Dual-Channel, 16-BIT, 1.25 GSPS Digital-to-Analog Converter (DAC)

Check for Samples: DAC3482

FEATURES

- **Very Low Power: 900 mW at 1.25 GSPS, Full Operating Conditions**
- **Multi-DAC Synchronization**
- **Selectable 2x, 4x, 8x, 16x Interpolation Filter**
  - **Stop-Band Attenuation > 90 dBc**
- **Flexible On-chip Complex Mixing**
  - **Fine Mixer with 32-bit NCO**
  - **Power Saving Coarse Mixer: ± n×Fs/8**
- **High Performance, Low Jitter Clock Multiplying PLL**
- **Digital I and Q Correction**
  - **Gain, Phase, Offset, and Group Delay Correction**
- **Digital Inverse Sinc Filter**
- **Flexible LVDS Input Data Bus**
  - **Word- or Byte-Wide Interface**
  - **8 Sample Input FIFO**
  - **Data Pattern Checker**
  - **Parity Check**
- **Temperature Sensor**
- **Differential Scalable Output: 10mA to 30mA**
- **Space Saving Package: 88-pin 9x9mm mRQFN (GREEN / Pb-Free)**

APPLICATIONS

- **Cellular Base Stations**
- **Diversity Transmit**
- **Wideband Communications**

DESCRIPTION

The DAC3482 is a very low power, high dynamic range, dual-channel, 16-bit digital-to-analog converter (DAC) with a sample rate as high as 1.25 GSPS.

The device includes features that simplify the design of complex transmit architectures: 2x to 16x digital interpolation filters with over 90 dB of stop-band attenuation simplify the data interface and reconstruction filters. A complex mixer allows flexible carrier placement. A high-performance low jitter clock multiplier simplifies clocking of the device without significant impact on the dynamic range. The digital Quadrature Modulator Correction (QMC) enables complete IQ compensation for gain, offset, phase and group delay between channels in direct up-conversion applications.

Digital data is input to the device through a flexible LVDS data bus with on-chip termination. Data can be input either word-wide or byte-wide. The device includes a FIFO, data pattern checker and parity test to ease the input interface. The interface also allows full synchronization of multiple devices.

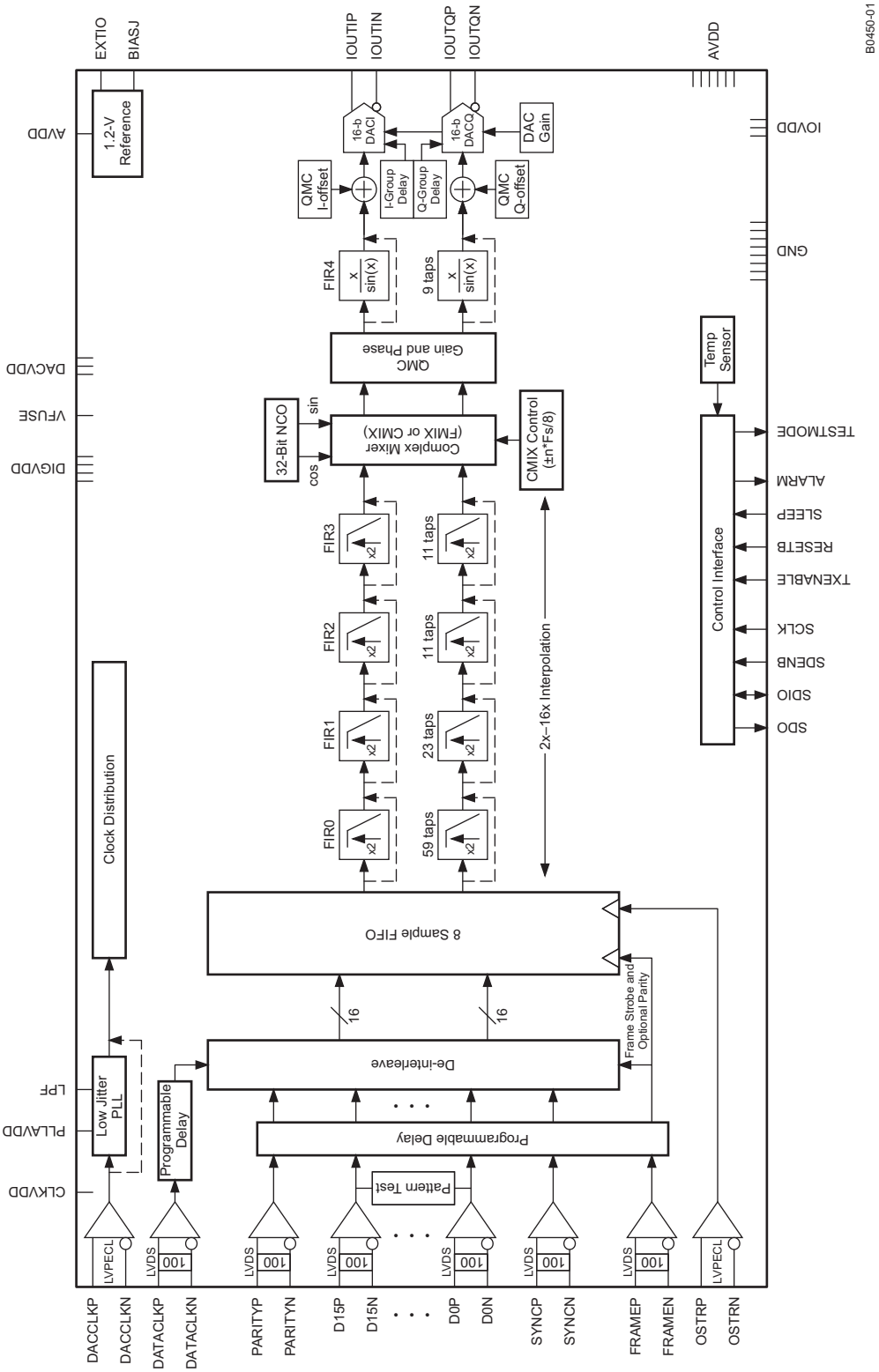
The device is characterized for operation over the entire industrial temperature range of –40°C to 85°C and is available in a very-small 88-pin 9x9mm mRQFN package.

The DAC3482 very low power, small size, superior crosstalk, high dynamic range and features are an ideal fit for today's communication systems.

PRODUCT PREVIEW

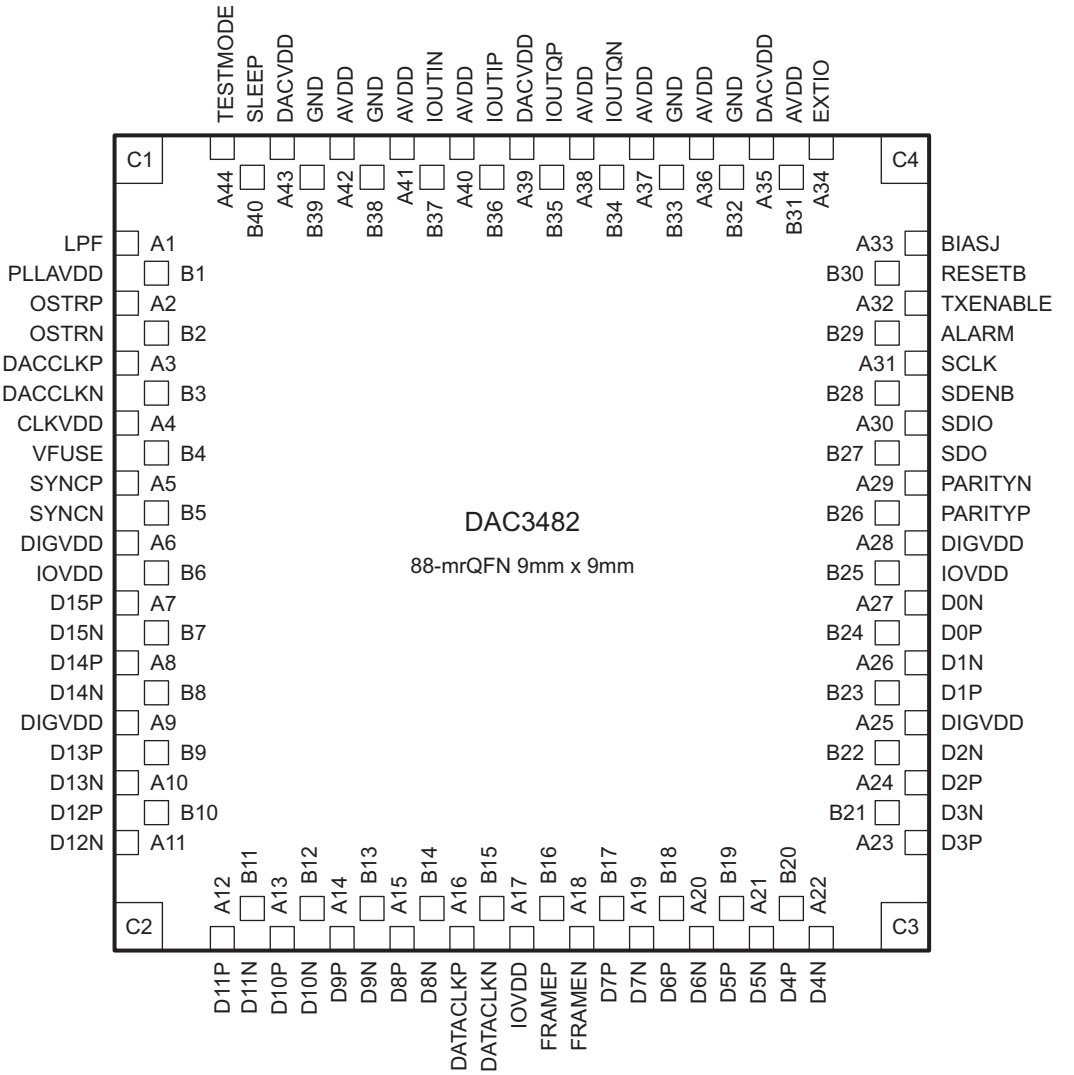
These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

FUNCTIONAL BLOCK DIAGRAM



PRODUCT PREVIEW

PINOUT
RKD Package
(Top View)



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PRODUCT PREVIEW

PIN FUNCTIONS

PIN		I/O	DESCRIPTION
NAME	NO.		
AVDD	A36, A37, A38, A40, A41, A42, B31	I	Analog supply voltage. (3.3 V)
ALARM	B29	O	CMOS output for ALARM condition. The ALARM output functionality is defined through the config7 register. Default polarity is active low, but can be changed to active high via *config0 alarm_out_pol* control bit.
BIASJ	A33	O	Full-scale output current bias. For 30mA full-scale output current, connect 1.28kΩ to ground. Change the full-scale output current through *coarse_dac(3:0)* in *config3, bit<15:12>*
CLKVDD	A4	I	Internal clock buffer supply voltage. (1.2 V) It is recommended to isolate this supply from DIGVDD and DACVDD.

PIN FUNCTIONS (continued)

PIN		I/O	DESCRIPTION
NAME	NO.		
D[15..0]P	A7, A8, B9, B10, A12, A13, A14, A15, B17, B18, B19, B20, A23, A24, B23, B24	I	LVDS positive input data bits 0 through 15. Internal 100 Ω termination resistor. Data format relative to DATACLKP/N clock is Double Data Rate (DDR) and can be transferred in either byte-wide or word-wide mode. In byte-wide mode the unused pins can be left unconnected. D15P is most significant data bit (MSB) in word-wide mode D7P is most significant data bit (MSB) in byte-wide mode D0P is least significant data bit (LSB) The order of the bus can be reversed via *config2 revbus* bit.
D[15..0]N	B7, B8, A10, A11, B11, B12, B13, B14, A19, A20, A21, A22, B21, B22, A26, A27	I	LVDS negative input data bits 0 through 15. (See D[15:0]P description above)
DACCLKP	A3	I	Positive external LVPECL clock input for DAC core with a self-bias.
DACCLKN	B3	I	Complementary external LVPECL clock input for DAC core. (see the DACCLKP description)
DACVDD	A35, A39, A43	I	DAC core supply voltage. (1.2 V). It is recommended to isolate this supply from CLKVDD and DIGVDD.
DATACLKP	A16	I	LVDS positive input data clock. Internal 100 Ω termination resistor. Input data D[15:0]P/N is latched on both edges of DATACLKP/N (Double Data Rate).
DATACLKN	B15	I	LVDS negative input data clock. (See DATACLKP description)
DIGVDD	A6, A9, A25, A28	I	Digital supply voltage. (1.2 V). It is recommended to isolate this supply from CLKVDD and DACVDD.
EXTIO	A34	I/O	Used as external reference input when internal reference is disabled through *config27 extref_ena* = '1'. Used as internal reference output when *config27 extref_ena* = '0' (default). Requires a 0.1 µF decoupling capacitor to AGND when used as reference output.
FRAMEP	B16	I	LVDS frame indicator positive input. Internal 100 Ω termination resistor. The main functions of this input are to reset the FIFO or to be used as a syncing source. These two functions are captured with the rising edge of DATACLKP/N. The signal captured by the falling edge of DATACLKP/N can be used as a block parity bit. The FRAMEP/N signal should be edge-aligned with D[15:0]P/N.
FRAMEN	A18	I	LVDS frame indicator negative input. (See the FRAMEP description)
GND	C1, C2, C3, C4, B32, B33, B38, B39, Thermal Pad	I	These pins are ground for all supplies.
IOUTIP	B36	O	I-Channel DAC current output. Connect directly to ground if unused.
IOUTIN	B37	O	I-Channel DAC complementary current output. Connect directly to ground if unused.
IOUTQP	B35	O	Q-Channel DAC current output. Connect directly to ground if unused.
IOUTQN	B34	O	Q-Channel DAC complementary current output. Connect directly to ground if unused.
IOVDD	B6, A17, B25	I	Supply voltage for all digital I/O. (3.3 V)
LPF	A1	I/O	PLL loop filter connection. If not using the clock multiplying PLL, the LPF pin can be left unconnected.
OSTRP	A2	I	LVPECL output strobe positive input. This positive/negative pair is captured with the rising edge of DACCLKP/N. It is used to sync the divided-down clocks and FIFO output pointer in Dual Sync Source Mode. If unused it can be left unconnected.
OSTRN	B2	I	LVPECL output strobe negative input. (See the OSTRP description)
PARITYP	B26	I	Optional LVDS positive input parity bit. The PARITYP/N LVDS pair has an internal 100 Ω termination resistor. If unused it can be left unconnected.
PARITYN	A29	I	Optional LVDS negative input parity bit.
PLLAVDD	B1	I	PLL analog supply voltage. (3.3 V)
SCLK	A31	I	Serial interface clock. Internal pull-down.
SDENB	B28	I	Active low serial data enable, always an input to the DAC3482. Internal pull-up.
SDIO	A30	I/O	Serial interface data. Bi-directional in 3-pin mode (default) and 4-pin mode. Internal pull-down.

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PIN FUNCTIONS (continued)

PIN		I/O	DESCRIPTION
NAME	NO.		
SDO	B27	O	Uni-directional serial interface data in 4-pin mode. The SDO pin is tri-stated in 3-pin interface mode (default).
SLEEP	B40	I	Active high asynchronous hardware power-down input. Internal pull-down.
SYNCP	A5	I	Optional LVDS SYNC positive input. The SYNCP/N LVDS pair has an internal 100 Ω termination resistor. If unused it can be left unconnected.
SYNCN	B5	I	Optional LVDS SYNC negative input.
RESETB	B30	I	Active low input for chip RESET, which resets all the programming registers to their default state. Internal pull-up.
TXENABLE	A32	I	Transmit enable active high input. Internal pull-down. To enable analog output data transmission, set *sif_txenable* in register *config3* to "1" **or** pull CMOS TXENABLE pin to high. To disable analog output, set *sif_txenable* to "0" **and** pull CMOS TXENABLE pin to low. The digital logic section is forced to all 0, and any input data is ignored.
TESTMODE	A44	I	This pin is used for factory testing. Internal pull-down. **Leave unconnected for normal operation.**
VFUSE	B4	I	Digital supply voltage. This supply pin is also used for factory fuse programming. **Connect to DACVDD for normal operation.**

ORDERING INFORMATION(1)

T_A	ORDER CODE	PACKAGE DRAWING/TYPE(2)(3)	TRANSPORT MEDIA	QUANTITY
–40°C to 85°C	DAC3482IRKDT	RKD / 88 mR-QFN Quad Flatpack No-Lead	Tape and Reel	250
	DAC3482IRKDR			2000

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or visit the device product folder at www.ti.com.
(2) Thermal Pad Size: 6.4 mm x 6.4 mm
(3) MSL Peak Temperature: Level-3-260C-168 HR

PRODUCT PREVIEW

ABSOLUTE MAXIMUM RATINGS

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

		VALUE		UNIT
		MIN	MAX	
Supply voltage range(2)	DACVDD, DIGVDD, CLKVDD	–0.5	1.5	V
	VFUSE	–0.5	1.5	V
	IOVDD	–0.5	4	V
	AVDD, PLLAVDD	–0.5	4	V
Pin voltage range(2)	D[15..0]P/N, DATACLKP/N, FRAMEP/N, PARITYP/N, SYNCP/N	–0.5	IOVDD + 0.5	V
	DACCLKP/N, OSTRP/N	–0.5	CLKVDD + 0.5	V
	ALARM, SDO, SDIO, SCLK, SDENB, SLEEP, RESETB, TESTMODE, TXENABLE	–0.5	IOVDD + 0.5	V
	IOUTIP/N, IOUTQP/N	–1.0	AVDD + 0.5	V
	EXTIO, BIASJ	–0.5	AVDD + 0.5	V
	LPF	0.5	PLLAVDD+0.5V	V
Peak input current (any input)			20	mA
Peak total input current (all inputs)			–30	mA
Operating free-air temperature range, T_A: DAC3482		–40	85	°C
Storage temperature range		–65	150	°C
Lead temperature 1,6 mm (1/16 inch) from the case for 10 seconds			260	°C

(1) Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only and functional operation of these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) Measured with respect to GND.

THERMAL INFORMATION

THERMAL METRIC(1)		DAC3482 RKD PACKAGE (88) PINS	UNITS
T_J	Maximum junction temperature	125	°C
θ_{JA}	Junction-to-ambient thermal resistance(2)	22.1	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance(3)	7.1	
θ_{JCbot}	Junction-to-case (bottom) thermal resistance(4)	0.6	
θ_{JB}	Junction-to-board thermal resistance(5)	4.7	
ψ_{JT}	Junction-to-top characterization parameter(6)	0.1	
ψ_{JB}	Junction-to-board characterization parameter(7)	4.6	

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, SPRA953.
(2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.
(3) The junction-to-case (top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.
(4) The junction-to-case (bottom) thermal resistance is obtained by simulating a cold plate test on the exposed (power) pad. No specific JEDEC standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.
(5) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.
(6) The junction-to-top characterization parameter, ψ_{JT}, estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA}, using a procedure described in JESD51-2a (sections 6 and 7).
(7) The junction-to-board characterization parameter, ψ_{JB}, estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining θ_{JA} , using a procedure described in JESD51-2a (sections 6 and 7).

ELECTRICAL CHARACTERISTICS – DC SPECIFICTIONS(1)

over recommended operating free-air temperature range, nominal supplies, $IOUT_{FS}$ = 20mA (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
Resolution			16			Bits
DC ACCURACY						
DNL	Differential nonlinearity	1 LSB = $IOUT_{FS}/2^{16}$		±2		LSB
INL	Integral nonlinearity			±4		LSB
ANALOG OUTPUT						
	Coarse gain linearity			±0.04		LSB
	Offset error	Mid code offset		±0.001		%FSR
	Gain error	With external reference		±2		%FSR
		With internal reference		±2		%FSR
	Gain mismatch	With internal reference		±2		%FSR
	Full scale output current		10	20	30	mA
	Output compliance range		–0.5		0.6	V
	Output resistance			300		kΩ
	Output capacitance			5		pF
REFERENCE OUTPUT						
V_{REF}	Reference output voltage			1.2		V
	Reference output current(2)			100		nA
REFERENCE INPUT						
V_{EXTIO}	Input voltage range	External Reference Mode	0.6	1.2	1.25	V
	Input resistance			1		MΩ
	Small signal bandwidth			472		kHz
	Input capacitance			100		pF
TEMPERATURE COEFFICIENTS						
	Offset drift			±1		ppm/°C
	Gain drift	With external reference		±15		ppm/°C
		With internal reference		±30		ppm/°C
	Reference voltage drift			±8		ppm/°C
POWER SUPPLY						
	AVDD, IOVDD, PLLAVDD		3.14	3.3	3.46	V
	CLKVDD, DACVDD, DIGVDD		1.14	1.2	1.26	V
PSRR	Power Supply Rejection Ratio	DC tested		±0.2		%FSR/V
POWER CONSUMPTION						
$I_{(AVDD)}$	Analog supply current(3)	MODE 1 f_{DAC} = 1.25GSPS, 2x interpolation, Mixer on, QMC on, invsinc on, PLL enabled, 20mA FS output, IF = 200MHz		77		mA
$I_{(DIGVDD)}$	Digital supply current			386		mA
$I_{(DACVDD)}$	DAC supply current			60		mA
$I_{(CLKVDD)}$	Clock supply current			90		mA
P	Power dissipation			900		mW
$I_{(AVDD)}$	Analog supply current(3)	MODE 2 f_{DAC} = 1.25GSPS, 2x interpolation, Mixer on, QMC on, invsinc on, PLL disabled, 20mA FS output, IF = 200MHz		63		mA
$I_{(DIGVDD)}$	Digital supply current			386		mA
$I_{(DACVDD)}$	DAC supply current			58		mA
$I_{(CLKVDD)}$	Clock supply current			70		mA
P	Power dissipation			825		mW

(1) Measured differentially across IOUTP/N with 25 Ω each to GND.
(2) Use an external buffer amplifier with high impedance input to drive any external load.
(3) Includes AVDD, PLLAVDD, and IOVDD

PRODUCT PREVIEW

ELECTRICAL CHARACTERISTICS – DC SPECIFICTIONS(1) (continued)

over recommended operating free-air temperature range, nominal supplies, $IOUT_{FS}$ = 20mA (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$I_{(AVDD)}$	Analog supply current(3)	MODE 3 f_{DAC} = 625MSPS, 2x interpolation, Mixer on, QMC on, invsinc off, PLL disabled, 20mA FS output, IF = 200MHz		63		mA
$I_{(DIGVDD)}$	Digital supply current			200		mA
$I_{(DACVDD)}$	DAC supply current			27		mA
$I_{(CLKVDD)}$	Clock supply current			41		mA
P	Power dissipation			530		mW
$I_{(AVDD)}$	Analog supply current(3)	MODE 4 f_{DAC} = 1.25GSPS, 2x interpolation, Mixer on, QMC on, invsinc on, PLL enabled, I/Q output sleep, IF = 200MHz,		33		mA
$I_{(DIGVDD)}$	Digital supply current			382		mA
$I_{(DACVDD)}$	DAC supply current			57		mA
$I_{(CLKVDD)}$	Clock supply current			90		mA
P	Power dissipation			745		mW
$I_{(AVDD)}$	Analog supply current(3)	Mode 5 Power-Down mode: No clock, DAC on sleep mode (clock receiver sleep), I/Q output sleep, static data pattern		18		mA
$I_{(DIGVDD)}$	Digital supply current			24		mA
$I_{(DACVDD)}$	DAC supply current			4		mA
$I_{(CLKVDD)}$	Clock supply current			8		mA
P	Power dissipation			100		mW
$I_{(AVDD)}$	Analog supply current(3)	Mode 6 f_{DAC} = 1GSPS, 2x interpolation, Mixer off, QMC off, invsinc off, PLL enabled, 20mA FS output, IF = 200MHz		77		mA
$I_{(DIGVDD)}$	Digital supply current			227		mA
$I_{(DACVDD)}$	DAC supply current			45		mA
$I_{(CLKVDD)}$	Clock supply current			82		mA
P	Power dissipation			680		mW
Operating Range			–40	25	85	°C

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ELECTRICAL CHARACTERISTICS – DIGITAL SPECIFICATIONS

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
LVDS INPUTS: D[15:0]P/N, DATACLKP/N, FRAMEP/N, SYNCP/N, PARITYP/N (1)						
$V_{A,B+}$	Logic high differential input voltage threshold		250	400	1000	mV
$V_{A,B-}$	Logic low differential input voltage threshold		–250	–400	–1000	mV
V_{COM}	Input common mode		1.075	1.2		V
Z_T	Internal termination			110		Ω
C_L	LVDS Input capacitance			2		pF
f_{INTERL}	Interleaved LVDS data transfer rate				1250	MSPS
f_{DATA}	Input data rate	Word-wide interface mode			625	MSPS
		Byte-wide interface mode			312.5	
CLOCK INPUT (DACCLKP/N)						
	Duty cycle		40%		60%	
	Differential voltage (2)		0.4	1.0		V
	DACCLKP/N Input Frequency				1250	MHz
OUTPUT STROBE (OSTRP/N)						
f_{OSTR}	Frequency	$f_{OSTR} = f_{DACCLK}$ / (n x 8 x Interp) where n is any positive integer f_{DACCLK} is DACCLK frequency in MHz			f_{DACCLK} / (8 x interp)	MHz
	Duty cycle			50%		
	Differential voltage		0.4	1.0		V
CMOS INTERFACE: ALARM, SDO, SDIO, SCLK, SDENB, SLEEP, RESETB, TXENABLE						
V_{IH}	High-level input voltage		2			V
V_{IL}	Low-level input voltage				0.8	V
I_{IH}	High-level input current		-40		40	µA
I_{IL}	Low-level input current		-40		40	µA
C_I	CMOS Input capacitance			2		pF
V_{OH}	ALARM, SDO, SDIO	Iload = –100 µa	IOVDD – 0.2			V
		Iload = –2 mA	0.8 x IOVDD			V
V_{OL}	ALARM, SDO, SDIO	Iload = 100 µA			0.2	V
		Iload = 2 mA			0.5	V
DIGITAL INPUT TIMING SPECIFICATIONS						
Timing LVDS inputs: D[15:0]P/N, FRAMEP/N, SYNCP/N, PARITYP/N, *double edge* latching						
$t_{s(DATA)}$	Setup time, D[15:0]P/N, FRAMEP/N, SYNCP/N and PARITYP/N, valid to either edge of DATACLKP/N	FRAMEP/N reset and frame indicator latched on rising edge of DATACLKP/N. FRAMEP/N parity bit latched on falling edge of DATACLKP/N.	200			ps
$t_{h(DATA)}$	Hold time, D[15:0]P/N, FRAMEP/N, SYNCP/N and PARITYP/N, valid after either edge of DATACLKP/N	FRAMEP/N reset and frame indicator latched on rising edge of DATACLKP/N. FRAMEP/N parity bit latched on falling edge of DATACLKP/N.	200			ps
$t_{(FRAME\_SYNC)}$	FRAMEP/N and SYNCP/N pulse width	$f_{DATACLK}$ is DATACLK frequency in MHz	$1/2f_{DATACLK}$			ns
$t_{(align)}$	Maximum offset between DATACLKP/N and DACCLKP/N rising edges	FIFO Bypass Mode only			±300	ps

(1) See LVDS INPUTS section for terminology.
(2) Driving the clock input with a differential voltage lower than 1 V will result in degraded performance.

PRODUCT PREVIEW

ELECTRICAL CHARACTERISTICS – DIGITAL SPECIFICATIONS (continued)

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
TIMING OUTPUT STROBE INPUT: DACCLKP/N *rising edge* LATCHING (3)						
$t_{s(OSTR)}$	Setup time, OSTRP/N valid to rising edge of DACCLKP/N		200			ps
$t_{h(OSTR)}$	Hold time, OSTRP/N valid after rising edge of DACCLKP/N		200			ps
TIMING SYNC INPUT: DACCLKP/N *rising edge* LATCHING (4)						
$t_{s(SYNC\_PLL)}$	Setup time, SYNCP/N valid to rising edge of DACCLKP/N			200		ps
$t_{h(SYNC\_PLL)}$	Hold time, SYNCP/N valid after rising edge of DACCLKP/N			300		ps
TIMING SERIAL PORT						
$t_{s(SDENB)}$	Setup time, SDENB to rising edge of SCLK		20			ns
$t_{s(SDIO)}$	Setup time, SDIO valid to rising edge of SCLK		10			ns
$t_{h(SDIO)}$	Hold time, SDIO valid to rising edge of SCLK		5			ns
$t_{(SCLK)}$	Period of SCLK	Register *config6* read (temperature sensor read)	1			µs
		All other registers	100			ns
$t_{d(Data)}$	Data output delay after falling edge of SCLK			10		ns
t_{RESET}	Minimum RESETB pulsewidth			25		ns

(3) OSTR is required in Dual Sync Source mode. In order to minimize the skew it is recommended to use the same clock distribution device such as Texas Instruments CDCE62005 to provide the DACCLK and OSTR signals to all the DAC3482 devices in the system. Swap the polarity of the DACCLK outputs with respect to the OSTR ones to establish proper phase relationship.

(4) SYNC is required to synchronize the PLL circuit in mulitple devices. The SYNC signal must meet the timing relationship with respect to the reference clock (DACCLKP/N) of the on-chip PLL circuit.

PRODUCT PREVIEW

ELECTRICAL CHARACTERISTICS – AC SPECIFICATIONS

over recommended operating free-air temperature range, nominal supplies, $IOUT_{FS}$ = 20mA (unless otherwise noted)

PARAMETER		TEST CONDITIONS / COMMENTS	MIN	TYP	MAX	UNIT
ANALOG OUTPUT(1)						
f_{DAC}	Maximum DAC rate		1250			MSPS
$t_{s(DAC)}$	Output settling time to 0.1%	Transition: Code 0x0000 to 0xFFFF		10		ns
t_{pd}	Output propagation delay	DAC outputs are updated on the falling edge of DAC clock. Does not include Digital Latency (see below).		2		ns
$t_{r(IOUT)}$	Output rise time 10% to 90%			220		ps
$t_{f(IOUT)}$	Output fall time 90% to 10%			220		ps
	Digital latency	No interpolation, FIFO off, Mixer off, QMC off, Inverse sinc off		128		DAC clock cycles
		2x Interpolation		216		
		4x Interpolation		376		
		8x Interpolation		726		
		16x Interpolation		1427		
		Fine Mixer		24		
		QMC		16		
		Inverse Sinc		20		
Power-up Time	DAC wake-up time	IOUT current settling to 1% of $IOUT_{FS}$ from deep sleep		90		µs
	DAC sleep time	IOUT current settling to less than 1% of $IOUT_{FS}$ in deep sleep		90		
AC PERFORMANCE(2)						
SFDR	Spurious free dynamic range (0 to f_{DAC}/2) Tone at 0 dBFS	f_{DAC} = 1.25 GSPS, f_{OUT} = 20 MHz		82		dBc
		f_{DAC} = 1.25 GSPS, f_{OUT} = 50 MHz		77		
		f_{DAC} = 1.25 GSPS, f_{OUT} = 70 MHz		72		
IMD3	Third-order two-tone intermodulation distortion Each tone at –12 dBFS	f_{DAC} = 1.25 MSPS, f_{OUT} = 30 ± 0.5 MHz		81		dBc
		f_{DAC} = 1.25 GSPS, f_{OUT} = 50 ± 0.5 MHz		79		
		f_{DAC} = 1.25 GSPS, f_{OUT} = 100 ± 0.5 MHz		77.5		
NSD	Noise spectral density Tone at 0dBFS	f_{DAC} = 1.25 GSPS, f_{OUT} = 10 MHz		160		dBc/Hz
		f_{DAC} = 1.25 GSPS, f_{OUT} = 80 MHz		155		
ACLR(3)	Adjacent channel leakage ratio, single carrier	f_{DAC} = 1.2288 GSPS, f_{OUT} = 30.72 MHz		77		dBc
		f_{DAC} = 1.2288 GSPS, f_{OUT} = 153.6 MHz		74		
	Alternate channel leakage ratio, single carrier	f_{DAC} = 1.2288 GSPS, f_{OUT} = 30.72 MHz		82		
		f_{DAC} = 1.2288 GSPS, f_{OUT} = 153.6 MHz		80		
	Channel isolation	f_{DAC} = 1.25 GSPS, f_{OUT} = 10 MHz		84		dBc

(1) Measured single ended into 50 Ω load.
(2) 4:1 transformer output termination, 50 Ω doubly terminated load
(3) Single carrier, W-CDMA with 3.84 MHz BW, 5-MHz spacing, centered at IF, PAR = 12dB. TESTMODEL 1, 10 ms

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DEFINITION OF SPECIFICATIONS

Adjacent Carrier Leakage Ratio (ACLR): Defined for a 3.84Mcps 3GPP W-CDMA input signal measured in a 3.84MHz bandwidth at a 5MHz offset from the carrier with a 12dB peak-to-average ratio.

Analog and Digital Power Supply Rejection Ratio (APSSR, DPSSR): Defined as the percentage error in the ratio of the delta IOUT and delta supply voltage normalized with respect to the ideal IOUT current.

Differential Nonlinearity (DNL): Defined as the variation in analog output associated with an ideal 1 LSB change in the digital input code.

Gain Drift: Defined as the maximum change in gain, in terms of ppm of full-scale range (FSR) per °C, from the value at ambient (25°C) to values over the full operating temperature range.

Gain Error: Defined as the percentage error (in FSR%) for the ratio between the measured full-scale output current and the ideal full-scale output current.

Integral Nonlinearity (INL): Defined as the maximum deviation of the actual analog output from the ideal output, determined by a straight line drawn from zero scale to full scale.

Intermodulation Distortion (IMD3): The two-tone IMD3 is defined as the ratio (in dBc) of the 3rd-order intermodulation distortion product to either fundamental output tone.

Offset Drift: Defined as the maximum change in DC offset, in terms of ppm of full-scale range (FSR) per °C, from the value at ambient (25°C) to values over the full operating temperature range.

Offset Error: Defined as the percentage error (in FSR%) for the ratio between the measured mid-scale output current and the ideal mid-scale output current.

Output Compliance Range: Defined as the minimum and maximum allowable voltage at the output of the current-output DAC. Exceeding this limit may result reduced reliability of the device or adversely affecting distortion performance.

Reference Voltage Drift: Defined as the maximum change of the reference voltage in ppm per degree Celsius from value at ambient (25°C) to values over the full operating temperature range.

Spurious Free Dynamic Range (SFDR): Defined as the difference (in dBc) between the peak amplitude of the output signal and the peak spurious signal within the first Nyquist zone.

Noise Spectral Density (NSD): Defined as the difference of power (in dBc) between the output tone signal power and the noise floor of 1Hz bandwidth within the first Nyquist zone.

SERIAL INTERFACE

The serial port of the DAC3482 is a flexible serial interface which communicates with industry standard microprocessors and microcontrollers. The interface provides read/write access to all registers used to define the operating modes of DAC3482. It is compatible with most synchronous transfer formats and can be configured as a 3 or 4 pin interface by *sif4_ena* in register *config2*. In both configurations, SCLK is the serial interface input clock and SDENB is serial interface enable. For 3 pin configuration, SDIO is a bidirectional pin for both data in and data out. For 4 pin configuration, SDIO is bidirectional and SDO is data out only. Data is input into the device with the rising edge of SCLK. Data is output from the device on the falling edge of SCLK.

Each read/write operation is framed by signal SDENB (Serial Data Enable Bar) asserted low. The first frame byte is the instruction cycle which identifies the following data transfer cycle as read or write as well as the 7-bit address to be accessed. Table 1 below indicates the function of each bit in the instruction cycle and is followed by a detailed description of each bit. The data transfer cycle consists of two bytes.

Table 1. Instruction Byte of the Serial Interface

	MSB							LSB
Bit	7	6	5	4	3	2	1	0
Description	R/W	A6	A5	A4	A3	A2	A1	A0

R/W Identifies the following data transfer cycle as a read or write operation. A high indicates a read operation from DAC3482 and a low indicates a write operation to DAC3482.

[A6 : A0] Identifies the address of the register to be accessed during the read or write operation.

Figure 1 shows the serial interface timing diagram for a DAC3482 write operation. SCLK is the serial interface clock input to DAC3482. Serial data enable SDENB is an active low input to DAC3482. SDIO is serial data in. Input data to DAC3482 is clocked on the rising edges of SCLK.

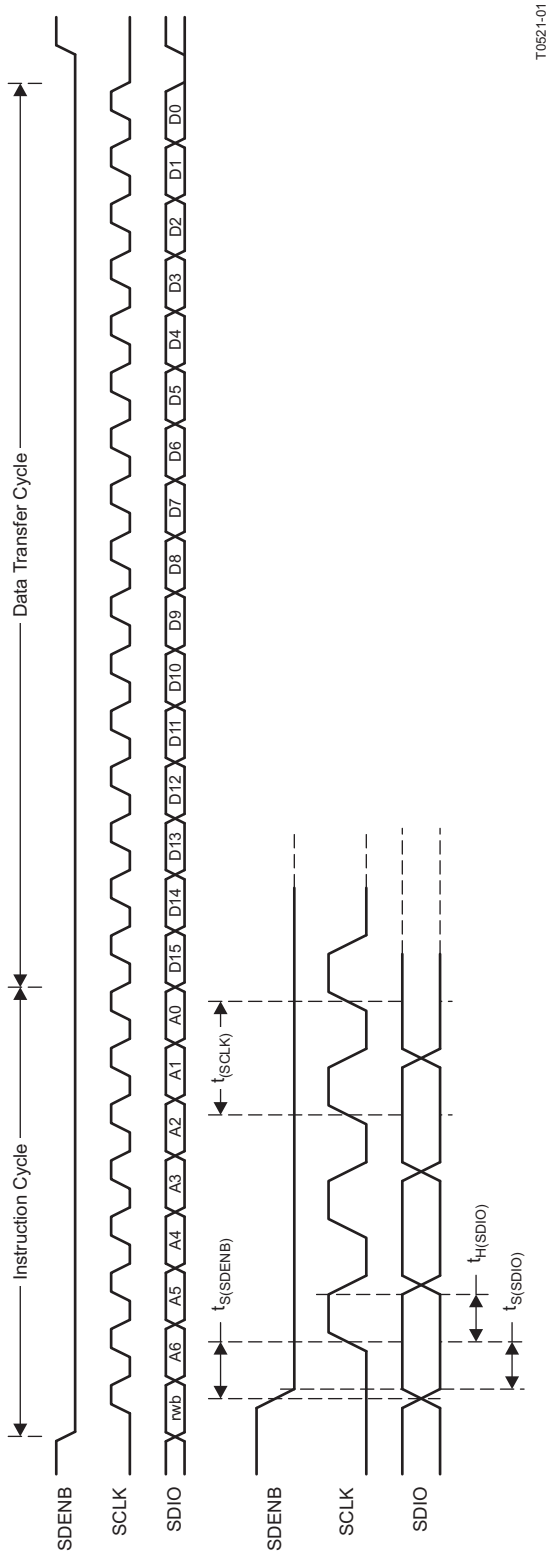

Figure 1. Serial Interface Write Timing Diagram

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Figure 2 shows the serial interface timing diagram for a DAC3482 read operation. SCLK is the serial interface clock input to DAC3482. Serial data enable SDENB is an active low input to DAC3482. SDIO is serial data in during the instruction cycle. In 3 pin configuration, SDIO is data out from the DAC3482 during the data transfer cycle, while SDO is in a high-impedance state. In 4 pin configuration, both SDIO and SDO are data out from the DAC3482 during the data transfer cycle. At the end of the data transfer, SDIO and SDO will output low on the final falling edge of SCLK until the rising edge of SDENB when they will 3-state.

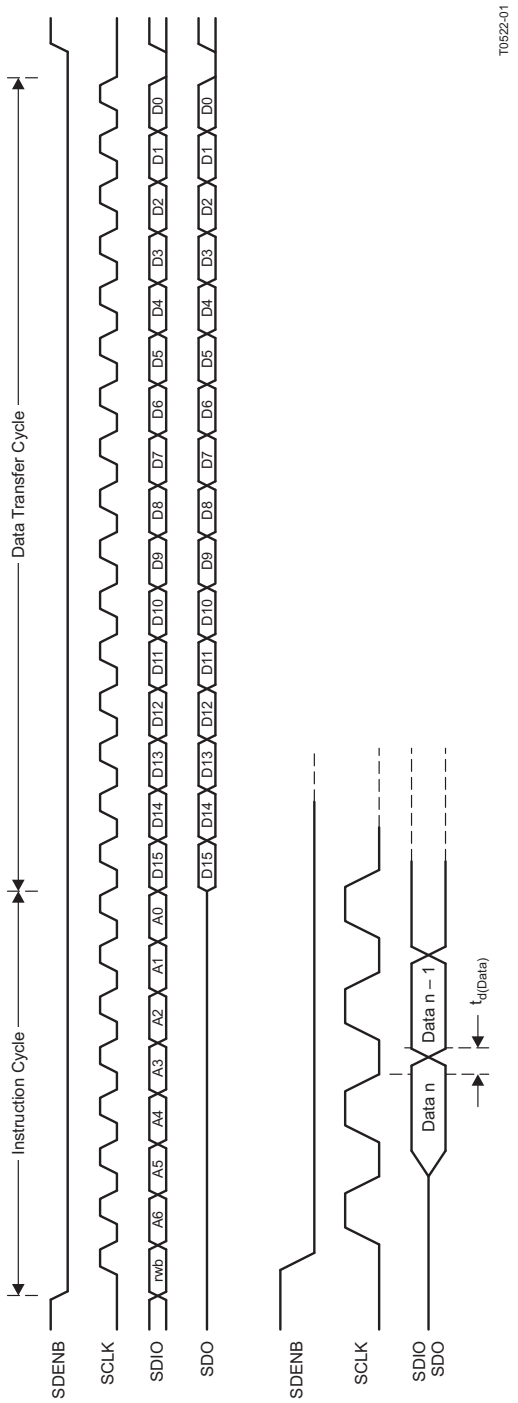

Figure 2. Serial Interface Read Timing Diagram

Table 2. Register Map

Name	Address	Default	(MSB) Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	(LSB) Bit 0
config0	0x00	0x049C	qmc_offset_ena	reserved	qmc_corr_ena	reserved	interp(3:0)				fifo_ena	reserved	reserved	alarm_out_ena	alarm_out pol	clkdiv_sync_ena	invsinc_ena	reserved
config1	0x01	0x050E	iotest_ena	reserved	reserved	64cnt_ena	oddeven_parity	word_parity_ena	frame_parity_ena	reserved	reserved	dacI_complement	dacQ_complement	reserved	alarm_2away_ena	alarm_1away_ena	alarm_collision_ena	reserved
config2	0x02	0x7000	16bit_in	dacclk gone_ena	dataclk gone_ena	collision_gone_ena	clkmon sync_ ena	reserved	reserved	reserved	sif4_ena	mixer_ena	mixer_gain	nco_ena	revbus	reserved	twos	reserved
config3	0x03	0xF000	coarse_dac(3:0)				reserved				reserved							sif_txenable
config4	0x04	NA	iotest_results(15:0)															
config5	0x05	0x0000	alarm_from_zerochk	reserved	alarms_from_fifo(2:0)			alarm_dacclk_gone	alarm_dataclk_gone	clock_gone	alarm_from _iotest	reserved	alarm_from_pll	alarm_rparity	alarm_fparity	alarm_frame_parity	reserved	reserved
config6	0x06	NA	tempdata(7:0)								reserved						reserved	reserved
config7	0x07	0xFFFF	alarms_mask(15:0)															
config8	0x08	0x0000	reserved	reserved	reserved	qmc_offsetI(12:0)												
config9	0x09	0x8000	fifo_offset(2:0)			qmc_offsetQ(12:0)												
config10	0x0A	0x0000	reserved	reserved	reserved	reserved												
config11	0x0B	0x0000	reserved	reserved	reserved	reserved												
config12	0x0C	0x0400	reserved	reserved	reserved	reserved	reserved	qmc_gainI(10:0)										
config13	0x0D	0x0400	cmix(3:0)				reserved	qmc_gainQ(10:0)										
config14	0x0E	0x0400	reserved	reserved	reserved	reserved	reserved	reserved										
config15	0x0F	0x0400	output_delay (1:0)		reserved		reserved	reserved										
config16	0x10	0x0000	reserved	reserved	reserved	reserved	qmc_phase(11:0)											
config17	0x11	0x0000	reserved	reserved	reserved	reserved	reserved											
config18	0x12	0x0000	phase_offset(15:0)															
config19	0x13	0x0000	reserved															
config20	0x14	0x0000	phase_add(15:0)															
config21	0x15	0x0000	phase_add(31:16)															
config22	0x16	0x0000	reserved															
config23	0x17	0x0000	reserved															
config24	0x18	NA	reserved			pll_reset	pll_ndivsync_ena	pll_ena	reserved		pll_cp(1:0)		pll_p(2:0)			pll_lfvolt(2:0)		
config25	0x19	0x0440	pll_m(7:0)								pll_n(3:0)				pll_vcoitune(2:0)		reserved	
config26	0x1A	0x0020	pll_vco(5:0)						reserved	reserved	bias_sleep	tsense_sleep	pll_sleep	clkrecv_sleep	reserved	reserved	reserved	reserved
config27	0x1B	0x0000	extref_ena	reserved	reserved	reserved	reserved	reserved	reserved	reserved	reserved	reserved	reserved					
config28	0x1C	0x0000	reserved								reserved							
config29	0x1D	0x0000	reserved								reserved							
config30	0x1E	0x1111	syncsel_qmoffset(4:0)				reserved				syncsel_qmcorr(4:0)				reserved			
config31	0x1F	0x1140	syncsel_mixer(4:0)				reserved				syncsel_nco(4:0)				syncsel_dataformatter		sif_sync	reserved

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Table 2. Register Map (continued)

Name	Address	Default	(MSB) Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8	Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	(LSB) Bit 0
config32	0x20	0x2400	syncsel_fifoin(4:0)				syncsel_fifoout(4:0)				reserved							clkdiv_ sync_sel
config33	0x21	0x0000	reserved															
config34	0x22	0x1B1B	reserved		reserved		reserved		reserved		reserved		reserved		reserved		reserved	
config35	0x23	0xFFFF	sleep_cntl(15:0)															
config36	0x24	0x0000	datadly(2:0)			clkdly(2:0)			reserved									
config37	0x25	0x7A7A	iotest_pattern0															
config38	0x26	0xB6B6	iotest_pattern1															
config39	0x27	0xEAEA	iotest_pattern2															
config40	0x28	0x4545	iotest_pattern3															
config41	0x29	0x1A1A	iotest_pattern4															
config42	0x2A	0x1616	iotest_pattern5															
config43	0x2B	0xAAAA	iotest_pattern6															
config44	0x2C	0xC6C6	iotest_pattern7															
config45	0x2D	0x0004	fifoalarm_ resync	ostrtodig_ sel	ramp_ena	reserved												sifdac_ena
config46	0x2E	0x0000	reserved								grp_delayI(7:0)							
config47	0x2F	0x0000	grp_delayQ(7:0)								reserved							
config48	0x30	0x0000	sifdac(15:0)															
version	0x7F	0x5409	reserved						reserved		reserved		reserved		deviceid(1:0)		versionid(2:0)	

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REGISTER DESCRIPTIONS

Register name: config0 – Address: 0x00, Default: 0x049C

Register Name	Address	Bit	Name	Function	Default Value
config0	0x00	15	qmc_offset_ena	When set, the digital Quadrature Modulator Correction (QMC) offset correction is enabled.	0
		14	Reserved	Reserved for factory use.	0
		13	qmc_corr_ena	When set, the QMC phase and gain correction circuitry is enabled.	0
		12	Reserved	Reserved for factory use.	0
		11:8	interp(3:0)	These bits define the interpolation factor **interp** / **Interpolation Factor** 0000 / 1x 0001 / 2x 0010 / 4x 0100 / 8x 1000 / 16x	0100
		7	fifo_ena	When set, the FIFO is enabled. **When the FIFO is disabled DACCCLKP/N and DATACLKP/N must be aligned to within $t_{(align)}$ (not recommended).**	1
		6	Reserved	Reserved for factory use.	0
		5	Reserved	Reserved for factory use.	0
		4	alarm_out_ena	When set, the ALARM pin becomes an output. When cleared, the ALARM pin is 3-stated.	1
		3	alarm_out_pol	This bit changes the polarity of the ALARM signal. 0: Negative logic 1: Positive logic	1
		2	clkdiv_sync_ena	When set, enables the syncing of the clock divider using the sync source selected by register *config19*. The internal divided-down clocks will be phase aligned after syncing. Setting to “0” after the DAC is initialized is recommended.	1
		1	invsinc_ena	When set, the inverse sinc filter is enabled.	0
		0	Reserved	Reserved for factory use.	0

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Register name: config1 – Address: 0x01, Default: 0x050E

Register Name	Address	Bit	Name	Function	Default Value
config1	0x01	15	iotest_ena	When set, enables the data pattern checker test. ***The outputs are deactivated regardless of the state of TXENABLE and sif_txenable.***	0
		14	Reserved	Reserved for factory use.	0
		13	Reserved	Reserved for factory use.	0
		12	64cnt_ena	When set, enables resetting of the alarms after 64 good samples with the goal of removing unnecessary errors. For instance, when checking setup/hold through the pattern checker test, there may initially be errors. Setting this bit removes the need for a SIF write to clear the alarm register.	0
		11	oddeven_parity	Selects between odd and even parity check 0: Even parity 1: Odd parity	0
		10	word_parity_ena	When set, enables parity checking of each input word using the PARITYP/N parity input. It should match the **oddeven_parity** register setting.	1
		9	frame_parity_ena	When set, enables parity checking using the FRAME signal to source the parity bit.	0
		8	Reserved	Reserved for factory use. **Note: Default value is '1'. Must be set to '0' for proper operation**	1
		7	Reserved	Reserved for factory use.	0
		6	dacI_complement	When set, the DACI output is complemented. This allows to effectively change the + and – designations of the LVDS data lines.	0
		5	dacQ_complement	When set, the DACQ output is complemented. This allows to effectively change the + and – designations of the LVDS data lines.	0
		4	Reserved	Reserved for factory use.	0
		3	alarm_2away_ena	When set, the alarm from the FIFO indicating the write and read pointers being 2 away is enabled.	1
		2	alarm_1away_ena	When set, the alarm from the FIFO indicating the write and read pointers being 1 away is enabled.	1
		1	alarm_collision_ena	When set, the alarm from the FIFO indicating a collision between the write and read pointers is enabled.	1
		0	Reserved	Reserved for factory use.	0

Register name: config2 – Address: 0x02, Default: 0x7000

Register Name	Address	Bit	Name	Function	Default Value
config2	0x02	15	16bit_in	When set, the input interface is set to word-wide mode. When cleared, the input interface is set to byte-wide mode.	0
		14	dacclkgone_ena	When set, the DACCLK-gone signal from the clock monitor circuit can be used to shut off the DAC outputs.	1
		13	dataclkgone_ena	When set, the DATACLK-gone signal from the clock monitor circuit can be used to shut off the DAC outputs.	1
		12	collisiongone_ena	When set, the FIFO collision alarms can be used to shut off the DAC outputs.	1
		11	clkmonsync_ena	When set, the clock monitor circuit is synced with every rising edge of the syncs chosen for the FIFO read and write pointers. See config32.	0
		10	Reserved	Reserved for factory use.	0
		9	Reserved	Reserved for factory use.	0
		8	Reserved	Reserved for factory use.	0
		7	sif4_ena	When set, the serial interface (SIF) is a 4 bit interface, otherwise it is a 3 bit interface.	0
		6	mixer_ena	When set, the mixer block is enabled.	0
		5	mixer_gain	When set, a 6dB gain is added to the mixer output.	0
		4	nco_ena	When set, the NCO is enabled. This is not required for coarse mixing.	0
		3	revbus	When set, the input bits for the data bus are reversed. MSB becomes LSB.	0
		2	Reserved	Reserved for factory use.	0
		1	twos	When set, the input data format is expected to be 2's complement. When cleared, the input is expected to be offset-binary.	0
		0	Reserved	Reserved for factory use.	0

Register name: config3 – Address: 0x03, Default: 0xF000

Register Name	Address	Bit	Name	Function	Default Value
config3	0x03	15:12	coarse_dac(3:0)	Scales the output current in 16 equal steps. $I_{FS} = \frac{V_{EXTIO}}{R_{BIAS}} \times 2 \times (\text{coarse\_dac} + 1)$	1111
		11:8	Reserved	Reserved for factory use.	0000
		7:1	Reserved	Reserved for factory use.	0000000
		0	sif_txenable	When set, the internal value of TXENABLE is set to "1". To enable analog output data transmission, set *sif_txenable* to "1" **or** pull CMOS TXENABLE pin (A32) to high. To disable analog output, set *sif_txenable* to "0" **and** pull CMOS TXENABLE pin (A32) to low.	0

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Register name: config4 – Address: 0x04, Default: No RESET Value (WRITE TO CLEAR)

Register Name	Address	Bit	Name	Function	Default Value
config4	0x04	15:0	iotest_results(15:0)	This register is used with pattern checker test enabled (*iotest_ena* in *config1*, *bit<15>* set to "1"). It does not have a default RESET value. The values of these bits tell which bit in the word failed during the pattern checker test. iotest_results(15:8) correspond to the data bits on D[15:8] and iotest_results(7:0) correspond to the data bits on D[7:0].	No RESET Value

Register name: config5 – Address: 0x05, Default: 0x0000 (WRITE TO CLEAR)

Register Name	Address	Bit	Name	Function	Default Value
config5	0x05	15	alarm_from_zerochk	Alarm indicating the FIFO write pointer has an all zeros pattern in it. Since this pointer is a shift register, all zeros will cause the input point to be stuck until the next sync. This alarm allows checking for this condition. This alarm indicates that another sync is necessary to restart the FIFO pointer	0
		14	Reserved	Reserved for factory use.	0
		13:11	alarms_from_fifo(2:0)	Alarm indicating FIFO pointer collisions and nearness: 000: All fine 001: Pointers are 2 away 01x: Pointers are 1 away 1xx: FIFO pointer collision If the FIFO pointer collision alarm is set when *collisiongone_ena* is enabled, the FIFO must be re-synchronized and the bits must be cleared to resume normal operation.	000
		10	alarm_dacclk_gone	Alarm indicating the DACCLK has been stopped. If the bit is set when *dacclkgone_ena* is enabled, the DACCLK must resume and the bit must be cleared to resume normal operation.	0
		9	alarm_dataclk_gone	If the bit is set when *dataclkgone_ena* is enabled, the DATACLK must resume and the bit must be cleared to resume normal operation.	0
		8	clock_gone	Alarm indicating either *alarm_daclk_gone* or *alarm_dataclk_gone* are asserted. It controls the output. When high it will output "0x8000" for each output connected to the DAC. If the bit is set when *dacclkgone_ena* and/or *dataclkgone_ena* are enabled, the DACCLK and/or the DATACLK must resume and the bit must be cleared to resume normal operation.	0
		7	alarm_from_iotest	Alarm indicating the input data pattern does not match the pattern in the iotest_pattern registers.	0
		6	Reserved	Reserved for factory use.	0
		5	alarm_from_pll	Alarm indicating the PLL has lost lock.	0
		4	alarm_rparity	Alarm indicating a parity error on data captured on the rising edge of DATACLKP/N.	0
		3	alarm_fparity	Alarm indicating a parity error on data captured on the falling edge of DATACLKP/N.	0
		2	alarm_frame_parity	Alarm indicating a parity error when using the FRAME as parity bit.	0
		1	Reserved	Reserved for factory use.	0
		0	Reserved	Reserved for factory use.	0

Register name: config6 – Address: 0x06, Default: No RESET Value (READ ONLY)

Register Name	Address	Bit	Name	Function	Default Value
config6	0x06	15:8	tempdata(7:0)	This is the output from the chip temperature sensor. The value of this register in two's complement format represents the temperature in degrees Celsius. **This register must be read with a minimum SCLK period of 1µs.**	No RESET Value
		7:2	Reserved	Reserved for factory use.	000000
		1	Reserved	Reserved for factory use.	0
		0	Reserved	Reserved for factory use.	0

Register name: config7 – Address: 0x07, Default: 0xFFFF

Register Name	Address	Bit	Name	Function		Default Value
config7	0x07	15:0	alarms_mask(15:0)	These bits control the masking of the alarms. (0=not masked, 1= masked)		0xFFFF
				alarm_mask	**Alarm that is Masked**	
				15	alarm_from_zerochk	
				14	not used	
				13	alarm_fifo_collision	
				12	alarm_fifo_1away	
				11	alarm_fifo_2away	
				10	alarm_dacclk_gone	
				9	alarm_dataclk_gone	
				8	alarm_output_gone	
				7	alarm_from_iotest	
				6	not used	
				5	alarm_from_pll	
				4	alarm_rparity	
				3	alarm_lparity	
				2	alarm_frame_parity	
				1	not used	
				0	not used	

Register name: config8 – Address: 0x08, Default: 0x0000 (CAUSES AUTO-SYNC)

Register Name	Address	Bit	Name	Function	Default Value
config8	0x08	15	Reserved	Reserved for factory use.	0
		14	Reserved	Reserved for factory use.	0
		13	Reserved	Reserved for factory use.	0
		12:0	qmc_offsetI(12:0)	DACI offset correction. The offset is measured in DAC LSBs. **If enabled in *config30* writing to this register causes an auto-sync to be generated. This loads the values of the QMC offset registers *(config8-config9)* into the offset block at the same time. When updating the offset values *config8* should be written last. Programming *config9* will not affect the offset setting.**	All zeros

Register name: config9 – Address: 0x09, Default: 0x8000

Register Name	Address	Bit	Name	Function	Default Value
config9	0x09	15:13	fifo_offset(2:0)	When the sync to the FIFO occurs, this is the value loaded into the FIFO read pointer. With this value the initial difference between write and read pointers can be controlled. This may be helpful in syncing multiple chips or controlling the delay through the device.	100
		12:0	qmc_offsetQ(12:0)	DACQ offset correction. The offset is measured in DAC LSBs.	All zeros

Register name: config10 – Address: 0x0A, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config10	0x0A	15	Reserved	Reserved for factory use.	0
		14	Reserved	Reserved for factory use.	0
		13	Reserved	Reserved for factory use.	0
		12:0	Reserved	Reserved for factory use.	All zeros

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Register name: config11 – Address: 0x0B, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config10	0x0A	15	Reserved	Reserved for factory use.	0
		14	Reserved	Reserved for factory use.	0
		13	Reserved	Reserved for factory use.	0
		12:0	Reserved	Reserved for factory use.	All zeros

Register name: config12 – Address: 0x0C, Default: 0x0400

Register Name	Address	Bit	Name	Function	Default Value
config12	0x0C	15	Reserved	Reserved for factory use.	0
		14	Reserved	Reserved for factory use.	0
		13	Reserved	Reserved for factory use.	0
		12	Reserved	Reserved for factory use.	0
		11	Reserved	Reserved for factory use.	0
		10:0	qmc_gainI(10:0)	QMC gain for DACI. The full 11-bit qmc_gainI(10:0) word is formatted as UNSIGNED with a range of 0 to 1.9990. The implied decimal point for the multiplication is between bit 9 and bit 10.	10000000 000

Register name: config13 – Address: 0x0D, Default: 0x0400

Register Name	Address	Bit	Name	Function	Default Value
config13	0x0D	15	cmix_mode(3:0)	Sets the mixing function of the coarse mixer. Bit 0: -Fs/4 mixer Bit 1: Fs/2 mixer Bit 2: Fs/4 mixer Bit 3: Fs/8 mixer The various mixers can be combined together to obtain a ±n×Fs/8 total mixing factor.	0000
		11	Reserved	Reserved for factory use.	0
		10:0	qmc_gainQ(10:0)	QMC gain for DACQ. The full 11-bit qmc_gainb(10:0) word is formatted as UNSIGNED with a range of 0 to 1.9990. The implied decimal point for the multiplication is between bit 9 and bit 10.	10000000 000

Register name: config14 – Address: 0x0E, Default: 0x0400

Register Name	Address	Bit	Name	Function	Default Value
config14	0x0E	15	Reserved	Reserved for factory use.	0
		14	Reserved	Reserved for factory use.	0
		13	Reserved	Reserved for factory use.	0
		12	Reserved	Reserved for factory use.	0
		11	Reserved	Reserved for factory use.	0
		10:0	Reserved	Reserved for factory use.	10000000 000

Register name: config15 – Address: 0x0F, Default: 0x0400

Register Name	Address	Bit	Name	Function	Default Value
config15	0x0F	15:14	output_ delay(1:0)	Delays the DAC outputs from 0 to 3 DAC clock cycles.	00
		13:12	Reserved	Reserved for factory use.	00
		11	Reserved	Reserved for factory use.	0
		10:0	Reserved	Reserved for factory use.	10000000 000

Register name: config16 – Address: 0x10, Default: 0x0000 (CAUSES AUTO-SYNC)

Register Name	Address	Bit	Name	Function	Default Value
config16	0x10	15	Reserved	Reserved for factory use.	0
		14	Reserved	Reserved for factory use.	0
		13	Reserved	Reserved for factory use. **Note: Default value is '0'. Must be set to '1' for proper operation**	0
		12	Reserved	Reserved for factory use. **Note: Default value is '0'. Must be set to '1' for proper operation**	0
		11:0	qmc_phase(11:0)	QMC correction phase. The 12-bit qmc_phase(11:0) word is formatted as two's complement and scaled to occupy a range of -0.5 to 0.49975 and a default phase correction of 0.00. To accomplish QMC phase correction, this value is multiplied by the current B sample, then summed into the A sample. **If enabled in *config30* writing to this register causes an auto-sync to be generated. This loads the values of the QMC offset registers *(config12, config13, and config16)* into the QMC block at the same time. When updating the QMC values *config16* should be written last. Programming *config12 and config13* will not affect the QMC settings.**	All zeros

Register name: config17 – Address: 0x11, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config17	0x11	15	Reserved	Reserved for factory use.	0
		14	Reserved	Reserved for factory use.	0
		13	Reserved	Reserved for factory use.	0
		12	Reserved	Reserved for factory use.	0
		11:0	Reserved	Reserved for factory use.	All zeros

Register name: config18 – Address: 0x12, Default: 0x0000 (CAUSES AUTO-SYNC)

Register Name	Address	Bit	Name	Function	Default Value
config18	0x12	15:0	phase_offset(15:0)	Phase offset added to the NCO accumulator before the generation of the SIN and COS values. The phase offset is added to the upper 16 bits of the NCO accumulator results and these 16 bits are used in the sin/cos lookup tables. **If enabled in *config31* writing to this register causes an auto-sync to be generated. This loads the values of the Qfine mixer block registers *(config18, config20, and config21)* at the same time. When updating the mixer values the *config18* should be written last. Programming *config20 and config21* will not affect the mixer settings.**	0x0000

Register name: config19 – Address: 0x13, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config19	0x13	15:0	Reserved	Reserved for factory use.	0x0000

Register name: config20 – Address: 0x14, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config20	0x14	15:0	phase_ add(15:0)	The phase_add(15:0) value is used to determine the NCO frequency. The two's complement formatted value can be positive or negative. Each LSB represents Fs/(2^32) frequency step.	0x0000

Register name: config21 – Address: 0x15, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config21	0x15	15:0	phase_ add(31:16)	See *config20* above.	0x0000

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Register name: config22 – Address: 0x16, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config22	0x16	15:0	Reserved	Reserved for factory use.	0x0000

Register name: config23 – Address: 0x17, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config23	0x17	15:0	Reserved	Reserved for factory use.	0x0000

Register name: config24 – Address: 0x18, Default: NA

Register Name	Address	Bit	Name	Function	Default Value
config24	0x18	15:13	Reserved	Reserved for factory use.	001
		12	pll_reset	When set, the PLL loop filter (LPF) is pulled down to 0V. Toggle from '1' to '0' to restart the PLL if an over-speed lock-up occurs. Over-speed can happen when the process is fast, the supplies are higher than nominal, etc. resulting in the feedback dividers missing a clock.	0
		11	pll_ndivsync_ena	When set, the LVDS SYNC input is used to sync the PLL N dividers.	1
		10	pll_ena	When set, the PLL is enabled. When cleared, the PLL is bypassed.	0
		9:8	Reserved	Reserved for factory use.	00
		7:6	pll_cp(1:0)	PLL pump charge select 00: No charge pump 01: Single pump charge 10: Not used 11: Dual pump charge	00
		5:3	pll_p(2:0)	PLL pre-scaler dividing module control. 010: 2 011: 3 100: 4 101: 5 110: 6 111: 7 000: 8	001
		2:0	pll_lfvolt(2:0)	PLL loop filter voltage. Read only bits.	NA

Register name: config25 – Address: 0x19, Default: 0x0440

Register Name	Address	Bit	Name	Function	Default Value
config25	0x19	15:8	pll_m(7:0)	M portion of the M/N divider of the PLL. If pll_m<7> = 0, the M divider value has the range of pll_m<6:0>, spanning from 4 to 127. (i.e. 0, 1, 2, and 3 are not valid.) If pll_m<7> = 1, the M divider value has the range of 2 × pll_m<6:0>, spanning from 8 to 254. (i.e. 0, 2, 4, and 6 are not valid. M divider has even value only.)	00000100
		7:4	pll_n(3:0)	N portion of the M/N divider of the PLL. (0000=1, 1111=16)	0100
		3:2	pll_vcoitune(1:0)	PLL VCO bias tuning bits.	00
		1:0	Reserved	Reserved for factory use.	00

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Register name: config26 – Address: 0x1A, Default: 0x0020

Register Name	Address	Bit	Name	Function	Default Value
config26	0x1A	15:10	pll_vco(6:0)	VCO frequency coarse tuning bits.	000000
		9	Reserved	Reserved for factory use.	0
		8	Reserved	Reserved for factory use.	0
		7	bias_sleep	When set, the bias amplifier is put into sleep mode.	0
		6	tsense_sleep	Turns off the temperature sensor when asserted.	0
		5	pll_sleep	When set, the PLL is put into sleep mode.	1
		4	clkrecv_sleep	When asserted the clock input receiver gets put into sleep mode. This affects the OSTR receiver as well.	0
		3	Reserved	Reserved for factory use.	0
		2	Reserved	Reserved for factory use.	0
		1	Reserved	Reserved for factory use.	0
		0	Reserved	Reserved for factory use.	0

Register name: config27 – Address: 0x1B, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config27	0x1B	15	extref_ena	Allows the device to use an external reference or the internal reference. 0: Internal reference 1: External reference	0
		14	Reserved	Reserved for factory use.	0
		13	Reserved	Reserved for factory use.	0
		12	Reserved	Reserved for factory use.	0
		11	Reserved	Reserved for factory use. **Note: Default value is '0'. Must be set to '1' for proper operation**	0
		10	Reserved	Reserved for factory use.	0
		9	Reserved	Reserved for factory use.	0
		8	Reserved	Reserved for factory use.	0
		7	Reserved	Reserved for factory use.	0
		6	Reserved	Reserved for factory use.	0
		5:0	Reserved	Reserved for factory use.	000000

Register name: config28 – Address: 0x1C, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config28	0x1C	15:8	Reserved	Reserved for factory use.	0x00
		7:0	Reserved	Reserved for factory use.	0x00

Register name: config29 – Address: 0x1D, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config29	0x1D	15:8	Reserved	Reserved for factory use.	0x00
		7:0	Reserved	Reserved for factory use.	0x00

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Register name: config30 – Address: 0x1E, Default: 0x1111

Register Name	Address	Bit	Name	Function	Default Value
config30	0x1E	15:12	syncsel_qmoffset(4:0)	Selects the syncing source(s) of the double buffered QMC offset registers. A '1' in the bit enables the signal as a sync source. More than one sync source is permitted. Bit 0: Auto-sync from register write Bit 1: OSTR Bit 2: SYNC from FIFO output Bit 3: sif_sync (via *config31*)	0001
		11:8	Reserved	Reserved for factory use.	0001
		7:4	syncsel_qmcorr(4:0)	Selects the syncing source(s) of the double buffered QMC correction registers. A '1' in the bit enables the signal as a sync source. More than one sync source is permitted. Bit 0: Auto-sync from register write Bit 1: OSTR Bit 2: SYNC from FIFO output Bit 3: sif_sync (via *config31*)	0001
		3:0	Reserved	Reserved for factory use.	0001

Register name: config31 – Address: 0x1F, Default: 0x1140

Register Name	Address	Bit	Name	Function	Default Value
config31	0x1F	15:12	syncsel_mixer(4:0)	Selects the syncing source(s) of the double buffered mixer registers. A '1' in the bit enables the signal as a sync source. More than one sync source is permitted. Bit 0: Auto-sync from register write Bit 1: OSTR Bit 2: SYNC from FIFO output Bit 3: sif_sync (via *config31*)	0001
		11:8	Reserved	Reserved for factory use.	0001
		7:4	syncsel_nco(4:0)	Selects the syncing source(s) of the two NCO accumulators. A '1' in the bit enables the signal as a sync source. More than one sync source is permitted. Bit 0: FRAME from FIFO output Bit 1: OSTR Bit 2: SYNC from FIFO output Bit 3: sif_sync (via *config31*)	0100
		3:2	syncsel_dataformatter	Selects the syncing source of the data formatter. Unlike the other syncs only one sync source is allowed. 00: FRAME from LVDS receivers 01: SYNC from LVDS receivers 10: No sync 11: No sync	00
		1	sif_sync	SIF created sync signal. Set to '1' to cause a sync and then clear to '0' to remove it.	0
		0	Reserved	Reserved for factory use.	0

Register name: config32 – Address: 0x20, Default: 0x2400

Register Name	Address	Bit	Name	Function	Default Value
config32	0x20	15:12	syncsel_fifoin(4:0)	Selects the syncing source(s) of the FIFO input side. A '1' in the bit enables the signal as a sync source. More than one sync source is permitted. Bit 0: SYNC from the data formatter block Bit 1: FRAME from the data formatter block Bit 2: Always zero Bit 3: sif_sync (via *config31*) – not recommended	0010
		11:8	syncsel_fifoout(4:0)	Selects the syncing source(s) of the FIFO output side. A '1' in the bit enables the signal as a sync source. More than one sync source is permitted. Bit 0: SYNC from the data formatter block – Single Sync Source mode Bit 1: FRAME from the data formatter block –Single Sync Source mode Bit 2: OSTR – Dual Sync Source Mode Bit 3: sif_sync (via *config31*) – not recommended	0100
		7:1	Reserved	Reserved for factory use.	0000
		0	clkdiv_sync_sel	Selects the signal source for clock divider synchronization. **multi_sync_sel** – **Sync Source** 0 – OSTR 1 – FRAME or SYNC, based on syncsel_fifoin source selection (config32, bit<15:12>)	0

Register name: config33 – Address: 0x21, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config33	0x21	15:0	Reserved	Reserved for factory use.	0x0000

Register name: config34 – Address: 0x22, Default: 0x1B1B

Register Name	Address	Bit	Name	Function	Default Value
config34	0x22	15:14	Reserved	Reserved for factory use.	00
		13:12	Reserved	Reserved for factory use.	01
		11:10	Reserved	Reserved for factory use.	10
		9:8	Reserved	Reserved for factory use.	11
		7:6	Reserved	Reserved for factory use.	00
		5:4	Reserved	Reserved for factory use.	01
		3:2	Reserved	Reserved for factory use.	10
		1:0	Reserved	Reserved for factory use.	11

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Register name: config35 – Address: 0x23, Default: 0xFFFF

Register Name	Address	Bit	Name	Function	Default Value
config35	0x23	15:0	sleep_cntl(15:0)	Controls the routing of the CMOS SLEEP signal (pin B40) to different blocks. When a bit is set, the SLEEP signal will be sent to the corresponding block. These bits do not override the SIF bits in register *config26*.	0xFFFF

sleep_cntl(bit)	Function
15	reserved
14	DACI sleep
13	DACQ sleep
12	reserved
11	Clock receiver sleep
10	PLL sleep
9	LVDS data sleep
8	LVDS control sleep
7	Temp sensor sleep
6	reserved
5	Bias amplifier sleep
All others	not used

Register name: config36 – Address: 0x24, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config36	0x24	15:13	datadly(2:0)	Controls the delay of the data inputs through the LVDS receivers. Each LSB addsapproximately 40 ps 0: Minimum	000
		12:10	clkdly(2:0)	Controls the delay of the data clock through the LVDS receivers. Each LSB adds approximately 40 ps 0: Minimum	000
		9:0	Reserved	Reserved for factory use.	0x000

Register name: config37 – Address: 0x25, Default: 0x7A7A

Register Name	Address	Bit	Name	Function	Default Value
config37	0x25	15:0	iotest_pattern0	Dataword0 in the IO test pattern. It is used with the seven other words to test the input data. At the start of the IO test pattern, this word should be aligned with rising edge of FRAME or SYNC signal to indicate sample 0.	0x7A7A

Register name: config38 – Address: 0x26, Default: 0xB6B6

Register Name	Address	Bit	Name	Function	Default Value
config38	0x26	15:0	iotest_pattern1	Dataword1 in the IO test pattern. It is used with the seven other words to test the input data.	0xB6B6

Register name: config39 – Address: 0x27, Default: 0xEAEA

Register Name	Address	Bit	Name	Function	Default Value
config39	0x27	15:0	iotest_pattern2	Dataword2 in the IO test pattern. It is used with the seven other words to test the input data.	0xEAEA

Register name: config40 – Address: 0x28, Default: 0x4545

Register Name	Address	Bit	Name	Function	Default Value
config40	0x28	15:0	iotest_pattern3	Dataword3 in the IO test pattern. It is used with the seven other words to test the input data.	0x4545

Register name: config41 – Address: 0x29, Default: 0x1A1A

Register Name	Address	Bit	Name	Function	Default Value
config41	0x29	15:0	iotest_pattern4	Dataword4 in the IO test pattern. It is used with the seven other words to test the input data.	0x1A1A

Register name: config42 – Address: 0x2A, Default: 0x1616

Register Name	Address	Bit	Name	Function	Default Value
config42	0x2A	15:0	iotest_pattern5	Dataword5 in the IO test pattern. It is used with the seven other words to test the input data.	0x1616

Register name: config43 – Address: 0x2B, Default: 0xAAAA

Register Name	Address	Bit	Name	Function	Default Value
config43	0x2B	15:0	iotest_pattern6	Dataword6 in the IO test pattern. It is used with the seven other words to test the input data.	0xAAAA

Register name: config44 – Address: 0x2C, Default: 0xC6C6

Register Name	Address	Bit	Name	Function	Default Value
config44	0x2C	15:0	iotest_pattern7	Dataword7 in the IO test pattern. It is used with the seven other words to test the input data.	0xC6C6

Register name: config45 – Address: 0x2D, Default: 0x0004

Register Name	Address	Bit	Name	Function	Default Value
config45	0x2D	15	fifoalarm_resync	When set, the FIFO gets re-synced automatically when a collision alarm occurs.	0
		14	ostrtodig_sel	When set, the OSTR signal is passed directly to the digital block. This is the signal that is used to clock the dividers.	0
		13	ramp_ena	When set, a ramp signal is inserted in the input data at the FIFO input.	0
		12:1	Reserved	Reserved for factory use.	0x0004
		0	sifdac_ena	When set, the DAC output is set to the value in sifdac(15:0) in register config48.	0

Register name: config46 – Address: 0x2E, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config46	0x2E	15:8	Reserved	Reserved for factory use.	0x00
		7:0	grp_delayI(7:0)	Sets the group delay function for DACI. The delay range is approximately 100ps.	0x00

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Register name: config47 – Address: 0x2F, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config47	0x2F	15:8	grp_delayQ(7:0)	Sets the group delay function for DACQ. The delay range is approximately 100ps.	0x00
		7:0	Reserved	Reserved for factory use.	0x00

Register name: config48 – Address: 0x30, Default: 0x0000

Register Name	Address	Bit	Name	Function	Default Value
config48	0x30	15:0	sifdac(15:0)	Value sent to the DACs when *sifdac_ena* is asserted. DATACLK must be running to latch this value into the DACs. The format would be based on *twos* in register *config2*.	0x0000

Register name: version– Address: 0x7F, Default: 0x5409 (READ ONLY)

Register Name	Address	Bit	Name	Function	Default Value
version	0x7F	15:10	Reserved	Reserved for factory use.	010101
		9	Reserved	Reserved for factory use.	0
		8:7	Reserved	Reserved for factory use.	00
		6:5	Reserved	Reserved for factory use.	00
		4:3	deviceid(1:0)	Returns ‘01’ for DAC3482.	01
		2:0	versionid(2:0)	A hardwired register that contains the version of the chip.	001

DATA INTERFACE

The DAC3482 has a 16-bit LVDS bus that accepts 16-bit I and Q data in either word-wide or byte-wide formats. In word-wide mode data is sent through a 16-bit bus while in byte-wide mode an 8-bit bus is used. The selection between the two modes is done through *16bit_in* in the *config2* register. The LVDS bus inputs in each mode are shown in Table 3.

Table 3. LVDS Bus Input Assignment

Input Mode	Pins
Word-wide	D[15..0]
Byte-wide(1)	D[7..0]

(1) The unused pins can be left floating. For word-by-word parity and IO pattern checker functionality, the pins need to have known logic values for valid functionality.

Data is sampled by the LVDS double data rate (DDR) clock DATACLK. Setup and hold requirements must be met for proper sampling.

For both input bus modes, a sync signal, either FRAME or SYNC, is required to sync the FIFO read and/or write pointers. In byte-wide mode the sync source is also used to establish the correct sample boundaries.

The sync signal, either FRAME or SYNC, can be either a pulse or a periodic signal where the sync period corresponds to multiples of 8 samples. FRAME or SYNC is sampled by a rising edge in DATACLK. The pulse-width (t_{FRAME_SYNC}) needs to be at least equal to 1/2 of the DATACLK period.

For both input bus mode, the value in FRAME sampled by the next falling edge in DATACLK can be used as a block parity value. This feature is enabled by setting *frame_parity_ena* in register *config1* to “1”. Refer to “Parity Check Test” section for more detail

WORD-WIDE FORMAT

The word-wide format is selected by setting 16bit_in to “1” in the *config2* register. In this mode the 16-bit data for channels I and Q is word-wide interleaved in the form I_0, Q_0, I_1, Q_1… into the D[15:0] 16-bit bus. Data into the DAC3482 is formatted according to the diagram shown in Figure 3 where index 0 is the data LSB and index 15 is the data MSB.

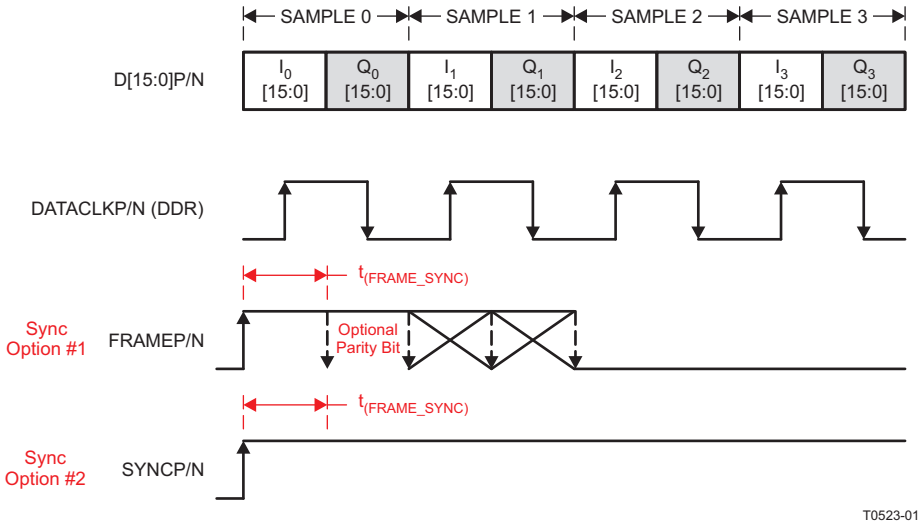

Figure 3. Word-wide Data Transmission Format

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BYTE-WIDE FORMAT

The byte-wide format is selected by setting *16bit_in* to “0” in the *config2* register. In this mode the 16-bit data for channels I and Q is byte-wide interleaved in the form I_0*[15:8], I_0*[7:0], Q_0*[15:8], Q_0*[7:0], I_1*[15:8]*… into the D[7:0] 8-bit bus. Data into the DAC3482 is formatted according to the diagram shown in Figure 4 where index 0 is the data LSB and index 15 is the data MSB. A rising edge transition of the sync signal, either FRAME or SYNC, is used to establish the correct sample boundaries.

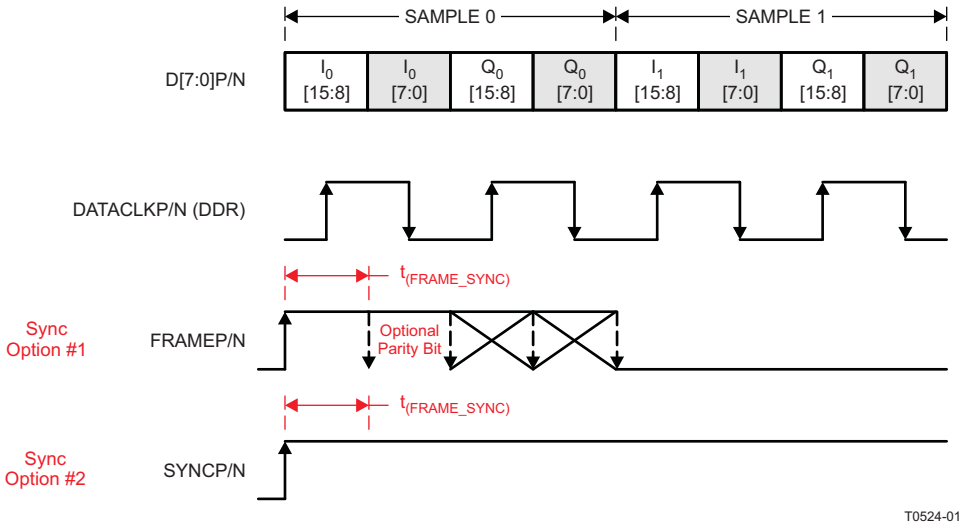

Figure 4. Byte-wide Data Transmission Format

INPUT FIFO

The DAC3482 includes a 2-channel, 16-bits wide and 8-samples deep input FIFO which acts as an elastic buffer. The purpose of the FIFO is to absorb any timing variations between the input data and the internal DAC data rate clock such as the ones resulting from clock-to-data variations from the data source.

Figure 5 shows a simplified block diagram of the FIFO.

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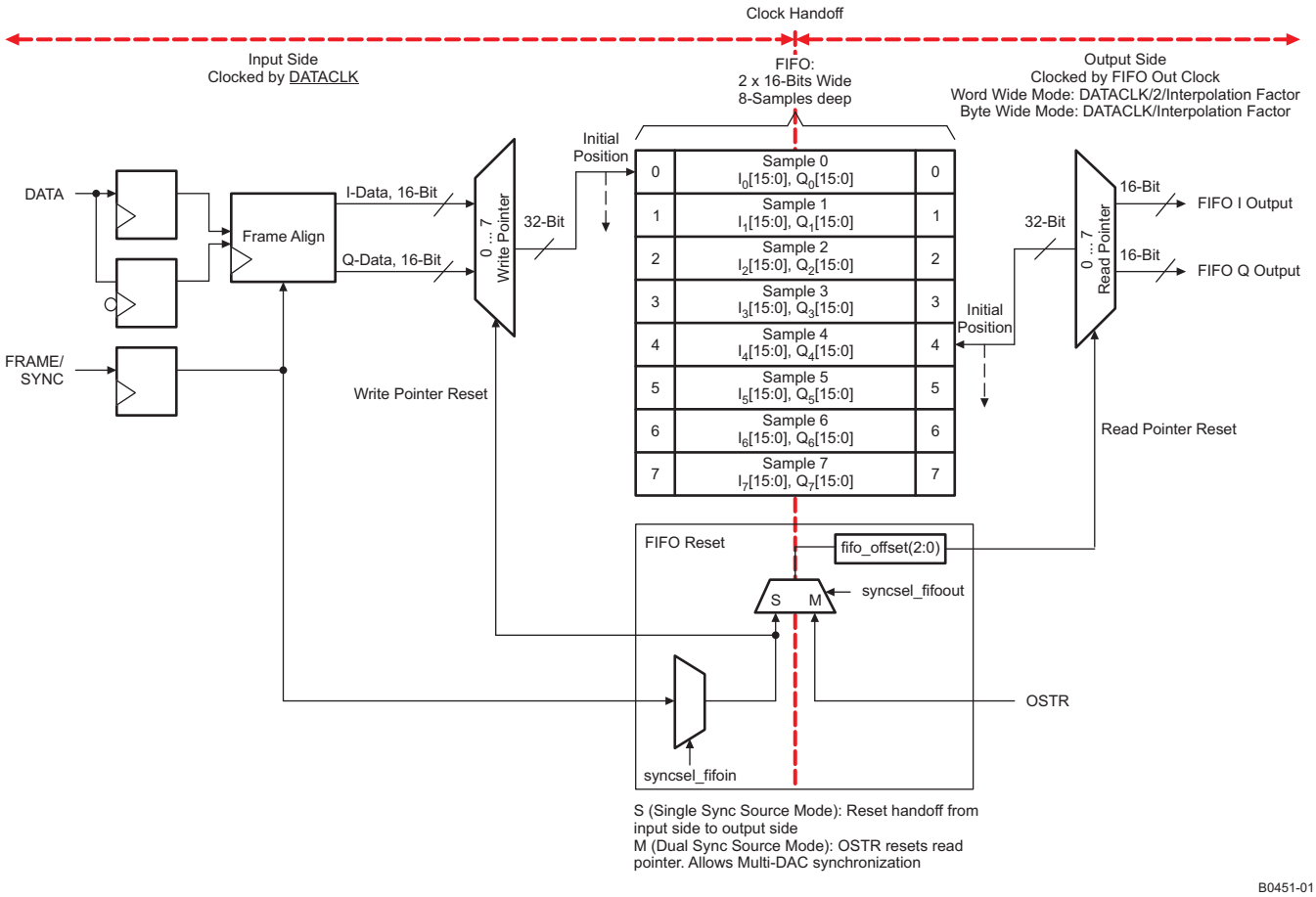

Figure 5. DAC3482 FIFO Block Diagram

Data is written to the device on the rising and falling edges of DATACLK. Each 32-bit wide sample (16-bit I-data and 16-bit Q-data) is written into the FIFO at the address indicated by the write pointer. Similarly, data from the FIFO is read by the FIFO Out Clock 32-bits at a time from the address indicated by the read pointer. The FIFO Out Clock is generated internally from the DACCLK signal. Its rate is equal to DACCLK/2/Interpolation for word-wide data transmission, or DACCLK/Interpolation for byte-wide data transmission. Each time a FIFO write or FIFO read is done the corresponding pointer moves to the next address.

The reset position for the FIFO read and write pointers is set by default to addresses 0 and 4 as shown in Figure 5. This offset gives optimal margin within the FIFO. The default read pointer location can be set to another value using *fifo_offset(2:0)* in register *config3* (address 4 by default). Under normal conditions data is written-to and read-from the FIFO at the same rate and consequently the write and read pointer gap remains constant. If the FIFO write and read rates are different, the corresponding pointers will be cycling at different speeds which could result in pointer collision. Under this condition the FIFO attempts to read and write data from the same address at the same time which will result in errors and thus must be avoided.

The write pointer sync source is selected by *syncsel_fifoin(4:0)* in register *config32*. In most applications either FRAME or SYNC is used to reset the write pointer. Unlike DATA, the sync signal is latched only on the rising edges of DATACLK. A rising edge on the sync signal source causes the pointer to return to its original position.

Similarly, the read pointer sync source is selected by *syncsel_fifoout(4:0)*. The write pointer sync source can be set to reset the read pointer as well. In this case, the read pointer is reset by an internal signal generated by recapturing the write pointer reset signal by the FIFO Out clock. This clock domain transfer (DATACLK to FIFO Out Clock) results in phase ambiguity of the reset signal. This limits the precise control of the output timing and makes full synchronization of multiple devices difficult.

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To alleviate this, the device offers the alternative of resetting the FIFO read pointer independently of the write pointer by using the OSTR signal. The OSTR signal is sampled by DACCLK and must satisfy the timing requirements in the specifications table. In order to minimize the skew it is recommended to use the same clock distribution device such as Texas Instruments CDCE62005 to provide the DACCLK and OSTR signals to all the DAC3482 devices in the system. Swapping the polarity of the DACCLK outputs with respect to the OSTR ones establishes proper phase relationship.

The FIFO pointers reset procedure can be done periodically or only once during initialization as the pointers automatically return to the initial position when the FIFO has been filled. To reset the FIFO periodically, the signals to sync the FIFO read and write pointer can repeat at multiples of 8 FIFO samples when the data interface is byte-wide format. When the data interface is word-wide format, the signal to sync the FIFO write pointer can repeat at multiples of 8 FIFO samples, and the signal to sync the FIFO read pointer can repeat at multiples of 16 FIFO samples.

The frequency limitation for FRAME and SYNC signals are the following:

$f_{sync} = f_{DATACLK}/(n \times 16)$ where n = 1, 2, … for Byte-Wide Mode

$f_{sync} = f_{DATACLK}/(n \times 8)$ where n = 1, 2, … for Word-Wide Mode where FRAME and SYNC are used to sync the FIFO write pointer only (Dual Sync Source Mode)

$f_{sync} = f_{DATACLK}/(n \times 16)$ where n = 1, 2, … for Word-Wide Mode where FRAME and SYNC are used to sync the both the FIFO read and write pointer (Single Sync Source Mode)

The frequency limitation for the OSTR signal with Dual Sync Source Mode is the following:

$f_{OSTR} = f_{DAC}/(n \times \text{interpolation} \times 8)$ where n = 1, 2, … for Byte-Wide Mode

$f_{OSTR} = f_{DAC}/(n \times \text{interpolation} \times 16)$ where n = 1, 2, … for World-Wide Mode

The frequencies above are at maximum when n = 1. This is when the FRAME, SYNC, or OSTR have a rising edge transition every 8 or 16 FIFO samples. The occurrence can be made less frequent by setting n > 1, for example, every n × 8 or n × 16 FIFO samples.

Additionally, the *fifoostrtodig_sel* in config45, bit <14> has to be enabled in Word-Wide Mode. The minimum pulse width for either f_{sync} or f_{OSTR} has to be greater than 2 x interpolation x DACCLK period.

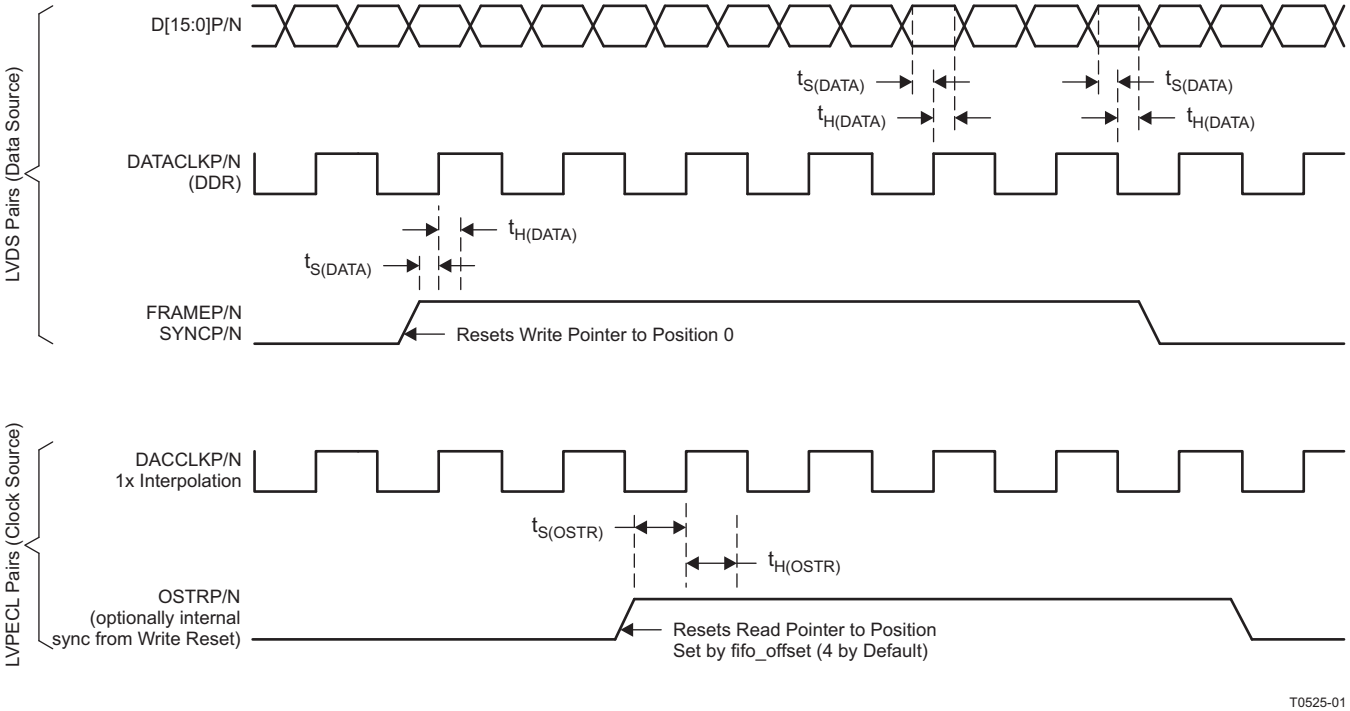

Figure 6. FIFO Write and Read Descriptions (Example Shown With Word Wide Mode)

FIFO MODES OF OPERATION

The DAC3482 input FIFO can be completely bypassed through registers *config1* and *config32*. The register configuration for each mode is described in Table 4.

Register	Control Bits
config1	fifo_ena
config32	syncsel_fifoout(4:0)

Table 4. FIFO Operation Modes

FIFO Mode	config1 and config32 FIFO Bits				
	fifo_ena	syncsel_fifoout			
		Bit 3: sif_sync	Bit 2: OSTR	Bit 1: FRAME	Bit 0: SYNC
Dual Sync Source	1	0	1	0	0
Single Sync Source	1	0	0	1 or 0 Depends on the sync source	1 or 0 Depends on the sync source
Bypass	0	X	X	X	X

DUAL SYNC SOURCE MODE

This is the recommended mode of operation for those applications that require precise control of the output timing. In Dual Sync Source mode, the FIFO write and read pointers are reset independently. The FIFO write pointer is reset using the LVDS FRAME or SYNC signal, and the FIFO read pointer is reset using the LVPECL OSTR signal. This allows LVPECL OSTR signal to control the phase of the output for either a single chip or multiple chips. Multiple devices can be fully synchronized in this mode.

SINGLE SYNC SOURCE MODE

In Single Sync Source mode, the FIFO write and read pointers are reset from the same source, either LVDS FRAME or LVDS SYNC signal. This mode has a possibility of up to 2 DAC clocks offset between the multiple DAC outputs. Applications requiring exact output timing control will need Dual Sync Source mode instead of Single Sync Source Mode.

BYPASS MODE

In FIFO bypass mode, the FIFO block is not used. As a result the input data is handed off from the DATACLK to the DACCLK domain without any compensation. In this mode the relationship between DATACLK and DACCLK ($t_{(align)}$) is critical and used as a synchronizing mechanism for the internal logic. Due to the $t_{(align)}$ constraint this mode is not recommended. In bypass mode the pointers have no effect on the data path or handoff.

CLOCKING MODES

The DAC3482 has a dual clock setup in which a DAC clock signal is used to clock the DAC cores and internal digital logic and a separate DATA clock is used to clock the input LVDS receivers and FIFO input. The DAC3482 DAC clock signal can be sourced directly or generated through an on-chip low-jitter phase-locked loop (PLL).

In those applications requiring extremely low noise it is recommended to bypass the PLL and source the DAC clock directly from a high-quality external clock to the DACCLK input. In most applications system clocking can be simplified by using the on-chip PLL to generate the DAC core clock while still satisfying performance requirements. In this case the DACCLK pins are used as the reference frequency input to the PLL.

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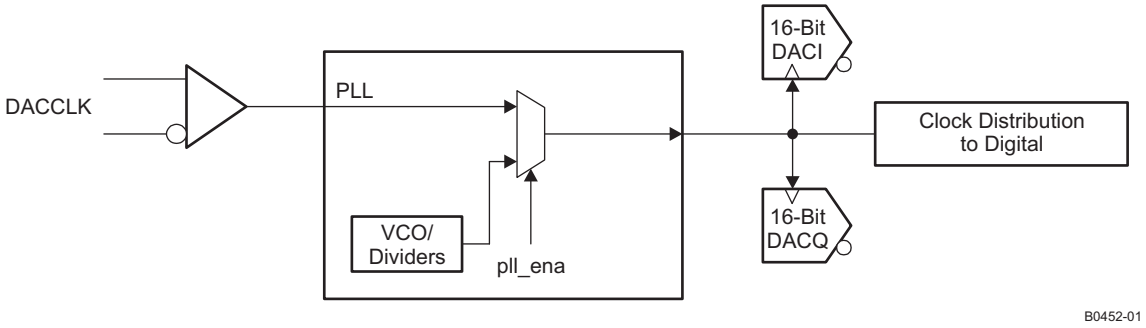

Figure 7. Top Level Clock Diagram

PLL BYPASS MODE

In PLL bypass mode a very high quality clock is sourced to the DACCLK inputs. This clock is used to directly clock the DAC3482 DAC cores. This mode gives the device best performance and is recommended for extremely demanding applications.

The bypass mode is selected by setting the following:

1. *pll_ena* bit in register *config24* to “0” to bypass the PLL circuitry.
2. *pll_sleep* bit in register *config24* to “1” to put the PLL and VCO into sleep mode.

PLL MODE

In this mode the clock at the DACCLK input functions as a reference clock source to the on-chip PLL. The on-chip PLL will then multiply this reference clock to supply a higher frequency DAC cores clock. Figure 8 shows the block diagram of the PLL circuit.

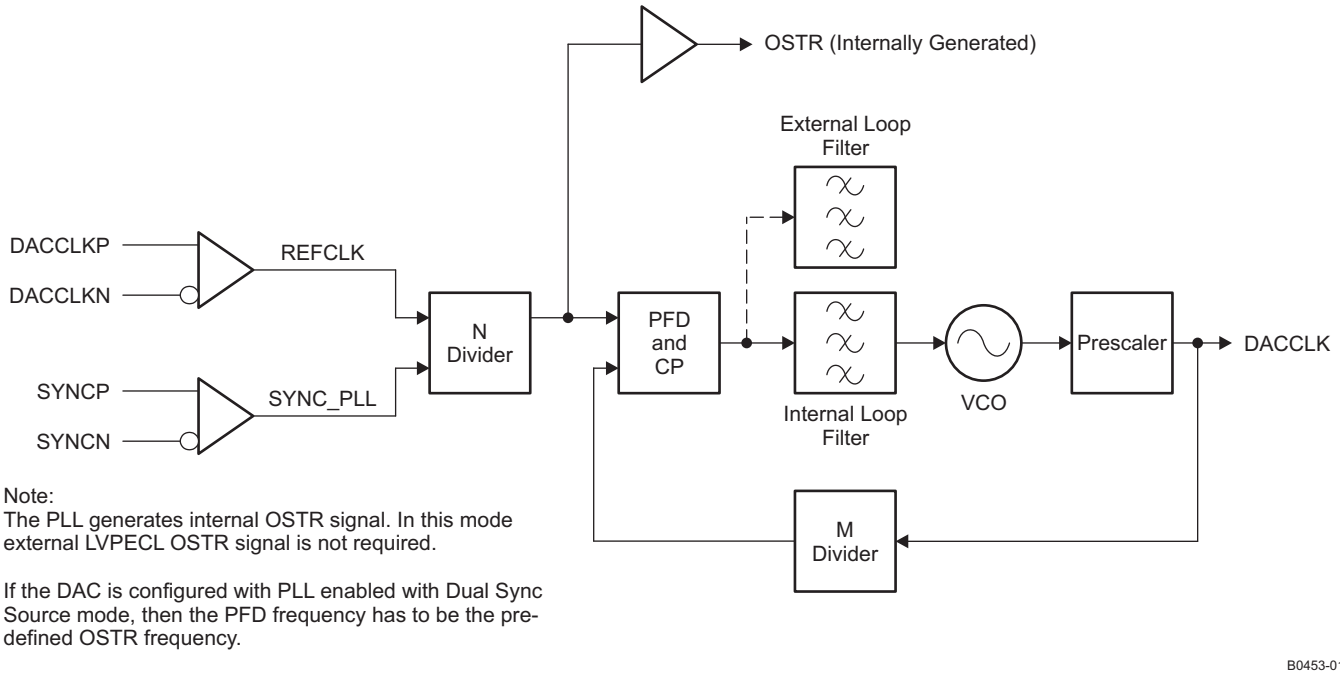

Figure 8. PLL Block Diagram

The DAC3482 PLL mode is selected by setting the following:

1. *pll_ena* bit in register *config24* to “1” to route to the PLL clock path.
2. *pll_sleep* bit in register *config24* to “0” to enable the PLL and VCO.

The output frequency of the VCO is designed to be the in the range from 3.3GHz to 4.0GHz. This VCO range is tuned to a target of 3.6864GHz but can be further adjusted by using the 6-bits *pll_vco* in register *config26*.

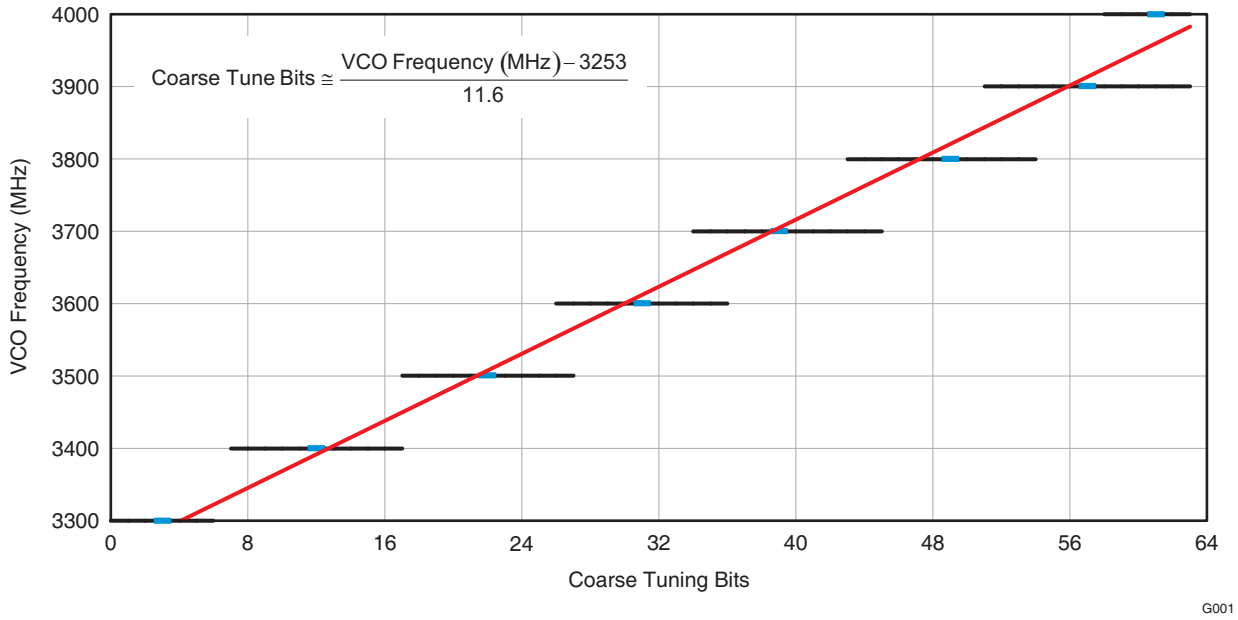

Figure 9. Typical PLL/VCO Lock Range vs Coarse Tuning Bits

Common wireless infrastructure frequencies (614.4MHz, 737.28MHz, 1.2288GHz, etc.) are generated from this VCO frequency in conjunction with the pre-scaler setting *pll_p* in register *config24* as shown in Table 5.

Table 5. VCO Operation

VCO Frequency (MHz)	Pre-Scale Divider	Desired DACCLK (MHz)	pll_p(2:0)
3440.64	7	491.52	111
3686.4	6	614.4	110
3686.4	5	737.28	101
3686.4	3	1228.8	011

The M divider is used to determine the phase-frequency-detector (PFD) and charge-pump (CP) frequency.

Table 6. PFD and CP Operation

DACCLK Frequency (MHz)	M Divider	PDF Update Rate (MHz)	pll_m(7:0)
491.52	4	122.88	00000100
491.52	8	61.44	00001000
491.52	16	30.72	00010000
491.52	32	15.36	00100000

The N divider in the loop allows the PFD to operate at a lower frequency than the reference clock.

The overall divide ratio inside the loop is the product of the Pre-Scale and M dividers (P * M) and the following guidelines should be followed:

- The overall divide ratio range is from 24 to 480
- When the overall divide ratio is less than 120, the internal loop filter can guarantee a stable loop
- When the overall divide ratio is greater than 120, either an external loop filter or a double charge pump setting are required to guarantee loop stability

The single and double charge pump current options are selected by setting *pll_cp* in register *config24* to “01” and “11” respectively. When using the double charge pump setting an external loop filter is not required.

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If an external filter is required, the following filter should be connected to the LPF pin (A1):

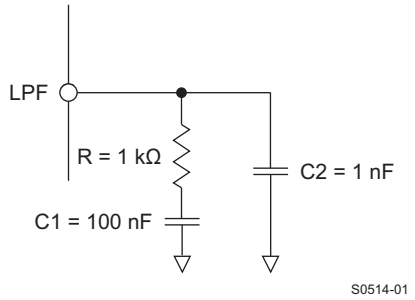

Figure 10. Recommended External Loop Filter

The PLL will generate an internal OSTR signal and does not require the external LVPECL OSTR signal. The OSTR signal is buffered from the N-divider output in the PLL block, and the frequency of the signal is the same as the PFD frequency. Therefore, using PLL with Dual Sync Source mode requires the PFD frequency to be the pre-defined OSTR frequency listed in Input FIFO section.

Additionally, if Dual Sync Source Mode is used with 16-bit data interface Word Wide Mode, then the PLL reference clock frequency at the DACCLKP/N pins will need to be equal or less than the following:

$f_{REF\_CLK} = f_{DAC}/(n \times \text{interpolation} \times 2)$ where n = 1, 2

For example, if the PLL needs to generate 1GHz of DACCLK with 16x interpolation and word-wide interface, the reference frequency will need to be f_{REF_CLK} = 1000MHz/32 = 31.25MHz. The *fifoostrtodig_sel* in config45, bit<14> has to be enabled. The OSTR or PFD frequency needs to be f_{OSTR} = 1000MHz/256 = 3.90625MHz. To achieve 1000MHz DACCLK with 3.90625MHz reference clock, the M/N ratio needs to be 256. Therefore, N is set to 1 and M is set to 256. Since P × M ratio is greater than 120, either external loop filter needs to be installed or double charge pump needs to be enabled.

MULTI-DEVICE SYNCHRONIZATION

In various applications, such as multi antenna systems where the various transmit channels information is correlated, it is required that multiple DAC devices are completely synchronized such that their outputs are phase aligned. The DAC3482 architecture supports this mode of operation.

MULTI-DEVICE SYNCHRONIZATION: PLL BYPASSED WITH DUAL SYNC SOURCE MODE

For single or multi-device synchronization it is important that delay differences in the data are absorbed by the device so that latency through the device remains the same. Furthermore, to guarantee that the outputs from each DAC are phase aligned it is necessary that data is read from the FIFO of each device simultaneously. In the DAC3482 this is accomplished by operating the multiple devices in Dual Sync Source mode. In this mode the additional OSTR signal is required by each DAC3482 to be synchronized.

Data into the device is input as LVDS signals from one or multiple baseband ASICs or FPGAs. Data into the multiple DAC devices can experience different delays due to variations in the digital source output paths or board level wiring. These different delays can be effectively absorbed by the DAC3482 FIFO so that all outputs are phase aligned correctly.

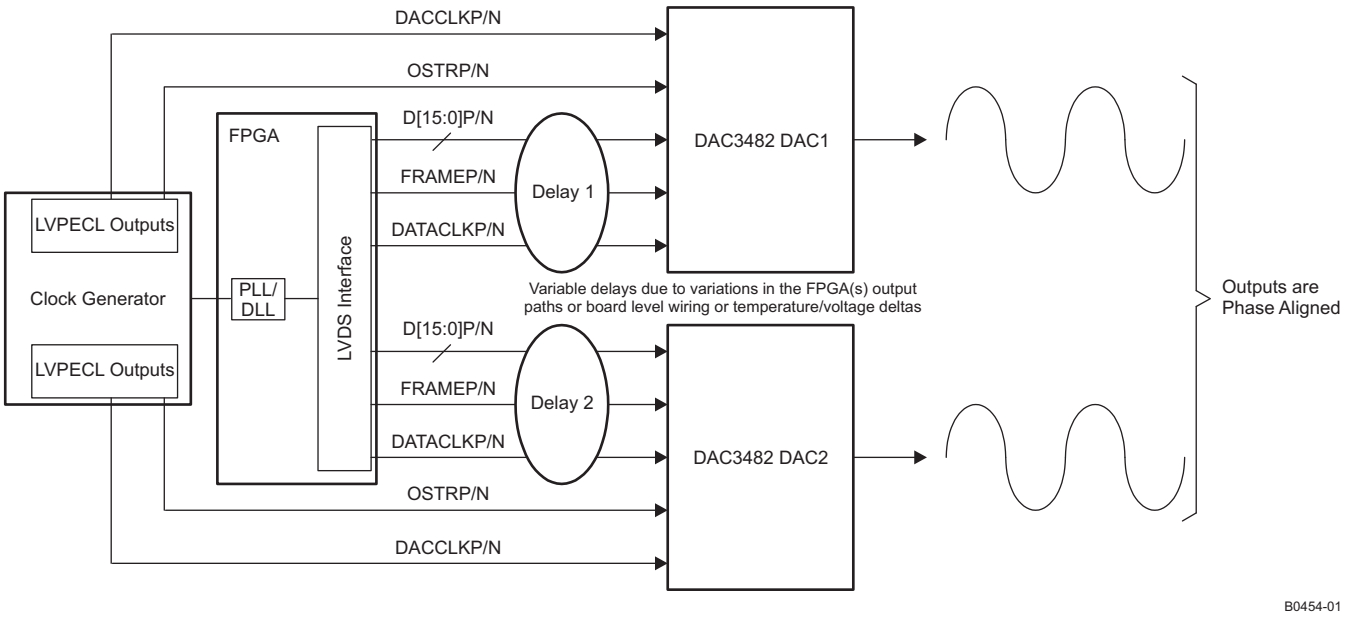

Figure 11. Synchronization System in Dual Sync Source Mode with PLL Bypassed

For correct operation both OSTR and DACCLK must be generated from the same clock domain. The OSTR signal is sampled by DACCLK and must satisfy the timing requirements in the specifications table. If the clock generator does not have the ability to delay the DACCLK to meet the OSTR timing requirement, the polarity of the DACCLK outputs can be swapped with respect to the OSTR ones to create 180 degree phase delay of the DACCLK. This may help establish proper setup and hold time requirement of the OSTR signal.

Careful board layout planning must be done to ensure that the DACCLK and OSTR signals are distributed from device to device with the lowest skew possible as this will affect the synchronization process. In order to minimize the skew across devices it is recommended to use the same clock distribution device to provide the DACCLK and OSTR signals to all the DAC devices in the system.

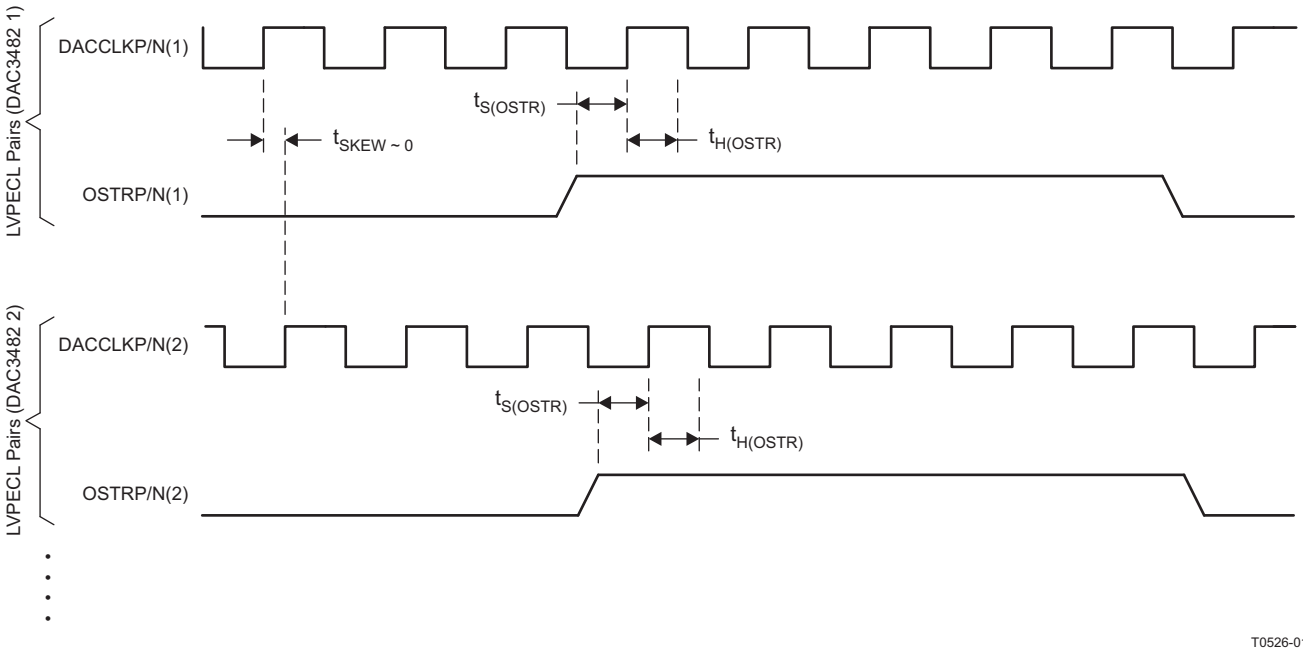

Figure 12. Timing Diagram for LVPECL Synchronization Signals

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The following steps are required to ensure the devices are fully synchronized. The procedure assumes all the DAC3482 devices have a DACCLK and OSTR signal and must be carried out on each device.

1. Start-up the device as described in the power-up sequence. Set the DAC3482 in Dual Sync Source mode and select OSTR as the clock divider sync source (*clkdiv_sync_sel* in register *config32*).
2. Sync the clock divider and FIFO pointers.
3. Verify there are no FIFO alarms either through register config5 or through the ALARM pin.

After these steps all the DAC3482 outputs will be synchronized.

MULTI-DEVICE SYNCHRONIZATION: PLL ENABLED WITH DUAL SYNC SOURCE MODE

The DAC3482 allows exact phase alignment between multiple devices even when operating with the internal PLL clock multiplier. In PLL clock mode, the PLL generates the DAC clock and an internal OSTR signal from the reference clock applied to the DACCLK inputs so there is no need to supply an additional LVPECL OSTR signal.

For this method to operate properly the SYNC signal should be set to reset the PLL N dividers to a known state by setting *pll_ndivsync_ena* in *register config24* to “1”. The SYNC signal resets the PLL N dividers with a rising edge, and the timing relationship $t_{(SYNC\_PLL)}$ are relative to the reference clock presented on the DACCLK pin.

Both SYNC and DACCLK can be set as low frequency signals to greatly simplifying trace routing (SYNC can be just a pulse as a single rising edge is required, if using a periodic signal it is recommended to clear the *pll_ndivsync_ena* bit after resetting the PLL dividers). Besides the $t_{(SYNC\_PLL)}$ requirement between SYNC and DACCLK, there is no additional required timing relationship between the SYNC and FRAME signals or between DACCLK and DATACLK. The only restriction as in the PLL disabled case is that the DACCLK and SYNC signals are distributed from device to device with the lowest skew possible.

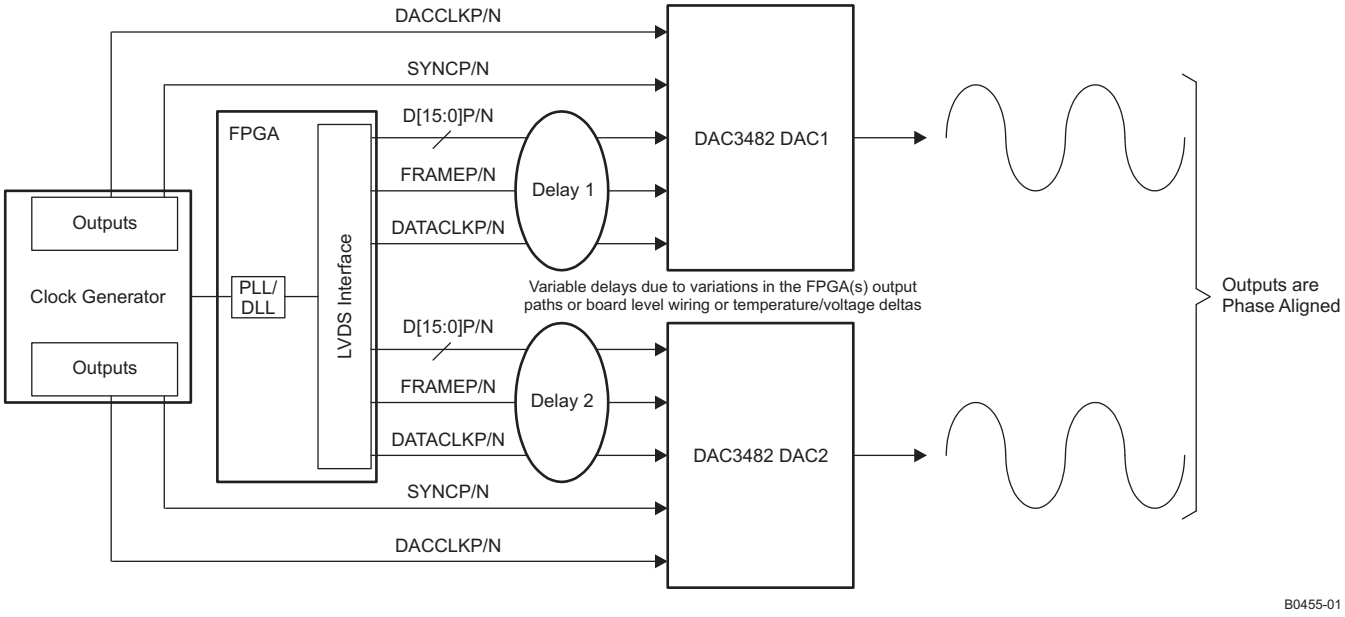

Figure 13. Synchronization System in Dual Sync Source Mode with PLL Enabled

The following steps are required to ensure the devices are fully synchronized. The procedure assumes all the DAC3482 devices have a DACCLK and OSTR signal and must be carried out on each device.

1. Start-up the device as described in the power-up sequence. Set the DAC3482 in Dual Sync Source mode and enable SYNC to reset the PLL dividers (set *pll_ndivsync_ena* in register *config24* to "1").
2. Reset the PLL dividers with a rising edge on SYNC.
3. Disable PLL dividers resetting.
4. Reset the FIFO pointers.
5. Verify there are no FIFO alarms either through register *config5* or through the ALARM pin.

After these steps all the DAC3482 outputs will be synchronized.

MULTI-DEVICE OPERATION: SINGLE SYNC SOURCE MODE

In Single Sync Source mode, the FIFO write and read pointers are reset from the same sync source, either FRAME or SYNC. Although the FIFO in this mode can still absorb the data delay differences due to variations in the digital source output paths or board level wiring it is impossible to guarantee data will be read from the FIFO of different devices simultaneously thus preventing exact phase alignment.

In Single Sync Source mode the FIFO read pointer reset is handoff between the two clock domains (DATACLK and FIFO OUT CLOCK) by simply re-sampling the write pointer reset. Since the two clocks are asynchronous there is a small but distinct possibility of a meta-stable situation during the pointer handoff. This meta-stable situation can cause the outputs of the multiple devices to slip by up to 2 DAC clock cycles.

When the PLL is enabled with Single Sync Source mode, the FIFO read pointer is not synchronized by the OSTR signal. Therefore, there is no restriction on the PLL PFD frequency as described in the previous section.

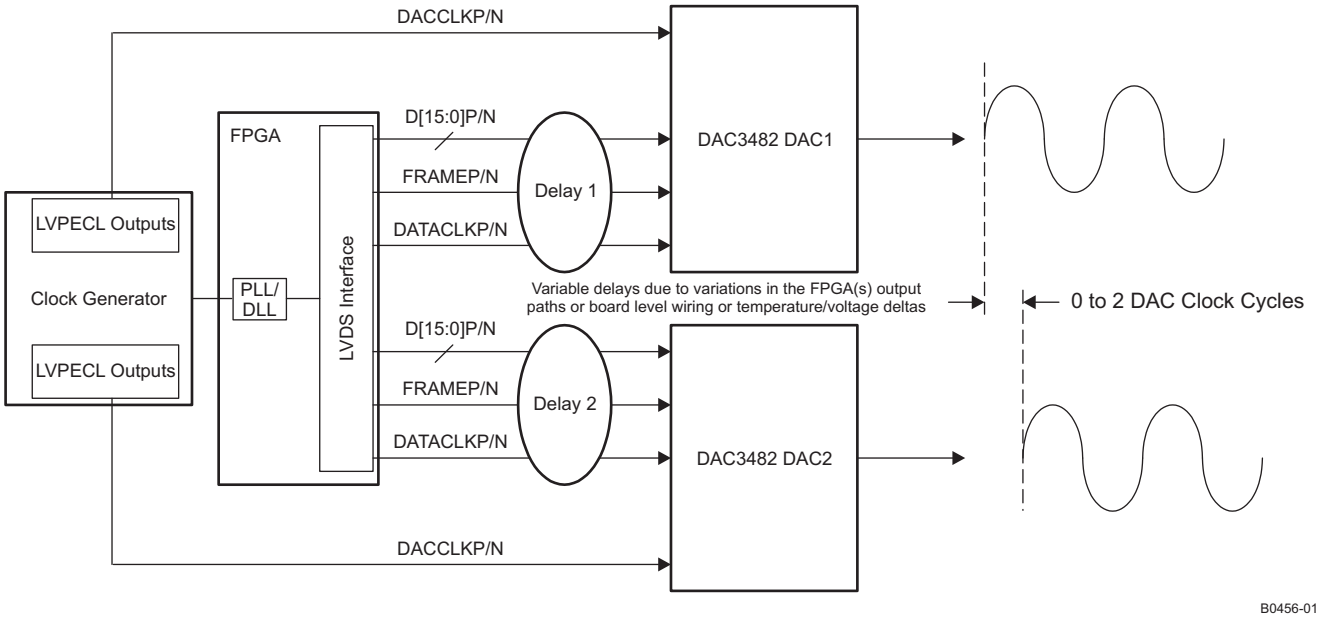

Figure 14. Multi-Device Operation in Single Sync Source Mode

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FIR FILTERS

Figure 15 through Figure 18 show the magnitude spectrum response for the FIR0, FIR1, FIR2 and FIR3 interpolating filters where f_{IN} is the input data rate to the FIR filter. Figure 19 to Figure 22 show the composite filter response for 2x, 4x, 8x and 16x interpolation. The transition band for all interpolation settings is from 0.4 to 0.6 x f_{DATA} (the input data rate to the device) with < 0.001dB of pass-band ripple and > 90 dB stop-band attenuation.

The DAC3482 also has a 9-tap inverse sinc filter (FIR4) that runs at the DAC update rate (f_{DAC}) that can be used to flatten the frequency response of the sample-and-hold output. The DAC sample-and-hold output sets the output current and holds it constant for one DAC clock cycle until the next sample, resulting in the well-known sin(x)/x or sinc(x) frequency response (Figure 15, red line). The inverse sinc filter response (Figure 16, blue line) has the opposite frequency response from 0 to 0.4 x Fdac, resulting in the combined response (Figure 16, green line). Between 0 to 0.4 x f_{DAC}, the inverse sinc filter compensates the sample-and-hold roll-off with less than 0.03 dB error.

The inverse sinc filter has a gain > 1 at all frequencies. Therefore, the signal input to FIR4 must be reduced from full scale to prevent saturation in the filter. The amount of back-off required depends on the signal frequency, and is set such that at the signal frequencies the combination of the input signal and filter response is less than 1 (0 dB). For example, if the signal input to FIR4 is at 0.25 x f_{DAC}, the response of FIR4 is 0.9 dB, and the signal must be backed off from full scale by 0.9 dB to avoid saturation. The gain function in the QMC blocks can be used to reduce the amplitude of the input signal. The advantage of FIR4 having a positive gain at all frequencies is that the user is then able to optimize the back-off of the signal based on its frequency.

The filter taps for all digital filters are listed in Table 4. Note that the loss of signal amplitude may result in lower SNR due to decrease in signal amplitude.

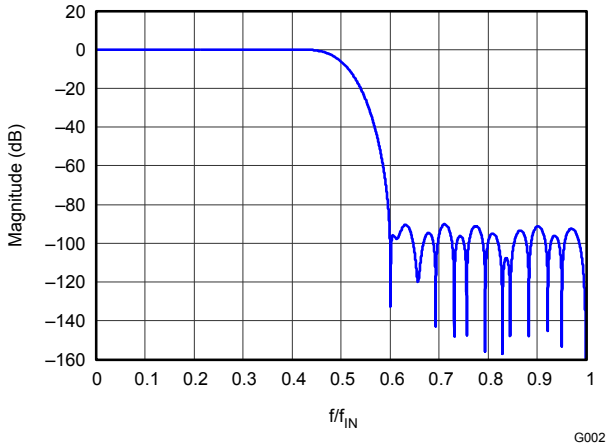

Figure 15. Magnitude Spectrum for FIR0

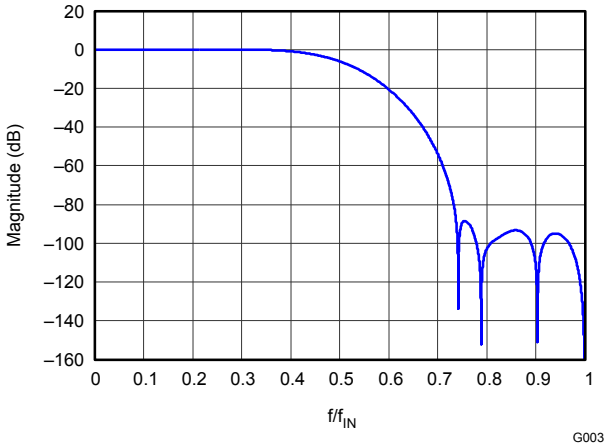

Figure 16. Magnitude Spectrum for FIR1

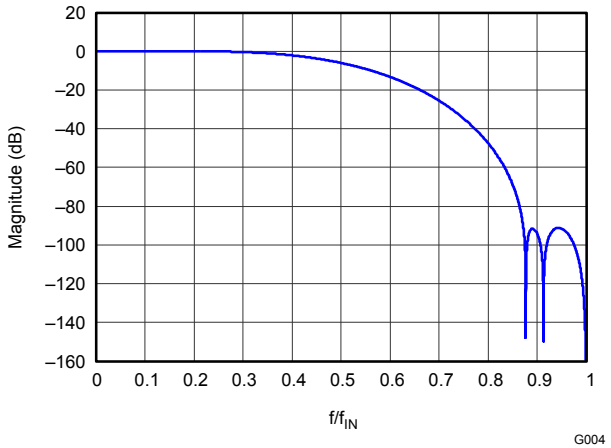

Figure 17. Magnitude Spectrum for FIR2

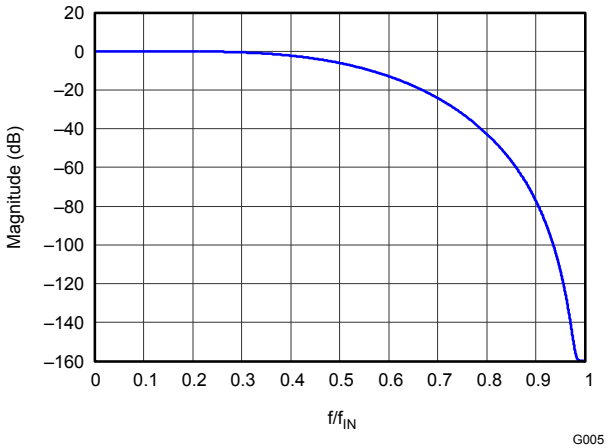

Figure 18. Magnitude Spectrum for FIR3

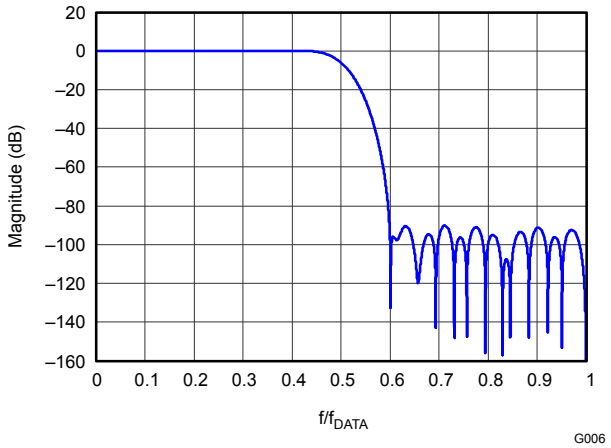

Figure 19. 2x Interpolation Composite Response

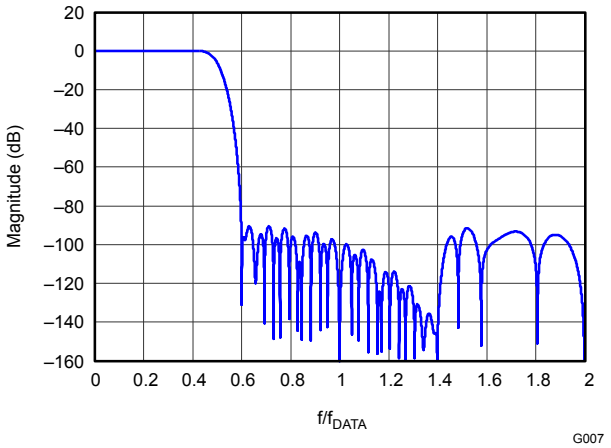

Figure 20. 4x Interpolation Composite Response

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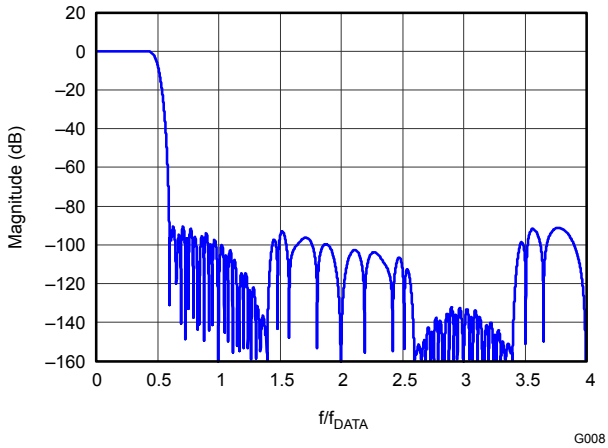

Figure 21. 8x Interpolation Composite Response

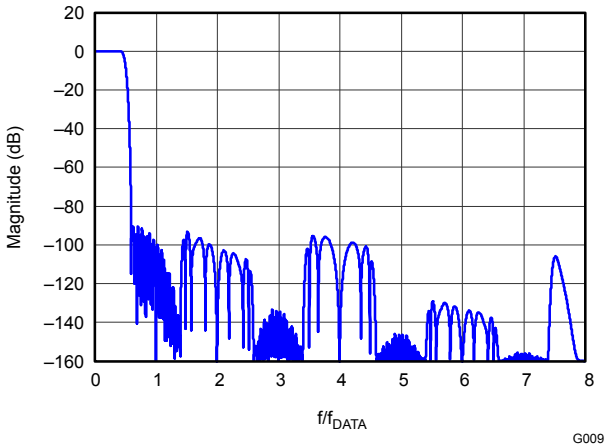

Figure 22. 16x Interpolation Composite Response

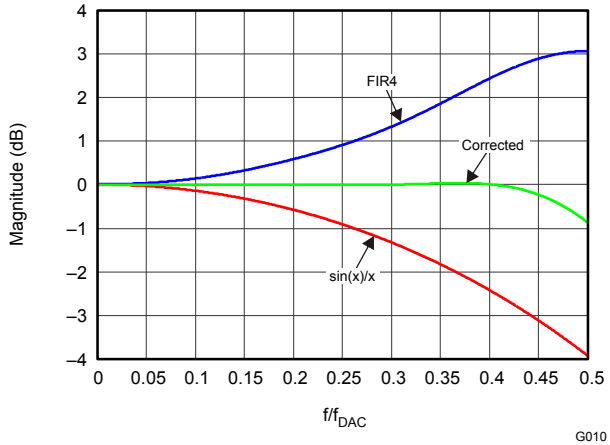

Figure 23. Magnitude Spectrum for Inverse Sinc Filter

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Table 7. FIR Filter Coefficients

2x Interpolating Half-band Filters								Non-Interpolating Inverse-SINC Filter	
FIR0		FIR1		FIR2		FIR3		FIR4	
59 Taps		23 Taps		11 Taps		11 Taps		9 Taps	
6	6	-12	-12	29	29	3	3	1	1
0	0	0	0	0	0	0	0	-4	-4
-19	-19	84	84	-214	-214	-25	-25	13	13
0	0	0	0	0	0	0	0	-50	-50
47	47	-336	-336	1209	1209	150	150	**592**(1)	
0	0	0	0	**2048**(1)		**256**(1)			
-100	-100	1006	1006						
0	0	0	0						
192	192	-2691	-2691						
0	0	0	0						
-342	-342	10141	10141						
0	0	**16384**(1)							
572	572								
0	0								
-914	-914								
0	0								
1409	1409								
0	0								
-2119	-2119								
0	0								
3152	3152								
0	0								
-4729	-4729								
0	0								
7420	7420								
0	0								
-13334	-13334								
0	0								
41527	41527								
65536(1)									

(1) Center taps are highlighted in BOLD

FULL COMPLEX MIXER

The DAC3482 has a full complex mixer (FMIX) block with a Numerically Controlled Oscillators (NCO) that enables flexible frequency placement without imposing additional limitations in the signal bandwidth. The NCO has a 32-bit frequency registers (*phaseadd(31:0)*) and a 16-bit phase register (*phaseoffset(15:0)*) that generate the sine and cosine terms for the complex mixing. The NCO block diagram is shown below in Figure 24.

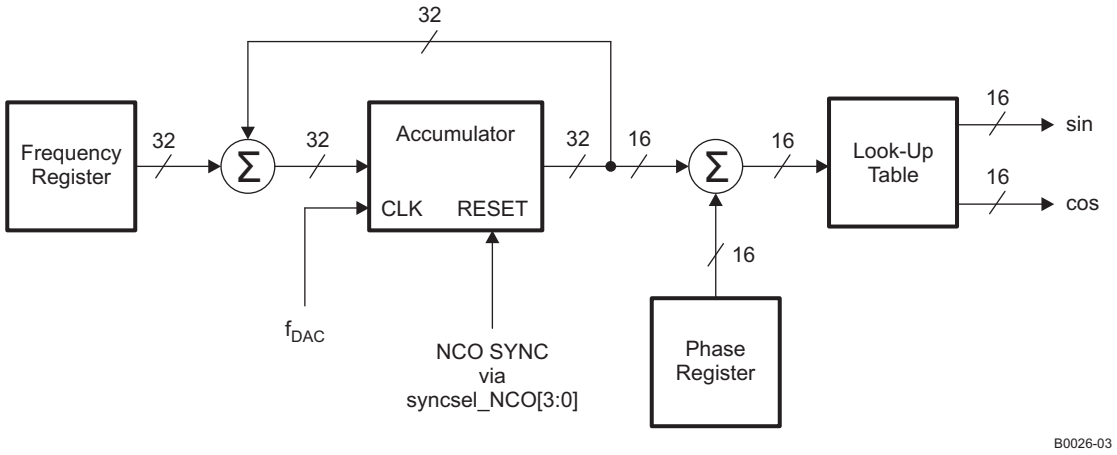

Figure 24. NCO Block Diagram

Synchronization of the NCOs occurs by resetting the NCO accumulators to zero. The synchronization source is selected by *syncsel_NCO(3:0)* in *config31*. The frequency word in the *phaseadd(31:0)* register is added to the accumulators every clock cycle, f_{DAC}. The output frequency of the NCO is

$$f_{NCO} = \frac{freq \times f_{NCO\_CLK}}{2^{32}} \quad (1)$$

Treating channels I and Q in the DAC3482 as a complex vectors of the form I + j Q, the output of FMIX $I_{OUT}(t)$ and $Q_{OUT}(t)$ is

$$I_{OUT}(t) = (I_{IN}(t)\cos(2\pi f_{NCO}t + \delta) - Q_{IN}(t)\sin(2\pi f_{NCO}t + \delta)) \times 2^{(mixer\_gain\ -\ 1)}$$
$$Q_{OUT}(t) = (I_{IN}(t)\sin(2\pi f_{NCO}t + \delta) + Q_{IN}(t)\cos(2\pi f_{NCO}t + \delta)) \times 2^{(mixer\_gain\ -\ 1)}$$

where t is the time since the last resetting of the NCO accumulator, δ is the phase offset value and *mixer_gain* is either 0 or 1. δ is given by:

$$\delta = 2\pi \times phase\_offset(15:0)/2^{16}$$

The maximum output amplitude of FMIX occurs if $I_{IN}(t)$ and $Q_{IN}(t)$ are simultaneously full scale amplitude and the sine and cosine arguments are equal to $2\pi \times f_{NCO}t + \delta$ (2N-1) × π/4 (N = 1, 2, ...).

With m*ixer_gain* = 0 in *config2*, the gain through FMIX is sqrt(2)/2 or –3 dB. This loss in signal power is in most cases undesirable, and it is recommended that the gain function of the QMC block be used to increase the signal by 3 dB to compensate. With *mixer_gain* = 1, the gain through FMIX is sqrt(2) or +3 dB, which can cause clipping of the signal if $I_{IN}(t)$ and $Q_{IN}(t)$ are simultaneously near full scale amplitude and should therefore be used with caution.

COARSE MIXER

In addition to the full complex mixer the DAC3482 also has a coarse mixer block capable of shifting the input signal spectrum by the fixed mixing frequencies $\pm n \times f_S/8$. Using the coarse mixer instead of the full mixer will result in lower power consumption.

Treating channels I and Q as a complex vector of the form I(t) + j Q(t), the outputs of the coarse mixer, $I_{OUT}(t)$ and $Q_{OUT}(t)$ are equivalent to:

$$I_{OUT}(t) = I(t)\cos(2\pi f_{CMIX}t) - Q(t)\sin(2\pi f_{CMIX}t)$$
$$Q_{OUT}(t) = I(t)\sin(2\pi f_{CMIX}t) + Q(t)\cos(2\pi f_{CMIX}t)$$

where f_{CMIX} is the fixed mixing frequency selected by *cmix(3:0)*. The mixing combinations are described in Table 8.

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Table 8. Coarse Mixer Combinations

cmix(3:0)	Fs/8 Mixer cmix(3)	Fs/4 Mixer cmix(2)	Fs/2 Mixer cmix(1)	–Fs/4 Mixer cmix(0)	Mixing Mode
0000	Disabled	Disabled	Disabled	Disabled	No mixing
0001	Disabled	Disabled	Disabled	Enabled	–Fs/4
0010	Disabled	Disabled	Enabled	Disabled	Fs/2
0100	Disabled	Enabled	Disabled	Disabled	+Fs/4
1000	Enabled	Disabled	Disabled	Disabled	+Fs/8
1010	Enabled	Disabled	Enabled	Disabled	–3Fs/8
1100	Enabled	Enabled	Disabled	Disabled	+3Fs/8
1110	Enabled	Enabled	Enabled	Disabled	–Fs/8
All others	–	–	–	–	Not recommended

QUADRATURE MODULATION CORRECTION (QMC)

GAIN AND PHASE CORRECTION

The DAC3482 includes a Quadrature Modulator Correction (QMC) block. The QMC blocks provide a mean for changing the gain and phase of the complex signals to compensate for any I and Q imbalances present in an analog quadrature modulator. The block diagram for the QMC block is shown in Figure 25. The QMC block contains 3 programmable parameters.

Register *qmc_gain(10:0)* controls the I and Q path gains and is an 11-bit unsigned value with a range of 0 to 1.9990 and the default gain is 1.0000. The implied decimal point for the multiplication is between bit 9 and bit 10.

Register *qmc_phase(11:0)* control the phase imbalance between I and Q and is a 12-bit values with a range of –0.5 to approximately 0.49975. The QMC phase term is not a direct phase rotation but a constant that is multiplied by each "Q" sample then summed into the "I" sample path. This is an approximation of a true phase rotation in order to keep the implementation simple. The corresponding phase rotation corresponds to approximately +3.75 to –3.75 degrees in 1024 steps.

LO feed-through can be minimized by adjusting the DAC offset feature described below.

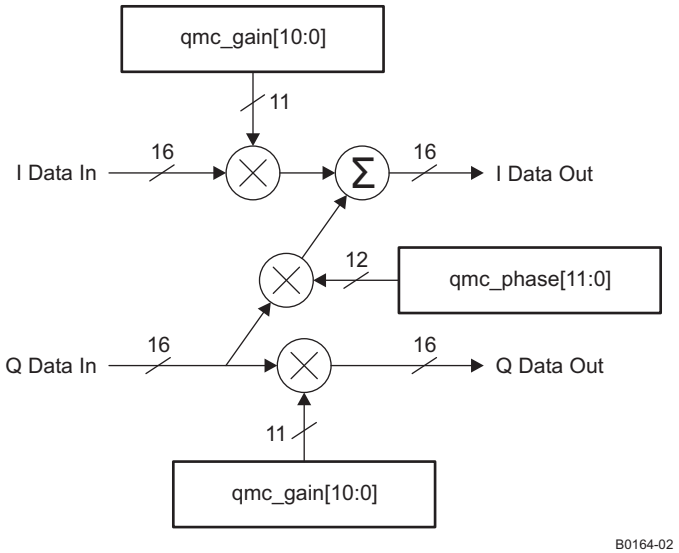

Figure 25. QMC Block Diagram

OFFSET CORRECTION

Registers *qmc_offsetI(12:0)* and *qmc_offsetQ(12:0)* can be used to independently adjust the DC offsets of each channel. The offset values are in represented in 2s-complement format with a range from –4096 to 4095.

The offset value adds a digital offset to the digital data before digital-to-analog conversion. Since the offset is added directly to the data it may be necessary to back off the signal to prevent saturation. Both data and offset values are LSB aligned.

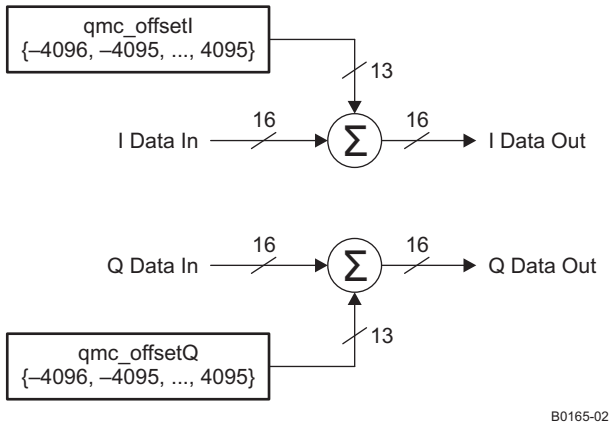

Figure 26. Digital Offset Block Diagram

GROUP DELAY CORRECTION

A complex transmitter system typically is consisted of a DAC, reconstruction filter network, and I/Q modulator. Besides the gain and phase mismatch contribution, there could also be timing mismatch contribution from each components. For instance, the timing mismatch could come from the PCB trace length variation between the I and Q channels and the group delay variation from the reconstruction filter.

This timing mismatch in the complex transmitter system creates phase mismatch that varies linearly with respect to frequency. To compensate for the I/Q imbalances due to this mismatch, the DAC3482 has group delay correction block for each DAC channel. Each DAC channel can adjust its delay through *grp_delayI(7:0)* and *grp_delayq(7:0)* in register *config46* and *config47*, respectively. The delay range is approximately 100ps over the 256 digital steps. The group delay correction, along with gain/phase correction, can be useful for correcting imbalances in wide-band transmitter system.

TEMPERATURE SENSOR

The DAC3482 incorporates a temperature sensor block which monitors the temperature by measuring the voltage across 2 transistors. The voltage is converted to an 8-bit digital word using a successive-approximation (SAR) analog to digital conversion process. The result is scaled, limited and formatted as a twos complement value representing the temperature in degrees Celsius.

The sampling is controlled by the serial interface signals SDENB and SCLK. If the temperature sensor is enabled (*tsense_sleep* = 0 in register *config26*) a conversion takes place each time the serial port is written or read. The data is only read and sent out by the digital block when the temperature sensor is read in *tempdata(7:0)* in *config6*. The conversion uses the first eight clocks of the serial clock as the capture and conversion clock, the data is valid on the falling eighth SCLK. The data is then clocked out of the chip on the rising edge of the ninth SCLK. No other clocks to the chip are necessary for the temperature sensor operation. As a result the temperature sensor is enabled even when the device is in sleep mode.

In order for the process described above to operate properly, the serial port read from *config6* must be done with an SCLK period of at least 1 µs. If this is not satisfied the temperature sensor accuracy is greatly reduced.

DATA PATTERN CHECKER

The DAC3482 incorporates a simple pattern checker test in order to determine errors in the data interface. The main cause of failures is setup/hold timing issues. The test mode is enabled by asserting *iotest_ena* in register *config1*. In test mode the analog outputs are deactivated regardless of the state of TXENABLE or *sif_texnable* in register *config3.*

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The data pattern key used for the test is 8 words long and is specified by the contents of *iotest_pattern[0:7]* in registers *config37* through *config44*. The data pattern key can be modified by changing the contents of these registers.

The first word in the test frame is determined by a rising edge transition in FRAME or SYNC, depending on the *syncsel_fifoin(4:0)* setting in *config32*. At this transition, the *pattern0* word should be input to the data pins. Patterns 1 through 7 should follow sequentially on each edge of DATACLK (rising and falling). The sequence should be repeated until the pattern checker test is disabled by setting *iotest_ena* back to 0. It is not necessary to have a rising FRAME or SYNC edge aligned with every *pattern0* word, just the first one to mark the beginning of the series.

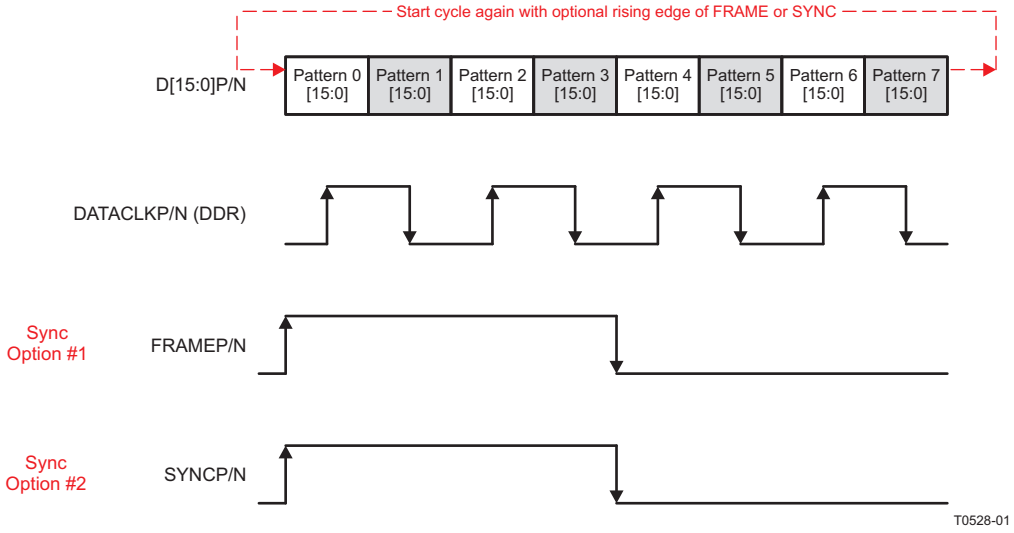

Figure 27. IO Pattern Checker Data Transmission Format

The test mode determines if the 16-bit LVDS data D[15:0]P/N of all the patterns were received correctly by comparing the received data against the data pattern key. If any of the 16-bit data D[15:0]P/N were received incorrectly, the corresponding bits in *iotest_results(15:0)* in register *config4* will be set to “1” to indicate bit error location. Furthermore, the error condition will trigger the *alarm_from_iotest* bit in register *config5* to indicate a general error in the data interface.

For instance, *pattern0* is programmed to the default of 0x7A7A. If the received Pattern 0 is 0x7A7B, then bit 0 in *iotest_results(15:0)* will be set to “1” to indicate an error in bit 0 location. The alarm_from_iotest will also be set to “1” to report the data transfer error. The user can then narrow down the error from the *alarm_from_iotest* bit location information and implement the fix accordingly.

The alarms can be cleared by writing 0x0000 to *iotest_results(15:0)* and “0” to *alarm_from_iotest* through the serial interface. The serial interface will read back 0s if there are no errors or if the errors are cleared. The corresponding alarm bit will remain a “1” if the errors remain.

Note that unless the unused data pins in byte-wide input format are forced to a known value the data pattern checker is only available for the word-wide input data format. In byte-wide input format, the first 8-bits of the *iotest_pattern[0:7]* in registers *config37* through *config44* will either need to be 0s or 1s for valid data pattern checking.

It is recommended to enable the pattern checker and then run the pattern sequence for 100 or more complete cycles before clearing the iotest_results(15:0) and *alarm_from_iotest*. This will eliminate the possibility of false alarms generated during the setup sequence.

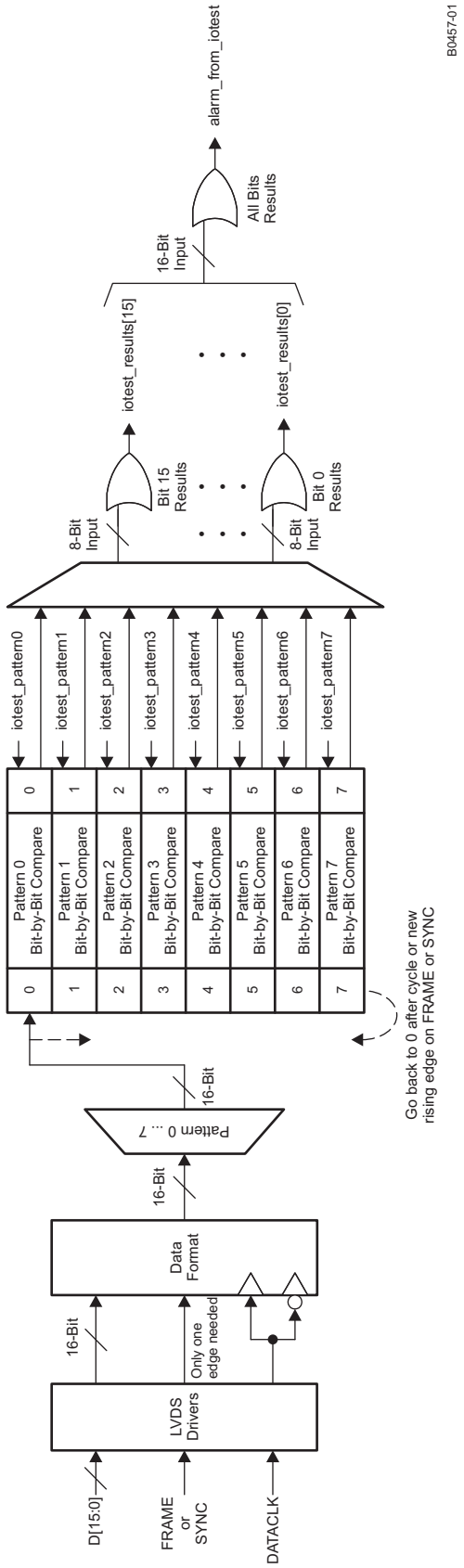

Figure 28. DAC3482 Pattern Check Block Diagram

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PARITY CHECK TEST

The DAC3482 has a parity check test that enables continuous validity monitoring of the data received by the DAC. Parity check testing in combination with the data pattern checker offer an excellent solution for detecting board assembly issues due to missing pad connections.

For the parity check test, an extra parity bit is added to the data bits to ensure that the total number of set bits (bits with logic value of “1”) is even or odd. This simple scheme is used to detect data transfer errors. Parity testing is implemented in the DAC3482 in two ways: word-by-word parity and block parity.

WORD-BY-WORD PARITY

Word-by-word parity is the easiest mode to implement. In this mode the additional parity bit is sourced to the parity input (PARITYP/N) for each data word transfer into the D[15:0]P/N inputs. This mode is enabled by setting the *word_parity_ena* bit. The input parity value is defined to be the total number of logic 1s on the 17-bit data bus, the D[15:0]P/N inputs and the PARITYP/N input. This value, the total number of logic 1s, must match the parity test selected in the *oddeven_parity* bit in register *config1*.

For example, if the *oddeven_parity* bit is set to “1” for odd parity, then the number of 1s on the 17-bit data bus should be odd. The DAC will check the data transfer through the parity input. If the data received has odd number of 1s, then the parity is correct. If the data received has even number of 1s, then the parity is incorrect. The corresponding alarm for parity error will be set accordingly.

Note that unless the unused data pins in byte-wide input format are forced to a known value the word-by-word parity is only available for the word-wide input data format.

Figure 29 shows the simple XOR structure used to check word parity. Parity is tested independently for data captured on both rising and falling edges of DATACLK (*alarm_rparity* and *alarm_fparity*, respectively). Testing on both edges helps in determining a possible setup/hold issue. Both alarms are captured individually in register *config5*.

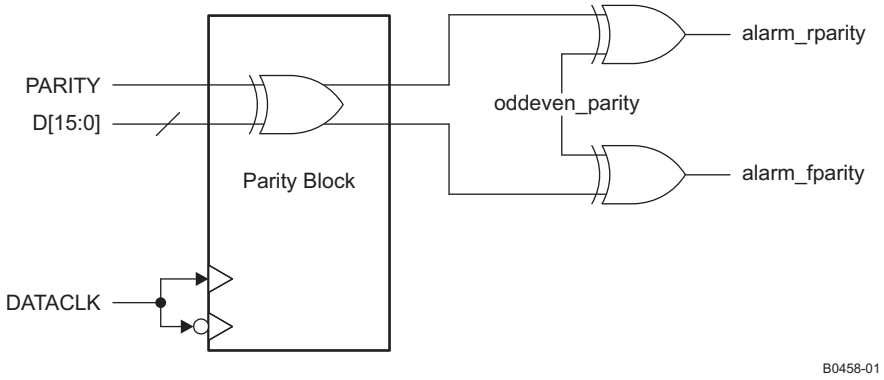


Figure 29. DAC3482 Word-by-Word Parity Check

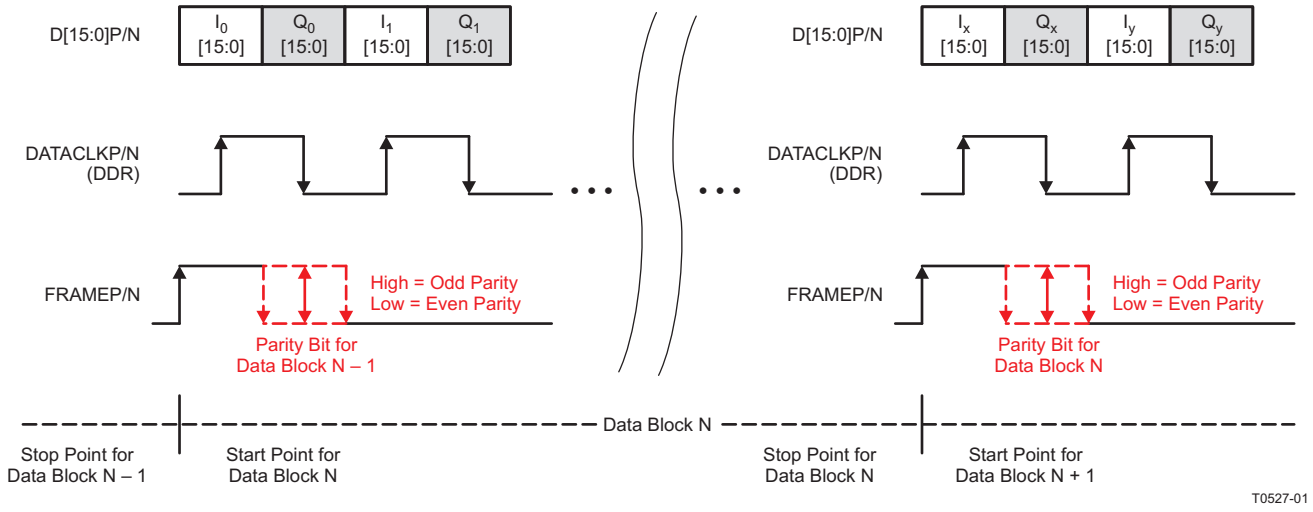
BLOCK PARITY

The block parity method uses the FRAME signal to determine the boundaries of the data block to compute parity. This mode is enabled by setting the *frame_parity_ena* bit in register *config1*.

A low-to-high transition of FRAME captured with the DATACLK rising edge determines the end point of the parity block and the beginning of the next one. In this method the parity bit of the completed block corresponds to the FRAME value captured on the DATACLK falling edge right after the STOP/START point.

The input parity value is defined to be the total number of logic 1s in the data block. A logic HIGH captured on the falling edge of DATACLK indicates odd parity or odd number of logic 1s, while a logic LOW indicates even parity or even number of logic 1s. If the expected parity does not match the number of logic 1s in the received data, then *alarm_frame_parity* in register *config5* will be set to “1”. The main advantage of the block parity mode is that there is no need for an additional parity LVDS input.

Since the FRAME signal is used for parity testing in addition to FIFO syncing and frame boundary assignment, it is mandatory to take some extra steps to avoid device malfunction. If FRAME is used to reset the FIFO pointers continuosly, the block size must be a multiple of 8 samples (each sample corresponding to 16-bits I and 16-bits Q). In addition since FRAME is used in byte-wide input data mode to establish the frame boundary, the parity block must be aligned with the data frame boundaries.



Notes: Rising edge of FRAMEP/N indicates the beginning of data block.

Parity bit for the current data block is latched on falling edge of DATACLK after the start point for next data block.

Figure 30. DAC3482 Block Parity Check (Example shown with Word Wide Mode)

DAC3482 ALARM MONITORING

The DAC3482 includes a flexible set of alarm monitoring that can be used to alert of a possible malfunction scenario. All the alarm events can be accessed either through the config5 register or through the ALARM pin. Once an alarm is set, the corresponding alarm bit in register config5 must be reset through the serial interface to allow further testing. The set of alarms includes the following conditions

Zero check alarm

- *Alarm_from_zerochk*. Occurs when the FIFO write pointer has an all zeros pattern. Since the write pointer is a shift register, all zeros will cause the input point to be stuck until the next sync event. When this happens a sync to the FIFO block is required.

FIFO alarms

- *alarm_from_fifo*. Occurs when there is a collision in the FIFO pointers or a collision event is close.
  - alarm_fifo_2away. Pointers are within two addresses of each other.
  - alarm_fifo_1away. Pointers are within one address of each other.
  - alarm_fifo_collision. Pointers are equal to each other.

Clock alarms

- *clock_gone*. Occurs when either the DACCLK or DATACLOCK have been stopped.
  - alarm_dacclk_gone. Occurs when the DACCLK has been stopped.
  - alarm_dataclk_gone. Occurs when the DATACLK has been stopped.

Pattern checker alarm

- *alarm_from_iotest*. Occurs when the input data pattern does not match the pattern key.

PLL alarm

- *alarm_from_pll*. Occurs when the PLL is out of lock.

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Parity alarms

- *alarm_rparity*. Occurs when there is a parity error in the data captured by the rising edge of DATACLKP/N. The PARITYP/N input is the parity bit (word-by-word parity test).
- *alarm_fparity*. Occurs when there is a parity error in the data captured by the falling edge of DATACLKP/N. The PARITYP/N input is the parity bit (word-by-word parity test).
- *alarm_frame_parity_err*. Occurs when there is a frame parity error when using the FRAME as the parity bit (block parity test).

To prevent unexpected DAC outputs from propagating into the transmit channel chain, the clock and alarm_ fifo_collision alarms can be set in *config2* to shut-off the DAC output automatically regardless of the state of TXENABLE or *sif_txenable*.

Alarm monitoring is implemented as follows:

- Power up the device using the recommended power-up sequence.
- Clear all the alarms in *config5* by setting them to 0.
- Unmask those alarms that will generate a hardware interrupt through the ALARM pin in *config7.*
- Enable automatic DAC shut-off in register *config2* if required.
- In the case of an alarm event, the ALARM pin will trigger. If automatic DAC shut-off has been enabled the DAC outputs will be disabled.
- Read registers *config5* to determine which alarm triggered the ALARM pin.
- Correct the error condition and re-synchronize the FIFO.
- Clear the alarms in *config5.*
- Re-read *config5* to ensure the alarm event has been corrected.
- Keep clearing and reading *config5* until no error is reported.

POWER-UP SEQUENCE

The following startup sequence is recommended to power-up the DAC3482:

- Set TXENABLE pin low.
- Supply all 1.2V voltages (DACVDD, DIGVDD, CLKVDD and VFUSE) and all 3.3V voltages (AVDD, IOVDD and PLLAVDD). The 1.2V and 3.3V supplies can be powered up simultaneously or in any order.
  There are no specific requirements on the ramp rate for the supplies.
- Provide all LVPECL inputs: DACCLKP/N and if used OSTRP/N.
- Toggle the RESETB pin for a minimum 25 ns active low pulse width.
- Program the SIF registers.
- Provide all LVDS inputs (D[15:0]P/N, DATACLKP/N, FRAMEP/N, SYNCP/N and PARITYP/N) simultaneously.
- Sync the clock dividers and FIFO. After a FRAMEP/N low-to-high transition, clock divider syncing can be disabled by setting *clkdiv_sync_ena* (config0, bit 2) to 0. Optionally, disable FIFO syncing by setting *syncsel_fifoin(4:0)* and *syncsel_fifoout(4:0)* to “0000” after initialization.
- Enable transmit of data by asserting the TXENABLE pin or set sif_txenable to “1”.

LVPECL INPUTS

Figure 31 shows an equivalent circuit for the DAC input clock (DACCLKP/N) and the output strobe clock (OSTRP/N).

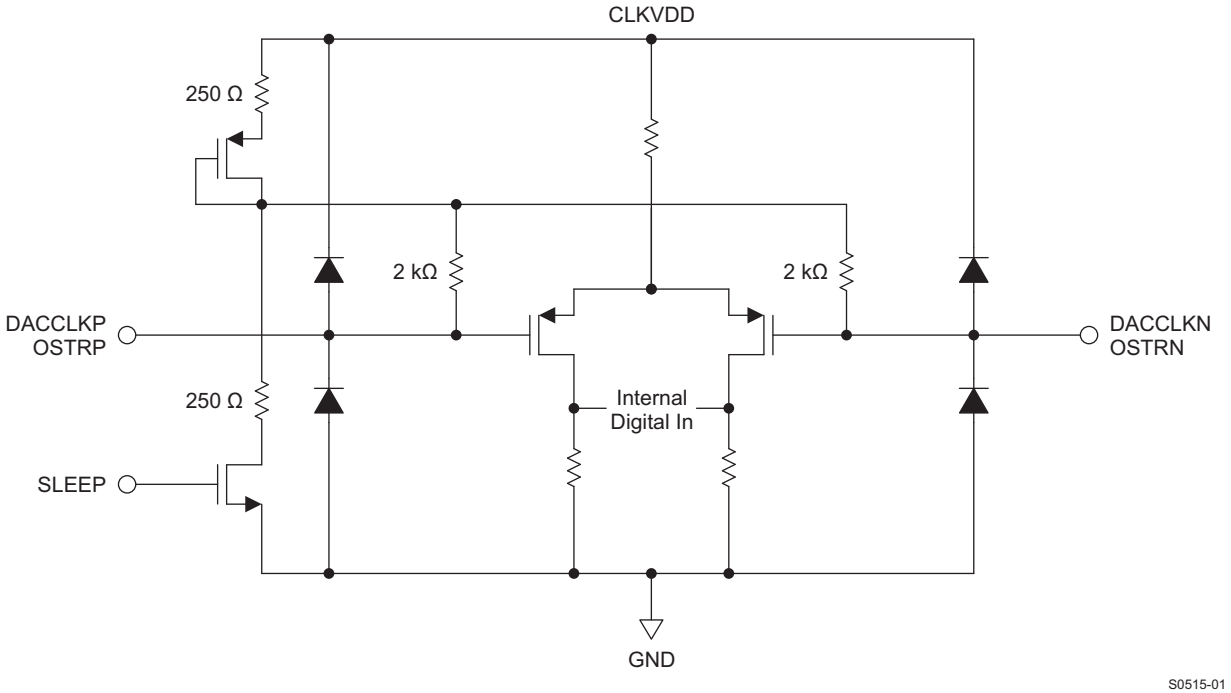

Figure 31. DACCLKP/N and OSTRP/N Equivalent Input Circuit

Figure 32 shows the preferred configuration for driving the CLKIN/CLKINC input clock with a differential ECL/PECL source.

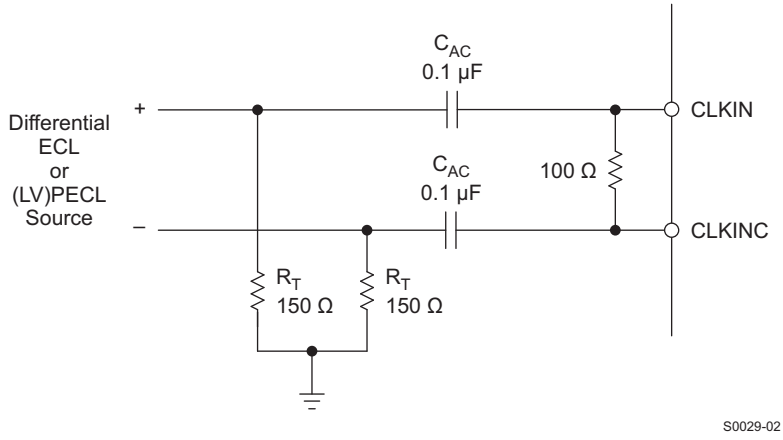

Figure 32. Preferred Clock Input Configuration With a Differential ECL/PECL Clock Source

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LVDS INPUTS

The D[15:0]P/N, DATACLKP/N, SYNCP/N, PARITYP/N and FRAMEP/N LVDS pairs have the input configuration shown in Figure 33. Figure 34 shows the typical input levels and common-move voltage used to drive these inputs.

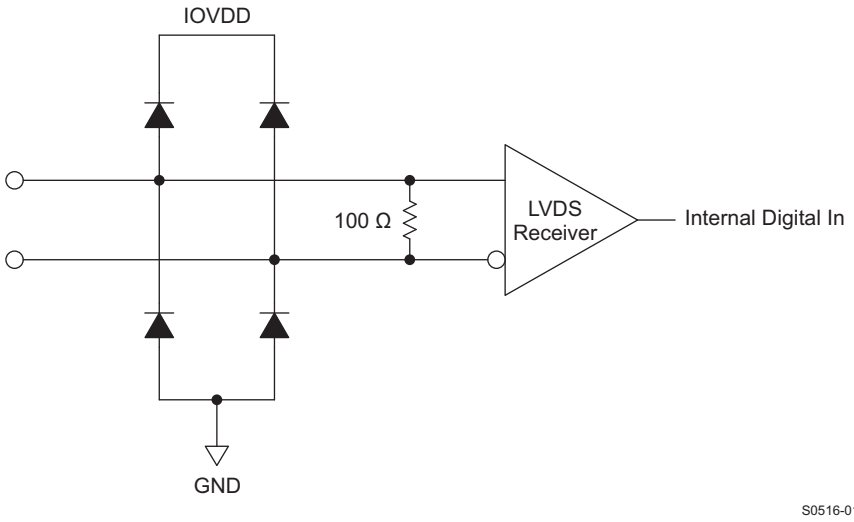

Figure 33. D[15:0]P/N, DATACLKP/N, FRAMEP/N, SYNCP/N and PARITYP/N LVDS Input Configuration

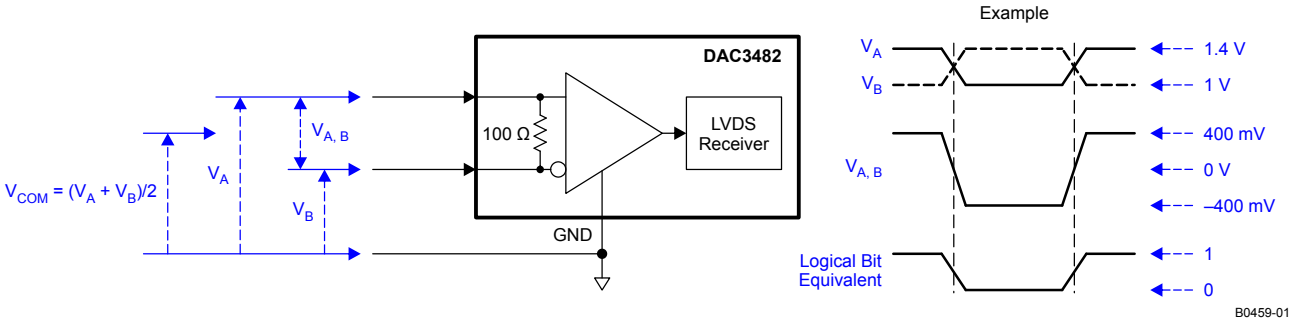

Figure 34. LVDS Data Input Levels

Table 9. Example LVDS Data Input Levels

Applied Voltages		Resulting Differential Voltage	Resulting Common-Mode Voltage	Logical Bit Binary Equivalent
V_A	V_B	$V_{A,B}$	V_{COM}	
1.4 V	1.0 V	400 mV	1.2 V	1
1.0 V	1.4 V	-400 mV		0
1.2 V	0.8 V	400 mV	1.0 V	1
0.8 V	1.2 V	-400 mV		0

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CMOS DIGITAL INPUTS

Figure 35 shows a schematic of the equivalent CMOS digital inputs of the DAC3482. SDIO, SCLK, SLEEP and TXENABLE have pull-down resistors while SDENB and RESETB have pull-up resistors internal to the DAC3482. See the specification table for logic thresholds. The pull-up and pull-down circuitry is approximately equivalent to 100kΩ.

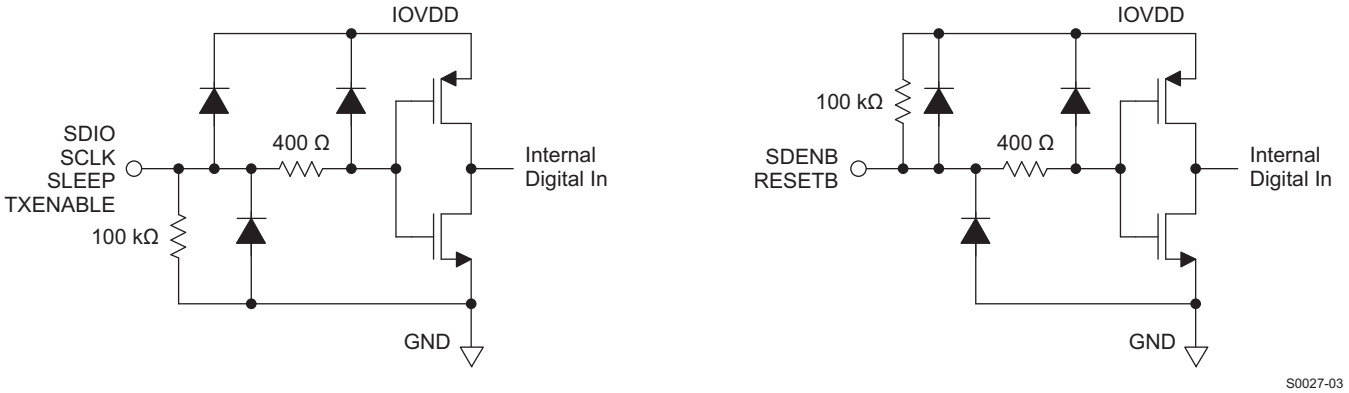

Figure 35. CMOS Digital Equivalent Input

REFERENCE OPERATION

The DAC3482 uses a bandgap reference and control amplifier for biasing the full-scale output current. The full-scale output current is set by applying an external resistor R_{BIAS} to pin BIASJ. The bias current I_{BIAS} through resistor R_{BIAS} is defined by the on-chip bandgap reference voltage and control amplifier. The default full-scale output current equals 64 times this bias current and can thus be expressed as:

$$IOUT_{FS} = 64 \times I_{BIAS} = 64 \times (V_{EXTIO} / R_{BIAS}) / 2$$

The DAC3482 has a 4-bit coarse gain control *coarse_dac(3:0)* in the *config3* register. Using gain control, the $IOUT_{FS}$ can be expressed as:

$$IOUT_{FS} = (coarse\_dac + 1)/16 \times IBIAS \times 64 = (coarse\_dac + 1)/16 \times (VEXTIO / RBIAS) / 2 \times 64$$

where V_{EXTIO} is the voltage at terminal EXTIO. The bandgap reference voltage delivers an accurate voltage of 1.2V. This reference is active when *extref_ena* = '0' in *config27*. An external decoupling capacitor C_{EXT} of 0.1 µF should be connected externally to terminal EXTIO for compensation. The bandgap reference can additionally be used for external reference operation. In that case, an external buffer with high impedance input should be applied in order to limit the bandgap load current to a maximum of 100 nA. The internal reference can be disabled and overridden by an external reference by setting the *extref_ena* control bit. Capacitor C_{EXT} may hence be omitted. Terminal EXTIO thus serves as either input or output node.

The full-scale output current can be adjusted from 30 mA down to 10 mA by varying resistor R_{BIAS} or changing the externally applied reference voltage.

DAC TRANSFER FUNCTION

The CMOS DAC's consist of a segmented array of PMOS current sources, capable of sourcing a full-scale output current up to 30 mA. Differential current switches direct the current to either one of the complementary output nodes IOUTP or IOUTN. Complementary output currents enable differential operation, thus canceling out common mode noise sources (digital feed-through, on-chip and PCB noise), dc offsets, even order distortion components, and increasing signal output power by a factor of two.

The full-scale output current is set using external resistor R_{BIAS} in combination with an on-chip bandgap voltage reference source (+1.2 V) and control amplifier. Current I_{BIAS} through resistor R_{BIAS} is mirrored internally to provide a maximum full-scale output current equal to 64 times I_{BIAS}.

The relation between IOUTP and IOUTN can be expressed as:

$$IOUT_{FS} = IOUTP + IOUTN$$

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We will denote current flowing into a node as – current and current flowing out of a node as + current. Since the output stage is a current source the current flows from the IOUTP and IOUTN pins. The output current flow in each pin driving a resistive load can be expressed as:

$IOUTP = IOUT_{FS} \times CODE / 65536$

$IOUTN = IOUT_{FS} \times (65535 - CODE) / 65536$

where CODE is the decimal representation of the DAC data input word

For the case where IOUTP and IOUTN drive resistor loads R_L directly, this translates into single ended voltages at IOUTP and IOUTN:

$VOUTP = IOUT1 \times R_L$

$VOUTN = IOUT2 \times R_L$

Assuming that the data is full scale (65535 in offset binary notation) and the R_L is 25 Ω, the differential voltage between pins IOUTP and IOUTN can be expressed as:

VOUTP = 20mA x 25 Ω = 0.5 V

VOUTN = 0mA x 25 Ω = 0 V

VDIFF = VOUTP – VOUTN = 0.5V

Note that care should be taken not to exceed the compliance voltages at node IOUTP and IOUTN, which would lead to increased signal distortion.

ANALOG CURRENT OUTPUTS

The DAC3482 can be easily configured to drive a doubly terminated 50 Ω cable using a properly selected RF transformer. Figure 36 and Figure 37 show the 50 Ω doubly terminated transformer configuration with 1:1 and 4:1 impedance ratio, respectively. Note that the center tap of the primary input of the transformer has to be grounded to enable a DC current flow. Applying a 20 mA full-scale output current would lead to a 0.5 Vpp for a 1:1 transformer and a 1 Vpp output for a 4:1 transformer. The low dc-impedance between IOUTP or IOUTN and the transformer center tap sets the center of the ac-signal to GND, so the 1 Vpp output for the 4:1 transformer results in an output between –0.5 V and +0.5 V.

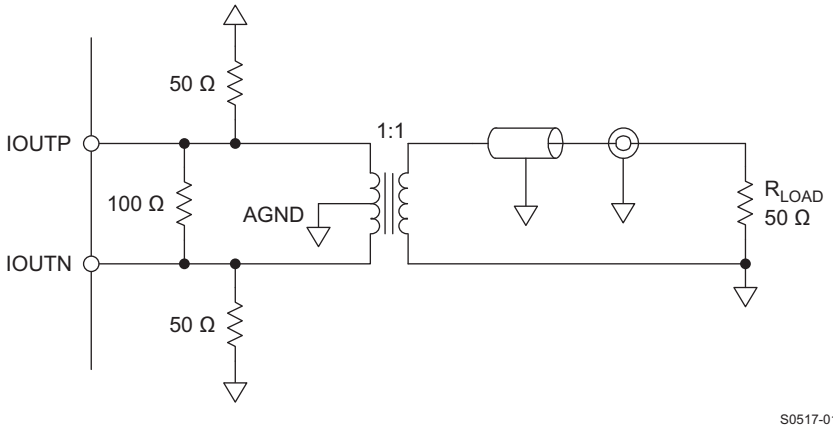

Figure 36. Driving a Doubly terminated 50 Ω Cable Using a 1:1 Impedance Ratio Transformer

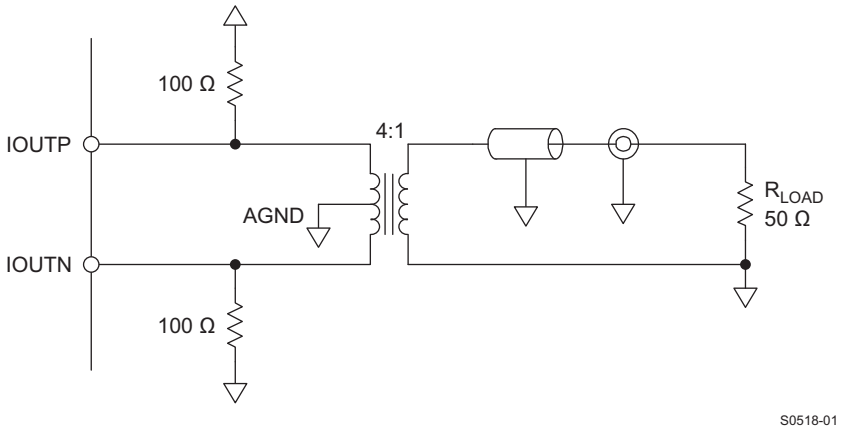

Figure 37. Driving a Doubly Terminated 50 Ω Cable Using a 4:1 Impedance Ratio Transformer

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