











SBAS809A - FEBRUARY 2017-REVISED MARCH 2017

ADC32RF44

ADC32RF44 Dual-Channel, 14-Bit, 2.6-GSPS, Analog-to-Digital Converter

Features

14-Bit, Dual-Channel, 2.6-GSPS ADC

Noise Floor: -154.2 dBFS/Hz

RF Input Supports Up to 4.0 GHz

Aperture Jitter: 90 f_S

Channel Isolation: 95 dB at f_{IN} = 1.8 GHz

Spectral Performance (f_{IN} = 900 MHz, -2 dBFS):

SNR: 61.2 dBFS

SFDR: 65-dBc HD2, HD3

SFDR: 79-dBc Worst Spur

Spectral Performance (f_{IN} = 1.85 GHz, -2 dBFS):

SNR: 58.3 dBFS

SFDR: 69-dBc HD2, HD3

SFDR: 74-dBc Worst Spur

On-Chip Digital Down-Converters:

Up to 4 DDCs (Dual-Band Mode)

Up to 3 Independent NCOs per DDC

On-Chip Input Clamp for Overvoltage Protection

Programmable On-Chip Power Detectors with Alarm Pins for AGC Support

On-Chip Dither

On-Chip Input Termination

Input Full-Scale: 1.35 VPP

Support for Multi-Chip Synchronization

JESD204B Interface:

Subclass 1-Based Deterministic Latency

4 Lanes Per Channel at 12.5 Gbps

Power Dissipation: 2.95 W/Ch at 2.6 GSPS

72-Pin VQFN Package (10 mm × 10 mm)

2 Applications

- Multi-Band, Multi-Mode 2G, 3G, 4G Cellular Receivers
- Phased Array Radars
- **Electronic Warfare**
- Cable Infrastructure
- **Broadband Wireless**
- **High-Speed Digitizers**
- Software-Defined Radios
- Communications Test Equipment
- Microwave and Millimeter Wave Receivers

3 Description

The ADC32RF44 device is a 14-bit, 2.6-GSPS, dualchannel, analog-to-digital converter (ADC) that supports RF sampling with input frequencies up to 4 GHz and beyond. Designed for high signal-to-noise ratio (SNR), the ADC32RF44 delivers a noise spectral density of -154.2 dBFS/Hz as well as dynamic range and channel isolation over a large input frequency range. The buffered analog input with on-chip termination provides uniform input impedance across a wide frequency range and minimizes sample-and-hold glitch energy.

Each ADC channel can be connected to a dual-band, digital down-converter (DDC) with up to three independent, 16-bit numerically-controlled oscillators (NCOs) per DDC for phase-coherent frequency hopping. Additionally, the ADC is equipped with frontend peak and RMS power detectors and alarm functions to support external automatic gain control (AGC) algorithms.

The ADC32RF44 supports the JESD204B serial interface with subclass 1-based deterministic latency using data rates up to 12.5 Gbps with up to four lanes per ADC. The device is offered in a 72-pin VQFN package (10 mm × 10 mm) and supports the industrial temperature range (-40°C to +85°C).

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
ADC32RF44	VQFN (72)	10.00 mm × 10.00 mm

(1) For all available packages, see the orderable addendum at the end of the data sheet.

Simplified Block Diagram

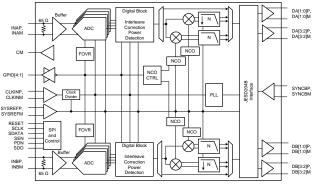




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4 Revision History

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

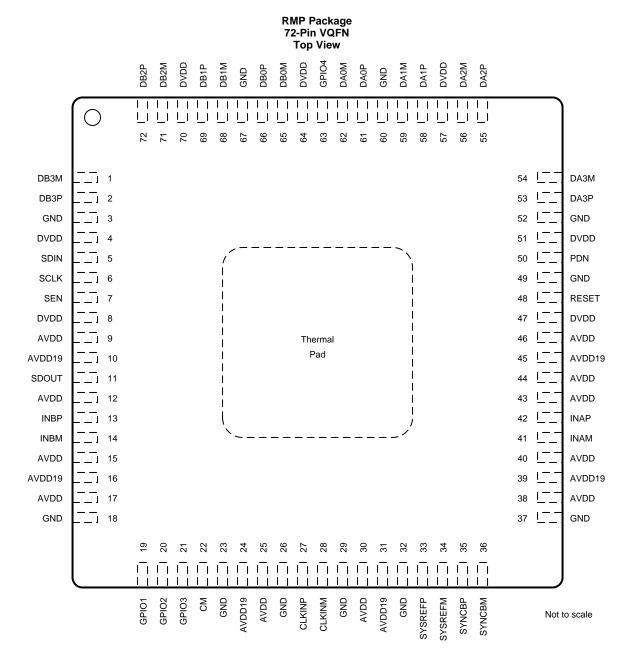
Cł	hanges from Original (February 2017) to Revision A	Page
•	Changed minimum specification of NSD parameter (f _{IN} = 1850 MHz) from 146.6 to 146.1	7
•	Changed minimum specifications of HD3, HD4 and HD5, and IL spur parameters (f _{IN} = 1850 MHz) from 63 to 62.5, from 70 to 69.5, and from 68 to 66.5, respectively	•



5 Device Comparison Table

PART NUMBER	SPEED GRADE (MSPS)	RESOLUTION (Bits)	CHANNELS
ADC32RF45	3000	14	2
ADC32RF44	2600	14	2

6 Pin Configuration and Functions



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Pin Functions

INPUT, REFERENCE INAM	
INAP 42 INBM 14 INBM 14 INBP 13 IDifferential analog input for channel A INBP 13 IDifferential analog input for channel B IDIfferential analog input for channel B IDIFFERENTIAL STATE AND INFORMATION INFO	
INAP 42 INBM 14 INBP 13 I Differential analog input for channel B CM 22 O Common-mode voltage for analog inputs, 1.2 V CLOCK, SYNC CLKINM 28 CLKINP 27 I Differential clock input for the analog-to-digital converter (ADC). This pin has an internal differential 100-Ω termination. SYSREFM 34 I External sync input. This pin has an internal, differential 100-Ω termination and requir biasing. GPIO1 19 GPIO2 20 GPIO3 21 GPIO4 63 CONTROL, SERIAL RESET 48 I Hardware reset; active high. This pin has an internal 20-kΩ pulldown resistor. SCLK 6 I Serial interface data input. This pin has an internal 20-kΩ pulldown resistor. SCIN 7 I Serial interface data input. This pin has an internal 20-kΩ pulldown resistor. SDIN 7 I Serial interface data input. This pin has an internal 20-kΩ pulldown resistor. SDIN 7 I Serial interface edata input. This pin has an internal 20-kΩ pulldown resistor. SDIN 10 Serial interface data input. This pin has an internal 20-kΩ pulldown resistor. SEN 7 I Serial interface data input. This pin has an internal 20-kΩ pulldown resistor. SDIN 11 O Serial interface data input and output in 3-wire mode. SEN 7 I Serial interface data input in 4-wire mode. POWER down; active high. This pin can be configured through the SPI. This pin has an internal 20-kΩ pulldown resistor to DVDD. SDOUT 11 O Serial interface data output in 4-wire mode. POWER down; active high. This pin can be configured through an SPI register setting a configured to a fast overrange output channel B through the SPI. This pin has an internal 20-kΩ pulldown resistor.	
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DATA INTERFACE	nd can be
DA0M 62	
DA0P 61	
DA1M 59	
DA1P 58 O JESD204B serial data output for channel A	
DA2M 56	
DA2P 55	
DA3M 54	
DA3P 53	
DB0M 65	
DB0P 66	
DB1M 68	
DB1P 69 O JESD204B serial data output for channel B	
DB2M 71	
DB2P 72	
DB3M 1	
DB3P 2	
SYNCBM 36 Synchronization input for the JESD204B port. This pin has an LVDS or 1.8-V logic input optional on-chip 100-Ω termination, and is selectable through the SPI.	ut, an
SYNCBP 35 Control of the state	
POWER SUPPLY	
AVDD19 10, 16, 24, 31, 39, 45 I Analog 1.9-V power supply	
AVDD 9, 12, 15, 17, 25, 30, 38, 40, 43, 44, 46 I Analog 1.15-V power supply	
DVDD 4, 8, 47, 51, 57, 64, 70 I Digital 1.15 V-power supply, including the JESD204B transmitter	
GND 3, 18, 23, 26, 29, 32, 37, 49, 52, 60, 67 I Ground; shorted to thermal pad inside device	

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7 Specifications

7.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)

		MIN	MAX	UNIT
	AVDD19	-0.3	2.1	
- 111 7 - 113 - 113	AVDD	-0.3	1.4	V
	DVDD	-0.3	1.4	
	INAP, INAM and INBP, INBM	-0.3	AVDD19 + 0.3	
	CLKINP, CLKINM	-0.3	AVDD + 0.6	V
Voltage applied to input pins	SYSREFP, SYSREFM, SYNCBP, SYNCBM	-0.3	AVDD + 0.6	
	SCLK, SEN, SDIN, RESET, PDN, GPIO1, GPIO2, GPIO3, GPIO4	-0.2	AVDD19 + 0.2	
Voltage applied to output pins		-0.3	2.2	V
Temperature	Operating free-air, T _A	-40	85	°C
	Storage, T _{stg}	-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.

7.2 ESD Ratings

			VALUE	UNIT
.,	Electroptatic dischause	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 (1)	±1000	
V _(ESD)	Electrostatic discharge	Charged-device model (CDM), per JEDEC specification JESD22-C101 ⁽²⁾	±500	V

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

7.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT	
Supply voltage ⁽¹⁾	AVDD19	1.8	1.9	2.0		
	AVDD	1.1	1.15	1.25	V	
	DVDD	1.1	1.15	1.2		
Temperature	Operating free-air, T _A	-40		85	°C	
	Operating junction, T _J		105 ⁽²⁾	125		

⁽¹⁾ Always power up the DVDD supply (1.15 V) before the AVDD19 (1.9 V) supply. The AVDD (1.15 V) supply can come up in any order.

7.4 Thermal Information

		ADC32RF44	
	THERMAL METRIC ⁽¹⁾	RMP (VQFN)	UNIT
		72 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	21.8	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	4.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	2.0	°C/W
ΨЈТ	Junction-to-top characterization parameter	0.1	°C/W
ΨЈВ	Junction-to-board characterization parameter	2.0	°C/W
R _θ JC(bot)	Junction-to-case (bottom) thermal resistance	0.2	°C/W

For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

Product Folder Links: ADC32RF44

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

⁽²⁾ Prolonged use above this junction temperature may increase the device failure-in-time (FIT) rate.



7.5 Electrical Characteristics

typical values are specified at an ambient temperature of 25° C; minimum and maximum values are specified over an ambient temperature range of -40° C to $+85^{\circ}$ C; and ADC sampling rate = 2.6 GHz, 50% clock duty cycle, AVDD19 = 1.9 V, AVDD = 1.15 V, -2-dBFS differential input, and 0-dB digital gain (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
POWER (CONSUMPTION ⁽¹⁾ (Dual-Channel Oper	ation, Both Channels A and B are Ac	tive; DDC Bypa	ass Mode ⁽²⁾)		
I _{AVDD19}	1.9-V analog supply current	12-bit, bypass mode, f _S = 2.6 GSPS		1730	1969	mA
I _{AVDD}	1.15-V analog supply current	12-bit, bypass mode, f _S = 2.6 GSPS		860	1079	mA
I _{DVDD}	1.15-V digital supply current	12-bit, bypass mode, f _S = 2.6 GSPS		1416	1846	mA
P _D	Power dissipation	12-bit, bypass mode, f _S = 2.6 GSPS		5.9	6.95	W
	Global power-down power dissipation			360		mW
ANALOG	INPUTS					
	Resolution			14		Bits
	Differential input full-scale			1.35		V_{PP}
V _{IC}	Input common-mode voltage			1.2 ⁽³⁾		V
R _{IN}	Input resistance	Differential resistance at dc		65		Ω
C _{IN}	Input capacitance	Differential capacitance at dc		2		рF
	V _{CM} common-mode voltage output			1.2		V
	Analog input bandwidth (-3-dB point)	ADC driven with 50-Ω source		3200		MHz
ISOLATIO	ON					
		f _{IN} = 100 MHz		100		
		f _{IN} = 900 MHz		99		
	Crosstalk isolation between channel A and channel B ⁽⁴⁾	f _{IN} = 1800 MHz		95		dBc
	A drid Gharmer B	f _{IN} = 2700 MHz		86		
		f _{IN} = 3500 MHz		85		
CLOCK II	NPUT ⁽⁵⁾					
	Input clock frequency		1.5	2.6		GHz
	Differential (peak-to-peak) input clock amplitude		0.5	1.5	2.5	V _{PP}
	Input clock duty cycle		45%	50%	55%	
	Internal clock biasing			1.0		V
	Internal clock termination (differential)			100		Ω

⁽¹⁾ See the *Power Consumption in Different Modes* section for more details.

(5) See Figure 57.

⁽²⁾ Full-scale signal is applied to the analog inputs of all active channels.

⁽³⁾ When used in dc-coupling mode, the common-mode voltage at the analog inputs should be kept within V_{CM} ±25 mV for best performance.

⁽⁴⁾ Crosstalk is measured with a -2-dBFS input signal on aggressor channel and no input on the victim channel.



7.6 AC Performance Characteristics

typical values specified at an ambient temperature of 25°C; minimum and maximum values are specified over an ambient temperature range of -40°C to +85°C; and ADC sampling rate = 2.6 GHz, 50% clock duty cycle, AVDD19 = 1.9 V, AVDD = 1.15 V, DVDD = 1.15 V, -2-dBFS differential input, and 0-dB digital gain (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	MIN ⁽¹⁾	NOM	MAX	UNIT
		$f_{IN} = 100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		62.5		
		$f_{IN} = 900 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		61.2		
CNID	Cinnal to mains watin	f_{IN} = 1850 MHz, A_{OUT} = -2 dBFS	55.5	58.3		4DE0
SNR	Signal-to-noise ratio	$f_{IN} = 2100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		57.5		dBFS
		$f_{IN} = 2500 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		56.4		
		f_{IN} = 3500 MHz, $A_{OUT}^{(2)}$ = -3 dBFS with 2-dB gain		54.0		
		$f_{IN} = 100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		153.6		
		$f_{IN} = 900 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		152.3		
NOD	Noise spectral density	f_{IN} = 1850 MHz, A_{OUT} = -2 dBFS	146.1	149.4		-IDEO/LI-
NSD	averaged across the Nyquist zone	$f_{IN} = 2100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		148.6		dBFS/Hz
	, 1	$f_{IN} = 2500 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		147.5		
		f_{IN} = 3500 MHz, $A_{OUT}^{(2)}$ = -3 dBFS with 2-dB gain		145.1		
	Small-signal SNR	f_{IN} = 1850 MHz, A_{OUT} = -40 dBFS		63.1		dBFS
NF ⁽³⁾	Input noise figure	f_{IN} = 1850 MHz, A_{OUT} = -40 dBFS		24.7		dB
		$f_{IN} = 100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		61.8		
CINIAD	Signal-to-noise and distortion ratio	$f_{IN} = 900 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		60.0		dBFS
		f_{IN} = 1850 MHz, A_{OUT} = -2 dBFS		58.0		
SINAD		$f_{IN} = 2100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		56.5		
		$f_{IN} = 2500 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		54.7		
		f_{IN} = 3500 MHz, $A_{OUT}^{(2)}$ = -3 dBFS with 2-dB gain		53.2		
		$f_{IN} = 100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		10.0		
		$f_{IN} = 900 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		9.7		
ENOD		f_{IN} = 1850 MHz, A_{OUT} = -2 dBFS		9.3		Dita
ENOB	Effective number of bits	$f_{IN} = 2100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		9.1		Bits
		$f_{IN} = 2500 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		8.8		
		f_{IN} = 3500 MHz, $A_{OUT}^{(2)}$ = -3 dBFS with 2-dB gain		8.5		
		$f_{IN} = 100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		68.0		
		$f_{IN} = 900 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		65.0		
CEDD	Spurious-free dynamic	f_{IN} = 1850 MHz, A_{OUT} = -2 dBFS	60	69.0		40.
SFDR	range	f_{IN} = 2100 MHz, A_{OUT} = -2 dBFS		62.0		dBc
		f_{IN} = 2500 MHz, A_{OUT} = -2 dBFS		59.0		
		f_{IN} = 3500 MHz, $A_{OUT}^{(2)}$ = -3 dBFS with 2-dB gain		57.0		
		f _{IN} = 100 MHz, A _{OUT} = -2 dBFS		68.0		
		$f_{IN} = 900 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		74.0	-	
HD2 ⁽⁴⁾	Second-order harmonic	f_{IN} = 1850 MHz, A_{OUT} = -2 dBFS	60	69.0		.15
HDZ\''	distortion	$f_{IN} = 2100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		62.0		dBc
		$f_{IN} = 2500 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		62.0		
		$f_{IN} = 3500 \text{ MHz}, A_{OUT}^{(2)} = -3 \text{ dBFS with } 2\text{-dB gain}$		57.0		

⁽¹⁾ Minimum values are specified at $A_{OUT} = -3$ dBFS, ADC sampling rate = 2.5 GHz.

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⁽²⁾ Output amplitude, A_{OUT} , refers to the signal amplitude in the ADC digital output that is same as the analog input amplitude, A_{IN} , except when the digital gain feature is used. If digital gain is G, then $A_{OUT} = G + A_{IN}$.

⁽³⁾ The ADC internal resistance = 65 Ω , the driving source resistance = 50 Ω .

⁽⁴⁾ The minimum value of HD2 is specified by bench characterization.



AC Performance Characteristics (continued)

typical values specified at an ambient temperature of 25°C; minimum and maximum values are specified over an ambient temperature range of -40°C to +85°C; and ADC sampling rate = 2.6 GHz, 50% clock duty cycle, AVDD19 = 1.9 V, AVDD = 1.15 V, DVDD = 1.15 V, -2-dBFS differential input, and 0-dB digital gain (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	MIN ⁽¹⁾	NOM	MAX	UNIT
		$f_{IN} = 100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		84.0		
		$f_{IN} = 900 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		65.0		
LIDO	Third-order harmonic distortion	f_{IN} = 1850 MHz, A_{OUT} = -2 dBFS	62.5	74.0		dBc
HD3		$f_{IN} = 2100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		67.0		
		$f_{IN} = 2500 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		59.0		
		$f_{IN} = 3500 \text{ MHz}, A_{OUT}^{(2)} = -3 \text{ dBFS with 2-dB gain}$		72.0		
		$f_{IN} = 100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		92.0		
		$f_{IN} = 900 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		82.0		
HD4,	Fourth- and fifth-order	f_{IN} = 1850 MHz, A_{OUT} = -2 dBFS	69.5	86.0		4D.
HD5	harmonic distortion	$f_{IN} = 2100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		87.0		dBc
		f _{IN} = 2500 MHz, A _{OUT} = -2 dBFS		90.0		
		f_{IN} = 3500 MHz, $A_{OUT}^{(2)}$ = -3 dBFS with 2-dB gain		87.0		
IL spur		$f_{IN} = 100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		93.0		
		$f_{IN} = 900 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		88.0		dBc
	Interleaving spurs: $f_S / 2 - f_{IN}$, $f_S / 4 \pm f_{IN}$	f _{IN} = 1850 MHz, A _{OUT} = -2 dBFS	66.5	80.0		
		f _{IN} = 2100 MHz, A _{OUT} = -2 dBFS		85.0		
		f _{IN} = 2500 MHz, A _{OUT} = -2 dBFS		81.0		
		$f_{IN} = 3500 \text{ MHz}, A_{OUT}^{(2)} = -3 \text{ dBFS with 2-dB gain}$		75.0		
		f _{IN} = 100 MHz, A _{OUT} = -2 dBFS		83.0		
		$f_{IN} = 900 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		82.0		
	Interleaving spur for HD2:	f _{IN} = 1850 MHz, A _{OUT} = -2 dBFS	68	80.0		15
HD2 IL	f _S / 2 – HD2	f _{IN} = 2100 MHz, A _{OUT} = -2 dBFS		75.0		dBc
		f _{IN} = 2500 MHz, A _{OUT} = -2 dBFS		77.0		
		$f_{IN} = 3500 \text{ MHz}, A_{OUT}^{(2)} = -3 \text{ dBFS with 2-dB gain}$		77.0		
		$f_{IN} = 100 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		79.0		
	Consideration of the control of the	$f_{IN} = 900 \text{ MHz}, A_{OUT} = -2 \text{ dBFS}$		79.0		
Vorst	Spurious-free dynamic range (excluding HD2, HD3,	f _{IN} = 1850 MHz, A _{OUT} = -2 dBFS		74.0		ID -
spur	HD4, HD5, and interleaving	f _{IN} = 2100 MHz, A _{OUT} = -2 dBFS		72.0		dBc
	spurs IL and HD2 IL)	f _{IN} = 2500 MHz, A _{OUT} = -2 dBFS		72.0		
		$f_{IN} = 3500 \text{ MHz}, A_{OUT}^{(2)} = -3 \text{ dBFS with 2-dB gain}$		69.0		
		f _{IN1} = 900 MHz, f _{IN2} = 960 MHz, A _{OUT} = -8 dBFS (each tone)		82		
MD3	Two-tone, third-order intermodulation distortion	f _{IN1} = 1850 MHz, f _{IN2} = 1870 MHz, A _{OUT} = -8 dBFS (each tone)		72		dBFS
		f_{IN1} = 3490 MHz, f_{IN2} = 3510 MHz, A _{OUT} = -8 dBFS (each tone) with 2-dB gain		69		



7.7 Digital Requirements

typical values are specified at an ambient temperature of 25° C; minimum and maximum values are specified over an ambient temperature range of -40° C to $+85^{\circ}$ C; and ADC sampling rate = 2.6 GHz, 50% clock duty cycle, AVDD19 = 1.9 V, AVDD = 1.15 V, -2-dBFS differential input, and 0-dB digital gain (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	MIN	NOM	MAX	UNIT			
DIGITAL INPUTS (RESET, SCLK, SEN, SDIN, PDN, GPIO1, GPIO2, GPIO3, GPIO4)									
V _{IH}	High-level input voltage		0.8			V			
V_{IL}	Low-level input voltage				0.4	V			
I _{IH}	High-level input current			50		μΑ			
I _{IL}	Low-level input current			-50		μΑ			
Ci	Input capacitance			4		pF			
DIGITAL	DIGITAL OUTPUTS (SDOUT, GPIO1, GPIO2, GPIO3, GPIO4)								
V _{OH}	High-level output voltage		AVDD19 -0.1	AVDD19		V			
V _{OL}	Low-level output voltage				0.1	V			
DIGITAL	. INPUTS (SYSREFP and SYSREFM	; SYNCBP and SYNCBM; Requires External	Biasing)						
V_{ID}	Differential input voltage		350	450	800	mV_{PP}			
V_{CM}	Input common-mode voltage		1.05	1.2	1.325	V			
DIGITAL	OUTPUTS (JESD204B Interface: D	A[3:0], DB[3:0], Meets JESD204B LV-0IF-11G	S-SR Standa	rd)					
V _{OD}	Output differential voltage			700		mV_PP			
V _{OCM}	Output common-mode voltage			450		mV			
	Transmitter short-circuit current	Transmitter pins shorted to any voltage between –0.25 V and 1.45 V	-100		100	mA			
Z _{os}	Single-ended output impedance			50		Ω			
Co	Output capacitance	Output capacitance inside the device, from either output to ground		2		pF			

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7.8 Timing Requirements

typical values are specified at an ambient temperature of 25°C; minimum and maximum values are specified over an ambient temperature range of -40°C to +85°C; and ADC sampling rate = 2.6 GHz, 50% clock duty cycle, AVDD19 = 1.9 V, AVDD = 1.15 V, DVDD = 1.15 V, -2-dBFS differential input, and 0-dB digital gain (unless otherwise noted)

			MIN	NOM	MAX	UNIT
SAMPLE T	IMING					
	Aperture delay		250		750	ps
	Aperture delay matching between		±15		ps	
	Aperture delay matching between temperature and supply voltage		±150		ps	
	Aperture jitter, clock amplitude = 2	V _{PP}		90		f _S
Latency	Data latency, ADC sample to digital output	12-bit bypass mode, LMFS = 82820		461		Input clock cycles
(1)(2)		14-bit bypass mode, LMFS = 8224		424		Input clock cycles
	Fast overrange latency, ADC sam		70			
t _{PD}	Propagation delay time: logic gate (does not change with f _S)		6		ns	
SYSREF T	iMING ⁽³⁾					
t _{SU_SYSREF}	SYSREF setup time: referenced to	clock rising edge, 2.6 GSPS	140	70		ps
t _{H_SYSREF}	SYSREF hold time: referenced to	50	20		ps	
	Valid transition window sampling p	period: t _{SU_SYSREF} - t _{H_SYSREF} , 2.6 GSPS	194			ps
JESD OUT	PUT INTERFACE TIMING		, ,		·	
UI	Unit interval: 12.5 Gbps		80	100	400	ps
	Serial output data rate	2.5	10.0	12.5	Gbps	
	Rise, fall times: 1-pF, single-ended		60		ps	
	Total jitter: BER of 1E-15 and lane		25		%UI	
	Random jitter: BER of 1E-15 and I		0.99		%UI, rms	
	Deterministic jitter: BER of 1E-15		9.1		%UI, pk-pk	

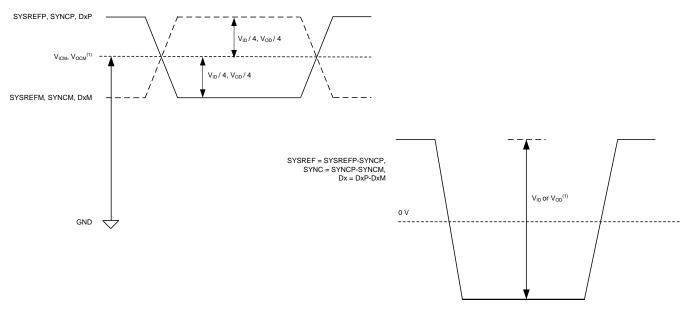
Product Folder Links: ADC32RF44

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 ⁽¹⁾ Overall latency = latency + t_{PD}.
 (2) Latency increases when the DDC modes are used; see Table 4.

Common-mode voltage for the SYSREF input is kept at 1.2 V.





(1) V_{OCM} is not the same as V_{ICM} . Similarly, V_{OD} is not the same as V_{ID} .

Figure 1. Logic Levels for Digital Inputs and Outputs

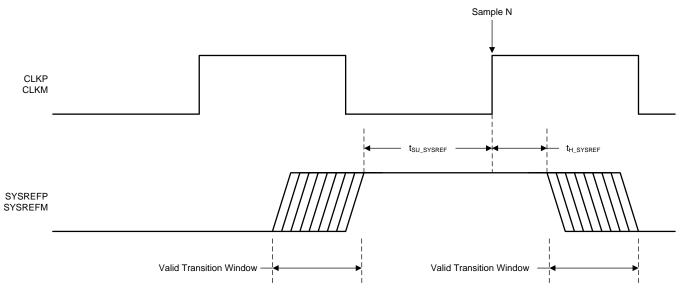
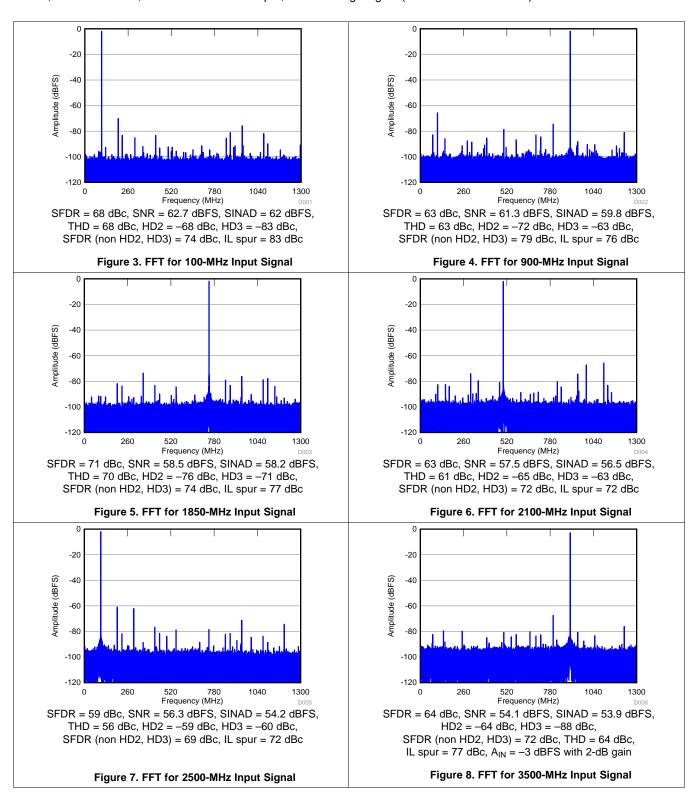


Figure 2. SYSREF Timing Diagram

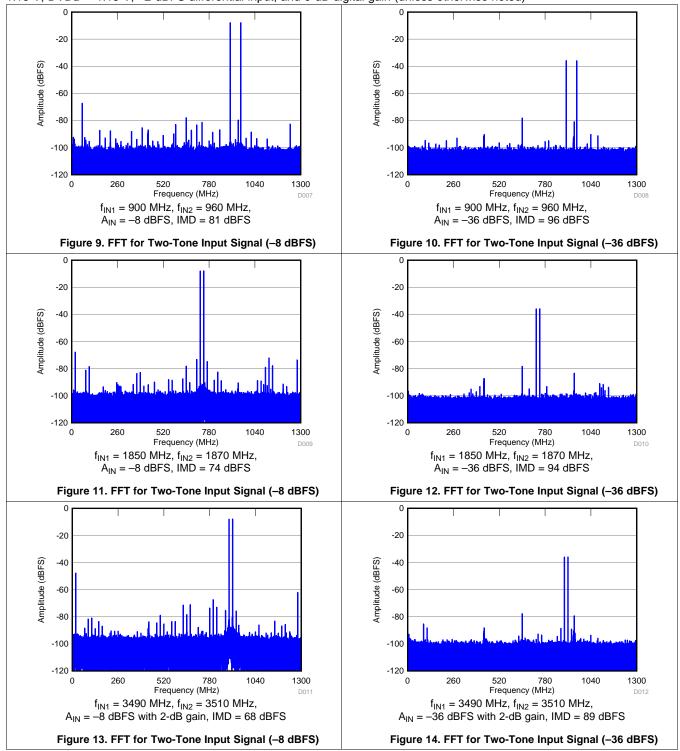


7.9 Typical Characteristics





typical values are specified at an ambient temperature of 25°C; minimum and maximum values are specified over an ambient temperature range of -40°C to +85°C; and ADC sampling rate = 2.6 GHz, 50% clock duty cycle, AVDD19 = 1.9 V, AVDD = 1.15 V, DVDD = 1.15 V, -2-dBFS differential input, and 0-dB digital gain (unless otherwise noted)



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typical values are specified at an ambient temperature of 25°C; minimum and maximum values are specified over an ambient temperature range of -40°C to +85°C; and ADC sampling rate = 2.6 GHz, 50% clock duty cycle, AVDD19 = 1.9 V, AVDD = 1.15 V, DVDD = 1.15 V, -2-dBFS differential input, and 0-dB digital gain (unless otherwise noted)

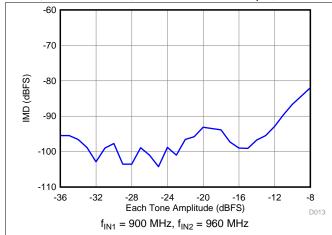


Figure 15. Intermodulation Distortion vs Input Amplitude (900 MHz and 960 MHz)

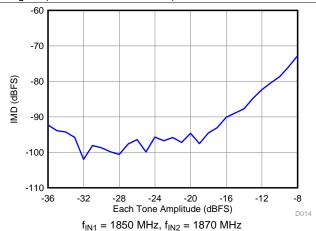


Figure 16. Intermodulation Distortion vs Input Amplitude (1850 MHz and 1870 MHz)

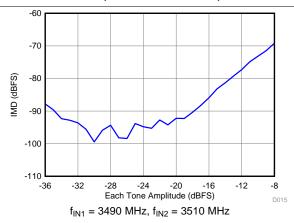
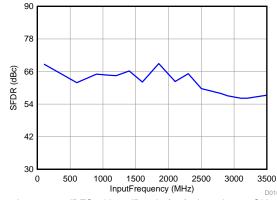


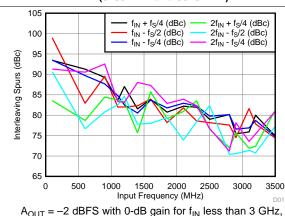
Figure 17. Intermodulation Distortion vs Input Amplitude (3490 MHz and 3510 MHz)



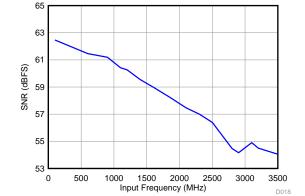
 $A_{OUT} = -2$ dBFS with 0-dB gain for f_{IN} less than 3 GHz, $A_{OUT} = -3$ dBFS with 2-dB gain for f_{IN} more than 3 GHz

Figure 18. Spurious-Free Dynamic Range vs Input

Frequency



 $A_{OUT} = -3$ dBFS with 2-dB gain for f_{IN} more than 3 GHz Figure 19. IL Spur vs Input Frequency

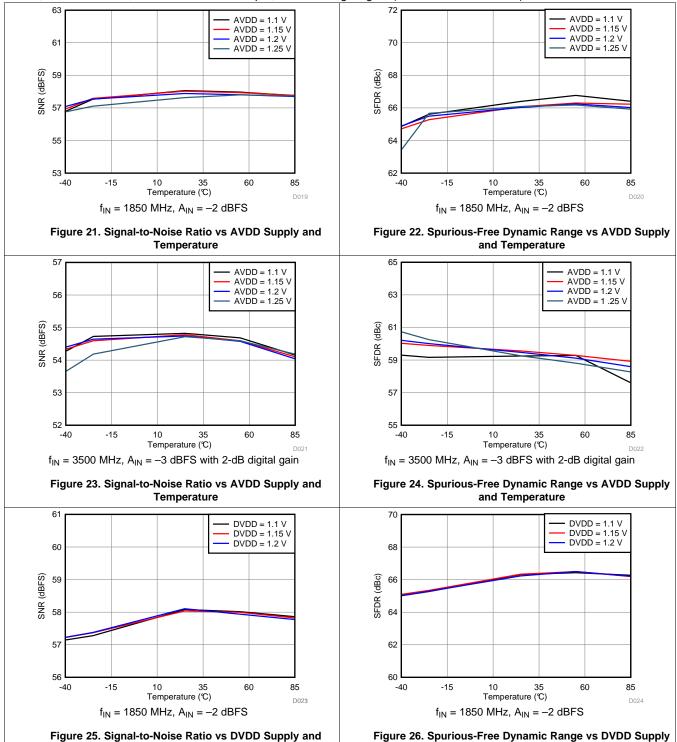


 A_{OUT} = -2 dBFS with 0-dB gain for f_{IN} less than 3 GHz, A_{OUT} = -3 dBFS with 2-dB gain for f_{IN} more than 3 GHz

Figure 20. Signal-to-Noise Ratio vs Input Frequency



typical values are specified at an ambient temperature of 25°C; minimum and maximum values are specified over an ambient temperature range of -40°C to +85°C; and ADC sampling rate = 2.6 GHz, 50% clock duty cycle, AVDD19 = 1.9 V, AVDD = 1.15 V, DVDD = 1.15 V, -2-dBFS differential input, and 0-dB digital gain (unless otherwise noted)



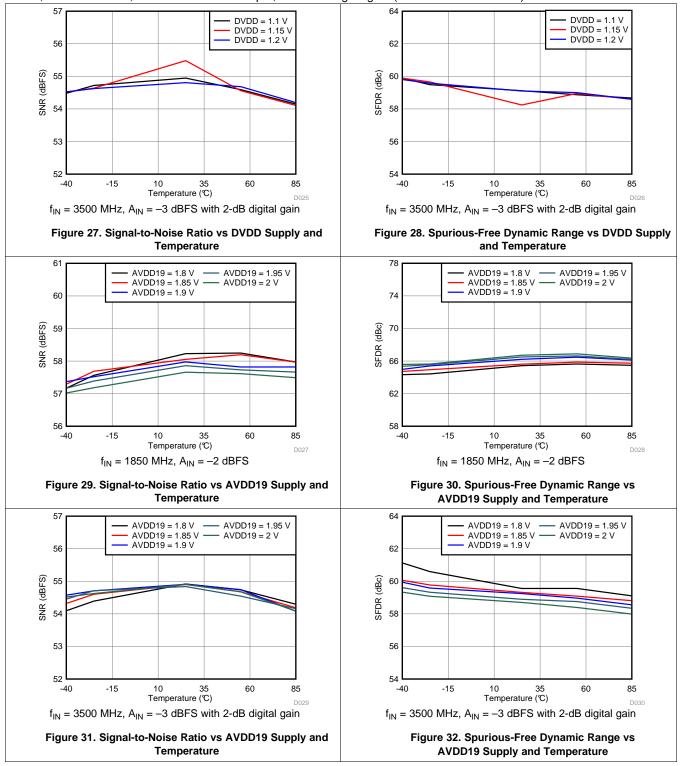
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Temperature

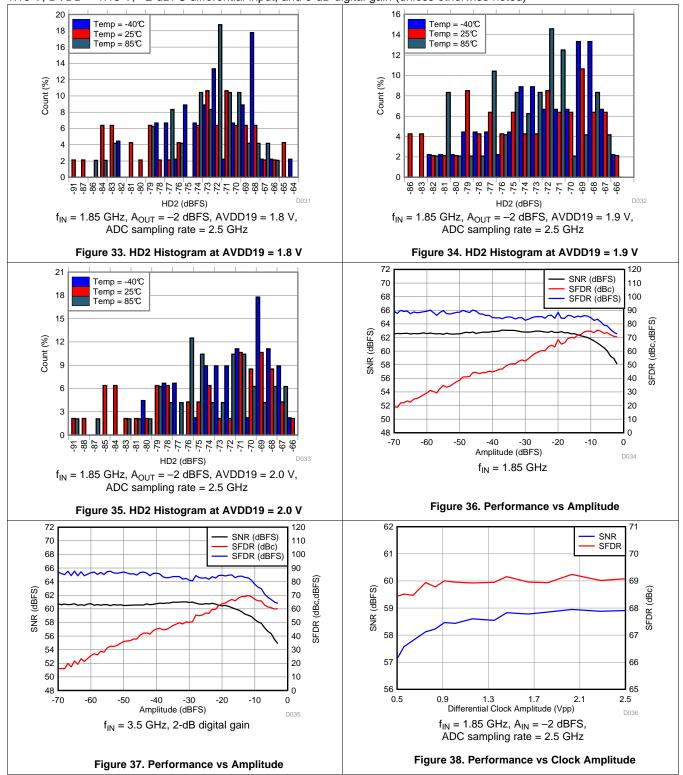
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and Temperature

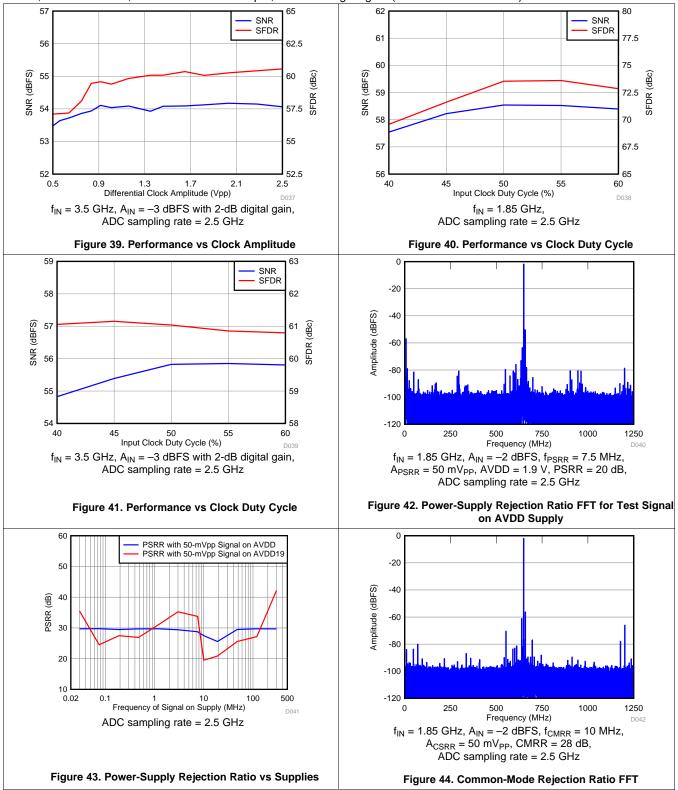




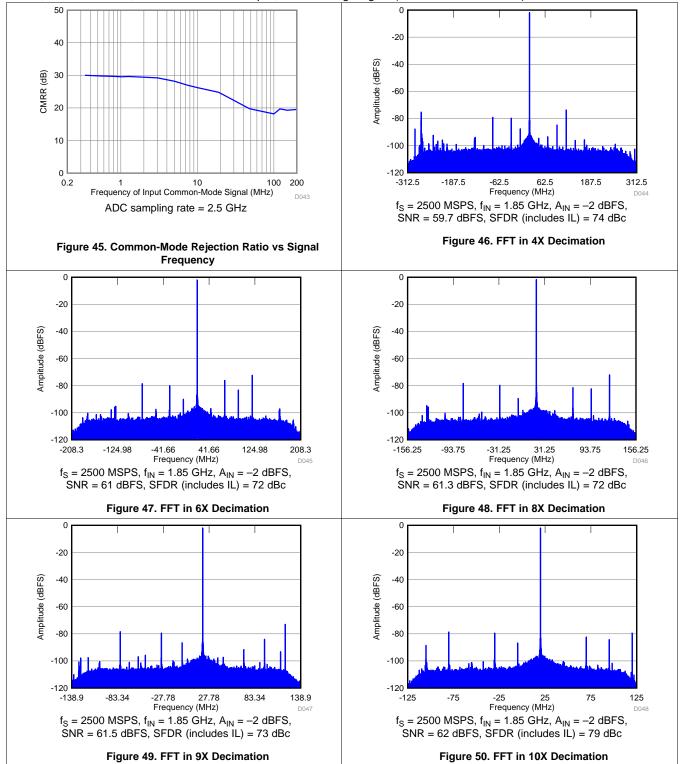




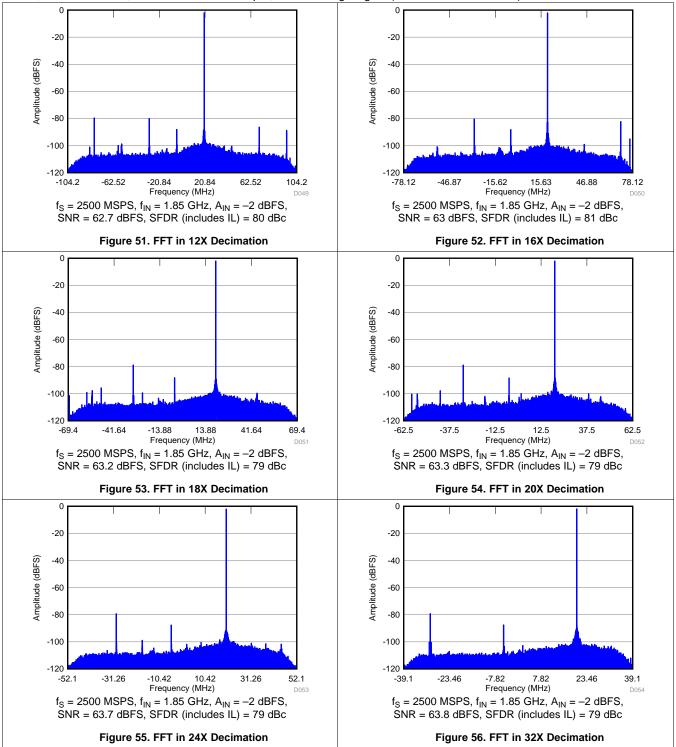














8 Parameter Measurement Information

8.1 Input Clock Diagram

Figure 57 shows the input clock diagram.

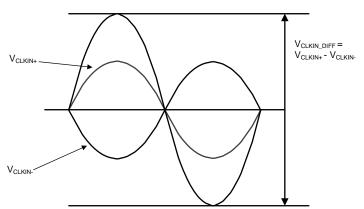


Figure 57. Input Clock Diagram



9 Detailed Description

9.1 Overview

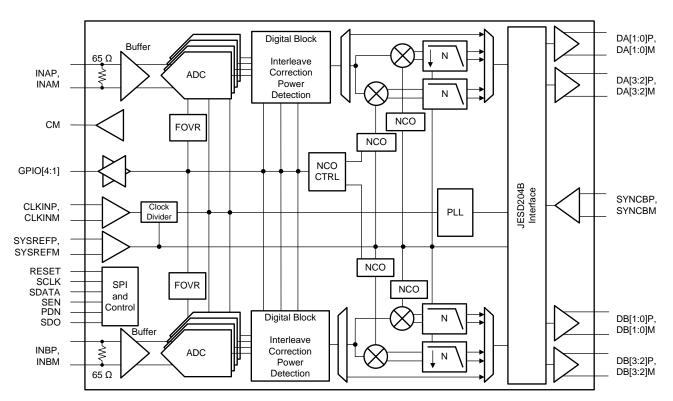
The ADC32RF44 is a dual, 14-bit, 2.6-GSPS, analog-to-digital converter (ADC) followed by a multi-band digital down-converter (DDC) that can be bypassed, and a back-end JESD204B digital interface.

The ADCs are preceded by an input buffer and on-chip termination to provide a uniform input impedance over a large input frequency range. Furthermore, an internal differential clamping circuit provides first-level protection against overvoltage conditions. Each ADC channel is internally interleaved four times and equipped with background, analog and digital, and interleaving correction.

The on-chip DDC enables single- or dual-band internal processing to pre-select and filter smaller bands of interest and also reduces the digital output data traffic. Each DDC is equipped with up to three independent, 16-bit numerically-controlled oscillators (NCOs) for phase coherent frequency hopping; the NCOs can be controlled through the SPI or GPIO pins. The ADC32RF44 also provides three different power detectors on-chip with alarm outputs in order to support external automatic gain control (AGC) loops.

The processed data are passed into the JESD204B interface where the data are framed, encoded, serialized, and output on one to four lanes per channel, depending on the ADC sampling rate and decimation. The CLKIN, SYSREF, and SYNCB inputs provide the device clock and the SYSREF and SYNCB signals to the JESD204B interface that are used to derive the internal local frame and local multiframe clocks and establish the serial link. All features of the ADC32RF44 are configurable through the SPI.

9.2 Functional Block Diagram



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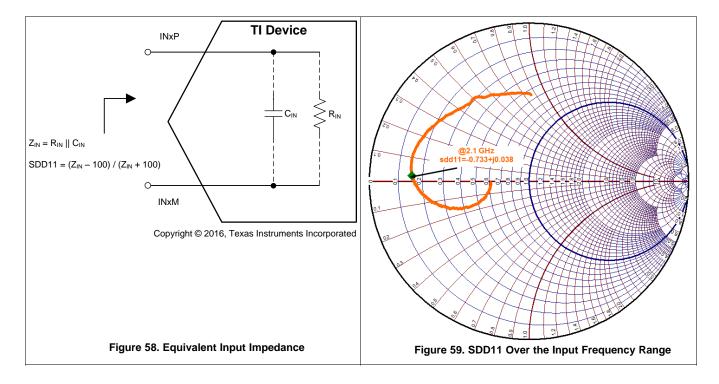


9.3 Feature Description

9.3.1 Analog Inputs

The ADC32RF44 analog signal inputs are designed to be driven differentially. The analog input pins have internal analog buffers that drive the sampling circuit. The ADC32RF44 provides on-chip, differential termination to minimize reflections. The buffer also helps isolate the external driving circuit from the internal switching currents of the sampling circuit, thus resulting in a more constant SFDR performance across input frequencies.

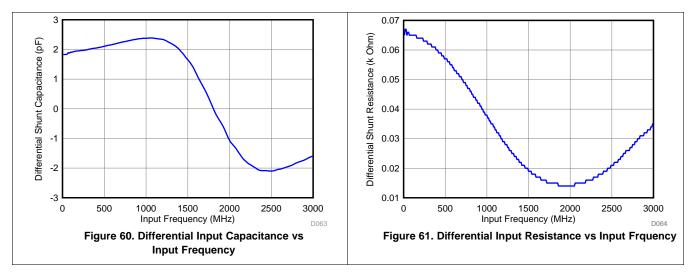
The common-mode voltage of the signal inputs is internally biased to CM using the 32.5- Ω termination resistors that allow for ac-coupling of the input drive network. Figure 58 and Figure 59 show SDD11 at the analog inputs from dc to 5 GHz with a 100- Ω reference impedance.



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The input impedance of analog inputs can also be modelled as parallel combination of equivalent resistance and capacitance. Figure 60 and Figure 61 show how equivalent impedance (C_{IN} and R_{IN}) vary over frequency.



Each input pin (INP, INM) must swing symmetrically between (CM + 0.3375 V) and (CM - 0.3375 V), resulting in a 1.35-V_{PP} (default) differential input swing. The input sampling circuit has a 3-dB bandwidth that extends up to approximately 3.2 GHz, as shown in Figure 62.

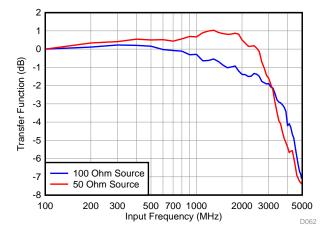


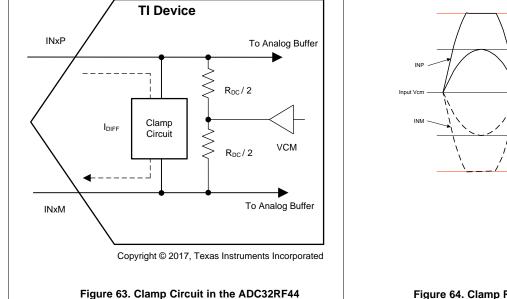
Figure 62. Input Bandwidth with a 100- Ω Source Resistance

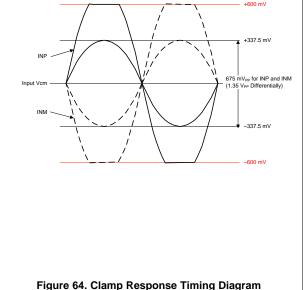


9.3.1.1 Input Clamp Circuit

The ADC32RF44 analog inputs include an internal, differential clamp for overvoltage protection. The clamp triggers for any input signals at approximately 600 mV above the input common-mode voltage, effectively limiting the maximum input signal to approximately 2.4 V_{PP}, as shown in Figure 63 and Figure 64.

When the clamp circuit conducts, the maximum differential current flowing through the circuit (via input pins) must be limited to 20 mA.







9.3.2 Clock Input

The ADC32RF44 sampling clock input includes internal $100-\Omega$ differential termination along with on-chip biasing. The clock input is recommended to be ac-coupled externally. The input bandwidth of the clock input is approximately 3 GHz; the clock input impedance is shown with a $100-\Omega$ reference impedance in the smith chart of Figure 65.

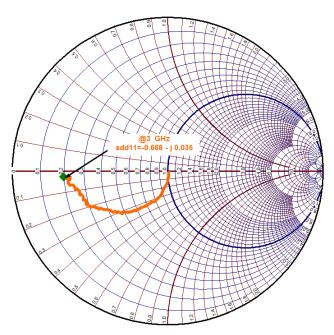


Figure 65. SDD11 of the Clock Input



The analog-to-digital converter (ADC) aperture jitter is a function of the clock amplitude applied to the pins. The equivalent aperture jitter for input frequencies at a 1-GHz and a 2-GHz input ($f_S = 2.6$ GSPS) is shown in Figure 66. Depending on the clock frequency, a matching circuit can be designed in order to maximize the clock amplitude.

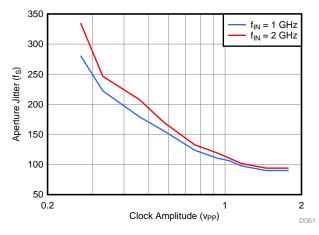


Figure 66. Equivalent Aperture Jitter vs Input Clock Amplitude

9.3.3 SYSREF Input

The SYSREF signal is a periodic signal that is sampled by the ADC32RF44 device clock and is used to align the boundary of the local multiframe clock inside the data converter. SYSREF is also used to reset critical blocks [such as the clock divider for the interleaved ADCs, numerically-controlled oscillators (NCOs), decimation filters and so forth].

The SYSREF input requires external biasing. Furthermore, SYSREF must be established before the SPI registers are programmed. A programmable delay on the SYSREF input, as shown in Figure 67, is available to help with skew adjustment when the sampling clock and SYSREF are not provided from the same source.

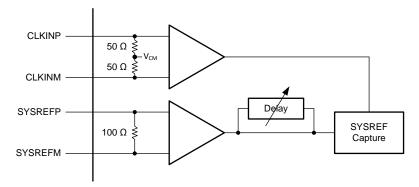


Figure 67. SYSREF Internal Circuit Diagram

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9.3.3.1 Using SYSREF

The ADC32RF44 uses SYSREF information to reset the clock divider, the NCO phase, and the LMFC counter of the JESD interface. The device provides flexibility to provide SYSREF information either from dedicated pins or through SPI register bits. SYSREF is asserted by a low-to-high transition on the SYSREF pins or a 0-to-1 change in the ASSERT SYSREF REG bit when using SPI registers, as shown in Figure 68.

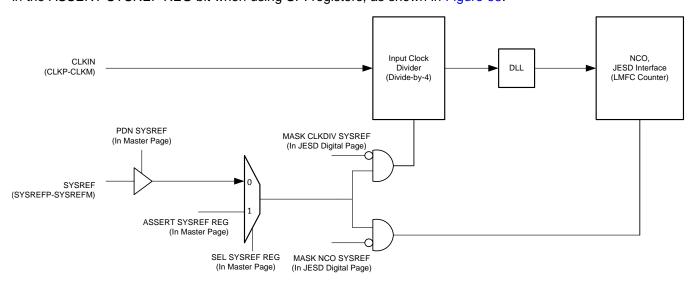


Figure 68. Using SYSREF to Reset the Clock Divider, the NCO, and the LMFC Counter

The ADC32RF44 samples the SYSREF signal on the input clock rising edge. Required setup and hold time are listed in the *Timing Requirements* table. The input clock divider gets reset each time that SYSREF is asserted, whereas the NCO phase and the LMFC counter of the JESD interface are reset on each SYSREF assertion after disregarding the first two assertions, as shown in Table 1.

Table 1. Asserting SYSREF

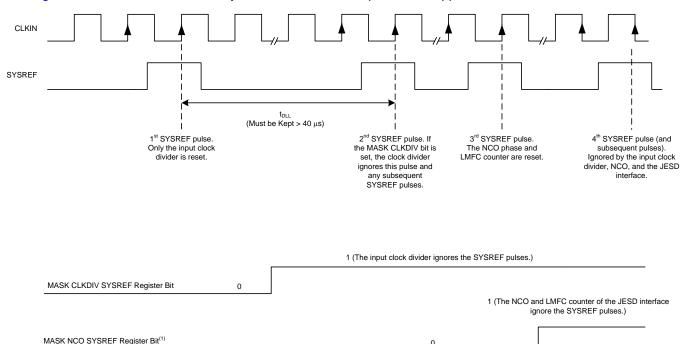
SYSREF ASSERTION INDEX	ACTION					
STOREF ASSERTION INDEX	INPUT CLOCK DIVIDER	NCO PHASE	LMFC COUNTER			
1	1 Gets reset		Does not get reset			
2	Gets reset	Does not get reset	Does not get reset			
3	Gets reset	Gets reset	Gets reset			
4 and onwards	Gets reset	Gets reset	Gets reset			



The SESREF use-cases can be classified broadly into two categories:

1. SYSREF is applied as aperiodic multi-shot pulses.

Figure 69 shows a case when only a counted number of pulses are applied as SYSREF to the ADC.



Alternatively, the SYSREF buffer can be powered down with the PDN SYSREF bit.

Figure 69. SYSREF Used as a Periodic, Finite Number of Pulses

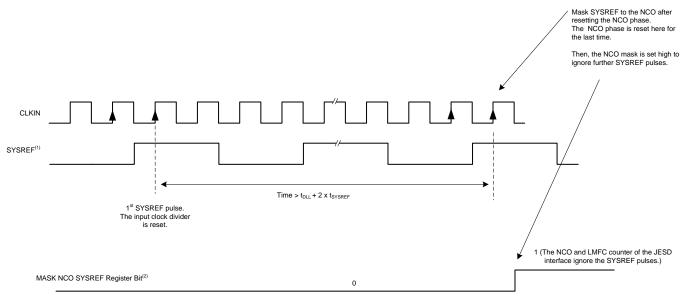
After the first SYSREF pulse is applied, allow the DLL in the clock path to settle by waiting for the t_{DLL} time (> 40 µs) before applying the second pulse. During this time, mask the SYSREF going to the input clock divider by setting the MASK CLKDIV SYSREF bit so that the divider output phase remains stable. The NCO phase and LMFC counter are reset on the third SYSREF pulse. After the third SYSREF pulse, the SYSREF going to the NCO and JESD block can be disabled by setting the MASK NCO SYSREF bit to avoid any unwanted resets.

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2. SYSREF is applied as a periodic pulse.

Figure 70 shows how SYSREF can be applied as a continuous periodic waveform.



t_{SYSREF} is a period of the SYSREF waveform.

Alternatively, the SYSREF buffer can be powered down using the PDN SYSREF bit.

Figure 70. SYSREF Used as a Periodic Waveform

After applying the SYSREF signal, DLL must be allowed to lock, and the NCO phase and LMFC counter must be allowed to reset by waiting for at least the t_{DLL} (40 μ s) + 2 × t_{SYSREF} time. Then, the SYSREF going to the NCO and JESD can be masked by setting the MASK NCO SYSREF register bit.

9.3.3.2 Frequency of the SYSREF Signal

When SYSREF is a periodic signal, its frequency is required to be a sub-harmonic of the internal local multi-frame clock (LMFC) frequency, as described in Equation 1. The LMFC frequency is determined by the selected decimation, frames per multi-frame setting (K), samples per frame (S), and device input clock frequency.

SYSREF = LMFC / N

where

N is an integer value (1, 2, 3, and so forth)

(1)

In order for the interleaving correction engine to synchronize properly, the SYSREF frequency must also be a multiple of f_S / 64. Table 2 provides a summary of the valid LMFC clock settings.

Table 2. . SYSREF and LMFC Clock Frequency

OPERATING MODE	LMFS SETTING	LMFC CLOCK FREQUENCY	SYSREF FRQUENCY
Bypass mode	82820	$f_S^{(1)} / (20 \times K)$	$f_S / (N \times LCM^{(2)} (64, 20 \times K^{(3)}))$
Bypass mode	8224	f _S /(4 × K)	$f_S / (N \times LCM (64, 4 \times K))$
Decimation	Various	$f_S / (D \times S^{(4)} \times K)$	$f_S / (N \times LCM (64, D^{(5)} \times S \times K))$

- f_S = sampling (device) clock frequency.
- (2) LCM = least-common multiple.
- (3) K = number of frames per multi-frame.
- (4) S =samples per frame.
- (5) D = decimation ratio.

The SYSREF signal is recommended to be a low-frequency signal less than 5 MHz in order to reduce coupling to the signal path both on the printed circuit board (PCB) as well as internal to the device.

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Example 1: $f_S = 2.6$ GSPS, Bypass Mode (LMFS = 82820), K = 16

SYSREF = 2.6 GSPS / LCM (64, 20 x 16) / N = 8.125 MHz / N

Operate SYSREF at 4.0625 MHz (effectively divide-by-640, N = 2)

Example 2: $f_S = 2.6$ GSPS, Divide-by-4 (LMFS = 8411), K = 16

SYSREF = 2.6 GSPS / LCM (4,64, 16) = 40.625 MHz / N

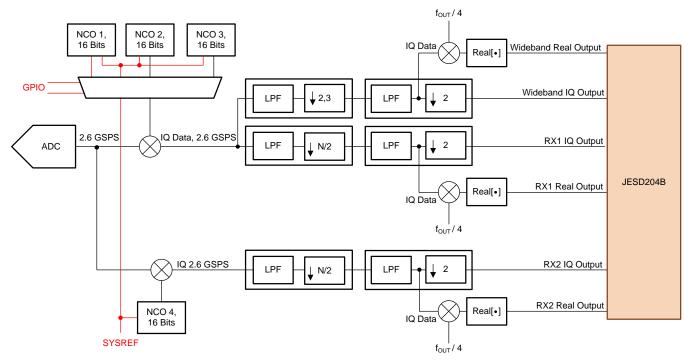
Operate SYSREF at 2.539063 MHz (effectively divide-by-1024, N = 16)

For proper device operation, disable the SYSREF signal after the JESD synchronization is established.

9.3.4 DDC Block

The ADC32RF44 provides a sophisticated on-chip, digital down converter (DDC) block that can be controlled through SPI register settings and the general-purpose input/output (GPIO) pins. The DDC block supports two basic operating modes: receiver (RX) mode with single- or dual-band DDC and wide-bandwidth observation receiver mode.

Each ADC channel is followed by two DDC chains consisting of the digital filter along with a complex digital mixer with a 16-bit numerically-controlled oscillator (NCO), as shown in Figure 71. The NCOs allow accurate frequency tuning within the Nyquist zone prior to the digital filtering. One DDC chain is intended for supporting a dual-band DDC configuration in receiver mode and the second DDC chain supports the wide-bandwidth output option for the observation configuration. At any given time, either the single-band DDC, the dual-band DDC, or the wideband DDC can be enabled. Furthermore, three different NCO frequencies can be selected on that path and are quickly switched using the SPI or the GPIO pins to enable wide-bandwidth observation in a multi-band application.



NOTE: Red traces show SYSREF going to the NCO blocks.

Figure 71. DDC Chains Overview (One ADC Channel Shown)

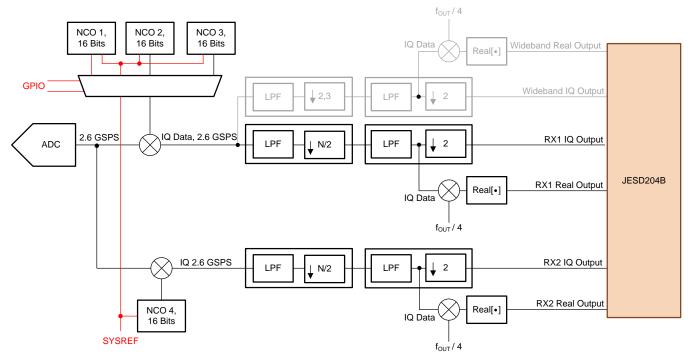
Additionally, the decimation filter block provides the option to convert the complex output back to real format at twice the decimated, complex output rate. The filter response with a real output is identical to a complex output. The band is centered in the middle of the Nyquist zone (mixed with f_{OUT} / 4) based on a final output data rate of f_{OUT} .

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9.3.4.1 Operating Mode: Receiver

In receiver mode, the DDC block can be configured to single- or dual-band operation, as shown in Figure 72. Both DDC chains use the same decimation filter setting and the available options are discussed in the *Decimation Filters* section. The decimation filter setting also directly affects the interface rate and number of lanes of the JESD204B interface.



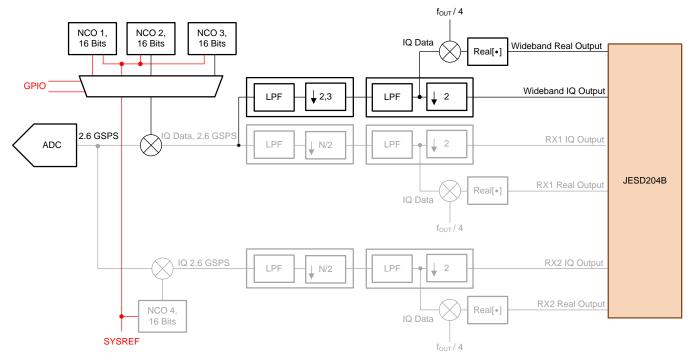
NOTE: Red traces show SYSREF going to the NCO blocks.

Figure 72. Decimation Filter Option for Single- or Dual-Band Operation



9.3.4.2 Operating Mode: Wide-Bandwidth Observation Receiver

This mode is intended for using a DDC with a wide bandwidth output, but for multiple bands. This mode uses a single DDC chain where up to three NCOs can be used to perform wide-bandwidth observation in a multi-band environment, as shown in Figure 73. The three NCOs can be switched dynamically using either the GPIO pins or an SPI command. All three NCOs operate continuously to ensure phase continuity; however, when the NCO is switched, the output data are invalid until the decimation filters are completely flushed with data from the new band.



NOTE: Red traces show SYSREF going to the NCO blocks.

Figure 73. Decimation Filter Implementation for Single-Band and Wide-Bandwidth Mode

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9.3.4.3 Decimation Filters

The stop-band rejection of the decimation filters is approximately 90 dB with a pass-band bandwidth of approximately 80%. Table 3 gives an overview of the pass-band bandwidth depending on decimation filter setting and ADC sampling rate.

Table 3. Decimation Filter Summary and Maximum Available Output Bandwidth

	NO. OF DDCS NOMINAL		BANDWIDTH		ADC SAMPLE RATE = N MSPS		ADC SAMPLE RATE = 2.6 GSPS	
DECIMATION SETTING	AVAILABLE PER CHANNEL	PASSBAND GAIN	3 dB (%)	1 dB (%)	OUTPUT RATE (MSPS) PER BAND	OUTPUT BANDWIDTH (MHz) PER BAND	COMPLEX OUTPUT RATE (MSPS) PER BAND	OUTPUT BANDWIDTH (MHz) PER BAND
Divide-by-4 complex	1	-0.4 dB	90.9	86.8	N / 4 complex	0.4 × N / 2	650	520
Divide-by-6 complex	1	-0.65 dB	90.6	86.1	N / 6 complex	0.4 × N / 3	433.3	346.64
Divide-by-8 complex	2	-0.27 dB	91.0	86.8	N / 8 complex	0.4 × N / 4	325	260
Divide-by-9 complex	2	-0.45 dB	90.7	86.3	N / 9 complex	0.4 × N / 4.5	288.9	231.12
Divide-by-10 complex	2	-0.58 dB	90.7	86.3	N / 10 complex	0.4 × N / 5	260	208
Divide-by-12 complex	2	–0.55 dB	90.7	86.4	N / 12 complex	0.4 × N / 6	216.7	173.36
Divide-by-16 complex	2	-0.42 dB	90.8	86.4	N / 16 complex	0.4 × N / 8	162.5	130
Divide-by-18 complex	2	-0.83 dB	91.2	87.0	N / 18 complex	0.4 × N / 9	144.4	115.52
Divide-by-20 complex	2	-0.91 dB	91.2	87.0	N / 20 complex	0.4 × N / 10	130	104
Divide-by-24 complex	2	-0.95 db	91.1	86.9	N / 24 complex	0.4 × N / 12	108.3	86.64
Divide-by-32 complex	2	-0.78 dB	91.1	86.8	N / 32 complex	0.4 × N / 16	81.3	65.04



A dual-band example with a divide-by-8 complex is shown in Figure 74.

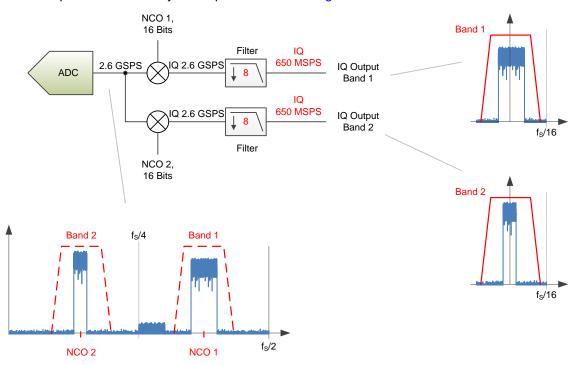


Figure 74. Dual-Band Example

The decimation filter responses normalized to the ADC sampling clock are illustrated in Figure 74 to Figure 97 and can be interpreted as follows:

Each figure contains the filter pass-band, transition bands, and alias bands, as shown in Figure 75. The x-axis in Figure 75 shows the offset frequency (after the NCO frequency shift) normalized to the ADC sampling clock frequency.

For example, in the divide-by-4 complex, the output data rate is an f_S / 4 complex with a Nyquist zone of f_S / 8 or 0.125 × f_S . The transition band is centered around 0.125 × f_S and the alias transition band is centered at 0.375 × f_S . The alias bands that alias on top of the wanted signal band are centered at 0.25 × f_S and 0.5 × f_S (and are colored in red).

The decimation filters of the ADC32RF44 provide greater than 90-dB attenuation for the alias bands.

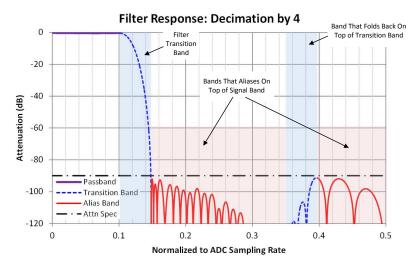


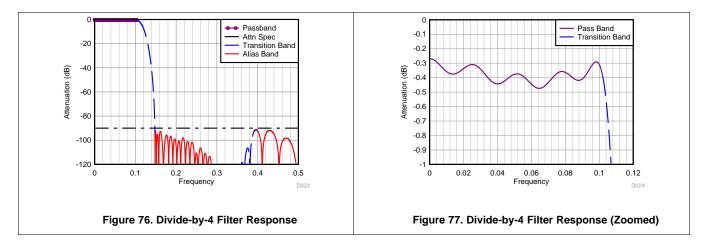
Figure 75. Interpretation of the Decimation Filter Plots

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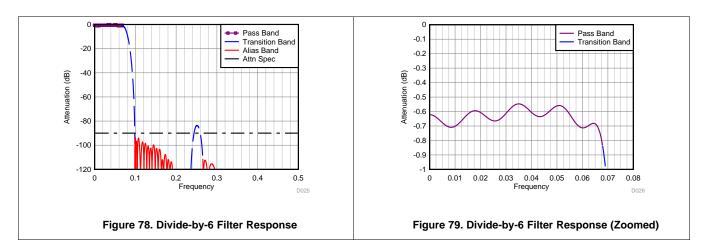
9.3.4.3.1 Divide-by-4

Peak-to-peak pass-band ripple: approximately 0.22 dB



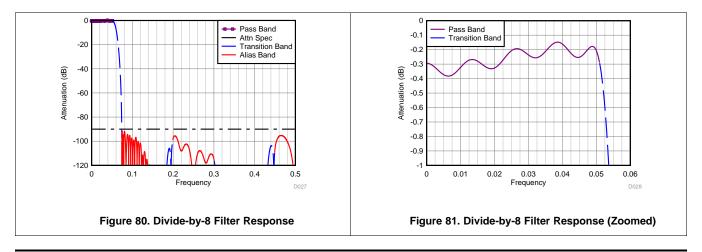
9.3.4.3.2 Divide-by-6

Peak-to-peak pass-band ripple: approximately 0.38 dB



9.3.4.3.3 Divide-by-8

Peak-to-peak pass-band ripple: approximately 0.25 dB



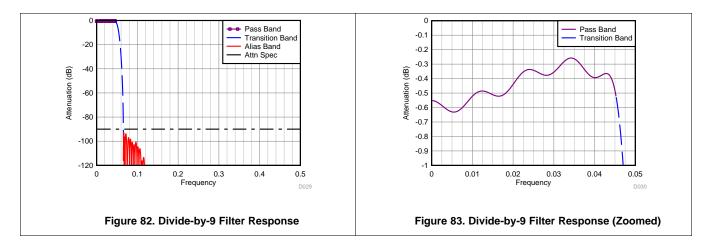
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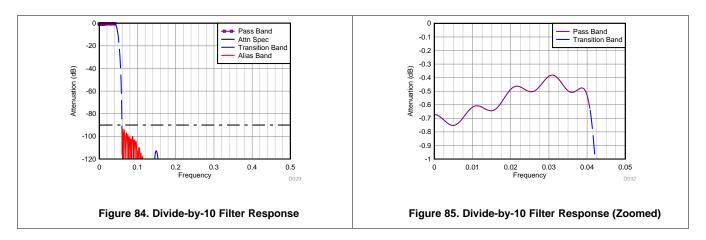
9.3.4.3.4 Divide-by-9

Peak-to-peak pass-band ripple: approximately 0.39 dB



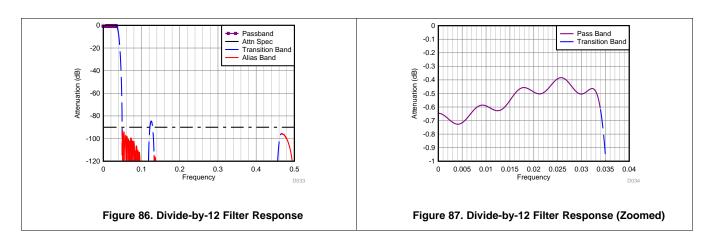
9.3.4.3.5 Divide-by-10

Peak-to-peak pass-band ripple: approximately 0.39 dB



9.3.4.3.6 Divide-by-12

Peak-to-peak pass-band ripple: approximately 0.36 dB

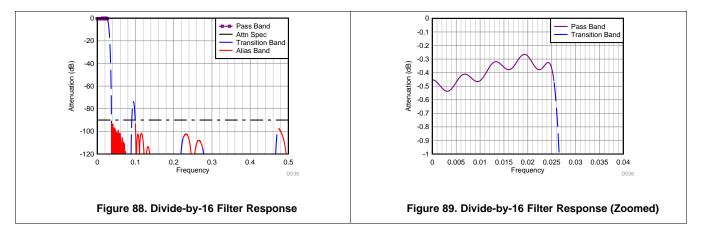


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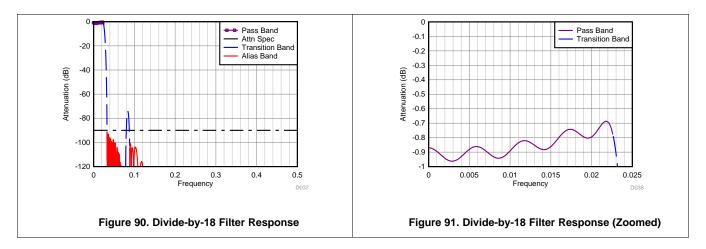
9.3.4.3.7 Divide-by-16

Peak-to-peak pass-band ripple: approximately 0.29 dB



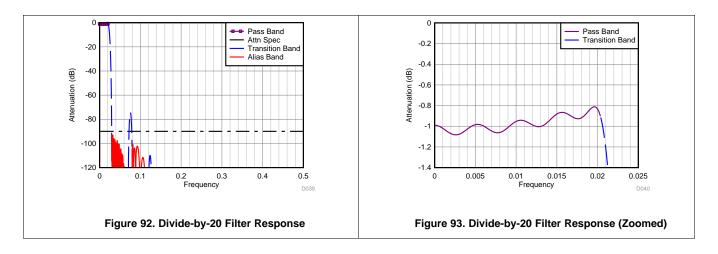
9.3.4.3.8 Divide-by-18

Peak-to-peak pass-band ripple: approximately 0.33 dB



9.3.4.3.9 Divide-by-20

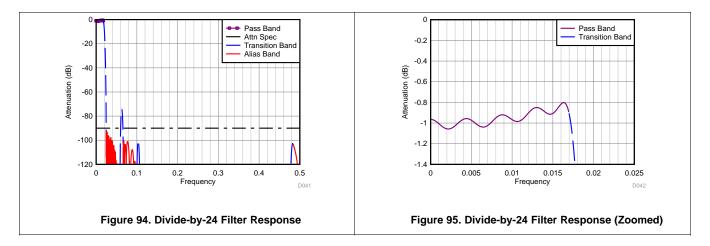
Peak-to-peak pass-band ripple: approximately 0.32 dB





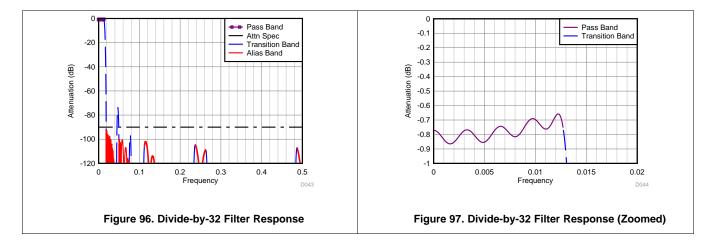
9.3.4.3.10 Divide-by-24

Peak-to-peak pass-band ripple: approximately 0.30 dB



9.3.4.3.11 Divide-by-32

Peak-to-peak pass-band ripple: approximately 0.24 dB





9.3.4.3.12 Latency with Decimation Options

Device latency in 12-bit bypass mode (with LMFS = 8224) is 424 clock cycles. When the DDC option is used, latency increases as a result of decimation filters, as described in Table 4.

Table 4. Latency with different Decimation options

DECIMATION OPTION	TOTAL LATENCY, DEVICE CLOCK CYCLES				
Divide-by-4	516				
Divide-by-6	746				
Divide-by-8	621				
Divide-by-9	763.5				
Divide-by-10	811				
Divide-by-12	897				
Divide-by-16	1045				
Divide-by-18	1164				
Divide-by-20	1256				
Divide-by-24	1443				
Divide-by-32	1773				

9.3.4.4 Digital Multiplexer (MUX)

The ADC32RF44 supports a mode where the output data of the ADC channel A can be routed internally to the digital blocks of both channel A and channel B. The ADC channel B can be powered down as shown in Figure 98. In this manner, the ADC32RF44 can be configured as a single-channel ADC with up to four independent DDC chains or two wideband DDC chains. All decimation filters and JESD204B format configurations are identical to the two ADC channel operation.

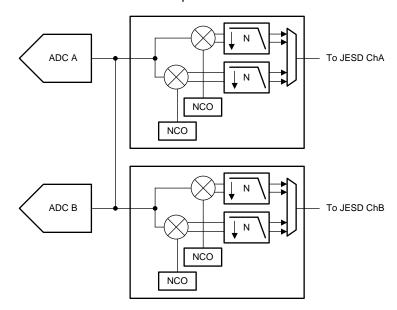


Figure 98. Digital Multiplexer Option

9.3.4.5 Numerically-Controlled Oscillators (NCOs) and Mixers

The ADC32RF44 is equipped with three independent, complex NCOs per ADC channel. The oscillator generates a complex exponential sequence, as shown in Equation 2.

 $x[n] = e^{-j\omega n}$

where

frequency (ω) is specified as a signed number by the 16-bit register setting

(2)



The complex exponential sequence is multiplied by the real input from the ADC to mix the desired carrier down to 0 Hz.

Each ADC channel has two DDCs. The first DDC has three NCOs and the second DDC has one NCO. The first DDC can dynamically select one of the three NCOs based on the GPIO pin or SPI selection. In wide-bandwidth mode (lower decimation factors, for example, 4 and 6), there can only be one DDC for each ADC channel. The NCO frequencies can be programmed independently through the DDCx, NCO[4:1], and the MSB and LSB register settings.

The NCO frequency setting is set by the 16-bit register value given by Equation 3:

$$f_{NCO} \, = \, \frac{DDCxNCOy \times f_S}{2^{16}}$$

where

•
$$x = 0, 1$$

• $y = 1 \text{ to } 4$ (3)

For example:

If $f_S = 2.6$ GSPS, then the NCO register setting = 38230 (decimal).

Thus, f_{NCO} is defined by Equation 4:

$$f_{NCO} = 38230 \times \frac{2.6 \text{ GSPS}}{2^{16}} = 1516.693 \text{ MHz}$$
(4)

Any register setting changes that occur after the JESD204B interface is operational results in a non-deterministic NCO phase. If a deterministic phase is required, the JESD204B interface must be reinitialized after changing the register setting.

In bypass mode (when decimation filters are not used), the NCOs are powered down in order to avoid creating unwanted spurs.

9.3.5 NCO Switching

The first DDC (DDC0) on each ADC channel provides three different NCOs that can be used for phase-coherent frequency hopping. This feature is available in both single-band and dual-band mode, but only affects DDC0.

The NCOs can be switched through an SPI control or by using the GPIO pins with the register configurations shown in Table 5 for channel A (50xxh) and channel B (58Xxh). The assignment of which GPIO pin to use for INSEL0 and INSEL1 is done based on Table 6, using registers 5438h and 5C38h. The NCO selection is done based on the logic selection on the GPIO pins; see Table 7 and Figure 99.

Table 5. NCO Register Configurations

REGISTER	ADDRESS	DESCRIPTION
NCO CONTROL THROUG	H GPIO PINS	
NCO SEL pin	500Fh, 580Fh	Selects the NCO control through the SPI (default) or a GPIO pin.
INSEL0, INSEL1	5438h, 5C38h	Selects which two GPIO pins are used to control the NCO.
NCO CONTROL THROUG	H SPI CONTROL	
NCO SEL pin	500Fh, 580Fh	Selects the NCO control through the SPI (default) or a GPIO pin.
NCO SEL	5010h, 5810h	Selects which NCO to use for DDC0.

Table 6. GPIO Pin Assignment

INSELx[1:0] (Where x = 0 or 1)	GPIO PIN SELECTED
00	GPIO4
01	GPIO1
10	GPIO3
11	GPIO2

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Table 7. NCO Selection

NCO SEL[1]	NCO SEL[0]	NCO SELECTED		
0	0	NCO1		
0	1	NCO2		
1	0	NCO3		
1	1	n/a		

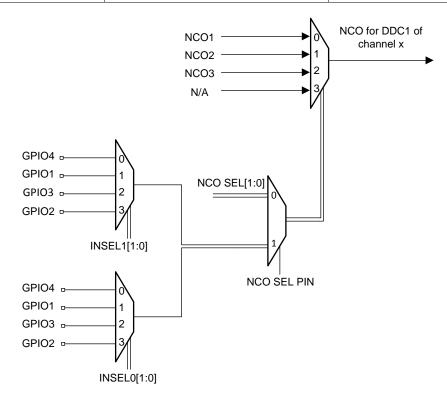


Figure 99. NCO Switching from GPIO and SPI

9.3.6 SerDes Transmitter Interface

Each 12.5-Gbps serializer, deserializer (SerDes) LVDS transmitter output requires ac-coupling between the transmitter and receiver. Terminate the differential pair with $100-\Omega$ resistance (that is, two $50-\Omega$ resistors) as close to the receiving device as possible to avoid unwanted reflections and signal degradation, as shown in Figure 100.

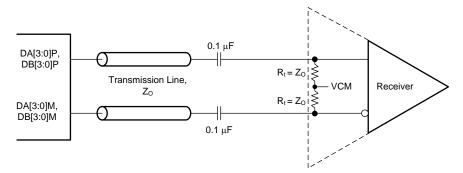


Figure 100. External Serial JESD204B Interface Connection

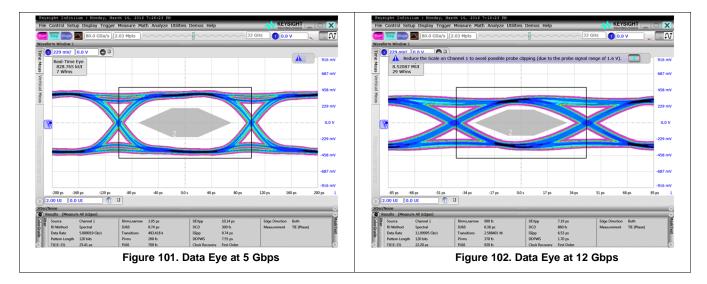
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9.3.7 Eye Diagrams

Figure 101 and Figure 102 show the serial output eye diagrams of the ADC32RF44 at 5.0 Gbps and 12 Gbps against the JESD204B mask.



9.3.8 Alarm Outputs: Power Detectors for AGC Support

The GPIO pins can be configured as alarm outputs for channels A and B. The ADC32RF44 supports three different power detectors (an absolute peak power detector, crossing detector, and RMS power detector) as well as fast overrange from the ADC. The power detectors operate off the full-rate ADC output prior to the decimation filters.

9.3.8.1 Absolute Peak Power Detector

In this detector mode, the peak is computed over eight samples of the ADC output. Next, the peak for a block of N samples (N x S') is computed over a programmable block length and then compared against a threshold to either set or reset the peak detector output (Figure 103 and Figure 104). There are two sets of thresholds and each set has two thresholds for hysteresis. The programmable DWELL-time counter is used for clearing the block detector alarm output.

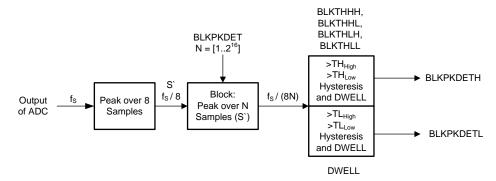


Figure 103. Peak Power Detector Implementation

Product Folder Links: ADC32RF44



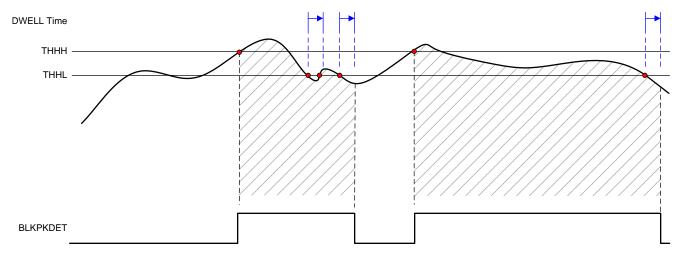


Figure 104. Peak Power Detector Timing Diagram

Table 8 shows the register configurations required to set up the absolute peak power detector. The detector operates in the f_S / 8 clock domain; one peak sample is calculated over eight actual samples.

The automatic gain control (AGC) modes can be configured separately for channel A (54xxh) and channel B (5Cxxh), although some registers are common in 54xxh (such as the GPIO pin selection).

Table 8. Registers Required for the Peak Power Detector

REGISTER	ADDRESS	DESCRIPTION
PKDET EN	5400, 5C00h	Enables peak detector
BLKPKDET	5401h, 5402h, 5403h, 5C01h, 5C02h, 5C03h	Sets the block length N of number of samples (S`). Number of actual ADC samples is 8X this value: N is 17 bits: 1 to 2 ¹⁶ .
BLKTHHH, BLKTHHL, BLKTHLH, BLKTHLL	5407h, 5408h, 5409h, 540Ah, 5C07h, 5C08h, 5C09h, 5C0Ah	Sets the different thresholds for the hysteresis function values from 0 to 256 (where 256 is equivalent to the peak amplitude). For example: if BLKTHHH is to -2 dBFS from peak, $10^{(-2/20)} \times 256 = 203$, then set 5407h and 5C07h = CBh.
DWELL	540Bh, 540Ch, 5C0Bh, 5C0Ch	When the computed block peak crosses the upper thresholds BLKTHHH or BLKTHLH, the peak detector output flags are set. In order to be reset, the computed block peak must remain continuously lower than the lower threshold (BLKTHHL or BLKTHLL) for the period specified by the DWELL value. This threshold is 16 bits and is specified in terms of f _S / 8 clock cycles.
OUTSEL GPIO[4:1]	5432h, 5433h, 5434h, 5435h	Connects the BLKPKDETH, BLKPKDETL alarms to the GPIO pins; common register.
IODIR	5437h	Selects the direction for the four GPIO pins; common register.
RESET AGC	542Bh, 5C2Bh	After configuration, reset the AGC module to start operation.

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9.3.8.2 Crossing Detector

In this detector mode the peak is computed over eight samples of the ADC output. Next, the peak for a block of N samples (N \times S`) is computed over a programmable block length and then the peak is compared against two sets of programmable thresholds (with hysteresis). The crossing detector counts how many f_S / 8 clock cycles that the block detector outputs are set high over a programmable time period and compares the counter value against the programmable thresholds. The alarm outputs are updated at the end of the time period, routed to the GPIO pins, and held in that state through the next cycle, as shown in Figure 105 and Figure 106. Alternatively, a 2-bit format can be used but (because the ADC32RF44 has four GPIO pins available) this feature uses all four pins for a single channel.

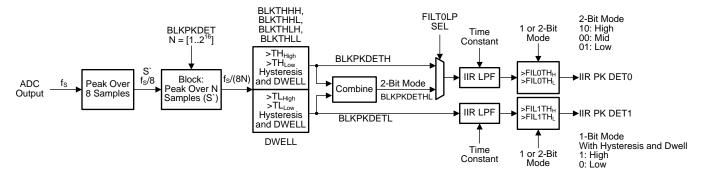


Figure 105. Crossing Detector Implementation

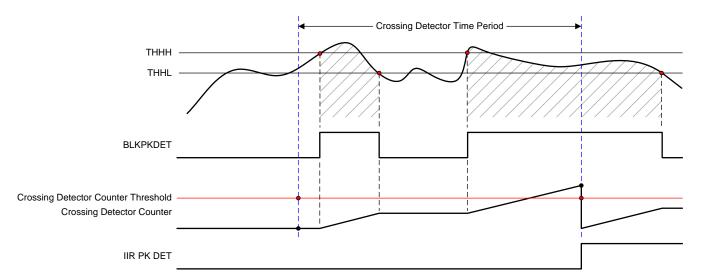


Figure 106. Crossing Detector Timing Diagram

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Table 9 shows the register configurations required to set up the crossing detector. The detector operates in the f_S / 8 clock domain. The AGC modes can be configured separately for channel A (54xxh) and channel B (5Cxxh), although some registers are common in 54xxh (such as the GPIO pin selection).

Table 9. Registers Required for the Crossing Detector Operation

REGISTER	ADDRESS	DESCRIPTION				
PKDET EN	5400h, 5C00h	Enables peak detector				
BLKPKDET	5401h, 5402h, 5403h, 5C01h, 5C02h, 5C03h	Sets the block length N of number of samples (S`). Number of actual ADC samples is 8X this value: N is 17 bits: 1 to 2 ¹⁶ .				
BLKTHHH, BLKTHHL, BLKTHLH, BLKTHLL	5407h, 5408h, 5409h, 540Ah, 5C07h, 5C08h, 5C09h, 5C0Ah	Sets the different thresholds for the hysteresis function values from 0 to 256 (where 256 is equivalent to the peak amplitude). For example: if BLKTHHH is to -2 dBFS from peak, $10^{(-2/20)} \times 256 = 203$, then set 5407h and 5C07h = CBh.				
FILT0LPSEL	540Dh, 5C0Dh	Select block detector output or 2-bit output mode as the input to the interrupt identification register (IIR) filter.				
TIMECONST 540Eh, 540Fh, 5C0Eh, 5C0Fh		Sets the crossing detector time period for N = 0 to 15 as 2N × f_S / 8 clock cycle. The maximum time period is 32768 × f_S / 8 clock cycles (approximately 101 μ s 2.6 GSPS).				
FILOTHH, FILOTHL, FIL1THH, FIL1THL	540Fh-5412h, 5C0Fh- 5C12h, 5416h-5419h, 5C16h-5C19h	Comparison thresholds for the crossing detector counter. These thresholds are 16-bit thresholds in 2.14-signed notation. A value of 1 (4000h) corresponds to 100% crossings, a value of 0.125 (0800h) corresponds to 12.5% crossings.				
DWELLIIR	541Dh, 541Eh, 5C1Dh, 5C1Eh	DWELL counter for the IIR filter hysteresis.				
IIRO 2BIT EN, IIR1 2BIT EN	5413h, 54114h, 5C13h, 5C114h	Enables 2-bit output format for the crossing detector.				
OUTSEL GPIO[4:1]	5432h, 5433h, 5434h, 5435h	Connects the IIRPKDET0, IIRPKDET1 alarms to the GPIO pins; common register.				
IODIR	5437h	Selects the direction for the four GPIO pins; common register.				
RESET AGC	542Bh, 5C2Bh	After configuration, reset the AGC module to start operation.				

Product Folder Links: ADC32RF44



9.3.8.3 RMS Power Detector

In this detector mode the peak power is computed for a block of N samples over a programmable block length and then compared against two sets of programmable thresholds (with hysteresis).

The RMS power detector circuit provides configuration options, as shown in Figure 107. The RMS power value (1 or 2 bit) can be output onto the GPIO pins. In 2-bit output mode, two different thresholds are used whereas the 1-bit output provides one threshold together with hysteresis.

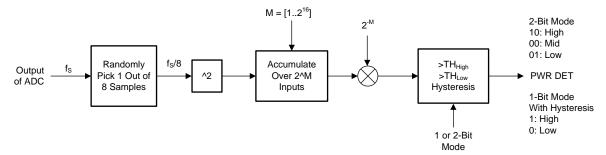


Figure 107. RMS Power Detector Implementation

Table 10 shows the register configurations required to set up the RMS power detector. The detector operates in the f_S / 8 clock domain. The AGC modes can be configured separately for channel A (54xxh) and channel B (5Cxxh), although some registers are common in 54xxh (such as the GPIO pin selection).

Table 10. Registers Required for Using the RMS Power Detector Feature

REGISTER	ADDRESS	DESCRIPTION
RMSDET EN	5420h, 5C20h	Enables RMS detector
PWRDETACCU	5421h, 5C21h	Programs the block length to be used for RMS power computation. The block length is defined in terms of f_S / 8 clocks. The block length can be programmed as 2^M with $M=0$ to 16.
PWRDETH, PWRDETL	5422h, 5423h, 5424h, 5425h, 5C22h, 5C23h, 5C24h, 5C25h	The computed average power is compared against these high and low thresholds. One LSB of the thresholds represents 1 / 2^{16} . For example: is PWRDETH is set to -14 dBFS from peak, $[10^{(-14/20)}]^2 \times 2^{16} = 2609$, then set 5422h, 5423h, 5C22h, 5C23h = 0A31h.
RMS2BIT EN	5427h, 5C27h	Enables 2-bit output format for the RMS detector output.
OUTSEL GPIO[4:1]	5432h, 5433h, 5434h, 5435h	Connects the PWRDET alarms to the GPIO pins; common register.
IODIR	5437h	Selects the direction for the four GPIO pins; common register.
RESET AGC	542Bh, 5C2Bh	After configuration, reset the AGC module to start operation.

9.3.8.4 GPIO AGC MUX

The GPIO pins can be used to control the NCO in wideband DDC mode or as alarm outputs for channel A and B. The GPIO pins can be configured through the SPI control to output the alarm from the peak power (1 bit), crossing detector (1 or 2 bit), faster overrange, or the RMS power output, as shown in Figure 108.

The programmable output MUX allows connecting any signal (including the NCO control) to any of the four GPIO pins. These pins can be configured as outputs (AGC alarm) or inputs (NCO control) through SPI programming.

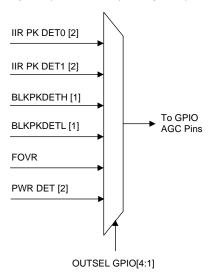


Figure 108. GPIO Output MUX Implementation

9.3.9 Power-Down Mode

The ADC32RF44 provides a lot of configurability for the power-down mode. Power-down can be enabled using the PDN pin or the SPI register writes.

9.3.10 ADC Test Pattern

The ADC32RF44 provides several different options to output test patterns instead of the actual output data of the ADC in order to simplify the serial interface and system debug of the JESD204B digital interface link. The output data path is shown in Figure 109.

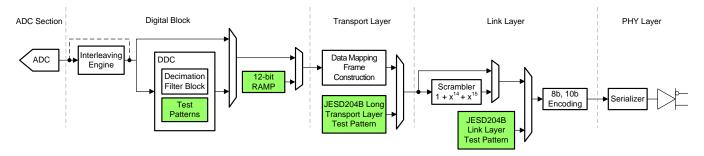


Figure 109. Test Pattern Generator Implementation

9.3.10.1 Digital Block

The ADC test pattern replaces the actual output data of the ADC. The test patterns listed in Table 11 are available when the DDC is enabled and located in register 37h of the decimation filter page. When programmed, the test patterns are output for each converter (M) stream. The number of converter streams per channel increases by 2 when complex (I, Q) output or dual-band DDC is selected. The test patterns can be synchronized for both ADC channels using the SYSREF signal.

Additionally, a 12-bit ramp test pattern is available in DDC bypass mode.



NOTE

The number of converters increases in dual-band DDC mode and with a complex output.

Table 11. Test Pattern Options (Register 37h)

BIT	NAME	DEFAULT	DESCRIPTION
7-4	TEST PATTERN	0000	Test pattern outputs on channel A and B. 0000 = Normal operation using ADC output data 0001 = Outputs all 0s 0010 = Outputs all 1s 0011 = Outputs toggle pattern: output data are an alternating sequence of 10101010101010 and 0101010101010 0100 = Output digital ramp: output data increment by one LSB every clock cycle from code 0 to 65535 0110 = Single pattern: output data are a custom pattern 1 (75h and 76h) 0111 Double pattern: output data alternate between custom pattern 1 and custom pattern 2 1000 = Deskew pattern: output data are AAAAh 1001 = SYNC pattern: output data are FFFFh

9.3.10.2 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, the JESD204B long transport layer test pattern can be substituted instead of the ADC data with the JESD frame, as shown in Table 12.

Table 12. Transport Layer Test Mode EN (Register 01h)

BIT	NAME	DEFAULT	DESCRIPTION
4	TESTMODE EN	0	Generates long transport layer test pattern mode according to section 5.1.6.3 of the JESD204B specification. 0 = Test mode disabled 1 = Test mode disabled

9.3.10.3 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 13.

Table 13. Link Layer Test Mode (Register 03h)

BIT	NAME	DEFAULT	DESCRIPTION
7-5	LINK LAYER TESTMODE	000	Generates a pattern according to section 5.3.3.8.2 of the JESD204B document. 000 = Normal ADC data 001 = D21.5 (high-frequency jitter pattern) 010 = K28.5 (mixed-frequency jitter pattern) 011 = Repeat the initial lane alignment (generates a K28.5 character and repeats lane alignment sequences continuously) 100 = 12-octet random pattern (RPAT) jitter pattern

Furthermore, a 2¹⁵ pseudo-random binary sequence (PRBS) can be enabled by setting up a custom test pattern (AAAAh) in the ADC section and running AAAAh through the 8b, 10b encoder with scrambling enabled.

Product Folder Links: ADC32RF44



9.4 Device Functional Modes

9.4.1 Device Configuration

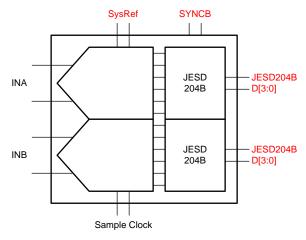
The ADC32RF44 can be configured using a serial programming interface, as described in the Serial Interface section. In addition, the device has one dedicated parallel pin (PDN) for controlling the power-down modes.

9.4.2 JESD204B Interface

The ADC32RF44 supports device subclass 1 with a maximum output data rate of 12.5 Gbps for each serial transmitter.

An external SYSREF signal is used to align all internal clock phases and the local multiframe clock to a specific sampling clock edge. This alignment allows synchronization of multiple devices in a system and minimizes timing and alignment uncertainty. The SYNCB input is used to control the JESD204B SerDes blocks, as shown in Figure 110.

Depending on the ADC sampling rate, the JESD204B output interface can be operated with one, two, or four lanes per ADC channel. The JESD204B setup and configuration of the frame assembly parameters is controlled through the SPI interface.



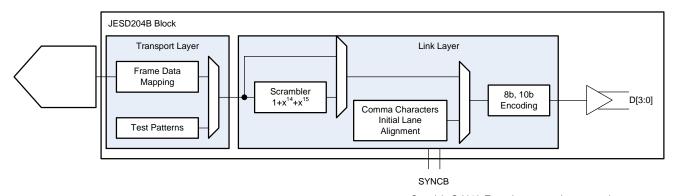
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Figure 110. JESD Signal Overview



Device Functional Modes (continued)

The JESD204B transmitter block consists of the transport layer, the data scrambler, and the link layer, as shown in Figure 111. The transport layer maps the ADC output data into the selected JESD204B frame data format and manages if the ADC output data or test patterns are transmitted. The link layer performs the 8b, 10b data encoding as well as the synchronization and initial lane alignment using the SYNC input signal. Optionally, data from the transport layer can be scrambled.



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Figure 111. JESD Digital Block Implementation

9.4.2.1 JESD204B Initial Lane Alignment (ILA)

The receiving device starts the initial lane alignment process by deasserting the SYNCB signal. The SYNCB signal can be issued using the SYNCB input pins or by setting the proper SPI bits. When a logic low is detected on the SYNCB input, the ADC32RF44 starts transmitting comma (K28.5) characters to establish the code group synchronization, as shown in Figure 112.

When synchronization completes, the receiving device reasserts the SYNCB signal and the ADC32RF44 starts the initial lane alignment sequence with the next local multiframe clock boundary. The ADC32RF44 transmits four multiframes, each containing K frames (K is SPI programmable). Each of the multiframes contains the frame start and end symbols. The second multiframe also contains the JESD204 link configuration data.

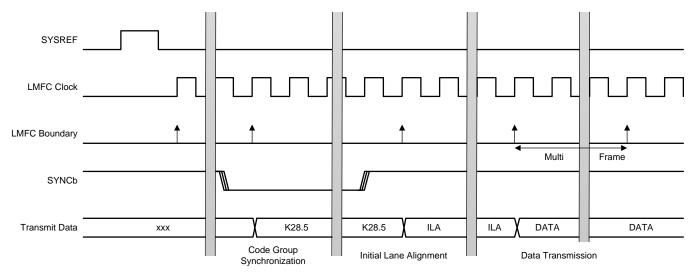


Figure 112. JESD Internal Timing Information

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Device Functional Modes (continued)

9.4.2.2 JESD204B Frame Assembly

The JESD204B standard defines the following parameters:

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

9.4.2.3 JESD204B Frame Assembly in Bypass Mode

Table 14 lists the available JESD204B formats and valid ranges for the ADC32RF44. The ranges are limited by the SerDes line rate and the maximum ADC sample frequency. The sample alignment for the bypass modes on the different lanes is shown in Table 15.

Table 14. JESD Mode Options: Bypass Mode

DECIMATION SETTING (Complex)	OUTPUT RESOLUTION (Bits)	L	М	F	s	12-BIT MODE	PLL MODE	JESD MODE 0	JESD MODE 1	JESD MODE 2	MAX f _{CLK} (Gsps)	RATIO [f _{SerDes} / f _{CLK} (Gbps / GSPS)]
Bypass	12 ⁽¹⁾	8	2	8	20	3	16X	3	0	0	2.6	4
	14	8	2	2	4	0	20X	1	0	0	2.5	5

⁽¹⁾ In full rate output, the two LSBs are truncated to a 12-bit output.

Table 15. JESD Sample Lane Alignments: Bypass Mode⁽¹⁾

OUTPUT LANE	LMFS	= 8224	LMFS = 82820							
DA0	A ₀ [13:6]	A ₀ [5:0], 00	A ₀ [11:4]	A ₀ [3:0], A ₁ [11:8]	A ₁ [7:0]	A ₂ [11:4]	A ₂ [3:0], A ₃ [11:8]	A ₃ [7:0]	A ₄ [11:4]	A ₄ [3:0], 0000
DA1	A ₁ [13:6]	A ₁ [5:0], 00	A ₅ [11:4]	A ₅ [3:0], A ₆ [11:8]	A ₆ [7:0]	A ₇ [11:4]	A ₇ [3:0], A ₈ [11:8]	A ₈ [7:0]	A ₉ [11:4]	A ₉ [3:0], 0000
DA2	A ₂ [13:6]	A ₂ [5:0], 00	A ₁₀ [11:4]	A ₁₀ [3:0], A ₁₁ [11:8]	A ₁₁ [7:0]	A ₁₂ [11:4]	A ₁₂ [3:0], A ₁₃ [11:8]	A ₁₃ [7:0]	A ₁₄ [11:4]	A ₁₄ [3:0], 0000
DA3	A ₃ [13:6]	A ₃ [5:0], 00	A ₁₅ [11:4]	A ₁₅ [3:0], A ₁₆ [11:8]	A ₁₆ [7:0]	A ₁₇ [11:4]	A ₁₇ [3:0], A ₁₈ [11:8]	A ₁₈ [7:0]	A ₁₉ [11:4]	A ₁₉ [3:0], 0000
DB0	B ₀ [13:6]	B ₀ [5:0], 00	B ₀ [11:4]	B ₀ [3:0], B ₁ [11:8]	B ₁ [7:0]	B ₂ [11:4]	B ₂ [3:0], B ₃ [11:8]	B ₃ [7:0]	B ₄ [11:4]	B ₄ [3:0], 0000
DB1	B ₁ [13:6]	B ₁ [5:0], 00	B ₅ [11:4]	B ₅ [3:0], B ₆ [11:8]	B ₆ [7:0]	B ₇ [11:4]	B ₇ [3:0], B ₈ [11:8]	B ₈ [7:0]	B ₉ [11:4]	B ₉ [3:0], 0000
DB2	B ₂ [13:6]	B ₂ [5:0], 00	B ₁₀ [11:4]	B ₁₀ [3:0], B ₁₁ [11:8]	B ₁₁ [7:0]	B ₁₂ [11:4]	B ₁₂ [3:0], B ₁₃ [11:8]	B ₁₃ [7:0]	B ₁₄ [11:4]	B ₁₄ [3:0], 0000
DB3	B ₃ [13:6]	B ₃ [5:0], 00	B ₁₅ [11:4]	B ₁₅ [3:0], B ₁₆ [11:8]	B ₁₆ [7:0]	B ₁₇ [11:4]	B ₁₇ [3:0], B ₁₈ [11:8]	B ₁₈ [7:0]	B ₁₉ [11:4]	B ₁₉ [3:0], 0000

⁽¹⁾ Blue shading indicates channel A and yellow shading indicates channel B.



9.4.2.4 JESD204B Frame Assembly with Decimation (Single-Band DDC): Complex Output

Table 16 lists the available JESD204B interface formats and valid ranges for the ADC32RF44 with decimation (single-band DDC) when using a complex output format. The ranges are limited by the SerDes line rate and the maximum ADC sample frequency. The sample alignment on the different lanes is shown in Table 17.

Table 16. JESD Mode Options: Single-Band Complex Output

DECIMATION SETTING (Complex)	NUMBER OF ACTIVE DDCS	L	М	F	S	PLL MODE	JESD MODE0	JESD MODE1	JESD MODE2	RATIO [f _{SerDes} / f _{CLK} (Gbps / GSPS)]
		8	4	1	1	20X	1	1	0	2.5
Divide by 4	1 nor shannal	8	4	2	2	20X	1	0	0	2.5
Divide-by-4	1 per channel	4	4	2	1	40X	0	0	1	5
		4	4	4	2	40X	2	0	0	5
		8	4	1	1	20X	1	1	0	1.67
Divide-by-6	1 per channel	8	4	2	2	20X	1	0	0	1.07
Divide-by-6	i per channer	4	4	2	1	40X	0	0	1	3.33
		4	4	4	2	40X	2	0	0	3.33
Divide-by-8	1 per channel	4	4	2	1	20X	1	0	0	2.5
Divide-by-6	i per channer	2	4	4	1	40X	2	0	0	5
Divide by 0	1 per channel	4	4	2	1	20X	1	0	0	2.22
Divide-by-9	i per channer	2	4	4	1	40X	2	0	0	4.44
Divide-by-10	1 per channel	4	4	2	1	20X	1	0	0	2
Divide-by-10	i per channer	2	4	4	1	40X	2	0	0	4
Divide-by-12	1 per channel	4	4	2	1	20X	1	0	0	1.67
Divide-by-12	i per channer	2	4	4	1	40X	2	0	0	3.33
Divide-by-16	1 per channel	4	4	2	1	20X	1	0	0	1.25
Divide-by-16	i per channer	2	4	4	1	40X	2	0	0	2.5
Divide-by-18	1 per channel	4	4	2	1	20X	1	0	0	1.11
Divide-by-16	i per channer	2	4	4	1	40X	2	0	0	2.22
Divido by 20	1 per channel	4	4	2	1	20X	1	0	0	1
Divide-by-20	1 per channel	2	4	4	1	40X	2	0	0	2
Divide-by-24	1 per channel	2	4	4	1	40X	1	0	0	1.67
Divide-by-32	1 per channel	2	4	4	1	40X	2	0	0	1.25

Table 17. JESD Sample Lane Alignments: Single-Band Complex Output⁽¹⁾

OUTPUT LANE	LMFS = 8411	LMFS	= 8422	_	= 4421 X		= 4421 OX		LMFS	= 4442		LMFS = 2441			
DA0	Al ₀ [15:8]	Al ₀ [15:8]	Al ₀ [7:0]	Al ₀ [15:8]	Al ₀ [7:0]										
DA1	Al ₀ [7:0]	Al ₁ [15:8]	Al ₁ [7:0]	AQ ₀ [15:8]	AQ ₀ [7:0]	Al ₀ [15:8]	Al ₀ [7:0]	Al ₀ [15:8]	Al ₀ [7:0]	Al ₁ [15:8]	Al₁ [7:0]	Al ₀ [15:8]	Al ₀ [7:0]	AQ ₀ [15:8]	AQ ₀ [7:0]
DA2	AQ ₀ [15:8]	AQ ₀ [15:8]	AQ ₀ [7:0]			AQ ₀ [15:8]	AQ ₀ [7:0]	AQ ₀ [15:8]	AQ ₀ [7:0]	AQ ₁ [15:8]	AQ ₁ [7:0]				
DA3	AQ ₀ [7:0]	AQ ₁ [15:8]	AQ ₁ [7:0]												
DB0	BI ₀ [15:8]	Bl ₀ [15:8]	Bl ₀ [7:0]	BI ₀ [15:8]	BI ₀ [7:0]										
DB1	BI ₀ [7:0]	BI ₁ [15:8]	BI ₁ [7:0]	BQ ₀ [15:8]	BQ ₀ [7:0]	BI ₀ [15:8]	BI ₀ [7:0]	BI ₀ [15:8]	BI ₀ [7:0]	BI ₁ [15:8]	Bl₁ [7:0]	Bl ₀ [15:8]	BI ₀ [7:0]	BQ ₀ [15:8]	BQ ₀ [7:0]
DB2	BQ ₀ [15:8]	BQ ₀ [15:8	BQ ₀ [7:0]			BQ ₀ [15:8]	BQ ₀ [7:0]	BQ ₀ [15:8]	BQ ₀ [7:0]	BQ ₁ [15:8]	BQ ₁ [7:0]				
DB3	BQ ₀ [7:0]	BQ ₁ [15:8]	BQ ₁ [7:0]												

⁽¹⁾ Blue shading indicates channel A and yellow shading indicates channel B.



9.4.2.5 JESD204B Frame Assembly with Decimation (Single-Band DDC): Real Output

Table 18 lists the available JESD204B formats and valid ranges for the ADC32RF44 with decimation (single-band DDC) when using real output format. The ranges are limited by the SerDes line rate and the maximum ADC sample frequency. The sample alignment on the different lanes is shown in Table 19.

Table 18. JESD Mode Options: Single-Band Real Output (Wide Bandwidth)

DECIMATION SETTING (Complex)	NUMBER OF ACTIVE DDCS	L	М	F	S	PLL MODE	JESD MODE0	JESD MODE1	JESD MODE2	RATIO [f _{SerDes} / f _{CLK} (Gbps / GSPS)]
		8	2	2	4	20X	1	0	0	2.5
Divide-by-4 (Divide-by-2 real) 1 per channel	4	2	4	4	40X	2	0	0		
(2.1.130 2) 2 103.)		4	2	1	1	40X	0	1	0	5
		8	2	2	4	20X	1	0	0	1.67
Divide-by-6 (Divide-by-3 real) 1 per channel	4	2	4	4	40X	2	0	0	0.00	
(225 3) 6 (64)		4	2	1	1	40X	0	0	1	3.33

Table 19. JESD Sample Lane Alignment: Single-Band Real Output (Wide Bandwidth)(1)

OUTPUT LANE	LMFS	= 8224		LMFS = 4244						
DA0	A ₀ [15:8]	A ₀ [7:0]								
DA1	A ₁ [15:8]	A ₁ [7:0]	A ₀ [15:8]	A ₀ [7:0]	A ₁ [15:8]	A ₁ [7:0]	A ₀ [15:8]			
DA2	A ₂ [15:8]	A ₂ [7:0]	A ₂ [15:8]	A ₂ [7:0]	A ₃ [15:8]	A ₃ [7:0]	A ₀ [7:0]			
DA3	A ₃ [15:8]	A ₃ [7:0]								
DB0	B ₀ [15:8]	B ₀ [7:0]								
DB1	B ₁ [15:8]	B ₁ [7:0]	B ₀ [15:8]	B ₀ [7:0]	B ₁ [15:8]	B ₁ [7:0]	B ₀ [15:8]			
DB2	B ₂ [15:8]	B ₂ [7:0]	B ₀ [15:8]	B ₂ [7:0]	B ₃ [15:8]	B ₃ [7:0]	B ₀ [7:0]			
DB3	B ₃ [15:8]	B ₃ [7:0]								

⁽¹⁾ Blue shading indicates channel A and yellow shading indicates channel B.

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9.4.2.6 JESD204B Frame Assembly with Decimation (Single-Band DDC): Real Output

Table 20 lists the available JESD204B formats and valid ranges for the ADC32RF44 with decimation (dual-band DDC) when using a complex output format. The sample alignment on the different lanes is shown in Table 21.

Table 20. JESD Mode Options: Single-Band Real Output

DECIMATION SETTING (Complex)	NUMBER OF ACTIVE DDCS	L	М	F	S	PLL MODE	JESD MODE0	JESD MODE1	JESD MODE2	RATIO [f _{SerDes} / f _{CLK} (Gbps / GSPS)]		
		4	2	1	1	20X	1	1	0	2.5		
Divide-by-8	1 per channel	4	2	2	2	20X	1	0	0	2.5		
(Divide-by-4 real)	i per channer	2	2	2	1	40X	0	0	1	5		
		2	2	4	2	40X	2	0	0	5		
		4	2	1	1	20X	1	1	0	2.22		
Divide-by-9	1 per channel	4	2	2	2	20X	1	0	0	2.22		
(Divide-by-4.5 real)	i per channer	2	2	2	1	40X	0	0	1	4.44		
		2	2	4	2	40X	2	0	0	4.44		
		4	2	1	1	20X	1	1	0	2		
Divide-by-10	1 per channel	4	2	2	2	20X	1	0	0	2		
(Divide-by-5 real)	1 per channel	2	2	2	1	40X	0	0	1	4		
		2	2	4	2	40X	2	0	0	4		
	1 per channel	4	2	1	1	20X	1	1	0	1.67		
Divide-by-12		4	2	2	2	20X	1	0	0	1.07		
(Divide-by-6 real)		2	2	2	1	40X	0	0	1	3.33		
		2	2	4	2	40X	2	0	0	3.33		
		4	2	1	1	20X	1	1	0	1.25		
Divide-by-16	1 per channel	4	2	2	2	20X	1	0	0	1.25		
(Divide-by-8 real)	i per channer	2	2	2	1	40X	0	0	1	2.5		
		2	2	4	2	40X	2	0	0	2.5		
		4	2	1	1	20X	1	1	0	1 11		
Divide-by-18	1 per channel	4	2	2	2	20X	1	0	0	1.11		
(Divide-by-9 real)	1 per channel	1 per channel	Per orialiner	2	2	2	1	40X	0	0	1	2.22
		2	2	4	2	40X	2	0	0	2.22		
		4	2	1	1	20X	1	1	0	1		
Divide-by-20	1 per channel	4	2	2	2	20X	1	0	0	1		
(Divide-by-10 real)	1 per channel	2	2	2	1	40X	0	0	1	2		
		2	2	4	2	40X	2	0	0			
Divide-by-24		2	2	2	1	40X	0	0	1	1.67		
(Divide-by-12 real)		2	2	4	2	40X	2	0	0	1.07		
Divide-by-32	Divide-by-32 (Divide-by-16 real) 1 per channel —	2	2	2	1	40X	0	0	1	1.25		
(Divide-by-16 real)		2	2	4	2	40X	2	0	0	1.23		

Table 21. JESD Sample Lane Assignment: Single-Band Real Output⁽¹⁾

OUTPUT LANE	LMFS = 4211	LMFS = 4222		LMFS = 2221		LMFS = 2242					
DA0	A ₀ [15:8]	A ₀ [15:8]	A ₀ [7:0]								
DA1	A ₀ [7:0]	A ₁ [15:8]	A ₁ [7:0]	A ₀ [15:8]	A ₀ [7:0]	A ₀ [15:8]	A ₀ [7:0]	A ₁ [15:8]	A ₁ [7:0]		
DB0	B ₀ [15:8]	B ₀ [15:8]	B ₀ [7:0]								
DB1	B ₀ [7:0]	B ₁ [15:8]	B ₁ [7:0]	B ₀ [15:8]	B ₀ [7:0]	B ₀ [15:8]	B ₀ [7:0]	B ₁ [15:8]	B ₁ [7:0]		

(1) Blue shading indicates channel A and yellow shading indicates channel B.



9.4.2.7 JESD204B Frame Assembly with Decimation (Dual-Band DDC): Complex Output

Table 22 lists the available JESD204B formats and valid ranges for the ADC32RF44 with decimation (dual-band DDC) when using a complex output format. The ranges are limited by the SerDes line rate and the maximum ADC sample frequency. The sample alignment on the different lanes is shown in Table 23.

Table 22. JESD Mode Options: Dual-Band Complex Output

DECIMATION SETTING (Complex)	NUMBER OF ACTIVE DDCS	L	М	F	S	PLL MODE	JESD MODE0	JESD MODE1	JESD MODE2	RATIO [f _{SerDes} / f _{CLK} (Gbps / GSPS)]
Divide-by-8	2 per channel	8	8	2	1	20X	1	0	0	2.5
Divide-by-6	2 per channer	4	8	4	1	40X	2	0	0	5
Divide-by-9	2 per channel	8	8	2	1	20X	1	0	0	2.22
Divide-by-9	2 per channer	4	8	4	1	40X	2	0	0	4.44
Divide by 10	2 nor shannal	8	8	2	1	20X	1	0	0	2
Divide-by-10	2 per channel	4	8	4	1	40X	2	0	0	4
Divide-by-12	2 nor shannal	8	8	2	1	20X	1	0	0	1.67
Divide-by-12	2 per channel	4	8	4	1	40X	2	0	0	3.33
Divide by 46	2 nor shannal	8	8	2	1	20X	1	0	0	1.25
Divide-by-16	2 per channel	4	8	4	1	40X	2	0	0	2.5
Divide by 10	2 nor shannal	8	8	2	1	20X	1	0	0	1.11
Divide-by-18	2 per channel	4	8	4	1	40X	2	0	0	2.22
Divide by 20	2 nor shannel	8	8	2	1	20X	1	0	0	1
Divide-by-20	2 per channel	4	8	4	1	40X	2	0	0	2
Divide-by-24	2 per channel	4	8	4	1	40X	2	0	0	1.67
Divide-by-32	2 per channel	4	8	4	1	40X	2	0	0	1.25

Table 23. JESD Sample Lane Assignment: Dual-Band Complex Output⁽¹⁾

OUTPUT LANE	LMFS	= 8821		LMFS	= 4841	
DA0	A1 ₀ [15:8]	A1 ₀ [7:0]				
DA1	A1Q ₀ [15:8]	A1Q ₀ [7:0]	A1I ₀ [15:8]	A1I ₀ [7:0]	A1Q ₀ [15:8]	A1Q ₀ [7:0]
DA2	A2I ₀ [15:8]	A2I ₀ [7:0]	A2I ₀ [15:8]	A2I ₀ [7:0]	A2Q ₀ [15:8]	A2Q ₀ [7:0]
DA3	A2Q ₀ [15:8]	A2Q ₀ [7:0]				
DB0	B1I ₀ [15:8]	B1I ₀ [7:0]				
DB1	B1Q ₀ [15:8]	B1Q ₀ [7:0]	B1I ₀ [15:8]	B1I ₀ [7:0]	B1Q ₀ [15:8]	B1Q ₀ [7:0]
DB2	B2I ₀ [15:8]	B2I ₀ [7:0]	B2I ₀ [15:8]	B2I ₀ [7:0]	B2Q ₀ [15:8]	B2Q ₀ [7:0]
DB3	B2Q ₀ [15:8]	B2Q ₀ [7:0]				

(1) Blue and green shading indicates the two bands for channel A; yellow and orange shading indicates the two bands for channel B.



9.4.2.8 JESD204B Frame Assembly with Decimation (Dual-Band DDC): Real Output

Table 24 lists the available JESD204B formats and valid ranges for the ADC32RF44 with decimation (dual-band DDC) when using real output format. The ranges are limited by the SerDes line rate and the maximum ADC sample frequency. The sample alignment on the different lanes is shown in Table 25.

Table 24. JESD Mode Options: Dual-Band Real Output

DECIMATION SETTING (Complex)	NUMBER OF ACTIVE DDCS	L	М	F	s	PLL MODE	JESD MODE0	JESD MODE1	JESD MODE2	RATIO [f _{SerDes} / f _{CLK} (Gbps / GSPS)]
		8	4	1	1	20X	1	1	0	2.5
Divide-by-8	2 per channel	8	4	2	2	20X	1	0	0	2.5
(Divide-by-4 real)	2 per chamiler	4	4	2	1	40X	0	0	1	5
		4	4	4	2	40X	2	0	0	3
		8	4	1	1	20X	1	1	0	2.22
Divide-by-9	2 per channel	8	4	2	2	20X	1	0	0	2.22
(Divide-by-4.5 real)	2 per chamiler	4	4	2	1	40X	0	0	1	4.44
		4	4	4	2	40X	2	0	0	4.44
		8	4	1	1	20X	1	1	0	2
Divide-by-10	2 per channel	8	4	2	2	20X	1	0	0	2
(Divide-by-5 real)	2 per chamiler	4	4	2	1	40X	0	0	1	4
		4	4	4	2	40X	2	0	0	4
		8	4	1	1	20X	1	1	0	1.67
Divide-by-12		8	4	2	2	20X	1	0	0	1.07
(Divide-by-6 real)		4	4	2	1	40X	0	0	1	3.33
		4	4	4	2	40X	2	0	0	3.33
		8	4	1	1	20X	1	1	0	1.25
Divide-by-16	2 per channel	8	4	2	2	20X	1	0	0	1.25
(Divide-by-8 real)	2 per chamile	4	4	2	1	40X	0	0	1	2.5
		4	4	4	2	40X	2	0	0	2.5
		8	4	1	1	20X	1	1	0	1.11
Divide-by-18	2 per channel	8	4	2	2	20X	1	0	0	1.11
(Divide-by-9 real)	2 per channer	4	4	2	1	40X	0	0	1	2.22
		4	4	4	2	40X	2	0	0	2.22
		8	4	1	1	20X	1	1	0	1
Divide-by-20	2 per channel	8	4	2	2	20X	1	0	0	ı
(Divide-by-10 real)		4	4	2	1	40X	0	0	1	2
		4	4	4	2	40X	2	0	0	
Divide-by-24		4	4	2	1	40X	0	0	1	1.67
(Divide-by-12 real)		4	4	4	2	40X	2	0	0	1.07
Divide-by-32	4	4	2	1	40X	0	0	1	1.25	
(Divide-by-16 real)		4	4	4	2	40X	2	0	0	1.20

Table 25. JESD Sample Lane Assignment: Dual-Band Complex Output⁽¹⁾

OUTPUT LANE	LMFS = 8411	LMFS = 8422		LMFS	= 4421	LMFS = 4442					
DA0	A1 ₀ [15:8]	A1 ₀ [15:8]	A1 ₀ [7:0]								
DA1	A1 ₀ [7:0]	A1 ₁ [15:8]	A1 ₁ [7:0]	A1 ₀ [15:8]	A1 ₀ [7:0]	A1 ₀ [15:8]	A1 ₀ [7:0]	A1 ₁ [15:8]	A1 ₁ [7:0]		
DA2	A2 ₀ [15:8]	A2 ₀ [15:8]	A2 ₀ [7:0]	A2 ₀ [15:8]	A2 ₀ [7:0]	A2 ₀ [15:8]	A2 ₀ [7:0]	A2 ₁ [15:8]	A2 ₁ [7:0]		
DA3	A2 ₀ [7:0]	A2 ₁ [15:8]	A2 ₁ [7:0]								
DB0	B1 ₀ [15:8]	B1 ₀ [15:8]	B1 ₀ [7:0]								
DB1	B1 ₀ [7:0]	B1 ₁ [15:8]	B1 ₁ [7:0]	B1 ₀ [15:8]	B1 ₀ [7:0]	B1 ₀ [15:8]	B1 ₀ [7:0]	B1₁[15:8]	B1 ₁ [7:0]		
DB2	B2 ₀ [15:8]	B2 ₀ [15:8]	B2 ₀ [7:0]	B2 ₀ [15:8]	B2 ₀ [7:0]	B2 ₀ [15:8]	B2 ₀ [7:0]	B2 ₁ [15:8]	B2 ₁ [7:0]		
DB3	B2 ₀ [7:0]	B2 ₁ [15:8]	B2 ₁ [7:0]								

(1) Blue and green shading indicates the two bands for channel A; yellow and orange shading indicates the two bands for channel B.



9.4.3 Serial Interface

The ADC 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 SDIN (serial interface data) pins. Serially shifting bits into the device is enabled when SEN is low. SDIN serial data are latched at every SCLK rising edge when SEN is active (low), as shown in Figure 113. The interface can function with SCLK frequencies from 20 MHz down to low speeds (of a few hertz) and also with a non-50% SCLK duty cycle, as shown in Table 26.

The SPI access uses 24 bits consisting of eight register data bits, 12 register address bits, and four special bits to distinguish between read/write, page and register, and individual channel access, as described in Table 27.

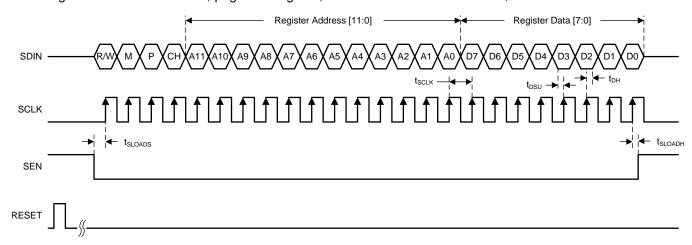


Figure 113. SPI Timing Diagram

Table 26. SPI Timing Information

		MIN	TYP	MAX	UNIT
f _{SCLK}	SCLK frequency (equal to 1 / t _{SCLK})	1		20	MHz
t _{SLOADS}	SEN to SCLK setup time	50			ns
t _{SLOADH}	SCLK to SEN hold time	50			ns
t _{DSU}	SDIN setup time	10			ns
t _{DH}	SDIN hold time	10			ns
t _{SDOUT}	Delay between SCLK falling edge to SDOUT		10		ns



Table 27. SPI Input Description

SPI BIT	DESCRIPTION	OPTIONS
R/W bit	Read/write bit	0 = SPI write 1 = SPI read back
M bit	SPI bank access	0 = Analog SPI bank (master) 1 = All digital SPI banks (main digital, interleaving, decimation filter, JESD digital, and so forth)
P bit	JESD page selection bit	0 = Page access 1 = Register access
CH bit	SPI access for a specific channel of the JESD SPI bank	0 = Channel B 1 = Channel A
ADDR[11:0]	SPI address bits	_
DATA[7:0]	SPI data bits	_

Figure 114 shows the SDOUT timing when data are read back from a register. Data are placed on the SDOUT bus at the SCLK falling edge so that the data can be latched at the SCLK rising edge by the external receiver.

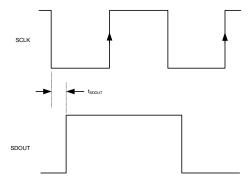


Figure 114. SDOUT Timing

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9.4.3.1 Serial Register Write: Analog Bank

The internal register of the ADC32RF44 analog bank (Figure 115) can be programmed by:

- 1. Driving the SEN pin low.
- Initiating a serial interface cycle selecting the page address of the register whose content must be written. To select the master page: write address 0012h with 04h. To select the ADC page: write address 0011h with FFh
- 3. Writing the register content. When a page is selected, multiple registers located in the same page can be programmed.

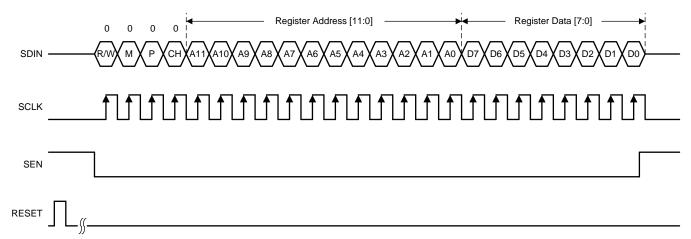


Figure 115. SPI Write Timing Diagram for the Analog Bank

9.4.3.2 Serial Register Readout: Analog Bank

Contents of the registers located in the two pages of the analog bank (Figure 116) can be readback by:

- 1. Driving the SEN pin low.
- 2. Selecting the page address of the register whose content must be read. Master page: write address 0012h with 04h. ADC page: write address 0011h with FFh.
- 3. Setting the R/W bit to 1 and writing the address to be read back.
- 4. Reading back the register content on the SDOUT pin. When a page is selected, the contents of multiple registers located in same page can be readback.

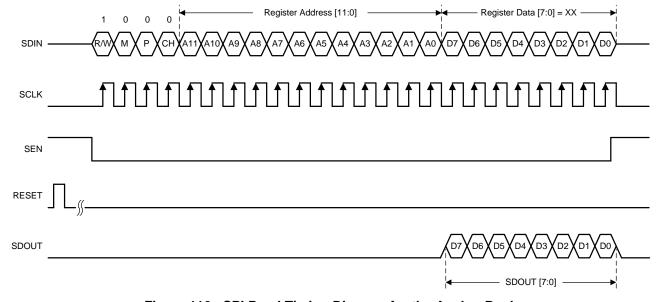


Figure 116. SPI Read Timing Diagram for the Analog Bank



9.4.3.3 Serial Register Write: Digital Bank

The digital bank contains seven pages (Offset Corrector Page for channel A and B; Digital Gain Page for channel A and B; Main digital Page for channel A and B; and JESD Digital Page). The timing for the individual page selection is shown in Figure 117. The registers located in the pages of the digital bank can be programmed by:

- 1. Driving the SEN pin low.
- 2. Setting the M bit to 1 and specifying the page with with the desired register. There are seven pages in Digital Bank. These pages can be selected by appropriately programming register bits DIGITAL BANK PAGE SEL, located in addresses 002h, 003h, and 004h, using three consecutive SPI cycles. Addressing in a SPI cycle begins with 4xxx when selecting a page from digital bank because the M bit must be set to 1.
 - To select the offset corrector page channel A: write address 4004h with 61h, 4003h with 00h, and 4002h with 00h.
 - To select the offset corrector page channel B: write address 4004h with 61h, 4003h with 01h, and 4002h with 00h.
 - To select the digital gain page channel A: write address 4004h with 61h, 4003h with 00h, and 4002h with 05h
 - To select the digital gain page channel B: write address 4004h with 61h, 4003h with 01h, and 4002h with 05h
 - To select the main digital page channel A: write address 4004h with 68h, 4003h with 00h, and 4002h with 00h.
 - To select the main digital page channel B: write address 4004h with 68h, 4003h with 01h, and 4002h with 00h.
 - To select the JESD digital page: write address 4004h with 69h, 4003h with 00h, and 4002h with 00h.

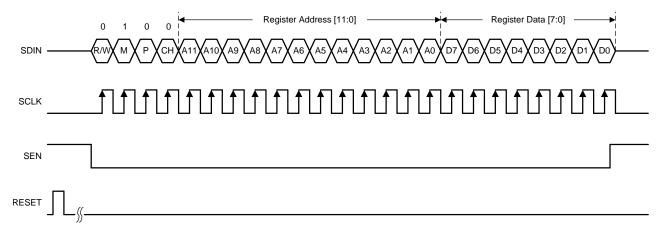


Figure 117. SPI Write Timing Diagram for Digital Bank Page Selection

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3. Writing into the desired register by setting both the M bit and P bit to 1. Write register content. When a page is selected, multiple writes into the same page can be done. Addressing in an SPI cycle begins with 6xxx when selecting a page from the digital bank because the M bit must be set to 1, as shown in Figure 118.

Note that the JESD digital page is common for both channels. The CH bit can be used to distinguish between two channels when programming registers in the JESD digital page. When CH = 0, registers are programmed for channel B; when CH = 1, registers are programmed for channel A. Thus, an SPI cycle to program registers for channel B begins with 6xxx and channel A begins with 7xxx.

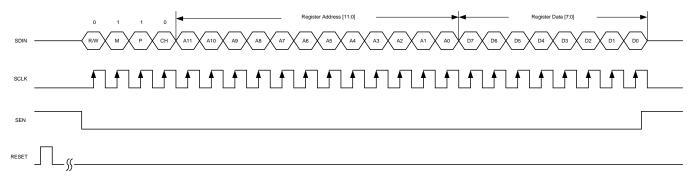


Figure 118. SPI Write Timing Diagram for Digital Bank Register Write



9.4.3.4 Serial Register Readout: Digital Bank

Readback of the register in one of the digital banks (as shown in Figure 119) can be accomplished by:

- 1. Driving the SEN pin low.
- 2. Selecting the page in the digital page: follow step 2 in the Serial Register Write: Digital Bank section.
- 3. Set the R/W, M, and P bits to 1, select channel A or channel B, and write the address to be read back.
 - JESD digital page: use the CH bit to select channel B (CH = 0) or channel A (CH = 1).
- 4. Read back the register content on the SDOUT pin. When a page is selected, multiple read backs from the same page can be done.

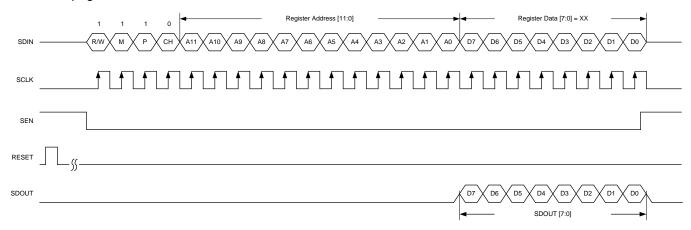


Figure 119. SPI Read Timing Diagram for the Digital Bank

9.4.3.5 Serial Register Write: Decimation Filter and Power Detector Pages

The decimation filter and power detector pages are special pages that accept direct addressing. The sampling clock and SYSREF signal are required to properly configure the decimation settings. Registers located in these pages can be programmed in one SPI cycle (Figure 120).

- 1. Drive the SEN pin low.
- 2. Directly write to the decimation filter or power detector pages. To program registers in these pages, set M = 1 and CH = 1. Additionally, address bit A[10] selects the decimation filter page (A[10] = 0) or the power detector page (A[10] = 1). Address bit A[11] selects channel A (A[11] = 0) or channel B (A[11] = 1).
 - Decimation filter page: write address 50xxh for channel A or 58xxh for channel B.
 - Power detector page: write address 54xxh for channel A or 5Cxxh for channel B.

Example: Writing address 5001h with 02h selects the decimation filter page for channel A and programs decimation factor of divide-by-8 (complex output).

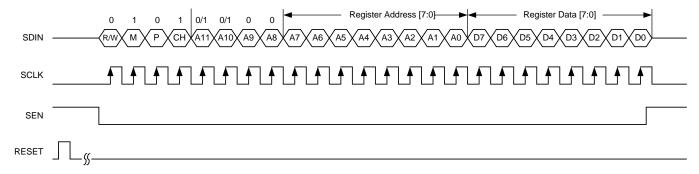


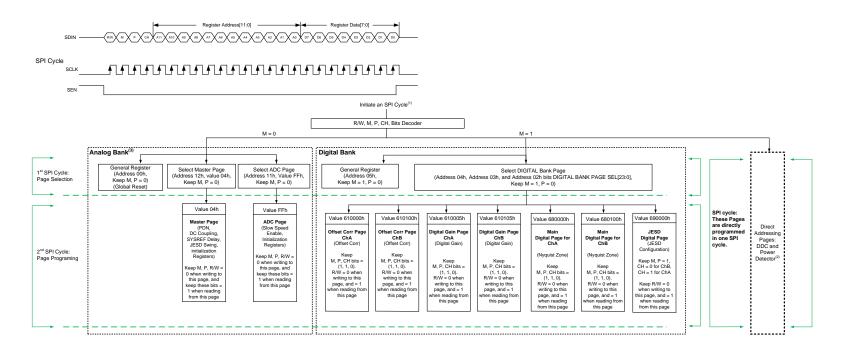
Figure 120. SPI Write Timing Diagram for the Decimation and Power Detector Pages

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9.5 Register Maps

The ADC32RF44 contains two main SPI banks. The analog SPI bank provides access to the ADC core and the digital SPI bank controls the digital blocks (including the serial JESD interface). Figure 121 and Figure 122 provide a conceptual view of the SPI registers inside the ADC32RF44. The analog SPI bank contains the master and ADC pages. The digital SPI bank is divided into multiple pages (the main digital, digital gain, decimation filter, JESD digital, and power detector pages).



In general, SPI writes are completed in two steps. The first step is to access the necessary page. The second step is to program the desired register in that page. When a page is accessed, the registers in that page can be programmed multiple times.

Registers in the decimation filter page and the power detector page can be directly programmed in one SPI cycle.

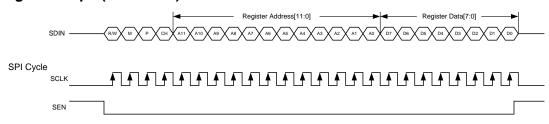
The CH bit is a don't care bit and is recommended to be kept at 0.

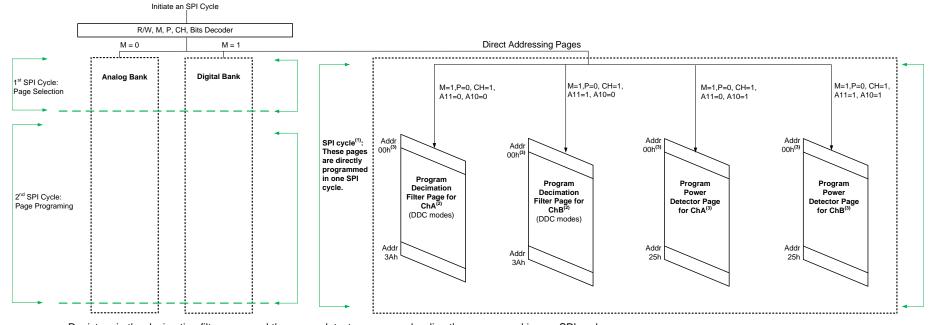
Figure 121. SPI Registers, Two-Step Addressing

Product Folder Links: ADC32RF44



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Registers in the decimation filter page and the power detector page can be directly programmed in one SPI cycle.

To program registers in the decimation filter page, aet M = 1, CH = 1, A[10] = 0, and A[11] = 0 or 1 for channel A or B. Addressing begins at 50xx for channel A and 58xx for channel B.

To program registers in power detector page, set M = 1, CH = 1, A[10] = 1, and A[11] = 0 or 1 for channel A or B. Addressing begins at 54xx for channel A and 5Cxx for channel B.

Figure 122. SPI Registers: Direct Addressing

Product Folder Links: ADC32RF44



Table 28 lists the register map for the ADC32RF44.

Table 28. Register Map

REGISTER				REGISTI	ER DATA			
ADDRESS A[11:0] (Hex)	7	6	5	4	3	2	1	0
GENERAL REGIS	TERS							
000	RESET	0	0	0	0	0	0	RESET
002				DIGITAL BANK	PAGE SEL[7:0]			
003				DIGITAL BANK	PAGE SEL[15:8]			
004				DIGITAL BANK F	PAGE SEL[23:16]			
010	0	0	0	0	0	0	0	3 or 4 WIRE
011				ADC PA	GE SEL			
012	0	0	0	0	0	MASTER PAGE SEL	0	0
MASTER PAGE (I	M = 0)						•	
020	0	0	0	PDN SYSREF	0	0	0	GLOBAL PDN
032	0	0	INCR CM IMPEDANCE	0	0	0	0	0
039	0	ALWAYS WRITE 1	0	ALWAYS WRITE 1	0	0	0	SYNC TERM DIS
03C	0	SYSREF DEL EN	0	0	0	0	SYSREF	DEL[4:3]
03D	0	0	0	0	0		JESD OUTPUT SWING	G
05A		SYSREF DEL[2:0]	I	0	0	0	0	0
057	0	0	0	SEL SYSREF REG	ASSERT SYSREF REG	0	0	0
058	0	0	SYNCB POL	0	0	0	0	0
ADC PAGE (FFh,	M = 0)							
03F	0	0	0	0	0	SLOW SP EN1	0	0
042	0	0	0	SLOW SP EN2	0	0	0	0
Offset Corr Page	Channel A (610000h,	M = 1)						
68	FREEZE OFFSET CORR	0	ALWAYS WRITE 1	0	0	DIS OFFSET CORR	ALWAYS WRITE 1	0
Offset Corr Page	Channel B (610100h,	M = 1)						
68	FREEZE OFFSET CORR	0	ALWAYS WRITE 1	0	0	DIS OFFSET CORR	ALWAYS WRITE 1	0
Digital Gain Page	Channel A (610005, N	l = 1)			,		•	
0A6	0	0	0	0		DIGITA	AL GAIN	

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Table 28. Register Map (continued)

REGISTER		REGISTER DATA										
ADDRESS A[11:0] (Hex)	7	6	5	4	3	2	1	0				
	Channel B (610105, M	VI = 1)		-		+		+				
0A6	0	0	0	0		DIGITA	AL GAIN					
Main Digital Page	Channel A (680000h,	M = 1)		•								
000	0	0	0	0	0	0	0	DIG CORE RESET				
0A2	0	0	0	0	NQ ZONE EN		NYQUIST ZONE					
Main Digital Page	Channel B (680100h,	M = 1)				_						
000	0	0	0	0	0	0	0	0				
0A2	0	0	0	0	NQ ZONE EN		NYQUIST ZONE					
JESD DIGITAL PA	GE (690000h, M = 1)											
001	CTRL K	0	0	TESTMODE EN	0	LANE ALIGN	FRAME ALIGN	TX LINK DIS				
002	SYNC REG	SYNC REG EN	0	0	12BIT MODE		JESD MODE0					
003	LI	LINK LAYER TESTMODE		LINK LAY RPAT	LMFC MASK RESET	JESD MODE1	JESD MODE2	RAMP 12BIT				
004	0	0	0	0	0	0	REL I	LA SEQ				
006	SCRAMBLE EN	0	0	0	0	0	0	0				
007	0	0	0		FRAMES PER MULTIFRAME (K)							
016	LAN	NE 0	LA	NE 1 LANE 2			LA	NE 3				
017	0	0	0	0	LANE0 POL	LANE1 POL	LANE2 POL	LANE3 POL				
032			SEL EM	P LANE 0			0	0				
033			SEL EM	IP LANE 1			0	0				
034			SEL EM	IP LANE 2			0	0				
035			SEL EM	P LANE 3			0	0				
036	80X MODE EN	CMOS SYNCB	0	0	0	0	0	0				
037	0	0	0	0	0	0 PLL MODE		MODE				
03E	0	MASK CLKDIV SYSREF	MASK NCO SYSREF	0	0	0	0	0				

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Table 28. Register Map (continued)

REGISTER				REGIST	ER DATA			
ADDRESS A[11:0] (Hex)	7	6	5	4	3	2	1	0
	R PAGE (Direct Ad	dressing, 16-Bit Add	lress, 5000h for Chan	nel A and 5800h fo	r Channel B)	-		
000	0	0	0	0	0	0	0	DDC EN
001	0	0	0	0		DECIN	M FACTOR	1
002	0	0	0	0	0	0	0	DUAL BAND EN
005	0	0	0	0	0	0	0	REAL OUT EN
006	0	0	0	0	0	0	0	DDC MUX
007		•		DDC0 N	CO1 LSB			
800				DDC0 N	CO1 MSB			
009				DDC0 N	ICO2 LSB			
00A				DDC0 N	CO2 MSB			
00B				DDC0 N	ICO3 LSB			
00C				DDC0 N	CO3 MSB			
00D				DDC1 N	ICO4 LSB			
00E				DDC1 N	CO4 MSB			
00F	0	0	0	0	0	0	0	NCO SEL PIN
010	0	0	0	0	0	0	NC	O SEL
011	0	0	0	0	0	0	LMFC RE	SET MODE
014	0	0	0	0	0	0	0	DDC0 6DB GAIN
016	0	0	0	0	0	0	0	DDC1 6DB GAIN
01E	0		DDC DET LAT		0	0	0	0
01F	0	0	0	0	0	0	0	WBF 6DB GAIN
033				CUSTOM PA	ATTERN1[7:0]			
034				CUSTOM PA	TTERN1[15:8]			
035				CUSTOM PA	ATTERN2[7:0]			
036				CUSTOM PA	TTERN2[15:8]			
037	0	0	0	0		TEST PA	ATTERN SEL	
038		TEST PATTER!	N DDC2 Q-DATA			TEST PATTE	RN DDC2 I -DATA	
039	0	0	0	0	0	0	0	USE COMMON TEST PATTERN
03A	0	0	0	0	0	0	TEST PAT RES	TP RES EN

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Table 28. Register Map (continued)

REGISTER				REGIS	TER DATA			
ADDRESS A[11:0] (Hex)								0
POWER DETECTOR	PAGE (Direct Addre	ssing, 16-Bit Addr	ess, 5400h for Chan	nel A and 5C00h fo	or Channel B)	•	•	
000	0	0	0	0	0	0	0	PKDET EN
001				BLKP	KDET [7:0]			
002				BLKPK	DET [15:8]			
003	0	0	0	0	0	0	0	BLKPKDET [16]
007				BLI	KTHHH			·
800				BL	KTHHL			
009				BL	KTHLH			
00A				BL	KTHLL			
00B				DW	ELL[7:0]			
00C				DWE	ELL[15:8]			
00D	0	0	0	0	0	0	0	FILT0LPSEL
00E	0	0	0	0		TIME	CONST	
00F				FIL0	THH[7:0]			
010				FIL07	THH[15:8]			
011				FIL0	THL[7:0]			
012				FIL07	ΓHL[15:8]			
013	0	0	0	0	0	0	0	IIR0 2BIT EN
016				FIL1	THH[7:0]			
017				FIL17	THH[15:8]			
018				FIL1	THL[7:0]			
019				FIL17	THL[15:8]			
01A	0	0	0	0	0	0	0	IIR1 2BIT EN
01D				DWE	LLIIR[7:0]			
01E				DWEL	LIIR[15:8]			
020	0	0	0	0	0	0	0	IIR0 2BIT EN
021	0	0	0			PWRDETACCU		
022				PWRI	DETH[7:0]			
023				PWRD	ETH[15:8]			
024				PWRI	DETL[7:0]			
025				PWRD	ETL[15:8]			

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Table 28. Register Map (continued)

REGISTER	REGISTER DATA									
ADDRESS A[11:0] (Hex)	7	6	5	4	3	2	1	0		
POWER DETECTOR	R PAGE (continued)		•	•			•	•		
027	0	0	0	0	0	0	0	RMS 2BIT EN		
02B	0	0	0	RESET AGC	0	0	0	0		
037	0	0	0	0	IODIR GPIO4	IODIR GPIO3	IODIR GPIO2	IODIR GPIO1		
038	0	0	INS	EL1	0	0	INS	INSEL0		
POWER DETECTOR	R PAGE (Direct Addı	ressing, 16-Bit Addr	ess, 5400h)							
032				OUTSE	_ GPIO1					
033				OUTSE	_ GPIO2					
034		OUTSEL GPIO3								
035				OUTSE	_ GPIO4					

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9.5.1 Example Register Writes

This section provides three different example register writes. Table 29 describes a global power-down register write, Table 30 describes the register writes when the scrambler is enabled, and Table 31 describes the register writes for 8X decimation for channels A and B (complex output, 1 DDC mode) with the NCO set to 1.56 GHz (f_S = 2.6 GSPS) and the JESD format configured to LMFS = 4421.

Table 29. Global Power-Down

ADDRESS	DATA	COMMENT	
12h	04h	Set the master page	
20h	01h	Set the global power-down	

Table 30. Scrambler Enable

ADDRESS	DATA	COMMENT	
4004h	69h	Coloot the digital IECD page	
4003h	00h	Select the digital JESD page	
6006h	80h	Scrambler enable, channel A	
7006h	80h	Scrambler enable, channel B	

Table 31. 8X Decimation for Channel A and B

ADDRESS	DATA	COMMENT
4004h	68h	Colors the main digital page for shappel A
4003h	00h	Select the main digital page for channel A
6000h	01h	Issue a digital reset for channel A
6000h	00h	Clear the digital for reset channel A
4003h	01h	Select the main digital page for channel B
6000h	01h	Issue a digital reset for channel B
6000h	00h	Clear the digital reset for channel B
4004h	69h	Colors the digital IECD name
4003h	00h	Select the digital JESD page
6002h	01h	Set JESD MODE0 = 1, channel A
7002h	01h	Set JESD MODE0 = 1, channel B
5000h	01h	Enable the DDC, channel A
5001h	02h	Set decimation to 8X complex
5007h	9Ah	Set the LSB of DDC0, NCO1 to 9Ah ($f_{NCO} = 1.56GHz$, $f_{S} = 2.6$ GSPS)
5008h	99h	Set the MSB of DDC0, NCO1 to 99h ($f_{NCO} = 1.56$ GHz, $f_{S} = 2.6$ GSPS)
5014h	01h	Enable the 6-dB digital gain of DDC0
5801h	02h	Set decimation to 8X complex
5807h	9Ah	Set the LSB of DDC0, NCO1 to 9Ah (f _{NCO} = 1.56 GHz, f _S = 2.6 GSPS)
5808h	99h	Set the MSB of DDC0, NCO1 to 99h ($f_{NCO} = 1.56$ GHz, $f_{S} = 2.6$ GSPS)
5814h	01h	Enable the 6-dB digital gain of DDC0

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9.5.2 Register Descriptions

9.5.2.1 General Registers

9.5.2.1.1 Register 000h (address = 000h), General Registers

Figure 123. Register 000h

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

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

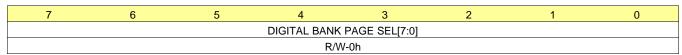
Table 32. Register 000h Field Descriptions

Bit	Field	Туре	Reset	Description
7	RESET	R/W	0h	0 = Normal operation 1 = Internal software reset, clears back to 0
6-1	0	W	0h	Must write 0
0	RESET	R/W	0h	0 = Normal operation ⁽¹⁾ 1 = Internal software reset, clears back to 0

(1) Both bits (7, 0) must be set simultaneously to perform a reset.

9.5.2.1.2 Register 002h (address = 002h), General Registers

Figure 124. Register 002h



LEGEND: R/W = Read/Write; -n = value after reset

Table 33. Register 002h Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DIGITAL BANK PAGE SEL[7:0]	R/W	0h	Program the JESD BANK PAGE SEL[23:0] bits to access the desired page in the JESD bank. 680000h = Main digital page CHA selected 680100h = Main digital page CHB selected 610000h = Digital function page CHA selected 610100h = Digital function page CHB selected 690000h = JESD digital page selected

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9.5.2.1.3 Register 003h (address = 003h), General Registers

Figure 125. Register 003h

7	6	5	4	3	2	1	0	
DIGITAL BANK PAGE SEL[15:8]								
			R/W	V-0h				

LEGEND: R/W = Read/Write; -n = value after reset

Table 34. Register 003h Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DIGITAL BANK PAGE SEL[15:8]	R/W	Oh	Program the JESD BANK PAGE SEL[23:0] bits to access the desired page in the JESD bank. 680000h = Main digital page CHA selected 680100h = Main digital page CHB selected 610000h = Digital function page CHA selected 610100h = Digital function page CHB selected 690000h = JESD digital page selected

9.5.2.1.4 Register 004h (address = 004h), General Registers

Figure 126. Register 004h

7	6	5	4	3	2	1	0		
DIGITAL BANK PAGE SEL[23:16]									
			R/W	/-0h					

LEGEND: R/W = Read/Write; -n = value after reset

Table 35. Register 004h Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DIGITAL BANK PAGE SEL[23:16]	R/W	Oh	Program the JESD BANK PAGE SEL[23:0] bits to access the desired page in the JESD bank. 680000h = Main digital page CHA selected 680100h = Main digital page CHB selected 610000h = Digital function page CHA selected 610100h = Digital function page CHB selected 690000h = JESD digital page selected

9.5.2.1.5 Register 010h (address = 010h), General Registers

Figure 127. Register 010h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	3 or 4 WIRE
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write; -n = value after reset

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Table 36. Register 010h Field Descriptions

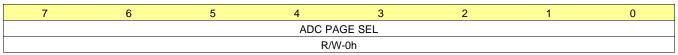
Bit	Field	Туре	Reset	Description		
7-1	0	W	0h	Must write 0		
0	3 or 4 WIRE	R/W	0h	0 = 4-wire SPI (default) 1 = 3-wire SPI where SDIN become input or output		

Draduct Folder Links, ADC22DE4



9.5.2.1.6 Register 011h (address = 011h), General Registers

Figure 128. Register 011h



LEGEND: R/W = Read/Write; -n = value after reset

Table 37. Register 011h Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	ADC PAGE SEL	R/W		00000000 = Normal operation, ADC page is not selected 11111111 = ADC page is selected; MASTER PAGE SEL must be set to 0

9.5.2.1.7 Register 012h (address = 012h), General Registers

Figure 129. Register 012h

7	6	5	4	3	2	1	0
0	0	0	0	0	MASTER PAGE SEL	0	0
W-0h	W-0h	W-0h	W-0h	W-0h	R/W-0h	W-0h	W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 38. Register 012h Field Descriptions

Bit	Field	Туре	Reset	Description
7-3	0	W	0h	Must write 0
2	MASTER PAGE SEL	R/W	Oh	0 = Normal operation 1 = Selects the master page address; ADC PAGE must be set to 0
1-0	0	W	0h	Must write 0



9.5.3 Master Page (M = 0)

9.5.3.1 Register 020h (address = 020h), Master Page

Figure 130. Register 020h

7	6	5	4	3	2	1	0
0	0	0	PDN SYSREF	0	0	PDN CHB	GLOBAL PDN
W-0h	W-0h	W-0h	R/W-0h	W-0h	R/W-0h	R/W-0h	R/W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 39. Register 020h Field Descriptions

			-	
Bit	Field	Туре	Reset	Description
7-5	0	W	0h	Must write 0
4	PDN SYSREF	R/W	Oh	This bit powers down the SYSREF input buffer. 0 = Normal operation 1 = SYSREF input capture buffer is powered down and further SYSREF input pulses are ignored
3-2	0	W	0h	Must write 0
1	PDN CHB	R/W	0h	This bit powers down channel B. 0 = Normal operation 1 = Channel B is powered down
0	GLOBAL PDN	R/W	0h	This bit enables the global power-down. 0 = Normal operation 1 = Global power-down enabled

9.5.3.2 Register 032h (address = 032h), Master Page

Figure 131. Register 032h

7	6	5	4	3	2	1	0
0	0	INCR CM IMPEDANCE	0	0	0	0	0
W-0h	W-0h	R/W-0h	W-0h	W-0h	W-0h	W-0h	W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 40. Register 032h Field Descriptions

Bit	Field	Туре	Reset	Description
7-6	0	W	0h	Must write 0
5	INCR CM IMPEDANCE	R/W	Oh	Only use this bit when analog inputs are dc-coupled to the driver. 0 = VCM buffer directly drives the common point of biasing resistors. 1 = VCM buffer drives the common point of biasing resistors with $> 5~\mathrm{k}\Omega$
4-0	0	W	0h	Must write 0



9.5.3.3 Register 039h (address = 039h), Master Page

Figure 132. Register 039h

7	6	5	4	3	2	1	0
0	ALWAYS WRITE 1	0	ALWAYS WRITE 1	0	0	PDN CHB EN	SYNC TERM DIS
W-0h	W-0h	W-0h	W-0h	W-0h	R/W-0h	R/W-0h	R/W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 41. Register 039h Field Descriptions

Bit	Field	Туре	Reset	Description
7	0	W	0h	Must write 0
6	ALWAYS WRITE 1	W	0h	Always set this bit to 1
5	0	W	0h	Must write 0
4	ALWAYS WRITE 1	W	0h	Always set this bit to 1
3-2	0	W	0h	Must write 0
1	PDN CHB EN	R/W	Oh	This bit enables the power-down control of channel B through the SPI in register 20h. 0 = PDN control disabled 1 = PDN control enabled
0	SYNC TERM DIS	R/W	Oh	This bit disables the on-chip, 100 - Ω termination resistors on the SYNCB input. $0 = \text{On-chip}$, 100 - Ω termination enabled $1 = \text{On-chip}$, 100 - Ω termination disabled

9.5.3.4 Register 03Ch (address = 03Ch), Master Page

Figure 133. Register 03Ch

7	6	5	4	3	2	1 0
0	SYSREF DEL EN	0	0	0	0	SYSREF DEL[4:3]
W-0h	R/W-0h	W-0h	W-0h	W-0h	W-0h	R/W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 42. Register 03Ch Field Descriptions

Bit	Field	Туре	Reset	Description
7	0	W	0h	Must write 0
6	SYSREF DEL EN	R/W	Oh	This bit allows an internal delay to be added to the SYSREF input. 0 = SYSREF delay disabled 1 = SYSREF delay enabled through register settings [3Ch (bits 1-0), 5Ah (bits 7-5)]
5-2	0	W	0h	Must write 0
1-0	SYSREF DEL[4:3]	R/W	Oh	When the SYSREF delay feature is enabled (3Ch, bit 6) the delay can be adjusted in 25-ps steps; the first step is 175 ps. The PVT variation of each 25-ps step is ±10 ps. The 175-ps step is ±50 ps; see Table 44.



9.5.3.5 Register 05Ah (address = 05Ah), Master Page

Figure 134. Register 05Ah

7	6	5	4	3	2	1	0
	SYSREF DEL[2:0]		0	0	0	0	0
W-0h	R/W-0h	W-0h	W-0h	W-0h	W-0h	W-0h	W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 43. Register 05Ah Field Descriptions

Bit	Field	Туре	Reset	Description
7	SYSREF DEL2	W	0h	When the SYSREF delay feature is enabled (3Ch, bit 6) the
6	SYSREF DEL1	R/W		delay can be adjusted in 25-ps steps; the first step is 175 ps. The PVT variation of each 25-ps step is ±10 ps. The 175-ps step
5	SYSREF DEL0	W		is ±50 ps; see Table 44.
4-0	0	W	0h	Must write 0

Table 44. SYSREF DEL[2:0] Bit Settings

STEP	SETTING	STEP (NOM)	TOTAL DELAY (NOM)
1	01000	175 ps	175 ps
2	00111	25 ps	200 ps
3	00110	25 ps	225 ps
4	00101	25 ps	250 ps
5	00100	25 ps	275 ps
6	00011	25 ps	300 ps

9.5.3.6 Register 03Dh (address = 3Dh), Master Page

Figure 135. Register 03Dh

7	6	5	4	3	2	1	0
0	0	0	0	0	JE	SD OUTPUT SWII	NG
W-0h	W-0h	W-0h	W-0h	W-0h		R/W-0h	

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 45. Register 03Dh Field Descriptions

Bit	Field	Туре	Reset	Description
7-3	0	W	0h	Must write 0
2-0	JESD OUTPUT SWING	R/W	Oh	These bits select the output amplitude, V_{OD} (mV _{PP}), of the JESD transmitter for all lanes. $0=860~\text{mV}_{PP}$ $1=810~\text{mV}_{PP}$ $2=770~\text{mV}_{PP}$ $3=745~\text{mV}_{PP}$ $4=960~\text{mV}_{PP}$ $5=930~\text{mV}_{PP}$ $6=905~\text{mV}_{PP}$ $7=880~\text{mV}_{PP}$



9.5.3.7 Register 057h (address = 057h), Master Page

Figure 136. Register 057h

7	6	5	4	3	2	1	0
0	0	0	SEL SYSREF REG	ASSERT SYSREF REG	0	0	0
W-0h	W-0h	W-0h	R/W-0h	R/W-0h	W-0h	W-0h	W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 46. Register 057h Field Descriptions

Bit	Field	Туре	Reset	Description
7-5	0	W	0h	Must write 0
4	SEL SYSREF REG	R/W	Oh	SYSREF can be asserted using this bit. Ensure that the SEL SYSREF REG register bit is set high before using this bit; see the <i>Using SYSREF</i> section. 0 = SYSREF is logic low 1 = SYSREF is logic high
3	ASSERT SYSREF REG	R/W	Oh	Set this bit to use the SPI register to assert SYSREF. 0 = SYSREF is asserted by device pins 1 = SYSREF can be asserted by the ASSERT SYSREF REG register bit Other bits = 0
2-0	0	W	0h	Must write 0

9.5.3.8 Register 058h (address = 058h), Master Page

Figure 137. Register 058h

7	6	5	4	3	2	1	0
0	0	SYNCB POL	0	0	0	0	0
W-0h	W-0h	R/W-0h	W-0h	W-0h	W-0h	W-0h	W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 47. Register 058h Field Descriptions

Bit	Field	Туре	Reset	Description
7-6	0	W	0h	Must write 0
5	SYNCB POL	R/W	Oh	This bit inverts the SYNCB polarity. 0 = Polarity is not inverted; this setting matches the timing diagrams in this document and is the proper setting to use 1 = Polarity is inverted
4-0	0	W	0h	Must write 0

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9.5.4 ADC Page (FFh, M = 0)

9.5.4.1 Register 03Fh (address = 03Fh), ADC Page

Figure 138. Register 03Fh

7	6	5	4	3	2	1	0
0	0	0	0	0	SLOW SP EN1	0	0
W-0h	W-0h	W-0h	W-0h	W-0h	R/W-0h	W-0h	W-0h

LEGEND: R/W = Read/Write; R = Read only; -n = value after reset

Table 48. Register 03Fh Field Descriptions

Bit	Field	Туре	Reset	Description
7-3	0	W	0h	Must write 0
2	SLOW SP EN1	R/W	Oh	This bit must be enabled for clock rates below 2.5 GSPS. 0 = ADC sampling rates are faster than 2.5 GSPS 1 = ADC sampling rates are slower than 2.5 GSPS
1-0	0	W	0h	Must write 0

9.5.4.2 Register 042h (address = 042h), ADC Page

Figure 139. Register 042h

7	6	5	4	3	2	1	0
0	0	0	SLOW SP EN2	0	0	0	0
W-0h	W-0h	W-0h	R/W-0h	W-0h	W-0h	W-0h	W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 49. Register 042h Field Descriptions

Bit	Field	Туре	Reset	Description
7-5	0	W	0h	Must write 0
4	SLOW SP EN2	R/W	0h	This bit must be enabled for clock rates below 2.5 GSPS. 0 = ADC sampling rates are faster than 2.5 GSPS 1 = ADC sampling rates are slower than 2.5 GSPS
3-0	0	W	0h	Must write 0



9.5.5 Digital Function Page (610000h, M = 1 for Channel A and 610100h, M = 1 for Channel B)

9.5.5.1 Register A6h (address = 0A6h), Digital Function Page

Figure 140. Register 0A6h

7	6	5	4	3	2	1	0
0	0	0	0		DIG (GAIN	
W-0h	W-0h	W-0h	W-0h		R/W	'-0h	

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 50. Register 0A6h Field Descriptions

Bit	Field	Туре	Reset	Description
7-4	0	W	0h	Must write 0
3-0	DIG GAIN	R/W	0h	These bits set the digital gain of the ADC output data prior to decimation up to 11 dB; see Table 51.

Table 51. DIG GAIN Bit Settings

SETTING	DIGITAL GAIN
0000	0 dB
0001	1 dB
0010	2 dB
1010	10 dB
1011	11 dB

9.5.6 Offset Corr Page Channel A (610000h, M = 1)

9.5.6.1 Register 034h (address = 034h), Offset Corr Page Channel A

Figure 141. Register 034h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	SEL EXT EST
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 52. Register 034h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	SEL EXT EST	R/W	0h	This bit selects the external estimate for the offset correction block; see the <i>Using DC Coupling in the ADC32RF44</i> section.

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9.5.6.2 Register 068h (address = 068h), Offset Corr Page Channel A

Figure 142. Register 068h

7	6	5	4	3	2	1	0
FREEZE OFFSET CORR	0	ALWAYS WRITE 1	0	0	DIS OFFSET CORR	ALWAYS WRITE 1	0
R/W-0h	W-0h	R/W-0h	W-0h	W-0h	R/W-0h	R/W-0h	R/W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 53. Register 068h Field Descriptions

Bit	Field	Туре	Reset	Description
7	FREEZE OFFSET CORR	R/W	Oh	Use this bit and bits 5 and 1 to freeze the offset estimation process of the offset corrector; see the <i>Using DC Coupling in the ADC32RF44</i> section. 011 = Apply this setting after powering up the device 111 = Offset corrector is frozen, does not estimate offset anymore, and applies the last computed value. Others = Do not use
6	0	W	0h	Must write 0
5	ALWAYS WRITE 1	R/W	0h	Always write this bit as 1 for the offset correction block to work properly.
4-3	0	W	0h	Must write 0
2	DIS OFFSET CORR	R/W	0h	$ 0 = Offset \ correction \ block \ works \ and \ removes \ f_{S/8}, \ f_{S/4}, \ 3f_{S/8}, \\ and \ f_{S/2} \ spurs \\ 1 = Offset \ correction \ block \ is \ disabled $
1	ALWAYS WRITE 1	R/W	0h	Always write this bit as 1 for the offset correction block to work properly.
0	0	W	0h	Must write 0

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9.5.7 Offset Corr Page Channel B (610000h, M = 1)

9.5.7.1 Register 068h (address = 068h), Offset Corr Page Channel B

Figure 143. Register 068h

7	6	5	4	3	2	1	0
FREEZE OFFSET CORR	0	ALWAYS WRITE 1	0	0	DIS OFFSET CORR	ALWAYS WRITE 1	0
R/W-0h	W-0h	R/W-0h	W-0h	W-0h	R/W-0h	R/W-0h	R/W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 54. Register 068h Field Descriptions

Bit	Field	Туре	Reset	Description
7,5,1	FREEZE OFFSET CORR	R/W	Oh	Use this bit and bits 5 and 1 to freeze the offset estimation process of the offset corrector; see the <i>Using DC Coupling in the ADC32RF44</i> section. 011 = Apply this setting after powering up the device 111 = Offset corrector is frozen, does not estimate offset anymore, and applies the last computed value. Others = Do not use
6	0	W	0h	Must write 0
5	ALWAYS WRITE 1	R/W	0h	Always write this bit as 1 for the offset correction block to work properly.
4-3	0	W	0h	Must write 0
2	DIS OFFSET CORR	R/W	0h	$ \begin{array}{l} 0 = \text{Offset correction block works and removes } f_{S/8}, \ f_{S/4}, \ 3f_{S/8}, \\ \text{and } f_{S/2} \ \text{spurs} \\ 1 = \text{Offset correction block is disabled} \end{array} $
1	ALWAYS WRITE 1	R/W	0h	Always write this bit as 1 for the offset correction block to work properly.
0	0	W	0h	Must write 0

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9.5.8 Digital Gain Page (610005h, M = 1 for Channel A and 610105h, M = 1 for Channel B)

9.5.8.1 Register 0A6h (address = 0A6h), Digital Gain Page

Figure 144. Register 0A6h

7	6	5	4	3	2	1	0
0	0	0	0		DIGITA	L GAIN	
W-0h	W-0h	W-0h	W-0h		R/W	/-0h	

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 55. Register 0A6h Field Descriptions

Bit	Field	Туре	Reset	Description
7-4	0	W	0h	Must write 0
3-0	DIGITAL GAIN	R/W	Oh	These bits apply a digital gain to the ADC data (before the DDC) up to 11 dB. 0000 = Default 0001 = 1 dB 1011 = 11 dB Others = Do not use

9.5.9 Main Digital Page Channel A (680000h, M = 1)

9.5.9.1 Register 000h (address = 000h), Main Digital Page Channel A

Figure 145. Register 000h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	DIG CORE RESET GBL
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 56. Register 000h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	DIG CORE RESET GBL	R/W		Pulse this bit $(0 \rightarrow 1 \rightarrow 0)$ to reset the digital core (applies to both channel A and B). All Nyquist zone settings take effect when this bit is pulsed.



9.5.9.2 Register 0A2h (address = 0A2h), Main Digital Page Channel A

Figure 146. Register 0A2h

7	6	5	4	3	2	1	0
0	0	0	0	NQ ZONE EN		NYQUIST ZONE	
W-0h	W-0h	W-0h	W-0h	R/W-0h		R/W-0h	

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 57. Register 0A2h Field Descriptions

Bit	Field	Туре	Reset	Description
7-4	0	W	0h	Must write 0
3	NQ ZONE EN	R/W	0h	This bit allows for specification of the operating Nyquist zone. 0 = Nyquist zone specification disabled 1 = Nyquist zone specification enabled
2-0	NYQUIST ZONE	R/W	Oh	These bits specify the operating Nyquist zone for the analog correction loop. Set the NQ ZONE EN bit before programming these bits. For example, at a 2.6-GSPS chip clock, the first Nyquist zone is from dc to 1.3 GHz, the second Nyquist zone is from 1.3 GHz to 2.6 GHz, and so on. $000 = \text{First Nyquist zone } (dc - f_S / 2) \\ 001 = \text{Second Nyquist zone } (f_S / 2 - f_S) \\ 010 = \text{Third Nyquist zone} \\ 011 = \text{Fourth Nyquist zone}$

9.5.10 Main Digital Page Channel B (680100h, M = 1)

9.5.10.1 Register 000h (address = 000h), Main Digital Page Channel B

Figure 147. Register 000h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	DIG CORE RESET GBL
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 58. Register 000h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	DIG CORE RESET GBL	R/W	0h	Pulse this bit $(0 \rightarrow 1 \rightarrow 0)$ to reset the digital core (applies to both channel A and B). All Nyquist zone settings take effect when this bit is pulsed.



9.5.10.2 Register 0A2h (address = 0A2h), Main Digital Page Channel B

Figure 148. Register 0A2h

7	6	5	4	3	2	1	0
0	0	0	0	NQ ZONE EN		NYQUIST ZONE	
W-0h	W-0h	W-0h	W-0h	R/W-0h		R/W-0h	

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 59. Register 0A2h Field Descriptions

Bit	Field	Туре	Reset	Description
7-4	0	W	0h	Must write 0
3	NQ ZONE EN	R/W	0h	This bit allows for specification of the operating Nyquist zone. 0 = Nyquist zone specification disabled 1 = Nyquist zone specification enabled
2-0	NYQUIST ZONE	R/W	Oh	These bits specify the operating Nyquist zone for the analog correction loop. Set the NQ ZONE EN bit before programming these bits. For example, at a 2.6-GSPS chip clock, first Nyquist zone is from dc to 1.3 GHz, the second Nyquist zone is from 1.3 GHz to 2.6 GHz, and so on. $000 = \text{First Nyquist zone } (dc - f_S / 2) \\ 001 = \text{Second Nyquist zone } (f_S / 2 - f_S) \\ 010 = \text{Third Nyquist zone}$



9.5.11 JESD Digital Page (6900h, M = 1)

9.5.11.1 Register 001h (address = 001h), JESD Digital Page

Figure 149. Register 001h

7	6	5	4	3	2	1	0
CTRL K	0	0	TESTMODE EN	0	LANE ALIGN	FRAME ALIGN	TX LINK DIS
R/W-0h	W-0h	W-0h	R/W-0h	W-0h	R/W-0h	R/W-0h	R/W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 60. Register 001h Field Descriptions

Bit	Field	Туре	Reset	Description
7	CTRL K	R/W	Oh	This bit is the enable bit for the number of frames per multiframe. 0 = Default is five frames per multiframe 1 = Frames per multiframe can be set in register 06h
6-5	0	R/W	0h	Must write 0
4	TESTMODE EN		0	This bit generates a long transport layer test pattern mode according to section 5.1.6.3 of the JESD204B specification. 0 = Test mode disabled 1 = Test mode enabled
3	0	W	0h	Must write 0
2	LANE ALIGN	R/W	0h	This bit inserts a lane alignment character (K28.3) for the receiver to align to the lane boundary per section 5.3.3.5 of the JESD204B specification. 0 = Normal operation 1 = Inserts lane alignment characters
1	FRAME ALIGN	R/W	0h	This bit inserts a frame alignment character (K28.7) for the receiver to align to the frame boundary per section 5.3.35 of the JESD204B specification. 0 = Normal operation 1 = Inserts frame alignment characters
0	TX LINK DIS	R/W	Oh	This bit disables sending the initial link alignment (ILA) sequence when SYNC is deasserted. 0 = Normal operation 1 = ILA disabled

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9.5.11.2 Register 002h (address = 002h), JESD Digital Page

Figure 150. Register 002h

7	6	5	4	3	2	1	0
SYNC REG	SYNC REG EN	0	0	12BIT MODE		JESD N	MODE0
R/W-0h	R/W-0h	W-0h	W-0h	R/W-0h		R/W	/-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 61. Register 002h Field Descriptions

Bit	Field	Туре	Reset	Description
7	SYNC REG	R/W	0h	This bit provides SYNC control through the SPI. 0 = Normal operation 1 = ADC output data are replaced with K28.5 characters
6	SYNC REG EN	R/W	0h	This bit is the enable bit for SYNC control through the SPI. 0 = Normal operation 1 = SYNC control through the SPI is enabled (ignores the SYNCB input pins)
5-4	0	W	0h	Must write 0
3-2	12BIT MODE	R/W	0h	This bit enables the 12-bit output mode for more efficient data packing. 00 = Normal operation, 14-bit output 01, 10 = Unused 11 = High-efficient data packing enabled
1-0	JESD MODE0	R/W	Oh	These bits select the configuration register to configure the correct LMFS frame assemblies for different decimation settings; see the JESD frame assembly tables in the <i>JESD204B Frame Assembly</i> section. $00 = 0$ $01 = 1$ $10 = 2$ $11 = 3$



9.5.11.3 Register 003h (address = 003h), JESD Digital Page

Figure 151. Register 003h

7	6	5	4	3	2	1	0
LINK LA	YER TESTI	MODE	LINK LAY RPAT	LMFC MASK RESET	JESD MODE1	JESD MODE2	RAMP 12BIT
	R/W-0h		R/W-0h	R/W-0h	R/W-1h	R/W-0h	R/W-0h

LEGEND: R/W = Read/Write; -n = value after reset

Table 62. Register 003h Field Descriptions

		_		<u> </u>
Bit	Field	Туре	Reset	Description
7-5	LINK LAYER TESTMODE	R/W	Oh	These bits generate a pattern according to section 5.3.3.8.2 of the JESD204B document. 000 = Normal ADC data 001 = D21.5 (high-frequency jitter pattern) 010 = K28.5 (mixed-frequency jitter pattern) 011 = Repeat initial lane alignment (generates a K28.5 character and repeats lane alignment sequences continuously) 100 = 12-octet RPAT jitter pattern
4	LINK LAY RPAT	R/W	0h	This bit changes the running disparity in a modified RPAT pattern test mode (only when link layer test mode = 100). 0 = Normal operation 1 = Changes disparity
3	LMFC MASK RESET	R/W	0h	0 = Normal operation
2	JESD MODE1	R/W	1h	These bits select the configuration register to configure the correct LMFS frame assemblies for different decimation settings; see the JESD frame assembly tables in the JESD204B Frame Assembly section
1	JESD MODE2	R/W	0h	These bits select the configuration register to configure the correct LMFS frame assemblies for different decimation settings; see the JESD frame assembly tables in the JESD204B Frame Assembly section
0	RAMP 12BIT	R/W	0h	This bit enables the RAMP test pattern for 12-bit mode only (LMFS = 82820). 0 = Normal data output 1 = Digital output is the RAMP pattern

9.5.11.4 Register 004h (address = 004h), JESD Digital Page

Figure 152. Register 004h

7	6	5	4	3	2	1 0
0	0	0	0	0	0	REL ILA SEQ
W-0h	W-0h	W-0h	W-0h	W-0h	W-0h	R/W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

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Table 63. Register 004h Field Descriptions

Bit	Field	Туре	Reset	Description
7-2	0	W	0h	Must write 0
1-0	REL ILA SEQ	R/W	Oh	These bits delay the generation of the lane alignment sequence by 0, 1, 2, or 3 multiframes after the code group synchronization. 00 = 0 multiframe delays 01 = 1 multiframe delay 10 = 2 multiframe delays 11 = 3 multiframe delays



9.5.11.5 Register 006h (address = 006h), JESD Digital Page

Figure 153. Register 006h

7	6	5	4	3	2	1	0
SCRAMBLE EN	0	0	0	0	0	0	0
R/W-0h	W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 64. Register 006h Field Descriptions

Bit	Field	Туре	Reset	Description
7	SCRAMBLE EN	R/W	0h	This bit is the scramble enable bit in the JESD204B interface. 0 = Scrambling disabled 1 = Scrambling enabled
6-0	0	W	0h	Must write 0

9.5.11.6 Register 007h (address = 007h), JESD Digital Page

Figure 154. Register 007h

7	6	5	4	3	2	1	0	
0	0	0	FRAMES PER MULTIFRAME (K)					
W-0h	W-0h	W-0h			R/W-0h			

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 65. Register 007h Field Descriptions

Bit	Field	Туре	Reset	Description
7-5	0	W	0h	Must write 0
4-0	FRAMES PER MULTIFRAME (K)	R/W	0h	These bits set the number of multiframes. Actual K is the value in hex + 1 (that is, 0Fh is K = 16).

Draduat Folder Links, ADC22D



9.5.11.7 Register 016h (address = 016h), JESD Digital Page

Figure 155. Register 016h

	7	6	5	4	3	2	1	0
Ī	LANE 0		LANE 1		LANE 2		LANE 03	
	R/W-0h		R/W	-0h	R/W	V-0h	R/W-0h	

LEGEND: R/W = Read/Write; -n = value after reset

Table 66. Register 016h Field Descriptions

Bit	Field	Туре	Reset	Description
7-6	LANE 0	R/W	0h	For 80X mode: set these bits as 70h. Also set the 80X MODE
5-4	LANE 1	R/W	0h	EN register bit. For 40X mode: set these bits as 70h.
3-2	LANE 2	R/W	0h	For 20X mode: these bits can be used to swap the data on
1-0	LANE 3	R/W	0h	output lanes as shown in Table 67 and Figure 156.

Table 67. Swapping Data on Output Lanes for 20X Serialization

REGISTER BIT LANE 0	OUTPUT LANE0 CARRIES	REGISTER BIT LANE 1	OUTPUT LANE1 CARRIES	REGISTER BIT LANE 2	OUTPUT LANE2 CARRIES	REGISTER BIT LANE 3	OUTPUT LANE3 CARRIES
00	D0	00	D1	00	D2	00	D3
01	D1	01	D2	01	D3	01	D0
10	D2	10	D3	10	D0	10	D1
11	D3	11	D0	11	D1	11	D2

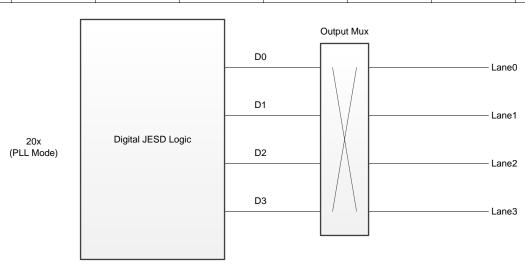


Figure 156. Output Lane Multiplexer

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9.5.11.8 Register 017h (address = 017h), JESD Digital Page

Figure 157. Register 017h

7	6	5	4	3	2	1	0
0	0	0	0	Lane0 POL	Lane1 POL	Lane2 POL	Lane3 POL
W-0h	R/W-0h	R/W-0h	R/W-0h	W-0h	W-0h	W-0h	W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 68. Register 017h Field Descriptions

Bit	Field	Туре	Reset	Description
7	0	W	0h	Must write 0
6-4	0	R/W	0h	Must write 0
3-0	Lane[3:0] POL	W	0h	These bits set the polarity of the individual JESD output lanes. 0 = Polarity as given in the pinout (noninverted) 1 = Inverts polarity (positive, P, or negative, M)

9.5.11.9 Register 032h-035h (address = 032h-035h), JESD Digital Page

Figure 158. Register 032h

7	6	5	4	3	2	1	0		
	SEL EMP LANE 0								
	R/W-0h								

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Figure 159. Register 033h

7	6	5	4	3	2	1	0
		0	0				
		W-0h	W-0h				

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Figure 160. Register 034h

7	6	5	4	3	2	1	0		
	SEL EMP LANE 2								
	R/W-0h								

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Figure 161. Register 035h

7	6	5	4	3	2	1	0		
	SEL EMP LANE 3								
	R/W-0h								

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset



Table 69. Register 032h-035h Field Descriptions

Bit	Field	Туре	Reset	Description
7-2	SEL EMP LANE	R/W	Oh	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. $0 = 0 \text{ dB}$ $1 = -1 \text{ dB}$ $3 = -2 \text{ dB}$ $7 = -4.1 \text{ dB}$ $15 = -6.2 \text{ dB}$ $15 = -6.2 \text{ dB}$ $15 = -6.2 \text{ dB}$ $15 = -8.2 \text{ dB}$
1-0	0	W	0h	Must write 0

9.5.11.10 Register 036h (address = 036h), JESD Digital Page

Figure 162. Register 036h

7	6	5	4	3	2	1	0
80X MODE EN	CMOS SYNCB	0	0	0	0	0	0
R/W-0h	R/W-0h	W-0h	W-0h	W-0h	W-0h	W-0h	W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 70. Register 036h Field Descriptions

Bit	Field	Туре	Reset	Description
7	80X MODE EN	R/W	Oh	This bit enables the 80X mode. 0 = 80X mode disable 1 = 80X mode enable
6	CMOS SYNCB	R/W	Oh	This bit enables single-ended control of SYNCB using the GPIO4 pin (pin 63). The differential SYNCB input is ignored. 0 = Differential SYNCB input 1 = Single-ended SYNCB input using pin 63
5-0	0	W	0h	Must write 0

9.5.11.11 Register 037h (address = 037h), JESD Digital Page

Figure 163. Register 037h

7	6	5	4	3	2	1 0	
0	0	0	0	0	0	PLL MODE	
W-0h	W-0h	W-0h	W-0h	W-0h	W-0h	R/W-0h	

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 71. Register 037h Field Descriptions

Bit	Field	Туре	Reset	Description
7-2	0	W	0h	Must write 0
1-0	PLL MODE	R/W	0h	These bits select the PLL multiplication factor; see the JESD tables in the <i>JESD204B Frame Assembly</i> section for settings. 00 = 20X mode 01 = 16X mode 10 = 40X mode (write register 16h with 70h) 11 = 80X mode (the 40X_80X MODE bit in register 16h must also be set)



9.5.11.12 Register 03Eh (address = 03Eh), JESD Digital Page

Figure 164. Register 03Eh

7	6	5	4	3	2	1	0
0	MASK CLKDIV SYSREF	MASK NCO SYSREF	0	0	0	0	0
W-0h	R/W-0h	R/W-0h	W-0h	W-0h	W-0h	W-0h	W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 72. Register 03Eh Field Descriptions

Bit	Field	Туре	Reset	Description
7	0	W	0h	Must write 0
6	MASK CLKDIV SYSREF	R/W	Oh	Use this bit to mask the SYSREF going to the input clock divider. 0 = Input clock divider is reset when SYSREF is asserted (that is, when SYSREF transitions from low to high) 1 = Input clock divider ignores SYSREF assertions
5	MASK NCO SYSREF	R/W	Oh	Use this bit to mask the SYSREF going to the NCO in the DDC block and LMFC counter of the JESD interface. 0 = NCO phase and LMFC counter are reset when SYSREF is asserted (that is, when SYSREF transitions from low to high) 1 = NCO and LMFC counter ignore SYSREF assertions
4-0	0	W	0h	Must write 0

9.5.12 Decimation Filter Page

Direct Addressing, 16-Bit Address, 5000h for Channel A, 5800h for Channel B

9.5.12.1 Register 000h (address = 000h), Decimation Filter Page

Figure 165. Register 000h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	DDC EN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 73. Register 000h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	DDC EN	R/W	Oh	This bit enables the decimation filter and disables the bypass mode. 0 = Bypass mode (DDC disabled) 1 = Decimation filter enabled



9.5.12.2 Register 001h (address = 001h), Decimation Filter Page

Figure 166. Register 001h

7	6	5	4	3	2	1	0
0	0	0	0		DECIM F	FACTOR	
W-0h	W-0h	W-0h	W-0h	R/W-0h			

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 74. Register 001h Field Descriptions

Bit	Field	Туре	Reset	Description
7-4	0	W	0h	Must write 0
3-0	DECIM FACTOR	R/W	Oh	These bits configure the decimation filter setting. 0000 = Divide-by-4 complex 0001 = Divide-by-6 complex 0010 = Divide-by-8 complex 0011 = Divide-by-9 complex 0100 = Divide-by-10 complex 0101 = Divide-by-12 complex 0101 = Divide-by-12 complex 0110 = Not used 0111 = Divide-by-18 complex 1000 = Divide-by-18 complex 1001 = Divide-by-20 complex 1011 = Not used 1100 = Divide-by-32 complex

9.5.12.3 Register 002h (address = 2h), Decimation Filter Page

Figure 167. Register 002h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	DUAL BAND EN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 75. Register 002h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	DUAL BAND EN	R/W	Oh	This bit enables the dual-band DDC filter for the corresponding channel. 0 = Single-band DDC 1 = Dual-band DDC

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9.5.12.4 Register 005h (address = 005h), Decimation Filter Page

Figure 168. Register 005h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	REAL OUT EN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 76. Register 005h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	REAL OUT EN	R/W	Oh	This bit converts the complex output to real output at 2x the output rate. 0 = Complex output format 1 = Real output format

9.5.12.5 Register 006h (address = 006h), Decimation Filter Page

Figure 169. Register 006h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	DDC MUX
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 77. Register 006h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	DDC MUX	R/W	Oh	This bit connects the DDC to the alternate channel ADC to enable up to four DDCs with one ADC and completely turn off the other ADC channel. 0 = Normal operation 1 = DDC block takes input from the alternate ADC

9.5.12.6 Register 007h (address = 007h), Decimation Filter Page

Figure 170. Register 007h

7	6	5	4	3	2	1	0
DDC0 NCO1 LSB							
			R/V	V-0h			

LEGEND: R/W = Read/Write; -n = value after reset

Table 78. Register 007h Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DDC0 NCO1 LSB	R/W	Oh	These bits are the LSB of the NCO frequency word for NCO1 of DDC0 (band 1). The LSB represents f_S / (2 ¹⁶), where f_S is the ADC sampling frequency.



9.5.12.7 Register 008h (address = 008h), Decimation Filter Page

Figure 171. Register 008h

7	6	5	4	3	2	1	0
DDC0 NCO1 MSB							
			R/V	V-0h			

LEGEND: R/W = Read/Write; -n = value after reset

Table 79. Register 008h Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DDC0 NCO1 MSB	R/W	0h	These bits are the MSB of the NCO frequency word for NCO1 of DDC0 (band 1). The LSB represents f_S / (2^{16}) , where f_S is the ADC sampling frequency.

9.5.12.8 Register 009h (address = 009h), Decimation Filter Page

Figure 172. Register 009h

7	6	5	4	3	2	1	0	
DDC0 NCO2 LSB								
			R/V	V-0h				

LEGEND: R/W = Read/Write; -n = value after reset

Table 80. Register 009h Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DDC0 NCO2 MSB	R/W	Oh	These bits are the LSB of the NCO frequency word for NCO2 of DDC0 (band 1). The LSB represents f_S / (2^{16}) , where f_S is the ADC sampling frequency.

9.5.12.9 Register 00Ah (address = 00Ah), Decimation Filter Page

Figure 173. Register 00Ah

7	6	5	4	3	2	1	0	
DDC0 NCO2 MSB								
			R/V	V-0h				

LEGEND: R/W = Read/Write; -n = value after reset

Table 81. Register 00Ah Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DDC0 NCO2 MSB	R/W	Oh	These bits are the MSB of the NCO frequency word for NCO2 of DDC0 (band 1). The LSB represents f_S / (2^{16}), where f_S is the ADC sampling frequency.

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9.5.12.10 Register 00Bh (address = 00Bh), Decimation Filter Page

Figure 174. Register 00Bh

7	6	5	4	3	2	1	0	
DDC0 NCO3 LSB								
			R/V	V-0h				

LEGEND: R/W = Read/Write; -n = value after reset

Table 82. Register 00Bh Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DDC0 NCO3 LSB	R/W	Oh	These bits are the LSB of the NCO frequency word for NCO3 of DDC0 (band 1). The LSB represents $f_{\rm S}$ / (2 ¹⁶), where $f_{\rm S}$ is the ADC sampling frequency.

9.5.12.11 Register 00Ch (address = 00Ch), Decimation Filter Page

Figure 175. Register 00Ch

7	6	5	4	3	2	1	0		
	DDC0 NCO3 MSB								
	R/W-0h								

LEGEND: R/W = Read/Write; -n = value after reset

Table 83. Register 00Ch Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DDC0 NCO3 MSB	R/W	Oh	These bits are the MSB of the NCO frequency word for NCO3 of DDC0 (band 1). The LSB represents f_S / (2^{16}), where f_S is the ADC sampling frequency.

9.5.12.12 Register 00Dh (address = 00Dh), Decimation Filter Page

Figure 176. Register 00Dh

7	6	5	4	3	2	1	0			
DDC1 NCO4 LSB										
	R/W-0h									

LEGEND: R/W = Read/Write; -n = value after reset

Table 84. Register 00Dh Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DDC1 NCO4 LSB	R/W	Oh	These bits are the LSB of the NCO frequency word for NCO4 of DDC1 (band 2, only when dual-band mode is enabled). The LSB represents f_S / (2^{16}) , where f_S is the ADC sampling frequency.



9.5.12.13 Register 00Eh (address = 00Eh), Decimation Filter Page

Figure 177. Register 00Eh

7	6	5	4	3	2	1	0		
	DDC1 NCO4 MSB								
	R/W-0h								

LEGEND: R/W = Read/Write; -n = value after reset

Table 85. Register 00Eh Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DDC1 NCO4 MSB	R/W		These bits are the MSB of the NCO frequency word for NCO4 of DDC1 (band 2, only when dual-band mode is enabled). The LSB represents f_S / (2 ¹⁶), where f_S is the ADC sampling frequency.

9.5.12.14 Register 00Fh (address = 00Fh), Decimation Filter Page

Figure 178. Register 00Fh

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	NCO SEL PIN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 86. Register 00Fh Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W 0h Must write 0		
0	NCO SEL PIN	R/W	0h	This bit enables NCO selection through the GPIO pins. 0 = NCO selection through SPI (see address 0h10) 1 = NCO selection through GPIO pins

9.5.12.15 Register 010h (address = 010h), Decimation Filter Page

Figure 179. Register 010h

1								
	7	6	5	4	3	2	1	0
	0	0	0	0	0	0	NCO SEL	
	W-0h	W-0h	W-0h	W-0h	W-0h	W-0h	R/W	′-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

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Table 87. Register 010h Field Descriptions

Bit	Field	Туре	Reset	Description
7-2	0	W	0h	Must write 0
1-0	NCO SEL	R/W		



9.5.12.16 Register 011h (address = 011h), Decimation Filter Page

Figure 180. Register 011h

7	6	5	4	3	2	1 0
0	0	0	0	0	0	LMFC RESET MODE
W-0h	W-0h	W-0h	W-0h	W-0h	W-0h	R/W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 88. Register 011h Field Descriptions

Bit	Field	Туре	Reset	Description
7-2	0	W	0h	Must write 0
1-0	LMFC RESET MODE	R/W	Oh	These bits reset the configuration for all DDCs and NCOs. 00 = All DDCs and NCOs are reset with every LMFC RESET 01 = Reset with first LMFC RESET after DDC start. Afterwards, reset only when analog clock dividers are resynchronized. 10 = Reset with first LMFC RESET after DDC start. Afterwards, whenever analog clock dividers are resynchronized, use two LMFC resets. 11 = Do not use an LMFC reset at all. Reset the DDCs only when a DDC start is asserted and afterwards continue normal operation. Deterministic latency is not ensured.

9.5.12.17 Register 014h (address = 014h), Decimation Filter Page

Figure 181. Register 014h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	DDC0 6DB GAIN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 89. Register 014h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	DDC0 6DB GAIN	R/W	0h	This bit scales the output of DDC0 by 2 (6 dB) to compensate for real-to-complex conversion and image suppression. This scaling does not apply to the high-bandwidth filter path (divide-by-4 and -6); see register 1Fh. 0 = Normal operation 1 = 6-dB digital gain is added



9.5.12.18 Register 016h (address = 016h), Decimation Filter Page

Figure 182. Register 016h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	DDC1 6DB GAIN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 90. Register 016h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	DDC1 6DB GAIN	R/W	Oh	This bit scales the output of DDC0 by 2 (6 dB) to compensate for real-to-complex conversion and image suppression. This scaling does not apply to the high-bandwidth filter path (divide-by-4 and -6); see register 1Fh. 0 = Normal operation 1 = 6-dB digital gain is added

9.5.12.19 Register 01Eh (address = 01Eh), Decimation Filter Page

Figure 183. Register 01Eh

7	6	5	4	3	2	1	0
0		DDC DET LAT		0	0	0	0
W-0h		R/W-0h		W-0h	W-0h	W-0h	W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 91. Register 01Eh Field Descriptions

Bit	Field	Туре	Reset	Description
7	0	W	0h	Must write 0
6-4	DDC DET LAT	R/W	0h	These bits ensure deterministic latency depending on the decimation setting used; see Table 92.
3-0	0	W	0h	Must write 0

Table 92. DDC DET LAT Bit Settings

SETTING	COMPLEX DECIMATION SETTING
10h	Divide-by-24, -32 complex
20h	Divide-by-16, -18, -20 complex
40h	Divide-by-by 6, -12 complex
50h	Divide-by-4, -8, -9, -10 complex

Product Folder Links: ADC32RF44

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9.5.12.20 Register 01Fh (address = 01Fh), Decimation Filter Page

Figure 184. Register 01Fh

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	WBF 6DB GAIN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 93. Register 01Fh Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	WBF 6DB GAIN	R/W	Oh	This bit scales the output of the wide bandwidth DDC filter by 2 (6 dB) to compensate for real-to-complex conversion and image suppression. This setting only applies to the high-bandwidth filter path (divide-by-4 and -6). 0 = Normal operation 1 = 6-dB digital gain is added

9.5.12.21 Register 033h-036h (address = 033h-036h), Decimation Filter Page

Figure 185. Register 033h

7	6	5	4	3	2	1	0		
CUSTOM PATTERN1[7:0]									
			R/V	V-0h					

LEGEND: R/W = Read/Write; -n = value after reset

Figure 186. Register 034h

7	6	5	4	3	2	1	0		
CUSTOM PATTERN1[15:8]									
R/W-0h									

LEGEND: R/W = Read/Write; -n = value after reset

Figure 187. Register 035h

7	6	5	4	3	2	1	0				
CUSTOM PATTERN2[7:0]											
	R/W-0h										

LEGEND: R/W = Read/Write; -n = value after reset

Figure 188. Register 036h

7	6	5	4	3	2	1	0			
CUSTOM PATTERN2[15:8]										
	R/W-0h									

LEGEND: R/W = Read/Write; -n = value after reset

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Table 94. Register 033h-036h Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	CUSTOM PATTERN	R/W	0h	These bits set the custom test pattern in address 33h, 34h, 35h, or 36h.



9.5.12.22 Register 037h (address = 037h), Decimation Filter Page

Figure 189. Register 037h

7	6	5	4	3	0			
0	0	0	0	TEST PATTERN SEL				
W-0h	W-0h	W-0h	W-0h	R/W-0h				

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 95. Register 037h Field Descriptions

Bit	Field	Туре	Reset	Description
7-3	0	W	0h	Must write 0
3-0	TEST PATTERN SEL	R/W	Oh	These bits select the test pattern output on the channel. 0000 = Normal operation using ADC output data 0001 = Outputs all 0s 0010 = Outputs all 1s 0011 = Outputs toggle pattern: output data are an alternating sequence of 101010101010101 and 01010101010101 0100 = Output digital ramp: output data increment by one LSB every clock cycle from code 0 to 16384 0110 = Single pattern: output data are custom pattern 1 (75h and 76h) 0111 = Double pattern: output data alternate between custom pattern 1 and custom pattern 2 1000 = Deskew pattern: output data are AAAAh 1001 = SYNC pattern: output data are FFFFh

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9.5.12.23 Register 038h (address = 038h), Decimation Filter Page

Figure 190. Register 038h

7	6	5	4	3	2	1	0		
	TEST PATTERN	I DDC2 Q-DATA		TEST PATTERN DDC2 I-DATA					
	R/W	/-0h		R/W-0h					

LEGEND: R/W = Read/Write; -n = value after reset

Table 96. Register 038h Field Descriptions

				•
Bit	Field	Type	Reset	Description
7-4	TEST PATTERN DDC2 Q-DATA	R/W	Oh	These bits select the test patten for the Q stream of the DDC2. 0000 = Normal operation using ADC output data 0001 = Outputs all 0s 0010 = Outputs all 1s 0011 = Outputs toggle pattern: output data are an alternating sequence of 10101010101010 and 0101010101010 0100 = Output digital ramp: output data increment by one LSB every clock cycle from code 0 to 65535 0110 = Single pattern: output data are a custom pattern 1 (75h and 76h) 0111 Double pattern: output data alternate between custom pattern 1 and custom pattern 2 1000 = Deskew pattern: output data are AAAAh 1001 = SYNC pattern: output data are FFFFh
3-0	TEST PATTERN DDC2 I-DATA	R/W	Oh	These bits select the test patten for the I stream of the DDC2. 0000 = Normal operation using ADC output data 0001 = Outputs all 0s 0010 = Outputs all 1s 0011 = Outputs toggle pattern: output data are an alternating sequence of 10101010101010 and 0101010101010 0100 = Output digital ramp: output data increment by one LSB every clock cycle from code 0 to 65535 0110 = Single pattern: output data are a custom pattern 1 (75h and 76h) 0111 Double pattern: output data alternate between custom pattern 1 and custom pattern 2 1000 = Deskew pattern: output data are AAAAh 1001 = SYNC pattern: output data are FFFFh

9.5.12.24 Register 039h (address = 039h), Decimation Filter Page

Figure 191. Register 039h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	USE COMMON TEST PATTERN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 97. Register 039h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	USE COMMON TEST PATTERN	R/W	Oh	0 = Each data stream sends test patterns programmed by bits[3:0] of register 37h. 1 = Test patterns are individually programmed for the I and Q stream of each DDC using the TEST PATTERN DDCx y-DATA register bits (where x = 1 or 2 and y = I or Q).



9.5.12.25 Register 03Ah (address = 03Ah), Decimation Filter Page

Figure 192. Register 03Ah

7	6	5	4	3	2	1	0
0	0	0	0	0	0	TEST PAT RES	TP RES EN
W-0h	W-0h	W-0h	W-0h	W-0h	W-0h	R/W-0h	R/W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 98. Register 03Ah Field Descriptions

Bit	Field	Туре	Reset	Description
7-2	0	W	0h	Must write 0
1	TEST PAT RES	R/W	0h	Pulsing this bit resets the test pattern. The test pattern reset must be enabled first (bit D0). 0 = Normal operation 1 = Reset the test pattern
0	TP RES EN	R/W	0h	This bit enables the test pattern reset. 0 = Reset disabled 1 = Reset enabled

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9.5.13 Power Detector Page

9.5.13.1 Register 000h (address = 000h), Power Detector Page

Figure 193. Register 000h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	PKDET EN
W-0h	R/W-0h						

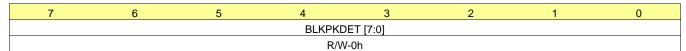
LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 99. Register 000h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	PKDET EN	R/W	Oh	This bit enables the peak power and crossing detector. 0 = Power detector disabled 1 = Power detector enabled

9.5.13.2 Register 001h-002h (address = 001h-002h), Power Detector Page

Figure 194. Register 001h



LEGEND: R/W = Read/Write; -n = value after reset

Figure 195. Register 002h

7	6	5	4	3	2	1	0		
BLKPKDET [15:8]									
	R/W-0h								

LEGEND: R/W = Read/Write; -n = value after reset

Table 100. Register 001h-002h Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	BLKPKDET	R/W	Oh	This register specifies the block length in terms of number of samples (S`) used for peak power computation. Each sample S` is a peak of 8 actual ADC samples. This parameter is a 17-bit value directly in linear scale. In decimation mode, the block length must be a multiple of a divide-by-4 or -6 complex: length = 5 × decimation factor. The divide-by-8 to -32 complex: length = 10 × decimation factor.



9.5.13.3 Register 003h (address = 003h), Power Detector Page

Figure 196. Register 003h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	BLKPKDET[16]
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 101. Register 003h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	BLKPKDET[16]	R/W	Oh	This register specifies the block length in terms of number of samples (S`) used for peak power computation. Each sample S` is a peak of 8 actual ADC samples. This parameter is a 17-bit value directly in linear scale. In decimation mode, the block length must be a multiple of a divide-by-4 or -6 complex: length = 5 × decimation factor. The divide-by-8 to -32 complex: length = 10 × decimation factor.

9.5.13.4 Register 007h-00Ah (address = 007h-00Ah), Power Detector Page

Figure 197. Register 007h

7	6	5	4	3	2	1	0	
BLKTHHH								
	R/W-0h							

LEGEND: R/W = Read/Write; -n = value after reset

Figure 198. Register 008h

7	6	5	4	3	2	1	0	
BLKTHHL								
	R/W-0h							

LEGEND: R/W = Read/Write; -n = value after reset

Figure 199. Register 009h

7	6	5	4	3	2	1	0				
	BLKTHLH										
			R/V	R/W-0h							

LEGEND: R/W = Read/Write; -n = value after reset

Figure 200. Register 00Ah

7	6	6 5 4		3	2	1	0	
BLKTHLL								
	R/W-0h							

LEGEND: R/W = Read/Write; -n = value after reset

Table 102. Register 007h-00Ah Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	BLKTHHH BLKTHHL BLKTHLH BLKTHLL	R/W	Oh	These registers set the four different thresholds for the hysteresis function threshold values from 0 to 256 (2TH), where 256 is equivalent to the peak amplitude. Example: BLKTHHH is set to –2 dBFS from peak: 10 ^{(-2 / 20) × 256} = 203, then set 5407h, 5C07h = CBh.



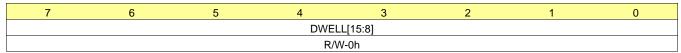
9.5.13.5 Register 00Bh-00Ch (address = 00Bh-00Ch), Power Detector Page

Figure 201. Register 00Bh

7	6	5	5 4		2	1	0
	DWELL[7:0]						
R/W-0h							

LEGEND: R/W = Read/Write; -n = value after reset

Figure 202. Register 00Ch



LEGEND: R/W = Read/Write; -n = value after reset

Table 103. Register 00Bh-00Ch Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DWELL	R/W	Oh	DWELL time counter. When the computed block peak crosses the upper thresholds BLKTHHH or BLKTHLH, the peak detector output flags are set. In order to be reset, the computed block peak must remain continuously lower than the lower threshold (BLKTHHL or BLKTHLL) for the period specified by the DWELL value. This threshold is 16 bits, is specified in terms of $f_{\rm S}$ / 8 clock cycles, and must be set to 0 for the crossing detector. Example: if $f_{\rm S}=3$ GSPS, $f_{\rm S}$ / 8 = 375 MHz, and DWELL = 0100h then the DWELL time = 2^9 / 375 MHz = 1.36 μs .

9.5.13.6 Register 00Dh (address = 00Dh), Power Detector Page

Figure 203. Register 00Dh

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	FILT0LPSEL
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 104. Register 00Dh Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	FILT0LPSEL	R/W	0h	This bit selects either the block detector output or 2-bit output as the input to the IIR filter. 0 = Use the output of the high comparators (HH and HL) as the input of the IIR filter 1 = Combine the output of the high (HH and HL) and low (LH and LL) comparators to generate a 3-level input to the IIR filter (-1, 0, 1)

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9.5.13.7 Register 00Eh (address = 00Eh), Power Detector Page

Figure 204. Register 00Eh

7	6	5	4	3	2	1	0	
0	0	0	0	TIMECONST				
W-0h	W-0h	W-0h	W-0h	R/W-0h				

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 105. Register 00Eh Field Descriptions

Bit	Field	Туре	Reset	Description
7-4	0	W	0h	Must write 0
3-0	TIMECONST	R/W		These bits set the crossing detector time period for N = 0 to 15 as $2^N \times f_S$ / 8 clock cycles. The maximum time period is 32768 × f_S / 8 clock cycles (approximately 100 μ s at 2.6 GSPS).

9.5.13.8 Register 00Fh, 010h-012h, and 016h-019h (address = 00Fh, 010h-012h, and 016h-019h), Power Detector Page

Figure 205. Register 00Fh

7	6	5	4	3	2	1	0	
FILOTHH[7:0]								
R/W-0h								

LEGEND: R/W = Read/Write; -n = value after reset

Figure 206. Register 010h

7	6	5	4	3	2	1	0	
FILOTHH[15:8]								
R/W-0h								

LEGEND: R/W = Read/Write; -n = value after reset

Figure 207. Register 011h

7	6	5	4	3	2	1	0	
FILOTHL[7:0]								
R/W-0h								

LEGEND: R/W = Read/Write; -n = value after reset

Figure 208. Register 012h

7	6	5	4	3	2	1	0		
FILOTHL[15:8]									
R/W-0h									

LEGEND: R/W = Read/Write; -n = value after reset

Figure 209. Register 016h

7	6	5	4	3	2	1	0	
FIL1THH[7:0]								
R/W-0h								

LEGEND: R/W = Read/Write; -n = value after reset

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Product Folder Links: ADC32RF44



Figure 210. Register 017h

7	6	5	4	3	2	1	0	
	FIL1THH[15:8]							
	R/W-0h							

LEGEND: R/W = Read/Write; -n = value after reset

Figure 211. Register 018h

7	6	5	4	3	2	1	0	
FIL1THL[7:0]								
	R/W-0h							

LEGEND: R/W = Read/Write; -n = value after reset

Figure 212. Register 019h

7	6	5	4	3	2	1	0	
	FIL1THL[15:8]							
	R/W-0h							

LEGEND: R/W = Read/Write; -n = value after reset

Table 106. Register 00Fh, 010h, 011h, 012h, 016h, 017h, 018h, and 019h Field Descriptions

В	3it	Field	Туре	Reset	Description
7	'-0	FILOTHH FILOTHL FIL1THH FIL1THL	R/W	Oh	Comparison thresholds for the crossing detector counter. This threshold is 16 bits in 2.14 signed notation. A value of 1 (4000h) corresponds to 100% crossings, a value of 0.125 (0800h) corresponds to 12.5% crossings.

9.5.13.9 Register 013h-01Ah (address = 013h-01Ah), Power Detector Page

Figure 213. Register 013h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	IIR0 2BIT EN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Figure 214. Register 01Ah

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	IIR1 2BIT EN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

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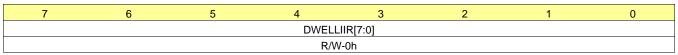
Table 107. Register 013h and 01Ah Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	IIR0 2BIT EN IIR1 2BIT EN	R/W	Oh	This bit enables 2-bit output format of the IIR0 and IIR1 output comparators. 0 = Selects 1-bit output format 1 = Selects 2-bit output format



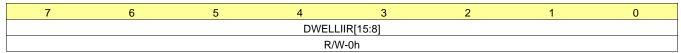
9.5.13.10 Register 01Dh-01Eh (address = 01Dh-01Eh), Power Detector Page

Figure 215. Register 01Dh



LEGEND: R/W = Read/Write; -n = value after reset

Figure 216. Register 01Eh



LEGEND: R/W = Read/Write; -n = value after reset

Table 108. Register 01Dh-01Eh Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	DWELLIIR	R/W	Oh	DWELL time counter for the IIR output comparators. When the IIR filter output crosses the upper thresholds FIL0THH or FIL1THH, the IIR peak detector output flags are set. In order to be reset, the output of the IIR filter must remain continuously lower than the lower threshold (FIL0THL or FIL1THL) for the period specified by the DWELLIIR value. This threshold is 16 bits and is specified in terms of $f_{\rm S}$ / 8 clock cycles. Example: if $f_{\rm S}=2.6$ GSPS, $f_{\rm S}$ / 8 = 325 MHz, and DWELLIIR = 0100h, then the DWELL time = 2^9 / 325 MHz = 1.57 μ s.

9.5.13.11 Register 020h (address = 020h), Power Detector Page

Figure 217. Register 020h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	RMSDET EN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 109. Register 020h Field Descriptions

Bit	Field	Туре	Reset Description	
7-1	0	W	0h	Must write 0
0	RMSDET EN	R/W	0h	This bit enables the RMS power detector. 0 = Power detector disabled 1 = Power detector enabled

Product Folder Links: ADC32RF44



9.5.13.12 Register 021h (address = 021h), Power Detector Page

Figure 218. Register 021h

7	6	5	4	3	2	1	0
0	0	0			PWRDETACCU		
W-0h	W-0h	W-0h			R/W-0h		

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 110. Register 021h Field Descriptions

Bit	Field	Туре	Reset	Description
7-5	0	W	0h	Must write 0
4-0	PWRDETACCU	R/W	Oh	These bits program the block length to be used for RMS power computation. The block length is defined in terms of $f_{\rm S}$ / 8 clocks and can be programmed as 2M, where M = 0 to 16.

9.5.13.13 Register 022h-025h (address = 022h-025h), Power Detector Page

Figure 219. Register 022h

7	6	5	4	3	2	1	0		
PWRDETH[7:0]									
	R/W-0h								

LEGEND: R/W = Read/Write; -n = value after reset

Figure 220. Register 023h

7	6	5	4	3	2	1	0			
	PWRDETH[15:8]									
	R/W-0h									

LEGEND: R/W = Read/Write; -n = value after reset

Figure 221. Register 024h

7	6	5	4	3	2	1	0		
PWRDETL[7:0]									
	R/W-0h								

LEGEND: R/W = Read/Write; -n = value after reset

Figure 222. Register 025h

7	6	5	4	3	2	1	0			
PWRDETL[15:8]										
	R/W-0h									

LEGEND: R/W = Read/Write; -n = value after reset

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Table 111. Register 022h-025h Field Descriptions

E	Bit	Field	Туре	Reset	Description
7	7-0	PWRDETH[15:0] PWRDETL[15:0]	R/W		The computed average power is compared against these high and low thresholds. One LSB of the thresholds represents $1/2^{16}$. Example: if PWRDETH is set to -14 dBFS from peak, $(10^{(-14/20)})^2 \times 2^{16} = 2609$, then set 5422h, 5423h, 5C22h, 5C23h = 0A31h.

Droduct Folder Links, ADC22D



9.5.13.14 Register 027h (address = 027h), Power Detector Page

Figure 223. Register 027h

7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	RMS 2BIT EN
W-0h	R/W-0h						

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 112. Register 027h Field Descriptions

Bit	Field	Туре	Reset	Description
7-1	0	W	0h	Must write 0
0	RMS 2BIT EN	R/W	Oh	This bit enables 2-bit output format on the RMS output comparators. 0 = Selects 1-bit output format 1 = Selects 2-bit output format

9.5.13.15 Register 02Bh (address = 02Bh), Power Detector Page

Figure 224. Register 02Bh

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

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 113. Register 02Bh Field Descriptions

Bit	Field	Туре	Reset	Description
7-5	0	W	0h	Must write 0
4	RESET AGC	R/W	Oh	After configuration, the AGC module must be reset and then brought out of reset to start operation. 0 = Clear AGC reset 1 = Set AGC reset Example: set 542Bh to 10h and then to 00h.
3-0	0	W	0h	Must write 0

Product Folder Links: ADC32RF44

112



9.5.13.16 Register 037h (address = 037h), Power Detector Page

Figure 225. Register 037h

7	6	5	4	3	2	1	0
0	0	0	0	IODIR GPIO4	IODIR GPIO3	IODIR GPIO2	IODIR GPIO1
W-0h	W-0h	W-0h	W-0h	R/W-0h	R/W-0h	R/W-0h	R/W-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 114. Register 037h Field Descriptions

Bit	Field	Туре	Reset	Description
7-4	0	W	0h	Must write 0
3-0	IODIRGPIO[4:1]	R/W	0h	These bits select the output direction for the GPIO[4:1] pins. 0 = Input (for the NCO control) 1 = Output (for the AGC alarm function)

9.5.13.17 Register 038h (address = 038h), Power Detector Page

Figure 226. Register 038h

7	6	5	4	3	2	1	0
0	0	INSE	L1	0	0	INSE	EL0
W-0h	W-0h	R/W-	-0h	R/W-0h	R/W-0h	R/W	-0h

LEGEND: R/W = Read/Write; W = Write only; -n = value after reset

Table 115. Register 038h Field Descriptions

Bit	Field	Туре	Reset	Description
7-6	0	W	0h	Must write 0
5-4	INSEL1	R/W	Oh	These bits select which GPIO pin is used for the INSEL1 bit. 00 = GPIO4 01 = GPIO1 10 = GPIO3 11 = GPIO2 Table 116 lists the NCO selection, based on the bit settings of the INSEL pins.
3-2	0	W	0h	Must write 0
1-0	INSEL0	R/W	Oh	These bits select which GPIO pin is used for the INSEL0 bit. 00 = GPIO4 01 = GPIO1 10 = GPIO3 11 = GPIO2 Table 116 lists the NCO selection, based on the bit settings of the INSEL pins.

Table 116. INSEL Bit Settings

INSEL1	INSEL2	NCO SELECTED
0	0	NCO1
0	1	NCO2
1	0	NCO3
1	1	n/a

Product Folder Links: ADC32RF44



9.5.13.18 Power Detector Page (Direct Addressing, 16-Bit Address, 5400h)

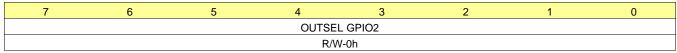
9.5.13.18.1 Register 032h-035h (address = 032h-035h), Power Detector Page

Figure 227. Register 032h

7	6	5	4	3	2	1	0
			OUTSEI	L GPIO1			
			R/W	/-0h			

LEGEND: R/W = Read/Write; -n = value after reset

Figure 228. Register 033h



LEGEND: R/W = Read/Write; -n = value after reset

Figure 229. Register 034h

7	6	5	4	3	2	1	0
			OUTSE	L GPIO3			
			R/V	V-0h			

LEGEND: R/W = Read/Write; -n = value after reset

Figure 230. Register 035h

7	6	5	4	3	2	1	0
			OUTSE	L GPIO4			
			R/V	V-0h			

LEGEND: R/W = Read/Write; -n = value after reset

Table 117. Register 032h-035h Field Descriptions

Bit	Field	Туре	Reset	Description
7-0	OUTSEL GPIOx	R/W	Oh	These bits set the function or signal for each GPIO pin. 0 = IIR PK DET0[0] of channel A 1 = IIR PK DET0[1] of channel A (2-bit mode) 2 = IIR PK DET1[0] of channel A 3 = IIR PK DET1[1] of channel A (2-bit mode) 4 = BLKPKDETH of channel A 5 = BLKPKDETL of channel A 6 = PWR Det[0] of channel A 7 = PWR Det[1] of channel A (2-bit mode) 8 = FOVR of channel A 9-17 = Repeat outputs 0-8 but for channel B instead

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Product Folder Links: ADC32RF44



10 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. Customers should validate and test their design implementation to confirm system functionality.

10.1 Application Information

10.1.1 Start-Up Sequence

The steps in Table 118 are recommended as the power-up sequence when the ADC32RF44 is in bypass mode with a 12-bit output (LMFS = 82820).

Table 118. Initialization Sequence

		•	
STEP	DESCRIPTION	PAGE, REGISTER ADDRESS AND DATA	COMMENT
1	Supply all supply voltages. There is no required power-supply sequence for the 1.15 V, 1.2 V, and 1.9 V supplies, and can be supplied in any order.	_	_
2	Provide the SYSREF signal.	_	_
3	Pulse a hardware reset (low-to-high-to-low) on pins 33 and 34.	_	_
4	Write the register addresses described in the PowerUpConfig file.	See the files located in SBAA226	The Power-up config file contains analog trim registers that are required for best performance of the ADC. Write these registers every time after power up.
5	Write the register addresses mentioned in the ILConfigNyqX_ChA file, where X is the Nyquist zone.	See the files located in SBAA226	Based on the signal band of interest, provide the Nyquist zone information to the device.
6	Write the register addresses mentioned in the ILConfigNyqX_ChB file, where X is the Nyquist zone.	See the files located in SBAA226	This step optimizes device' performance by reducing interleaving mismatch errors.
6.1	Wait for 50 ms for the device to estimate the interleaving errors.	_	_
7	Depending upon the Nyquist band of operation, choose and write the registers from the appropriate file, <i>NLConfigNyqX_ChA</i> , where X is the Nyquist zone.	See the files located in SBAA226	Third-order nonlinearity of the device is optimized by this step for channel A.
7.1	Depending upon the Nyquist band of operation, choose and write the registers from the appropriate file, <i>NLConfigNyqX_ChB</i> , where X is the Nyquist zone.	See the files located in SBAA226	Third-order nonlinearity of the device is optimized by this step for channel B.
8	Configure the JESD interface and DDC block by writing the registers mentioned in the <i>DDC Config</i> file.	See the files located in SBAA226	Determine the DDC and JESD interface LMFS options. Program these options in this step.

Product Folder Links: ADC32RF44

10.1.2 Hardware Reset

Timing information for the hardware reset is shown in Figure 231 and Table 119.

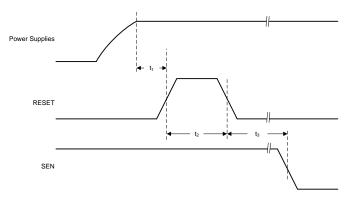


Figure 231. Hardware Reset Timing Diagram

Table 119. Hardware Reset Timing Information

		MIN	TYP	MAX	UNIT
t ₁	Power-on delay from power-up to active high RESET pulse	1			ms
t ₂	Reset pulse duration: active high RESET pulse duration	1			μs
t ₃	Register write delay from RESET disable to SEN active	100			ns



10.1.3 SNR and Clock Jitter

The signal-to-noise ratio (SNR) of the ADC is limited by three different factors: quantization noise, thermal noise, and jitter, as shown in Equation 5. The quantization noise is typically not noticeable in pipeline converters and is 84 dB for a 14-bit ADC. The thermal noise limits the SNR at low input frequencies and the clock jitter sets the SNR for higher input frequencies.

$$SNRADC \Big[dBc \Big] = -20log \sqrt{10^{\frac{SNR_{Quantization \, Noise}}{20}}} \right]^{2} + \left(10^{\frac{SNR_{Thermal \, Noise}}{20}}\right)^{2} + \left(10^{\frac{SNR_{Jitter}}{20}}\right)^{2} + \left(10^{\frac{SNR_{Jitter}}{20}}\right)^{2}$$

The SNR limitation resulting from sample clock jitter can be calculated by Equation 6:

$$SNR_{Jitter}[dBc] = -20log(2\pi \times f_{IN} \times t_{Jitter})$$
(6)

The total clock jitter (T_{Jitter}) has two components: the internal aperture jitter (90 f_S) is set by the noise of the clock input buffer and the external clock jitter. T_{Jitter} can be calculated by Equation 7:

$$t_{\text{Jitter}} = \sqrt{\left(t_{\text{Jitter}}, \text{ Ext_Clock_Input}\right)^2 + \left(t_{\text{Aperture_ADC}}\right)^2}$$
 (7)

External clock jitter can be minimized by using high-quality clock sources and jitter cleaners as well as band-pass filters at the clock input. A faster clock slew rate also improves the ADC aperture jitter.

The ADC32RF44 has a thermal noise of approximately 63 dBFS and an internal aperture jitter of 90 f_S. The SNR, depending on the amount of external jitter for different input frequencies, is shown in Figure 232.

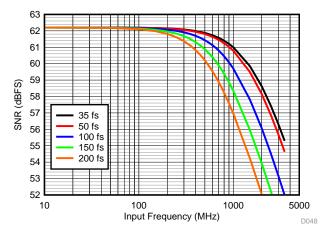


Figure 232. ADC SNR vs Input Frequency and External Clock Jitter

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10.1.3.1 External Clock Phase Noise Consideration

External clock jitter can be calculated by integrating the phase noise of the clock source out to approximately two times of the ADC sampling rate ($2 \times f_S$), as shown in Figure 233. In order to maximize the ADC SNR, an external band-pass filter is recommended to be used on the clock input. This filter reduces the jitter contribution from the broadband clock phase noise floor by effectively reducing the integration bandwidth to the pass band of the band-pass filter. This method is suitable when estimating the overall ADC SNR resulting from clock jitter at a certain input frequency.

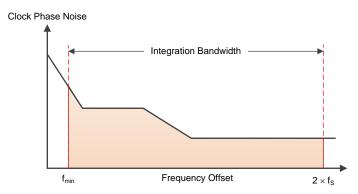


Figure 233. Integration Bandwidth for Extracting Jitter from Clock Phase Noise

However, when estimating the affect of a nearby blocker (such as a strong in-band interferer to the sensitivity, the phase noise information can be used directly to estimate the noise budget contribution at a certain offset frequency, as shown in Figure 234.

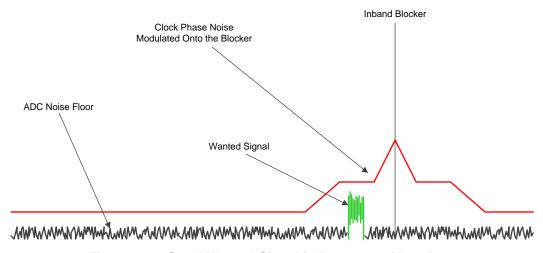


Figure 234. Small Wanted Signal in Presence of Interferer

At the sampling instant, the phase noise profile of the clock source convolves with the input signal (for example, the small wanted signal and the strong interferer merge together). If the power of the clock phase noise in the signal band of interest is too large, the wanted signal cannot not be recovered.

The resulting equivalent phase noise at the ADC input is also dependent on the sampling rate of the ADC and frequency of the input signal. The ADC sampling rate scales the clock phase noise, as shown in Equation 8.

$$ADC_{NSD}\left(dBc / Hz\right) = PN_{CLK}\left(dBc / Hz\right) - 20 \times log\left(\frac{f_{S}}{f_{IN}}\right) \tag{8}$$

Using this information, the noise contribution resulting from the phase noise profile of the ADC sampling clock can be calculated.



10.1.4 Power Consumption in Different Modes

The ADC32RF44 consumes approximately 5.8 W of power when both channels are active with a 12-bit, 2.6-GSPS output and a DDC option is not used (bypass mode). When different DDC options are used, the power consumption on the DVDD supply changes by a small amount but remains unaffected on other supplies. In the applications requiring just one channel to be active, channel A must be chosen as the active channel and channel B can be powered down. Power consumption reduces to approximately 3.5 W in single-channel operation with a 12-bit, 2.6-GSPS output (bypass mode).

Table 120 shows power consumption in different DDC modes for dual-channel and single-channel operation.

Table 120. Power Consumption in Different DDC Modes

DECIMATION OPTION	ACTIVE CHANNEL	ACTIVE DDC	AVDD1P9 (mA)	AVDD1P2 (mA)	DVDD1P2 (mA)	TOTAL POWER (mW)
Bypass mode	Channels A, B	NA	1730	860	1416	5904
Divide-by-4	Channels A, B	Single	1725	867	1530	6034
Divide-by-8	Channels A, B	Dual	1724	854	1674	6183
Divide-by-8	Channels A, B	Single	1724	860	1466	5951
Divide-by-16	Channels A, B	Dual	1724	870	1674	6201
Divide-by-16	Channels A, B	Single	1725	868	1448	5941
Divide-by-24	Channels A, B	Dual	1721	867	1684	6204
Divide-by-24	Channels A, B	Single	1722	865	1391	5866
Divide-by-32	Channels A, B	Dual	1721	860	1534	6023
Divide-by-32	Channels A, B	Single	1721	860	1326	5784
Bypass mode	Channel A	NA	940	550	913	3468
Divide-by-4	Channel A	Single	939	556	958	3525
Divide-by-8	Channel A	Dual	941	553	1024	3601
Divide-by-8	Channel A	Single	941	546	911	3463
Divide-by-16	Channel A	Dual	937	562	1039	3621
Divide-by-16	Channel A	Single	939	553	930	3490
Divide-by-24	Channel A	Dual	935	561	1023	3598
Divide-by-24	Channel A	Single	937	553	899	3450
Divide-by-32	Channel A	Dual	936	557	961	3524
Divide-by-32	Channel A	Single	937	549	848	3387

Product Folder Links: ADC32RF44

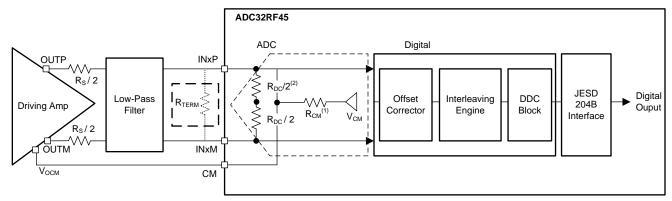


10.1.5 Using DC Coupling in the ADC32RF44

The ADC32RF44 can be used in dc-coupling applications. However, the following points must be considered when designing the system:

1. Ensure that the correct common-mode voltage is used at the ADC analog inputs.

The analog inputs are internally self-biased to V_{CM} through approximately a 33- Ω resistor. The internal biasing resistors also function as a termination resistor. However, if a different termination is required, the external resistor R_{TERM} can be differentially placed between the analog inputs, as shown in Figure 235. The amplifier V_{OCM} pin is recommended to be driven from the CM pin of the ADC to help the amplifier output common-mode voltage track the required common-mode voltage of the ADC.



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Set the INCR CM IMPEDANCE bit to increase the RCM from 0 Ω to > 5000 Ω . R_{DC} is approximately 65 Ω .

Figure 235. The ADC32RF44 in a DC-Coupling Application

2. Ensure that the correct SPI settings are written to the ADC.

As shown in Figure 236, the ADC32RF44 has a digital block that estimates and corrects the offset mismatch among four interleaving ADC cores for a given channel.

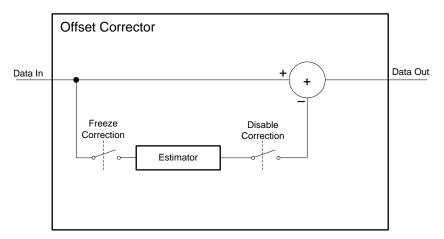


Figure 236. Offset Corrector in the ADC32RF44

The offset corrector block nullifies dc, f_S / 8, f_S / 4, 3 f_S / 8, and f_S / 2. The resulting spectrum becomes free from static spurs at these frequencies. The corrector continuously processes the data coming from the interleaving ADC cores and cannot distinguish if the tone at these frequencies is part of signal or if the tone originated from a mismatch among the interleaving ADC cores. Thus, in applications where the signal is present at these frequencies, the offset corrector block can be bypassed.

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10.1.5.1 Bypassing the Offset Corrector Block

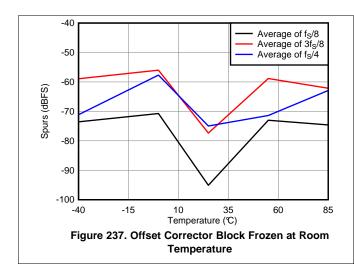
When the offset corrector is bypassed, offset mismatch among interleaving ADC cores appears in the ADC output spectrum. To correct the effects of mismatch, place the ADC in an idle channel state (no signal at the ADC inputs) and the corrector must be allowed to run for some time to estimate the mismatch, then the corrector is frozen so that the last estimated value is held. Required register writes are provided in Table 121.

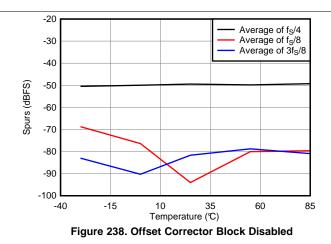
Table 121. Freezing and Bypassing the Offset Corrector Block

	Table 121.11e	ezing and bypassing the Offset Corrector Block				
STEP	REGISTER WRITE	COMMENT				
STEPS FOR	FREEZING THE CORRECTOR BL	OCK				
1	_	Signal source is turned off. The device detects an idle channel at its input.				
2	_	Wait for at least 0.4 ms for the corrector to estimate the internal offset				
	Address 4001h, value 00h					
	Address 4002h, value 00h	Solost Offset Core Page Channel A				
	Address 4003h, value 00h	Select Offset Corr Page Channel A				
3	Address 4004h, value 61h					
	Address 6068h, value C2h	Freeze the corrector for channel A				
	Address 4003h, value 01h	Select Offset Corr Page Channel B				
	Address 6068h, value C2h	Freeze the corrector for channel B				
4	_	Signal source can now be turned on				
STEPS FOR	BYPASSING THE CORRECTOR E	BLOCK				
	Address 4001h, value 00h					
	Address 4002h, value 00h	_				
	Address 4003h, value 00h					
1	Address 4004h, value 61h	Select Offset Corr Page Channel A				
	Address 6068h, value 46h	Disable the corrector for channel A				
	Address 4003h, value 01h	Select Offset Corr Page Channel B				
	Address 6068h, value 46h	Disable the corrector for channel B				

10.1.5.1.1 Effect of Temperature

Figure 237 and Figure 238 show the behavior of nf_S / 8 tones with respect to temperature when the offset corrector block is frozen or disabled.



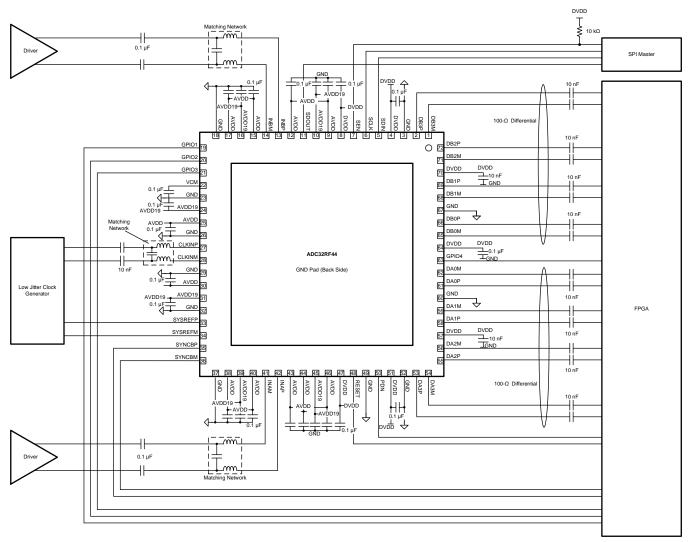




10.2 Typical Application

The ADC32RF44 is designed for wideband receiver applications demanding high dynamic range over a large input frequency range. A typical schematic for an ac-coupled receiver is shown in Figure 239.

Decoupling capacitors with low ESL are recommended to be placed as close as possible at the pins indicated in Figure 239. Additional capacitors can be placed on the remaining power pins.



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Figure 239. Typical Application Implementation Diagram



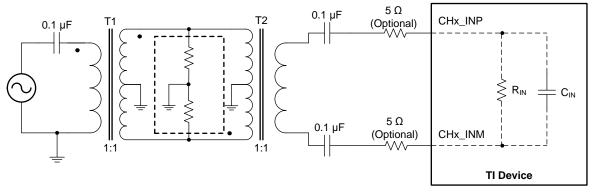
Typical Application (continued)

10.2.1 Design Requirements

10.2.1.1 Transformer-Coupled Circuits

Typical applications involving transformer-coupled circuits are discussed in this section. To ensure good amplitude and phase balance at the analog inputs, transformers (such as TC1-1-13 and TC1-1-43) can be used from the dc to 1000-MHz range and from the 1000-MHz to 4-GHz range of input frequencies, respectively. When designing the driving circuits, the ADC input impedance (or $S_{DD}11$) must be considered.

By using the simple drive circuit of Figure 240, uniform performance can be obtained over a wide frequency range. The buffers present at the analog inputs of the device help isolate the external drive source from the switching currents of the sampling circuit.



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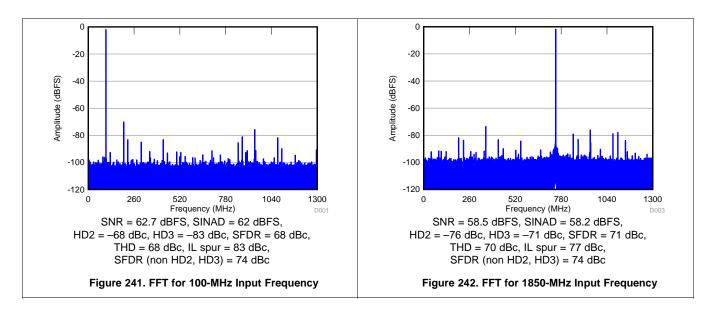
Figure 240. Input Drive Circuit

10.2.2 Detailed Design Procedure

For optimum performance, the analog inputs must be driven differentially. This architecture improves common-mode noise immunity and even-order harmonic rejection. A small resistor (5 Ω to 10 Ω) in series with each input pin is recommended to damp out ringing caused by package parasitics, as shown in Figure 240.

10.2.3 Application Curves

Figure 241 and Figure 242 show the typical performance at 100 MHz and 1850 MHz, respectively.



11 Power Supply Recommendations

The DVDD power supply (1.15 V) must be stable before ramping up the AVDD19 supply (1.9 V), as shown in Figure 243. The AVDD supply (1.15 V) can come up in any order during the power sequence. The power supplies can ramp up at any rate and there is no hard requirement for the time delay between DVDD (1.15 V) ramping up to AVDD (1.9 V) ramping up (which can be in orders of microseconds but is recommended to be a few milliseconds).

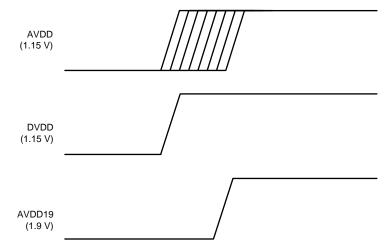


Figure 243. Power Sequencing for the ADC32RF8x Family of Devices

12 Layout

12.1 Layout Guidelines

The device evaluation module (EVM) layout can be used as a reference layout to obtain the best performance. A layout diagram of the EVM top layer is provided in Figure 244. The *ADC32RF45/RF80 EVM Quick Startup Guide* provides a complete layout of the EVM. Some important points to remember during board layout are:

- Analog inputs are located on opposite sides of the device pinout to ensure minimum crosstalk on the package level. To minimize crosstalk onboard, the analog inputs must exit the pinout in opposite directions, as shown in the reference layout of Figure 244 as much as possible.
- In the device pinout, the sampling clock is located on a side perpendicular to the analog inputs in order to minimize coupling. This configuration is also maintained on the reference layout of Figure 244 as much as possible.
- Keep digital outputs away from the analog inputs. When these digital outputs exit the pinout, the digital output
 traces must not be kept parallel to the analog input traces because this configuration can result in coupling
 from the digital outputs to the analog inputs and degrade performance. All digital output traces to the receiver
 [such as field-programmable gate arrays (FPGAs) or application-specific integrated circuits (ASICs)] must be
 matched in length to avoid skew among outputs.
- At each power-supply pin (AVDD, DVDD, or AVDD19), keep a 0.1-μF decoupling capacitor close to the device. A separate decoupling capacitor group consisting of a parallel combination of 10-μF, 1-μF, and 0.1-μF capacitors can be kept close to the supply source.



12.2 Layout Example

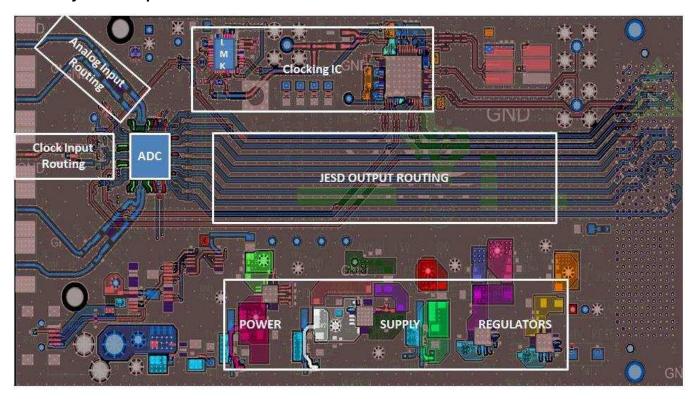


Figure 244. ADC32RF44EVM Layout



13 Device and Documentation Support

13.1 Documentation Support

13.1.1 Related Documentation

For related documentation see the following:

- ADC32RF45/RF80 EVM Quick Startup Guide
- Configuration Files for the ADC32RF45

13.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* 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.

13.3 Community Resources

The following links connect to TI community resources. Linked contents are provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

TI E2E™ Online Community TI's Engineer-to-Engineer (E2E) Community. Created to foster collaboration among engineers. At e2e.ti.com, you can ask questions, share knowledge, explore ideas and help solve problems with fellow engineers.

Design Support *TI's Design Support* Quickly find helpful E2E forums along with design support tools and contact information for technical support.

13.4 Trademarks

E2E is a trademark of Texas Instruments.

All other trademarks are the property of their respective owners.

13.5 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.

13.6 Glossary

SLYZ022 — TI Glossary.

This glossary lists and explains terms, acronyms, and definitions.

14 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.

www.ti.com 10-Nov-2025

PACKAGING INFORMATION

Orderable part number	Status	Material type	Package Pins	Package qty Carrier	RoHS	Lead finish/ Ball material	MSL rating/ Peak reflow	Op temp (°C)	Part marking
	(1)	(2)			(3)	(4)	(5)		(6)
ADC32RF44IRMP	Active	Production	VQFN (RMP) 72	168 JEDEC TRAY (5+1)	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	AZ32RF44
ADC32RF44IRMP.A	Active	Production	VQFN (RMP) 72	168 JEDEC TRAY (5+1)	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	AZ32RF44
ADC32RF44IRMPG4	Active	Production	VQFN (RMP) 72	168 JEDEC TRAY (5+1)	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	AZ32RF44
ADC32RF44IRMPG4.A	Active	Production	VQFN (RMP) 72	168 JEDEC TRAY (5+1)	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	AZ32RF44
ADC32RF44IRMPR	Active	Production	VQFN (RMP) 72	1500 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	AZ32RF44
ADC32RF44IRMPR.A	Active	Production	VQFN (RMP) 72	1500 LARGE T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	AZ32RF44
ADC32RF44IRMPT	Active	Production	VQFN (RMP) 72	250 SMALL T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	AZ32RF44
ADC32RF44IRMPT.A	Active	Production	VQFN (RMP) 72	250 SMALL T&R	Yes	NIPDAU	Level-3-260C-168 HR	-40 to 85	AZ32RF44

⁽¹⁾ Status: For more details on status, see our product life cycle.

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.

⁽²⁾ 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.

⁽³⁾ RoHS values: Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

⁽⁴⁾ 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.

⁽⁵⁾ 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.

⁽⁶⁾ 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.



PACKAGE OPTION ADDENDUM

www.ti.com 10-Nov-2025

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PACKAGE MATERIALS INFORMATION

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TAPE AND REEL INFORMATION





A0	Dimension designed to accommodate the component width
В0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing		SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
ADC32RF44IRMPR	VQFN	RMP	72	1500	330.0	24.4	10.25	10.25	2.25	16.0	24.0	Q2
ADC32RF44IRMPT	VQFN	RMP	72	250	180.0	24.4	10.25	10.25	2.25	16.0	24.0	Q2

PACKAGE MATERIALS INFORMATION

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*All dimensions are nominal

Device	Package Type	Package Drawing	Pins SPQ		Length (mm)	Width (mm)	Height (mm)	
ADC32RF44IRMPR	VQFN	RMP	72	1500	350.0	350.0	43.0	
ADC32RF44IRMPT	VQFN	RMP	72	250	213.0	191.0	55.0	



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TRAY

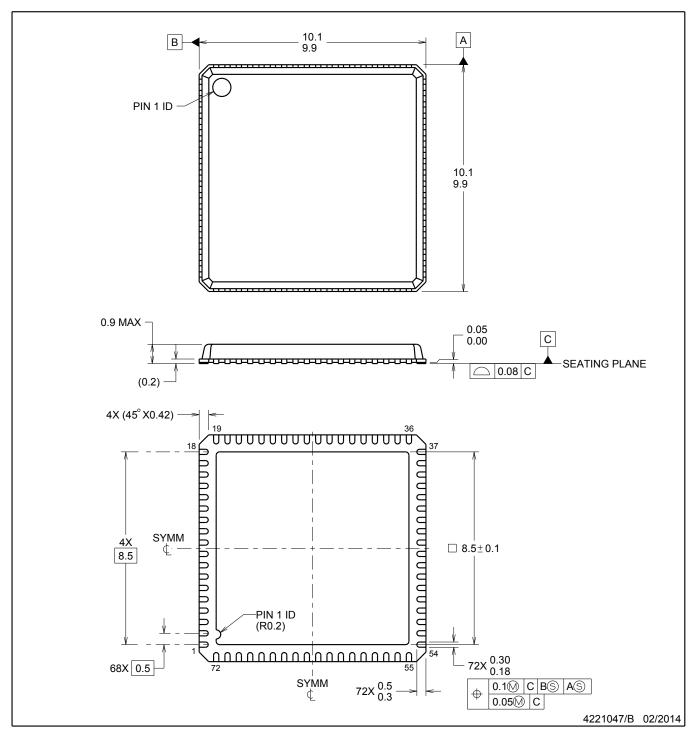


Chamfer on Tray corner indicates Pin 1 orientation of packed units.

*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	Unit array matrix	Max temperature (°C)	L (mm)	W (mm)	Κ0 (μm)	P1 (mm)	CL (mm)	CW (mm)
ADC32RF44IRMP	RMP	VQFNP	72	168	8 X 21	150	315	135.9	7620	14.65	11	11.95
ADC32RF44IRMP.A	RMP	VQFNP	72	168	8 X 21	150	315	135.9	7620	14.65	11	11.95
ADC32RF44IRMPG4	RMP	VQFNP	72	168	8 X 21	150	315	135.9	7620	14.65	11	11.95
ADC32RF44IRMPG4.A	RMP	VQFNP	72	168	8 X 21	150	315	135.9	7620	14.65	11	11.95





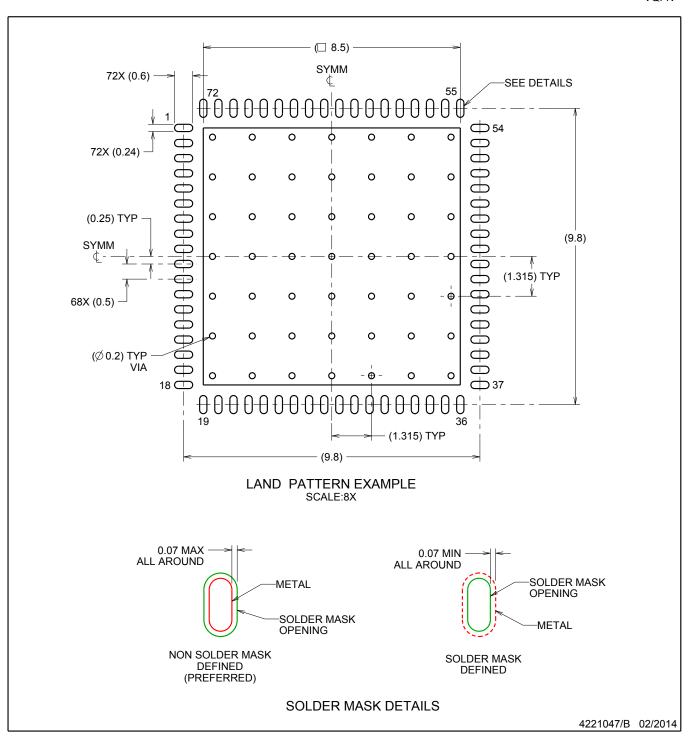
NOTES:

- 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.



VQFN

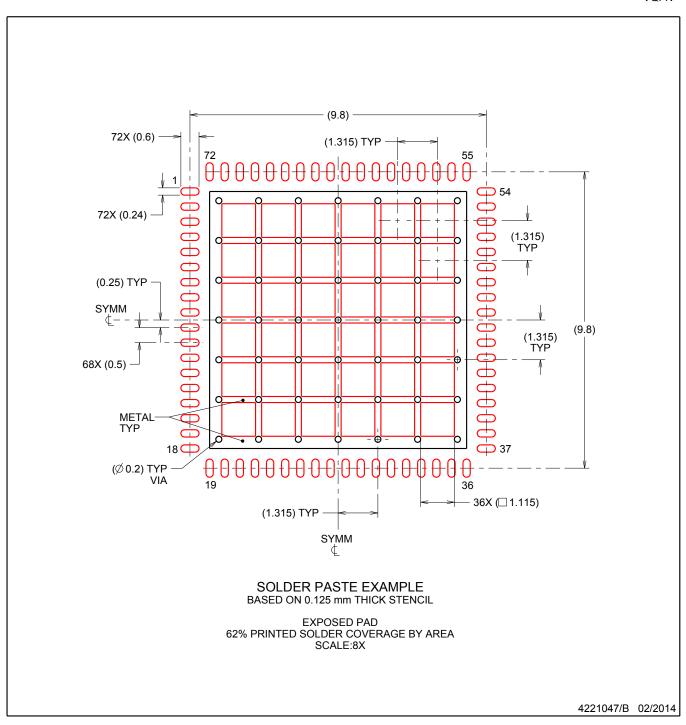


NOTES: (continued)

4. This package is designed to be soldered to a thermal pad on the board. For more information, see QFN/SON PCB application report in literature No. SLUA271 (www.ti.com/lit/slua271).



VQFN



NOTES: (continued)

5. 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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