DAC3xJ84 Quad-Channel, 16-Bit, 1.6/2.5 GSPS, Digital-to-Analog Converters with 12.5 Gbps JESD204B Interface

1 Features

- Resolution: 16-Bit
- Maximum Sample Rate:
  - DAC37J84: 1.6 GSPS
  - DAC38J84: 2.5 GSPS
- Maximum Input Data Rate: 1.23GSPS
- JESD204B Interface
  - 8 JESD204B Serial Input Lanes
  - 12.5 Gbps Maximum Bit Rate per Lane
  - Subclass 1 Multi-DAC Synchronization
- On-Chip Very Low Jitter PLL
- Selectable 1x -16x Interpolation
- Independent Complex Mixers with 48-bit NCO/ or ±n×Fs/8
- Wideband Digital Quadrature Modulator Correction
- Sinx/x Correction Filters
- Fractional Sample Group Delay Correction
- Multi-Band Mode: Digital Summation of Independent Complex Signals
- 3/4-Wire Serial Control Bus (SPI):1.5V – 1.8V
- Integrated Temperature Sensor
- JTAG Boundary Scan
- Terminal-Compatible with Dual-Channel DAC37J82/DAC38J82 Family
- Power Dissipation: 1.8W at 2.5GSPS
- Package: 10x10mm, 144-Ball Flip-Chip BGA

2 Applications

- Cellular Base Stations
- Diversity Transmit
- Wideband Communications
- Direct Digital Synthesis (DDS) instruments
- Millimeter/Microwave Backhaul
- Automated Test Equipment
- Cable Infrastructure

3 Description

The terminal-compatible DAC37J84/DAC38J84 family is a low power, 16-bit, quad-channel, 1.6/2.5 GSPS digital to analog converter (DAC) with JESD204B interface.

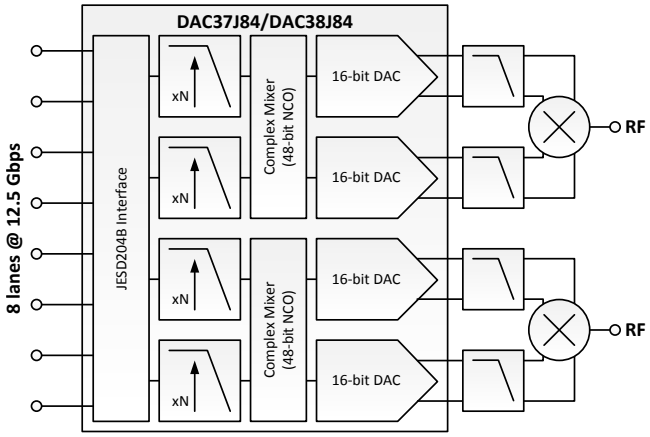
Digital data is input to the device through 1, 2, 4 or 8 configurable serial JESD204B lanes running up to 12.5 Gbps with on-chip termination and programmable equalization. The interface allows JESD204B Subclass 1 SYSREF based deterministic latency and full synchronization of multiple devices.

The device includes features that simplify the design of complex transmit architectures. Fully bypassable 2x to 16x digital interpolation filters with over 90 dB of stop-band attenuation simplify the data interface and reconstruction filters. An on-chip 48-bit Numerically Controlled Oscillator (NCO) and independent complex mixers allow flexible and accurate carrier placement.

A high-performance low jitter PLL simplifies clocking of the device without significant impact on the dynamic range. The digital Quadrature Modulator Correction (QMC) and Group Delay Correction (QDC) enable complete IQ compensation for gain, offset, phase, and group delay between channels in direct up-conversion applications. A programmable Power Amplifier (PA) protection mechanism is available to provide PA protection in cases when the abnormal power behavior of the input data is detected.

Device Information

ORDER NUMBER	PACKAGE	BODY SIZE
DAC37J84IAAV	FCBGA (144)	10 mm x 10 mm
DAC38J84IAAV	FCBGA (144)	10 mm x 10 mm



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4 Revision History

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

Changes from Revision A (January 2014) to Revision B	Page
• Changed from Product Preview to Production Data	1

Changes from Original (January 2014) to Revision A	Page
• Changed Terminal Configuration	4

Device Comparison Table

DEVICE	MAXIMUM SAMPLE RATE	PACKAGE DRAWING/TYPE(1)	T_A
DAC37J84IAAV	1.6 GSPS	AAV/144-ball flip chip BGA	–40°C to 85°C
DAC38J84IAAV	2.5 GSPS	AAV/144-ball flip chip BGA	–40°C to 85°C

(1) MSL Peak Temperature: Level-3-260C-168 HR

5 Terminal Configuration and Functions

144-Ball Flip Chip BGA
AAV Package
(Top View)

	A	B	C	D	E	F	G	H	J	K	L	M	
12	GND	IOUTAP	IOUTAN	IOUTBN	IOUTBP	GND	GND	IOUTCP	IOUTCN	IOUTDN	IOUTDP	GND	12
11	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	GND	11
10	DACCLKP	VDDAPLL 1.8V	VDDAREF 1.8V	VDDADAC 3.3V	VDDADAC 3.3V	EXTIO	RBIAS	VDDADAC 3.3V	VDDADAC 3.3V	VDDAREF 1.8V	SDIO	SDO	10
9	DACCLKN	VDDAPLL 1.8V	LPF	VDDDAC 0.9V	VDDDAC 0.9V	VDDDAC 0.9V	VDDDAC 0.9V	VDDDAC 0.9V	VDDDAC 0.9V	ATEST	SCLK	SDENB	9
8	VDDCLK 0.9V	VDDCLK 0.9V	GND	GND	GND	GND	GND	GND	GND	RESETB	ALARM	SLEEP	8
7	SYSREFP	SYNCBP	VDDS 1.8V	VDDS 1.8V	GND	GND	GND	GND	VDDDIG 0.9V	VDDIO 1.8V	SYNC_N_CD	NC	7
6	SYSREFN	SYNCBN	VDDS 1.8V	VDDS 1.8V	GND	GND	GND	GND	VDDDIG 0.9V	VDDIO 1.8V	SYNC_N_AB	NC	6
5	GND	GND	IFORCE	VDDDIG 0.9V	GND	GND	GND	GND	VDDDIG 0.9V	TXENABLE	TDI	TDO	5
4	GND	GND	VSENSE	VDDDIG 0.9V	VDDDIG 0.9V	VDDDIG 0.9V	VDDDIG 0.9V	VDDDIG 0.9V	VDDDIG 0.9V	TCLK	TMS	GND	4
3	RXP7	GND	GND	VDDDIG 0.9V	AMUX1	VDDT 0.9V	VDDT 0.9V	AMUX0	TRSTB	TESTMODE	GND	RXP3	3
2	RXN7	GND	GND	GND	GND	VDDR 1.8V	VDDR 1.8V	GND	GND	GND	GND	RXN3	2
1	RXN6	RXP6	RXP5	RXN5	RXN4	RXP4	RXP0	RXN0	RXN1	RXP1	RXP2	RXN2	1
	A	B	C	D	E	F	G	H	J	K	L	M	

Terminal Functions

TERMINAL		I/O	DESCRIPTION
NAME	NUMBER		
ALARM	L8	O	CMOS output for ALARM condition. The ALARM output functionality is defined through the *config7 register*. Default polarity is active high, but can be changed to active high via *config0 alarm_out_pol* control bit. If not used it can be left open.
AMUX0	H3	I/O	Analog test terminal for SerDes, Lane 0 to Lane 3. It can be left open if not used.
AMUX1	E3	I/O	Analog test terminal for SerDes, Lane 4 to Lane 7. It can be left open if not used.
ATEST	K9	I/O	Analog test terminal for DAC, references and PLL. It can be left open if not used.
DACCLKP	A10	I	Positive LVPECL clock input for DAC core with V_{cm} = 0.5V. It can be PLL reference clock or external DAC sampling rate clock. If not used, DACCLK is self-biased with 100mV differential at V_{cm} = 0.5V.
DACCLKN	A9	I	Complementary LVPECL clock input for DAC core. (see the DACCLKP description)
EXTIO	F10	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 analog GND when used as reference output. It can be left open if not used.
GND	A12, F12, G12, M12, A11, B11, C11, D11, E11, F11, G11, H11, J11, K11, L11, M11, C8, D8, E8, F8, G8, H8, J8, E7, F7, G7, H7, E6, F6, G6, H6, A5, B5, E5, F5, G5, H5, A4, B4, M4, B3, C3, L3, B2, C2, D2, E2, H2, J2, K2, L2	I	These terminals are ground for all supplies.
IFORCE	C5	I/O	Analog test terminal for on chip parametric. It can be left open if not used.
IOUTAP	B12	O	A-Channel DAC current output. Must tied to GND if not used.
IOUTAN	C12	O	A-Channel DAC complementary current output. Must tied to GND if not used.
IOUTBP	E12	O	B-Channel DAC current output. Must tied to GND if not used.
IOUTBN	D12	O	B-Channel DAC complementary current output. Must tied to GND if not used.
IOUTCP	H12	O	C-Channel DAC current output. Must tied to GND if not used.
IOUTCN	J12	O	C-Channel DAC complementary current output. Must tied to GND if not used.
IOUTDP	L12	O	D-Channel DAC current output. Must tied to GND if not used.
IOUTDN	K12	O	D-Channel DAC complementary current output. Must tied to GND if not used.
LPF	C9	I/O	External PLL loop filter connection. It can be left open if not used.
RBIAS	G10	O	Full-scale output current bias. Change the full-scale output current through *coarse_dac(3:0)*. Expected to be 1.92kΩ to GND.
RESETB	K8	I	Active low input for chip RESET, which resets all the programming registers to their default state. Internal pull-up. It can be left open if not used.
RX0P	G1	I	CML SerDes interface lane 0 input, positive, expected to be AC coupled. It can be left open if not used.
RX0N	H1	I	CML SerDes interface lane 0 input, negative, expected to be AC coupled. It can be left open if not used.
RX1P	K1	I	CML SerDes interface lane 1 input, positive, expected to be AC coupled. It can be left open if not used.
RX1N	J1	I	CML SerDes interface lane 1 input, negative, expected to be AC coupled. It can be left open if not used.
RX2P	L1	I	CML SerDes interface lane 2 input, positive, expected to be AC coupled. It can be left open if not used.
RX2N	M1	I	CML SerDes interface lane 2 input, negative, expected to be AC coupled. It can be left open if not used.
RX3P	M3	I	CML SerDes interface lane 3 input, positive, expected to be AC coupled. It can be left open if not used.

Terminal Functions (continued)

TERMINAL		I/O	DESCRIPTION
NAME	NUMBER		
RX3N	M2	I	CML SerDes interface lane 3 input, negative, expected to be AC coupled. It can be left open if not used.
RX4P	F1	I	CML SerDes interface lane 4 input, positive, expected to be AC coupled. It can be left open if not used.
RX4N	E1	I	CML SerDes interface lane 4 input, negative, expected to be AC coupled. It can be left open if not used.
RX5P	C1	I	CML SerDes interface lane 5 input, positive, expected to be AC coupled. It can be left open if not used.
RX5N	D1	I	CML SerDes interface lane 5 input, negative, expected to be AC coupled. It can be left open if not used.
RX6P	B1	I	CML SerDes interface lane 6 input, positive, expected to be AC coupled. It can be left open if not used.
RX6N	A1	I	CML SerDes interface lane 6 input, negative, expected to be AC coupled. It can be left open if not used.
RX7P	A3	I	CML SerDes interface lane 7 input, positive, expected to be AC coupled. It can be left open if not used.
RX7N	A2	I	CML SerDes interface lane 7 input, negative, expected to be AC coupled. It can be left open if not used.
SYSREFP	A7	I	LVPECL SYSREF positive input with V_{cm} = 0.5V. This positive/negative pair is captured with the rising edge of DACCLKP/N. It is used for JESD204B Subclass 1 deterministic latency and multiple DAC synchronization, which can be periodic or pulsed. If not used, it is self-biased with 100mV differential at V_{cm} = 0.5V.
SYSREFN	A6	I	LVPECL SYSREF negative input with V_{cm} = 0.5V. (See the SYSREFP description)
SCLK	L9	I	Serial interface clock. Internal pull-down. It can be left open if not used.
SDENB	M9	I	Active low serial data enable, always an input to the DAC37J84/DAC38J84. Internal pull-up. It can be left open if not used.
SDIO	L10	I/O	Serial interface data. Bi-directional in 3-terminal mode (default) and 4-terminal mode. Internal pull-down. It can be left open if not used.
SDO	M10	O	Uni-directional serial interface data in 4-terminal mode. The SDO terminal is tri-stated in 3-terminal interface mode (default). It can be left open if not used.
SLEEP	M8	I	Active high asynchronous hardware power-down input. Internal pull-down. It can be left open if not used.
SYNCBP	B7	O	Synchronization request to transmitter, LVDS positive output. It can be left open if not used.
SYNCBN	B6	O	Synchronization request to transmitter, LVDS negative output. It can be left open if not used.
SYNC_N_AB	L6	O	Synchronization request to transmitter, CMOS output. Defaults to link 0, but can be programmable for any link. It can be left open if not used.
SYNC_N_CD	L7	O	Synchronization request to transmitter, CMOS output. Defaults to link 1, but can be programmable for any link. It can be left open if not used.
TCLK	K4	I	JTAG test clock. It can be left open if not used.
TDI	L5	I	JTAG test data in. It can be left open if not used.
TDO	M5	O	JTAG test data out. It can be left open if not used.
TMS	L4	I	JTAG test mode select. It can be left open if not used.
TRSTB	J3	I	JTAG test reset. Must be tied to GND to hold the JTAG state machine status reset if the JTAG port is not used.
TXENABLE	K5	I	To enable analog output data transmission, set *sif_txenable* in register *config3* to “1” or pull CMOS TXENABLE terminal to high. Transmit enable active high input. Internal pull-down. To disable analog output, set *sif_txenable* to “0” and pull CMOS TXENABLE terminal to low. The DAC output is forced to midscale. It can be left open if not used.
TESTMODE	K3	O	This terminal is used for factory testing. Internal pull-down. It can be left open if not used.
VDDADAC33	D10, E10, H10, J10,	I	Analog supply voltage. (3.3V)
VDDAPLL18	B10, B9	I	PLL analog supply voltage. (1.8V)
VDDAREF18	C10, K10	I	Analog reference supply voltage (1.8V)

Terminal Functions (continued)

TERMINAL		I/O	DESCRIPTION
NAME	NUMBER		
VDDCLK09	A8, B8	I	Internal clock buffer supply voltage (0.9V). It is recommended to isolate this supply from VDDDIG09.
VDDDAC09	D9, E9, F9, G9, H9, J9	I	DAC core supply voltage. (0.9V). It is recommended to isolate this supply from VDDDIG09.
VDDDIG09	J7, J6, D5, J5, D4, E4, F4, G4, H4, J4, D3	I	Digital supply voltage. (0.9V). It is recommended to isolate this supply from VDDCLK09 and VDDDAC09.
VDDIO18	K7, K6	I	Supply voltage for all digital I/O and CMOS I/O. (1.8V)
VDDR18	F2, G2	I	Supply voltage for SerDes (1.8V)
VDDS18	C7, C6	I	Supply voltage for LVDS SYNCBP/N (1.8V)
VDDT09	F3, G3	I	Supply voltage for SerDes termination (0.9V)
VQPS18	D7, D6	I	Fuse supply voltage. This supply terminal is also used for factory fuse programming. Connect to 1.8V.
VSENSE	C4	I/O	Analog test terminal for on chip parametric. It can be left open if not used.

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Supply Voltage Range(2)	VDDDAC09, VDDDIG09	–0.3	1.3	V
	VDDCLK09	–0.3	1.3	V
	VDDT09	–0.3	1.3	V
	VDDR18, VDDIO, VDDS18, VQPS18	–0.3	2.45	V
	VDDAPLL18, VDDAREF18	–0.3	2.45	V
	VDDADAC33	–0.3	4.0	V
Terminal Voltage Range(2)	RX[7..0]P/N	–0.5 V	VDDT09 + 0.5 V	V
	SDENB, SCLK, SDIO, SDO, TXENA, ALARM, RESETB, SLEEP, TMS, TCLK, TDI, TDO, TRSTB, TESTMODE, SYNC_N_AB, SYNC_N_CD	–0.5 V	VDDIO18 + 0.5 V	V
	DACCLKP/N, SYSREFP/N	–0.5 V	VDDAPLL18 + 0.5 V	V
	SYNCBP/N	–0.5 V	VDDS18 + 0.5 V	V
	LPF	–0.5 V	VDDAPLL18 + 0.5 V	V
	IOUTAP/N, IOUTBP/N, IOUTCP/N, IOUTDP/N	–0.5 V	1.0 V	V
	RBIAS, EXTIO, ATEST	–0.5 V	VDDAREF18 + 0.5 V	V
	IFORCE, VSENSE	–0.5 V	VDDDIG09 + 0.5 V	V
	AMUX1, AMUX0	–0.5 V	VDDT09 + 0.5 V	V
Peak input current (any input)			20	mA
Peak total input current (all inputs)			–30	mA
Absolute maximum junction temperature T_J			150	°C
Operating free-air temperature range, T_A: DAC37J84/DAC38J84		–40	85	°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.

6.2 Handling Ratings

PARAMETER	DEFINITION	MIN	MAX	UNIT
T_{stg}	Storage temperature range	–65	150	°C

6.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
T_J	Recommended operating junction temperature(1)			105	°C
	Maximum rated operating junction temperature	125			°C
T_A	Recommended free-air temperature	-40	25	85	°C

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

6.4 Thermal Information

THERMAL CONDUCTIVITY(1)		DAC3xJ84 AAV (144 TERMINALS)	UNIT
$R_{\theta JA}$	Theta junction-to-ambient (still air)	31.4	°C/W
$R_{\theta JB}$	Theta junction-to-board	12.6	
$R_{\theta JC}$	Theta junction-to-case, top	1.8	
ψ_{JT}	Psi junction-to-top of package	0.2	
ψ_{JB}	Psi junction-to-bottom of package	12	

(1) Air flow or heat sinking reduces θ_{JA} and may be required for sustained operation at 85° and maximum operating conditions.

6.5 DC Electrical Characteristics

Typical values at T_A = 25°C, full temperature range is T_{MIN} = -40°C to T_{MAX} = 85°C, nominal supplies, unless otherwise noted.

PARAMETER		TEST CONDITIONS	DAC37J84			DAC38J84			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
Resolution			16			16			Bits
DC ACCURACY									
DNL	Differential nonlinearity	1 LSB = $IOUT_{FS}/2^{16}$		±4			±4		LSB
INL	Integral nonlinearity			±6			±6		LSB
ANALOG OUTPUT									
	Coarse gain linearity			±0.04			±0.04		LSB
	Offset error	Mid code offset		±0.001			±0.001		%FSR
	Gain error	With external reference		±2			±2		%FSR
		With internal reference		±2			±2		
	Gain mismatch	With internal reference		±2			±2		%FSR
	Full scale output current			20	30		20	30	mA
	Output compliance		–0.5		0.6	–0.5		0.6	V
	Output resistance			300			300		kΩ
	Output capacitance			5			5		pF
REFERENCE OUTPUT									
V_{REF}	Reference output voltage			0.9			0.9		V
	Reference output current(1)			100			100		nA
REFERENCE INPUT									
V_{EXTIO}	Input voltage	External Reference Mode	0.1	0.9	1	0.1	0.9	1	V
	Input resistance			1			1		MΩ
	Input capacitance			50			50		pF
TEMPERATURE COEFFICIENTS									
	Offset drift			±1			±1		ppm/°C
	Gain drift	with external reference		±15			±15		ppm/°C
		with internal reference		±30			±30		
	Reference voltage drift			±8			±8		ppm/°C

(1) Use an external buffer amplifier with high impedance input to drive any external load

DC Electrical Characteristics (continued)

Typical values at T_A = 25°C, full temperature range is T_{MIN} = -40°C to T_{MAX} = 85°C, nominal supplies, unless otherwise noted.

PARAMETER		TEST CONDITIONS	DAC37J84			DAC38J84			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
POWER SUPPLY									
	VDDADAC33		3.15	3.3	3.45	3.15	3.3	3.45	V
	VDDAPLL18, VDDAREF18, VDDS18, VQPS18, VDDR18		1.71	1.8	1.89	1.71	1.8	1.89	V
	VDDIO18		1.71	1.8	1.89	1.71	1.8	1.89	V
	VDDDIG09, VDDDAC09, VDDCLK09, VDDT09		0.85	0.9	0.95	0.85	0.9	0.95	V
PSRR	Power Supply Rejection Ratio	DC tested		±0.2			±0.2		%FSR/V
POWER CONSUMPTION									
$I_{(VDDADAC33)}$	Analog supply current	MODE 1:(DAC38J84) f_{DAC}=2.46GSPS, 2x interpolation, NCO on, QMC on, inverse sinc on, GDC off, PAP off, PLL on, LMF=841, SerDes rate = 12.3Gbps, 20mA FS output, IF=150MHz.		-			114	135	mA
$I_{(VDDDIG09)}$	Digital supply current			-			1028	1250	
$I_{(VDDDAC09)}$	DAC supply current			-			20	30	
$I_{(VDDCLK09)}$	Clock supply current			-			87	120	
$I_{(VDDT09)}$	SerDes core supply current			-			323	450	
$I_{(VDDR18)}$	SerDes analog supply current			-			37	60	
$I_{(VDD18)}$	Other 1.8V supply current			-			58	80	
P	Power Dissipation			-			1859	1980	mW
$I_{(VDDADAC33)}$	Analog supply current	MODE 2: (DAC37J84) f_{DAC}=1.6GSPS, 2x interpolation, NCO on, QMC on, invsinc on, GDC off, PAP off, PLL on, LMF=841, SerDes rate = 8Gbps, 20mA FS output, IF=150MHz.		114			-		mA
$I_{(VDDDIG09)}$	Digital supply current			627			-		
$I_{(VDDDAC09)}$	DAC supply current			14			-		
$I_{(VDDCLK09)}$	Clock supply current			57			-		
$I_{(VDDT09)}$	SerDes core supply current			268			-		
$I_{(VDDR18)}$	SerDes analog supply current			25			-		
$I_{(VDD18)}$	Other 1.8V supply current			54			-		
P	Power Dissipation			1388			-		mW
$I_{(VDDADAC33)}$	Analog supply current	MODE 3: f_{DAC}=1.47456GSPS, 2x interpolation, NCO on, QMC off, invsinc off, GDC off, PAP off, PLL off, LMF=841, SerDes rate = 7.3728Gbps, 20mA FS output, IF=150MHz.		114			114		mA
$I_{(VDDDIG09)}$	Digital supply current			556			556		
$I_{(VDDDAC09)}$	DAC supply current			14			14		
$I_{(VDDCLK09)}$	Clock supply current			51			51		
$I_{(VDDT09)}$	SerDes core supply current			260			260		
$I_{(VDDR18)}$	SerDes analog supply current			24			24		
$I_{(VDD18)}$	Other 1.8V supply current			36			36		
P	Power Dissipation			1277			1277		mW
$I_{(VDDADAC33)}$	Analog supply current	MODE 4: f_{DAC}=1.47456GSPS, 4x interpolation, NCO on, QMC off, invsinc off, GDC off, PAP off, PLL off, LMF=442, SerDes rate = 7.3728Gbps, 20mA FS output, IF=150MHz.		114			114		mA
$I_{(VDDDIG09)}$	Digital supply current			468			468		
$I_{(VDDDAC09)}$	DAC supply current			14			14		
$I_{(VDDCLK09)}$	Clock supply current			50			50		
$I_{(VDDT09)}$	SerDes core supply current			135			135		
$I_{(VDDR18)}$	SerDes analog supply current			12			12		
$I_{(VDD18)}$	Other 1.8V supply current			36			36		
P	Power Dissipation			1063			1063		mW
$I_{(VDDADAC33)}$	Analog supply current	MODE 5: f_{DAC}=1.47456GSPS, x4, NCO off, QMC off, invsinc off, GDC off, PAP off, PLL off, LMF=442, SerDes rate = 7.3728Gbps, DAC output in sleep mode.		13			13		mA
$I_{(VDDDIG09)}$	Digital supply current			368			368		
$I_{(VDDDAC09)}$	DAC supply current			10			10		
$I_{(VDDCLK09)}$	Clock supply current			50			50		
$I_{(VDDT09)}$	SerDes core supply current			135			135		
$I_{(VDDR18)}$	SerDes analog supply current			12			12		
$I_{(VDD18)}$	Other 1.8V supply current			28			28		
P	Power Dissipation			622			622		mW

DC Electrical Characteristics (continued)

Typical values at T_A = 25°C, full temperature range is T_{MIN} = -40°C to T_{MAX} = 85°C, nominal supplies, unless otherwise noted.

PARAMETER		TEST CONDITIONS	DAC37J84			DAC38J84			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
$I_{(VDDADAC33)}$	Analog supply current	MODE 6: f_{DAC}=1000MSPS, 2x interpolation, NCO off, QMC off, invsinc off, GDC off, PAP off, PLL on, LMF=442, SerDes rate = 10Gbps, 20mA FS output, IF=150MHz.		114			114		mA
$I_{(VDDDIG09)}$	Digital supply current			373			373		
$I_{(VDDDAC09)}$	DAC supply current			12			12		
$I_{(VDDCLK09)}$	Clock supply current			37			37		
$I_{(VDDT09)}$	SerDes core supply current			151			151		
$I_{(VDDR18)}$	SerDes analog supply current			15			15		
$I_{(VDD18)}$	Other 1.8V supply current			56			56		
P	Power Dissipation			1020			1020		mW
$I_{(VDDADAC33)}$	Analog supply current	MODE 7: f_{DAC}=1000MSPS, 2x interpolation, NCO off, QMC off invsinc off, GDC off, PAP off, PLL off, LMF=442, SerDes rate = 10Gbps, 20mA FS output, IF=150MHz.		114			114		mA
$I_{(VDDDIG09)}$	Digital supply current			372			372		
$I_{(VDDDAC09)}$	DAC supply current			12			12		
$I_{(VDDCLK09)}$	Clock supply current			35			35		
$I_{(VDDT09)}$	SerDes core supply current			151			151		
$I_{(VDDR18)}$	SerDes analog supply current			15			15		
$I_{(VDD18)}$	Other 1.8V supply current			35			35		
P	Power Dissipation			979			979		mW
$I_{(VDDADAC33)}$	Analog supply current	MODE 8: f_{DAC}=625MSPS, 2x interpolation, NCO off, QMC off, invsinc off, GDC off, PAP off, PLL off, LMF=841, SerDes rate = 3.125Gbps, 20mA FS output, IF=20MHz.		114			114		mA
$I_{(VDDDIG09)}$	Digital supply current			247			247		
$I_{(VDDDAC09)}$	DAC supply current			5			5		
$I_{(VDDCLK09)}$	Clock supply current			22			22		
$I_{(VDDT09)}$	SerDes core supply current			228			228		
$I_{(VDDR18)}$	SerDes analog supply current			21			21		
$I_{(VDD18)}$	Other 1.8V supply current			26			26		
P	Power Dissipation			913			913		mW
$I_{(VDDADAC33)}$	Analog supply current	MODE 9: f_{DAC}=1.23GSPS, no interpolation, NCO off, QMC off, invsinc off, GDC off, PAP off, PLL off, LMF=841, SerDes rate = 12.3Gbps, 20mA FS output, IF=150MHz;		114			114		mA
$I_{(VDDDIG09)}$	Digital supply current			477			477		
$I_{(VDDDAC09)}$	DAC supply current			12			12		
$I_{(VDDCLK09)}$	Clock supply current			44			44		
$I_{(VDDT09)}$	SerDes core supply current			322			322		
$I_{(VDDR18)}$	SerDes analog supply current			39			39		
$I_{(VDD18)}$	Other 1.8V supply current			36			36		
P	Power Dissipation			1281			1281		mW
$I_{(VDDADAC33)}$	Analog supply current	MODE 10: Power down mode, no clock, DAC in sleep mode, SerDes in sleep mode		5			5		mA
$I_{(VDDDIG09)}$	Digital supply current			75			75		
$I_{(VDDDAC09)}$	DAC supply current			1			1		
$I_{(VDDCLK09)}$	Clock supply current			1			1		
$I_{(VDDT09)}$	SerDes core supply current			9			9		
$I_{(VDDR18)}$	SerDes analog supply current			0			0		
$I_{(VDD18)}$	Other 1.8V supply current			10			10		
P	Power Dissipation			112			112		mW

6.6 Digital Electrical Characteristics

Typical values at T_A = 25°C, full temperature range is T_{MIN} = –40°C to T_{MAX} = 85°C, nominal supplies, unless otherwise noted.

PARAMETER		TEST CONDITIONS	DAC37J84			DAC38J84			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
CML SERDES INPUTS: RX[7:0]P/N									
V_{DIFF}	Receiver Input Amplitude		50		1200	50		1200	mV
V_{COM}	Input Common Mode (TERM=111)			600			600		mV
	Input Common Mode (TERM=001)			700			700		
	Input Common Mode (TERM=100)			0			0		
	Input Common Mode (TERM=101)			250			250		
Z_{DIFF}	Internal differential termination		85	100	115	85	100	115	Ω
f_{DATA}	Serdes bit rate		0.78125		12.5	0.78125		12.5	Gbps
LVPECL INPUTS: SYSREFP/N									
V_{COM}	Input common mode voltage			0.5			0.5		V
V_{IDPP}	Differential input peak-to-peak voltage		400	800		400	800		mV
Z_T	Internal termination			100			100		Ω
C_L	Input capacitance			2			2		pF
LVPECL INPUTS: DACCLKP/N									
V_{COM}	Input common mode voltage			0.5			0.5		V
V_{IDPP}	Differential input peak-to-peak voltage		400	800		400	800		mV
Z_T	Internal termination			100			100		Ω
C_L	Input capacitance			2			2		pF
	Duty cycle		40%		60%	40%		60%	
f_{DACCLK}	DACCLKP/N Input Frequency				1.6			2.5	GHz
LVDS OUTPUTS: SYNCBP/N									
V_{COM}	Output common mode voltage			1.2			1.2		V
Z_T	Internal termination			100			100		Ω
V_{OD}	Differential output voltage swing			0.5			0.5		V
CMOS INTERFACE: SDENB, SCLK, SDIO, SDO, TXENA, ALARM, RESETB, SLEEP, TMS, TCLK, TDI, TDO, TRSTB, TESTMODE, SYNC_N_AB, SYNC_N_CD									
V_{IH}	High-level input voltage		0.7 x VDDIO			0.7 x VDDIO			V
V_{IL}	Low-level input voltage				0.3 x VDDIO			0.3 x VDDIO	V
I_{IH}	High-level input current		-40		40	-40		40	µA
I_{IL}	Low-level input current		-40		40	-40		40	µA
C_I	CMOS Input capacitance			2			2		pF
V_{OH}	ALARM, SDO, SDIO, TDO	Iload =–100 µA	VDDIO – 0.2			VDDIO – 0.2			V
		Iload = –2 mA	0.8 x VDDIO			0.8 x VDDIO			
V_{OL}	ALARM, SDO, SDIO, TDO	Iload = 100 µA			0.2			0.2	V
		Iload = 2 mA			0.5			0.5	

Digital Electrical Characteristics (continued)

Typical values at T_A = 25°C, full temperature range is T_{MIN} = –40°C to T_{MAX} = 85°C, nominal supplies, unless otherwise noted.

PARAMETER	TEST CONDITIONS	DAC37J84			DAC38J84			UNIT
		MIN	TYP	MAX	MIN	TYP	MAX	
PHASE LOCKED LOOP								
PLL/VCO Operating Frequency	pll_vcosel = '1', pll_vco = '010001'(17), pll_vcoitune = '10', VCO Frequency = 3932.16MHz		Assured			Assured		
	pll_vcosel = '1', pll_vco = '011111'(31), pll_vcoitune = '10', VCO Frequency = 4120MHz		Assured			Assured		
	pll_vcosel = '1', pll_vco = '110010'(50), pll_vcoitune = '10', VCO Frequency = 4423.68MHz		Assured			Assured		
	pll_vcosel = '0', pll_vco = '001101'(13), pll_vcoitune = '11', VCO Frequency = 4608MHz		Assured			Assured		
	pll_vcosel = '0', pll_vco = '011010'(26), pll_vcoitune = '11', VCO Frequency = 4800MHz		Assured			Assured		
	pll_vcosel = '0', pll_vco = '100001'(33), pll_vcoitune = '11', VCO Frequency = 4915.2MHz		Assured			Assured		
	pll_vcosel = '0', pll_vco = '100110'(38), pll_vcoitune = '11', VCO Frequency = 5000MHz		Assured			Assured		

6.7 AC Electrical Characteristics

Typical values at T_A = 25°C, full temperature range is T_{MIN} = –40°C to T_{MAX} = 85°C, nominal supplies, unless otherwise noted.

PARAMETER		TEST CONDITIONS / COMMENTS	DAC37J84			DAC38J84			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
ANALOG OUTPUT (1)									
f_{DAC}	Maximum DAC rate	4x or higher interpolation	1600			2500			MSPS
		2x interpolation	1600			2460			
		1x interpolation	1230			1230			
	Digital Latency (F=2, 2x interpolation)	No interpolation, FIFO off, Mixer off, QMC off, Inverse sinc off		11			11		DAC clock cycles
		2x Interpolation		83			83		
		4x Interpolation		211			211		
		8x Interpolation		483			483		
		16x Interpolation		1051			1051		
		NCO		48			48		
		QMC		32			32		
		Inverse Sinc		36			36		
		PA Protection (*pap_dlylen_sel* = "0")		68			68		
		Dithering		0			0		
		Complex Summation		0			0		
		Coarse Fractional Delay		51			51		
		Fine Fractional Delay		52			52		

(1) Measured single ended into 50 Ω load.

AC Electrical Characteristics (continued)

Typical values at T_A = 25°C, full temperature range is T_{MIN} = –40°C to T_{MAX} = 85°C, nominal supplies, unless otherwise noted.

PARAMETER		TEST CONDITIONS / COMMENTS	DAC37J84			DAC38J84			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
AC PERFORMANCE (2)									
SFDR	Spurious Free Dynamic (0 to f_{DAC}/2)	f_{DAC} = 2.5 GSPS, f_{OUT} = 20 MHz, 0 dBFS		-			79		dBc
		f_{DAC} = 2.5 GSPS, f_{OUT} = 70 MHz, 0dBFS		-			78		
		f_{DAC} = 2.5 GSPS, f_{OUT} = 150 MHz, 0 dBFS		-			72		
		f_{DAC} = 2.5 GSPS, f_{OUT} = 230 MHz, 0dBFS		-			67		
		f_{DAC} = 2.5 GSPS, f_{OUT} = 20 MHz, -12 dBFS		-			79		
		f_{DAC} = 2.5 GSPS, f_{OUT} = 70 MHz, –12dBFS		-			75		
		f_{DAC} = 2.5 GSPS, f_{OUT} = 150 MHz, -12 dBFS		-			70		
		f_{DAC} = 2.5 GSPS, f_{OUT} = 230 MHz, –12dBFS		-			65		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 20 MHz, 0 dBFS		81			81		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 70 MHz, 0 dBFS		77			77		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 150 MHz, 0 dBFS		72			72		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 230 MHz, 0 dBFS		68			68		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 20 MHz, -12 dBFS		76			76		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 70 MHz, –12 dBFS		72			72		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 150 MHz, -12 dBFS		67			67		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 230 MHz, –12 dBFS		64			64		
IMD3	Third-order two-tone intermodulation distortion Each tone at –6dBFS	f_{DAC} = 2.5 GSPS, f_{OUT} = 70 ± 0.5 MHz		-			83		dBc
		f_{DAC} = 2.5 GSPS, f_{OUT} = 150 ± 0.5 MHz		-			75		
		f_{DAC} = 2.5 GSPS, f_{OUT} = 230 ± 0.5 MHz		-			70		
		f_{DAC} = 2.0 GSPS, f_{OUT} = 70 ± 0.5 MHz		-			86		
		f_{DAC} = 2.0 GSPS, f_{OUT} = 150 ± 0.5 MHz		-			78		
		f_{DAC} = 2.0 GSPS, f_{OUT} = 230 ± 0.5 MHz		-			73		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 70 ± 0.5 MHz		83			83		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 150 ± 0.5 MHz		73			73		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 230 ± 0.5 MHz		66			66		
NSD	Noise Spectral Density (2) Tone at –6dBFS	f_{DAC} = 2.5 GSPS, f_{OUT} = 70 MHz		-			-161		dBFS/Hz
		f_{DAC} = 2.5 GSPS, f_{OUT} = 150 MHz		-			–159		
		f_{DAC} = 2.5 GSPS, f_{OUT} = 230 MHz		-			-157		
		f_{DAC} = 2.0 GSPS, f_{OUT} = 70 MHz		-			-161		
		f_{DAC} = 2.0 GSPS, f_{OUT} = 150 MHz		-			-160		
		f_{DAC} = 2.0 GSPS, f_{OUT} = 230 MHz		-			-158		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 70 MHz		-161			-161		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 150 MHz		-159			-159		
		f_{DAC} = 1.6 GSPS, f_{OUT} = 230 MHz		-157			-157		
ACLR (3)	Adjacent channel leakage ratio, single carrier	f_{DAC} = 2.4576 GSPS, f_{OUT} = 70 MHz		-			82		dBc
		f_{DAC} = 2.4576 GSPS, f_{OUT} = 150 MHz		-			80		
		f_{DAC} = 2.4576 GSPS, f_{OUT} = 230 MHz		-			78		
		f_{DAC} = 1.96608 GSPS, f_{OUT} = 70 MHz		-			82		
		f_{DAC} = 1.96608 GSPS, f_{OUT} = 150 MHz		-			80		
		f_{DAC} = 1.96608 GSPS, f_{OUT} = 230 MHz		-			77		
		f_{DAC} = 1.47456 GSPS, f_{OUT} = 70 MHz		82			82		
		f_{DAC} = 1.47456 GSPS, f_{OUT} = 150 MHz		80			80		
		f_{DAC} = 1.47456 GSPS, f_{OUT} = 230 MHz		76			76		
	Channel Isolation	f_{DAC} = 2.5 GSPS, f_{OUT} = 20 MHz		-			93		dBc
		f_{DAC} = 1.6 GSPS, f_{OUT} = 20 MHz		93			93		

(2) 2:1 transformer output termination, 50 Ω doubly terminated load.
(3) Single carrier, W-CDMA with 3.84 MHz BW, 5-MHz spacing, centered at IF. TESTMODEL 1, 10 ms

6.8 Timing Requirements

Typical values at T_A = 25°C, full temperature range is T_{MIN} = –40°C to T_{MAX} = 85°C, nominal supplies, unless otherwise noted.

PARAMETER		TEST CONDITIONS	DAC37J84			DAC38J84			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
DIGITAL INPUT TIMING SPECIFICATIONS									
TIMING SYSREF INPUT: DACCLKP/N RISING EDGE LATCHING									
$t_{s(SYSREF)}$	Setup time, SYSREFP/N valid to rising edge of DACCLKP/N			50			50		ps
$t_{h(SYSREF)}$	Hold time, SYSREF/N valid after rising edge of DACCLKP/N			50			50		ps
TIMING SERIAL PORT									
$t_{s(SDENB)}$	Setup time, SDENB to rising edge of SCLK			20			20		ns
$t_{s(SDIO)}$	Setup time, SDIO valid to rising edge of SCLK			10			10		ns
$t_{h(SDIO)}$	Hold time, SDIO valid to rising edge of SCLK			5			5		ns
$t_{(SCLK)}$	Period of SCLK	Register config7 read (temperature sensor read)		1			1		µs
		All other registers		100			100		ns
$t_{d(Data)}$	Data output delay after falling edge of SCLK			10			10		ns
t_{RESET}	Minimum RESETB pulsewidth			25			25		ns
ANALOG OUTPUT (1)									
$t_{s(DAC)}$	Output settling time to 0.1%	Transition: Code 0x0000 to 0xFFFF		10			10		ns
Power-up Time	DAC Wake-up Time	IOUT current settling to 1% of $IOUT_{FS}$ from deep sleep		90			90		µs
	DAC Sleep Time	IOUT current settling to less than 1% of $IOUT_{FS}$ in deep sleep		90			90		

(1) Measured single ended into 50 Ω load.

6.9 Switching Characteristics

Typical values at T_A = 25°C, full temperature range is T_{MIN} = –40°C to T_{MAX} = 85°C, nominal supplies, unless otherwise noted.

PARAMETER		TEST CONDITIONS	DAC37J84			DAC38J84			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	
ANALOG OUTPUT (1)									
t_{pd}	Output propagation delay	DAC outputs are updated on the falling edge of DAC clock. Does not include Digital Latency (see below).		2			2		ns
$t_{r(IOUT)}$	Output rise time 10% to 90%			50			50		ps
$t_{f(IOUT)}$	Output fall time 90% to 10%			50			50		ps

(1) Measured single ended into 50 Ω load.

6.10 Typical Characteristics

Unless otherwise noted, all plots are at T_A = 25°C, nominal supply voltages, f_{DAC} = 2460MSPS, 2x interpolation, 0dBFS digital input, 20mA full scale output current with 2:1 transformer, LMF = 841 and PLL is disabled.

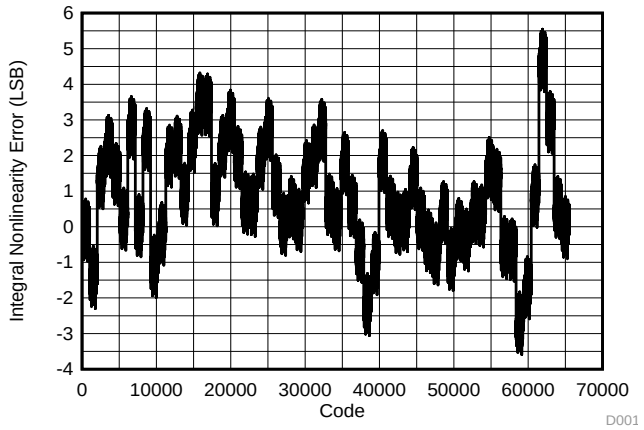


Figure 1. Integral Nonlinearity

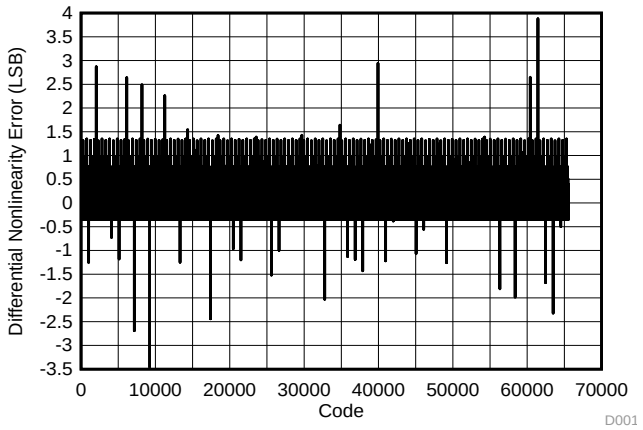


Figure 2. Differential Nonlinearity

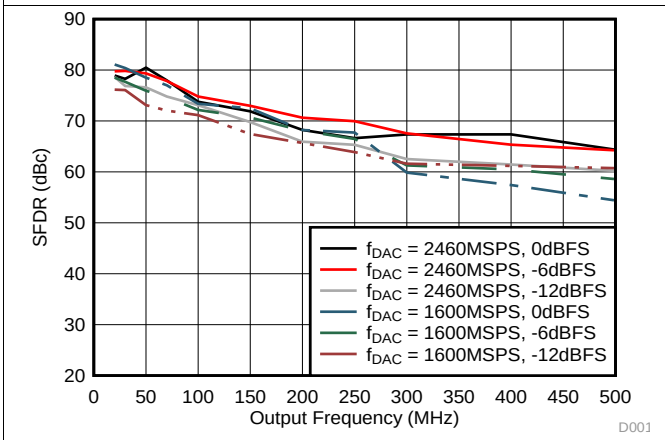


Figure 3. SFDR vs Output Frequency Over Input Scale

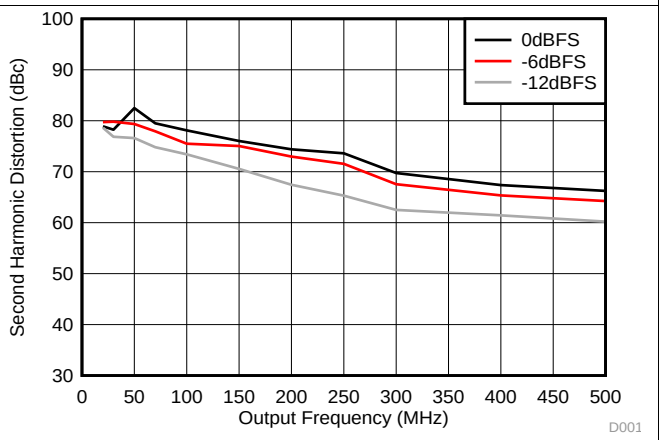


Figure 4. Second Harmonic Distortion vs Output Frequency Over Input Scale

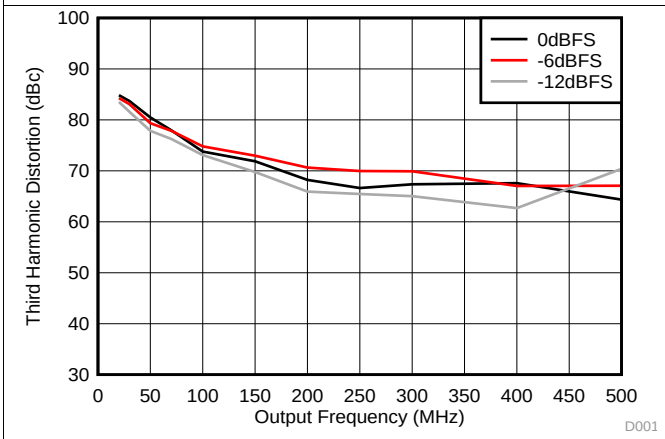


Figure 5. Third Harmonic Distortion vs Output Frequency Over Input Scale

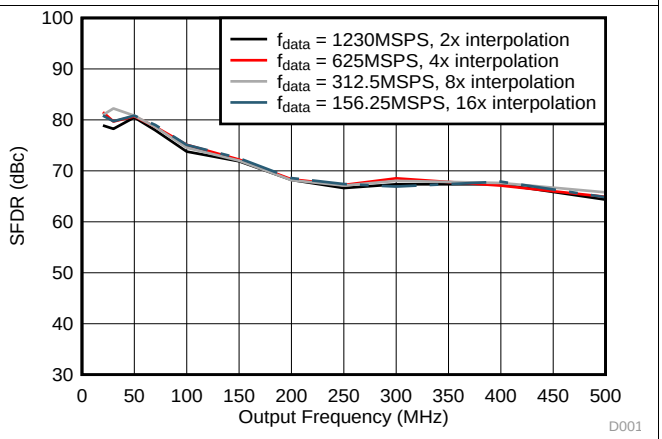


Figure 6. SFDR vs Output Frequency Over Interpolation

Typical Characteristics (continued)

Unless otherwise noted, all plots are at T_A = 25°C, nominal supply voltages, f_{DAC} = 2460MSPS, 2x interpolation, 0dBFS digital input, 20mA full scale output current with 2:1 transformer, LMF = 841 and PLL is disabled.

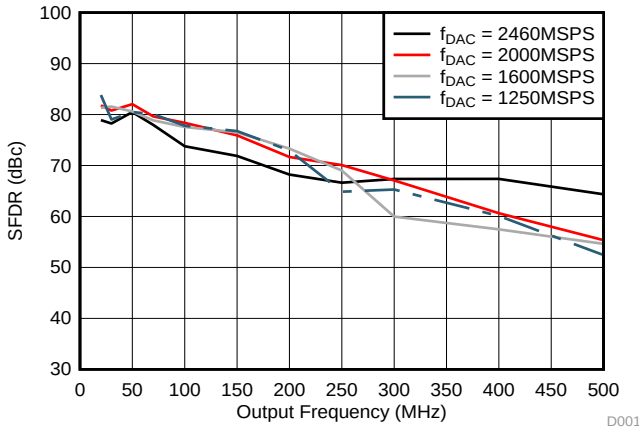


Figure 7. SFDR vs Output Frequency Over f_{DAC}

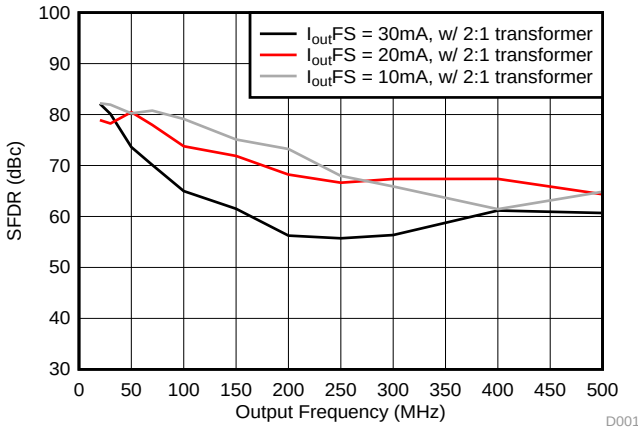
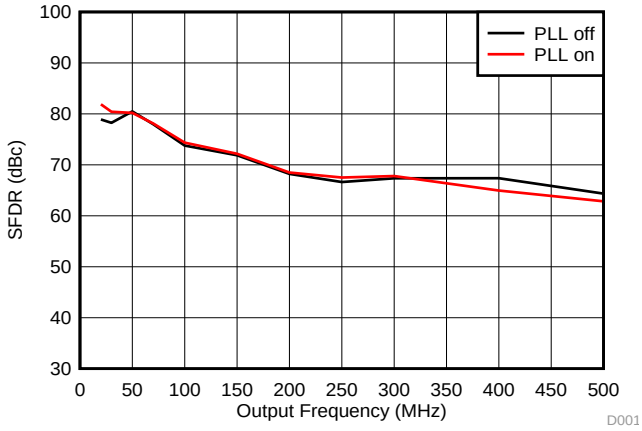
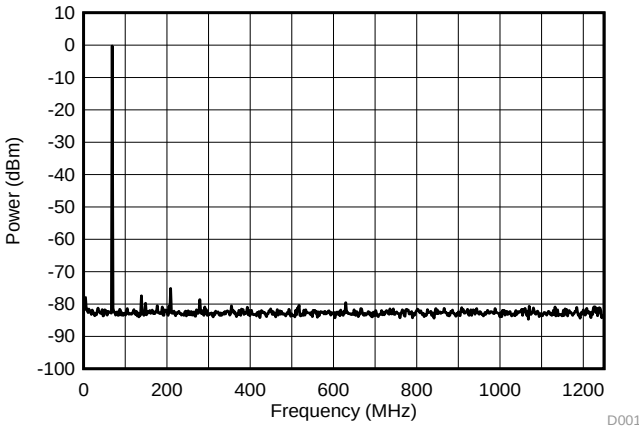


Figure 8. SFDR vs Output Frequency Over $I_{out}FS$



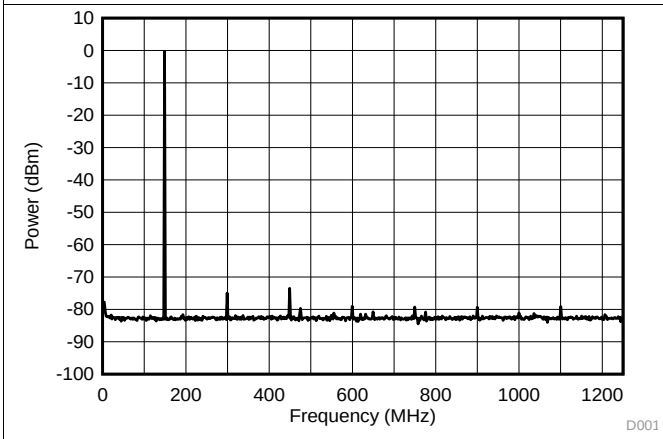
$f_{ref} = f_{DAC}/4$, M = 32, N = 8, Prescaler = 2 for PLL On

Figure 9. SFDR vs Output Frequency Over Clocking Options



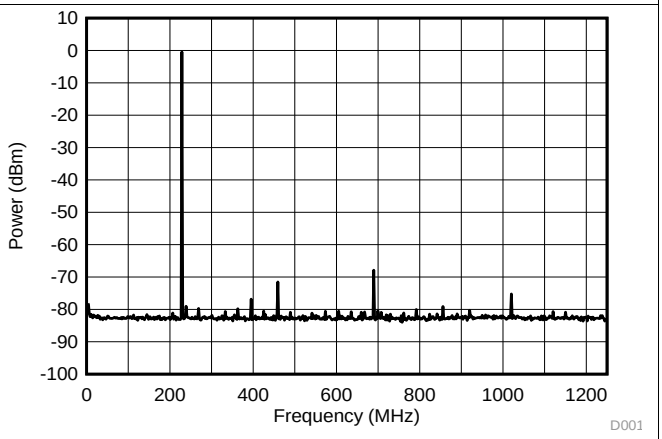
IF = 70MHz

Figure 10. Single Tone Spectral Plot



IF = 150MHz

Figure 11. Single Tone Spectral Plot



IF = 230MHz

Figure 12. Single Tone Spectral Plot

Typical Characteristics (continued)

Unless otherwise noted, all plots are at T_A = 25°C, nominal supply voltages, f_{DAC} = 2460MSPS, 2x interpolation, 0dBFS digital input, 20mA full scale output current with 2:1 transformer, LMF = 841 and PLL is disabled.

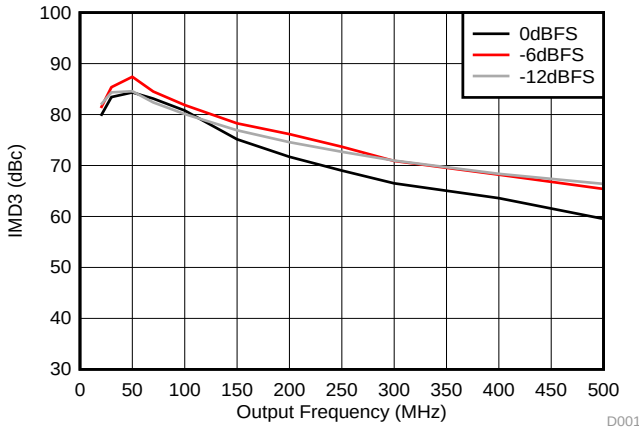


Figure 13. IMD3 vs Output Frequency Over Input Scale

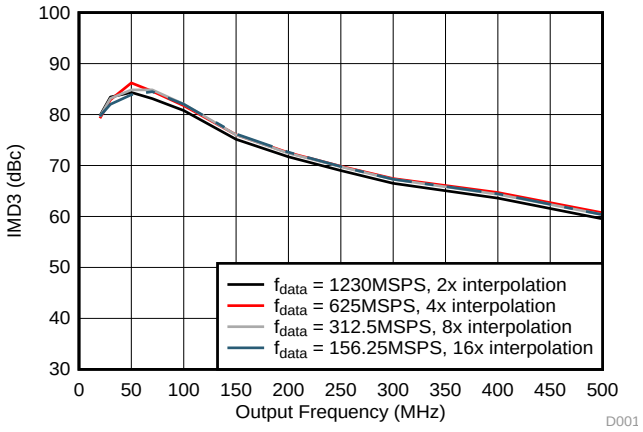


Figure 14. IMD3 vs Output Frequency Over Interpolation

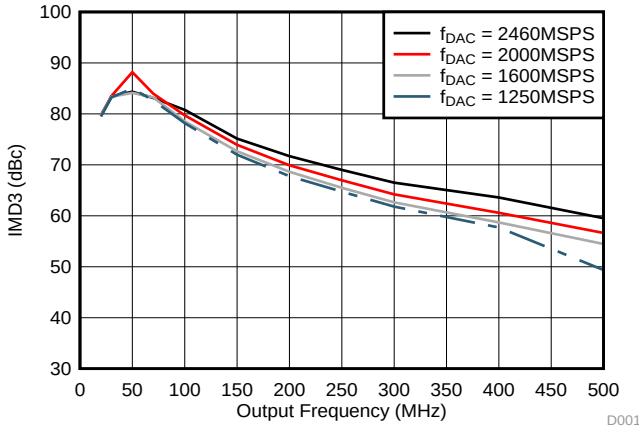


Figure 15. IMD3 vs Output Frequency Over f_{DAC}

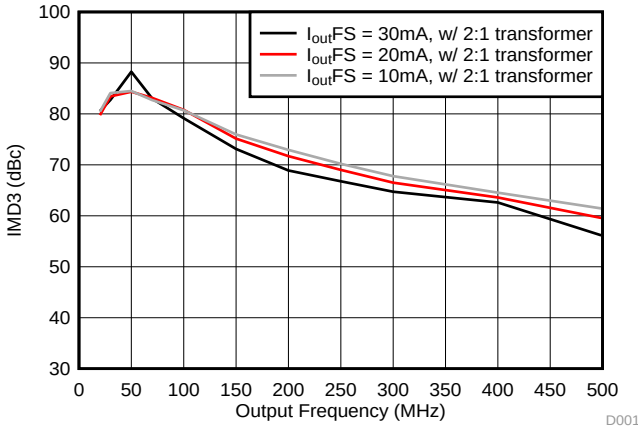
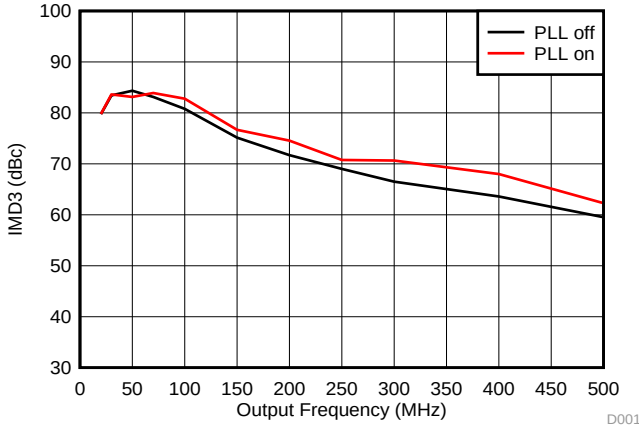
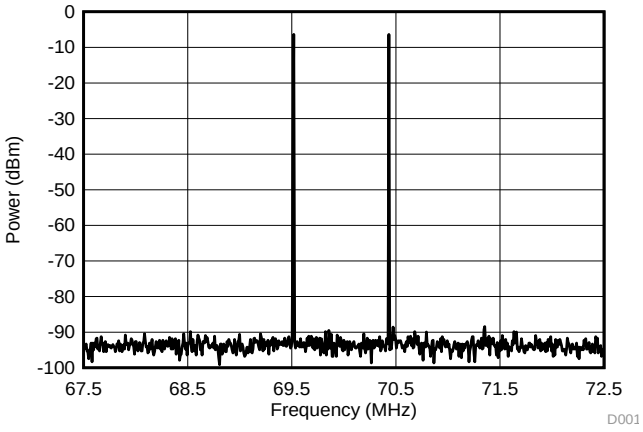


Figure 16. IMD3 vs Output Frequency Over Output Current $I_{out}FS$



$f_{ref} = f_{DAC}/4$, M = 32, N = 8, Prescaler = 2 for PLL On

Figure 17. IMD3 vs Output Frequency Over Clocking Options

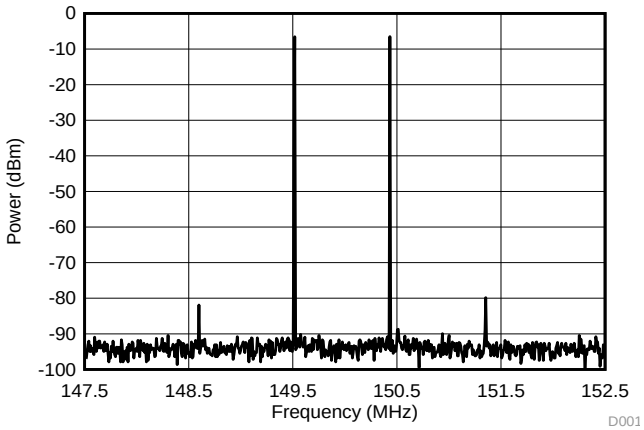


IF = 70MHz, Tone Spacing = 1MHz

Figure 18. Two-tone Spectral Plot

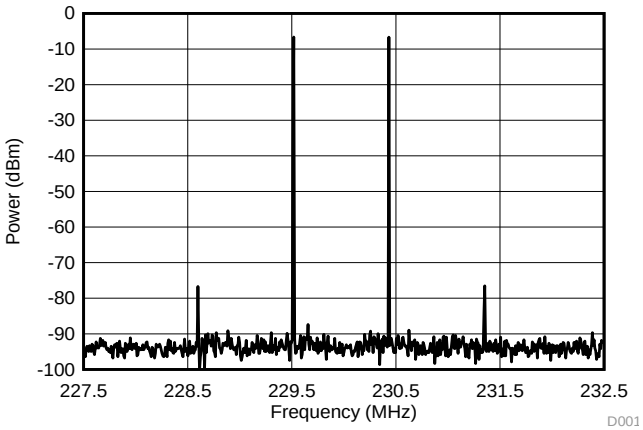
Typical Characteristics (continued)

Unless otherwise noted, all plots are at T_A = 25°C, nominal supply voltages, f_{DAC} = 2460MSPS, 2x interpolation, 0dBFS digital input, 20mA full scale output current with 2:1 transformer, LMF = 841 and PLL is disabled.



IF = 150MHz, Tone Spacing = 1MHz

Figure 19. Two-tone Spectral Plot



IF = 230MHz, Tone Spacing = 1MHz

Figure 20. Two-tone Spectral Plot

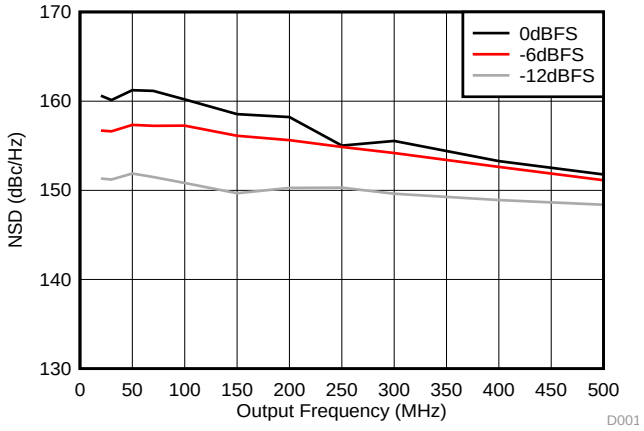


Figure 21. NSD vs Output Frequency Over Input Scale

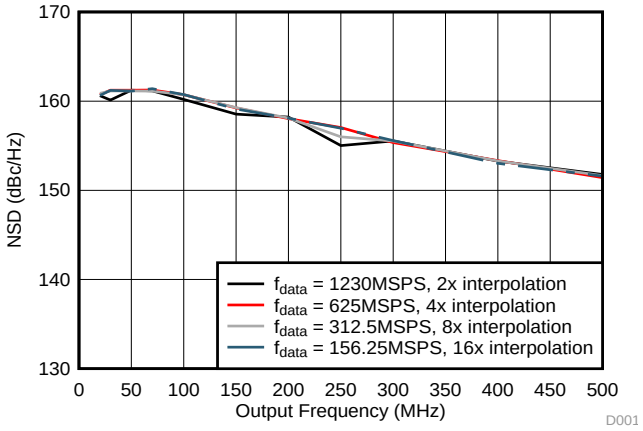


Figure 22. NSD vs Output Frequency Over Interpolation

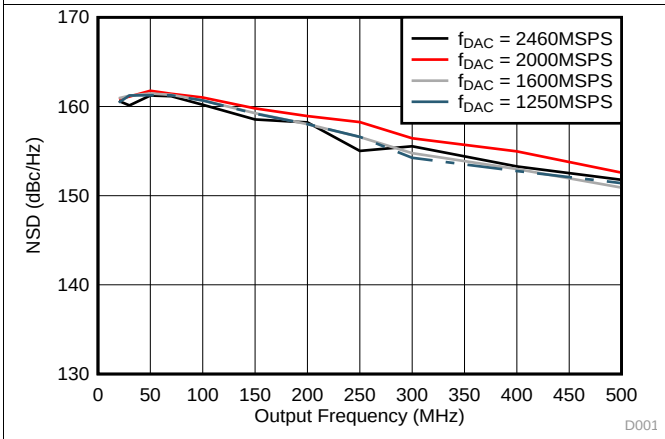


Figure 23. NSD vs Output Frequency Over f_{DAC}

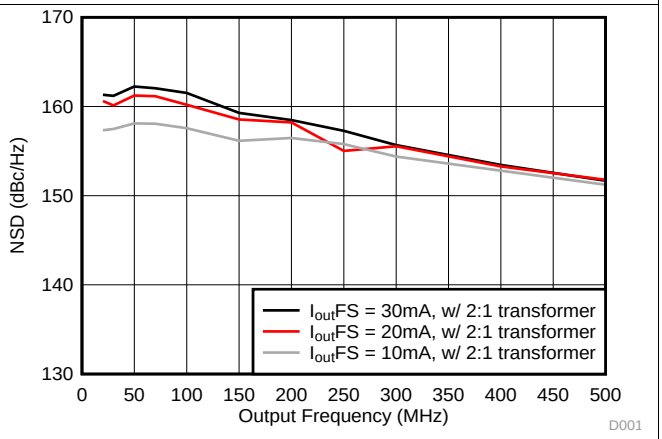
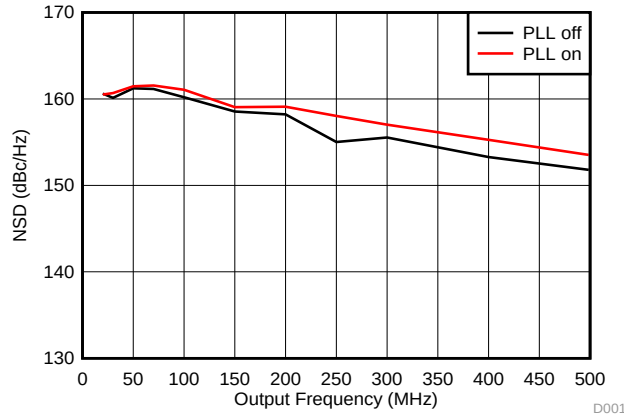


Figure 24. NSD vs Output Frequency Over Output Current I_{outFS}

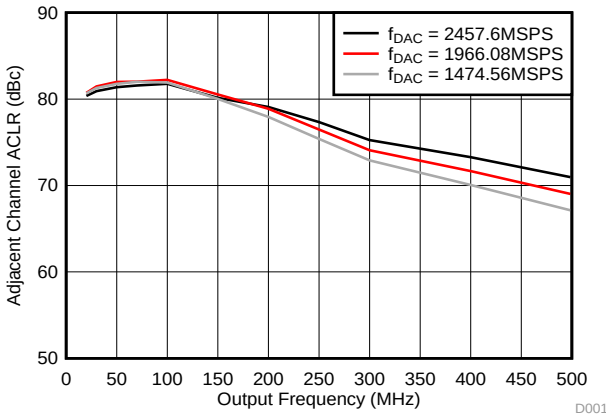
Typical Characteristics (continued)

Unless otherwise noted, all plots are at T_A = 25°C, nominal supply voltages, f_{DAC} = 2460MSPS, 2x interpolation, 0dBFS digital input, 20mA full scale output current with 2:1 transformer, LMF = 841 and PLL is disabled.



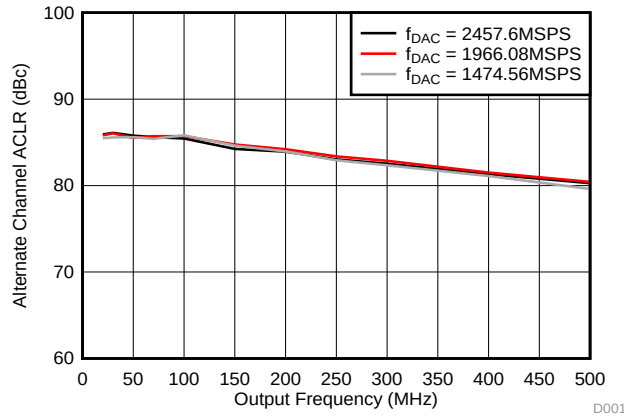
$f_{ref} = f_{DAC}/4$, M = 32, N = 8, Prescaler = 2 for PLL On

Figure 25. NSD vs Output Frequency Over Clocking Options



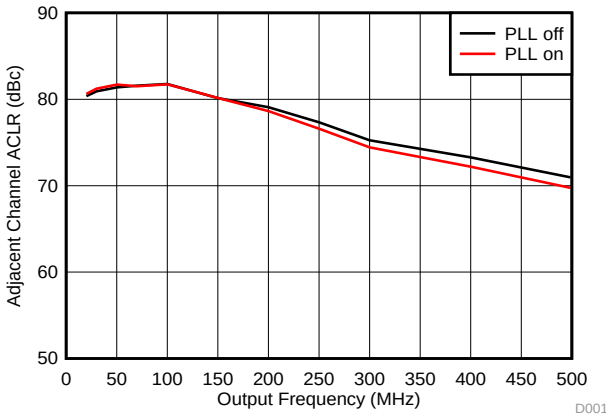
Single Carrier WCDMA

Figure 26. ACLR (Adjacent Channel) vs Output Frequency Over f_{DAC}



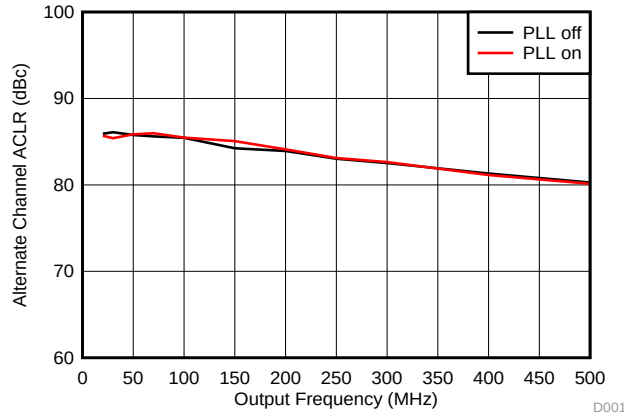
Single Carrier WCDMA

Figure 27. ACLR (Alternate Channel) vs Output Frequency Over f_{DAC}



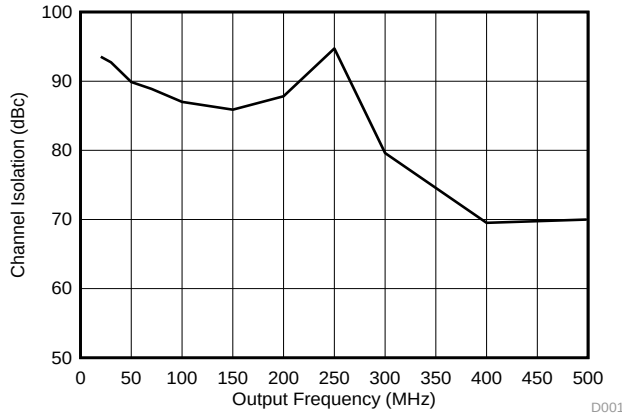
Single Carrier WCDMA; $f_{ref} = f_{DAC}/4$, M = 32, N = 8, Prescaler = 2 for PLL On

Figure 28. ACLR (Adjacent Channel) vs Output Frequency Over Clocking Options



Single Carrier WCDMA; $f_{ref} = f_{DAC}/4$, M = 32, N = 8, Prescaler = 2 for PLL On

Figure 29. ACLR (Alternate Channel) vs Output Frequency Over Clocking Options



Between Channel AB pair and CD pair

Figure 30. Channel Isolation

Typical Characteristics (continued)

Unless otherwise noted, all plots are at T_A = 25°C, nominal supply voltages, f_{DAC} = 2460MSPS, 2x interpolation, 0dBFS digital input, 20mA full scale output current with 2:1 transformer, LMF = 841 and PLL is disabled.

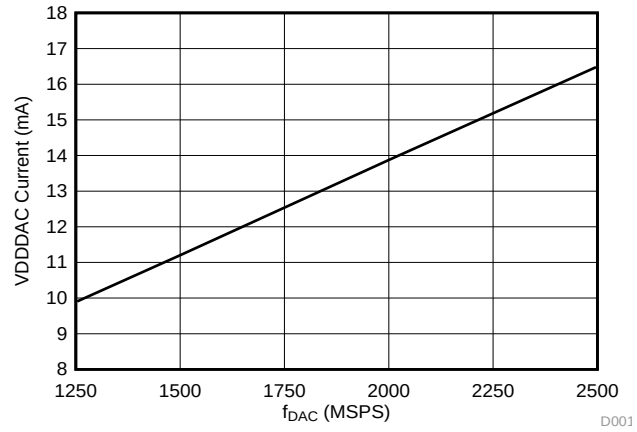


Figure 31. VDDDAC Current vs f_{DAC}

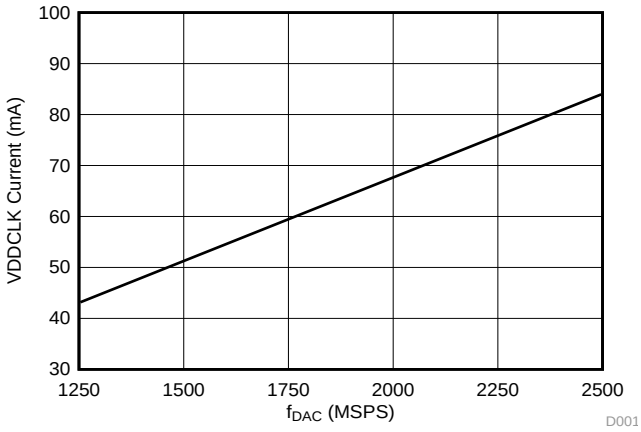


Figure 32. VDDCLK Current vs f_{DAC}

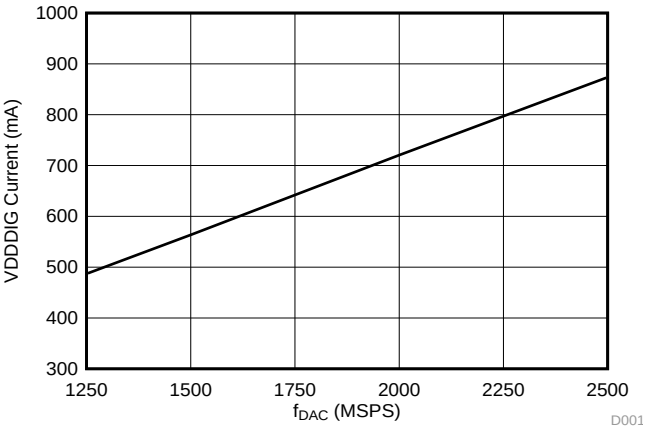


Figure 33. VDDDIG Current vs f_{DAC}

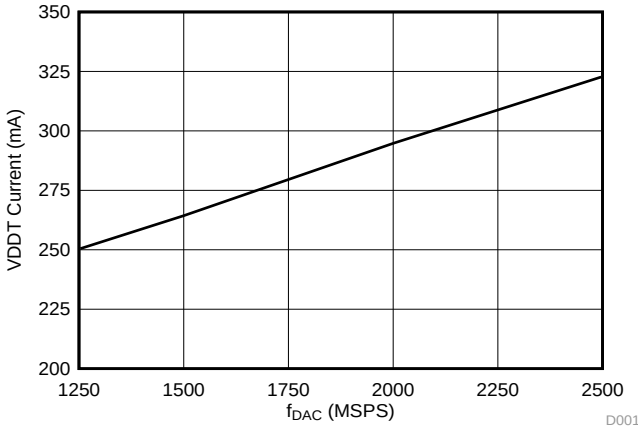


Figure 34. VDDT Current vs f_{DAC}

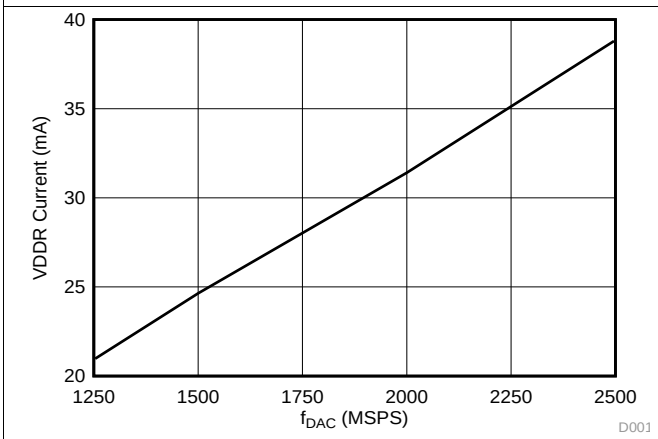


Figure 35. VDDR Current vs f_{DAC}

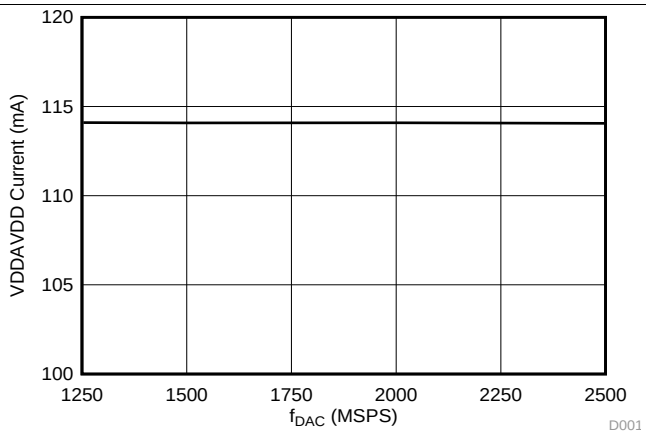


Figure 36. VDDAVDD Current vs f_{DAC}

Typical Characteristics (continued)

Unless otherwise noted, all plots are at T_A = 25°C, nominal supply voltages, f_{DAC} = 2460MSPS, 2x interpolation, 0dBFS digital input, 20mA full scale output current with 2:1 transformer, LMF = 841 and PLL is disabled.

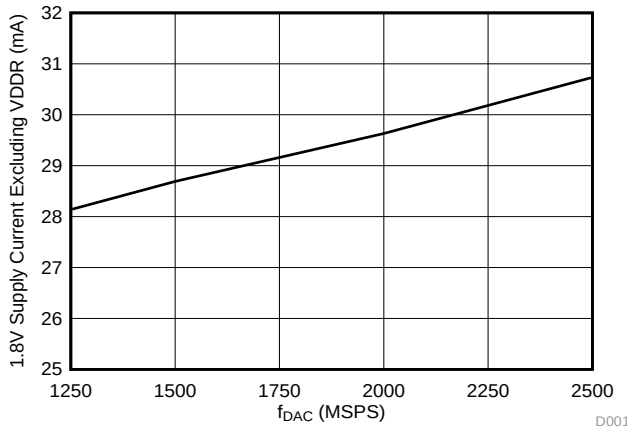


Figure 37. 1.8V Supply Current Excluding VDDR vs f_{DAC}

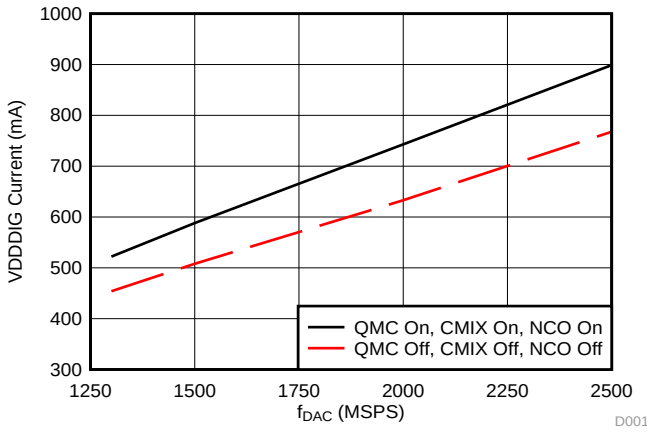


Figure 38. VDDDIG Current vs f_{DAC} Over Digital Processing Functions

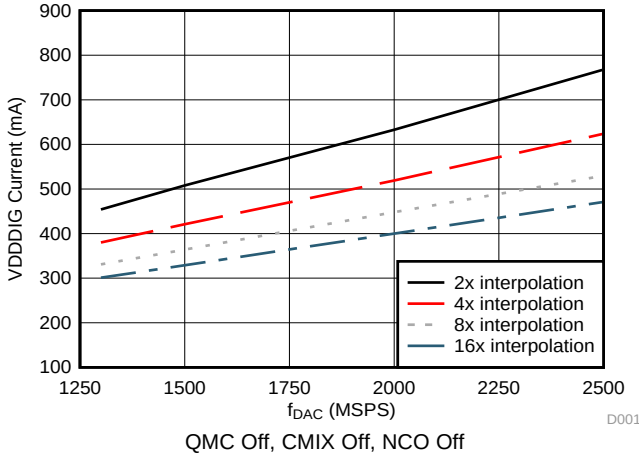


Figure 39. VDDDIG Current vs f_{DAC} Over Interpolation

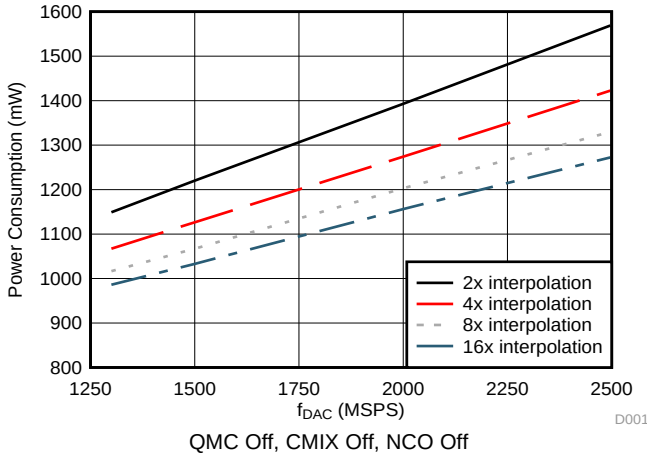


Figure 40. Power Consumption vs f_{DAC} Over Interpolation

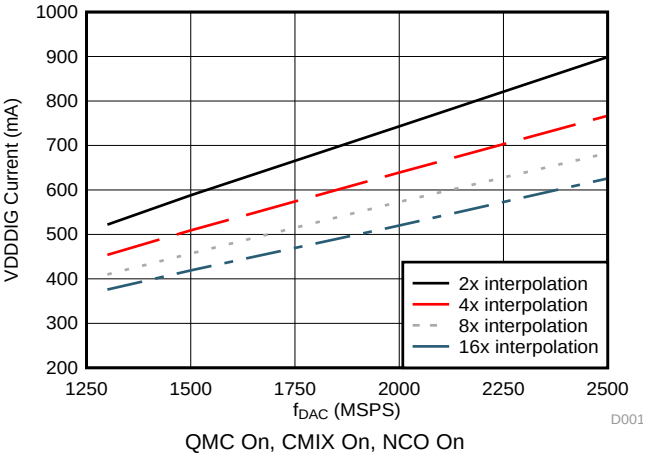


Figure 41. VDDDIG Current vs f_{DAC} Over Interpolation

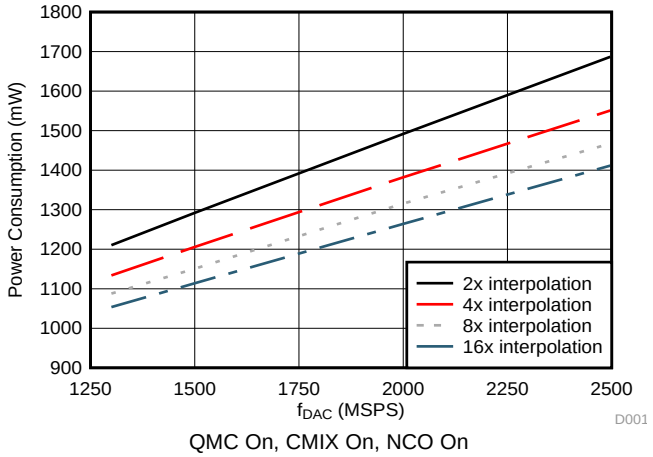


Figure 42. Power Consumption vs f_{DAC} Over Interpolation

Typical Characteristics (continued)

Unless otherwise noted, all plots are at T_A = 25°C, nominal supply voltages, f_{DAC} = 2460MSPS, 2x interpolation, 0dBFS digital input, 20mA full scale output current with 2:1 transformer, LMF = 841 and PLL is disabled.

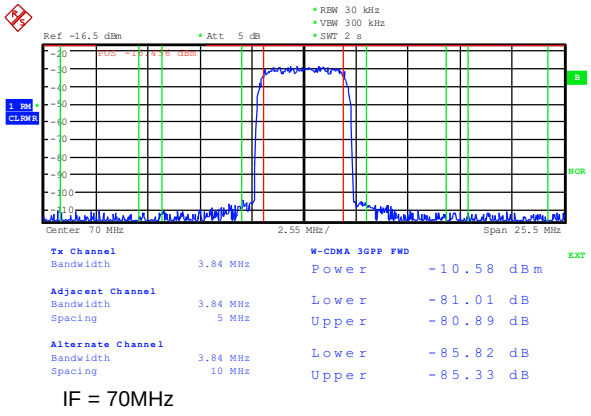


Figure 43. Single Carrier W-CDMA Test Mode 1

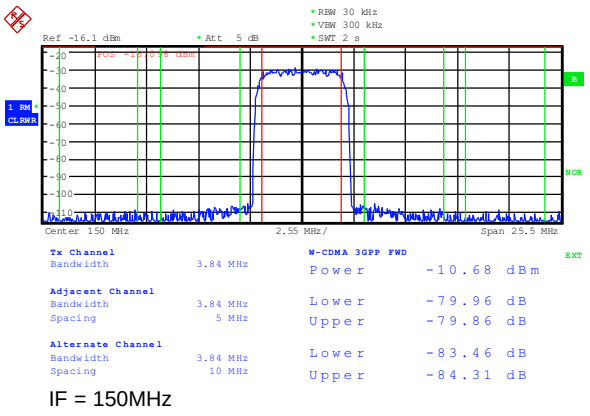


Figure 44. Single Carrier W-CDMA Test Mode 1

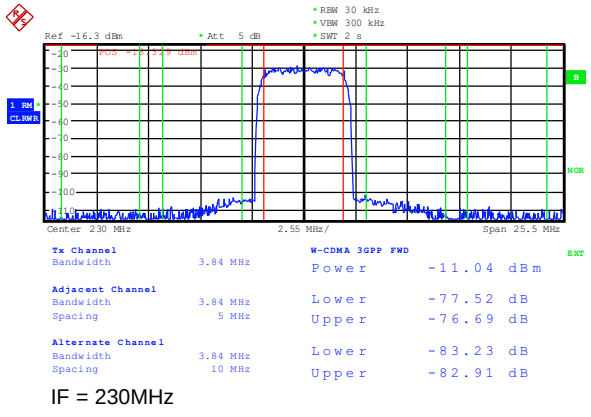


Figure 45. Single Carrier W-CDMA Test Mode 1

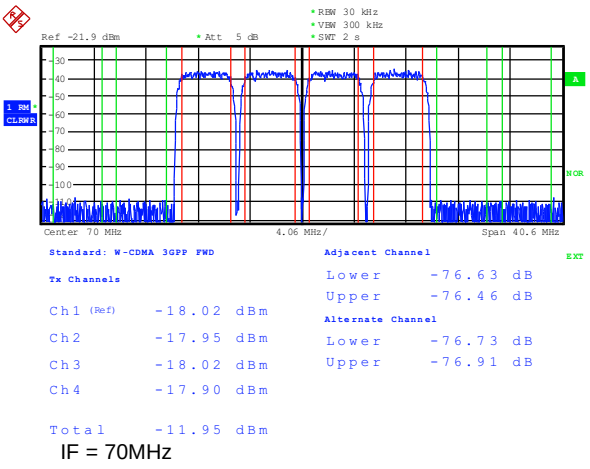


Figure 46. Four Carrier W-CDMA Test Mode 1

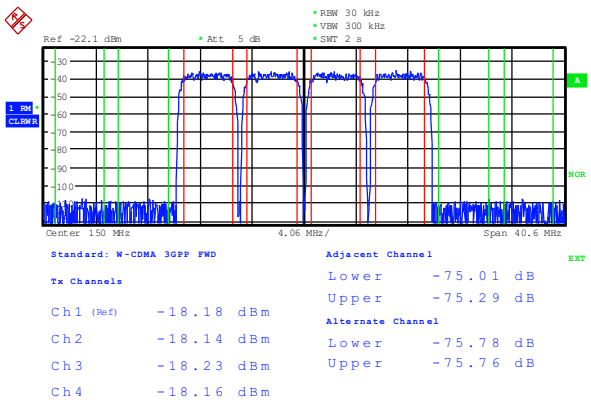


Figure 47. Four Carrier W-CDMA Test Mode 1

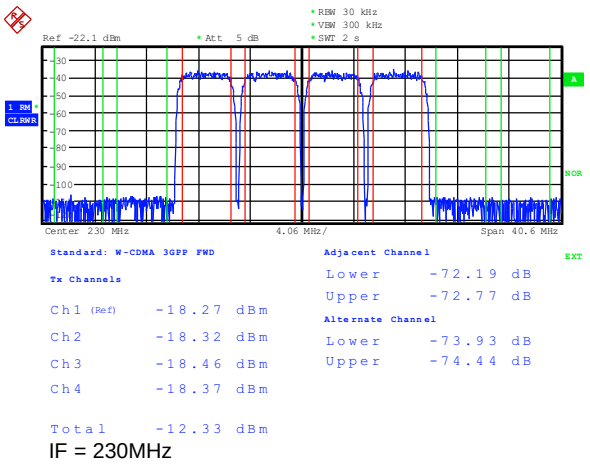
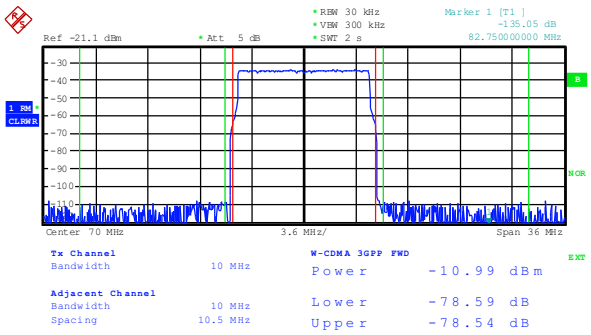


Figure 48. Four Carrier W-CDMA Test Mode 1

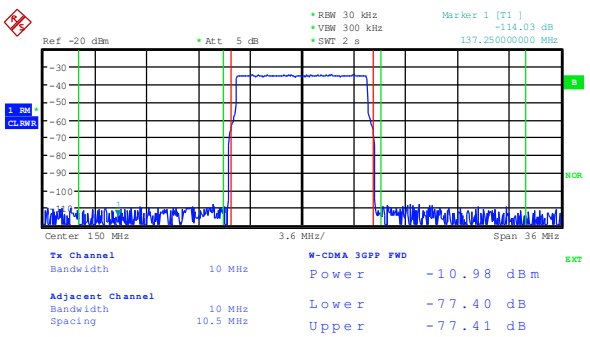
Typical Characteristics (continued)

Unless otherwise noted, all plots are at T_A = 25°C, nominal supply voltages, f_{DAC} = 2460MSPS, 2x interpolation, 0dBFS digital input, 20mA full scale output current with 2:1 transformer, LMF = 841 and PLL is disabled.



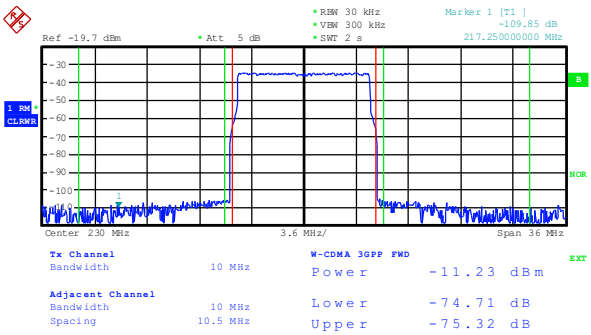
IF = 70MHz

Figure 49. 10MHz Single Carrier LTE Test Mode 3.1



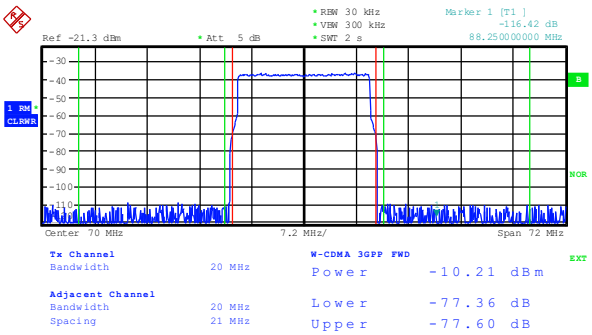
IF = 150MHz

Figure 50. 10MHz Single Carrier LTE Test Mode 3.1



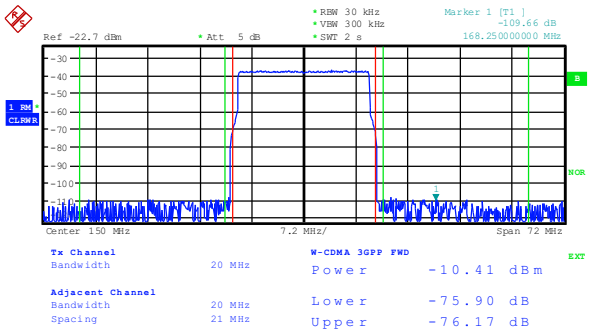
IF = 230MHz

Figure 51. 10MHz Single Carrier LTE Test Mode 3.1



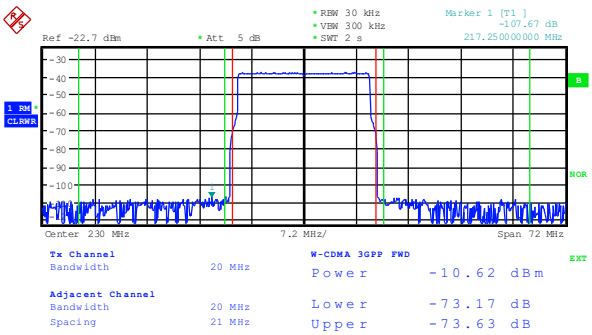
IF = 70MHz

Figure 52. 20MHz Single Carrier LTE Test Mode 3.1



IF = 150MHz

Figure 53. 20MHz Single Carrier LTE Test Mode 3.1



IF = 230MHz

Figure 54. 20MHz Single Carrier LTE Test Mode 3.1

7 Detailed Description

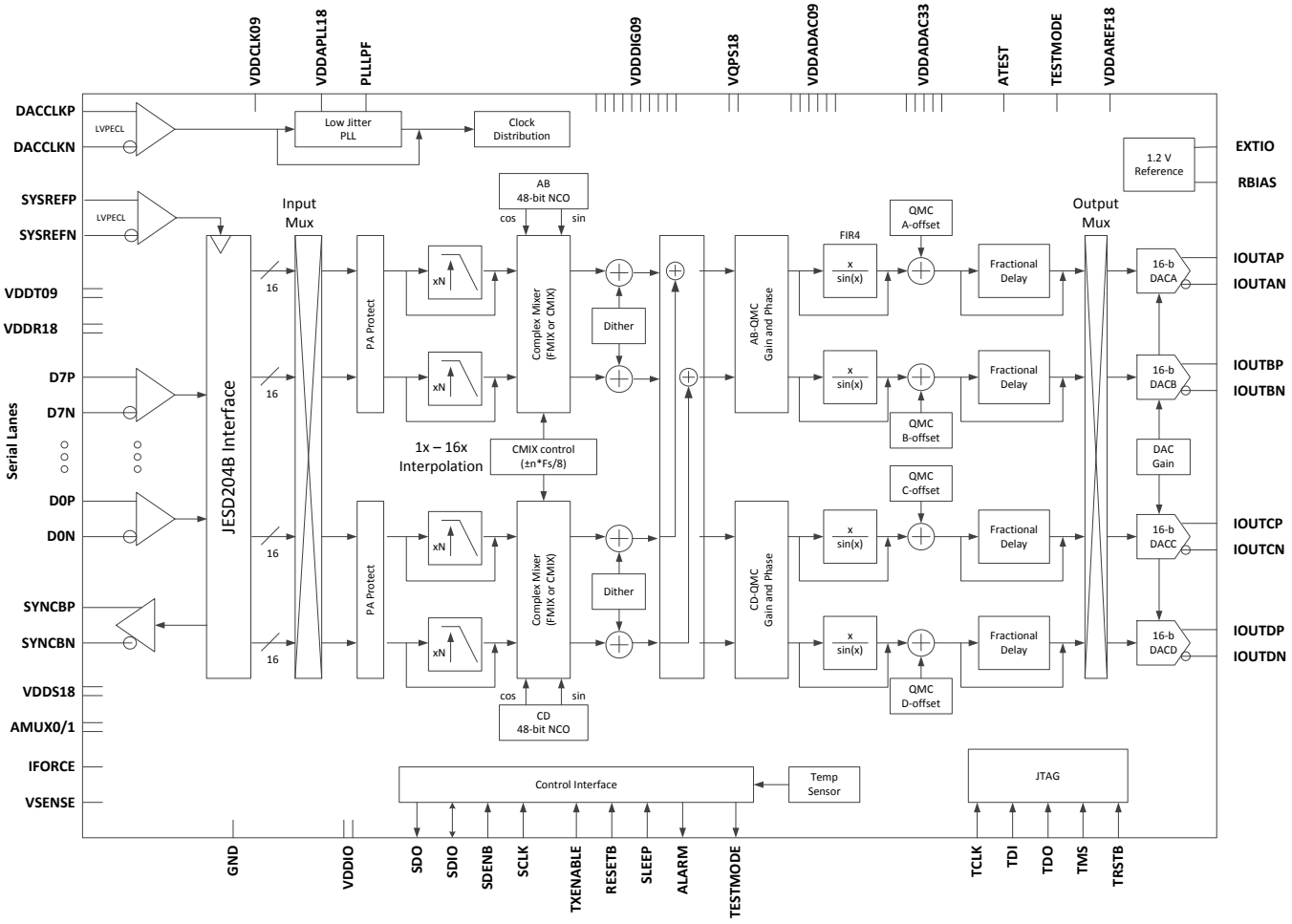
7.1 Overview

The terminal-compatible DAC37J84/DAC38J84 family is a very low power, 16-bit, 1.6/2.5 GSPS digital to analog converter (DAC) with JESD204B interface up to 12.5 Gbps. The maximum input data rate is 1.23 GSPS. The DAC37J84/DAC38J84 family is also terminal-compatible with the 16-bit, dual-channel, 1.6/2.5GSPS DAC37J82/DAC38J82.

Digital data is input to the device through 1, 2, 4 or 8 configurable serial JESD204B lanes running up to 12.5 Gbps with on-chip termination and programmable equalization. The interface allows JESD204B Subclass 1 SYSREF based deterministic latency and full synchronization of multiple devices.

The device includes features that simplify the design of complex transmit architectures. Fully bypassable 2x to 16x digital interpolation filters with over 90 dB of stop-band attenuation simplify the data interface and reconstruction filters. An on-chip 48-bit Numerically Controlled Oscillator (NCO) and independent complex mixers allow flexible and accurate carrier placement. A high-performance low jitter PLL simplifies clocking of the device without significant impact on the dynamic range. The digital Quadrature Modulator Correction (QMC) and Group Delay Correction (GDC) enable complete wideband IQ compensation for gain, offset, phase, and group delay between channels in direct up-conversion applications. A programmable Power Amplifier (PA) protection mechanism is available to provide PA protection in cases when the abnormal power behavior of the input data is detected.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Serdes Input

The RX [7:0]P/N differential inputs are each internally terminated to a common point via 50Ω, as shown in Figure 55.

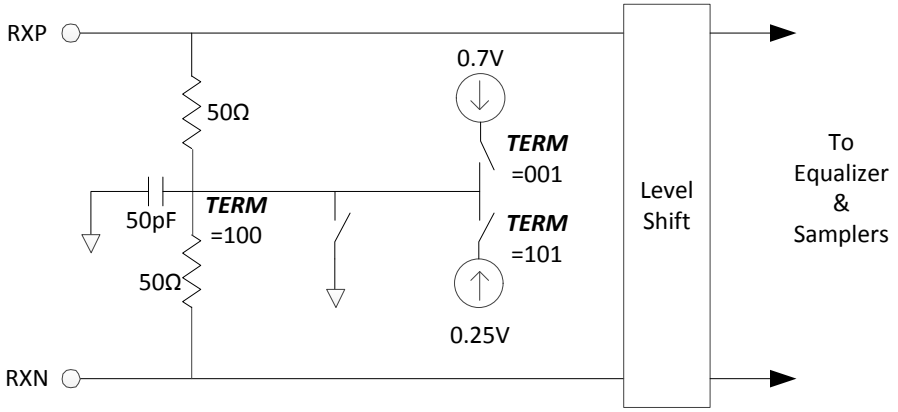


Figure 55. Serial Lane Input Termination

Common mode termination is via a 50pF capacitor to GND. The common mode voltage and termination of the differential signal can be controlled in a number of ways to suit a variety of applications via ***rw_cfgrx0*** [10:8] (**TERM**), as described in Table 1.
(Note: AC coupling is recommended for JESD204B compliance.)

Table 1. Receiver Termination Selection

TERM	EFFECT
000	Reserved
001	Common point set to 0.7V. This configuration is for AC coupled systems. The transmitter has no effect on the receiver common mode, which is set to optimize the input sensitivity of the receiver.
01x	Reserved
100	Common point set to GND. This configuration is for applications that require a 0V common mode.
101	Common point set to 0.25V. This configuration is for applications that require a low common mode.
110	Reserved
111	Common point floating. This configuration is for DC coupled systems in which the common mode voltage is set by the attached transmit link parter to 0 and 0.6V. Note: this mode is not compatible with JESD204B.

Data input is sampled by the differential sensing amplifier using clocks derived from the clock recovery algorithm. The polarity of RXP and RXN can be inverted by setting the **INVPAIR** [7:0] bit of the corresponding lane to “1”. This can potentially simplify PCB layout and improve signal integrity by avoiding the need to swap over the differential signal traces.

Due to processing effects, the devices in the RXP and RXN differential sense amplifiers will not be perfectly matched and there will be some offset in switching threshold. DAC38J84/DAC37J84 family contains circuitry to detect and correct for this offset. This feature can be enabled by setting the ***rw_cfgrx0*** [23] (**ENOC**) bit to “1”. It is anticipated the most users will enable this feature. During the compensation process, ***rw_cfgrx0*** [25:24] (**LOOPBACK**) bit must be set to “00”.

7.3.2 Serdes Rate

DAC37J84/DAC38J84 has 8 configurable JESD204B serial lanes. The highest speed of each SerDes lane is 12.5Gbps. Because the primary operating frequency of the SerDes is determined by its reference clock and PLL multiplication factor, there is a limit on the lowest SerDes rate supported, refer to Table 2 for details. To support lower speed application, each receiver should be configured to operate at half, quarter or eighth of the full rate via ***rw_cfgrx0*** [6:5] (**RATE**).

Table 2. Lane Rate Selection

RATE	EFFECT
00	*Full rate*. Four data samples taken per SerDes PLL output clock cycle.
01	*Half rate*. Two data samples taken per SerDes PLL output clock cycle..
10	*Quarter rate*. One data samples taken per SerDes PLL output clock cycle.
11	*Eighth rate*. One data samples taken every two SerDes PLL output clock cycles.

7.3.3 Serdes PLL

DAC37J84/DAC38J84 has two integrated PLLs, one PLL is to provide the clocking of DAC, which will be discussed in a DAC PLL section; the other PLL is to provide the clocking for the high speed SerDes. The reference frequency of the SerDes PLL can be in the range of 100-800MHz nominal, and 300-800MHz optimal.

The reference frequency is derived from DACCLK divided down based on the ***serdes_refclk_div*** programming, as shown in Figure 56.

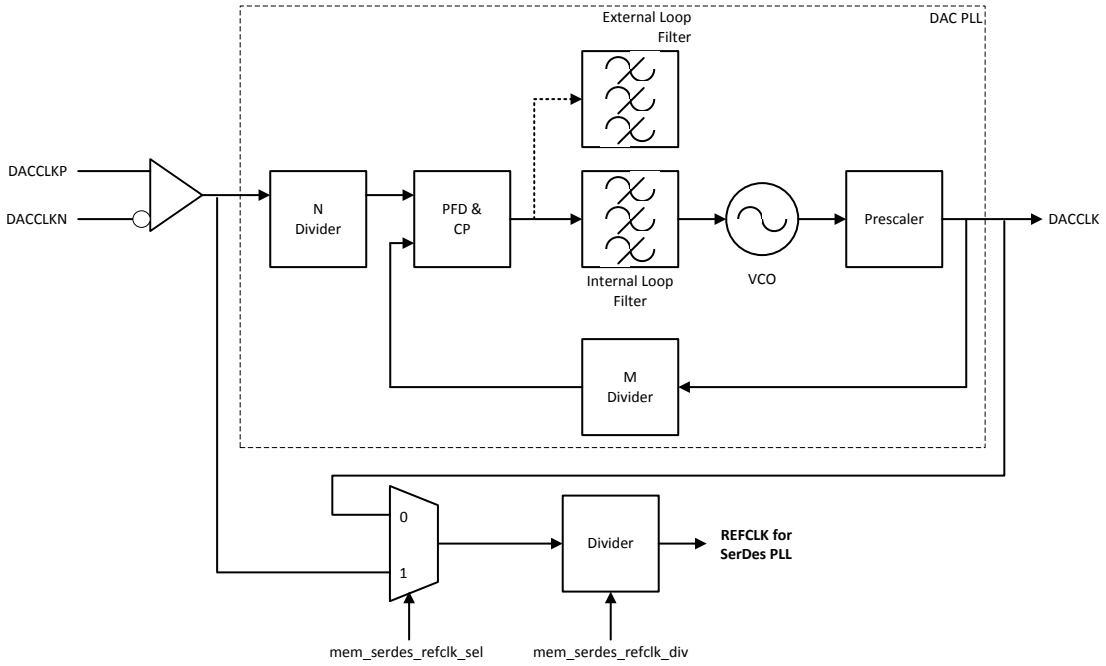


Figure 56. Reference Clock of SerDes PLL

During normal operation, the clock generated by PLL will be 4-25 times the reference frequency, according to the multiply factor selected via ***rw_cfgpll*** [8:1] (**MPY**). In order to select the appropriate multiply factor and refclkp/n frequency, it is first necessary to determine the required PLL output clock frequency. The relationship between the PLL output clock frequency and the lane rate is shown in Table 3. Having computed the PLL output frequency, the reference frequency can be obtained by dividing this by the multiply factor specified via **MPY**.

NOTE

High multiplication factor settings will be especially sensitive to reference clock jitter and should not be employed without prior consultation with TI.

Table 3. Relationship Between Lane Rate and SerDes PLL Output Frequency

RATE	LINE RATE	PLL OUTPUT FREQUENCY
Full	*x* Gbps	0.25x GHz
Half	*x* Gbps	0.5x GHz

Table 3. Relationship Between Lane Rate and SerDes PLL Output Frequency (continued)

RATE	LINE RATE	PLL OUTPUT FREQUENCY
Quarter	*x* Gbps	1x GHz
Eigth	*x* Gbps	2x GHz

Table 4. SerDes PLL Modes Selection

MPY	EFFECT
00010000	4x
00010100	5x
00011000	6x
00100000	8x
00100001	8.25x
00101000	10x
00110000	12x
00110010	12.5x
00111100	15x
01000000	16x
01000010	16.5x
01010000	20x
01011000	22x
01100100	25x
Other codes	reserved

The wide range of multiply factors combined with the different rate modes means it will often be possible to achieve a given line rate from multiple different reference frequencies. The configuration which utilizes the highest reference frequency achievable is always preferable.

The SerDes PLL VCO must be in the nominal range of 1.5625 - 3.125 GHz. It is necessary to adjust the loop filter depending on the operating frequency of the VCO. To indicate the selection the user must set the ***rw_cfgpll*** [9] (**VRANGE**) bit. If the PLL output frequency is below 2.17GHz, **VRANGE** should be set high.

Performance of the integrated PLL can be optimized according to the jitter characteristics of the reference clock by setting the appropriate loop bandwidth via ***rw_cfgpll*** [12:11] (**LB**) bits. The loop bandwidth is obtained by dividing the reference frequency by BWSCALE, where the BWSCALE is a function of both LB and PLL output frequency as shown in Table 5.

Table 5. SerDes PLL Loop Bandwidth Selection

LB	EFFECT	BWSCALE vs PLL OUTPUT FREQUENCY		
		3.125 GHz	2.17 GHz	1.5625 GHz
00	Medium loop bandwidth	13	14	16
01	Ultra high loop bandwidth	7	8	8
10	Low loop bandwidth	21	23	30
11	High loop bandwidth	10	11	14

An approximate loop bandwidth of 8–30MHz is suitable and recommended for most systems where the reference clock is via low jitter clock input buffer. For systems where the reference clock is via a low jitter input cell, but of low quality, an approximate loop bandwidth of less than 8MHz may offer better performance. For systems where the reference clock is cleaned via an ultra low jitter LC-based cleaner PLL, a high loop bandwidth up to 60MHz is more appropriate. Note that the use of ultra high loop bandwidth setting is not recommended for PLL multiply factor of less than 8.

A free running clock output is available when ***rw_cfgpll*** [15:14] (**ENDIVCLK**) is set high. It runs at a fixed divided-by-5 of the PLL output frequency and has a duty cycle of 50%. A divided-by-16 of this free running clock can be configured to come out the alarm terminal during digital test, see ***dtest*** [11:8] for the specific configuration needed.

7.3.4 Serdes Equalizer

All channels of the DAC37J84/DAC38J84 incorporate an adaptive equalizer, which can compensate for channel insertion loss by attenuating the low frequency components with respect to the high frequency components of the signal, thereby reducing inter-symbol interference. Figure 57 shows the response of the equalizer, which can be expressed in terms of the amount of low frequency gain and the frequency up to which this gain is applied (i.e., the frequency of the 'zero'). Above the zero frequency, the gain increases at 6dB/octave until it reaches the high frequency gain.

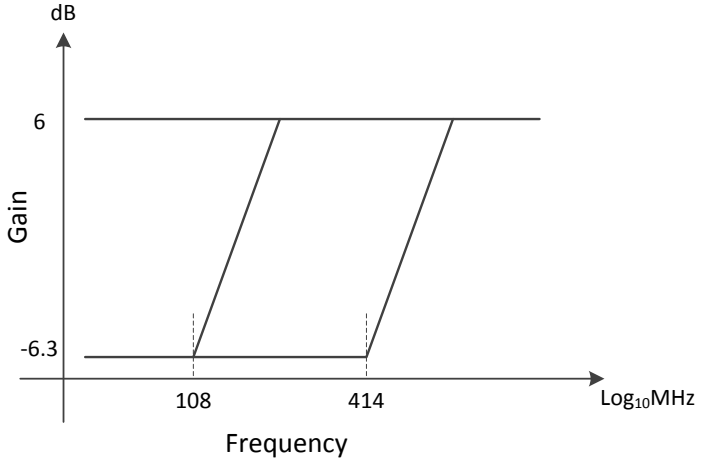


Figure 57. Equalizer Frequency Response

The equalizer can be configured via rw_cfgrx0[21:19] (EQ) and rx_cfgrx0[22] (EQHLD). Table 6 and Table 7 summarize the options. When enabled, the receiver equalization logic analyzes data patterns and transition times to determine whether the low frequency gain should be increased or decreased. The decision logic is implemented as a voting algorithm with a relatively long analysis interval. The slow time constant that results reduces the probability of incorrect decisions but allows the equalizer to compensate for the relatively stable response of the channel. The lock time for the adaptive equalizer is data dependent, and so it is not possible to specify a generally applicable absolute limit. However, assuming random data, the maximum lock time will be $6x10^6$ divided by the CDR activity level. For CDR (***rw_cfgrx0***[18:16]) = 110, this is $1.5x10^6$UI.

When EQ[2] = 0, finer control of gain boost is available using the EQBOOSTi IEEE1500 tuning chain field, as shown in Table 8.

Table 6. Receiver Equalization Configuration

EQ		EFFECT
[1:0]	0	*No equalization*. The equalizer provides a flat response at the maximum gain. This setting may be appropriate if jitter at the receiver occurs predominantly as a result of crosstalk rather than frequency dependent loss.
	1	*Fully adaptive equalization*. The zero position is determined by the selected operating rate, and the low frequency gain of the equalizer is determined algorithmically by analyzing the data patterns and transition positions in the received data. This setting should be used for most applications.
	10	*Precursor equalization analysis*. The data patterns and transition positions in the received data are analyzed to determine whether the transmit link partner is applying more or less precursor equalization than necessary.
	11	*Postcursor equalization analysis*. The data patterns and transition positions in the received data are analyzed to determine whether the transmit link partner is applying more or less postcursor equalization than necessary.
[2]	0	Default
	1	*Boost*. Equalizer gain boosted by 6dB, with a 20% reduction in bandwidth, and an increase of 5mW power consumption. May improve performance over long links.

Table 7. Receiver Equalizer Hold

EQHOLD	EFFECT
0	*Equalizer adaption enabled.* The equalizer adaption and analysis algorithm is enabled. This should be the default state.
1	*Equalizer adaption held.* The equalizer is held in it's current state. Additionally, the adaption and analysis algorithm is reset. See section 7.2.5.1 for further details..

Table 8. Receiver Equalizer Gain Boost

EQBoost VALUE	GAIN BOOST (dB)	BANDWIDTH CHANGE (%)	POWER INCREASE (mW)
0	0	0	0
1	2	–30	0
10	4	10	5
11	6	–20	5

When EQ is set to 010 or 011, the equalizer is reconfigured to provide analytical data about the amount of pre and post cursor equalization respectively present in the received signal. This can in turn be used to adjust the equalization settings of the transmitting link partner, where a suitable mechanism for communicating this data back to the transmitter exists. Status information is provided via***dtest***[11:8] (EQOVER, EQUNDER), by using the following method:

1. Enable the equalizer by setting EQHLD low and EQ to 001. Allow sufficient time for the equalizer to adapt;
2. Set EQHLD to 1 to lock the equalizer and reset the adaption algorithm. This also causes both EQOVER and EQUNDER to become low;
3. Wait at least 48UI, and proportionately longer if the CDR activity is less than 100%, to ensure the 1 on EQHLD is sampled and acted upon;
4. Set EQ to 010 or 011, and EQHLD to 0. The equalization characteristics of the received signal are analysed (the equalizer response will continue to be locked);
5. Wait at least 150×10^3UI to allow time for the analysis to occur, proportionately longer if the CDR activity is less than 100%;
6. Examine EQOVER and EQUNDER for results of analysis.
   – If EQOVER is high, it indicates the signal is over equalized;
   – If EQUNDER is high, it indicates the signal is under equalized;
7. Set EQHLD to 1;
8. Repeat items 3–7 if required;
9. Set EQ to 001, and EQHLD to 0 to exit analysis mode and return to normal adaptive equalization.

Note that when changing EQ from one non-zero value to another, EQHLD must already be 1. If this is not the case, there is a chance the equalizer could be reset by a transitory input state (i.e., if EQ is momentarily 000). EQHLD can be set to 0 at the same time as EQ is changed.

As the equalizer adaption algorithm is designed to equalize the post cursor, EQOVER or EQUNDER will only be set during post cursor analysis if the amount of post cursor equalization required is more or less than the adaptive equalizer can provide.

7.3.5 JESD204B Descrambler

The descrambler is a 16-bit parallel self-synchronous descrambler based on the polynomial $1 + x^{14} + x^{15}$. From the JESD204B specification, the scrambling/descrambling process only occurs on the user data, not on the code group synchronization or the ILA sequence. The descrambler output can be selected to sent out during JESD test, see ***jesd_testbus_sel*** for the specific configuration needed.

7.3.6 JESD204B Frame Assembly

The JESD204B defines the following parameters:

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

- S is the number of samples per frame
- HD is the High-Density bit which controls whether a sample may be divided over more lanes.

Table 9 and Table 10 list the available JESD204B formats for the DAC38J84/DAC38J84. Table 11 and Table 12 list the speed limits of DAC38J84/DAC37J84. The ranges are limited by the Serdes PLL VCO frequency range, the Serdes PLL reference clock range, the maximum Serdes line rate, and the maximum DAC sample frequency.

Table 9. JESD204B Frame Assembly Byte Representation (Quad-channel)

	LMF = 841				LMF = 442				LMF = 244				LMF = 148							
Lane 0	DA0[15:8]	DA1[15:8]	DA2[15:8]		DA0[15:8]	DA0[7:0]	DA1[15:8]	DA1[17:0]	DA0[15:8]	DA0[7:0]	DB0[15:8]	DB1[7:0]	DA0[15:8]	DA0[7:0]	DB0[15:8]	DB0[7:0]	DC0[15:8]	DC0[7:0]	DD0[15:8]	DD0[7:0]
Lane 1	DA0[7:0]	DA1[7:0]	DA2[7:0]		DB0[15:8]	DB0[7:0]	DB1[15:8]	DB1[7:0]	DC0[15:8]	DC0[7:0]	DD0[15:8]	DD0[7:0]								
Lane 2	DB0[15:8]	DB1[15:8]	DB2[15:8]		DC0[15:8]	DC0[7:0]	DC1[15:8]	DC1[7:0]												
Lane 3	DB0[7:0]	DB1[7:0]	DB2[7:0]		DD0[15:8]	DD0[7:0]	DD1[15:8]	DD1[7:0]												
Lane 4	DC0[15:8]	DC1[15:8]	DC2[15:8]																	
Lane 5	DC0[7:0]	DC1[7:0]	DC2[7:0]																	
Lane 6	DD0[15:8]	DD1[15:8]	DD2[15:8]																	
Lane 7	DD0[7:0]	DD1[7:0]	DD2[7:0]																	

Table 10. JESD204B Frame Assembly Byte Representation (Dual-Channel)

	LMF = 821				LMF = 421					LMF = 222					LMF = 124							
Lane 0	I0[15:8]	I2[15:8]	I4[15:8]		I0[15:8]	I1[15:8]	I2[15:8]	I3[15:8]		I0[15:8]	I0[7:0]	I1[15:8]	I1[7:0]		I0[15:8]	I0[7:0]	Q0[15:8]	Q0[7:0]	I1[15:8]	I1[7:0]	Q1[15:8]	Q1[7:0]
Lane 1	I0[7:0]	I2[7:0]	I4[7:0]		I0[7:0]	I1[7:0]	I2[7:0]	I3[7:0]		Q0[15:8]	Q0[7:0]	Q1[15:8]	Q7:0]									
Lane 2	I1[15:8]	I3[15:8]	I5[15:8]		Q0[15:8]	Q1[15:8]	Q2[15:8]	Q3[15:8]														
Lane 3	I1[7:0]	I3[7:0]	I5[7:0]		Q0[7:0]	Q1[7:0]	Q2[7:0]	Q3[7:0]														
Lane 4	Q0[15:8]	Q2[15:8]	Q4[15:8]																			
Lane 5	Q0[7:0]	Q2[7:0]	Q4[7:0]																			
Lane 6	Q1[15:8]	Q3[15:8]	Q5[15:8]																			
Lane 7	Q1[7:0]	Q3[7:0]	Q5[7:0]																			

Table 11. DAC38J84 Speed Limits

L	M	F	S	HD	INTERPOLATION	Min f_{SERDES} (Gbps)	Max f_{SERDES} (Gbps)	Min f_{DATA} (MSPS)	Max f_{DATA} (MSPS)	Min f_{DAC} (MSPS)	Max f_{DAC} (MSPS)	Max BW (MHz)
8	4	1	1	1	1	1.5625	12.3	156.25	1230	156.25	1230	1230
					2	0.78125	12.3	78.125	1230	156.25	2460	984
					4	0.78125	6.25	78.125	625	312.5	2500	500
					8	0.78125	3.125	78.125	312.5	625	2500	250
					16	0.78125	1.5625	78.125	156.25	1250	2500	125
4	4	2	1	0	1	2	12.5	100	625	100	625	625
					2	1	12.5	50	625	100	1250	500
					4	0.78125	12.5	39.0625	625	156.25	2500	500
					8	0.78125	6.25	39.0625	312.5	312.5	2500	250
					16	0.78125	3.125	39.0625	156.25	625	2500	125
2	4	4	1	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					2	2	12.5	50	312.5	100	625	250
					4	1	12.5	25	312.5	100	1250	250
					8	0.78125	12.5	19.53125	312.5	156.25	2500	250
					16	0.78125	6.25	1953125	156.25	312.5	2500	125
1	4	8	1	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					4	2	12.5	25	156.25	100	625	125
					8	1	12.5	12.5	156.25	100	1250	125
					16	0.78125	12.5	9.765625	156.25	156.25	2500	125
8	2	1	2	1	1	0.78125	6.15	156.25	1230	156.25	1230	1230
					2	0.78125	6.15	156.25	1230	312.5	2460	984
					4	0.78125	3.125	156.25	625	625	2500	500
					8	0.78125	1.5625	156.25	312.5	1250	2500	250
					16	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	2	1	1	1	1	1	12.3	100	1230	100	1230	1230
					2	0.78125	12.3	78.125	1230	156.25	2460	984
					4	0.78125	6.25	78.125	625	312.5	2500	500
					8	0.78125	3.125	78.125	3.125	625	2500	250
					16	0.78125	1.5625	78.125	156.25	1250	2500	125
2	2	2	1	0	1	2	12.5	100	625	100	625	625
					2	1	12.5	50	625	100	1250	500
					4	0.78125	12.5	39.0625	625	156.25	2500	500
					8	0.78125	6.25	39.0625	312.5	312.5	2500	250
					16	0.78125	3.125	39.0625	156.25	625	2500	125
1	2	4	1	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					2	2	12.5	50	312.5	100	625	250
					4	1.5625	12.5	39.0625	312.5	156.25	1250	250
					8	1.5625	12.5	39.0625	312.5	312.5	2500	250
					16	1.5625	6.25	39.0625	156.25	625	2500	125

L = # of lanes
M = # of DACs
F = # of Octets per lane per frame cycle
S = # of Samples per DAC per frame cycle
HD = High density mode

f_{SERDES} = Serdes line rate
f_{DATA} = Input data rate per DAC
f_{DAC} = Output sample rate
BW = Complex bandwidth (= f_{DATA} × 0.8 with interpolation, = f_{DATA} without interpolation)

Table 12. DAC37J84 Speed Limits

L	M	F	S	HD	INTERPOLATION	Min f_{SERDES} (Gbps)	Max f_{SERDES} (Gbps)	Min f_{DATA} (MSPS)	Max f_{DATA} (MSPS)	Min f_{DAC} (MSPS)	Max f_{DAC} (MSPS)	Max BW (MHz)
8	4	1	1	1	1	1.5625	12.3	156.25	1230	156.25	1230	1230
					2	0.78125	8	78.125	800	156.25	1600	640
					4	0.78125	4	78.125	400	312.5	1600	320
					8	0.78125	2	78.125	200	625	1600	160
					16	0.78125	1	78.125	100	1250	1600	80
4	4	2	1	0	1	2	12.5	100	625	100	625	625
					2	1	12.5	50	625	100	1250	500
					4	0.78125	8	39.0625	400	156.25	1600	320
					8	0.78125	4	39.0625	200	312.5	1600	160
					16	0.78125	2	39.0625	100	625	1600	80
2	4	4	1	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					2	2	12.5	50	312.5	100	625	250
					4	1	12.5	25	312.5	100	1250	250
					8	0.78125	8	19.53125	200	156.25	1600	160
					16	0.78125	4	1953125	100	312.5	1600	80
1	4	8	1	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					2	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					4	2	12.5	25	156.25	100	625	125
					8	1	12.5	12.5	156.25	100	1250	125
					16	0.78125	8	9.765625	100	156.25	1600	80
8	2	1	2	1	1	0.78125	6.15	156.25	1230	156.25	1230	1230
					2	0.78125	4	156.25	800	312.5	1600	640
					4	0.78125	2	156.25	400	625	1600	320
					8	0.78125	1	156.25	200	1250	1600	160
					16	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	2	1	1	1	1	1	12.3	100	1230	100	1230	1230
					2	0.78125	8	78.125	800	156.25	1600	640
					4	0.78125	4	78.125	400	312.5	1600	320
					8	0.78125	2	78.125	200	625	1600	160
					16	0.78125	1	78.125	100	1250	1600	80
2	2	2	1	0	1	2	12.5	100	625	100	625	625
					2	1	12.5	50	625	100	1250	500
					4	0.78125	8	39.0625	400	156.25	1600	320
					8	0.78125	4	39.0625	200	312.5	1600	160
					16	0.78125	2	39.0625	100	625	1600	80
1	2	4	1	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
					2	2	12.5	50	312.5	100	625	250
					4	1.5625	12.5	39.0625	312.5	156.25	1250	250
					8	1.5625	8	39.0625	200	312.5	1600	160
					16	1.5625	4	39.0625	100	625	1600	80

L = # of lanes
M = # of DACs
F = # of Octets per lane per frame cycle
S = # of Samples per DAC per frame cycle
HD = High density mode

f_{SERDES} = Serdes line rate
f_{DATA} = Input data rate per DAC
f_{DAC} = Output sample rate
BW = Complex bandwidth (= f_{DATA} × 0.8 with interpolation, = f_{DATA} without interpolation)

7.3.7 Serial Peripheral Interface (SPI)

The serial port of the DAC37J84/DAC38J84 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 DAC37J84/DAC38J84. It is compatible with most synchronous transfer formats and can be configured as a 3 or 4 terminal 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 terminal configuration, SDIO is a bidirectional terminal for both data in and data out. For 4 terminal 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 13 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 13. 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 DAC37J84/DAC38J84 and a low indicates a write operation to DAC37J84/DAC38J84.

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

Figure 58 shows the serial interface timing diagram for a DAC37J84/DAC38J84 write operation. SCLK is the serial interface clock input to DAC37J84/DAC38J84. Serial data enable SDENB is an active low input to DAC37J84/DAC38J84. SDIO is serial data in. Input data to DAC37J84/DAC38J84 is clocked on the rising edges of SCLK.

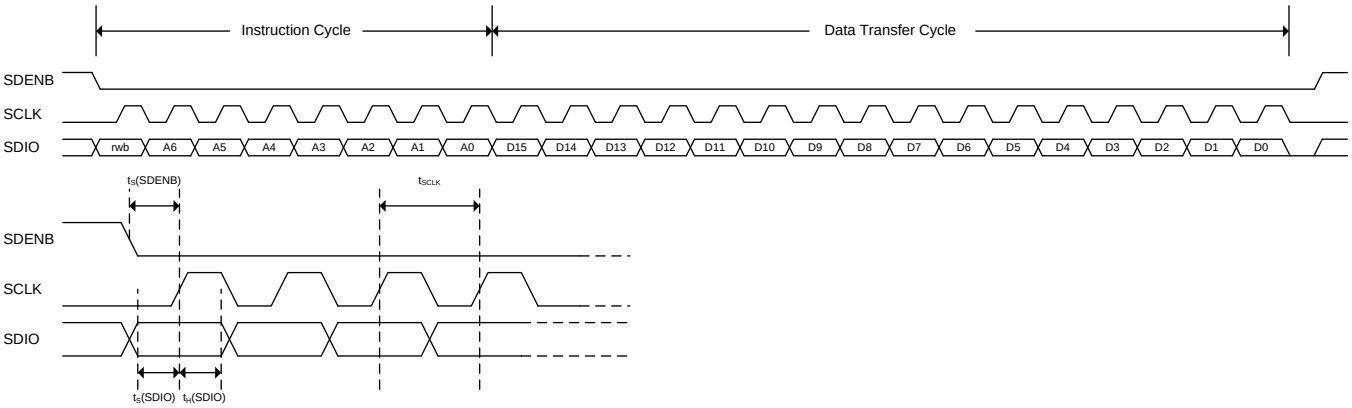


Figure 58. Serial Interface Write Timing Diagram

Figure 59 shows the serial interface timing diagram for a DAC37J84/DAC38J84 read operation. SCLK is the serial interface clock input to DAC37J84/DAC38J84. Serial data enable SDENB is an active low input to DAC37J84/DAC38J84. SDIO is serial data in during the instruction cycle. In 3 terminal configuration, SDIO is data out from the DAC37J84/DAC38J84 during the data transfer cycle, while SDO is in a high-impedance state. In 4 terminal configuration, both SDIO and SDO are data out from the DAC37J84/DAC38J84 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.

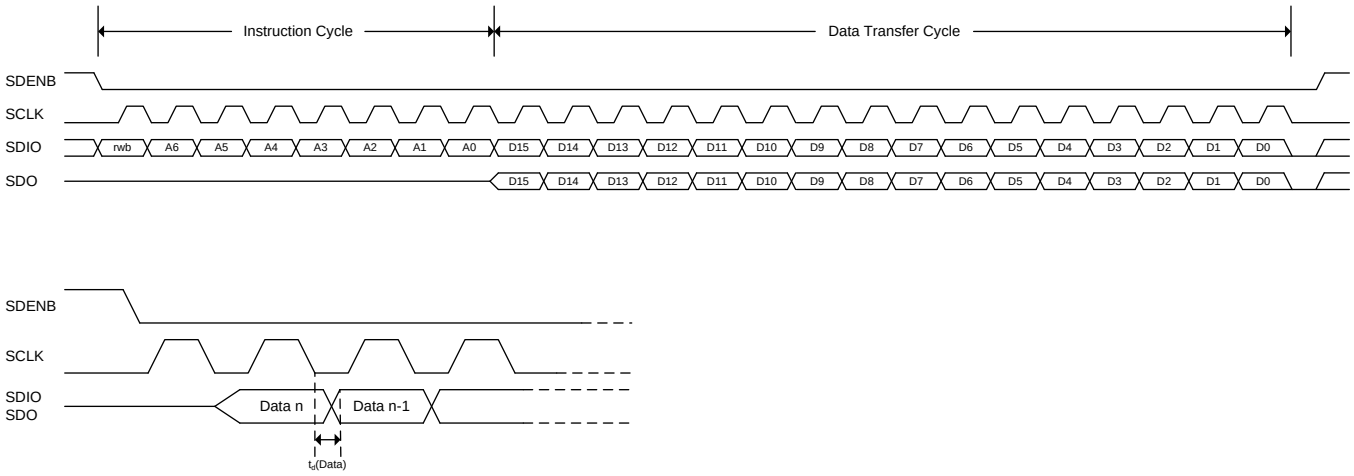


Figure 59. Serial Interface Read Timing Diagram

In the SIF interface there are four types of registers:

- **NORMAL:** The NORMAL register type allows data to be written and read from. All 16-bits of the data are registered at the same time. There is no synchronizing with an internal clock thus all register writes are asynchronous with respect to internal clocks. There are three subtypes of NORMAL:
  - **AUTOSYNC:** A NORMAL register that causes a sync to be generated after the write is finished. These are used when it is desirable to synchronize the block after writing the register or in the case of a single field that spans across multiple registers. For instance, the NCO requires three 16-bit register writes to set the frequency. Upon writing the last of these registers an autosync is generated to deliver the entire field to the NCO block at once, rather than in pieces after each invidiual register write. For a field that spans multiple registers, all non-AUTOSYNC registers for the field must be written first before the actual AUTOSYNC register.
  - **No RESET Value:** These are NORMAL registers, but the reset value **cannot** be guaranteed. This could be because the register has some read_only bits or some internal logic partially controls the bit values.
- **READ_ONLY:** Registers that can be read from but not written to.
- **WRITE_TO_CLEAR:** These registers are just like NORMAL registers with one exception. They can be written and read, however, when the internal logic asynchronously sets a bit high in one of these registers, that bit stays high until it is written to '0'. This way interrupts will be captured and stay constant until cleared by the user. In DAC37J84/DAC38J84, register *config100-108* are WRTE_TO_CLEAR registers.

7.3.8 Multi-Device Synchronization

In many applications, such as multi antenna systems where the various transmit channels information is correlated, it is required that the latency across the link is deterministic and multiple DAC devices are completely synchronized such that their outputs are phase aligned. DAC37J84/DAC38J84 achieves the deterministic latency using SYSREF (JESD204B Subclass 1).

SYSREF is generated from the same clock domain as DACCLK, and is sampled at the rising edges of the device clock. It can be periodic, single-shot or "gapped" periodic. After having resynchronized its local multiframe clock (LMFC) to SYSREF, the DAC will request a link re-initialization via SYNC interface. Processing of the signal on the SYSREF input can be enabled and disabled via the SPI interface.

7.3.9 Input Multiplexer

The DAC37J84/DAC38J84 includes a multiplexer after the JESD204B interface that allows any input stream A-B to be routed to any signal cannel A-B. See ***pathx_in_sel*** for details on how to configure the cross-bar switches.

7.3.10 FIR Filters

Figure 60 through Figure 63 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 64 to Figure 67 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 DAC37J84/DAC38J84 includes a no interpolation 1x mode. However, the input data rate in this mode is limited to 1230MSPS. See more details in Table 11 and Table 12.

The DAC37J84/DAC38J84 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 68, red line). The inverse sinc filter response (Figure 68, blue line) has the opposite frequency response from 0 to 0.4 x F_{dac}, resulting in the combined response (Figure 68, 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 14. Note that the loss of signal amplitude may result in lower SNR due to decrease in signal amplitude.

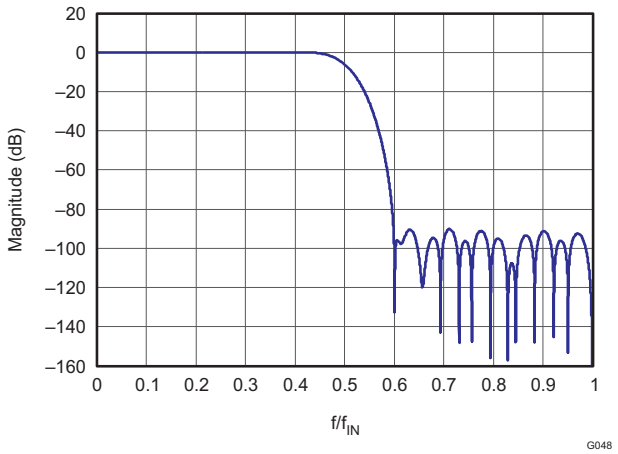


Figure 60. Magnitude Spectrum for FIR0

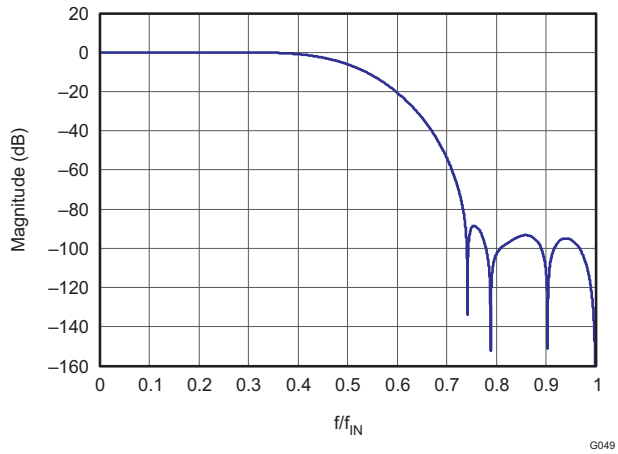


Figure 61. Magnitude Spectrum for FIR1

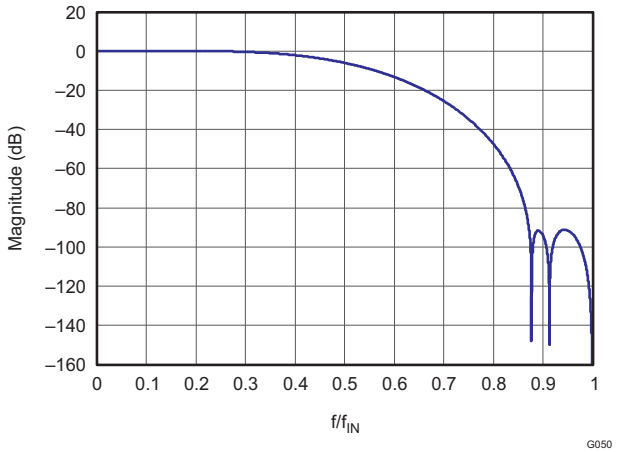


Figure 62. Magnitude Spectrum for FIR2

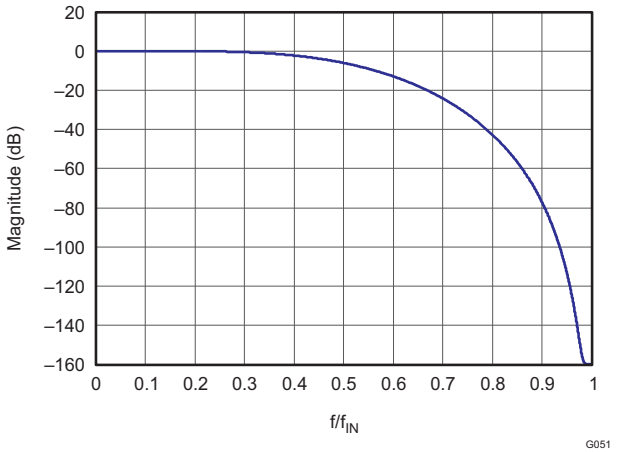


Figure 63. Magnitude Spectrum for FIR3

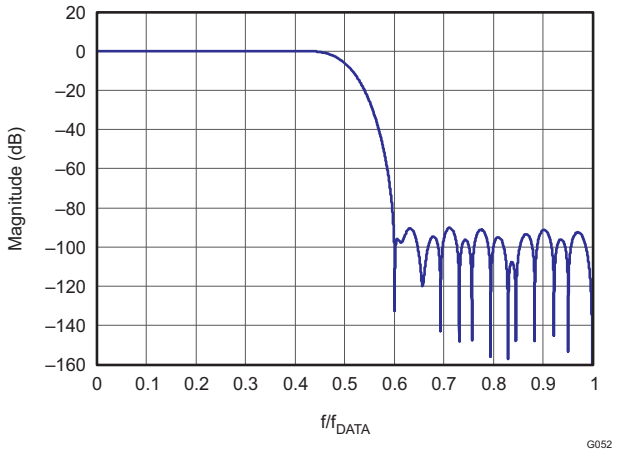


Figure 64. 2x Interpolation Composite Response

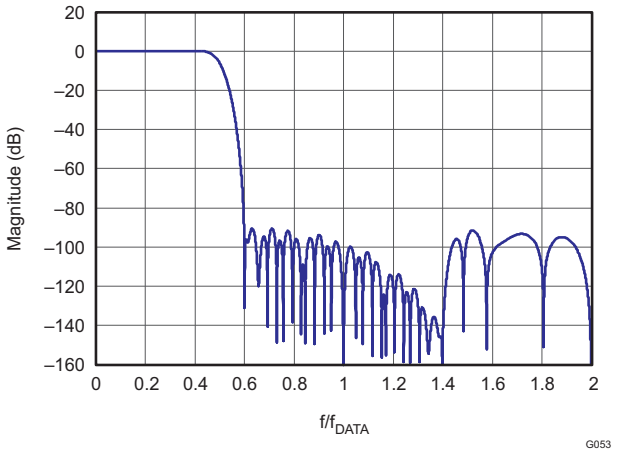


Figure 65. 4x Interpolation Composite Response

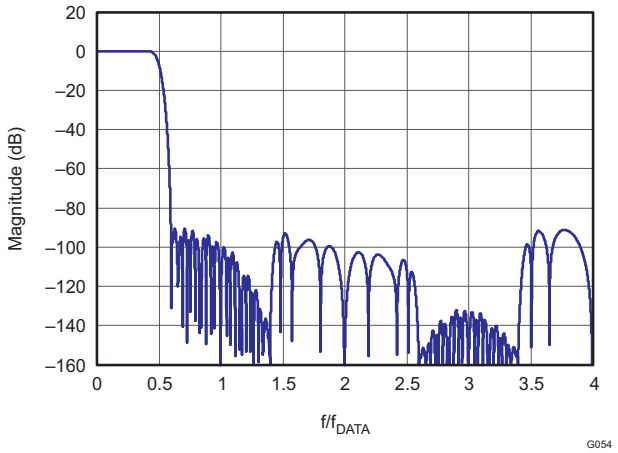


Figure 66. 8x Interpolation Composite Response

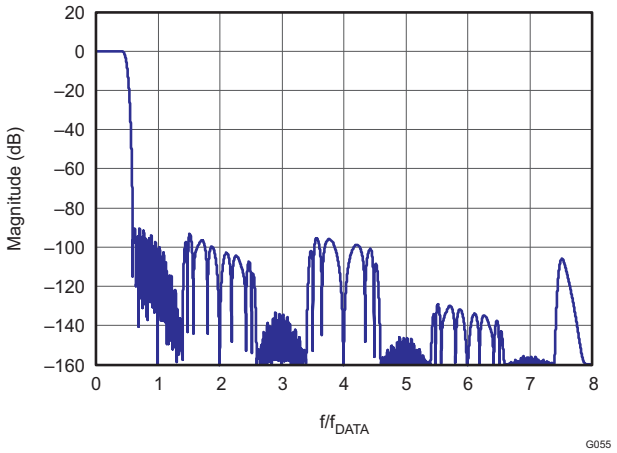


Figure 67. 16x Interpolation Composite Response

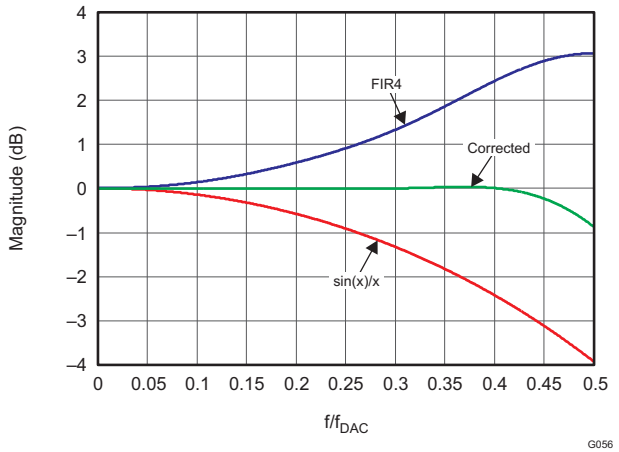


Figure 68. Magnitude Spectrum for Inverse Sinc Filter

Table 14. 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**.

7.3.11 Full Complex Mixer

The DAC37J84/DAC38J84 has two full complex mixer (FMIX) blocks with independent Numerically Controlled Oscillators (NCO) that enables flexible frequency placement without imposing additional limitations in the signal bandwidth. The NCOs have 48-bit frequency registers (***phaseaddab*** *(47:0)* and ***phaseaddcd*** *(47:0)*) and 16-bit phase registers (***phaseoffsetab*** *(15:0)* and ***phaseoffsetcd*** *(15:0)*) that generate the sine and cosine terms for the complex mixing. The NCO block diagram is shown in Figure 69.

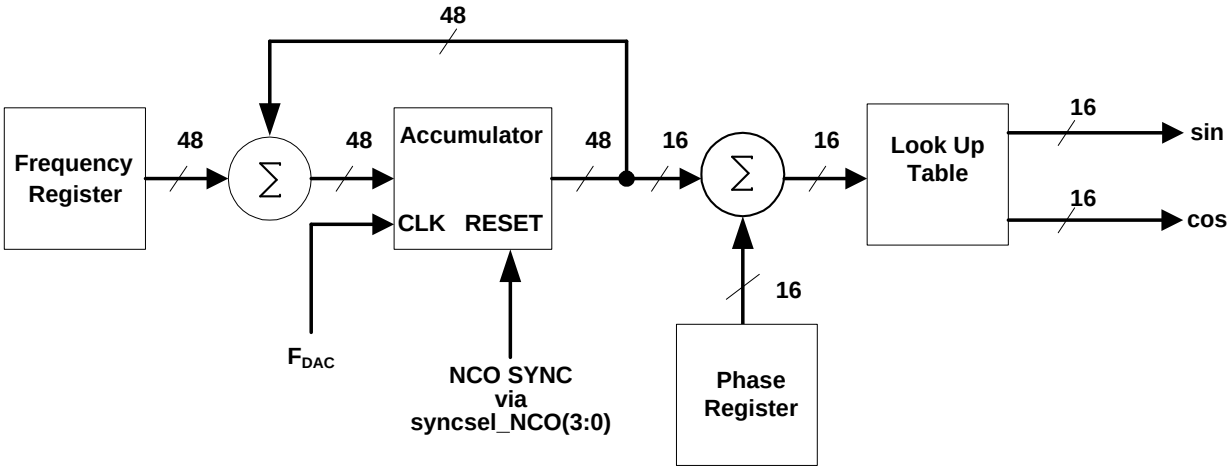


Figure 69. NCO Block Diagram

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 ***phaseaddab*** *(47:0)* and ***phaseaddcd*** *(47:0)* registers is added to the accumulators every clock cycle, f_{DAC}. The output frequency of the NCO is

$$f_{NCO} = \frac{freq \times f_{NCO\_CLK}}{2^{48}}$$

Treating the two complex channels in the DAC37J84/DAC38J84 as 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:

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

A block diagram of the mixer is shown in Figure 70. The complex mixer can be used as a digital quadrature modulator with a real output simply by only using the I_{OUT} branch and ignoring the Q_{OUT} branch.

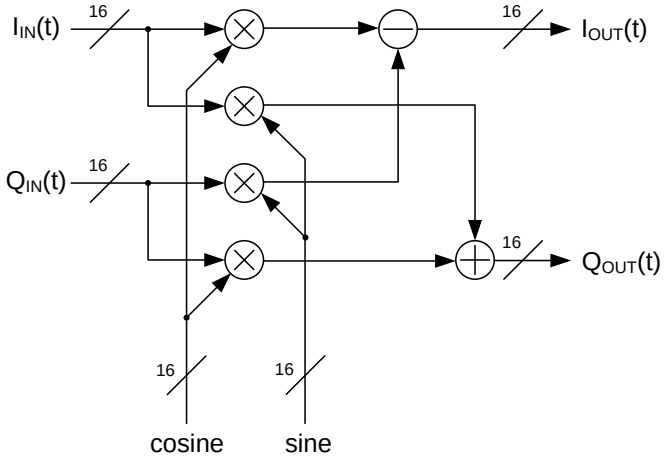


Figure 70. Complex Mixer Block Diagram

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) x π/4 (N = 1, 2, ...).

With ***mixer_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.

7.3.12 Coarse Mixer

In addition to the full complex mixers the DAC37J84/DAC38J84 also has a coarse mixer block capable of shifting the input signal spectrum by the fixed mixing frequencies ±n × $f_S/8$. Using the coarse mixer instead of the full mixers will result in lower power consumption.

Treating the two complex channels as complex vectors 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****=(fs8, fs4, fs2, fsm4)*. The mixing combinations are described in Table 15.

Table 15. 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

7.3.13 Dithering

DAC37J84/DAC38J84 supports the addition of a band limited dither to the DAC output after the complex mixer. This feature is enabled by set ***dither_ena*** to “1” and can be useful in reducing the high order harmonics. The generated dithering sequence can be optionally up-converted to an offset of Fs/2 by setting ***dither_mixer_ena*** to “1”. The added dithering sequence has variable amplitude in 6 dB steps via ***dither_sra_sel***.

7.3.14 Complex Summation

The DAC37J84/DAC38J84 has a complex summation block which is to sum channel A with channel C, channel B with Channel D, and the resulted complex summation are divided by 2 and sent via channel A and channel B. This feature is enabled by set ***output_sum*** to “1” and can be useful for multi-band application.

7.3.15 Quadrature Modulation Correction (QMC)

7.3.15.1 Gain and Phase Correction

The DAC37J84/DAC38J84 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 71. The QMC block contains 3 programmable parameters.

Registers ***qmc_gaina/b*** *(10:0)* and ***qmc_gainc/d*** *(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. The resolution allows suppression to > 65 dBc for a frequency independent IQ imbalance (the fine delay FIR block also contains gain control through the filter taps or inverse gain block that allows control with > 20 bits resolution, which can be used to improve the sideband suppression).

Register ***qmc_phaseab/cd*** *(11:0)* control the phase imbalance between I and Q and are 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 resolution of the phase term allows suppression to > 80 dBc for a frequency independent IQ imbalance.

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

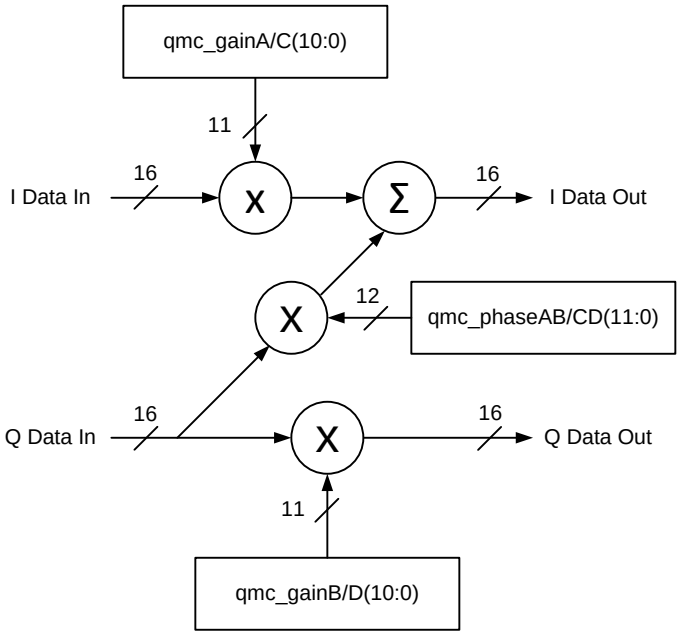


Figure 71. QMC Block Diagram

7.3.15.2 Offset Correction

Registers ***qmc_offseta*** *(12:0)*, ***qmc_offsetb*** *(12:0)*, ***qmc_offsetc*** *(12:0)* and ***qmc_offsetd*** *(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 LSB resolution of the offset allows LO suppression to better than 90 dBFS.

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.

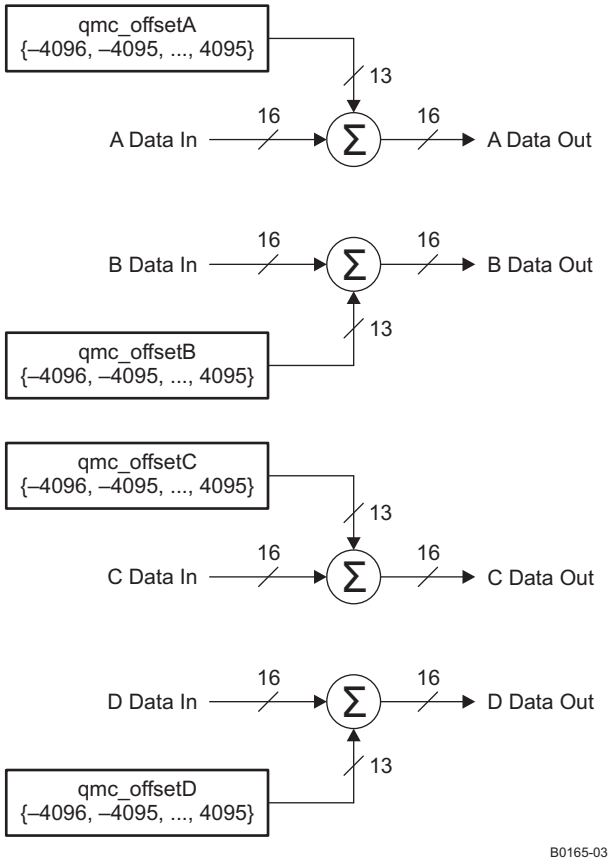


Figure 72. Digital Offset Block Diagram

7.3.16 Group Delay Correction Block

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 DAC37J84/DAC38J84 has group delay correction block for each DAC channel.

DAC38J84/DAC37J84 incorporates 2 FIR filters for small fractional group delay and 4 FIR filters for large fractional group delay. The input data to this block consists of 2, complex data (I/Q) channels i.e. 4 buses of 16-bit data. Control bits from configuration registers select the data path for all inputs through this block. Each input can either go through the small fractional delay filter (while its conjugate part goes through the matched delay line) or bypass the small fractional delay sub-block completely (matched delay line is bypassed for the conjugate part). The input to the large fractional delay F can either come from the output of small fractional delay sub-block or the original input to the block. The large fractional delay sub-block can also be completely bypassed if desired.

DAC38J84/DAC37J84 also include an integer delay block following each large fractional group delay filter, which can further delay the DAC output by [0-3]×Tdac. Channel A&B share the same control signal ***output_delayab***, and channel C&D share the same control signal ***output_delaycd***, which means that channel A&B have the same integer delay, and channel C&D have the same integer delay.

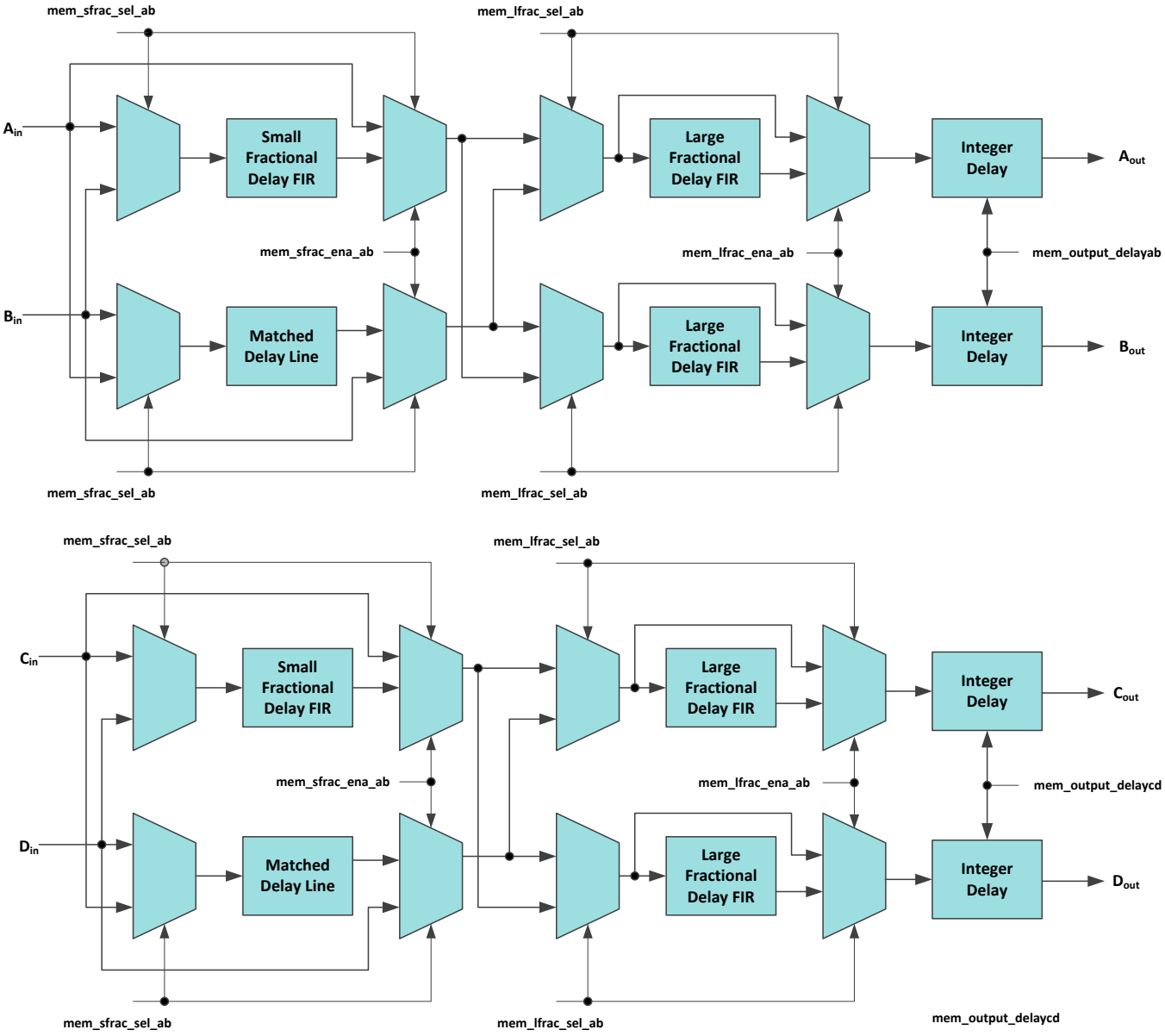


Figure 73. Diagram of Group Delay Correction

7.3.16.1 Fine Fractional Delay FIR Filter

The coefficients of the FIR filters for small fractional delay are programmable to user defined values which allows users to implement their own filter transfer functions. Filter designs supporting group delay variation in the range [0.002 0.198]×Tdac, where T is the time period of DAC Clock, is listed in Table 17. The bit widths of all coefficients are fixed, which puts limits on the range of values each coefficient can acquire.

Table 16. Small Fractional Delay FIR Coefficient Range

COEFFICIENT	RANGE
C0	[–2,1]
C1	[–16,15]
C2	[–128,127]
C3	[–512,511]
C4	[–262144,262143]

Table 16. Small Fractional Delay FIR Coefficient Range (continued)

COEFFICIENT	RANGE
C5	[–512,511]
C6	[–256,255]
C7	[–64,63]
C8	[–16,15]
C9	[–2,1]

Table 17. Example Coefficient Sets for the Small Fractional Delay

C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	InvGain NUMERATOR	DELAY [Tdac]
1	-12	64	–273	195897	393	-137	43	-9	1	5479	0.002
1	-12	64	-272	97872	393	-137	43	-9	1	10963	0.004
1	-12	64	-271	65138	394	-137	43	-9	1	16465	0.006
1	-12	64	-270	48873	395	-137	43	-9	1	21936	0.008
1	-12	64	-270	39068	395	-137	43	-9	1	27431	0.01
1	-12	64	-269	32555	396	-137	43	-9	1	32904	0.012
1	-12	63	-269	27892	396	-137	43	-9	1	38390	0.014
1	-12	63	-268	24387	397	-138	43	-9	1	43889	0.016
1	-12	63	-267	21666	398	-138	43	-9	1	49377	0.018
1	-12	63	-267	19496	398	-138	43	-9	1	54850	0.02
1	-12	63	-266	17722	399	-138	43	-9	1	60309	0.022
1	-12	63	-265	16235	400	-138	43	-9	1	65797	0.024
1	-12	63	-265	14981	400	-138	43	-9	1	71274	0.026
1	-12	63	-264	13907	401	-138	43	-9	1	76734	0.028
1	-12	63	-263	12973	402	-138	43	-9	1	82210	0.03
1	-12	63	-263	12159	402	-138	43	-9	1	87674	0.032
1	-12	63	-262	11439	403	-138	43	-9	1	93134	0.034
1	-12	63	-262	10798	404	-138	43	-9	1	98608	0.036
1	-12	62	-261	10227	404	-139	43	-9	1	104075	0.038
1	-12	62	-261	9714	405	-139	43	-9	1	109510	0.04
1	-12	62	-260	9246	406	-139	43	-9	1	114974	0.042
1	-12	62	-259	8823	406	-139	43	-9	1	120415	0.044
1	-12	62	-259	8435	407	-139	43	-9	1	125878	0.046
1	-12	62	-258	8080	408	-139	43	-9	1	131312	0.048
1	-12	62	-257	7754	408	-139	43	-9	1	136748	0.05
1	-12	62	-257	7454	409	-139	43	-9	1	142161	0.052
1	-12	62	-256	7174	410	-139	43	-9	1	147593	0.054
1	-12	62	-256	6916	411	-139	43	-9	1	152998	0.056
1	-12	62	-255	6675	411	-139	43	-9	1	158416	0.058
1	-12	62	-255	6450	412	-139	43	-9	1	163830	0.06
1	-12	61	-254	6239	413	-140	43	-9	1	169280	0.062
1	-12	61	-253	6042	413	-140	43	-9	1	174677	0.064
1	-12	61	-253	5856	414	-140	43	-9	1	180098	0.066
1	-12	61	-252	5683	415	-140	43	-9	1	185416	0.068
1	-12	61	-252	5518	416	-140	43	-9	1	190820	0.07
1	-12	61	-251	5363	416	-140	43	-9	1	196189	0.072
1	-12	61	-251	5215	417	-140	43	-9	1	201604	0.074
1	-12	61	-250	5076	418	-140	43	-9	1	206927	0.076

Table 17. Example Coefficient Sets for the Small Fractional Delay (continued)

C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	InvGain NUMERATOR	DELAY [Tdac]
1	-12	61	-249	4944	419	-140	43	-9	1	212244	0.078
1	-12	61	-249	4819	419	-140	43	-9	1	217621	0.08
1	-12	61	-248	4700	420	-140	43	-9	1	222907	0.082
1	-12	61	-248	4586	421	-141	43	-9	1	228310	0.084
1	-12	60	-247	4477	422	-141	43	-9	1	233676	0.086
1	-12	60	-247	4375	422	-141	43	-9	1	238981	0.088
1	-12	60	-246	4275	423	-141	43	-9	1	244310	0.09
1	-12	60	-246	4181	424	-141	44	-9	1	249533	0.092
1	-12	60	-245	4090	425	-141	44	-9	1	254803	0.094
1	-12	60	-245	4003	425	-141	44	-9	1	260175	0.096
1	-12	60	-244	3920	426	-141	44	-9	1	265384	0.098
1	-12	60	-243	3840	427	-141	44	-9	1	270600	0.1
1	-12	60	-243	3763	428	-141	44	-9	1	275884	0.102
1	-12	60	-242	3690	429	-141	44	-9	1	281011	0.104
1	-12	60	-242	3619	429	-142	44	-9	1	286408	0.106
1	-12	60	-241	3550	430	-142	44	-9	1	291619	0.108
1	-12	60	-241	3484	431	-142	44	-9	1	296860	0.11
1	-12	59	-240	3421	432	-142	44	-9	1	302037	0.112
1	-12	59	-240	3360	433	-142	44	-9	1	307222	0.114
1	-12	59	-239	3300	433	-142	44	-9	1	312498	0.116
1	-12	59	-239	3243	434	-142	44	-9	1	317675	0.118
1	-12	59	-238	3188	435	-142	44	-9	1	322736	0.12
1	-12	59	-238	3134	436	-142	44	-9	1	327960	0.122
1	-12	59	-237	3082	437	-142	44	-9	1	333046	0.124
1	-12	59	-237	3033	438	-143	44	-9	1	338186	0.126
1	-12	59	-236	2984	438	-143	44	-9	1	343378	0.128
1	-11	59	-236	2937	439	-143	44	-9	1	348391	0.13
1	-11	59	-235	2891	440	-143	44	-9	1	353437	0.132
1	-11	59	-235	2847	441	-143	44	-9	1	358511	0.134
1	-11	58	-234	2804	442	-143	44	-9	1	363611	0.136
1	-11	58	-234	2762	443	-143	44	-9	1	368730	0.138
1	-11	58	-233	2722	443	-143	44	-9	1	373735	0.14
1	-11	58	-233	2682	444	-143	44	-9	1	378879	0.142
1	-11	58	-232	2644	445	-143	44	-9	1	383753	0.144
1	-11	58	-232	2607	446	-143	44	-9	1	388755	0.146
1	-11	58	-231	2570	447	-144	44	-9	1	393889	0.148
1	-11	58	-231	2535	448	-144	44	-9	1	398864	0.15
1	-11	58	-230	2501	449	-144	44	-9	1	403662	0.152
1	-11	58	-230	2467	449	-144	44	-9	1	408889	0.154
1	-11	58	-229	2435	450	-144	44	-9	1	413614	0.156
1	-11	58	-229	2403	451	-144	44	-9	1	418613	0.158
1	-11	58	-228	2372	452	-144	44	-9	1	423400	0.16
1	-11	57	-228	2342	453	-144	44	-9	1	428468	0.162
1	-11	57	-227	2313	454	-144	44	-9	1	433135	0.164
1	-11	57	-227	2284	455	-144	44	-9	1	438083	0.166
1	-11	57	-226	2256	456	-145	44	-9	1	442963	0.168

Table 17. Example Coefficient Sets for the Small Fractional Delay (continued)

C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	InvGain NUMERATOR	DELAY [Tdac]
1	-11	57	-226	2228	457	-145	44	-9	1	447952	0.17
1	-11	57	-225	2202	458	-145	44	-9	1	452483	0.172
1	-11	57	-225	2175	459	-145	44	-9	1	457495	0.174
1	-11	57	-224	2150	459	-145	44	-9	1	462222	0.176
1	-11	57	-224	2125	460	-145	44	-9	1	467047	0.178
1	-11	57	-223	2100	461	-145	44	-9	1	471767	0.18
1	-11	57	-223	2076	462	-145	44	-9	1	476583	0.182
1	-11	57	-223	2053	463	-145	44	-9	1	481283	0.184
1	-11	57	-222	2030	464	-145	44	-9	1	485856	0.186
1	-11	57	-222	2008	465	-146	44	-9	1	490741	0.188
1	-11	56	-221	1986	466	-146	44	-9	1	495497	0.19
1	-11	56	-221	1964	467	-146	44	-9	1	500346	0.192
1	-11	56	-220	1943	468	-146	44	-9	1	504815	0.194
1	-11	56	-220	1923	469	-146	44	-9	1	509365	0.196
1	-11	56	-219	1903	470	-146	44	-9	1	513752	0.198

7.3.16.2 Coarse Fractional Delay FIR Filter

The coefficients of FIR filters for large fractional delay can only be chosen from a predefined set of values. Each set of values produces a specific delay with a step of 1/8×Tdac. The value of coefficients as well as their resultant fractional delay is provided in Table 18.

Table 18. Available Coefficient Sets for Large Fractional Delay FIR

lfras_coefsel_x	C0	C1	C2	C3	C4	C5	C6	C7	InvGain NUMERATOR	DELAY [Tdac]
000	-1	9	-39	532	76	-24	7	-1	7503	0.1250
001	-1	8	-35	259	87	-25	7	-1	14028	0.2500
010	-1	7	-31	168	101	-26	7	-1	18725	0.3750
011	-1	7	-27	122	122	-27	7	-1	20764	0.5000
100	—	—	—	—	—	—	—	—	—	—
101	-1	7	-26	101	168	-31	7	-1	18725	06250
110	-1	7	-25	87	259	-35	8	-1	14028	0.7500
111	-1	7	-24	76	532	-39	9	-1	7503	0.8750

7.3.17 Output Multiplexer

The DAC37J84/DAC38J84 includes an output multiplexer before the digital to analog converters that allows any signal channel A-D to be routed to any DAC A-D. See ***pathx_out_sel*** for details on how to configure the cross-bar switches.

7.3.18 Power Measurement And Power Amplifier Protection

DAC37J84/DAC38J84 provides an optional mechanism to protect the Power Amplifier (PA) in cases when the signal power shows some abnormality. For example, if the data clock is lost, the FIFO would automatically generate a single tone signal, which causes abnormally high average power and could be dangerous to the PA. In the PA protection mechanism, the signal power is monitored by maintaining an sliding window accumulation of last N samples. N is selectable to be 64 or 128 based on the setting of ***pap_dlylen_sel***. The average amplitude of input signal is computed by dividing accumulated value by the number of samples in the delay-line (N). The result is then compared against a threshold (***pap_vth***). If the threshold is violated, the delayed input signal is divided by a value chosen by ***pap_gain***, to form a scaled down version of the input signal. Since PAP output derives from a delay-line, there is deterministic latency of at least N cycles from the block input to block output. The PA protection is enabled by setting the ***pap_ena*** bit to “1”.

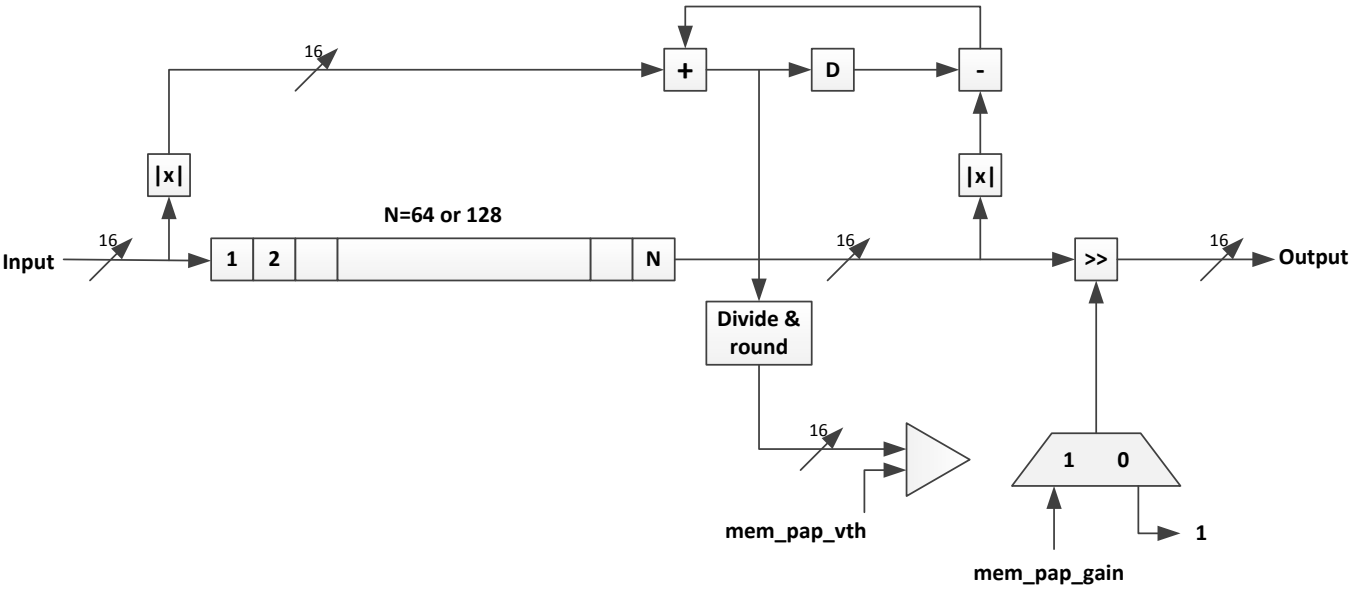


Figure 74. Diagram of Power Measurement and PA Protection Mechanism

7.3.19 Serdes Test Modes

DAC37J84/DAC38J84 supports a number of basic pattern generation and verification of SerDes via SIF. Three pseudo random bit stream (PRBS) sequences are available, along with an alternating 0/1 pattern and a 20-bit user-defined sequence. The 2^7-1,2^{31}-1 or 2^{23}-1 sequences implemented can often be found programmed into standard test equipment, such as a Bit Error Rate Tester (BERT). Pattern generation and verification selection is via the **TESTPATT** fields of ***rw_cfgrx0***[14:12], as shown in Table 19.

Table 19. SerDes Test Pattern Selection

TESTPATT	EFFECT
000	Test mode disabled.
001	Alternating 0/1 Pattern. An alternating 0/1 pattern with a period of 2UI.
010	Generate or Verify 2^7-1 PRBS. Uses a 7-bit LFSR with feedback polynomial $x^7 + x^6 + 1$.
011	Generate or Verify 2^{23} -1 PRBS. Uses an ITU O.150 conformant 23-bit LFSR with feedback polynomial $x^{23} + x^{18} + 1$.
100	Generate or Verify 2^{31}-1 PRBS. Uses an ITU O.150 conformant 31-bit LFSR with feedback polynomial $x^{31} + x^{28} + 1$.
101	User-defined 20-bit pattern. Uses the USR PATT IEEE1500 Tuning instruction field to specify the pattern. The default value is 0x66666.
11x	Reserved

Pattern verification compares the output of the serial to parallel converter with an expected pattern. When there is a mismatch, the **TESTFAIL** bit is driven high, which can be programmed to come out the ALARM terminal by setting ***dtest***[3:0] to “0011”.

DAC37J84/DAC38J84 also provide a number of advanced diagnostic capabilities controlled by the IEEE 1500 interface. These are:

- Accumulation of pattern verification errors;
- The ability to map out the width and height of the receive eye, known as Eye Scan;
- Real-time monitoring of internal voltages and currents;

The SerDes blocks support the following IEEE1500 instructions:

Table 20. IEEE1500 Instruction for SerDes Receivers

INSTRUCTION	OPCODE	DESCRIPTION
ws_bypass	0x00	Bypass. Selects a 1-bit bypass data register. Use when accessing other macros on the same IEEE1500 scan chain.
ws_cfg	0x35	Configuration. Write protection options for other instructions.
ws_core	0x30	Core. Fields also accessible via dedicated core-side ports.
ws_tuning	0x31	Tuning. Fields for fine tuning macro performance.
ws_debug	0x32	Debug. Fields for advanced control, manufacturing test, silicon characterization and debug
ws_unshadowed	0x34	Unshadowed. Fields for silicon characterization.
ws_char	0x33	Char. Fields used for eye scan.

The data for each SerDes instruction is formed by chaining together sub-components called head, body (receiver or transmitter) and tail. DAC37J84/DAC38J84 uses two SerDes receiver blocks R0 and R1, each of which contains 4 receive lanes (channels), the data for each IEEE1500 instruction is formed by chaining **{head, receive lane 0, receive lane 1, receive lane 2, receive lane 3, tail}**. A description of bits in head, body and tail for each instruction is given as follows:

NOTE

All multi-bit signals in each chain are packed with bits reversed e.g. mpy[7:0] in ws_core head subchain is packed as {retime, enpll, *mpy[0:7]*, vrange,**lb[0:1]}**. All DATA REGISTER READS from SerDes Block R0 should read 1 bit more than the desired number of bits and discard the first bit received on TDO e.g., to read 40-bit data from R0 block, 41 bits should be read off from TDO and the first bit received should be discarded. Similarly, any data written to SerDes Block R0 Data Registers should be prefixed with an extra 0.

Table 21. *ws_cfg* Chain

FIELD	DESCRIPTION
HEAD (STARTING FROM THE MSB OF CHAIN)	
RETIME	No function.
CORE_WE	Core chain write enable.
RECEIVER (FOR EACH LANE 0,1,2,3)	
CORE_WE	Core chain write enable.
TUNING_WE	Tuning chain write enable.
DEBUG_WE	Reserved.
CHAR_WE	Char chain write enable.
UNSHADOWED_WE	Reserved.
TAIL (ENDING WITH THE LSB OF CHAIN)	
CORE_WE	Core chain write enable.
TUNING_WE	Tuning chain write enable.
DEBUG_WE	Reserved.
RETIME	No function.
CHAIN LENGTH = 26 BITS	

Table 22. *ws_core* Chain

FIELD	DESCRIPTION
HEAD (STARTING FROM THE MSB OF CHAIN)	
RETIME	No function.
ENPLL	PLL enable.
MPY[7:0]	PLL multiply.
VRANGE	VCO range.
ENDIVCLK	Enable DIVCLK output

Table 22. *ws_core* Chain (continued)

FIELD	DESCRIPTION
LB[1:0]	Loop bandwidth
RECEIVER (FOR EACH LANE 0,1,2,3)	
ENRX	Receiver enable.
SLEEPRX	Receiver sleep mode.
BUSWIDTH[2:0]	Bus width.
RATE[1:0]	Operating rate.
INVPAIR	Invert polarity.
TERM[2:0]	Termination.
ALIGN[1:0]	Symbol alignment.
LOS[2:0]	Loss of signal enable.
CDR[2:0]	Clock/data recovery.
EQ[2:0]	Equalizer.
EQHLD	Equalizer hold.
ENOC	Offset compensation.
LOOPBACK[1:0]	Loopback.
BSINRXP	Boundary scan initialization.
BSINRXN	Boundary scan initialization.
RESERVED	Reserved.
testpatt[2:0]	Testpattern selection.
TESTFAIL	Test failure (real time).
LOSDTCT	Loss of signal detected (real time).
BSRXP	Boundary scan data.
BSRXN	Boundary scan data.
OCIP	Offset compensation in progress.
EQOVER	Received signal over equalized.
EQUNDER	Received signal under equalized.
LOSDTCT	Loss of signal detected (sticky).
SYNC	Re-alignment done, or aligned comma output (sticky)
RETIME	No function.
TAIL (ENDING WITH THE LSB OF CHAIN)	
CLKBYP[1:0]	Clock bypass.
SLEEPPLL	PLL sleep mode.
RESERVED	Reserved.
LOCK	PLL lock (real time).
BSINITCLK	Boundary scan initialization clock.
ENBSTX	Enable Tx boundary scan.
ENBSRX	Enable Rx boundary scan.
ENBSPT	Rx pulse boundary scan.
RESERVED	Reserved.
NEARLOCK	PLL near to lock.
UNLOCK	PLL lock (sticky).
CFG OVR	Configuration over-ride.
RETIME	No function.
CHAIN LENGTH = 196 BITS	

Table 23. *ws_tuning* Chain

FIELD	DESCRIPTION
HEAD (STARTING FROM THE MSB OF CHAIN)	
RETIME	No function.
RECEIVER (FOR EACH LANE 0,1,2,3)	
PATTERRTHR[2:0]	Resync error threshold.
PATT TIMER	PRBS Timer.
RXDSEL[3:0]	Status select.
ENCOR	Enable clear-on-read for error counter.
EQZERO[4:0]	EQZ OVRi Equalizer zero.
EQZ OVR	Equalizer zero over-ride.
EQLEVEL[15:0]	EQ OVRi Equalizer gain observe or set.
EQ OVR	Equalizer over-ride.
EQBOOST[1:0]	Equalizer gain boost.
RXASEL[2:0]	Selects amux output.
TAIL (ENDING WITH THE LSB OF CHAIN)	
ASEL[3:0]	Selects amux output.
USR PATT[19:0]	User-defined test pattern.
RETIME	No function.
CHAIN LENGTH = 174 BITS	

Table 24. *ws_char* Chain

FIELD	DESCRIPTION
HEAD (STARTING FROM THE MSB OF CHAIN)	
RETIME	No function.
RECEIVER (FOR EACH LANE 0,1,2,3)	
TESTFAIL	Test failure (sticky).
ECOUNT[11:0]	Error counter.
ESWORD[7:0]	Eye scan word masking.
ES[3:0]	Eye scan.
ESPO[6:0]	Eye scan phase offset.
ES BIT SELECT[4:0]	Eye scan compare bit select.
ESVO[5:0]	Eye scan voltage offset.
ESVO OVR	Eye scan voltage offset override.
ESLEN[1:0]	Eye scan run length.
ESRUN	Eye scan run.
ESDONE	Eye scan done.
TAIL (ENDING WITH THE LSB OF CHAIN)	
RETIME	No function.
CHAIN LENGTH = 194 BITS	

7.3.20 Error Counter

All receive channels include a 12-bit counter for accumulating pattern verification errors. This counter is accessible via the ECOUNT IEEE1500 Char field. It is an essential part of the eye scan capability (see next section), though can be used independently of this..

The counter increments once for every cycle that the TESTFAIL bit is detected. The counter will not increment when at its maximum value (i.e., all 1s). When an IEEE1500 capture is performed, the count value is loaded into the ECOUNT scan elements (so that it can be scanned out), and the counter is then reset, provided ENCOR is set high.

ECOUNT can be used to get a measure of the bit error rate. However, as the error rate increases, it will become less accurate due to limitations of the pattern verification capabilities. Specifically, the pattern verifier checks multiple bits in parallel (as determined by the Rx bus width), and it is not possible to distinguish between 1 or more errors in this.

7.3.21 Eye Scan

All receive channels provide features which facilitate mapping the received data eye or extracting a symbol response. A number of fields accessible via the IEEE1500 Char scan chain allow the required low level data to be gathered. The process of transforming this data into a map of the eye or a symbol response must then be performed externally, typically in software.

The basic principle used is as follows:

- Enable dedicated eye scan input samplers, and generate an error when the value sampled differs from the normal data sample;
- Apply a voltage offset to the dedicated eye scan input samplers, to effectively reduce their sensitivity;
- Apply a phase offset to adjust the point in the eye that the dedicated eye scan data samples are taken;
- Reset the error counter to remove any false errors accumulated as a result of the voltage or phase offset adjustments;
- Run in this state for a period of time, periodically checking to see if any errors have occurred;
- Change voltage and/or phase offset, and repeat.

Alternatively, the algorithm can be configured to optimize the voltage offset at a specified phase offset, over a specified time interval.

Eye scan can be used in both synchronous and asynchronous systems, while receiving normal data traffic. The IEEE1500 Char fields used to directly control eye scan and symbol response extraction are ES, ESWORD, ES BIT SELECT, ESLEN, ESPO, ESVO, ESVO OVR, ESRUN and ESDONE, see Table 24. Eye scan errors are accumulated in ECOUNT.

The required eyescan mode is selected via the ES field, as shown in Table 25. When enabled, only data from the bit position within the 20-bit word specified via ES BIT SELECT is analyzed. In other words, only eye scan errors associated with data output at this bit position will accumulate in ECOUNT. The maximum legal ES BIT SELECT is 10011.

Table 25. Eye Scan Mode Selection

ES[3:0]	EFFECT
0000	Disabled. Eye scan is disabled.
0x01	Compare. Counts mismatches between the normal sample and the eye scan sample if ES[2] = 0, and matches otherwise.
0x10	Compare zeros. As ES = 0x01, but only analyses zeros, and ignores ones.
0x11	Compare ones. As ES = 0x01, but only analyses ones, and ignores zeroes
0100	Count ones. Increments ECOUNT when the eye scan sample is a 1.
1x00	Average. Adjusts ESVO to the average eye opening over the time interval specified by ESLEN. Analyses zeroes when ES[2] = 0, and ones when ES[2]= 1.
1001 1110	Outer. Adjusts ESVO to the outer eye opening (i.e. lowest voltage zero, highest voltage 1) over the time interval specified by ESLEN. 1001 analyses zeroes, 1110 analyses ones.
1010 1101	Inner. Adjusts ESVO to the inner eye opening (i.e. highest voltage zero, lowest voltage 1) over the time interval specified by ESLEN. 1010 analyses zeroes, 1101 analyses ones.
1x11	Timed Compare. As ES = 001x, but analyses over the time interval specified by ESLEN. Analyses zeroes when ES[2] = 0, and ones when ES[2] = 1.

When ES[3] = 0, the selected analysis runs continuously. However, when ES[3] = 1, only the number of qualified samples specified by ESLEN, as shown in Table 26. In this case, analysis is started by writing a 1 to ESRUN (it is not necessary to set it back to 0). When analysis completes, ESDONE will be set to 1.

Table 26. Eye Scan Run Length

ESLen	NUMBER OF SAMPLES ANALYZED
00	127
01	1023
10	8095
11	65535

When ESVO OVR = 1, the ESVO field determines the amount of offset voltage that is applied to the eye scan data samplers associated with rxpi and rxni. The amount of offset is variable between 0 and 300mV in increments of ~10mV, as shown in Table 27. When ES[3] = 1, ESVO OVR must be 0 to allow the optimized voltage offset to be read back via ESVO.

Table 27. Eye Scan Voltage Offset

ESVO	OFFSET (mV)
100000	–310
..	..
111110	–20
111111	–10
000000	0
000001	10
000010	20
..	..
011111	300

The phase position of the samplers associated with rxpi and rxni, is controlled to a precision of 1/32UI. When ES is not 00, the phase position can be adjusted forwards or backwards by more than one UI using the ESPO field, as shown in Table 28. In normal use, the range should be limited to ±0.5UI (+15 to –16 phase steps).

Table 28. Eye Scan Phase Offset

ESPO	OFFSET (1/32UI)
011111	+63
..	..
000001	+1
000000	0
111111	–1
..	..
100000	–64

7.3.22 JESD204B Pattern Test

DAC37J84/DAC38J84 supports the following test patterns for JESD204B:

- Link layer test pattern
  - Verify repeating /D.21.5/ high frequency pattern for random jitter (RJ)
  - Verify repeating /K.28.5/ mixed frequency pattern for deterministic jitter (DJ)
  - Verify repeating initial lane alignment (ILA) sequence
  - RPAT, JSPAT or JTSPAT pattern can be verified using errors counter of 8b/10b errors produced over an amount of time to get an estimate of BER.
- Transport layer test pattern: implements a short transport layer pattern check based on F = 1,2,4 or 8. The short test pattern has a duration of one frame period and is repeated continuously for the duration of the test. Refer to JESD204B standard section 5.1.6 for more details.
  - F = 1 : Looks for a constant 0xF1.
  - F = 2 : Each frame should consist of 0xF1, 0xE2
  - F = 4 : Looks for a constant 0xF1, 0xE2, 0xD3, 0xC4
  - F = 8 : Each frame should consist of 0xF1, 0xE2, 0xD3, 0xC4, 0xB5, 0xA6, 0x97, 0x81

Users can select to output the internal data (ex, the 8b/10 decoder output, comma alignment output, lane alignment output, frame alignment output, descrambler output, etc) of a JESD link for test purpose. See ***jesd_testbus_sel*** for configuration details.

7.3.23 Temperature Sensor

The DAC37J84/DAC38J84 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 ***memin_tempdata*** in *config7*. 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.

7.3.24 Alarm Monitoring

The DAC37J84/DAC38J84 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 SIP registers and/or through the ALARM terminal. Once an alarm is set, the corresponding alarm bit in register *configtbd* must be reset through the serial interface to allow further testing. The set of alarms includes the following conditions:

- *JESD alarms*
  - multiframe alignment_error. Occurs when multiframe alignment fails.
  - frame alignment error. Occurs when multiframe alignment fails.
  - link configuration error. Occurs when there is wrong link configuration.
  - elastic buffer overflow. Occurs when bad RBD value is used.
  - elastic buffer match error. Occurs when the first non-/K/ doesn’t match the programmed data.
  - code synchronization error.
  - 8b/10b not-in-table decode error.
  - 8b/10 disparity error.
  - alarm_from_shorttest. Occurs when fails the short pattern test.
- *SerDes alarms*
  - memin_rw_losdct. Occurs when there are loss of signal detect from SerDes lanes.

- FIFO write error. Occurs if write request and FIFO is full.
- FIFO write full: Occurs if FIFO is full.
- FIFO read error. Occurs if read request and FIFO is empty.
- FIFO read empty: Occurs if FIFO is empty.
- alarm_rw0_pll. Occurs if the PLL in the SerDes block R0 goes out of clock.
- alarm_rw1_pll. Occurs if the PLL in the SerDes block R0 goes out of clock.

- *SYSREF alarm*
  - alarm_sysref_err. Occurs when the SYSREF is received at an unexpected time. If too many of these occur it will cause the JESD to go into synchronization mode again.
- *DAC PLL alarm*
  - alarm_from_pll. Occurs when the DAC PLL is out of lock.
- *PAP alarms*
  - alarm_pap. Occurs when the average power is above the threshold. While any alarm_pap is asserted the attenuation for the appropriate data path is applied.

7.3.25 LVPECL Inputs

Figure 75 shows an equivalent circuit for the DAC input clock (DACCLKP/N) and the SYSREF (SYSREFP/N).

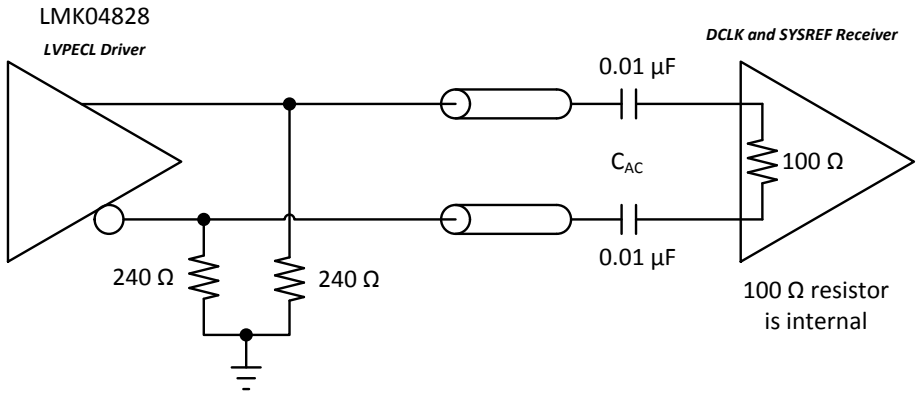


Figure 75. DACCLKP/N and SYSREFP/N Equivalent Input Circuit

7.3.26 CMOS Digital Inputs

Figure 76 shows a schematic of the equivalent CMOS digital inputs of the DAC37J84/DAC38J84. SDIO, SCLK, TCLK, SLEEP, TESTMODE and TXENABLE have pull-down resistors while SDENB, RESETB, TMS, TDI and TRSTB have pull-up resistors internal to the DAC37J84/DAC38J84. See the specification table for logic thresholds. The pull-up and pull-down circuitry is approximately equivalent to 100kΩ.

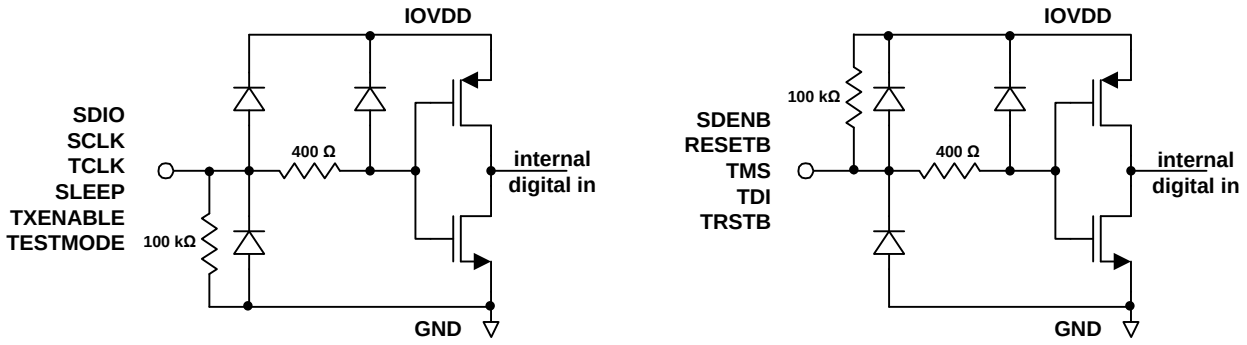


Figure 76. CMOS Digital Equivalent Input

7.3.27 Reference Operation

The DAC37J84/DAC38J84 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 terminal 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:

$$IOUT_{FS} = 16 \times I_{BIAS} = 64 \times V_{EXTIO} / R_{BIAS}$$

The DAC37J84/DAC38J84 has a 4-bit coarse gain control *coarse_dac(3:0)* in the *configtbd* register. Using gain control, the $IOUT_{FS}$ can be expressed as:

$$IOUT_{FS} = (coarse\_dac + 1) /16 \times I_{BIAS} \times 64 = (coarse\_dac + 1) /16 \times V_{EXTIO} / R_{BIAS} \times 64$$

where V_{EXTIO} is the voltage at terminal EXTIO. The bandgap reference voltage delivers an accurate voltage of 0.9V. This reference is active when *extref_ena* = '0' in *configtbd*. 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.

7.3.28 Analog Outputs

The CMOS DACs 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 complimentary output nodes IOUTP or IOUTN. Complimentary 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 four.

The full-scale output current is set using external resistor R_{BIAS} in combination with an on-chip bandgap voltage reference source (+0.9 V) and control amplifier. Current I_{BIAS} through resistor R_{BIAS} is mirrored internally to provide a maximum full-scale output current equal to 16 times I_{BIAS}.

The relation between IOUTP and IOUTN can be expressed as:

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

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 terminals. The output current flow in each terminal 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 terminals IOUTP and IOUTN can be expressed as:

$$VOUTP = 20mA \times 25\ \Omega = 0.5\ V$$

$$VOUTN = 0mA \times 25\ \Omega = 0\ V$$

$$VDIFF = VOUTP – VOUTN = 0.5V$$

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

7.3.29 DAC Transfer Function

The DAC37J84/DAC38J84 can be easily configured to drive a doubly terminated 50 Ω cable using a properly selected RF transformer. Figure 77 and Figure 78 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.

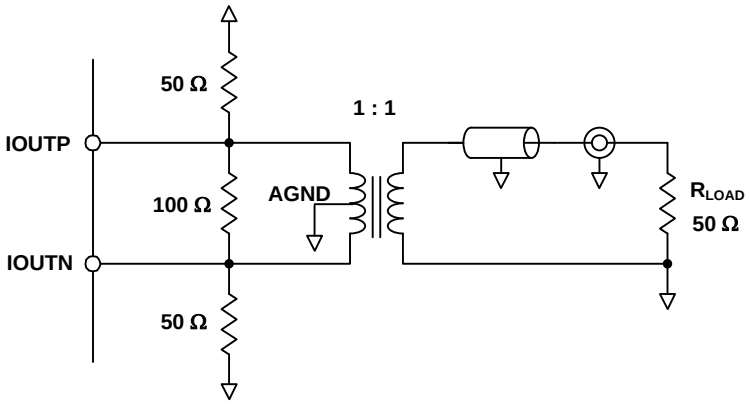


Figure 77. Driving a Doubly Terminated 50 Ω Cable Using a 1:1 Impedance Ratio Transformer

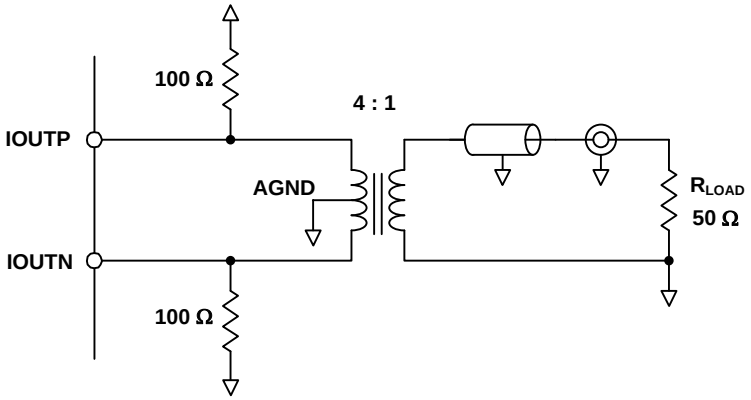


Figure 78. Driving a Doubly Terminated 50 Ω Cable Using a 4:1 Impedance Ratio Transformer

7.4 Device Functional Modes

7.4.1 Clocking Modes

The DAC37J84/DAC38J84 has a single differential clock DACCLKN/P to clock the DAC cores and internal digital logic. The DAC37J84/DAC38J84 DACCLK 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 terminals are used as the reference frequency input to the PLL.

7.4.1.1 PLL Bypass Mode

In PLL bypass mode a high quality clock is sourced to the DACCLK inputs. This clock is used to directly clock the DAC37J84/DAC38J84 DAC cores. This mode gives the device best performance and is recommended for extremely demanding applications.

Device Functional Modes (continued)

The bypass mode is selected by setting the following:

1. ***pll_ena*** bit in register *config49* to “0” to bypass the PLL circuitry.
2. ***pll_sleep*** bit in register *config26* to “1” to put the PLL and VCO into sleep mode.

7.4.1.2 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 79 shows the block diagram of the PLL circuit, where N divider ratio ranges from 1 to 32, M divider ratio ranges from 1 to 256, and VCO prescaler divider from 2 to 18.

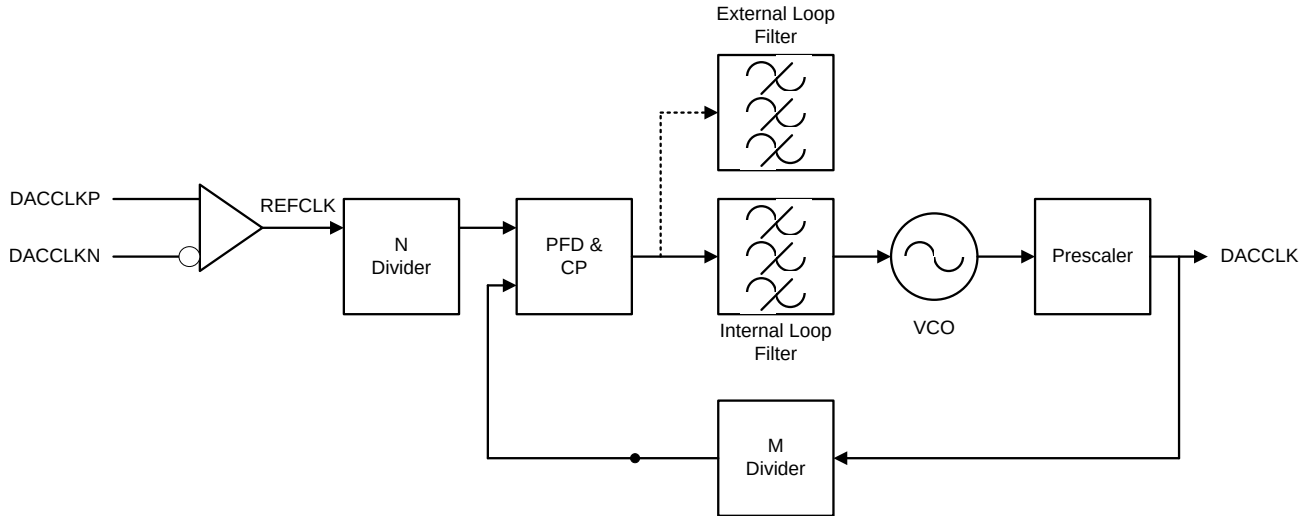


Figure 79. PLL Block Diagram

The DAC37J84/DAC38J84 PLL mode is selected by setting the following:

1. ***pll_ena*** bit in register *config49* to “1” to route to the PLL and clock path.
2. ***pll_sleep*** bit in register *config26* to “0” to enable the PLL and VCO.

The output frequency of the VCO covers two frequency spans: H-band (4.44–5.6GHz) and L-band (3.7–4.66GHz). When ***pll_vcosel*** in register *config51* is “1”, the L-band is selected; when ***pll_vcosel*** is “0”, the H-band is selected. At each band, the VCO range can be further adjusted by using the 6-bits ***pll_vco*** in register *config51*. Figure 80 shows a typical relationship between the PLL VCO coarse tuning bits *pll_vco* and the VCO center frequency. The corresponding equations for the H-band and L-band VCO are given in Equation 1 and Equation 2, respectively. Note that It is recommended to shift *pll_vco* by +1 to guarantee the VCO operation at hot temp environment. In case of cold temp environment, shift by -1 on the variable *pll_vco* is recommended.

H-Band: VCO Frequency (MHz) = 0.10998*pll_vco^2+10.574*pll_vco+4446.3, (1)

where *pll_vcosel* = "0" and *pll_vcoitune* = "11".

L-Band: VCO Frequency (MHz) = 0.089703*pll_vco^2+8.8312*pll_vco+3752.5, (2)

where *pll_vcosel* = "1" and *pll_vcoitune* = "10".

Device Functional Modes (continued)

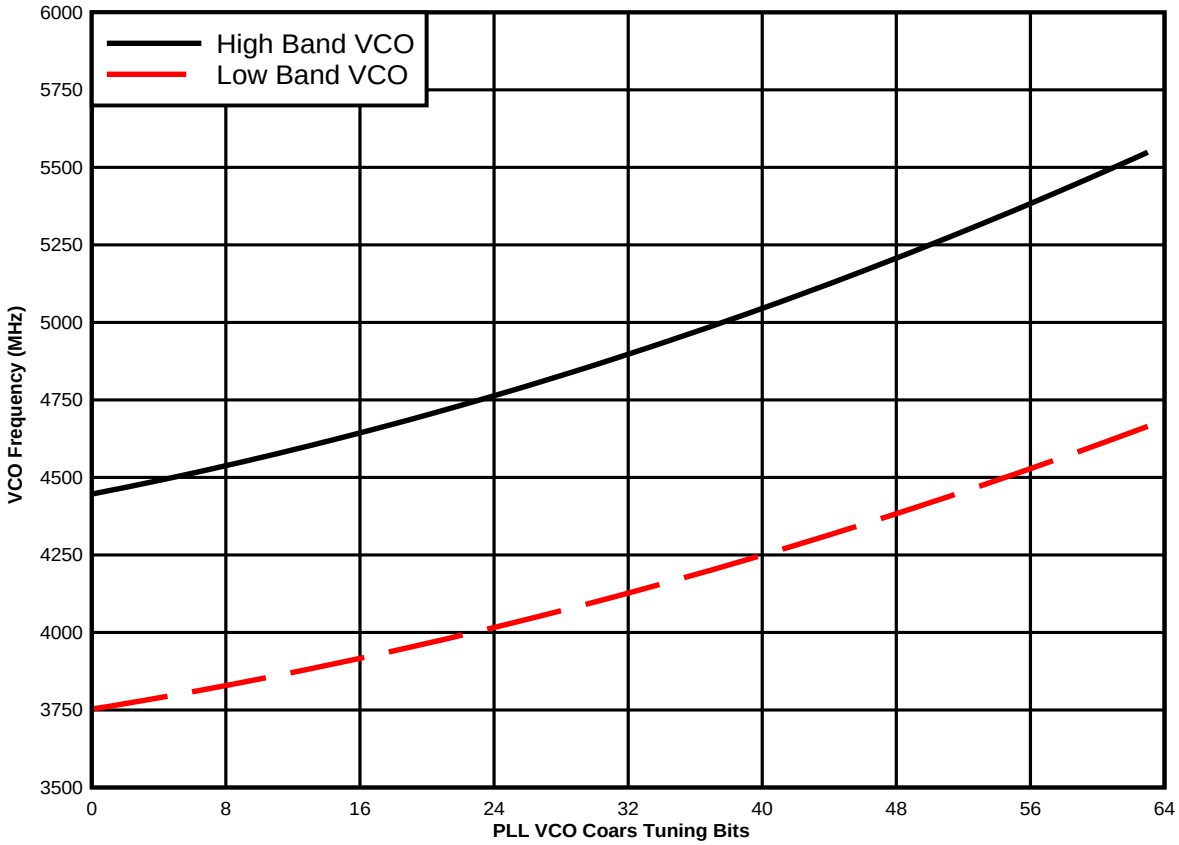


Figure 80. Typical PLL VCO Center Frequency vs Coarse Tuning Bits

Common wireless infrastructure frequencies are generated from this VCO frequency in conjunction with the pre-scaler setting ***pll_p*** in register *config50* as shown in Table 29. When there are multiple valid VCO frequency and the pre-scaler settings to generate the same desired DACCLK frequency, higher pre-scaler divider ratio is recommended for better phase noise performance.

Table 29. VCO Operation

VCO FREQUENCY (MHz)	pll_vcosel	PRE-SCALE DIVIDER	DESIRED DACCLK (MHz)	pll_p(3:0)
4915.2	0	2	2457.6	0000
3932.16	1	2	1966.08	0000
4423.68	1	3	1474.56	0001
4915.2	0	4	1228.8	0010
4915.2	0	5	983.04	0011
5160.96	0	7	737.28	0101
4915.2	0	8	614.4	0110
4915.2	0	10	491.52	0111

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

Table 30. PFD and CP Operation

DACCLK FREQUENCY (MHz)	M DIVIDER	PFD UPDATE RATE (MHz)	pll_m(7:0)
1474.56	12	122.88	00001011
1474.56	24	61.44	00010111
1474.56	48	30.72	00101111
1474.56	64	15.36	00111111

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). The 5-bit ***pll_cp_adj*** is to set the charge pump current from 0 to 1.55mA with a step of 50µA. In nominal condition, if vco runs at 5GHz with P-ratio and M-ratio set as 2 and 4, the DACCLK frequency would be 2.5GHz and PFD frequency 625MHz. This needs 600µA charge pump current to stabilize the loop and gives the optimized phase noise performance. When P*M ratio increases, the charge pump current needs to be increased accordingly to sustain enough phase margin for the loop. By tuning the charge pump current, a wide range of PM ratio can be supported with the internal loop filter. In very extreme cases when the P*M ratio is huge (ex. PFD frequency of 10MHz, VCO frequency of 4GHz) and the loop cannot be stabilized even with the largest charge pump current, an external loop filter is required.

If an external filter is required, the following filter should be connected to the LPF terminal (C9):

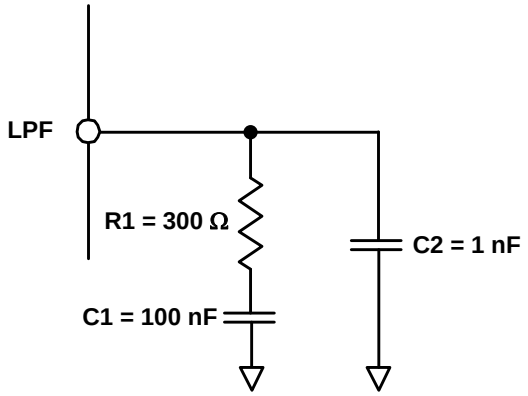


Figure 81. Recommended External Loop Filter

7.4.2 PRBS TEST MODE

DAC37J84 and DAC38J84 support three types of PRBS sequences (2^7-1, 2^{23}-1, and 2^{31}-1) to verify the SerDes via SIF. To run the PRBS test on the DAC, users first need to setup the DAC for normal use, then make the following SPI writes:

1. *config74*, set bits 4:0 to 0x1E to disable JESD clock.
2. *config61*, set bits 14:12 to 0x2 to enable the 7-bit PRBS test pattern; or set bits 14:12 to 0x3 to enable the 23-bit PRBS test pattern; or set bits 14:12 to 0x4 to enable the 31-bit PRBS test pattern.
3. *config27*, set bits 11:8 to 0x3 to output PRBS testfail on ALARM terminal.
4. *config27*, set bits 14:12 to the lane to be tested (0 through 7).
5. *config62*, make sure bits 12:11 are set to 0x0 to disable character alignment.

Users should monitor the ALARM terminal to see the results of the test. If the test is failing, ALARM will be high (or toggling if marginal). If the test is passing, the ALARM will be low.

7.5 Register Map

Table 31. 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	0x0218	qmc_ offsetab _ena	qmc_ offsetcd _ena	qmc _corrab _ena	qmc_ corrcd _ena	interp(3:0)				alarm_zer os _txenable _ena	outsum _ena	alarm_ zeros _jesd data_ena	alarm_out _ena	alarm _out_pol	pap _ena	inv_sinc _ab _ena	inv_sinc _cd_ena
config1	0x01	0x0003	sfrac_ ena_ab	sfrac_ ena_cd	lfrac_ ena_ab	lfrac_ ena_cd	sfrac_ sel_ab	sfrac_ sel_cd	reserved	reserved	daca_ complime nt	dacb_ complime nt	dacc_ complime nt	dacd_ complime nt	reserved	reserved	reserved	reserved
config2	0x02	0x2002	dac_bitwidth(1:0)		zer _invalid _data	shorttest _ena	reserved	reserved	reserved	reserved	sif4 _ena	mixer _ena	mixer _gain	nco _ena	reserved	reserved	twos	sif_reset
config3	0x03	0xF380	coarse_dac(3:0)				reserved				fif _error _zeros _data _ena	reserved						sif _txenable
config4	0x04	0x00FF	alarms_mask(15:0)															
config5	0x05	0xFFFF	alarms_mask(31:16)															
config6	0x06	0xFFFF	alarms_mask(47:32)															
config7	0x07	0x0000	memin_tempdata(7:0)								reserved			memin_lane_skew(4:0)				
config8	0x08	0x0000	reserved	reserved	reserved	qmc_offseta(12:0)												
config9	0x09	0x0000	reserved	reserved	reserved	qmc_offsetb(12:0)												
config10	0x0A	0x0000	reserved	reserved	reserved	qmc_offsetc(12:0)												
config11	0x0B	0x0000	reserved	reserved	reserved	qmc_offsetd(12:0)												
config12	0x0C	0x0400	reserved	reserved	reserved	reserved	reserved	qmc_gaina(10:0)										
config13	0x0D	0x0400	fs8	fs4	fs2	fsm4	reserved	qmc_gainb(10:0)										
config14	0x0E	0x0400	reserved	reserved	reserved	reserved	reserved	qmc_gainc(10:0)										
config15	0x0F	0x0400	output _delayab _reserved(1:0)		output _delaycd _reserved(1:0)		reserved	qmc_gaind(10:0)										
config16	0x10	0x0000	reserved	reserved	reserved	reserved	qmc_phaseab(11:0)											
config17	0x11	0x0000	reserved	reserved	reserved	reserved	qmc_phasecd(11:0)											
config18	0x12	0x0000	phaseoffsetab(15:0)															
config19	0x13	0x0000	phaseoffsetcd(15:0)															
config20	0x14	0x0000	phaseaddab(15:0)															
config21	0x15	0x0000	phaseaddab(31:16)															
config22	0x16	0x0000	phaseaddab(47:32)															
config23	0x17	0x0000	phaseaddcd(15:0)															
config24	0x18	0x0000	phaseaddcd(31:16)															
config25	0x19	0x0000	phaseaddcd(47:32)															
config26	0x1A	0x0020	reserved						reserved	vbgr _sleep	biasopam p _sleep	tsense _sleep	pll _sleep	clkrecv _sleep	daca _sleep	dacb _sleep	dacc _sleep	dacd _sleep
config27	0x1B	0x0000	extref _ena	dtest_lane(2:0)			dtest(3:0)				reserved	reserved	atest(5:0)					
config28	0x1C	0x0000	reserved								reserved							
config29	0x1D	0x0000	reserved								reserved							
config30	0x1E	0x1111	syncsel_qmoffsetab(3:0)				syncsel_qmoffsetcd(3:0)				syncsel_qmcorrab(3:0)				syncsel_qmcorrcd(3:0)			
config31	0x1F	0x1140	syncsel_mixerab(3:0)				syncsel_mixercd(3:0)				syncsel_nco(3:0)				reserved		sif_sync	reserved

Table 31. 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	0x0000	syncsel_dither(3:0)				reserved				syncsel_pap(3:0)				syncsel_fir5a(3:0)			
config33	0x21	0x0000	reserved															
config34	0x22	0x1B1B	patha_in_sel(1:0)		pathb_in_sel(1:0)		pathc_in_sel(1:0)		pathd_in_sel(1:0)		patha_out_sel(1:0)		pathb_out_sel(1:0)		pathc_out_sel(1:0)		pathd_out_sel(1:0)	
config35	0x23	0xFFFF	sleep_cntl(15:0)															
config36	0x24	0x0000	reserved									cdrvser_sysref_mode(2:0)			reserved		reserved	
config37	0x25	0x0000	clkjesd_div(2:0)			reserved			reserved			reserved			reserved			reserved
config38	0x26		dither_ena(3:0)				dither_mixer_ena(3:0)				dither_sra_sel3:0)				reserved		reserved	dither _zero
config39	0x27	0x0000	reserved(15:0)															
config40	0x28	0x0000	reserved(15:0)															
config41	0x29	0x0000	reserved(15:0)															
config42	0x2A	0x0000	reserved(15:0)															
config43	0x2B	0x0000	reserved(15:0)															
config44	0x2C	0x0000	reserved(15:0)															
config45	0x2D	0x0000	reserved	reserved											pap_ dlylen_sel	pap_gain(2:0)		
config46	0x2E	0xFFFF	pap_vth(15:0)															
config47	0x2F	0x0004	reserved	titest_dieid _read_ena	reserved	reserved										reserved	reserved	sifdac_ena
config48	0x30	0x0000	sifdac(15:0)															
config49	0x31	0x0000	lockdet_adj(2:0)			pll_reset	pll_ndivsync _ena	pll_ena	pll_cp(1:0)		pll_n(4:0)				memin_pll_lfvolt(2:0)			
config50	0x32	0x0000	pll_m(7:0)								pll_p(3:0)				reserved			
config51	0x33	0x0100	pll_vcosel	pll_vco(5:0)						pll_vcoitune(1:0)		pll_cp_adj(4:0)					reserved	
config52	0x34	0x0000	syncb _lvds _lopwrb	syncb _lvds _lopwra	syncb _lvds _lpsel	syncb _lvds _effuse _sel	reserved		reserved	lvds _sleep	lvds _sub_ena	reserved(6:0)						
config53	0x35	0x0000	reserved				reserved				reserved				reserved			
config54	0x36	0x0000	reserved															
config55	0x37	0x0000	reserved															
config56	0x38	0x0000	reserved															
config57	0x39	0x0000	reserved															
config58	0x3A	0x0000	reserved															
config59	0x3B	0x0000	serdes _clk_sel	serdes_refclk_div(3:0)				reserved									reserved	
config60	0x3C	0x0000	rw_cfgpll(15:0)															
config61	0x3D	0x0000	reserved	rw_cfgrx0(14:0)														
config62	0x3E	0x0000	rw_cfgrx0(15:0)															
config63	0x3F	0x0000	reserved								INVPAIR(7:0)							
config64	0x40	0x0000	reserved															
config65	0x41	0x0000	errorcnt_link0(15:0)															
config66	0x42	0x0000	errorcnt_link1(15:0)															

Table 31. 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
config67	0x43	0x0000	errorcnt_link2(15:0)															
config68	0x44	0x0000	errorcnt_link3(15:0)															
config69	0x45	0x0000	reserved															
config70	0x46	0x0044	lid0(4:0)					lid1(4:0)					lid2(4:0)					reserved
config71	0x47	0x190A	lid3(4:0)					lid4(4:0)					lid5(4:0)					reserved
config72	0x48	0x31C3	lid6(4:0)					lid7(4:0)					reserved		subclassv(2:0)			jesdv
config73	0x49	0x0000	link_assign(15:0)															
config74	0x4A	0x001E	lane_ena(7:0)								jesd_test _seq(1:0)		dual	init_state(3:0)				jesd _reset_n
config75	0x4B	0x0000	reserved			rbd_m1(4:0)					f_m1(7:0)							
config76	0x4C	0x0000	reserved			k_m1(4:0)					reserved	reserved	reserved	l_m1(4:0)				
config77	0x4D	0x0300	m_m1(7:0)								reserved			s_m1(4:0)				
config78	0x4E	0x0F0F	reserved			nprime_m1(4:0)					reserved	hd	scr	n_m1(4:0)				
config79	0x4F	0x1CC1	match_data(7:0)								match _specific	match _ctrl	no_lane _sync	reserved				jesd _commaalign _ena
config80	0x50	0x0000	adjcnt_link0(3:0)				adjdir_link0	bid_link0(3:0)				cf_link0(4:0)					cs_link0(1:0)	
config81	0x51	0x00FF	did_link0(7:0)								sync_request_ena_link0(7:0)							
config82	0x52	0x00FF	reserved						disable _err_repor t _link0	phadj _link0	error_ena_link0(7:0)							
config83	0x53	0x0000	adjcnt_link1(3:0)				adjdir_link1	bid_link1(3:0)				cf_link1(4:0)					cs_link1(1:0)	
config84	0x54	0x00FF	did_link1(7:0)								sync_request_ena_link1(7:0)							
config85	0x55	0x00FF	reserved						disable _err _report _link1	phadj _link1	error_ena_link1(7:0)							
config86	0x56	0x0000	adjcnt_link2(3:0)				adjdir_link2	bid_link2(3:0)				cf_link2(4:0)					cs_link2(1:0)	
config87	0x57	0x00FF	did_link2(7:0)								sync_request_ena_link2(7:0)							
config88	0x58	0x00FF	reserved						disable _err _report _link2	phadj _link2	error_ena_link2(7:0)							
config89	0x59	0x0000	adjcnt_link3(3:0)				adjdir_link3	bid_link3(3:0)				cf_link3(4:0)					cs_link3(1:0)	
config90	0x5A	0x00FF	did_link3(7:0)								sync_request_ena_link3(7:0)							
config91	0x5B	0x00FF	reserved						disable _err _report _link3	phadj _link3	error_ena_link3(7:0)							
config92	0x5C	0x1111	err_cnt _clr_link3	sysref_mode_link3(2:0)			err_cnt _clr_link2	sysref_mode_link2(2:0)			err_cnt _clr_link1	sysref_mode_link1(2:0)			err_cnt _clr_link0	sysref_mode_link0(2:0)		
config93	0x5D	0x0000	reserved															
config94	0x5E	0x0000	res1(7:0)								res2(7:0)							
config95	0x60	0x0123	reserved	octetpath_sel(0)(2:0)			reserved	octetpath_sel(1)(2:0)			reserved	octetpath_sel(2)(2:0)			reserved	octetpath_sel(3)(2:0)		
config96	0x61	0x0456	reserved	octetpath_sel(4)(2:0)			reserved	octetpath_sel(5)(2:0)			reserved	octetpath_sel(6)(2:0)			reserved	octetpath_sel(7)(2:0)		

Table 31. 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
config97	0x62	0x000F	syncn_pol	reserved			syncncd_sel(3:0)				syncnab_sel(3:0)				syncn_sel(3:0)			
config98	0x63	0x0000	reserved	reserved			reserved				reserved							
config98	0x64	0x0000	reserved	reserved			reserved				reserved				Reserved			
config100	0x65	0x0000	alarm_l_error(0)(7:0)								reserved				alarm_fifo_flags(0)(3:0)			
config101	0x66	0x0000	alarm_l_error(1)(7:0)								reserved				alarm_fifo_flags(1)(3:0)			
config102	0x67	0x0000	alarm_l_error(2)(7:0)								reserved				alarm_fifo_flags(2)(3:0)			
config103	0x68	0x0000	alarm_l_error(3)(7:0)								reserved				alarm_fifo_flags(3)(3:0)			
config104	0x69	0x0000	alarm_l_error(4)(7:0)								reserved				alarm_fifo_flags(4)(3:0)			
config105	0x6A	0x0000	alarm_l_error(5)(7:0)								reserved				alarm_fifo_flags(5)(3:0)			
config106	0x6B	0x0000	alarm_l_error(6)(7:0)								reserved				alarm_fifo_flags(6)(3:0)			
config107	0x6C	0x0000	alarm_l_error(7)(7:0)								reserved				alarm_fifo_flags(7)(3:0)			
config108	0x6D	0x0000	alarm_sysref_err(3:0)				alarm_pap(3:0)				reserved				alarm_rw0_pll	alarm_rw1_pll	reserved	alarm_from_pll
config109	0x6E	0x00xx	alarm_from_shorttest(7:0)								memin_rw_losdct(7:0)							
config110	0x6F	0x0000	sfrac_coef0_ab(1;0)		sfrac_coef1_ab(4;0)					sfrac_coef2_ab(7;0)								Reserved
config111	0x70	0x0000	reserved						sfrac_coef3_ab(9;0)									
config112	0x71	0x0000	sfrac_coef4_ab(15;0)															
config113	0x72	0x0000	sfrac_coef4_ab(18:16)			reserved			sfrac_coef5_ab(9;0)									
config114	0x73	0x0000	reserved							sfrac_coef6_ab(8;0)								
config115	0x74	0x0000	sfrac_coef7_ab(6;0)							sfrac_coef8_ab(4;0)					sfrac_coef9_ab(1;0)		Reserved	
config116	0x75	0x0000	sfrac_invgain_ab(15:0)															
config117	0x76	0x0000	sfrac_invgain_ab(19:16)				reserved						lfras_coefsel_a(2:0)			lfras_coefsel_b(2:0)		
config118	0x77	0x0000	sfrac_coef0_cd(1;0)		sfrac_coef1_cd(4;0)					sfrac_coef2_cd7;0)								Reserved
config119	0x78	0x0000	reserved						sfrac_coef3_cd(9;0)									
config120	0x79	0x0000	sfrac_coef4_cd(15;0)															
config121	0x7A	0x0000	sfrac_coef4_cd(18:16)			reserved			sfrac_coef5_cd(9;0)									
config122	0x7B	0x0000	reserved							sfrac_coef6_cd(8;0)								
config123	0x7C	0x0000	sfrac_coef7_cd(6;0)							sfrac_coef8_cd(4;0)					sfrac_coef9_cd(1;0)		Reserved	
config124	0x7D	0x0000	sfrac_invgain_cd(15:0)															
config125	0x7E	0x0000	sfrac_invgain_cd(19:16)				reserved						lfras_coefsel_c(2:0)			lfras_coefsel_d(2:0)		
config126	0x7F	0x0000	reserved				reserved				reserved				reserved			
config127	0x80	0x0000	memin_efc_autoload_done		memin_efc_error(4:0)				reserved		reserved			vendorid(1:0)		versionid(2:0)		

7.5.1 Register Descriptions

Register Name: config0 – Address: 0x00, Default: 0x0218

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config0	0x0	15	qmc_offsetab_ena	Enable the offset function for the AB data path when asserted.	0
		14	qmc_offsetcd_ena	Enable the offset function for the CD data path when asserted.	0
		13	qmc_corrab_ena	Enable the Quadrature Modulator Correction (QMC) function for the AB data path when asserted.	0
		12	qmc_corrcd_ena	Enable the QMC function for the CD data path when asserted.	0
		11:08	interp	Determines the interpolation amount. 0000: 1x 0001: 2x 0010: 4x 0100: 8x 1000: 16x	0010
		7	alarm_zeros_txenable_ena	When asserted any alarm that isn't masked will mid-level the DAC output.	0
		6	outsum_ena	Turns on the summing of the A+C and B+D data paths.	0
		5	alarm_zeros_jesd_data_ena	When asserted any alarm that isn't masked will zero the data coming out of the JESD block.	0
		4	alarm_out_ena	When asserted the terminal ALARM becomes an output instead of a tri-stated terminal.	1
		3	alarm_out_pol	This bit changes the polarity of the ALARM signal. (0=negative logic, 1=positive logic)	1
		2	pap_ena	Turns on the Power Amp Protection (PAP) logic.	0
		1	inv_sinc_ab_ena	Turns on the inverse sinc filter for the AB path when programmed to '1'.	0
		0	inv_sinc_cd_ena	Turns on the inverse sinc filter for the CD path when programmed to '1'.	0

Register Name: config1 – Address: 0x01, Default: 0x0003

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config1	0x1	15	sfrac_ena_ab	Turn on the small fractional delay filter for the AB data path.	0
		14	sfrac_ena_cd	Turn on the small fractional delay filter for the CD data path.	0
		13	lfrac_ena_ab	Turn on the large fractional delay filter for the AB data path.	0
		12	lfrac_ena_cd	Turn on the large fractional delay filter for the CD data path.	0
		11	sfrac_sel_ab	Select which data path is delay through the filter and which is delayed through the matched delay line. 0 : Data path B goes through filter 1 : Data path A goes through filter	0
		10	sfrac_sel_cd	Select which data path is delay through the filter and which is delayed through the matched delay line. 0 : Data path D goes through filter 1 : Data path C goes through filter	0
		9	reserved	Reserved	0
		8	reserved	Reserved	0
		7	daca_ compliment	When asserted the output to the DACA is complimented. This allows the user of the chip to effectively change the + and – designations of the IOUTA terminals.	0
		6	dacb_ compliment	When asserted the output to the DACB is complimented. This allows the user of the chip to effectively change the + and – designations of the IOUTB terminals.	0
		5	dacc_ compliment	When asserted the output to the DACC is complimented. This allows the user of the chip to effectively change the + and – designations of the IOUTC terminals.	0
		4	dacd_ compliment	When asserted the output to the DACD is complimented. This allows the user of the chip to effectively change the + and – designations of the IOUTD terminals.	0
		3	reserved	Reserved	0
		2	reserved	Reserved	0
		1	reserved	Reserved	1
		0	reserved	Reserved	1

Register Name: config2 – Address: 0x02, Default: 0x2002

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config2	0x2	10:14	dac_ bitwidth	Determines the bit width of the DAC. 00 : 16 bits 01 : 14 bits 10 : 16 bits 11 : 12 bits	00
		13	zero_ invalid_data	Zero the data from the JESD block when the link is not established.	1
		12	shorttest_ ena	Turns on the short test pattern of the JESD interface.	0
		11	reserved	Reserved	0
		10	reserved	Reserved	0
		9	reserved	Reserved	0
		8	reserved	Reserved	0
		7	sif4_ena	When asserted the SIF interface becomes a 4 terminal interface. This bit has a lower priority than the **dieid_ena** bit.	0
		6	mixer_ ena	When set high, the mixer block is turned on.	0
		5	mixer_ gain	Add 6dB of gain to the mixer output when asserted.	0
		4	nco_ena	When set high, the full NCO block is turned on. This is not necessary for the fs/2, fs/4, -fs/4 and fs/8 modes.	0
		3	reserved	Reserved	0
		2	reserved	Reserved	0
		1	twos	When asserted, this bit tells the chip to presume that 2's complement data is arriving at the input. Otherwise offset binary is presumed.	1
		0	sif_reset	A transition from 0->1 causes a reset of the SIF registers. This bit is self clearing.	0

Register Name: config3 – Address: 0x03, Default: 0xF380

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config3	0x3	15:12	coarse_dac	Scales the output current in 16 equal steps. $\frac{\text{VrefIO}}{\text{Rbias}} \times 4 \times (\text{mem\_coarse\_daca} + 1)$	1111
		11:8	reserved	Reserved	0011
		7	fifo_error_zeros_data_ena	When asserted SerDes FIFO errors zero the data out of the JESD block.	1
		6:1	reserved	Reserved	000000
		0	sif_ txenable	When asserted the internal value of TXENABLE is '1'.	0

Register Name: config4 – Address: 0x04, Default: 0x00FF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config4	0x4	15:0	alarms_mask(15:0)	Each bit is used to mask an alarm. Assertion masks the alarm: bit15 = mask lane7 lane errors bit14 = mask lane6 lane errors bit13 = mask lane5 lane errors bit12 = mask lane4 lane errors bit11 = mask lane3 lane errors bit10 = mask lane2 lane errors bit9 = mask lane1 lane errors bit8 = mask lane0 lane errors bit7 = mask lane7 FIFO flags bit6 = mask lane6 FIFO flags bit5 = mask lane5 FIFO flags bit4 = mask lane4 FIFO flags bit3 = mask lane3 FIFO flags bit2 = mask lane2 FIFO flags bit1 = mask lane1 FIFO flags bit0 = mask lane0 FIFO flags	0x00FF

Register Name: config5 – Address: 0x05, Default: 0xFFFF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config5	0x5	15:0	alarms_mask(31:16)	Each bit is used to mask an alarm. Assertion masks the alarm: bit15 = mask SYSREF errors on link3 bit14 = mask SYSREF errors on link2 bit13 = mask SYSREF errors on link1 bit12 = mask SYSREF errors on link0 bit11 = mask alarm from PAP A block bit10 = mask alarm from PAP B block bit9 = mask alarm from PAP C block bit8 = mask alarm from PAP D block bit7 = reserved bit6 = reserved bit5 = reserved bit4 = reserved bit3 = mask alarm from SerDes block 0 PLL lock bit2 = mask alarm from SerDes block 1 PLL lock bit1 = mask SYSREF setup/hold measurement alarm bit0 = mask DAC PLL lock alarm	0xFFFF

Register Name: config6 – Address: 0x06, Default: 0xFFFF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config6	0x6	15:0	alarms_mask(47:32)	Each bit is used to mask an alarm. Assertion masks the alarm: bit15 = mask alarm from lane7 short test bit14 = mask alarm from lane6 short test bit13 = mask alarm from lane5 short test bit12 = mask alarm from lane4 short test bit11 = mask alarm from lane3 short test bit10 = mask alarm from lane2 short test bit9 = mask alarm from lane1 short test bit8 = mask alarm from lane0 short test bit7 = mask alarm from lane7 loss of signal detect bit6 = mask alarm from lane6 loss of signal detect bit5 = mask alarm from lane5 loss of signal detect bit4 = mask alarm from lane4 loss of signal detect bit3 = mask alarm from lane3 loss of signal detect bit2 = mask alarm from lane2 loss of signal detect bit1 = mask alarm from lane1 loss of signal detect bit0 = mask alarm from lane0 loss of signal detect	0xFFFF

Register Name: config7 – Address: 0x07, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config7 No RESET Value	0x7	15:8	memin_ tempdata	This is the output from the chip temperature sensor. NOTE: when reading these bits the SIF interface must be extremely slow, 1MHz range.	0x00
		7:5	reserved	Reserved	000
		4:0	memin_lane_ skew	Measure of the lane skew for link0 only. Updated when the RBD is released and measured in terms of JESD clock. **NOTE: these bits are READ_ONLY**	0000

Register Name: config8 – Address: 0x08, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config8 AUTO SYNC	0x8	15	reserved	Reserved	0
		14	reserved	Reserved	0
		13	reserved	Reserved	0
		12:0	qmc_offseta	The DAC A offset correction. The offset is measured in DAC LSBs. **NOTE: Writing this register causes an auto-sync to be generated in the QMC OFFSET block.**	0x0000

Register Name: config9 – Address: 0x09, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config9	0x9	15:13	reserved	Reserved	000
		12:0	qmc_offsetb	The DAC B offset correction. The offset is measured in DAC LSBs.	0x0000

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config10 AUTO SYNC	0xA	15:13	reserved	Reserved	000
		12:0	qmc_offsetc	The DAC C offset correction. The offset is measured in DAC LSBs. **NOTE: Writing this register causes an auto-sync to be generated in the QMC OFFSET block.**	0x0000

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config11	0xB	15:13	reserved	Reserved	000
		12:0	qmc_offsetd	The DAC D offset correction. The offset is measured in DAC LSBs	0x0000

Register Name: config12 – Address: 0xC, Default: 0x0400

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config12	0xC	15	reserved	Reserved	0
		14	reserved	Reserved	0
		13	reserved	Reserved	0
		12	reserved	Reserved	0
		11	reserved	Reserved	0
		10:0	gmc_gaina	The quadrature correction gain A for DACAB path. The decimal point for the multiplication is just left of bit9. This word is treated as unsigned so the range is 0 to 1.9990. LSB=0.0009766	0x400

Register Name: config13 – Address: 0xD, Default: 0x0400

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config13	0xD	15	fs8	These bits turn on the different coarse mixing options. Combining the different options together can result in every possible n*Fs/8 [n=0->7]. Below is the valid programming table: cmix=(fs8, fs4, fs2, fsm4) 0000 : no mixing 0001 : -fs/4 0010 : fs/2 0100 : fs/4 1000 : fs/8 1100 : 3fs/8 1010 : 5fs/8 1110 : 7fs/8	0
		14	fs4		0
		13	fs2		0
		12	fsm4		0
		11	reserved	Reserved	0
		10:0	qmc_ gainb	The quadrature correction gain B for DAC AB path. The decimal point for the multiplication is just left of bit9. This word is treated as unsigned so the range is 0 to 1.9990. LSB=0.0009766.	0x400

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config14	0xE	15	reserved	Reserved	0
		14	reserved	Reserved	0
		13	reserved	Reserved	0
		12	reserved	Reserved	0
		11	reserved	Reserved	0
		10:0	gmc_gainc	The quadrature correction gain A for DACCD path. The decimal point for the multiplication is just left of bit9. This word is treated as unsigned so the range is 0 to 1.9990. LSB=0.0009766.	0x400

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config15	0xF	15:14	output _delayab	Delays the output to the DACs from 0 to 3 DAC clock cycles.	00
		13:12	output _delaycd	Delays the output to the DACs from 0 to 3 DAC clock cycles.	00
		11	reserved	Reserved	0
		10:0	qmc_ gaind	The quadrature correction gain B for DACCD path. The decimal point for the multiplication is just left of bit9. This word is treated as unsigned so the range is 0 to 1.9990. LSB=0.0009766.	0x400

Register Name: config16 – Address: 0x10, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config16 AUTO SYNC	0x10	15	reserved	Reserved	0
		14	reserved	Reserved	0
		13	reserved	Reserved	0
		12	reserved	Reserved	0
		11:0	qmc_phaseab	The QMC correction phase term for the DACAB path. The range is –0.5 to 0.49975. Programming “100000000000” = –0.5. Programming “011111111111” = 0.49975.	0x000

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config17 AUTO SYNC	0x11	15	reserved	Reserved	0
		14	reserved	Reserved	0
		13	reserved	Reserved	0
		12	reserved	Reserved	0
		11:0	qmc_phasecd	The QMC correction phase term for the DACAD path. The range is –0.5 to 0.49975. Programming “100000000000” = –0.5. Programming “011111111111” = 0.49975.	0x000

Register Name: config18 – Address: 0x12, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config18 AUTO SYNC	0x12	15:0	phaseoffsetab	Phase offset for NCO in DACAB path	0x0000

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config19 AUTO SYNC	0x13	15:0	phaseoffsetcd	Phase offset for NCO in DACAB path	0x0000

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config20	0x14	15:0	phaseaddab	Lower 16 bits of NCO Frequency adjust word for DACAB path.	0x0000

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config21	0x15	15:0	phaseaddab	Middle 16 bits of NCO Frequency adjust word for DACAB path.	0x0000

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config22	0x16	15:0	phaseaddab	Upper 16 bits of NCO Frequency adjust word for DACAB path.	0x0000

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config23	0x17	15:0	phaseaddcd	Lower 16 bits of NCO Frequency adjust word for DACCD path.	0x0000

Register Name: config24 – Address: 0x18, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config24	0x18	15:0	phaseaddcd	Middle 16 bits of NCO Frequency adjust word for DACCD path.	0x0000

Register Name: config25 – Address: 0x19, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config25	0x19	15:0	phaseaddcd	Upper 16 bits of NCO Frequency adjust word for DACCD path.	0x0000

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config26	0x1A	15:10	reserved	Reserved	000000
		9	reserved	Reserved	0
		8	vbgr_ sleep	Turns off the Bandgap over internal R bias current generator bias	0
		7	biasopamp_ sleep	Turns off the bias OP amp when high.	0
		6	tsense_ sleep	Turns off the temperature sensor when asserted.	0
		5	pll_sleep	Puts the DAC PLL into sleep mode when asserted.	1 FUSE controlled
		4	clkrecv_sleep	When asserted the clock input receiver gets put into sleep mode. This also affects the SYSREF receiver as well.	0
		3	daca_sleep	When asserted DACA is put into sleep mode	0
		2	dacb_sleep	When asserted DACB is put into sleep mode	0
		1	dacc_sleep	When asserted DACC is put into sleep mode	0
		0	dacd_sleep	When asserted DACD is put into sleep mode	0

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config27	0x1B	15	extref_ ena	Allows the chip to use an external reference or the internal reference. (0=internal, 1=external)	0
		14:12	dtest_ lane	Selects the lane to output the test signal. 0=lane0, 7=lane7	000
		11:8	dtest	Allows digital test signals to come out the ALARM terminal. 0000 : Test disabled, normal ALARM terminal function 0001 : SERDES Block0 PLL clock/80 0010 : SERDES Block1 PLL clock/80 0011 : TESTFAIL (lane selected by dtest_lane) 0100 : SYNC(lane selected by dtest_lane) 0101 : OCIP (lane selected by dtest_lane) 0110 : EQUNDER (lane selected by dtest_lane) 0111 : EQOVER (lane selected by dtest_lane) 1000 – 1111 : not used	0000
		7	reserved	Reserved	0
		6	reserved	Reserved	0
		5:0	atest	Selects measurement of various internal signals at the ATEST terminal. 0=off 000001 : DAC PLL VSSA (0V) 000010 : DAC PLL VDD at DACCLK receiver and ndivider (0.9V) 000011 : DAC PLL 100uA bias current measurement into 0V 000100 : DAC PLL 100uA vbias at VCO (~0.8V nmos diode) 000101 : DAC PLL VDD at prescaler and mdivider (0.9V) 000110 : DAC PLL VSSA (0V) 000111 : DAC PLL VDDA1.8 (1.8V) 001000 : DAC PLL loop filter voltage (0 to 1V, ~0.5V when locked) 001001 : DACA VDDA18 (1.8V) 001010 : DACA VDDCLK (0.9) 001011 : DACA VDDDAC (0.9) 001100 : DACA VSSA (0V) 001101 : DACA VSSESD (0V) 001110 : DACA VSSA (0V) 001111 : DACA main current source PMOS cascode bias (1.65V) 010000 : DACA output switch cascode bias (0.4V) 010001 : DACB VDDA18 (1.8V) 010010 : DACB VDDCLK (0.9) 010011 : DACB VDDDAC (0.9) 010100 : DACB VSSA (0V) 010101 : DACB VSSESD (0V) 010110 : DACB VSSA (0V) 010111 : DACB main current source PMOS cascode bias (1.65V) 011000 : DACB output switch cascode bias (0.4V) 011001 : DACC VDDA18 (1.8V) 011010 : DACC VDDCLK (0.9) 011011 : DACC VDDDAC (0.9) 011100 : DACC VSSA (0V) 011101 : DACC VSSESD (0V) 011110 : DACC VSSA (0V) 011111 : DACC main current source PMOS cascode bias (1.65V)	000000

Register Name: config27 – Address: 0x1B, Default: 0x0000 (continued)

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config27 (continued)	0x1B	5:0	atest	100000 : DACC output switch cascode bias (0.4V) 100001 : DACD VDDA18 (1.8V) 100010 : DACD VDDCLK (0.9) 100011 : DACD VDDDAC (0.9) 100100 : DACD VSSA (0V) 100101 : DACD VSSESD (0V) 100110 : DACD VSSA (0V) 100111 : DACD main current source PMOS cascode bias (1.65V) 101000 : DACD output switch cascode bias (0.4V) 101001 : Temp Sensor VSSA (0V) 101010 : Temp Sensor amplifier output (0 to 1.8V) 101011 : Temp Sensor reference output (~0.6V, can be trimmed) 101100 : Temp Sensor comparator output (0 to 1.8V) 101101 : Temp Sensor 64uA bias voltage (~0.8V nmos diode) 101110 : BIASGEN 100uA bias measured to 0V (to be trimmed) 101111 : Temp Sensor VDD (0.9V) 110000 : Temp Sensor VDDA18 (1.8V) 110001: DAC bias current measured into 1.8V. scales with coarse DAC setting (7.3µA to 117µA) 110010: Bangap PTAT current measured into 0V (~20µA) 110011: CoarseDAC PMOS current source gate (~1V) 110100: RBIAS (0.9V) 110101: EXTIO (0.9V) 110110: Bandgap PMOS cascode gate (0.7V) 110111: Bandgap startup circuit output (~0V when BG started) 111000: Bandgap output (0.9V, can be trimmed) 111001: SYNCB LVDS buffer reference voltage (1.2V) must set syncb_lvds_efuse_sel to measure. 111010: VSS in digital core MET1 (0V) 111011: VSS in digital core MET1 (0V) 111100: VSS near bump (0V) 111101: VDDDIG in digital core MET1 (0.9V) 111110: VDDDIG in digital core MET1 (0.9V)	000000

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config28	0x1C	15:8	reserved	reserved	0x00
		7:0	reserved	reserved	0x00

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config29	0x1D	15:8	reserved	reserved	0x00
		7:0	reserved	reserved	0x00

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config30	0x1E	15:12	syncsel_ qmoffsetab	Select the sync for the QMCoffsetAB block. A '1' in the selected bit place allows the selected sync to pass to the block. bit0 = auto-sync from SIF register write bit1 = sysref bit2 = sync_out from JESD bit3 = sif_sync	0x1
		11:8	syncsel_ qmoffsetcd	Select the sync for the QMCoffsetCD block. A '1' in the selected bit place allows the selected sync to pass to the block. bit0 = auto-sync from SIF register write bit1 = sysref bit2 = sync_out from JESD bit3 = sif_sync	0x1
		7:4	syncsel_ qmcorrab	Select the sync for the QMCcorrAB block. A '1' in the selected bit place allows the selected sync to pass to the block. bit0 = auto-sync from SIF register write bit1 = sysref bit2 = sync_out from JESD bit3 = sif_sync	0x1
		3:0	syncsel_ qmcorrcd	Select the sync for the QMCcorrCD block. A '1' in the selected bit place allows the selected sync to pass to the block. bit0 = auto-sync from SIF register write bit1 = sysref bit2 = sync_out from JESD bit3 = sif_sync	0x1

Register Name: config31 – Address: 0x1F, Default: 0x1111

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config31	0x1F	15:12	syncsel_ mixerab	Select the sync for the mixerAB block. A '1' in the selected bit place allows the selected sync to pass to the block. bit0 = auto-sync from SIF register write bit1 = sysref bit2 = sync_out from JESD bit3 = sif_sync	0x1
		11:8	syncsel_ mixercd	Select the sync for the mixerCD block. A '1' in the selected bit place allows the selected sync to pass to the block. bit0 = auto-sync from SIF register write bit1 = sysref bit2 = sync_out from JESD bit3 = sif_sync	0x1
		7:4	syncsel_ nco	Select the sync for the NCO accumulators. A '1' in the selected bit place allows the selected sync to pass to the block. bit0 = '0' bit1 = sysref bit2 = sync_out from JESD bit3 = sif_sync	0x4
		3:2	reserved	Reserved	00
		1	sif_sync	This is the SIF SYNC signal.	0
		0	reserved	Reserved	0

Register Name: config32 – Address: 0x20, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config32	0x20	15:12	syncsel_ dither	Select the sync for the Dithering block. bit0 = '0' bit1 = sysref bit2 = sync_out from JESD bit3 = sif_sync	0x0
		11:8	reserved	Reserved	0x0
		7:4	syncsel_ pap	7:4 Select the sync for the PA Protection block. bit0 = '0' bit1 = sysref bit2 = sync_out from JESD bit3 = sif_sync 0x0	0x0
		3:0	syncsel_ fir5a	Select the sync for the small fractional delay FIR filter coefficient loading. bit0 = '0' bit1 = sysref bit2 = sync_out from JESD bit3 = sif_sync	0x0

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config33	0x21	15:0	reserved	Reserved	0x0000

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config34	0x22	15:14	patha_in _sel	This selects the word used for the path A input. 00 = Sample 0 from JESD is selected for data path A 01 = Sample 1 from JESD is selected for data path A 10 = Sample 2 from JESD is selected for data path A 11 = Sample 3 from JESD is selected for data path A	00
		13:12	pathb_in _sel	This selects the word used for the path B input. 00 = Sample 0 from JESD is selected for data path B 01 = Sample 1 from JESD is selected for data path B 10 = Sample 2 from JESD is selected for data path B 11 = Sample 3 from JESD is selected for data path B	01
		11:10	pathc_in _sel	This selects the word used for the path C input. 00 = Sample 0 from JESD is selected for data path C 01 = Sample 1 from JESD is selected for data path C 10 = Sample 2 from JESD is selected for data path C 11 = Sample 3 from JESD is selected for data path C	10
		9:8	pathd_in _sel	This selects the word used for the path D input. 00 = Sample 0 from JESD is selected for data path D 01 = Sample 1 from JESD is selected for data path D 10 = Sample 2 from JESD is selected for data path D 11 = Sample 3 from JESD is selected for data path D	11
		7:6	patha_ out_sel	This selects the word used for the DACA output. 00 = data path A goes to DACA 01 = data path B goes to DACA 10 = data path C goes to DACA 11 = data path D goes to DACA	00
		5:4	pathb_ out_sel	This selects the word used for the DACB output. 00 = data path A goes to DACB 01 = data path B goes to DACB 10 = data path C goes to DACB 11 = data path D goes to DACB	01
		3:2	pathc_ out_sel	This selects the word used for the DACC output. 00 = data path A goes to DACC 01 = data path B goes to DACC 10 = data path C goes to DACC 11 = data path D goes to DACC	10
		1:0	pathd_ out_sel	This selects the word used for the DACD output. 00 = data path A goes to DACD 01 = data path B goes to DACD 10 = data path C goes to DACD 11 = data path D goes to DACD	11

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config35	0x23	15:0	sleep_cntl	This controls the routing of the SLEEP terminal signal to different blocks. Assertion means that the SLEEP signal will be sent to the block. These bits do not override the SIF bits, just the SLEEP signal from the terminal. When asserted, bit15 through bit9 = Not used bit8 = Allows the Band gap over R to sleep **(BUG… in this PG it is hooked to bit7)** bit7 = Allows the Bias OP Amp to sleep bit6 = Allows the TEMP Sensor to sleep bit5 = Allows the PLL to sleep bit4 = Allows the CLK_RECV to sleep bit3 = Allows DACD to sleep bit2 = Allows DACC to sleep bit1 = Allows DACB to sleep bit0 = Allows DACA to sleep	0xFFFF

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config36	0x24	15:13	reserved	Reserved	000
		12:7	reserved	Reserved	000000
		6:4	cdrvser_ sysref_mode	Determines how SYSREF is used to sync the clock dividers in the device. 000 = Don't use SYSREF pulse 001 = Use all SYSREF pulses 010 = Use only the next SYSREF pulse 011 = Skip one SYSREF pulse then use only the next one 100 = Skip one SYSREF pulse then use all pulses.	000
		3:2	reserved	Reserved	00
		1:0	reserved	Reserved	00

Register Name: config37 – Address: 0x25, Default: 0x8000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config37	0x25	15:13	clkjesd_ div	This controls the amount of dividing down the DACCLK gets to generate the JESD clock. It is independent of the interpolation because of the different JESD interfaces. "000" : DACCLK "001" : div2 "010" : div4 "011" : div8 "100" : div16 "101" : div32 "110" : always 1 "111" : always 0	100
		12:10	reserved	Reserved	000
		9:7	reserved	Reserved	000
		6:4	reserved	Reserved	000
		3:1	reserved	Reserved	000
		0	reserved	Reserved	0

Register Name: config38 – Address: 0x26, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config38	0x26	15:12	dither_ ena	Turns on DITHER block for each data path bit15 = data path D bit14 = data path C bit13 = data path B bit12 = data path A	0000
		11:8	dither_ mixer_ena	Turns on the FS/2 mixer at the output of the CIC in the DITHER block. bit11 = data path D bit10 = data path C bit9 = data path B bit8 = data path A	0000
		7:4	dither_sra_sel	Select the amount of dithering added to the signal. 0 is the maximum dithering.	0000
		3:2	reserved	Reserved	00
		1	reserved	Reserved	0
		0	reserved	Reserved	0

Register Name: config39 – Address: 0x27, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config39	0x27	15:0	reserved	Reserved	0x0000

Register Name: config40 – Address: 0x28, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config40 WRITE TO CLEAR	0x28	15:0	reserved	Reserved	0x0000

Register Name: config41 – Address: 0x29, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config41	0x29	15:0	reserved	Reserved	0xFFFF

Register Name: config42 – Address: 0x2A, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config42	0x2A	15:0	reserved	Reserved	0000

Register Name: config43 – Address: 0x2B, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config43	0x2B	15:0	reserved	Reserved	0x0000

Register Name: config44 – Address: 0x2C, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config44	0x2C	15:0	reserved	Reserved	0000

Register Name: config45 – Address: 0x2D, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config45	0x2D	15	reserved	Reserved	0
		14:4	reserved	Reserved	00000000000
		3	pap_ dlylen_sel	Select the length of the PAP average: 0 : 64 samples 1 : 128 samples	0
		2:0	pap_gain	The amount of attenuation to apply when the threshold for PAP is met: 000 : no attenuation 001 : divide by 2 010 : divided by 4 011 : divided by 8 100 : divided by 16 101 : no attenuation 110 : no attenuation 111 : no attenuation	000

Register Name: config46 – Address: 0x2E, Default: 0xFFFF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config46	0x2E	15:0	pap_vth	The threshold value for the PA protection logic. When the power measurement is greater than this activate the PA protection logic.	0xFFFF

Register Name: config47 – Address: 0x2F, Default: 0x0004

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config47	0x2F	15	reserved	Reserved	0
		14	titest_dieid_read_ena	When asserted, the die ID can be read out after fuse autoload is finished on register 100-107. When de-asserted normal function of the registers is read out.	0
		13	reserved	Reserved	0
		12:3	reserved	Reserved	0000000000
		2	reserved	Reserved	1
		1	reserved	Reserved	0
		0	sifdac_ena	When asserted the DAC output is set to the value in register sifdac.	0

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

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config48	0x30	15:0	sifdc	This is the value that is sent to the digital blocks when register sifdac_ena is asserted.	0x0000

Register Name: config49 – Address: 0x31, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config49	0x31	15:13	lockdet_ adj	Adjusts the sensitivity of the DAC PLL lock detector; 4 settings from 000 to 011. The 011 setting has the widest lock detection window, tolerating more jitter while reporting a lock. The 000 setting has a narrow window and will indicate an unlocked state more often.	000
		12	pll_reset	When set, the M divider, N divider and PFD are held reset.	0
		11	pll_ ndivsync_ena	When on, the SYSREF input is used to sync the N dividers of the PLL.	0
		10	pll_ena	Enables the PLL output as the DAC clock when set; the clock provided at the DACCLKP/N is used as the PLL reference clock. When cleared, the PLL is bypassed and the clock provided at the DACCLKP/N terminals is used as the DAC clock	0 FUSE controlled
		9:8	pll_cp	Must be set to 00 for proper PLL operation	00
		7:3	pll_n	Reference clock divider; divide by is N+1	00000
		2:0	memin_pll_lfvolt	Indicates the loop filter voltage; 111 is max, 000 is min. When the PLL is correctly programmed, this will read 011 or 100 for a centered loop filter voltage.	000 READ ONLY

Register Name: config50 – Address: 0x32, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config50	0x32	15:8	PLL_M	VCO feedback divider; divide by is M+1	00000000
		7:4	PLL_P	VCO prescaler divider; 0000 : div by 2 0001 : div by 3 0010 : div by 4 0011 : div by 5 0100 : div by 6 0101 : div by 7 0110 : div by 8 0111 : div by 9 1000 : div by 4 1001 : div by 6 1010 : div by 8 1011 : div by 10 1100 : div by 12	0000
		3:0	reserved	Reserved	0000

Register Name: config51 – Address: 0x33, Default: 0x0100

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config51	0x33	15	pll_vcosel	4GHz VCO selected when set, 5GHz VCO selected when cleared.	0
		14:9	pll_vco	VCO frequency range control; 000000 is fmin, 11111 is fmax	000000
		8:7	pll_ vcoitune	VCO core bias current adjustment; 00 is 7mA, 01 is 8.4mA, 10 is 9.8mA, 11 is11.2mA.	10
		6:2	pll_cp_adj	adjusts the charge pump current; 0 to 1.55mA is 50µA steps. Setting to 00000 will hold the LPF terminal at 0V.	00000
		1:0	reserved	Reserved	00

Register Name: config52 – Address: 0x34, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config52	0x34	15	syncb_lvds_ lopwrb	SYNCB LVDS Output current control LSB; allows output current to be scaled from ~2mA to ~4mA	0
		14	syncb_lvds_ lopwra	SYNCB LVDS Output current control MSB; allows output current to be scaled from ~2mA to ~4mA	0
		13	syncb_lvds_ lpsel	SYNCB LVDS output on chip termination control; 100 Ω when cleared, 200 Ω when set.	0
		12	syncb_lvds_ effuse_sel	Enabled SYNCB LVDS bias bandgap reference voltage to the ATEST multiplexer. ATEST must be set to 111001 to enable this output.	0
		11:10	reserved	Reserved	00
		9	reserved	Reserved	0
		8	syncb_lvds_ sleep	The SYNCB LVDS output is in power down when set, active when cleared.	0
		7	syncb_lvds_ sub_ena	SYNCB LVDS output common mode is 1.2V when cleared, 0.9V when set.	0
		6:0	reserved	Reserved	0000000

Register Name: config53 – Address: 0x35, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config53	0x35	15:12	reserved	Reserved	0000
		11:8	reserved	Reserved	0000
		7:2	reserved	Reserved	000000
		1:0	reserved	Reserved	00

Register Name: config54 – Address: 0x36, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config54	0x36	15:0	reserved	Reserved	0x0000

Register Name: config55 – Address: 0x37, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config55	0x37	15:0	reserved	Reserved	0x0000

Register Name: config56 – Address: 0x38, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config56	0x38	15:0	reserved	Reserved	0x0000

Register Name: config57 – Address: 0x39, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config57	0x39	15:0	reserved	Reserved	0x0000

Register Name: config58 – Address: 0x3A, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config58	0x3A	15:0	reserved	Reserved	0x0000

Register Name: config59 – Address: 0x3B, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config59	0x3B	15	serdes_ clk_sel	Select either the DAC PLL output or the DACCLK from the terminals to be the SerDes PLL reference divider input clock.	0
		14:11	serdes_ refclk_div	The divide amount for the serdes PLL reference clock divider. The divider amount is serdes_refclk_div plus one.	0000
		10:2	reserved	Reserved	000000000
		1:0	reserved	Reserved	00

Register Name: config60 – Address: 0x3C, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config60	0x3C	15:0	rw_cfgpll	Control the PLL of the SerDes. Bit15 – ENDIVCLK, enables output of a divide-by-5 of PLL clock. Bit14:13 – reserved. Bit12:11 – LB, specify loop bandwidth settings. Bit10 – SLEEPPLL, puts the PLL into sleep state when high. Bit9 – VRANGE, select between high and low VCO. Bit8:1 – MPY, select PLL multiply factor between 4 and 25. Bit0 – reserved.	0x0000

Register Name: config61 – Address: 0x3D, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config61	0x3D	15	reserved	Reserved	0
		14:0	rw_cfgrx0	Upper 15 bits of the configuration info for SerDes receivers. Bit14:12 – TESTPATT, Enables and selects verification of one of three PRBS patterns, a user defined pattern or a clock test pattern. Bit11 – reserved Bit10 – reserved Bit9:8 – reserved Bit7 – ENOC, enable samplers offset compensation. Bit6 – EQHLD, hold the equalizer in its current status. Bit5:3 – EQ, enable and configure the equalizer to compensate the loss in the transmission media. Bit2:0 – CDR, configure the clock/data recovery algorithm.	000000000000000

Register Name: config62 – Address: 0x3E, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config62	0x3E	15:0	rw_cfgrx0	Lower 16 bits of the configuration info for SerDes receivers. Bit15:13 – LOS, enable loss of signal detection. Bit12:11 – reserved. Bit10:8 – TERM, select input termination options for serial lanes. **Note: AC coupling is recommended for JESD204B compliance.** Bit7 – reserved Bit6:5 – RATE, operating rate, select full, half, quarter or eighth rate operation. Bit4:2 – BUSWIDTH, select the parallel interface width (16 bit or 20bit). **Note: 16bit is not compatible with JESD204B.** Bit1 SLEEPRX, powers the receiver down into sleep (fast power up) state when high. Bit0 – reserved.	0x0000

Register Name: config63 – Address: 0x3F, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config63	0x3F	15:8	Not Used	Not Used	0x00
		7:0	INVPAIR	Allows the PN pairs of the SerDes lanes to be inverted. bit7 = lane7 bit6 = lane6 bit5 = lane5 bit4 = lane4 bit3 = lane3 bit2 = lane2 bit1 = lane1 bit0 = lane0	0x00

Register Name: config64 – Address: 0x40, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config64	0x40	15:0	reserved	Reserved	0x0000

Register Name: config65 – Address: 0x41, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config65 READ ONLY	0x41	15:0	errorcnt_ link0	This is the error count for link0. What is counted as an error is determined by error_ena_link0. This is a 16bit value that is cleared when a JESD synchronization is performed or err_cnt_clr_link0 is programmed to a ‘1’.	0x0000

Register Name: config66 – Address: 0x42, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config66 READ ONLY	0x42	15:0	errorcnt_ link1	This is the error count for link1. What is counted as an error is determined by error_ena_link1. This is a 16bit value that is cleared when a JESD synchronization is performed or err_cnt_clr_link0 is programmed to a ‘1’.	0x0000

Register Name: config67 – Address: 0x43, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config67 READ ONLY	0x43	15:0	errorcnt_ link2	This is the error count for link2. What is counted as an error is determined by error_ena_link2. This is a 16bit value that is cleared when a JESD synchronization is performed or err_cnt_clr_link0 is programmed to a ‘1’.	0x0000

Register Name: config68 – Address: 0x44, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config68 READ ONLY	0x44	15:0	errorcnt_ link3	This is the error count for link3. What is counted as an error is determined by error_ena_link3. This is a 16bit value that is cleared when a JESD synchronization is performed or err_cnt_clr_link0 is programmed to a ‘1’.	0x0000

Register Name: config69 – Address: 0x45, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config69	0x45	15:0	reserved	Reserved	0x0000

Register Name: config70 – Address: 0x46, Default: 0x0120

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config70	0x46	15:11	lid0	The JESD ID for JESD lane 0.	00000
		10:6	lid1	The JESD ID for JESD lane 1.	00001
		5:1	lid2	The JESD ID for JESD lane 2.	00010
		0	reserved	Reserved	0

Register Name: config71 – Address: 0x47, Default: 0x3450

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config71	0x47	15:11	lid3	The JESD ID for JESD lane 3.	00011
		10:6	lid4	The JESD ID for JESD lane 4.	00100
		5:1	lid5	The JESD ID for JESD lane 5.	00101
		0	reserved	Reserved	0

Register Name: config72 – Address: 0x48, Default: 0x31C3

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config72	0x48	15:11	lid6	The JESD ID for JESD lane 6.	00110
		10:6	lid7	The JESD ID for JESD lane 7.	00111
		5:4	reserved	reserved	00
		3:1	subclassv	Selects the JESD subclass supported. **Note: "001" is subclass 1 and this is the only mode supported**	001
		0	jesdv	Selects the version of JESD supported (0=A, 1=B) **Note: JESD 204B is only supported version.**	1

Register Name: config73 – Address: 0x49, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config73	0x49	15:0	link_ assign	Each JESD lane can be assigned to any of the 4 links. There are two bits for each lane: "00"=link0, "01"=link1, "10"=link2 and "11"=link3 bits(15:14) : JESD lane7 link selection bits(13:12) : JESD lane6 link selection bits(11:10) : JESD lane5 link selection bits(9:8) : JESD lane4 link selection bits(7:6) : JESD lane3 link selection bits(5:4) : JESD lane2 link selection bits(3:2) : JESD lane1 link selection bits(1:0) : JESD lane0 link selection	0x0000

Register Name: config74 – Address: 0x4A, Default: 0x001E

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config74	0x4A	15:8	lane_ena	Turn on each SerDes lane as needed. Signal is active high. bit15 : SerDes lane7 enable bit14 : SerDes lane6 enable bit13 : SerDes lane5 enable bit12 : SerDes lane4 enable bit11 : SerDes lane3 enable bit10 : SerDes lane2 enable bit9 : SerDes lane1 enable bit8 : SerDes lane0 enable	0x00
		7:6	jesd_test_seq	Set to select and verify link layer test sequences. The error for these sequences comes out the lane alarms bit0. 1= fail and 0 = pass. 00 : test sequence disabled 01 : verify repeating D.21.5 high frequency pattern for random jitter 10 : verify repeating K.28.5 mixed frequency pattern for deterministic jitter 11 : verify repeating ILA sequence	00
		5	dual	Turn on “DUAL DAC” mode. This disables the clocks to the C and D data paths, reducing the power of the DIG block.	0
		4:1	init_ state	Put the JESD block into “INIT_STATE” mode when high. During this mode the JESD can be programmed and its outputs will stay at zero. **NOTE: See the JESD description of the correct startup sequence.**	1111
		0	jesd_ reset_n	Reset the JESD block when low. **NOTE: See the JESD description of the correct startup sequence.**	0

Register Name: config75 – Address: 0x4B, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config75	0x4B	15:13	reserved	Reserved	000
		12:8	rbd_m1	This controls the amount of elastic buffers being used in the JESD. Larger numbers will mean more latency, but smaller numbers may not hold enough data to capture the input skew. This value must always be ≤ k_m1	00000
		7:0	f_m1	This is the number of octets in the frame. The DAC37J84/DAC38J84 only supports 1,2,4 or 8 octets per frame so the only valid values are 0,1,3, and 7.	0x00

Register Name: config76 – Address: 0x4C, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config76	0x4C	15:13	reserved	Reserved	000
		12:8	k_m1	This is the number of frames in a multi-frame. The range is 0-31.	00000
		7	reserved	Reserved	0
		6	reserved	Reserved	0
		5	reserved	Reserved	0
		4:0	l_m1	This is the number of lanes used by the JESD. Possible values are 0-7.	00000

Register Name: config77 – Address: 0x4D, Default: 0x0300

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config77	0x4D	15:8	m_m1	This is the number of converters per link. **NOTE: Valid programmed values are 0, 1 and 3.**	0x03
		7:5	reserved	Reserved	000
		4:0	s_m1	This is the number of converter samples per frame. **NOTE: Valid programming is 0 or 1.**	00000

Register Name: config78 – Address: 0x4E, Default: 0x0F0F

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config78	0x4E	15:13	reserved	Reserved	000
		12:8	nprime_ m1	This is the number of adjusted bits per sample. **NOTE: 15 is the only valid value.**	01111
		7	reserved	Reserved	0
		6	hd	High Density mode for the JESD. When asserted samples are split across lanes.	0
		5	scr	Turns on the scrambler function in the JESD block.	0
		4:0	n_m1	This is the number of bits per sample. **NOTE: 15 is the only valid value.**	01111

Register Name: config79 – Address: 0x4F, Default: 0x1CC1

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config79	0x4F	15:8	match_ data	The character to match. Normally it is a /R/=/K28.0/=0x1C, but the user can program it to any character.	00011100
		7	match_ specific	Match a specified character to start JESD buffering when '1'. If programmed to '0' then the first non-K will start the buffering.	1
		6	match_ctrl	When asserted, the match character is a CONTROL character instead of a DATA character.	1
		5	no_lane_ sync	Assert if the TX side does not support lane initialization. This way the RX won't flag errors in the configuration portion of the ILA.	0
		4:1	reserved	Reserved	0000
		0	jesd_commaalign_ena	always "1"	1

Register Name: config80 – Address: 0x50, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config80	0x50	15:12	adjcnt_ link0	Lane configuration data for link0. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0000
		11	adjdir_ link0	Lane configuration data for link0. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0
		10:7	bid_link0	Lane configuration data for link0. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0000
		6:2	cf_link0	Lane configuration data for link0. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	00000
		1:0	cs_link0	Lane configuration data for link0. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	00

Register Name: config81 – Address: 0x51, Default: 0x00FF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config81	0x51	15:8	did_link0	Lane configuration data for link0. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0x00
		7:0	sync_ request_ena_ link0	These bits select which errors cause a sync request. Sync requests take priority over the error notification, so if sync request isn't desired, set these bits to a '0'. bit7 = multi-frame alignment error bit6 = frame alignment error bit5 = link configuration error bit4 = elastic buffer overflow (bad RBD value) bit3 = elastic buffer end char mismatch (match_ctrl match_data) bit2 = code synchronization error bit1 = 8b/10b not-in-table code error bit0 = 8b/10b disparity error	0xFF

Register Name: config82 – Address: 0x52, Default: 0x00FF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config82	0x52	15:10	reserved	Reserved	000000
		9	disable_ err_report_link0	Assertion means that errors will not be reported on the sync_n output.	0
		8	phadj_ link0	Lane configuration data for link0. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0
		7:0	error_ena_link0	These bits select the errors generated are counted in the err_c for the link. The bits also control what signals are sent out the pad_syncb terminal for error notification. bit7 = multi-frame alignment error bit6 = frame alignment error bit5 = link configuration error bit4 = elastic buffer overflow (bad RBD value) bit3 = elastic buffer end char mismatch (match_ctrl match_data) bit2 = code synchronization error bit1 = 8b/10b not-in-table code error bit0 = 8b/10b disparity error	0xFF

Register Name: config83 – Address: 0x53, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config83	0x53	15:12	adjcnt_ link1	Lane configuration data for link1. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0000
		11	adjdir_ link1	Lane configuration data for link1. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0
		10:7	bid_link1	Lane configuration data for link1. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0000
		6:2	cf_link1	Lane configuration data for link1. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	00000
		1:0	cs_link1	Lane configuration data for link1. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	00

Register Name: config84 – Address: 0x54, Default: 0x00FF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config84	0x54	15:8	did_link1	Lane configuration data for link1. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0x00
		7:0	sync_ request_ena_ link1	These bits select which errors cause a sync request. Sync requests take priority over the error notification, so if sync request isn't desired, set these bits to a '0'. bit7 = multi-frame alignment error bit6 = frame alignment error bit5 = link configuration error bit4 = elastic buffer overflow (bad RBD value) bit3 = elastic buffer end char mismatch (match_ctrl match_data) bit2 = code synchronization error bit1 = 8b/10b not-in-table code error bit0 = 8b/10b disparity error	0xFF

Register Name: config85 – Address: 0x55, Default: 0x00FF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config85	0x55	15:10	reserved	Reserved	000000
		9	disable_ err_report_link1	Assertion means that errors will not be reported on the sync_n output.	0
		8	phadj_ link1	Lane configuration data for link1. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0
		7:0	error_ena_link1	These bits select the errors generated are counted in the err_cnt for the link. The bits also control what signals are sent out the pad_syncb terminal for error notification. bit7 = multi-frame alignment error bit6 = frame alignment error bit5 = link configuration error bit4 = elastic buffer overflow (bad RBD value) bit3 = elastic buffer end char mismatch (match_ctrl match_data) bit2 = code synchronization error bit1 = 8b/10b not-in-table code error bit0 = 8b/10b disparity error	0xFF

Register Name: config86 – Address: 0x56, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config86	0x56	15:12	adjcnt_ link2	Lane configuration data for link2. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0000
		11	adjdir_ link2	Lane configuration data for link2. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0
		10:7	bid_link2	Lane configuration data for link2. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0000
		6:2	cf_link2	Lane configuration data for link2. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	00000
		1:0	cs_link2	Lane configuration data for link2. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	00

Register Name: config87 – Address: 0x57, Default: 0x00FF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config87	0x57	15:8	did_link2	Lane configuration data for link2. Not used by DAC37J84/DAC38J84 except for lane configuration checking.	0x00
		7:0	sync_ request_ena_ link2	These bits select which errors cause a sync request. Sync requests take priority over the error notification, so if sync request isn't desired, set these bits to a '0'. bit7 = multi-frame alignment error bit6 = frame alignment error bit5 = link configuration error bit4 = elastic buffer overflow (bad RBD value) bit3 = elastic buffer end char mismatch (match_ctrl match_data) bit2 = code synchronization error bit1 = 8b/10b not-in-table code error bit0 = 8b/10b disparity error	0xFF

Register Name: config88 – Address: 0x58, Default: 0x00FF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config88	0x58	15:10	reserved	Reserved	000000
		9	disable_ err_report_link2	Assertion means that errors will not be reported on the sync_n output.	0
		8	phadj_ link2	Lane configuration data for link2. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0
		7:0	error_ena_link2	These bits select the errors generated are counted in the err_cnt for the link. The bits also control what signals are sent out the pad_syncb terminal for error notification. bit7 = multi-frame alignment error bit6 = frame alignment error bit5 = link configuration error bit4 = elastic buffer overflow (bad RBD value) bit3 = elastic buffer end char mismatch (match_ctrl match_data) bit2 = code synchronization error bit1 = 8b/10b not-in-table code error bit0 = 8b/10b disparity error	0xFF

Register Name: config89 – Address: 0x59, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config89	0x59	15:12	adjcnt_ link3	Lane configuration data for link3. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0000
		11	adjdir_ link3	Lane configuration data for link3. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0
		10:7	bid_link3	Lane configuration data for link3. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0000
		6:2	cf_link3	Lane configuration data for link3. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	00000
		1:0	cs_link3	Lane configuration data for link3. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	00

Register Name: config90 – Address: 0x5A, Default: 0x00FF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config90	0x5A	15:8	did_link3	Lane configuration data for link3. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0x00
		7:0	sync_ request_ena_ link3	These bits select which errors cause a sync request. Sync requests take priority over the error notification, so if sync request isn't desired, set these bits to a '0'. bit7 = multi-frame alignment error bit6 = frame alignment error bit5 = link configuration error bit4 = elastic buffer overflow (bad RBD value) bit3 = elastic buffer end char mismatch (match_ctrl match_data) bit2 = code synchronization error bit1 = 8b/10b not-in-table code error bit0 = 8b/10b disparity error	0xFF

Register Name: config91 – Address: 0x5B, Default: 0x00FF

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config91	0x5B	15:10	reserved	Reserved	000000
		9	disable_ err_report_link3	Assertion means that errors will not be reported on the sync_n output.	0
		8	phadj_ link3	Lane configuration data for link3. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	0
		7:0	error_ena_link3	These bits select the errors generated are counted in the err_cnt for the link. The bits also control what signals are sent out the pad_syncb terminal for error notification. bit7 = multi-frame alignment error bit6 = frame alignment error bit5 = link configuration error bit4 = elastic buffer overflow (bad RBD value) bit3 = elastic buffer end char mismatch (match_ctrl match_data) bit2 = code synchronization error bit1 = 8b/10b not-in-table code error bit0 = 8b/10b disparity error	0xFF

Register Name: config92 – Address: 0x5C, Default: 0x1111

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config92	0x5C	15	err_cnt_ clr_link3	A transition from 0≥1 causes the error_cnt for link3 to be cleared.	0
		14:12	sysref_ mode_link3	Determines how SYSREF is used in the JESD synchronizing block. 000 = Don't use SYSREF pulse 001 = Use all SYSREF pulses 010 = Use only the next SYSREF pulse 011 = Skip one SYSREF pulse then use only the next one 100 = Skip one SYSREF pulse then use all pulses. 101 = Skip two SYSREF pulses then use only the next one 110 = Skip two SYSREF pulses then use all pulses.	001
		11	err_cnt_ clr_link2	A transition from 0≥1 causes the error_cnt for link2 to be cleared.	0
		10:8	sysref_ mode_link2	Determines how SYSREF is used in the JESD synchronizing block. 000 = Don't use SYSREF pulse 001 = Use all SYSREF pulses 010 = Use only the next SYSREF pulse 011 = Skip one SYSREF pulse then use only the next one 100 = Skip one SYSREF pulse then use all pulses. 101 = Skip two SYSREF pulses then use only the next one 110 = Skip two SYSREF pulses then use all pulses.	001
		7	err_cnt_ clr_link1	A transition from 0≥1 causes the error_cnt for link1 to be cleared.	0
		6:4	sysref_ mode_link1	Determines how SYSREF is used in the JESD synchronizing block. 000 = Don't use SYSREF pulse 001 = Use all SYSREF pulses 010 = Use only the next SYSREF pulse 011 = Skip one SYSREF pulse then use only the next one 100 = Skip one SYSREF pulse then use all pulses. 101 = Skip two SYSREF pulses then use only the next one 110 = Skip two SYSREF pulses then use all pulses.	001
		3	err_cnt_ clr_link0	A transition from 0≥1 causes the error_cnt for link0 to be cleared.	0
		2:0	sysref_ mode_link0	Determines how SYSREF is used in the JESD synchronizing block. 000 = Don't use SYSREF pulse 001 = Use all SYSREF pulses 010 = Use only the next SYSREF pulse 011 = Skip one SYSREF pulse then use only the next one 100 = Skip one SYSREF pulse then use all pulses. 101 = Skip two SYSREF pulses then use only the next one 110 = Skip two SYSREF pulses then use all pulses.	001

Register Name: config93 – Address: 0x5D, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config93	0x5D	15:0	reserved	Reserved	0x0000

Register Name: config94 – Address: 0x5E, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config94	0x5E	15:8	res1	Since these bits are reserved, these values are shared across all links for the checksum comparison against ILA values. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	00000000
		7:0	res2	Since these bits are reserved, these values are shared across all links for the checksum comparison against ILA values. **Not used by DAC37J84/DAC38J84 except for lane configuration checking.**	00000000

Register Name: config95 – Address: 0x5F, Default: 0x0123

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config95	0x5F	15	reserved	Reserved	0
		14:12	octetpath_sel(0)	These bits are used by the cross-bar switch to map any SerDes lane to any JESD lane. “000” = pass SerDes lane0 to JESD lane0 “001” = pass SerDes lane1 to JESD lane0 “010” = pass SerDes lane2 to JESD lane0 “011” = pass SerDes lane3 to JESD lane0 “100” = pass SerDes lane4 to JESD lane0 “101” = pass SerDes lane5 to JESD lane0 “110” = pass SerDes lane6 to JESD lane0 “111” = pass SerDes lane7 to JESD lane0	000
		11	reserved	Reserved	0
		10:8	octetpath_sel(1)	These bits are used by the cross-bar switch to map any SerDes lane to any JESD lane. “000” = pass SerDes lane0 to JESD lane1 “001” = pass SerDes lane1 to JESD lane1 “010” = pass SerDes lane2 to JESD lane1 “011” = pass SerDes lane3 to JESD lane1 “100” = pass SerDes lane4 to JESD lane1 “101” = pass SerDes lane5 to JESD lane1 “110” = pass SerDes lane6 to JESD lane1 “111” = pass SerDes lane7 to JESD lane1	001
		7	reserved	Reserved	0
		6:4	octetpath_sel(2)	These bits are used by the cross-bar switch to map any SerDes lane to any JESD lane. “000” = pass SerDes lane0 to JESD lane2 “001” = pass SerDes lane1 to JESD lane2 “010” = pass SerDes lane2 to JESD lane2 “011” = pass SerDes lane3 to JESD lane2 “100” = pass SerDes lane4 to JESD lane2 “101” = pass SerDes lane5 to JESD lane2 “110” = pass SerDes lane6 to JESD lane2 “111” = pass SerDes lane7 to JESD lane2	010
		3	reserved	Reserved	0
		2:0	octetpath_sel(3)	These bits are used by the cross-bar switch to map any SerDes lane to any JESD lane. “000” = pass SerDes lane0 to JESD lane3 “001” = pass SerDes lane1 to JESD lane3 “010” = pass SerDes lane2 to JESD lane3 “011” = pass SerDes lane3 to JESD lane3 “100” = pass SerDes lane4 to JESD lane3 “101” = pass SerDes lane5 to JESD lane3 “110” = pass SerDes lane6 to JESD lane3 “111” = pass SerDes lane7 to JESD lane3	011

Register Name: config96 – Address: 0x60, Default: 0x4567

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config96	0x60	15	reserved	Reserved	0
		14:12	octetpath_sel(4)	These bits are used by the cross-bar switch to map any SerDes lane to any JESD lane. “000” = pass SerDes lane0 to JESD lane4 “001” = pass SerDes lane1 to JESD lane4 “010” = pass SerDes lane2 to JESD lane4 “011” = pass SerDes lane3 to JESD lane4 “100” = pass SerDes lane4 to JESD lane4 “101” = pass SerDes lane5 to JESD lane4 “110” = pass SerDes lane6 to JESD lane4 “111” = pass SerDes lane7 to JESD lane4	100
		11	reserved	Reserved	0
		10:8	octetpath_sel(5)	These bits are used by the cross-bar switch to map any SerDes lane to any JESD lane. “000” = pass SerDes lane0 to JESD lane5 “001” = pass SerDes lane1 to JESD lane5 “010” = pass SerDes lane2 to JESD lane5 “011” = pass SerDes lane3 to JESD lane5 “100” = pass SerDes lane4 to JESD lane5 “101” = pass SerDes lane5 to JESD lane5 “110” = pass SerDes lane6 to JESD lane5 “111” = pass SerDes lane7 to JESD lane5	101
		7	reserved	Reserved	0
		6:4	octetpath_sel(6)	These bits are used by the cross-bar switch to map any SerDes lane to any JESD lane. “000” = pass SerDes lane0 to JESD lane6 “001” = pass SerDes lane1 to JESD lane6 “010” = pass SerDes lane2 to JESD lane6 “011” = pass SerDes lane3 to JESD lane6 “100” = pass SerDes lane4 to JESD lane6 “101” = pass SerDes lane5 to JESD lane6 “110” = pass SerDes lane6 to JESD lane6 “111” = pass SerDes lane7 to JESD lane6	110
		3	reserved	Reserved	0
		2:0	octetpath_sel(7)	These bits are used by the cross-bar switch to map any SerDes lane to any JESD lane. “000” = pass SerDes lane0 to JESD lane7 “001” = pass SerDes lane1 to JESD lane7 “010” = pass SerDes lane2 to JESD lane7 “011” = pass SerDes lane3 to JESD lane7 “100” = pass SerDes lane4 to JESD lane7 “101” = pass SerDes lane5 to JESD lane7 “110” = pass SerDes lane6 to JESD lane7 “111” = pass SerDes lane7 to JESD lane7	111

Register Name: config97 – Address: 0x61, Default: 0x000F

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config97	0x61	15	syncn_pol	Sets the polarity of the SYNC_N_AB and SYNC_N_CD outputs.	0
		14:2	reserved	Reserved	000
		11:8	syncncd_ sel	Select which link sync_n outputs are ANDed together to generate the SYNC_N_CD CMOS output. bit0=link0 bit1=link1 bit2=link2 bit3=link3	0000
		7:4	syncnab_ sel	Select which link sync_n outputs are ANDed together to generate the SYNC_N_AB CMOS output. bit0=link0 bit1=link1 bit2=link2 bit3=link3	0000
		3:0	syncn_ sel	Select which link sync_n outputs are ANDed together to generate the SYNCB LVDS output. bit0=link0 bit1=link1 bit2=link2 bit3=link3	1111

Register Name: config98 – Address: 0x62, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config98	0x62	15	reserved	Reserved	0
		14:12	reserved	Reserved	000
		11:8	reserved	Reserved	0000
		7:0	reserved	Reserved	0x00

Register Name: config99 – Address: 0x63, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config99	0x63	15	reserved	Reserved	0
		14:12	reserved	Reserved	000
		11:8	reserved	Reserved	0000
		7:0	reserved	Reserved	0000

Addresses config100 – config107 are dual purpose registers. When config47(14) is set to a '1' then config100 – config107 become the DIEID(127:0). Normal function (config47(14)='0') is shown below.

Register Name: config100 – Address: 0x64, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config100 WRITE TO CLEAR	0x64	15:8	alarm_l_ error(0)	Lane0 errors: bit15 = multiframe alignment error bit14 = frame alignment error bit13 = link configuration error bit12 = elastic buffer overflow (bad RBD value) bit11 = elastic buffer match error. The first non-/K/ doesn't match "match_ctrl" and "match_data" programmed values. bit10 = code synchronization error bit9 = 8b/10b not-in-table code error bit8 = 8b/10b disparity error	0x00
		7:4	Not Used	Not Used	0000
		3:0	alarm_fifo_ flags(0)	Lane0 FIFO errors: bit3 = write_error : Asserted if write request and FIFO is full bit2 = write_full : FIFO is FULL bit1 = read_error : Asserted if read request with empty FIFO bit0 = read_empty : FIFO is empty	0000

Register Name: config101 – Address: 0x65, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config101 WRITE TO CLEAR	0x65	15:8	alarm_l_ error(1)	Lane0 errors: bit15 = multiframe alignment error bit14 = frame alignment error bit13 = link configuration error bit12 = elastic buffer overflow (bad RBD value) bit11 = elastic buffer match error. The first non-/K/ doesn't match "match_ctrl" and "match_data" programmed values. bit10 = code synchronization error bit9 = 8b/10b not-in-table code error bit8 = 8b/10b disparity error	0x00
		7:4	Not Used	Not Used	0000
		3:0	alarm_fifo_ flags(0)	Lane0 FIFO errors: bit3 = write_error : Asserted if write request and FIFO is full bit2 = write_full : FIFO is FULL bit1 = read_error : Asserted if read request with empty FIFO bit0 = read_empty : FIFO is empty	0000

Register Name: config102 – Address: 0x66, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config102 WRITE TO CLEAR	0x66	15:8	alarm_lane_ error(2)	Lane0 errors: bit15 = multiframe alignment error bit14 = frame alignment error bit13 = link configuration error bit12 = elastic buffer overflow (bad RBD value) bit11 = elastic buffer match error. The first non-/K/ doesn't match "match_ctrl" and "match_data" programmed values. bit10 = code synchronization error bit9 = 8b/10b not-in-table code error bit8 = 8b/10b disparity error	0x00
		7:4	reserved	Reserved	0000
		3:0	alarm_fifo_ flags(0)	Lane0 FIFO errors: bit3 = write_error : Asserted if write request and FIFO is full bit2 = write_full : FIFO is FULL bit1 = read_error : Asserted if read request with empty FIFO bit0 = read_empty : FIFO is empty	0000

Register Name: config103 – Address: 0x67, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config103 WRITE TO CLEAR	0x67	15:8	alarm_land_ error(3)	Lane0 errors: bit15 = multiframe alignment error bit14 = frame alignment error bit13 = link configuration error bit12 = elastic buffer overflow (bad RBD value) bit11 = elastic buffer match error. The first non-/K/ doesn't match "match_ctrl" and "match_data" programmed values. bit10 = code synchronization error bit9 = 8b/10b not-in-table code error bit8 = 8b/10b disparity error	0x00
		7:4	reserved	Reserved	0000
		3:0	alarm_fifo_ flags(0)	Lane0 FIFO errors: bit3 = write_error : Asserted if write request and FIFO is full bit2 = write_full : FIFO is FULL bit1 = read_error : Asserted if read request with empty FIFO bit0 = read_empty : FIFO is empty	0000

Register Name: config104 – Address: 0x68, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config104 WRITE TO CLEAR	0x68	15:8	alarm_lane_ error(4)	Lane0 errors: bit15 = multiframe alignment error bit14 = frame alignment error bit13 = link configuration error bit12 = elastic buffer overflow (bad RBD value) bit11 = elastic buffer match error. The first non-/K/ doesn't match "match_ctrl" and "match_data" programmed values. bit10 = code synchronization error bit9 = 8b/10b not-in-table code error bit8 = 8b/10b disparity error	0x00
		7:4	reserved	Reserved	0000
		3:0	alarm_fifo_ flags(0)	Lane0 FIFO errors: bit3 = write_error : Asserted if write request and FIFO is full bit2 = write_full : FIFO is FULL bit1 = read_error : Asserted if read request with empty FIFO bit0 = read_empty : FIFO is empty	0000

Register Name: config105 – Address: 0x69, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config105 WRITE TO CLEAR	0x69	15:8	alarm_lane_ error(5)	Lane0 errors: bit15 = multiframe alignment error bit14 = frame alignment error bit13 = link configuration error bit12 = elastic buffer overflow (bad RBD value) bit11 = elastic buffer match error. The first non-/K/ doesn't match "match_ctrl" and "match_data" programmed values. bit10 = code synchronization error bit9 = 8b/10b not-in-table code error bit8 = 8b/10b disparity error	0x00
		7:4	reserved	Reserved	0000
		3:0	alarm_fifo_ flags(0)	Lane0 FIFO errors: bit3 = write_error : Asserted if write request and FIFO is full bit2 = write_full : FIFO is FULL bit1 = read_error : Asserted if read request with empty FIFO bit0 = read_empty : FIFO is empty	0000

Register Name: config106 – Address: 0x6A, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config106 WRITE TO CLEAR	0x6A	15:8	alarm_lane_ error(6)	Lane0 errors: bit15 = multiframe alignment error bit14 = frame alignment error bit13 = link configuration error bit12 = elastic buffer overflow (bad RBD value) bit11 = elastic buffer match error. The first non-/K/ doesn't match "match_ctrl" and "match_data" programmed values. bit10 = code synchronization error bit9 = 8b/10b not-in-table code error bit8 = 8b/10b disparity error	0x00
		7:4	reserved	Reserved	0000
		3:0	alarm_fifo_ flags(0)	Lane0 FIFO errors: bit3 = write_error : Asserted if write request and FIFO is full bit2 = write_full : FIFO is FULL bit1 = read_error : Asserted if read request with empty FIFO bit0 = read_empty : FIFO is empty	0000

Register Name: config107 – Address: 0x6B, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config107 WRITE TO CLEAR	0x6B	15:8	alarm_lane_ error(7)	Lane7 errors: bit15 = multiframe alignment error bit14 = frame alignment error bit13 = link configuration error bit12 = elastic buffer overflow (bad RBD value) bit11 = elastic buffer match error. The first non-/K/ doesn't match "match_ctrl" and "match_data" programmed values. bit10 = code synchronization error bit9 = 8b/10b not-in-table code error bit8 = 8b/10b disparity error	0x00
		7:4	reserved	Reserved	0000
		3:0	alarm_fifo_ flags(0)	Lane0 FIFO errors: bit3 = write_error : Asserted if write request and FIFO is full bit2 = write_full : FIFO is FULL bit1 = read_error : Asserted if read request with empty FIFO bit0 = read_empty : FIFO is empty	0000

Register Name: config108 – Address: 0x6C, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config108 WRITE TO CLEAR	0x6C	15:12	alarm_sysref_ err	SYSREF Errors discovered for each lane. bit15 = lane3 bit14 = lane2 bit13 = lane1 bit12 = lane0	0000
		11:8	alarm_pap	Alarms from the PAP blocks bit11 = data path D bit10 = data path C bit9 = data path B bit8 = data path A While any alarm_pap is asserted the attenuation for the appropriate data path is applied.	0000
		7:4	reserved	Reserved	0000
		3	alarm_ rw0_pll	Driven high if the PLL in the SerDes block0 goes out of lock. A false alarm is generated at startup when the PLL is locking. User will have to reset this bit after start to monitor accurately.	0
		2	alarm_ rw1_pll	Driven high if the PLL in the SerDes block1 goes out of lock. A false alarm is generated at startup when the PLL is locking. User will have to reset this bit after start to monitor accurately.	0
		1	reserved	Reserved	0
		0	alarm_from_pll	When this bit is a ‘1’ the DAC PLL is out of lock.	0

Register Name: config109 – Address: 0x6D, Default: 0x00xx

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config109	0x6D	15:8	alarm_from_ shorttest	These are the alarms from the different lanes during JESD short test checking. bit15 = lane7 alarm bit14 = lane6 alarm bit13 = lane5 alarm bit12 = lane4 alarm bit11 = lane3 alarm bit10 = lane2 alarm bit9 = lane1 alarm bit8 = lane0 alarm	0x00
		7:0	memin_rw_ losdct	These are the loss of signal detect outputs from the SERDES lanes: bit7 = lane7 loss off signal bit6 = lane6 loss off signal bit5 = lane5 loss off signal bit4 = lane4 loss off signal bit3 = lane3 loss off signal bit2 = lane2 loss off signal bit1 = lane1 loss off signal bit0 = lane0 loss off signal	No default

Register Name: config110 – Address: 0x6E, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config110	0x6E	15:14	sfrac_ coef0_ab	Small delay fractional filter tap0: Valid values [-2 to 1]	00
		13:9	sfrac_ coef1_ab	Small delay fractional filter tap1: Valid values [-16 to 15]	00000
		8:1	sfrac_ coef2_ab	Small delay fractional filter tap2: Valid values [-128 127]	00000000
		0	reserved	Reserved	0

Register Name: config111 – Address: 0x6F, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config111	0x6F	15:10	reserved	Reserved	000000
		9:0	sfrac_ coef3_ab	Small delay fractional filter tap3: Valid values [-512 to 511]	0000000000

Register Name: config112 – Address: 0x70, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config112	0x70	15:0	sfrac_ coef4_ab(15:0)	Small delay fractional filter tap4: Valid values [-262144 to 262143]	0x0000

Register Name: config113 – Address: 0x71, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config113	0x71	15:13	sfrac_ coef4_ab(18:16)	Upper bits of small delay fraction filter tap4.	000
		12:10	reserved	Reserved	000
		9:0	sfrac_ coef5_ab	Small delay fractional filter tap5: Valid values [-512 to 511]	0000000000

Register Name: config114 – Address: 0x72, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config114	0x72	15:9	reserved	Reserved	0000000
		8:0	sfrac_ coef6_ab	Small delay fractional filter tap6: Valid values [-256 to 255]	000000000

Register Name: config115 – Address: 0x73, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config115	0x73	15:9	sfrac_ coef7_ab	Small delay fractional filter tap7: Valid values [–64 to 63]	0000000
		8:4	sfrac_ coef8_ab	Small delay fractional filter tap8: Valid values [–16 to 15]	00000
		3:2	sfrac_ coef9_ab	Small delay fractional filter tap9: Valid values [–2 to 1]	00
		1:0	Not Used	Not Used	00

Register Name: config116 – Address: 0x74, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config116	0x74	15:0	sfrac_ invgain_ab(15:0)	Controls the divide amount in the small fractional delay gain computation: Valid values [–524288 to 524284]	0x0000

Register Name: config117 – Address: 0x75, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config117	0x75	15:12	sfrac_ invgain_ ab(19:16)	Upper bits of the small fraction delay FIR gain value.	0000
		11:3	reserved	Reserved	000000000
		5:3	lfras_ coefsel_a	Selected that coefficients used for the A data path FIR5B or large fractional delay FIR.	000
		2:0	lfrac_ coefsel_b	Selected that coefficients used for the B data path FIR5B or large fractional delay FIR.	000

Register Name: config118 – Address: 0x76, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config118	0x76	15:14	sfrac_ coef0_cd	Small delay fractional filter tap0: Valid values [–2 to 1]	00
		13:9	sfrac_ coef1_cd	Small delay fractional filter tap1: Valid values [–16 to 15]	00000
		8:1	sfrac_ coef2_cd	Small delay fractional filter tap2: Valid values [–128 127]	00000000
		0	reserved	Reserved	0

Register Name: config119 – Address: 0x77, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config119	0x77	15:10	reserved	Reserved	000000
		9:0	sfrac_ coef3_cd	Small delay fractional filter tap3: Valid values [–512 to 511]	0000000000

Register Name: config120 – Address: 0x78, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config120	0x78	15:0	sfrac_ coef4_cd(15:0)	Small delay fractional filter tap4: Valid values [–262144 to 262143]	0x0000

Register Name: config121 – Address: 0x79, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config121	0x79	15:13	sfrac_ coef4_cd(18:16)	Upper bits of small delay fraction filter tap4.	000
		12:10	reserved	Reserved	000
		9:0	sfrac_ coef5_cd	Small delay fractional filter tap5: Valid values [–512 to 511]	0000000000

Register Name: config122 – Address: 0x7A, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config122	0x7A	15:9	reserved	Reserved	0000000
		8:0	sfrac_ coef6_cd	Small delay fractional filter tap6: Valid values [–256 to 255]	

Register Name: config123 – Address: 0x7B, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config123	0x7B	15:9	sfrac_ coef7_cd	Small delay fractional filter tap7: Valid values [–64 to 63]	0000000
		8:4	sfrac_ coef8_cd	Small delay fractional filter tap8: Valid values [–16 to 15]	00000
		3:2	sfrac_ coef9_cd	Small delay fractional filter tap9: Valid values [–2 to 1]	00
		1:0	Not Used	Not Used	00

Register Name: config124 – Address: 0x7C, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config124	0x7C	15:0	sfrac_ invgain_cd(15:0)	Controls the divide amount in the small fractional delay gain computation: Valid values [–524288 to 524284]	0x0000

Register Name: config125 – Address: 0x7D, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config125	0x7D	15:12	sfrac_invgain_ cd(19:16)	Upper bits of the small fraction delay FIR gain value.	0000
		11:6	reserved	Reserved	000000000
		5:3	lfrac_ coefsel_c	Selected that coefficients used for the C data path FIR5B or large fractional delay FIR.	000
		2:0	lfrac_ coefsel_d	Selected that coefficients used for the D data path FIR5B or large fractional delay FIR.	000

Register Name: config126 – Address: 0x7E, Default: 0x0000

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config126	0x7E	15:12	reserved	Reserved	0000
		11:8	reserved	Reserved	0000
		7:4	reserved	Reserved	0000
		3:0	reserved	Reserved	0000

Register Name: config127 – Address: 0x7F, Default: 0x0009

Register Name	Addr (Hex)	Bit	Name	Function	Default Value
config127 READ ONLY/No RESET Value	0x7F	15	memin_efc_autoload _done	Goes high when the autoload from the fusefarm is done.	0
		14:10	memin_efc_ error	Resulting error code from last Fusefarm instruction	00000
		9:8	not used	Not Used	00
		7:5	not used	Not Used	000
		4:3	vendorid	This is the vendor ID. It shouldn't change but will have access to change through a hardwire connection outside the DIG block.	01
		2:0	versionid	A hardwired register that contains the version of the chip. This value is accessible outside the DIG block for changing.	001

8 Applications and Implementation

8.1 Application Information

The DAC37J84/DAC38J84 family is a 16-bit DAC with max input data rate up to 1.23GSPS per DAC. It provides two independent transmit paths with up to 1GHz complex information bandwidth each. It also integrates a multi-band summation block that allows two complex signal carrier blocks to be independently mixed to the desired frequency before being summed together for a single path complex transmit. This supports up to 2 GHz of information bandwidth from one pair of 2.5GSPS output DACs. DAC37J84/DAC38J84 consumes about 1.3W at 1.6GSPS and 1.8W at 2.5GSPS. The digital Quadrature Modulator Correction and Group Delay Correction enable complete IQ compensation for gain, offset, phase, and group delay between channels in direct up-conversion applications. DAC37J84 and DAC38J84 provide the bandwidth, performance, small footprint and low power consumption needed for multi-mode 2G/3G/4G cellular base stations to migrate to more advanced technologies, such as LTE-Advanced and carrier aggregation on multiple antennas.

8.2 Typical Applications

8.2.1 Dual Low-IF Wideband LTE Transmitter

Figure 82 shows an example block diagram for a direct conversion radio. Here it has been assumed that the desired output bandwidth is 80-MHz which could be, for instance, four 20-MHz LTE signals. It is also assumed that digital pre-distortion (DPD) is used to correct 3rd order distortion so the total DAC output bandwidth is 240 MHz. Interpolation is used to output the signal at the highest sampling rate possible to simplify the analog filtering requirements and move high order harmonics out of band. The internal PLL is used to generate the final DAC output clock from a reference clock of 307.2 MHz. The complex mixer will be used to place the baseband input signal at a desired intermediate frequency (IF). The maximum serdes rate that the chosen FPGA supports is 12.5 Gbps and the minimum number of serdes lanes is desired.

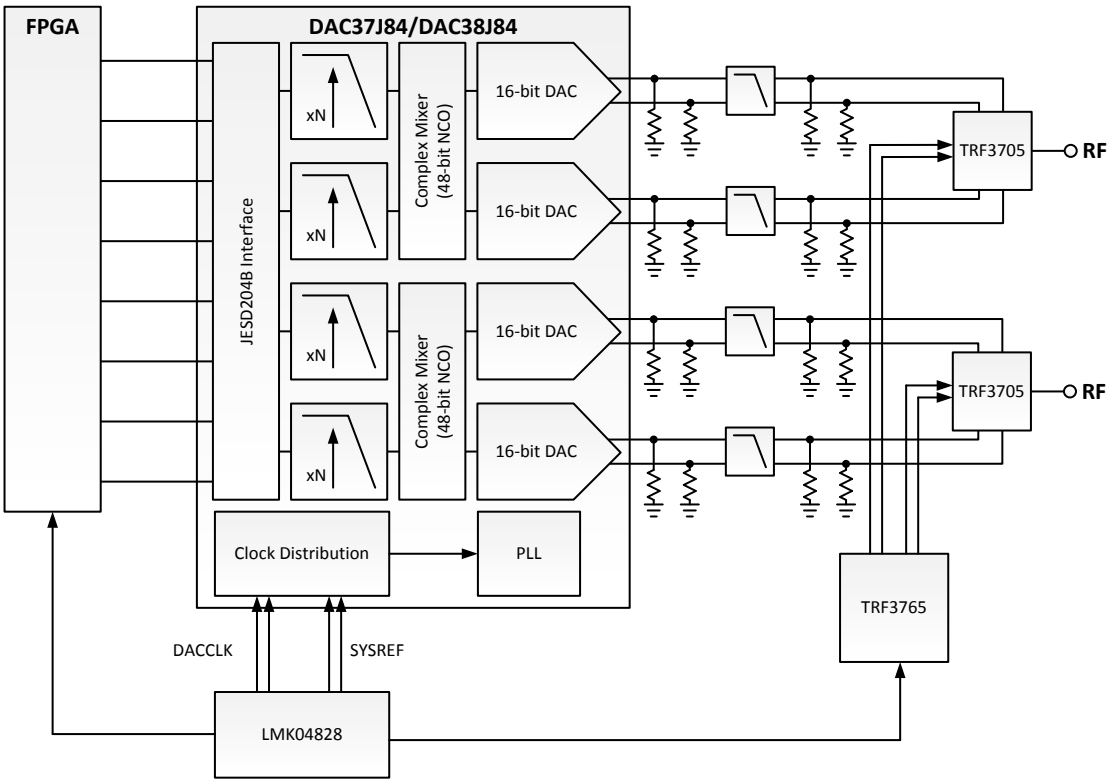


Figure 82. Dual Low-IF Wideband LTE Transmitter Diagram

Typical Applications (continued)

8.2.1.1 Design Requirements

For this design example, use the parameters listed in the table below as the input parameters.

DESIGN PARAMETER	EXAMPLE VALUE
Signal Bandwidth (BW_{signal})	80 MHz
Total DAC Output Bandwidth (BW_{total})	240 MHz
DAC PLL	On
DAC PLL Reference Frequency	307.2 MHz
Maximum FPGA Serdes Data Rate	12.5 Gbps

8.2.1.2 Detailed Design Procedure

8.2.1.2.1 Data Input Rate

Nyquist theory says that the data rate must be at least two times the highest signal frequency. The data will be sent to the DAC as complex baseband data. For 240 MHz of signal bandwidth only 120 MHz of input bandwidth is needed, setting the minimum data input rate as 240 MSPS. Further, the process of interpolation requires low pass filters that limit the useable input bandwidth to about 40 percent of Fdata. Therefore, the minimum data input rate is 300 MSPS. The standard telecom data rate of 307.2 MSPS is chosen.

8.2.1.2.2 Intermediate Frequency

The intermediate frequency is chosen to keep low order harmonics out of band while staying low enough to not degrade the ACPR performance. The band of interest is 240 MHz wide, while the signal bandwidth is 80 MHz wide. The lowest frequency that the second harmonic of the signal will fall at is given on the left side of the inequality shown below based on the chosen IF center frequency. The highest frequency in the band of interest (Total DAC Output Bandwidth) is the right side of the inequality. Solving the inequality for IF and choosing a center frequency higher than that will keep the second harmonic out of the bandwidth of interest.

$$(IF - BWsignal / 2) * 2 \geq IF + BWtotal/2 \quad (3)$$

The lowest IF that satisfies the inequality is shown below.

$$IF \geq BWsignal + BWtotal / 2 \quad (4)$$

So for a signal bandwidth of 80 MHz and a total bandwidth of 240 MHz, the lowest IF that satisfies the inequality is 200 MHz. Choose 220 MHz to move HD2 slightly away from the band. The full complex mixer can be enabled with the NCO frequency chosen as 220 MHz to realize this IF frequency.

8.2.1.2.3 Interpolation

It is desired to use the highest DAC output rate as possible to move the DAC images further from the signal of interest to ease the analog filter requirements. The DAC output rate must be greater than two times the highest output frequency, in this case 2 * (220 MHz + BWtotal/2) = 680 MHz. The table below shows the possible DAC output rates based on the data input rate and available interpolation settings. The DAC image frequency is also listed. Based on the result, 8x interpolation will push the image frequency 1777.6 MHz away from the band of interest, so the DAC output rate is chosen as 2457.6 MSPS.

Although not shown the high output rate also pushes higher order harmonics out of the band of interest that would have aliased back in at 1228.8 MSPS.

INTERPOLATION	DAC OUTPUT RATE	POSSIBLE?	LOWEST IMAGE FREQUENCY	DISTANCE FROM BAND OF INTEREST
1	307.2 MSPS	No	N/A	N/A
2	614.4 MSPS	No	N/A	N/A
4	1228.8 MSPS	Yes	888.8 MHz	548.8 MHz
8	2457.6 MSPS	Yes	2117.6 MHz	1777.6 MHz
16	4915.2 MSPS	No	N/A	N/A

8.2.1.2.4 DAC PLL Setup

The reference frequency from an onboard clock chip, like the LMK04828, is 307.2 MHz. It is desired to use the highest PFD update rate to maintain the best phase noise performance, but not too high to avoid spurs, therefore the N Divider is chosen to be 2 for a PFD frequency of 153.6 MHz. In order to have the feedback side of the PFD be equal to the reference side (153.6 MHz) and create a DACCLK rate of 2457.6 MHz, the M Divider must be set to 16. Using Table 29, it is found that a VCO frequency of 4915.2 MHz can be used to generate a DACCLK frequency of 2457.6 MHz, so the Prescalar is set to 2 and the H-band VCO is selected.

8.2.1.2.5 Serdes Lanes

It is desired to use the minimum number of serdes lanes while staying under the maximum serdes line rate possible with the chosen FPGA. In the design requirements, the FPGA maximum serdes data rate was given as 12.5 Gbps. For the chosen input data rate of 307.2 MSPS and with 8b/10b encoding on the serdes lanes, each DAC requires a serialized data rate of 6144 Mbps, as given by the equation below.

Serialized Data Rate = Fdata * 16 * (10 / 8) (5)

The total serialized data rate with a quad DAC is 6144 Mbps * 4 = 24.576 Gbps. This total serialized data rate is split among the total number of lanes. The table below shows the line rate versus the total number of lanes. Two lanes running at 12.288 Gbps is chosen since the minimum number of lanes is desired. This sets the JESD204B mode (LMF) for the DAC as 244 mode.

NUMBER OF LANES	LINE RATE	POSSIBLE?
1	24.576 Gbps	No
2	12.288 Gbps	Yes
4	6144 Gbps	Yes
8	3072 Gbps	Yes

8.2.1.3 Application Performance Plots

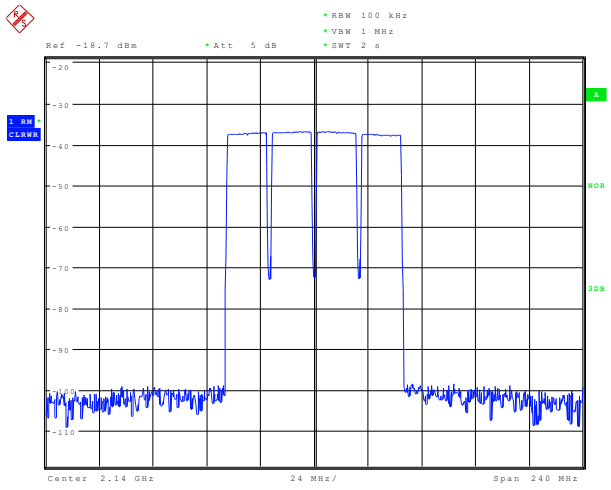


Figure 83. Four Carrier 20MHz LTE Signal Spectrum

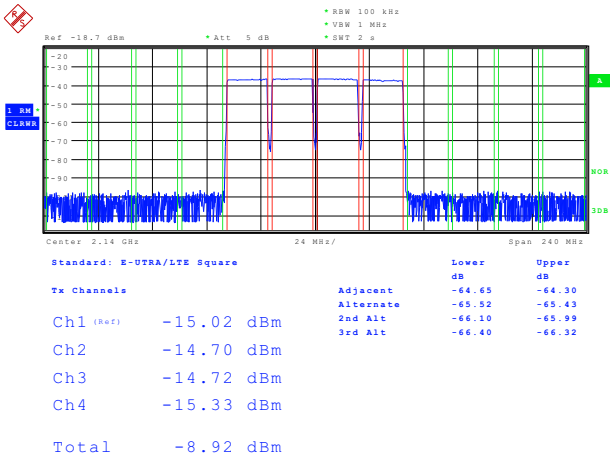


Figure 84. Four Carrier 20MHz LTE Signal ACPR

8.2.2 Dual Zero-IF Wideband Transmitter

The block diagram shown in Figure 85 also applies for a zero-IF wideband transmitter. However in this case the signal bandwidth is 192 MHz and digital predistortion is used to correct third and fifth order distortion, meaning the total bandwidth of interest is 960 MHz. Interpolation is used to output the signal at the highest sampling rate possible to simplify the analog filtering requirements. The DAC sample clock is provided directly from a clock chip, such as TI's LMK04828. The maximum serdes rate that the chosen FPGA supports is 12.5 Gbps and the minimum number of serdes lanes is desired.

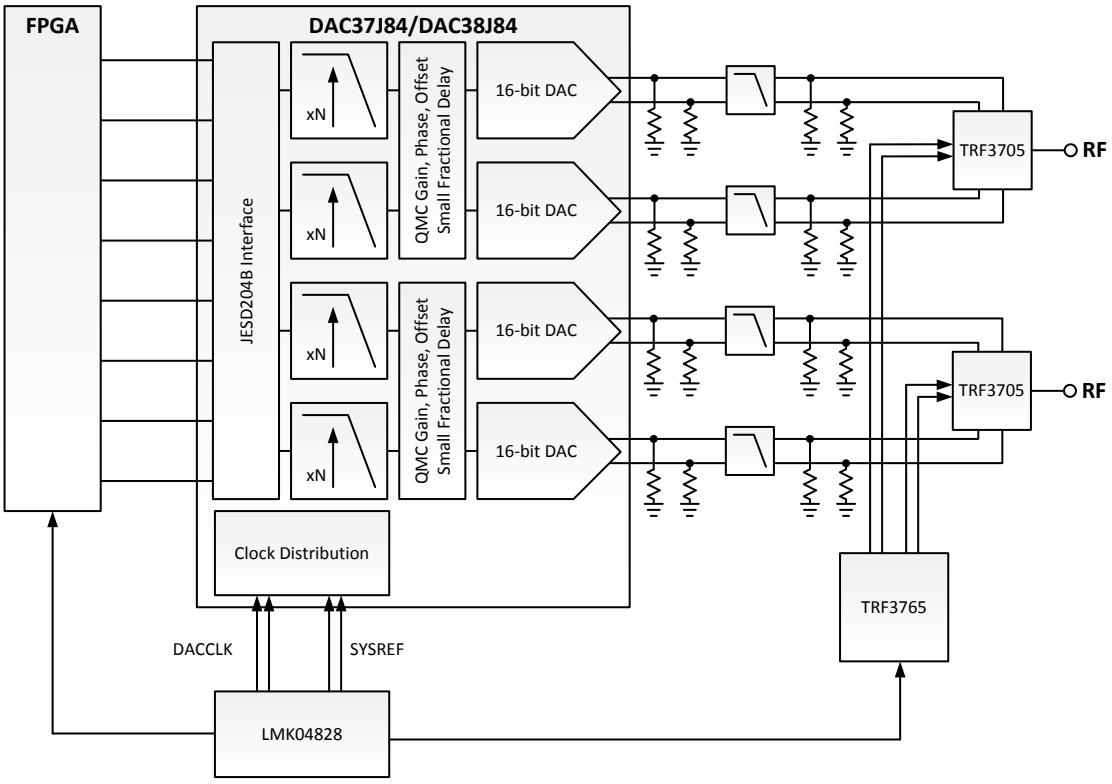


Figure 85. Dual Zero-IF Wideband Transmitter Diagram

8.2.2.1 Design Requirements

For this design example, use the parameters listed in the table below as the input parameters.

DESIGN PARAMETER	EXAMPLE VALUE
Signal Bandwidth (BW_{signal})	192 MHz
Total DAC Output Bandwidth (BW_{total})	960 MHz
DAC PLL	Off
Maximum FPGA Serdes Data Rate	12.5 Gbps

8.2.2.2 Detailed Design Procedure

8.2.2.2.1 Data Input Rate

In this application the total complex bandwidth is 960 MHz meaning that at least 480 MHz of real bandwidth is needed, setting the minimum data input rate at 960 MSPS. However, the process of interpolation requires digital low pass filters that limit the useable input bandwidth to about 40 percent of Fdata. Therefore, the minimum data input rate is 1.2 GSPS.

8.2.2.2.2 Interpolation

It is desired to use the highest DAC output rate as possible to move the DAC images further from the signal of interest to ease the analog filter requirements. The DAC output rate must be greater than two times the highest output frequency, in this case 2 * 960 MHz / 2 = 960 MHz. The table below shows the possible DAC output rates based on the data input rate and available interpolation settings. The DAC image frequency is also listed. Based on the result, 2x interpolation is chosen which will push the image frequency 1.44 GHz away from the band of interest.

INTERPOLATION	DAC OUTPUT RATE	POSSIBLE?	LOWEST IMAGE FREQUENCY	DISTANCE FROM BAND OF INTEREST
1	1.2 GSPS	Yes	720 MHz	240 MHz
2	2.4 GSPS	Yes	1920 MHz	1440 MHz
4	4.8 GSPS	No	N/A	N/A
8	9.6 GSPS	No	N/A	N/A
16	19.2 GSPS	No	N/A	N/A

8.2.2.2.3 Serdes Lanes

It is desired to use the minimum number of serdes lanes while staying under the maximum serdes line rate possible with the chosen FPGA. In the design requirements, the FPGA maximum serdes data rate was given as 12.5 Gbps. For the chosen input data rate of 1.2 GSPS and with 8b/10b encoding on the serdes lanes, each DAC requires a serialized data rate of 24 Gbps, as given by the equation below.

$$\text{Serialized Data Rate} = \text{Fdata} * 16 * (10 / 8) \quad (6)$$

The total serialized data rate with a quad DAC is 24 Gbps * 4 = 96 Gbps. This total serialized data rate is split among the total number of lanes. The table below shows the line rate versus the total number of lanes. Eight lanes must be chosen to support this data rate. This sets the JESD204B mode (LMF) for the DAC as 841 mode.

NUMBER OF LANES	LINE RATE	POSSIBLE?
1	96 Gbps	No
2	48 Gbps	No
4	24 Gbps	No
8	12 Gbps	Yes

8.2.2.2.4 LO Feedthrough and Sideband Correction

Although the I/Q modulation process will inherently reduce the level of the RF sideband signal, a zero-IF system will likely need additional sideband suppression to maximize performance. Further, any mixing process will result in some feedthrough of the LO source. The DAC37J84 and DAC38J84 contain digital features to cancel both the LO feedthrough and sideband signal. The LO feedthrough is corrected by adding a DC offset to the DAC outputs until the LO feedthrough is suppressed. The sideband suppression can be improved by correcting gain, phase, and group delay differences between the I and Q analog outputs. The phase and gain adjustments are made using the QMC block of the DAC while the group delay adjustments are done using the small fractional delay filter. First the phase should be adjusted to suppress the sideband signal at low DAC output frequencies due to phase error. Then the gain can be adjusted to further improve the suppression. Finally, the small fractional filter can be used to improve the sideband suppression across the rest of the signal bandwidth.

8.2.2.3 Application Performance Plots

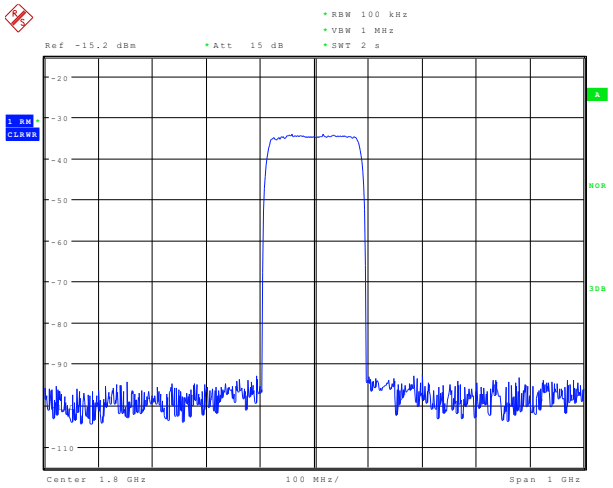


Figure 86. 192MHz Wideband 256QAM Signal Spectrum

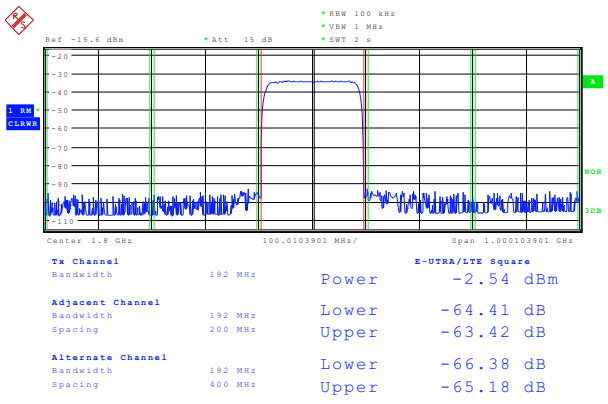


Figure 87. 192MHz Wideband 256QAM Signal ACPR

8.3 Initialization Set Up

The following start up sequence is recommended to power up DAC38J84/DAc37J84 family.

1. Set TXENABLE low
2. Supply all 0.9-V supplies (VDDDIG, VDDT, VDDDAC, VDDCLK), all 1.8-V supplies (VDDR, VDDS, VQPS, VDDIO, VDDAPLL, VDDAREF), and all 3.3-V supplies (VDDADAC). The supplies can be powered up simultaneously or in any order. There are no specific requirements on the ramp rate for the supplies.
3. RESET the JTAG port by either toggling TRSTB low if using the JTAG port or holding TRSTB low if not using JTAG.
4. Start the DACCLK generation
5. Toggle RESETB low to reset the SIF registers
6. Program the DAC PLL settings (*config26, config49, config50, config51*). If the PLL is not used, set ***pll_sleep*** and ***pll_reset*** to “1” and ***pll_ena*** to “0”.
7. Program the SERDES settings (*config61, config62*) including the ***serdes_clk_sel*** and ***serdes_refclk_div***.
8. Program the SERDES lane settings (*config63, config71, config73, config74, config96*).
9. Program ***clkjesd_div, cdrvser_sysref_mode,*** and ***interp***.
10. Program the JESD settings (config3, config74-77, config79, config80-85, config92, config97).
11. Program the DIG block settings (NCO, PA protection, QMC, fractional delay, etc.) and set the preferred SYNC modes for the digital blocks (config30-32).
12. Verify the SERDES PLL lock status by checking the SERDES PLL alarms: ***alarm_rw0_pll*** (alarm for lanes 0 through 3) and ***alarm_rw1_pll*** (alarm for lanes 4 through 7).
13. Set ***init_state*** to “0000” and ***jesd_reset_n*** to “1” to start the JESD204B link initialization.
14. Start the SYSREF generation.
15. Enable transmission of data by asserting the TXENABLE terminal or setting ***sif_txenable*** to “1”.
16. Clear the alarms, then wait approximately 1-2µs and check values
17. Verify that DAC output is the desired output.

9 Power Supply Recommendations

The DAC37J84 and DAC38J84 use three different power supply voltages. Some of the DAC power supplies are noise sensitive. The table below is a summary of the various power supply of the DAC. Care should be taken to keep clean power supplies routing away from noisy digital supplies. It is recommended to use at least two power layers. Avoid placing digital supplies and clean supplies on adjacent board layers and use a ground layer between noisy and clean supplies if possible. All supplies terminals should be decoupled as close to the terminals as possible using small value capacitors, with larger bulk capacitors placed further away.

POWER SUPPLY	VOLTAGE	NOISE SENSITIVE?	RECOMMENDATION
VDDADAC33	3.3 V	Yes	Provide clean voltage, avoid spurious noise
VDDAPLL18	1.8 V	Yes	Provide clean voltage, avoid spurious noise
VDDAREF18	1.8 V	Yes	Provide clean voltage, avoid spurious noise
VDDCLK09	0.9 V	Yes	Provide clean voltage, avoid spurious noise
VDDDAC09	0.9 V	Yes	Provide clean voltage, avoid spurious noise
VDDDIG09	0.9 V	No	Digital supply, keep separated from noise sensitive 0.9 V supplies.
VDDIO18	1.8 V	No	No concern
VDDR18	1.8 V	Yes	Provide clean voltage
VDDS18	1.8 V	No	No concern
VDDT09	0.9 V	Yes	Provide clean voltage
VQPS18	1.8 V	No	No concern

10 Layout

10.1 Layout Guidelines

- DAC output termination resistors should be placed as close to the output terminals as possible to provide a DC path to ground and set the source impedance.
- For PLL mode, if the external loop filter is not used then leave the terminal floating without any board routing. Signals coupling to this node may cause clock mixing spurs in the DAC output.
- Route the high speed serdes lanes as impedance-controlled, tightly-coupled, differential traces.
- Maintain a solid ground plane under the serdes lanes without any ground plane splits.
- AC couple the serdes lines between the logic device and the DAC using 0201 size capacitors that maintain low impedance at the serialized data rate.
- Simulation of the serdes channel is recommended to verify JESD204B standard compliance to ensure compatibility between devices.
- Keep the SYSREF routing away from the DACCLK routing to reduce coupling. Using a pulsed SYSREF or disabling a continuous SYSREF is recommended during normal operation to avoid spurs in the output spectrum.
- Keep routing for RBIAS short, for instance a resistor can be placed on the bottom of the board directly connecting the RBIAS ball to a GND ball.
- Decoupling capacitors should be placed as close to the supply terminals as possible, for instance a capacitor can be placed on the bottom of the board directly connecting the supply ball to a GND ball.
- Noisy power supplies should be routed away from clean supplies. Use two power plane layers, preferably with a GND layer in between.

10.2 Layout Examples

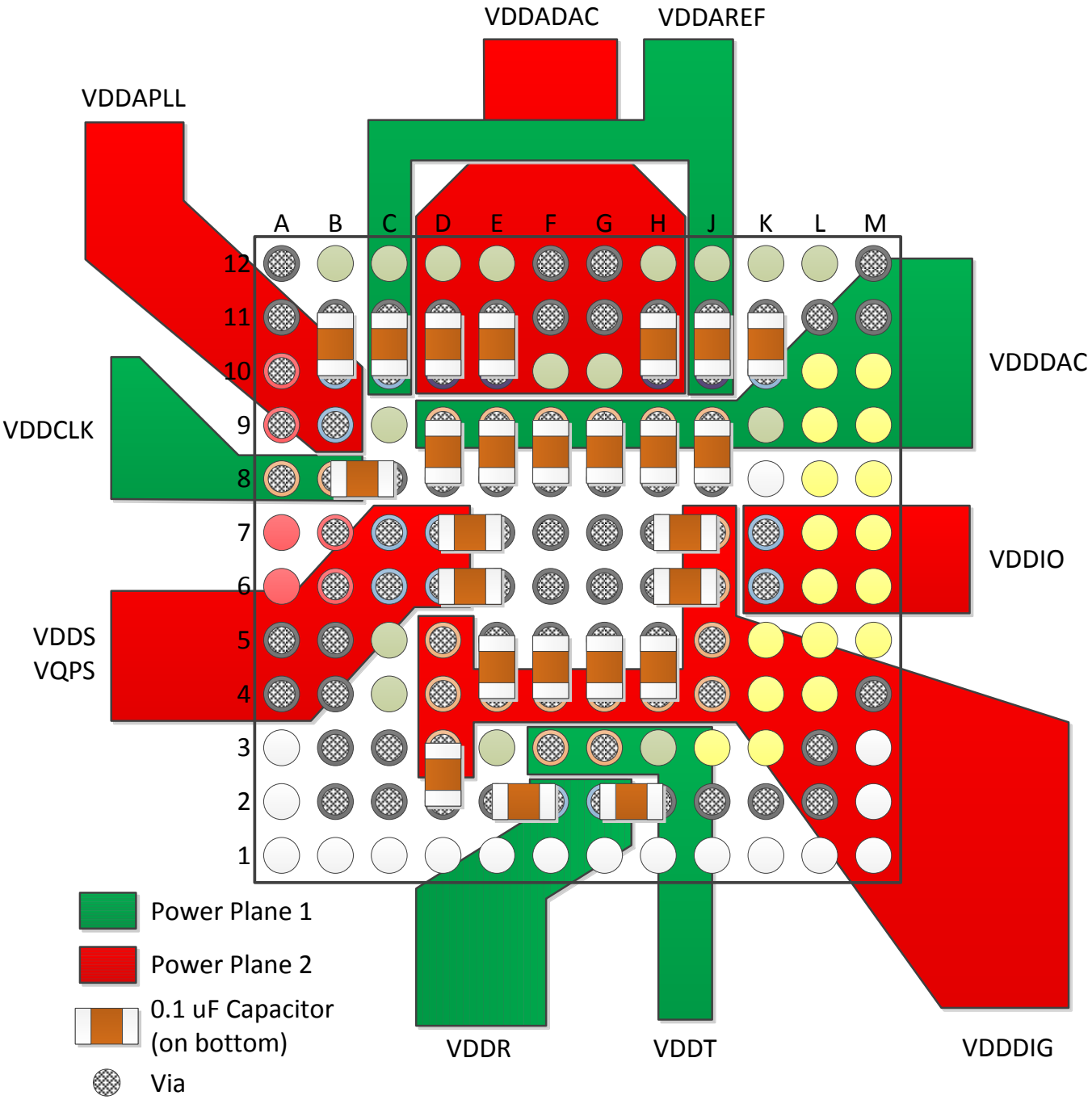


Figure 88. DAC37J84/DAC38J84 Layout for Power Supplies

Layout Examples (continued)

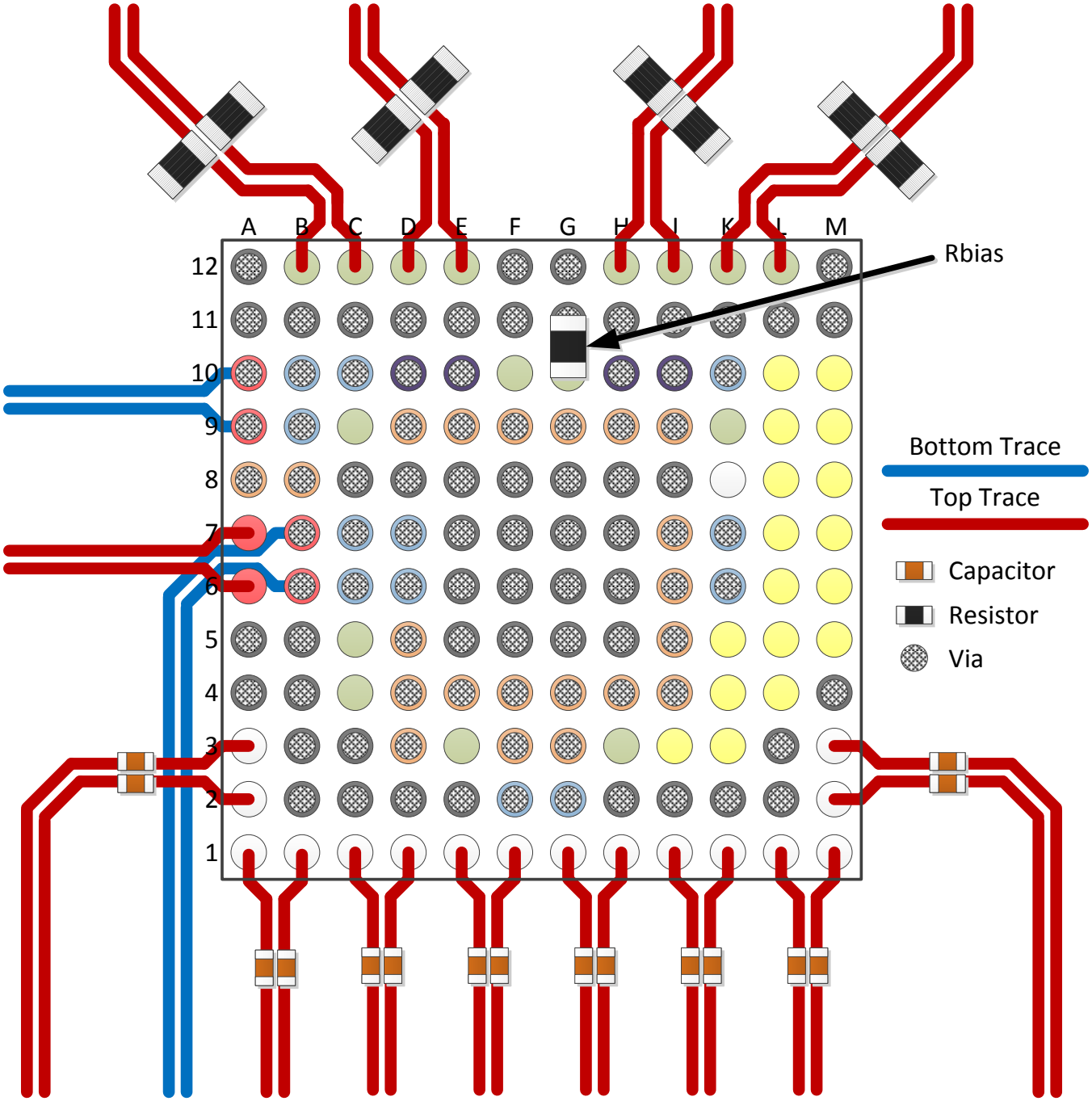


Figure 89. DAC37J84/DAC38J84 Layout for Signals

11 Device and Documentation Support

11.1 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 32. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
DAC37J84	Click here	Click here	Click here	Click here	Click here
DAC38J84	Click here	Click here	Click here	Click here	Click here

11.2 Trademarks

All trademarks are the property of their respective owners.

11.3 Electrostatic Discharge Caution

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.

11.4 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms and definitions.

12 Mechanical, Packaging, and Orderable Information

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

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
DAC37J84IAAV	ACTIVE	FCBGA	AAV	144	168	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	DAC37J84I	Samples
DAC37J84IAAVR	ACTIVE	FCBGA	AAV	144	1000	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	DAC37J84I	Samples
DAC38J84IAAV	ACTIVE	FCBGA	AAV	144	168	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	DAC38J84I	Samples
DAC38J84IAAVR	ACTIVE	FCBGA	AAV	144	1000	RoHS & Green	SNAGCU	Level-3-260C-168 HR	-40 to 85	DAC38J84I	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals.
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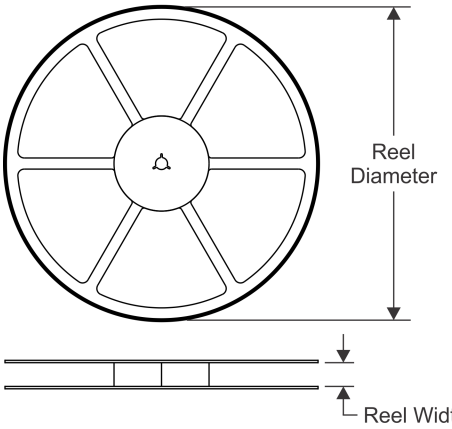
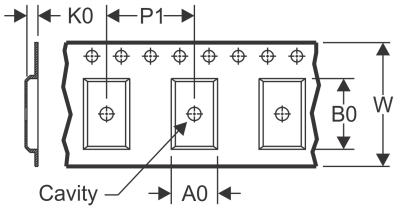
TAPE AND REEL INFORMATION

REEL DIMENSIONS

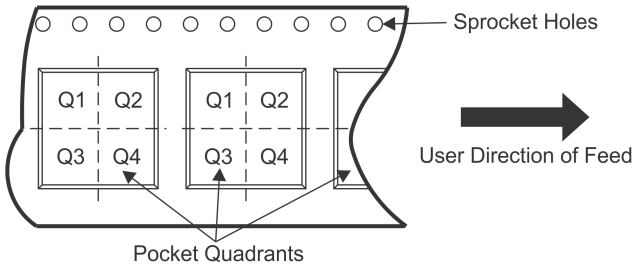


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

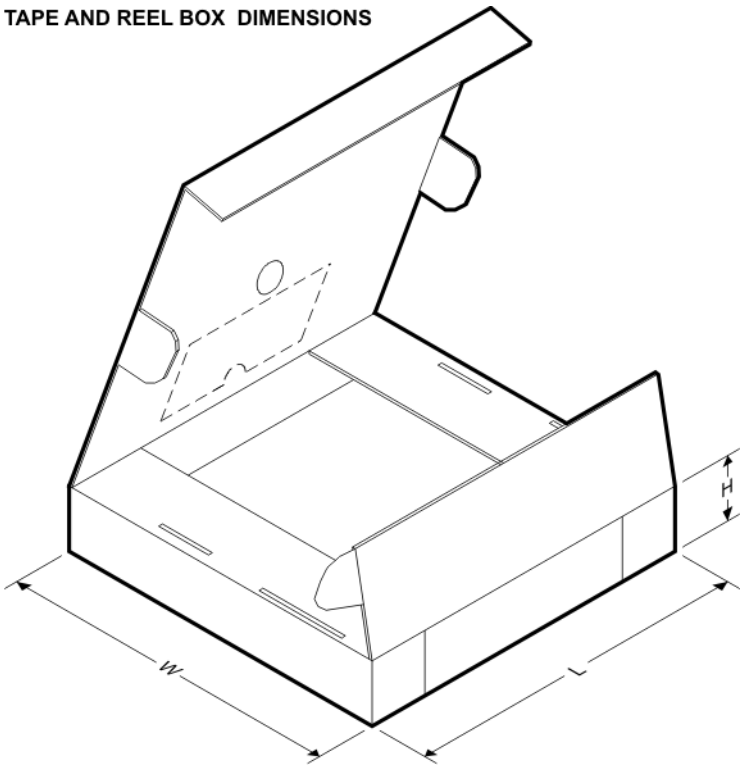
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
DAC37J84IAAVR	FCBGA	AAV	144	1000	330.0	24.4	10.3	10.3	2.5	16.0	24.0	Q1
DAC38J84IAAVR	FCBGA	AAV	144	1000	330.0	24.4	10.3	10.3	2.5	16.0	24.0	Q1

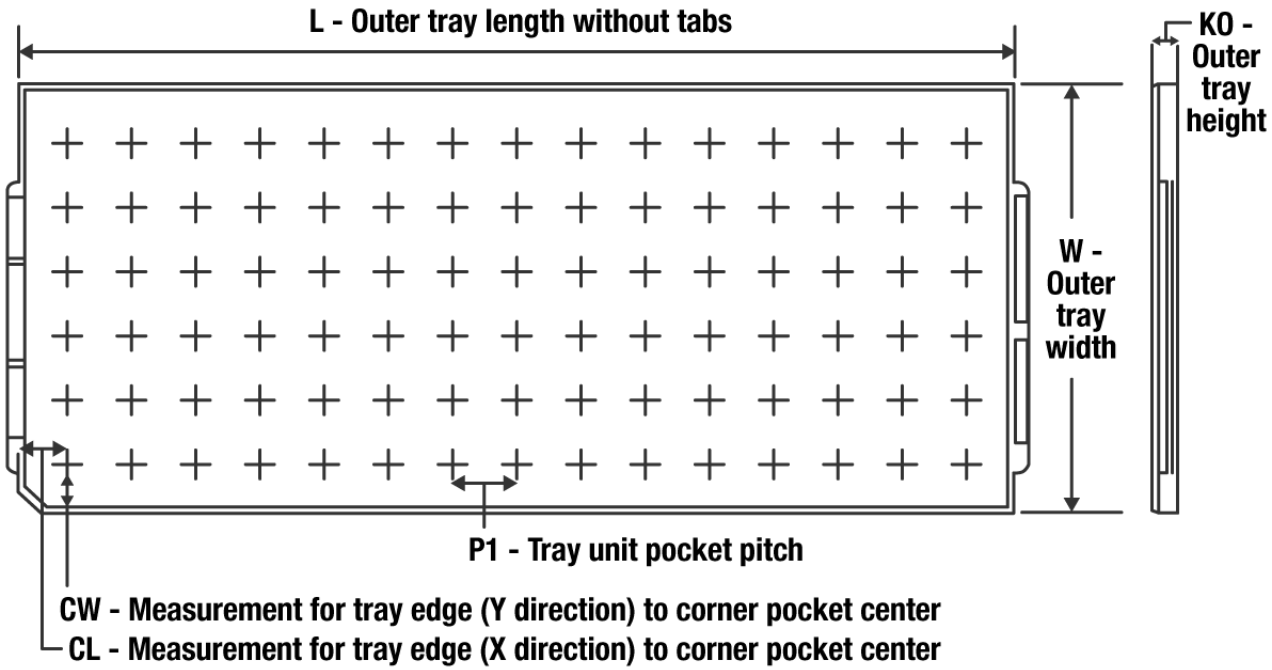
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
DAC37J84IAAVR	FCBGA	AAV	144	1000	350.0	350.0	43.0
DAC38J84IAAVR	FCBGA	AAV	144	1000	350.0	350.0	43.0

TRAY



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

*All dimensions are nominal

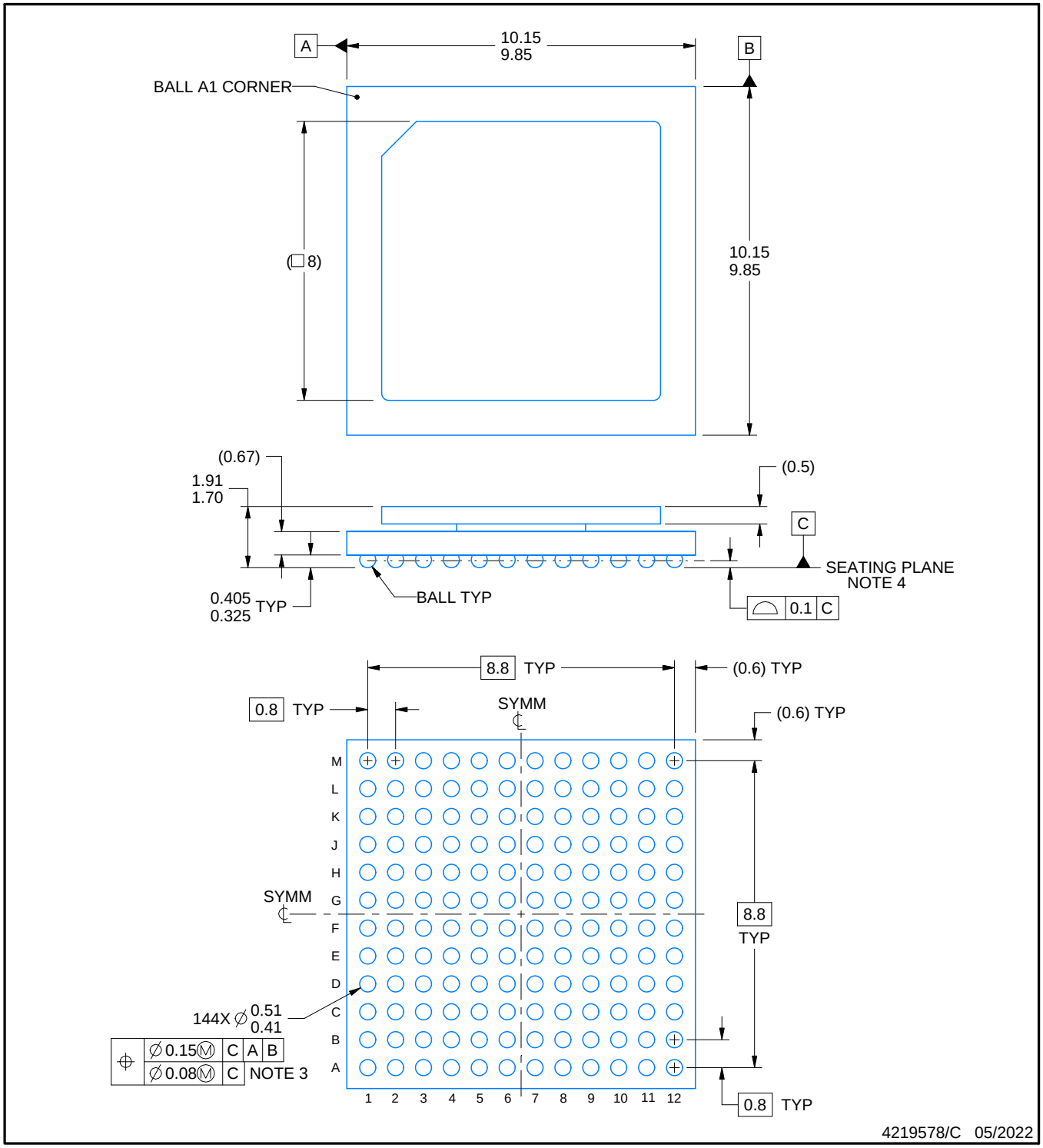
Device	Package Name	Package Type	Pins	SPQ	Unit array matrix	Max temperature (°C)	L (mm)	W (mm)	K0 (µm)	P1 (mm)	CL (mm)	CW (mm)
DAC37J84IAAV	AAV	FCBGA	144	168	8 X 21	150	315	135.9	7620	14.65	11	11.95
DAC38J84IAAV	AAV	FCBGA	144	168	8 X 21	150	315	135.9	7620	14.65	11	11.95

AAV0144A

PACKAGE OUTLINE

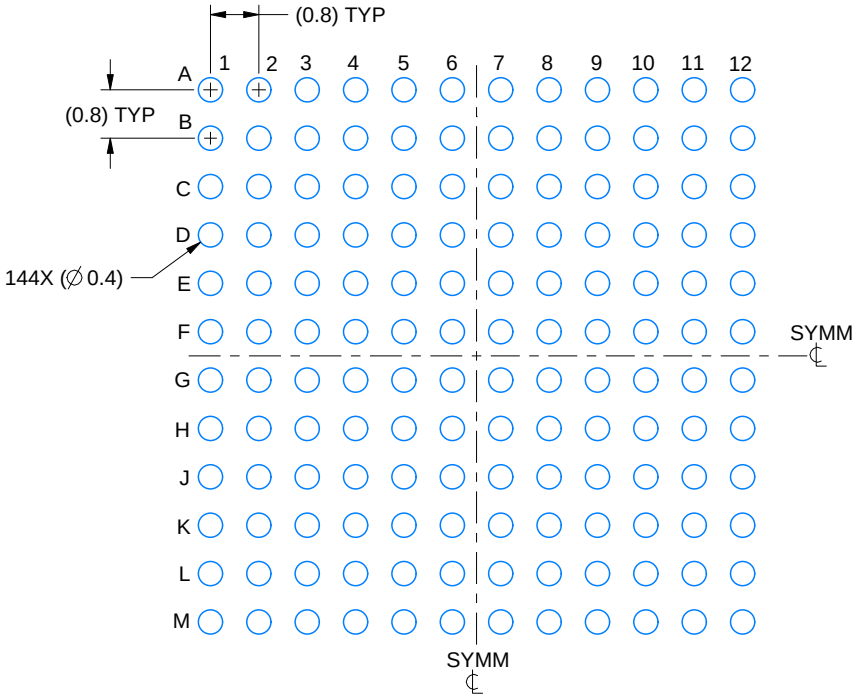
FCBGA - 1.91 mm max height

BALL GRID ARRAY

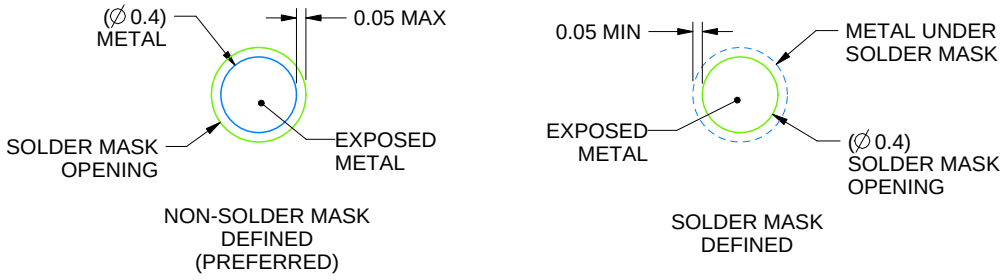


NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Dimension is measured at the maximum solder ball diameter, parallel to primary datum C.
4. Primary datum C and seating plane are defined by the spherical crowns of the solder balls.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:8X



SOLDER MASK DETAILS
NOT TO SCALE

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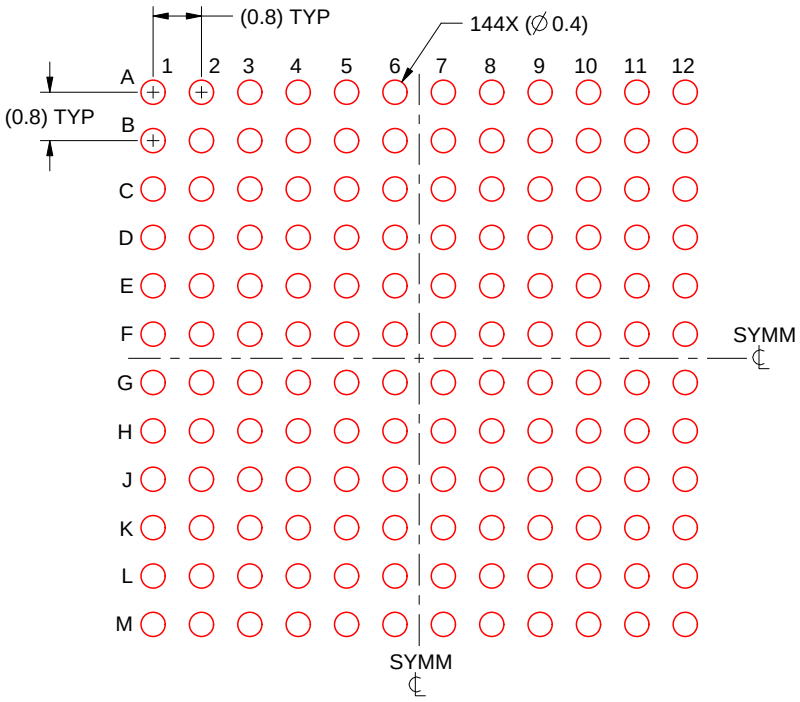
NOTES: (continued)

5. Final dimensions may vary due to manufacturing tolerance considerations and also routing constraints.
For more information, see Texas Instruments literature number SPRU811 (www.ti.com/lit/spru811).



SOLDER PASTE EXAMPLE
BASED ON 0.15 mm THICK STENCIL
SCALE:8X

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NOTES: (continued)

6. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release.

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