x01 | 0x89                                         | 0x00 |
| 0xAE    | 0xC8 | 0x110   | 0x10 | 0x95                                         | 0x00 |
| 0xAF    | 0x00 | 0x111   | 0x42 | 0x96                                         | 0x00 |
| 0xB0    | 0x4C | 0x112   | 0xA6 | 0x97                                         | 0x00 |
| 0xB1    | 0x3F | 0x112   | 0xD6 | 0x9C                                         | 0x00 |
| 0x4F    | 0x46 | 0x113   | 0xBB | 0x57                                         | 0x1A |
| 0x50    | 0x2C | 0x113   | 0xDB | 0x57                                         | 0x3A |
| 0x51    | 0x05 | 0x114   | 0xF4 | 0x57                                         | 0x7A |
| 0x154   | 0x7C | 0x114   | 0x64 | 0x57                                         | 0xFA |
| 0x158   | 0x7C | 0x115   | 0x0E | 0x58                                         | 0x01 |
| 0x159   | 0x6F | 0x115   | 0xFE | 0x58                                         | 0x03 |
| 0x15C   | 0x7C | 0x116   | 0x0D | 0x58                                         | 0x07 |
| 0x15D   | 0x3F | 0x116   | 0xDD | 0x58                                         | 0x0F |
| 0x160   | 0x7C | 0x117   | 0x0D | 0x58                                         | 0x1F |
| 0x161   | 0x3F | 0x117   | 0xDD | 0x58                                         | 0x3F |
| 0x164   | 0x7C | 0x46    | 0x03 | 0x45                                         | 0x8A |
| 0x165   | 0x4F | 0x3D    | 0x00 | 0x45                                         | 0x0A |
| 0x16C   | 0x7C | 0x45    | 0x0A | Delay 2.6 x 1.5 GSPS/ F <sub>S</sub> seconds |      |
| 0x1B0   | 0x1C | 0x46    | 0x02 | 0x47                                         | 0xC0 |
| 0x1B1   | 0x5F | 0x64    | 0x4A | 0x46                                         | 0x03 |
| 0x1D8   | 0x1C | 0x65    | 0x05 | 0x47                                         | 0xC0 |
| 0x1D9   | 0xAF | 0x68    | 0x28 | 0x05                                         | 0x80 |
| 0xB2    | 0x1F | 0x69    | 0x5E | 0x20                                         | 0x1F |
| 0xB5    | 0x7F | 0x6A    | 0x3D | 0x9D                                         | 0x05 |
| 0x165   | 0xFF | 0x6B    | 0x8F | 0x9E                                         | 0x08 |
| 0x38    | 0x01 | 0x6C    | 0x44 | 0x8B                                         | 0x40 |
| 0xA4    | 0x30 | 0x57    | 0xDA | 0x20                                         | 0x00 |
| 0xC5    | 0x7F | 0x57    | 0x9A | 0x05                                         | 0x00 |
| 0xA8    | 0x00 | 0x57    | 0x1A | 0x04                                         | 0x01 |
| 0xA2    | 0x63 | 0x58    | 0x3E | 0x20                                         | 0x1F |
| 0xA3    | 0x00 | 0x58    | 0x3C | 0x9D                                         | 0x05 |
| 0xAD    | 0x02 | 0x58    | 0x38 | 0x9E                                         | 0x08 |
| 0x05    | 0x80 | 0x58    | 0x30 | 0x8B                                         | 0x40 |
| 0x20    | 0x1F | 0x58    | 0x20 | 0x20                                         | 0x00 |
| 0x93    | 0x20 | 0x58    | 0x00 | 0x04                                         | 0x00 |
| 0x20    | 0x00 | 0x89    | 0x20 |                                              |      |

### 8.3.1.10 STEP 10: JESD Interface Synchronization

The JESD interface can be synchronized using SPI writes or the GPIO1 pin.

**Table 8-14. JESD Interface Synchronization Using SPI Writes**

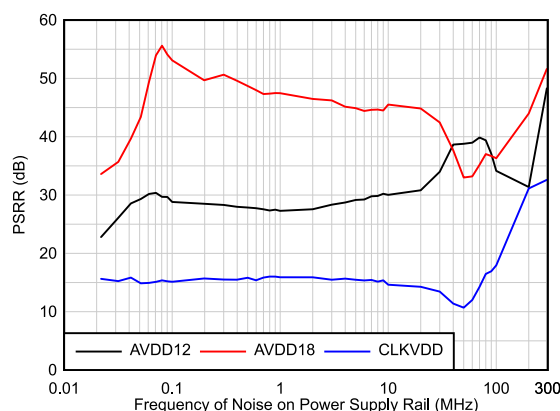
| ADDRESS | DATA | DESCRIPTION                                                                    |
|---------|------|--------------------------------------------------------------------------------|
| 0x05    | 0x04 | Select JESD page                                                               |
| 0x21    | 0x41 | Configure ADC to control SYNC using SPI writes                                 |
| 0x21    | 0x61 | Configure JESD interface to send K28.5 characters for receiver synchronization |
| 0x21    | 0x41 | Configure JESD interface to send normal ADC data                               |

## 8.4 Power Supply Recommendations

The ADC32RF5x requires four different power-supplies. The AVDD18, AVDD12 and CLKVDD rail provides power for the internal analog and clocking circuits of the ADC while the DVDD rail powers the digital logic (including averaging and decimation filter) and the JESD204B digital interface.

Power sequencing is required as shown in [Section 8.3](#). The AVDD18, AVDD12 and especially the CLKVDD power supply must be low noise to achieve data sheet performance. For applications operating near DC, the 1/f noise contribution of the power supply needs to be considered as well.

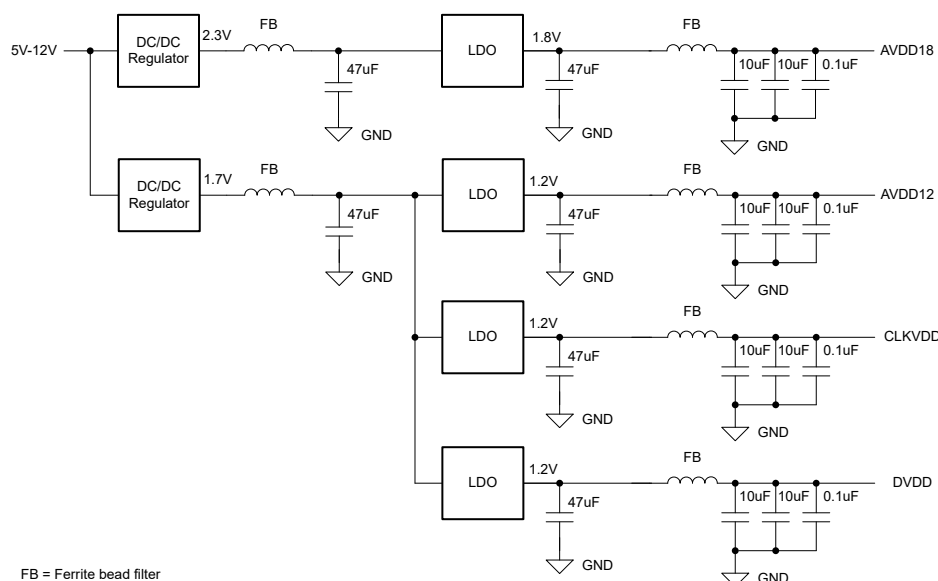
Power supply decoupling capacitors (0.1  $\mu\text{F}$ ) as close to the pins as possible on the top layer are recommended.



**Figure 8-5. Power supply rejection ratio (PSRR) vs frequency**

The recommended power supply architecture for a low noise design is to first use a high-efficiency step down switching regular, followed by a second stage of regulation using a low noise LDO for each power rail as shown in [Figure 8-6](#). This provides additional switching noise reduction and improved voltage accuracy.

TI WEBENCH® Power Designer can be used to select and design the individual power-supply elements. Recommended switching regulators for the first stage include the LMS3635, and similar devices. Recommended low dropout (LDO) linear regulators include the TPS7A8400, and similar devices.



**Figure 8-6. Power supply design example**

AVDD12 or CLKVDD should not be shared with the DVDD to prevent digital switching noise from coupling into the analog domain.

## 8.5 Layout

### 8.5.1 Layout Guidelines

There are several critical signals which require specific care during board design:

1. Analog input and clock signals
  - Traces should be as short as possible and vias should be avoided where possible to minimize impedance discontinuities.
  - Traces should be routed using loosely coupled 100- $\Omega$  differential traces.
  - Differential trace lengths should be matched as close as possible to minimize phase imbalance and HD2 degradation.
2. Digital JESD204B output interface
  - Traces should be routed using tightly coupled 100- $\Omega$  differential traces.
3. Power and ground connections
  - Provide low resistance connection paths to all power and ground pins.
  - Use power and ground planes instead of traces.
  - Avoid narrow, isolated paths which increase the connection resistance.
  - Use a signal/ground/power circuit board stackup to maximize coupling between the ground and power plane.

### 8.5.2 Layout Example

The following screen shot shows the top layer of the ADC32RF5x EVM.

- The input signal traces are routed as differential signals on the top layer avoiding vias. Care is taken to maintain symmetry between positive and negative input with matched trace length to minimize phase imbalance.  
[Figure 8-7](#) shows the layout example for 1x and 2x averaging configuration  
[Figure 8-8](#) shows the layout example for 4x averaging configuration
- JESD204B output interface lanes are routed differential and length matched
- Bypass caps are close to the power pins on the top layer avoiding vias.

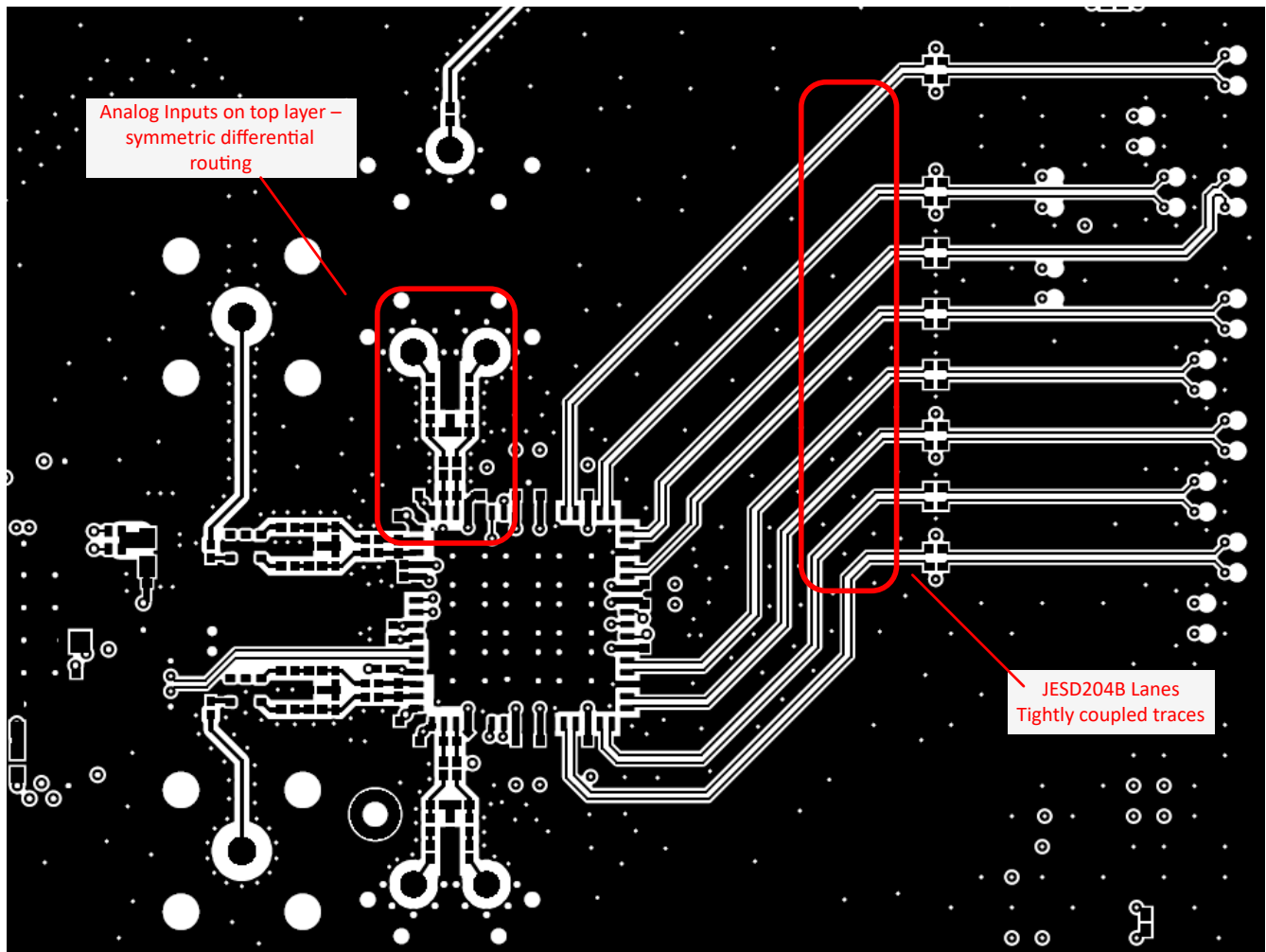


Figure 8-7. Layout example: top layer of ADC32RF5x EVM

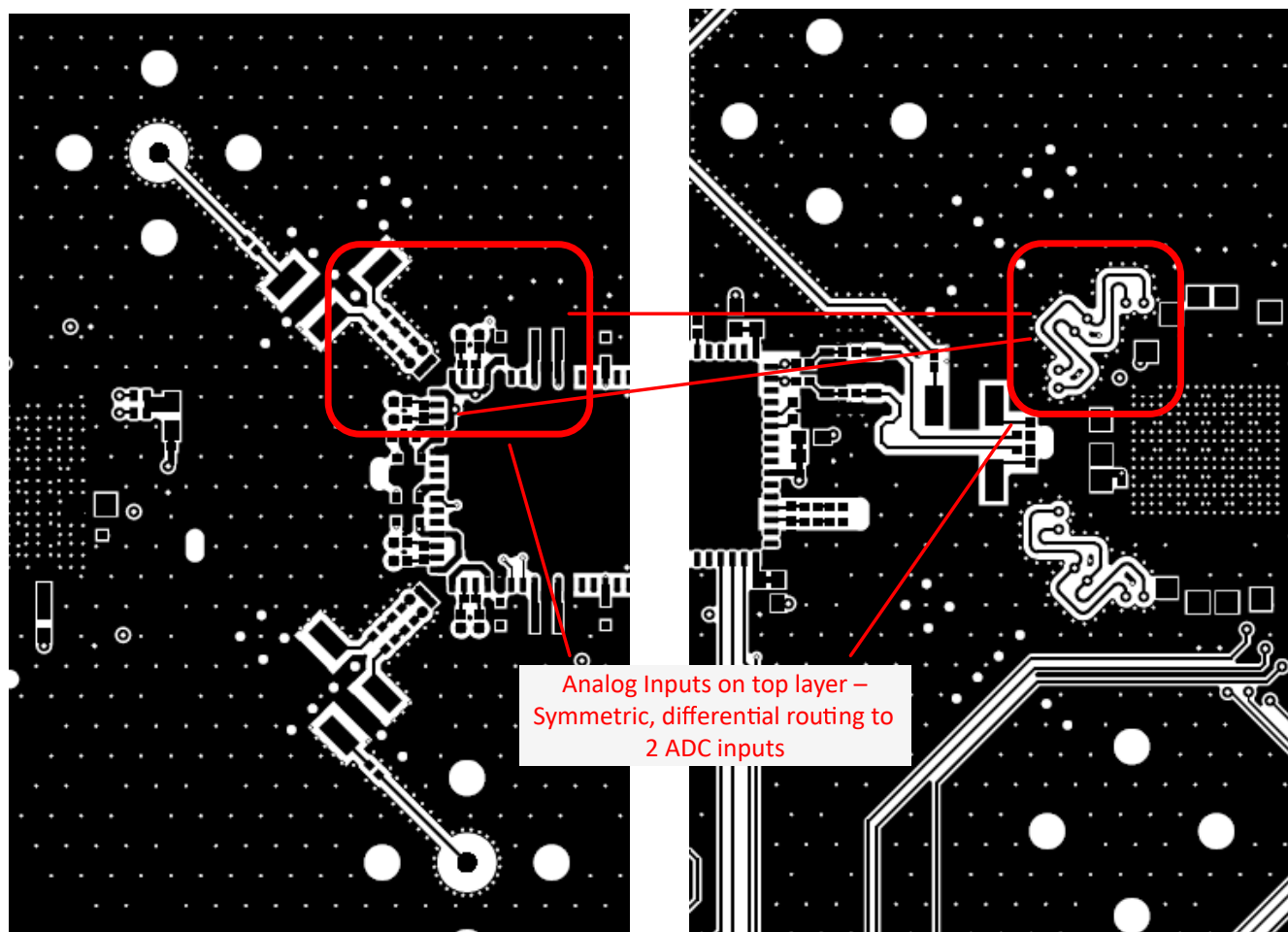


Figure 8-8. Layout example for 4x AVG: ADC32RF5x EVM

## 9 Device and Documentation Support

### 9.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 9.2 Support Resources

[TI E2E™ support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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### 9.3 Trademarks

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### 9.4 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 9.5 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 10 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

## PACKAGING INFORMATION

| Orderable part number          | Status<br>(1) | Material type<br>(2) | Package   Pins  | Package qty   Carrier  | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|--------------------------------|---------------|----------------------|-----------------|------------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">ADC32RF52IRTD</a>  | Active        | Production           | VQFN (RTD)   64 | 260   JEDEC TRAY (5+1) | Yes         | NIPDAU   NIPDAUAG                    | Level-3-260C-168 HR               | -40 to 85    | AZ32RF52            |
| ADC32RF52IRTD.A                | Active        | Production           | VQFN (RTD)   64 | 260   JEDEC TRAY (5+1) | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 85    | AZ32RF52            |
| <a href="#">ADC32RF52IRTDI</a> | Active        | Production           | VQFN (RTD)   64 | 250   SMALL T&R        | Yes         | NIPDAU   NIPDAUAG                    | Level-3-260C-168 HR               | -40 to 85    | AZ32RF52            |
| ADC32RF52IRTDI.A               | Active        | Production           | VQFN (RTD)   64 | 250   SMALL T&R        | Yes         | NIPDAU                               | Level-3-260C-168 HR               | -40 to 85    | AZ32RF52            |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

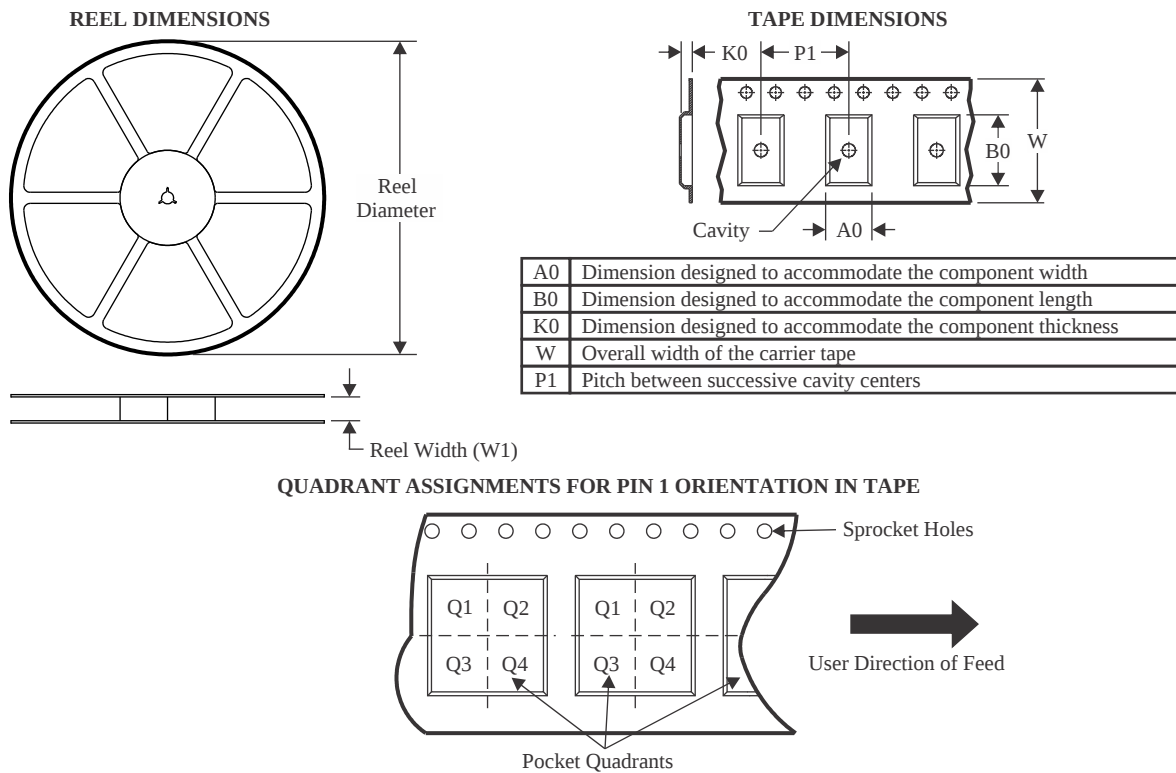
<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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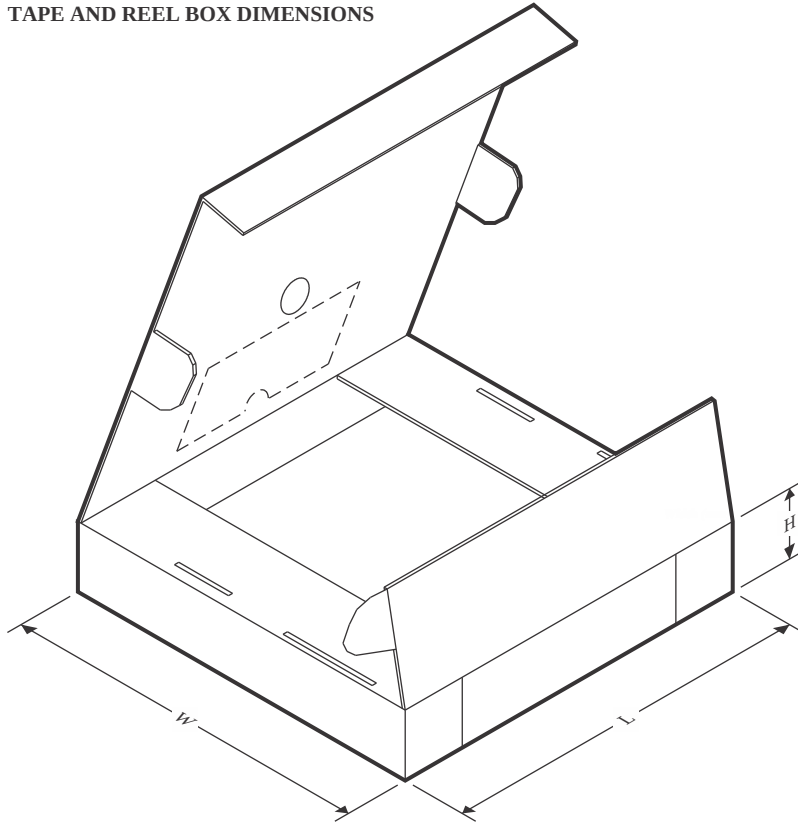
## TAPE AND REEL INFORMATION



\*All dimensions are nominal

| Device        | Package Type | Package Drawing | Pins | SPQ | Reel Diameter (mm) | Reel Width W1 (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---------------|--------------|-----------------|------|-----|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| ADC32RF52IRTD | VQFN         | RTD             | 64   | 250 | 180.0              | 16.4               | 9.3     | 9.3     | 1.5     | 12.0    | 16.0   | Q2            |

## TAPE AND REEL BOX DIMENSIONS



\*All dimensions are nominal

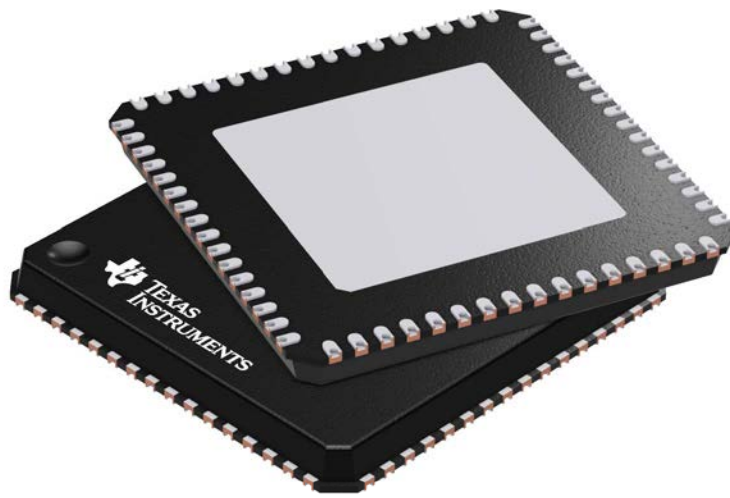
| Device        | Package Type | Package Drawing | Pins | SPQ | Length (mm) | Width (mm) | Height (mm) |
|---------------|--------------|-----------------|------|-----|-------------|------------|-------------|
| ADC32RF52IRTD | VQFN         | RTD             | 64   | 250 | 213.0       | 191.0      | 55.0        |

## GENERIC PACKAGE VIEW

**RTD 64**

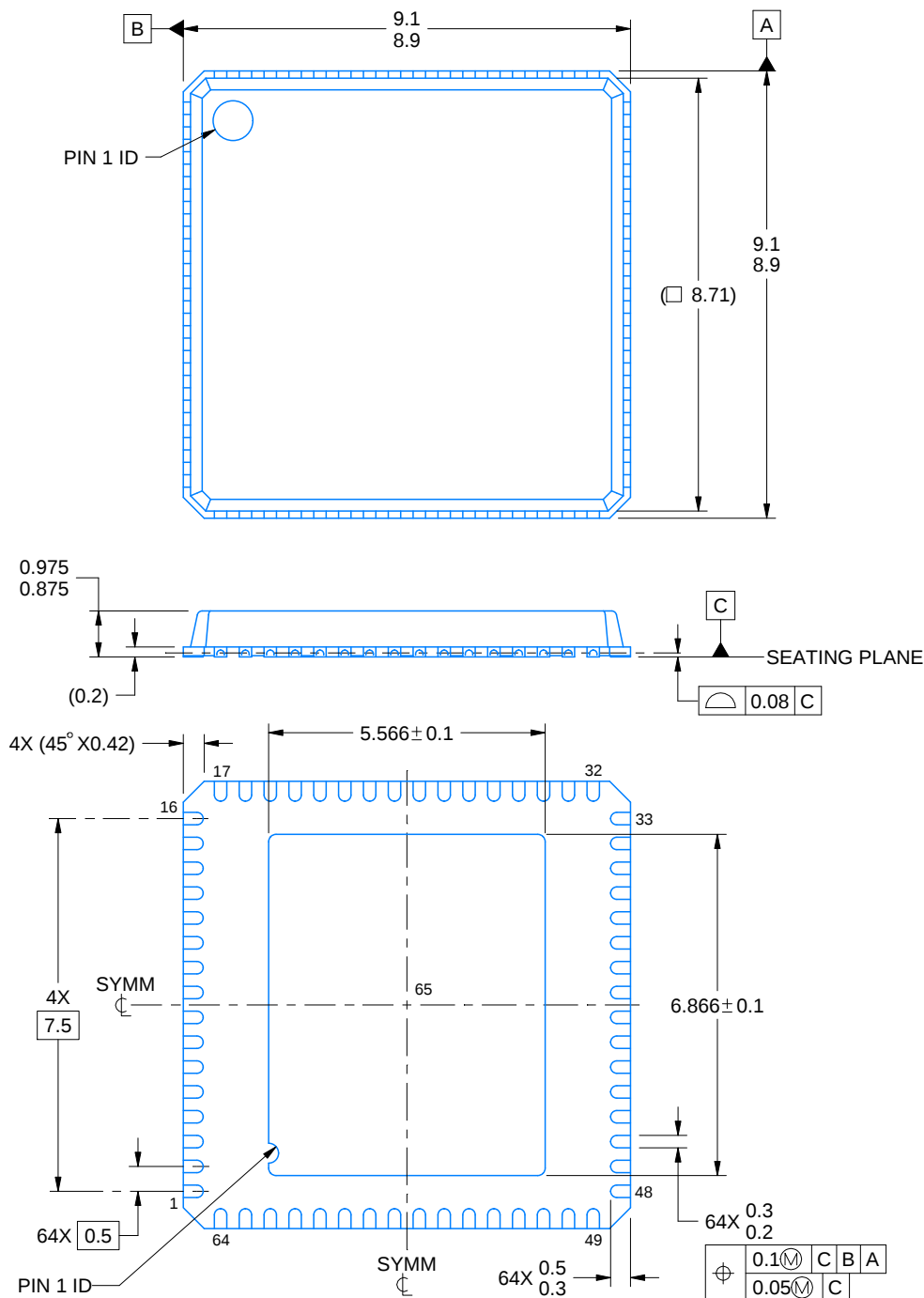
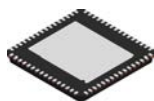
**VQFNP - 0.9 mm max height**

PLASTIC QUAD FLATPACK - NO LEAD



Images above are just a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.

4205146/D



4226371/A 11/2020

## NOTES:

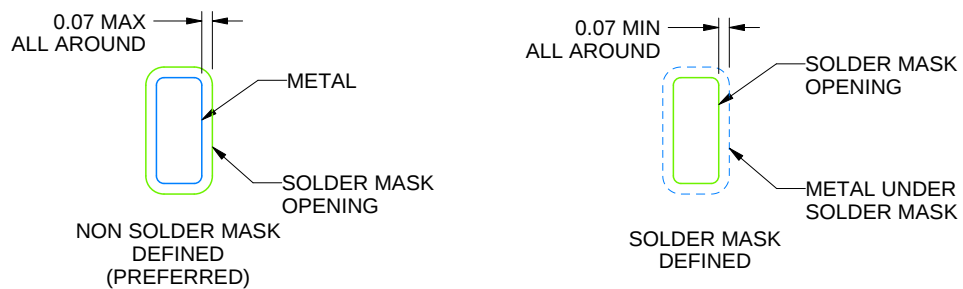
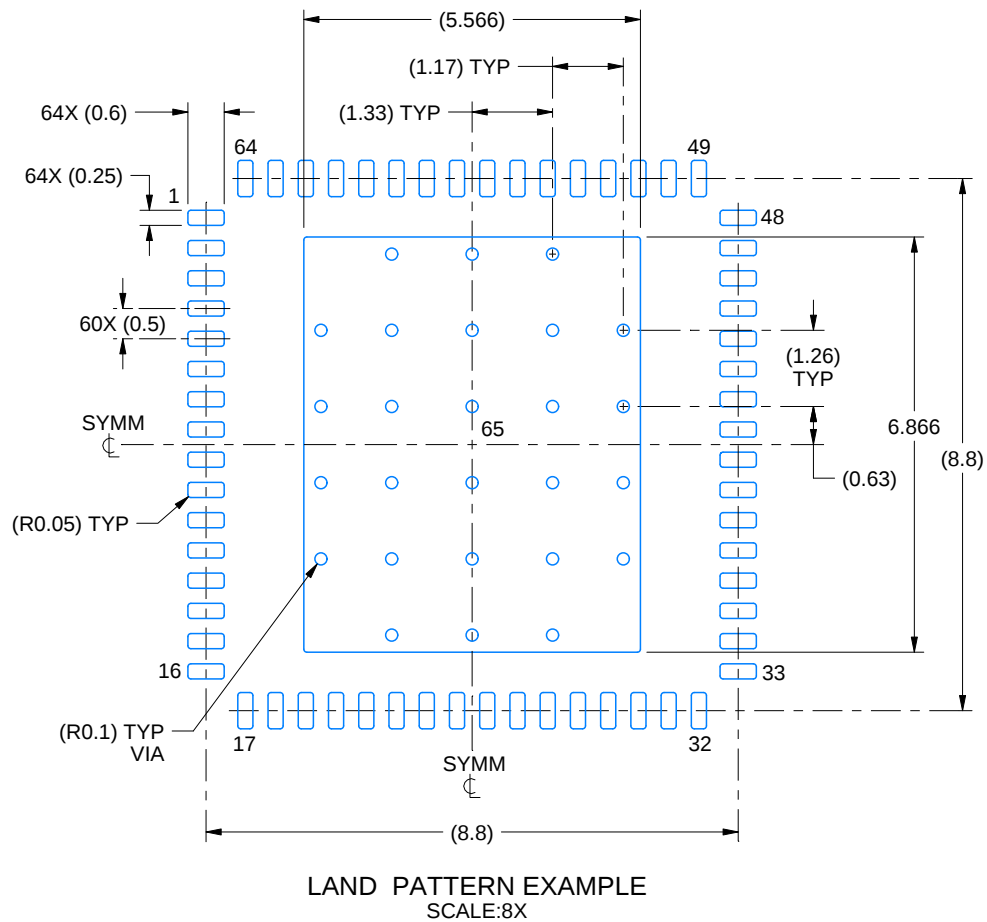
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for thermal and mechanical performance.

# EXAMPLE BOARD LAYOUT

RTD0064N

VQFN - 0.9 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



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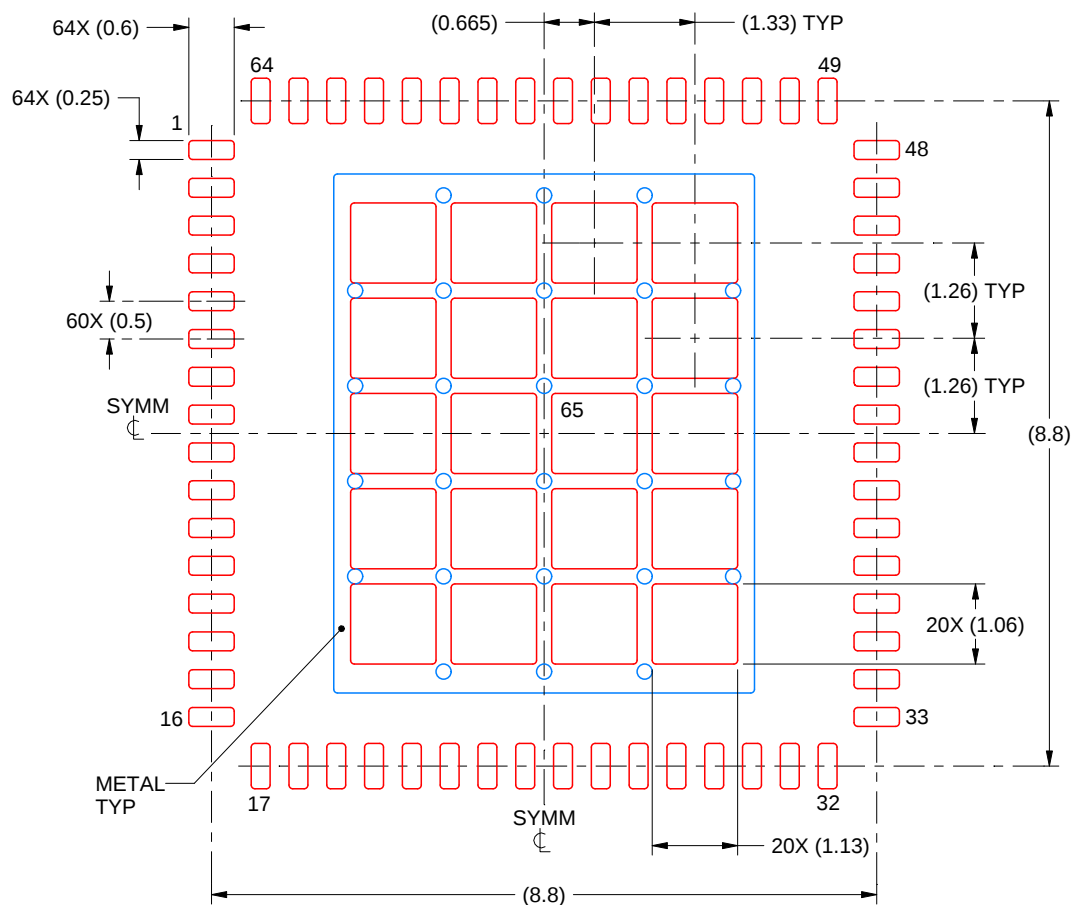
NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 ([www.ti.com/lit/sluea271](http://www.ti.com/lit/sluea271)).
5. Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

RTD0064N

### VQFN - 0.9 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



## SOLDER PASTE EXAMPLE BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD 65:  
63% PRINTED SOLDER COVERAGE BY AREA UNDER PACKAGE  
SCALE:10X

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.

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