

# PCM1840 Quad Channel, 32-Bit, 192-kHz, Burr-Brown™ Audio ADC



## 1 Features

- Multichannel high-performance ADC:
  - 4-channel analog microphones or line-in
- ADC line and microphone differential input performance:
  - Dynamic range:
    - 123-dB, dynamic range enhancer enabled
    - 113-dB, dynamic range enhancer disabled
  - THD+N: –98 dB
- ADC differential  $2\text{-}V_{\text{RMS}}$  full-scale input
- ADC sample rate ( $f_s$ ) = 8 kHz to 192 kHz
- Hardware pin control configurations
- Linear-phase or low-latency filter selection
- Flexible audio serial data interface:
  - Master or slave interface selection
  - 32-bits, 4-channel TDM
  - 32-bits, 2-channel TDM
  - 32-bits, 2-channel I<sup>2</sup>S
  - 32-bits, 2-channel left-justified (LJ)
- Automatic power-down upon loss of audio clocks
- Integrated high-performance audio PLL
- Low-noise MICBIAS 2.75-V output
- Single-supply operation: 3.3 V
- I/O-supply operation: 3.3 V or 1.8 V
- Power consumption for 3.3-V AVDD supply:
  - 17.0 mW/channel at 16-kHz sample rate
  - 18.4 mW/channel at 48-kHz sample rate

## 2 Applications

- Smart speakers
- DVD recorders and players
- AV receivers
- Video conference systems
- IP network cameras

## 3 Description

The PCM1840 is a high-performance, Burr-Brown™ audio analog-to-digital converter (ADC) that supports simultaneous sampling of up to four analog channels. The device supports differential line and microphone inputs with  $2\text{-}V_{\text{RMS}}$  full-scale signal. The device integrates microphone bias voltage, a phase-locked loop (PLL), a DC removal high-pass filter (HPF), and supports sample rates up to 192 kHz. The device supports time-division multiplexing (TDM), I<sup>2</sup>S, or left-justified (LJ) audio formats, selectable with the hardware pin level. Additionally, the PCM1840 supports master and slave mode selection for the audio bus interface operation. These integrated high-performance features, along with the ability to be powered from a single supply of 3.3 V, make the device an excellent choice for cost-sensitive, space-constrained audio systems in far-field microphone recording applications.

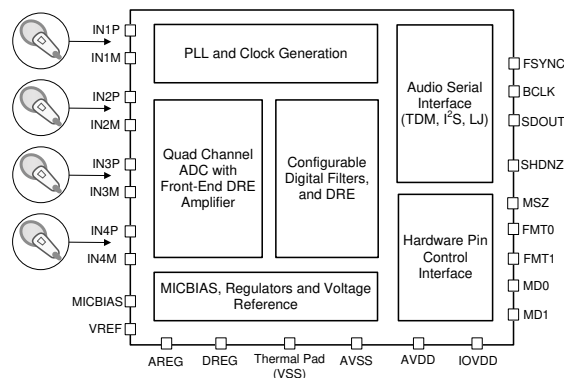
The PCM1840 is specified from  $-40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ , and is offered in a 24-pin WQFN package.

### Device Information<sup>(1)</sup>

PART NUMBER	PACKAGE	BODY SIZE (NOM)
PCM1840	WQFN (24)	4.00 mm × 4.00 mm with 0.5-mm pitch

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

### Simplified Block Diagram



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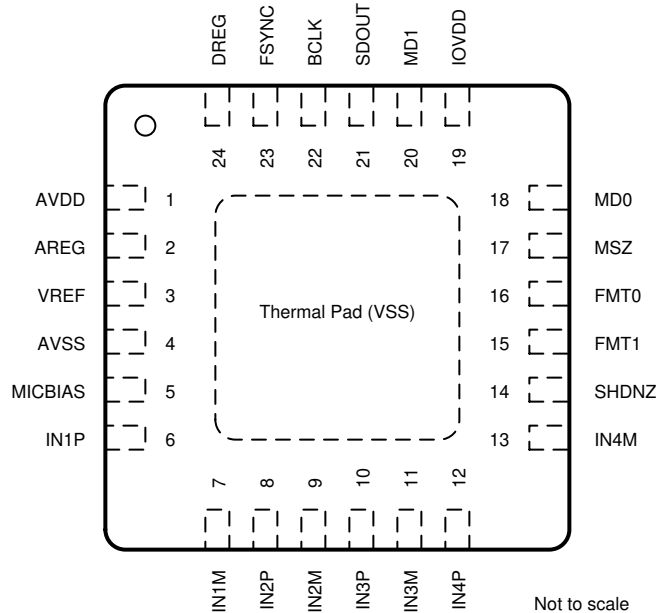
## 4 Revision History

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

DATE	REVISION	NOTES
April 2020	*	Initial release.

## 5 Pin Configuration and Functions

**RTW Package**  
**24-Pin WQFN With Exposed Thermal Pad**  
**Top View**



### Pin Functions

PIN		TYPE	DESCRIPTION
NO.	NAME		
1	AVDD	Analog supply	Analog power (3.3 V, nominal)
2	AREG	Analog Supply	Analog on-chip regulator output voltage for analog supply (1.8 V, nominal)
3	VREF	Analog	Analog reference voltage filter output
4	AVSS	Analog supply	Analog ground. Short this pin directly to the board ground plane.
5	MICBIAS	Analog	MICBIAS output
6	IN1P	Analog input	Analog input 1P pin
7	IN1M	Analog input	Analog input 1M pin
8	IN2P	Analog input	Analog input 2P pin
9	IN2M	Analog input	Analog input 2M pin
10	IN3P	Analog input	Analog input 3P pin
11	IN3M	Analog input	Analog input 3M pin
12	IN4P	Analog input	Analog input 4P pin
13	IN4M	Analog input	Analog input 4M pin
14	SHDNZ	Digital input	Device hardware shutdown and reset (active low)
15	FMT1	Digital input	Audio interface format select 1 pin
16	FMT0	Digital input	Audio interface format select 0 pin
17	MSZ	Digital input	Audio interface bus master or slave select pin
18	MD0	Digital input	Device configuration mode select 0 pin
19	IOVDD	Digital supply	Digital I/O power supply (1.8 V or 3.3 V, nominal)
20	MD1	Digital input	Device configuration mode select 1 pin
21	SDOUT	Digital output	Audio serial data interface bus output
22	BCLK	Digital I/O	Audio serial data interface bus bit clock
23	FSYNC	Digital I/O	Audio serial data interface bus frame synchronization signal

**Pin Functions (continued)**

PIN		TYPE	DESCRIPTION
NO.	NAME		
24	DREG	Digital supply	Digital regulator output voltage for digital core supply (1.5 V, nominal)
Thermal Pad (VSS)		Ground supply	Thermal pad shorted to internal device ground. Short thermal pad directly to board ground plane.

**6 Specifications**

**6.1 Absolute Maximum Ratings**

over the operating ambient temperature range (unless otherwise noted)<sup>(1)</sup>

		MIN	MAX	UNIT
Supply voltage	AVDD to AVSS	-0.3	3.9	V
	AREG to AVSS	-0.3	2.0	
	IOVDD to VSS (thermal pad)	-0.3	3.9	
Ground voltage differences	AVSS to VSS (thermal pad)	-0.3	0.3	V
Analog input voltage	Analog input pins voltage to AVSS	-0.3	AVDD + 0.3	V
Digital input voltage	Digital input pins voltage to VSS (thermal pad)	-0.3	IOVDD + 0.3	V
Temperature	Operating ambient, T <sub>A</sub>	-40	125	°C
	Junction, T <sub>J</sub>	-40	150	
	Storage, T <sub>stg</sub>	-65	150	

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

**6.2 ESD Ratings**

			VALUE	UNIT
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>	±500	

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

**6.3 Recommended Operating Conditions**

		MIN	NOM	MAX	UNIT
<b>POWER</b>					
AVDD, AREG <sup>(1)</sup>	Analog supply voltage AVDD to AVSS (AREG is generated using onchip regulator) - AVDD 3.3-V operation	3.0	3.3	3.6	V
IOVDD	IO supply voltage to VSS (thermal pad) - IOVDD 3.3-V operation	3.0	3.3	3.6	V
	IO supply voltage to VSS (thermal pad) - IOVDD 1.8-V operation	1.65	1.8	1.95	
<b>INPUTS</b>					
	Analog input pins voltage to AVSS	0		AVDD	V
	Digital input pins voltage to VSS (thermal pad)	0		IOVDD	V
<b>TEMPERATURE</b>					
T <sub>A</sub>	Operating ambient temperature	-40		125	°C
<b>OTHERS</b>					
	Digital input pin used as MCLK input clock frequency			36.864	MHz
C <sub>L</sub>	Digital output load capacitance		20	50	pF

(1) AVSS and VSS (thermal pad): all ground pins must be tied together and must not differ in voltage by more than 0.2 V.

## 6.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>		PCM1840	UNIT
		RTW (WQFN)	
		24 PINS	
R <sub>θJA</sub>	Junction-to-ambient thermal resistance	32.6	°C/W
R <sub>θJC(top)</sub>	Junction-to-case (top) thermal resistance	25.0	°C/W
R <sub>θJB</sub>	Junction-to-board thermal resistance	11.9	°C/W
ψ <sub>JT</sub>	Junction-to-top characterization parameter	0.2	°C/W
ψ <sub>JB</sub>	Junction-to-board characterization parameter	11.9	°C/W
R <sub>θJC(bot)</sub>	Junction-to-case (bottom) thermal resistance	2.9	°C/W

- (1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 6.5 Electrical Characteristics

at T<sub>A</sub> = 25°C, AVDD = 3.3 V, IOVDD = 3.3 V, f<sub>IN</sub> = 1-kHz sinusoidal signal, f<sub>S</sub> = 48 kHz, 32-bit audio data, BCLK = 256 × f<sub>S</sub>, TDM slave mode (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT		
<b>ADC CONFIGURATION</b>							
	AC input impedance	Input pins INxP or INxM		2.5	kΩ		
<b>ADC PERFORMANCE FOR LINE/MICROPHONE INPUT RECORDING : AVDD 3.3-V OPERATION</b>							
	Differential input full-scale AC signal voltage	AC-coupled input		2	V <sub>RMS</sub>		
SNR	Signal-to-noise ratio, A-weighted <sup>(1)(2)</sup>	IN1 differential input selected and AC signal shorted to ground, DRE enabled (DRE_LVL = -36 dB, DRE_MAXGAIN = 24 dB)		115	122	dB	
		IN1 differential input selected and AC signal shorted to ground, DRE disabled		106	112		
DR	Dynamic range, A-weighted <sup>(2)</sup>	IN1 differential input selected and -60-dB full-scale AC signal input, DRE enabled (DRE_LVL = -36 dB, DRE_MAXGAIN = 24 dB)		123		dB	
		IN1 differential input selected and -60-dB full-scale AC signal input, DRE disabled		113			
THD+N	Total harmonic distortion <sup>(2)(3)</sup>	IN1 differential input selected and -1-dB full-scale AC signal input, DRE enabled (DRE_LVL = -36 dB, DRE_MAXGAIN = 24 dB)		-98	-80	dB	
		IN1 differential input selected and -1-dB full-scale AC signal input, DRE disabled		-98			
<b>ADC OTHER PARAMETERS</b>							
	Output data sample rate			7.35	192	kHz	
	Output data sample word length					32	Bits
	Interchannel isolation	-1-dB full-scale AC-signal input to non measurement channel				-124	dB
	Interchannel gain mismatch	-6-dB full-scale AC-signal input				0.1	dB
	Gain drift	across temperature range 15°C to 35°C				-4.4	ppm/°C
	Interchannel phase mismatch	1-kHz sinusoidal signal				0.02	Degrees
	Phase drift	1-kHz sinusoidal signal, across temperature range 15°C to 35°C				0.0005	Degrees/°C
PSRR	Power-supply rejection ratio	100-mV <sub>pp</sub> , 1-kHz sinusoidal signal on AVDD, differential input selected, 0-dB channel gain				102	dB
CMRR	Common-mode rejection ratio	Differential microphone input selected, 100-mV <sub>pp</sub> , 1-kHz signal on both pins and measure level at output				60	dB

- (1) Ratio of output level with 1-kHz full-scale sine-wave input, to the output level with the AC signal input shorted to ground, measured A-weighted over a 20-Hz to 20-kHz bandwidth using an audio analyzer.
- (2) All performance measurements done with 20-kHz low-pass filter and, where noted, A-weighted filter. Failure to use such a filter may result in higher THD and lower SNR and dynamic range readings than shown in the Electrical Characteristics. The low-pass filter removes out-of-band noise, which, although not audible, may affect dynamic specification values.
- (3) For best distortion performance, use input AC-coupling capacitors with low-voltage-coefficient.

## Electrical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $AVDD = 3.3\text{ V}$ ,  $IOVDD = 3.3\text{ V}$ ,  $f_{IN} = 1\text{-kHz}$  sinusoidal signal,  $f_S = 48\text{ kHz}$ , 32-bit audio data,  $BCLK = 256 \times f_S$ , TDM slave mode (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
<b>MICROPHONE BIAS</b>						
	MICBIAS noise	BW = 20 Hz to 20 kHz, A-weighted, 1- $\mu\text{F}$ capacitor between MICBIAS and AVSS		1.6		$\mu\text{V}_{\text{RMS}}$
	MICBIAS voltage			VREF		V
	MICBIAS current drive				20	mA
	MICBIAS load regulation	Measured up to max load	0.1	0.6	1.8	%
	MICBIAS over current protection threshold		30			mA
<b>DIGITAL I/O</b>						
$V_{IL}$	Low-level digital input logic voltage threshold	All digital pins, IOVDD 1.8-V operation	-0.3		$0.30 \times \text{IOVDD}$	V
		All digital pins, IOVDD 3.3-V operation	-0.3		0.8	
$V_{IH}$	High-level digital input logic voltage threshold	All digital pins, IOVDD 1.8-V operation	$0.7 \times \text{IOVDD}$		$\text{IOVDD} + 0.3$	V
		All digital pins, IOVDD 3.3-V operation	2.1		$\text{IOVDD} + 0.3$	
$V_{OL}$	Low-level digital output voltage	All digital pins, $I_{OL} = -2\text{ mA}$ , IOVDD 1.8-V operation			0.45	V
		All digital pins, $I_{OL} = -2\text{ mA}$ , IOVDD 3.3-V operation			0.4	
$V_{OH}$	High-level digital output voltage	All digital pins, $I_{OH} = 2\text{ mA}$ , IOVDD 1.8-V operation	$\text{IOVDD} - 0.45$			V
		All digital pins, $I_{OH} = 2\text{ mA}$ , IOVDD 3.3-V operation	2.4			
$I_{IH}$	Input logic-high leakage for digital inputs	All digital pins, input = IOVDD	-5	0.1	5	$\mu\text{A}$
$I_{IL}$	Input logic-low leakage for digital inputs	All digital pins, input = 0 V	-5	0.1	5	$\mu\text{A}$
$C_{IN}$	Input capacitance for digital inputs	All digital pins		5		pF
$R_{PD}$	Pulldown resistance for digital I/O pins when asserted on			20		k $\Omega$
<b>TYPICAL SUPPLY CURRENT CONSUMPTION</b>						
$I_{AVDD}$	Current consumption in hardware shutdown mode	SHDNZ = 0, AVDD = 3.3 V, internal AREG		0.5		$\mu\text{A}$
$I_{IOVDD}$		SHDNZ = 0, all external clocks stopped, IOVDD = 3.3 V		0.1		
$I_{IOVDD}$		SHDNZ = 0, all external clocks stopped, IOVDD = 1.8 V		0.1		
$I_{AVDD}$	Current consumption with ADC 4-channel operating at $f_S = 16\text{-kHz}$ , $BCLK = 256 \times f_S$ and DRE disable	AVDD = 3.3 V, internal AREG		20.6		mA
$I_{IOVDD}$		IOVDD = 3.3 V		0.05		
$I_{IOVDD}$		IOVDD = 1.8 V		0.02		
$I_{AVDD}$	Current consumption with ADC 4-channel operating at $f_S = 48\text{-kHz}$ , $BCLK = 256 \times f_S$ and DRE disable	AVDD = 3.3 V, internal AREG		22.3		mA
$I_{IOVDD}$		IOVDD = 3.3 V		0.1		
$I_{IOVDD}$		IOVDD = 1.8 V		0.05		
$I_{AVDD}$	Current consumption with ADC 4-channel operating at $f_S = 48\text{-kHz}$ , $BCLK = 256 \times f_S$ and DRE enable	AVDD = 3.3 V, internal AREG		24.4		mA
$I_{IOVDD}$		IOVDD = 3.3 V		0.1		
$I_{IOVDD}$		IOVDD = 1.8 V		0.05		

## 6.6 Timing Requirements: TDM, I<sup>2</sup>S or LJ Interface

at T<sub>A</sub> = 25°C, IOVDD = 3.3 V or 1.8 V and 20-pF load on all outputs (unless otherwise noted); see Figure 3 for timing diagram

		MIN	NOM	MAX	UNIT
t <sub>(BCLK)</sub>	BCLK period	40			ns
t <sub>H(BCLK)</sub>	BCLK high pulse duration <sup>(1)</sup>	18			ns
t <sub>L(BCLK)</sub>	BCLK low pulse duration <sup>(1)</sup>	18			ns
t <sub>SU(FSYNC)</sub>	FSYNC setup time	8			ns
t <sub>HLD(FSYNC)</sub>	FSYNC hold time	8			ns
t <sub>r(BCLK)</sub>	BCLK rise time	10% - 90% rise time		10	ns
t <sub>f(BCLK)</sub>	BCLK fall time	90% - 10% fall time		10	ns

(1) The BCLK minimum high or low pulse duration must be higher than 25 ns (to meet the timing specifications), if the SDOUT data line is latched on the opposite BCLK edge polarity than the edge used by the device to transmit SDOUT data.

## 6.7 Switching Characteristics: TDM, I<sup>2</sup>S or LJ Interface

at T<sub>A</sub> = 25°C, IOVDD = 3.3 V or 1.8 V and 20-pF load on all outputs (unless otherwise noted); see Figure 3 for timing diagram

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t <sub>d(SDOUT-BCLK)</sub>	BCLK to SDOUT delay	50% of BCLK to 50% of SDOUT		18	ns
t <sub>d(SDOUT-FSYNC)</sub>	FSYNC to SDOUT delay in TDM or LJ mode (for MSB data with TX_OFFSET = 0)	50% of FSYNC to 50% of SDOUT		18	ns
f <sub>(BCLK)</sub>	BCLK output clock frequency: master mode <sup>(1)</sup>			24.576	MHz
t <sub>H(BCLK)</sub>	BCLK high pulse duration: master mode	14			ns
t <sub>L(BCLK)</sub>	BCLK low pulse duration: master mode	14			ns
t <sub>d(FSYNC)</sub>	BCLK to FSYNC delay: master mode	50% of BCLK to 50% of FSYNC		18	ns
t <sub>r(BCLK)</sub>	BCLK rise time: master mode	10% - 90% rise time		8	ns
t <sub>f(BCLK)</sub>	BCLK fall time: master mode	90% - 10% fall time		8	ns

(1) The BCLK output clock frequency must be lower than 18.5 MHz (to meet the timing specifications), if the SDOUT data line is latched on the opposite BCLK edge polarity than the edge used by the device to transmit SDOUT data.

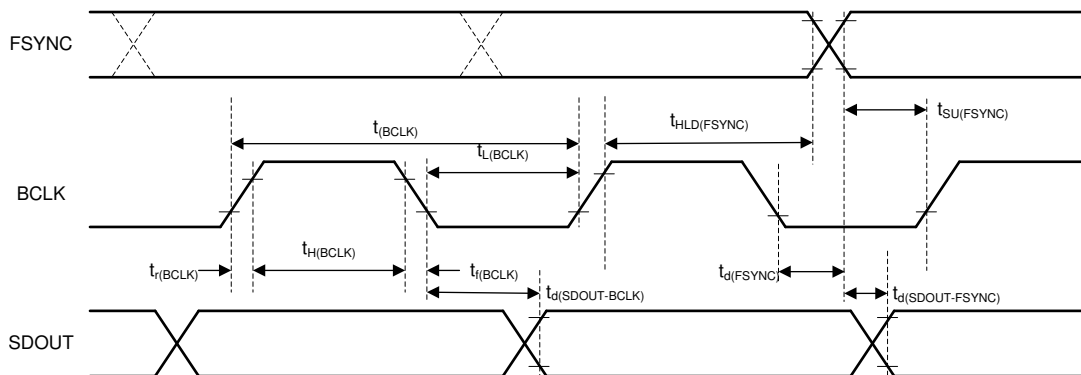


Figure 1. TDM, I<sup>2</sup>S, and LJ Interface Timing Diagram

## 6.8 Typical Characteristics

at  $T_A = 25^\circ\text{C}$ ,  $AV_{DD} = 3.3\text{ V}$ ,  $IO_{VDD} = 3.3\text{ V}$ ,  $f_{IN} = 1\text{-kHz}$  sinusoidal signal,  $f_S = 48\text{ kHz}$ , 32-bit audio data,  $BCLK = 256 \times f_S$ , TDM slave mode, PLL on,  $DRE\_LVL = -36\text{ dB}$ , channel gain = 0 dB, and linear phase decimation filter (unless otherwise noted); all performance measurements are done with a 20-kHz, low-pass filter, and an A-weighted filter

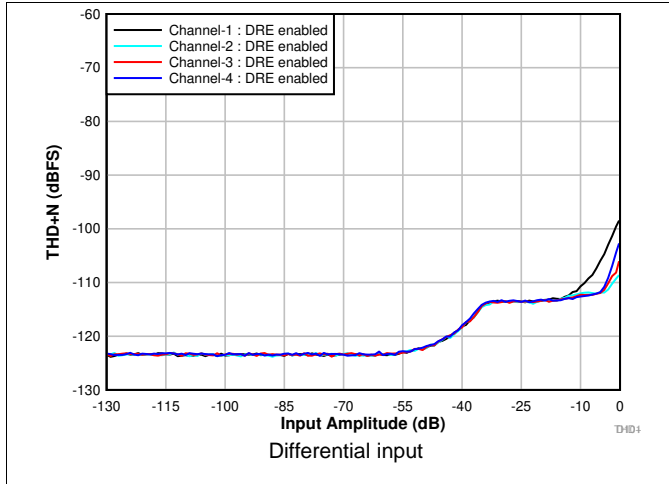


Figure 2. THD+N vs Input Amplitude With DRE Enabled

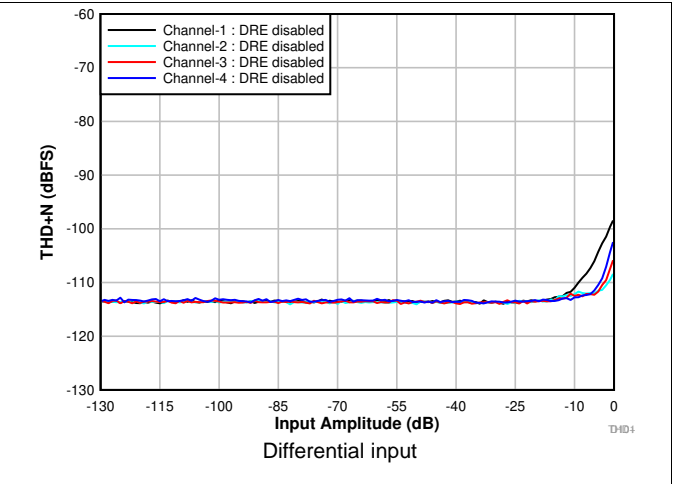


Figure 3. THD+N vs Input Amplitude With DRE Disabled

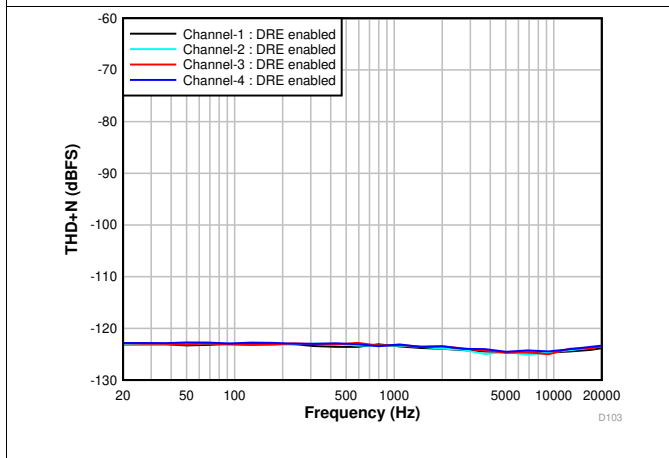


Figure 4. THD+N vs Input Frequency With a -60-dBr Input

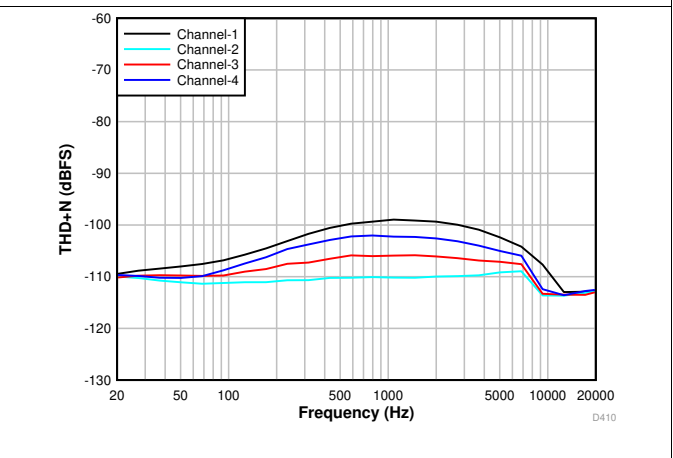


Figure 5. THD+N vs Input Frequency With a -1-dBr Input

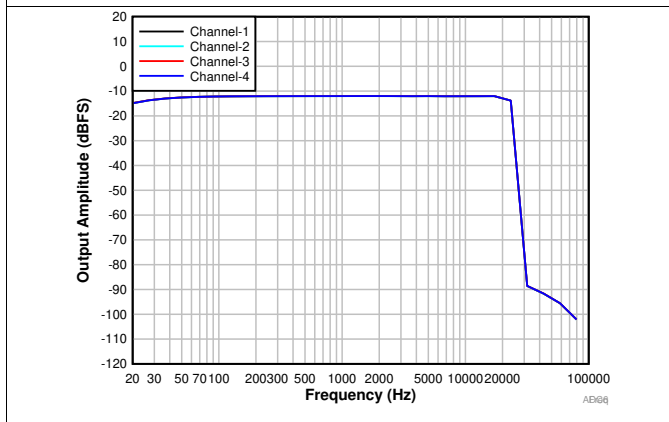


Figure 6. Frequency Response With a -12-dBr Input

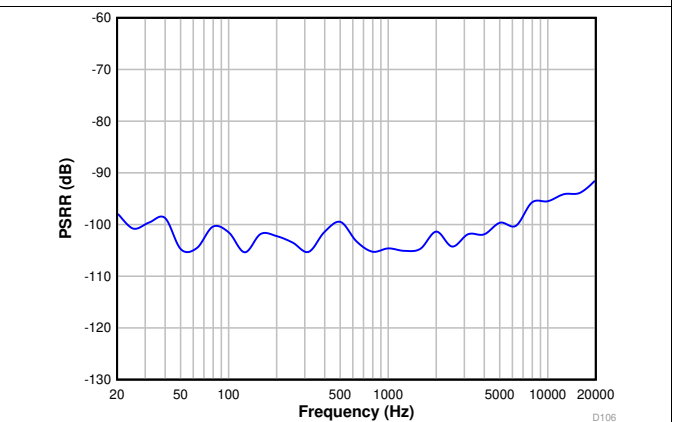


Figure 7. Power-Supply Rejection Ratio vs Ripple Frequency With 100-mV<sub>pp</sub> Amplitude



### Typical Characteristics (continued)

at  $T_A = 25^\circ\text{C}$ ,  $AVDD = 3.3\text{ V}$ ,  $IOVDD = 3.3\text{ V}$ ,  $f_{IN} = 1\text{-kHz}$  sinusoidal signal,  $f_S = 48\text{ kHz}$ , 32-bit audio data,  $BCLK = 256 \times f_S$ , TDM slave mode, PLL on, DRE\_LVL =  $-36\text{ dB}$ , channel gain =  $0\text{ dB}$ , and linear phase decimation filter (unless otherwise noted); all performance measurements are done with a 20-kHz, low-pass filter, and an A-weighted filter

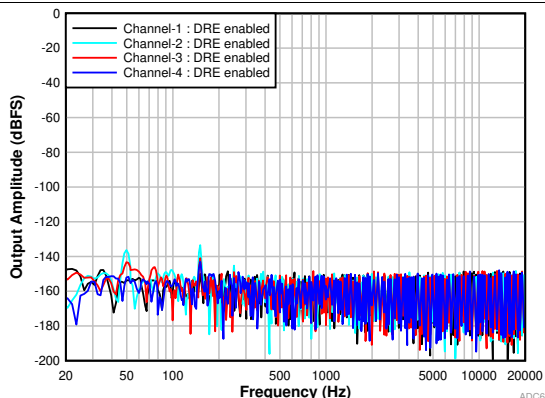


Figure 8. FFT With Idle Input With DRE Enabled

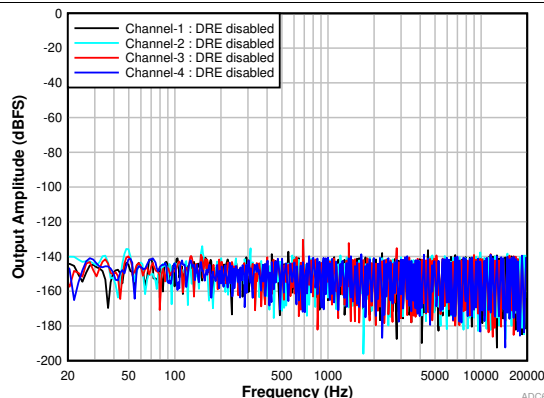


Figure 9. FFT With Idle Input With DRE Disabled

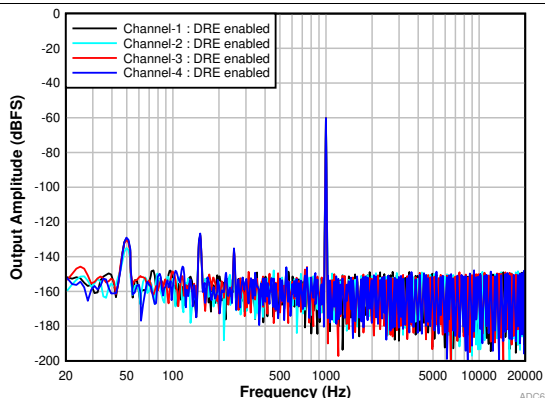


Figure 10. FFT With a  $-60\text{-dBr}$  Input With DRE Enabled

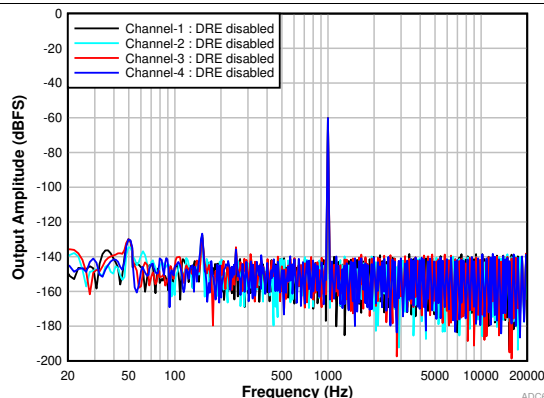


Figure 11. FFT With a  $-60\text{-dBr}$  Input With DRE Disabled

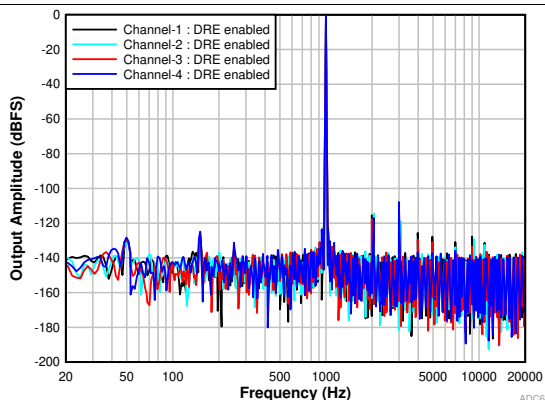


Figure 12. FFT With a  $-1\text{-dBr}$  Input With DRE Enabled

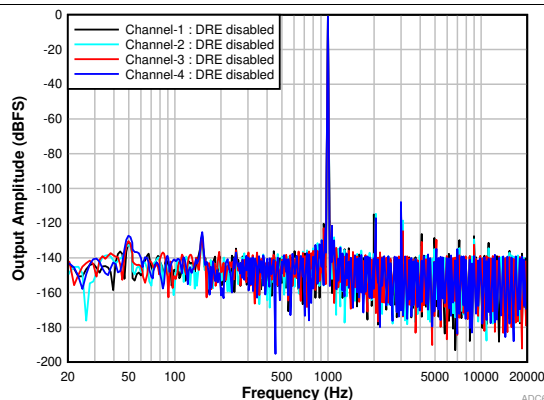


Figure 13. FFT With a  $-1\text{-dBr}$  Input With DRE Disabled

## 7 Detailed Description

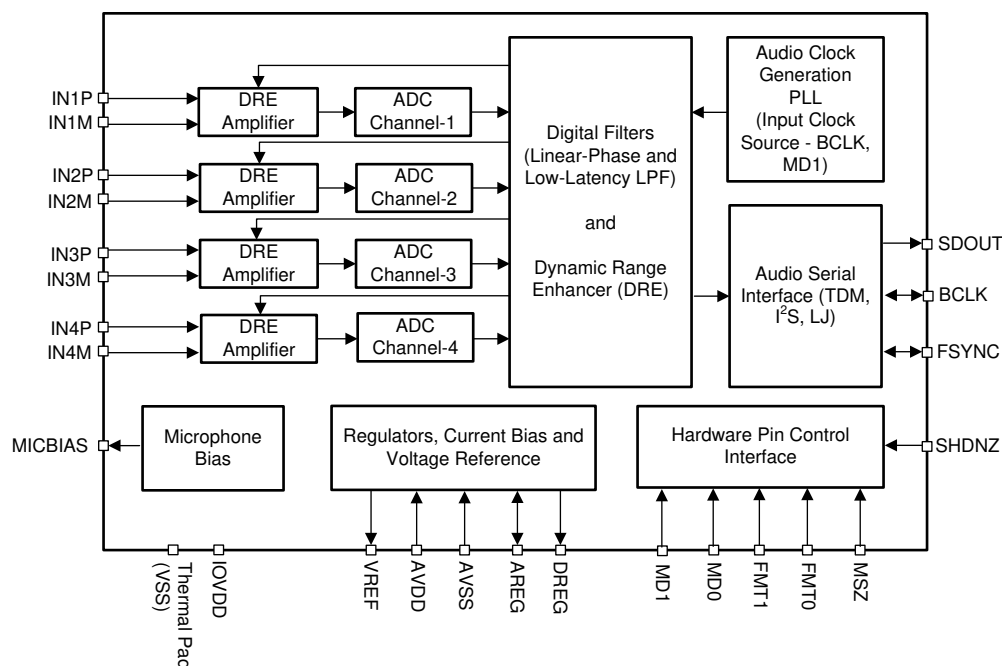
### 7.1 Overview

The PCM1840 is a high-performance, low-power, quad-channel, audio analog-to-digital converter (ADC) with flexible audio interface control options. This device is intended for applications in voice-activated systems, AV receivers, TV and blu-ray players, professional microphones, audio conferencing, portable computing, communication, and entertainment applications. The high dynamic range of the device enables far-field audio recording with high fidelity. This device integrates a host of features that reduces cost, board space, and power consumption in space-constrained, battery-powered, consumer, home, and industrial applications. The device features are controlled through hardware by pulling pins high or low with resistors or a controller GPIO. The PCM1808 also supports a power-down and reset function by means of halting the system clock.

The PCM1840 consists of the following blocks and features:

- Quad-channel, multibit, high-performance delta-sigma ( $\Delta\Sigma$ ) ADC
- Differential audio inputs with a  $2 \cdot V_{RMS}$  full-scale signal
- Low-noise,  $1.6 \cdot \mu V_{RMS}$ , microphone bias output
- Hardware pin control operation to select the device features
- Audio bus serial interface master or slave select option
- Audio bus serial interface format select option
- Audio bus serial interface supported up to 192 kHz sampling
- Slave mode supports dynamic range enhancer (DRE) with 123-dB dynamic range
- Slave mode supports decimation filters with linear-phase or low-latency filter selection
- Master mode operation supported using system clock of  $256 \times f_s$  or  $512 \times f_s$
- Power-down function by means of halting the audio clocks
- Integrated high-pass filter (HPF) that removes the dc component of the input signal
- Integrated low-jitter phase-locked loop (PLL) supporting a wide range of system clocks
- Integrated digital and analog voltage regulators to support single-supply 3.3-V operation

### 7.2 Functional Block Diagram



## 7.3 Feature Description

### 7.3.1 Hardware Control

The device supports simple hardware pin controlled options to select specific mode of operation and audio interface for a given system. The MSZ, MD0, MD1, FMT0, and FMT1 pins allow the device to be controlled by either pullup or pulldown resistors as well as the GPIO from a digital device.

### 7.3.2 Audio Serial Interfaces

Digital audio data flows between the host processor and the PCM1840 on the digital audio serial interface (ASI), or audio bus. This highly flexible ASI bus includes a TDM mode for multichannel operation, support for I<sup>2</sup>S or left-justified protocols format, and the pin-selectable master-slave configurability for bus clock lines.

The device supports audio bus master or slave mode of operation using the hardware pin MSZ. In slave mode, FSYNC and BCLK work as input pins whereas in master mode, FSYNC and BCLK work as output pins generated by the device. [Table 1](#) shows the master and slave mode selection using the MSZ pin.

**Table 1. Master and Slave Mode Selection**

MSZ	MASTER AND SLAVE SELECTION
LOW	Slave mode of operation
HIGH	Master mode of operation

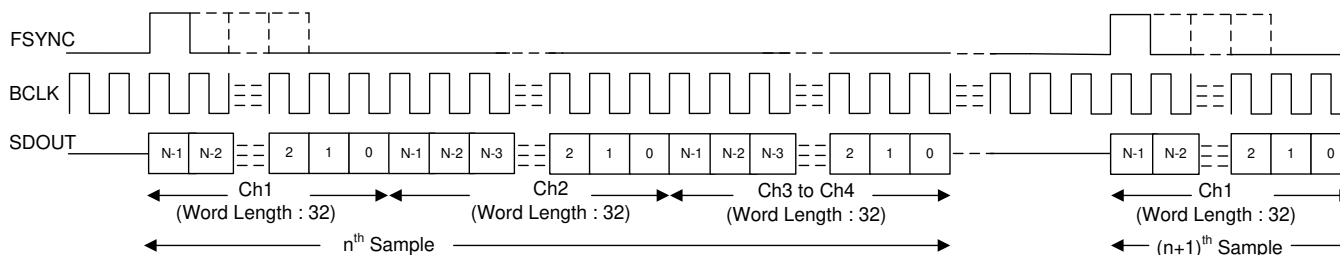
The bus protocol TDM, I<sup>2</sup>S, or left-justified (LJ) format can be selected by using the FMT0 and FMT1 pins. As shown in [Table 2](#), these modes are all most significant byte (MSB)-first, pulse code modulation (PCM) data format, with the output channel data word-length of 32 bits.

**Table 2. Audio Serial Interface Format**

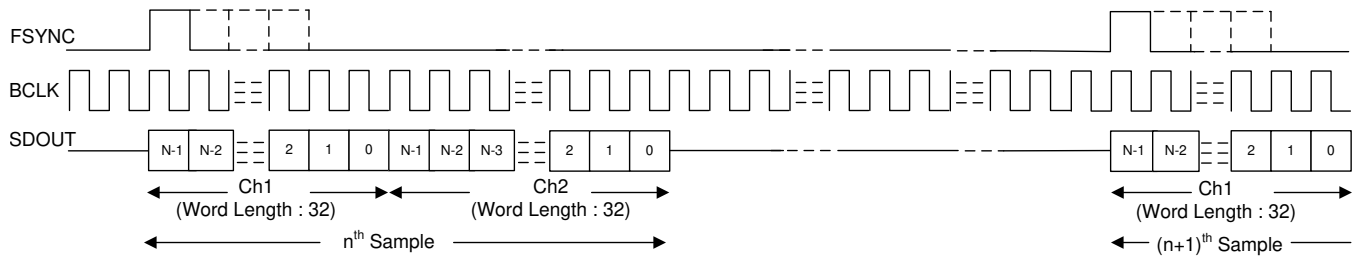
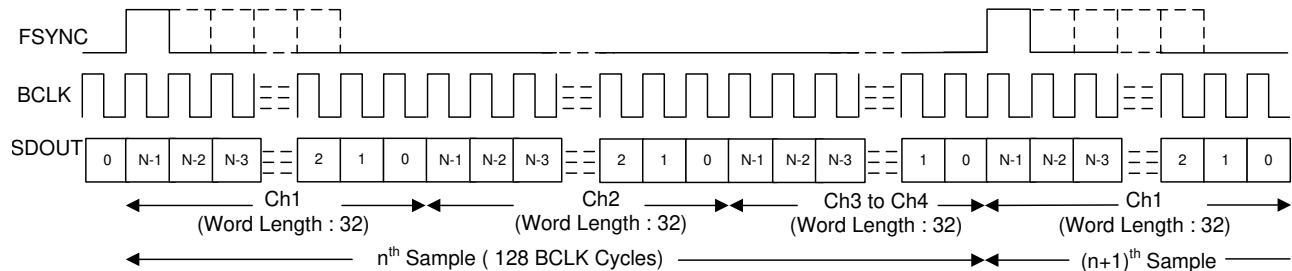
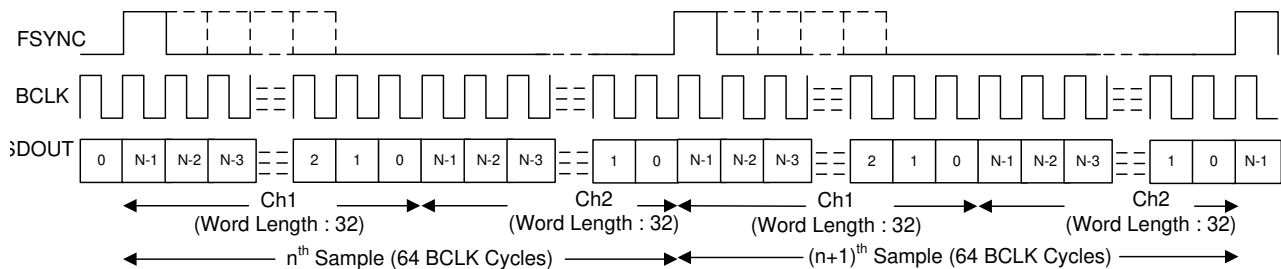
FMT1	FMT0	AUDIO SERIAL INTERFACE FORMAT
LOW	LOW	4-channel output with time division multiplexing (TDM) mode
LOW	HIGH	2-channel output with time division multiplexing (TDM) mode
HIGH	LOW	2-channel output with left-justified (LJ) mode
HIGH	HIGH	2-channel output with inter IC sound (I <sup>2</sup> S) mode

#### 7.3.2.1 Time Division Multiplexed Audio (TDM) Interface

In TDM mode, also known as DSP mode, the rising edge of FSYNC starts the data transfer with the slot 0 data first. Immediately after the slot 0 data transmission, the remaining slot data are transmitted in order. FSYNC and each data bit (except the MSB of slot 0 when TX\_OFFSET equals 0) is transmitted on the rising edge of BCLK. [Figure 14](#) to [Figure 17](#) illustrate the protocol timing for TDM operation with various configurations.



**Figure 14. TDM Mode Protocol Timing (FMT0 = LOW) In Slave Mode**


**Figure 15. TDM Mode Protocol Timing (FMT0 = HIGH) In Slave Mode**

**Figure 16. TDM Mode Protocol Timing (FMT0 = LOW) In Master Mode**

**Figure 17. TDM Mode Protocol Timing (FMT0 = HIGH) In Master Mode**

For proper operation of the audio bus in TDM mode, the number of bit clocks per frame must be greater than or equal to the number of active output channels times the 32-bits word length of the output channel data. The device transmits a zero data value on SDOUT for the extra unused bit clock cycles. The device supports FSYNC as a pulse with a 1-cycle-wide bit clock, but also supports multiples as well.

### 7.3.2.2 Inter IC Sound (I<sup>2</sup>S) Interface

The standard I<sup>2</sup>S protocol is defined for only two channels: left and right. In I<sup>2</sup>S mode, the MSB of the left slot 0 is transmitted on the falling edge of BCLK in the second cycle after the *falling* edge of FSYNC. The MSB of the right slot 0 is transmitted on the falling edge of BCLK in the second cycle after the *rising* edge of FSYNC. Each subsequent data bit is transmitted on the falling edge of BCLK. In master mode, FSYNC is transmitted on the rising edge of BCLK. [Figure 18](#) and [Figure 19](#) illustrate the protocol timing for I<sup>2</sup>S operation in slave and master mode of operation.

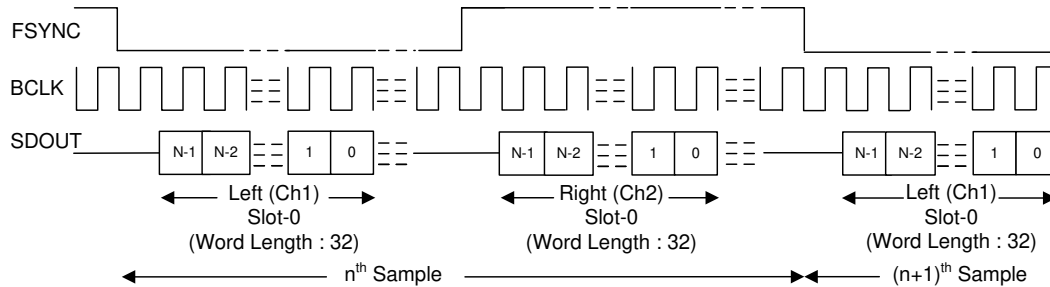


Figure 18. I²S Mode Protocol Timing in Slave Mode

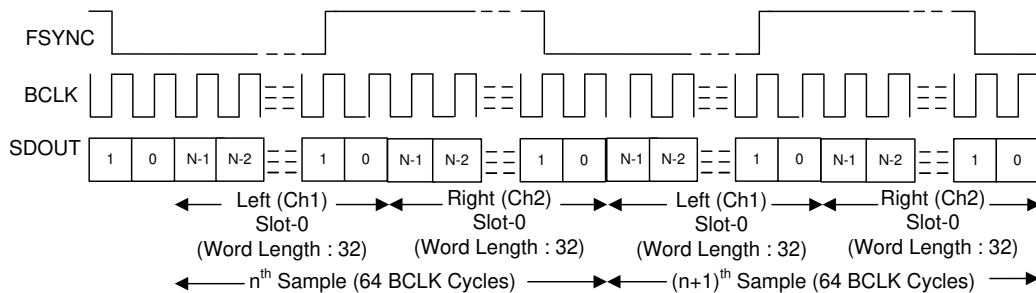


Figure 19. I²S Protocol Timing In Master Mode

For proper operation of the audio bus in I²S mode, the number of bit clocks per frame must be greater than or equal to the number of active output channels (including left and right slots) times the 32-bits word length of the output channel data. The device FSYNC low pulse must be a number of BCLK cycles wide that is greater than or equal to the number of active left slots times the 32-bits data word length. Similarly, the FSYNC high pulse must be a number of BCLK cycles wide that is greater than or equal to the number of active right slots times the 32-bits data word length. The device transmit zero data value on SDOUT for the extra unused bit clock cycles.

### 7.3.2.3 Left-Justified (LJ) Interface

The standard LJ protocol is defined for only two channels: left and right. In LJ mode, the MSB of the left slot 0 is transmitted in the same BCLK cycle after the rising edge of FSYNC. Each subsequent data bit is transmitted on the falling edge of BCLK. The MSB of the right slot 0 is transmitted in the same BCLK cycle after the falling edge of FSYNC. Each subsequent data bit is transmitted on the falling edge of BCLK. In master mode, FSYNC is transmitted on the rising edge of BCLK. Figure 20 and Figure 21 illustrate the protocol timing for LJ operation in slave and master mode of operation.

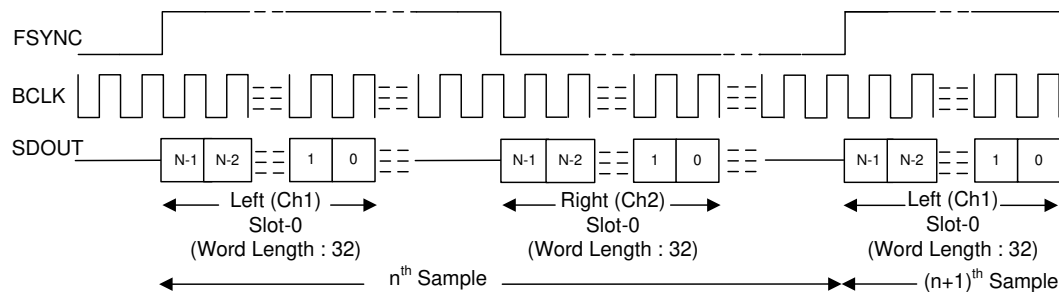
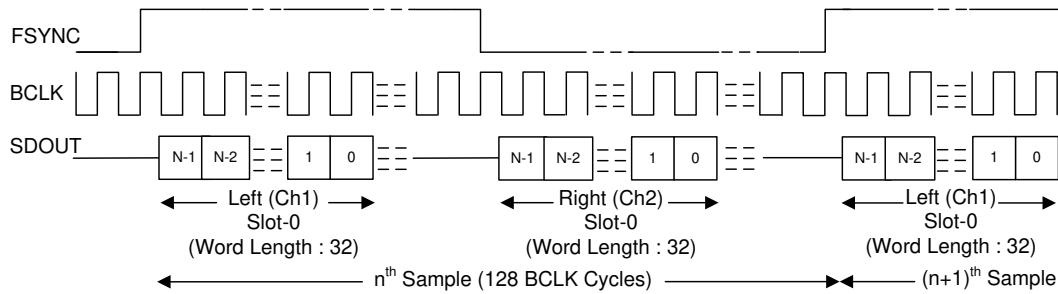


Figure 20. LJ Mode Protocol Timing In Slave Mode



**Figure 21. LJ Mode Protocol Timing In Master Mode**

For proper operation of the audio bus in LJ mode, the number of bit clocks per frame must be greater than or equal to the number of active output channels (including left and right slots) times the 32-bits word length of the output channel data. The device FSYNC high pulse must be a number of BCLK cycles wide that is greater than or equal to the number of active left slots times the 32-bits data word length. Similarly, the FSYNC low pulse must be number of BCLK cycles wide that is greater than or equal to the number of active right slots times the 32-bits data word length. The device transmit zero data value on SDOUT for the extra unused bit clock cycles.

### 7.3.3 Phase-Locked Loop (PLL) and Clock Generation

The device uses an integrated, low-jitter, phase-locked loop (PLL) to generate internal clocks required for the ADC modulator and digital filter engine, as well as other control blocks.

In slave mode of operation, the device supports the various output data sample rates (of the FSYNC signal frequency) and the BCLK to FSYNC ratio to configure all clock dividers, including the PLL configuration, internally without host programming. [Table 3](#) and [Table 4](#) list the supported FSYNC and BCLK frequencies.

**Table 3. Supported FSYNC (Multiples or Submultiples of 48 kHz) and BCLK Frequencies**

BCLK TO FSYNC RATIO	BCLK (MHz)						
	FSYNC (8 kHz)	FSYNC (16 kHz)	FSYNC (24 kHz)	FSYNC (32 kHz)	FSYNC (48 kHz)	FSYNC (96 kHz)	FSYNC (192 kHz)
16	Reserved	0.256	0.384	0.512	0.768	1.536	3.072
24	Reserved	0.384	0.576	0.768	1.152	2.304	4.608
32	0.256	0.512	0.768	1.024	1.536	3.072	6.144
48	0.384	0.768	1.152	1.536	2.304	4.608	9.216
64	0.512	1.024	1.536	2.048	3.072	6.144	12.288
96	0.768	1.536	2.304	3.072	4.608	9.216	18.432
128	1.024	2.048	3.072	4.096	6.144	12.288	24.576
192	1.536	3.072	4.608	6.144	9.216	18.432	Reserved
256	2.048	4.096	6.144	8.192	12.288	24.576	Reserved
384	3.072	6.144	9.216	12.288	18.432	Reserved	Reserved
512	4.096	8.192	12.288	16.384	24.576	Reserved	Reserved

**Table 4. Supported FSYNC (Multiples or Submultiples of 44.1 kHz) and BCLK Frequencies**

BCLK TO FSYNC RATIO	BCLK (MHz)						
	FSYNC (7.35 kHz)	FSYNC (14.7 kHz)	FSYNC (22.05 kHz)	FSYNC (29.4 kHz)	FSYNC (44.1 kHz)	FSYNC (88.2 kHz)	FSYNC (176.4 kHz)
16	Reserved	Reserved	0.3528	0.4704	0.7056	1.4112	2.8224
24	Reserved	0.3528	0.5292	0.7056	1.0584	2.1168	4.2336
32	Reserved	0.4704	0.7056	0.9408	1.4112	2.8224	5.6448
48	0.3528	0.7056	1.0584	1.4112	2.1168	4.2336	8.4672
64	0.4704	0.9408	1.4112	1.8816	2.8224	5.6448	11.2896
96	0.7056	1.4112	2.1168	2.8224	4.2336	8.4672	16.9344
128	0.9408	1.8816	2.8224	3.7632	5.6448	11.2896	22.5792
192	1.4112	2.8224	4.2336	5.6448	8.4672	16.9344	Reserved
256	1.8816	3.7632	5.6448	7.5264	11.2896	22.5792	Reserved
384	2.8224	5.6448	8.4672	11.2896	16.9344	Reserved	Reserved
512	3.7632	7.5264	11.2896	15.0528	22.5792	Reserved	Reserved

In the master mode of operation, the device uses the MD1 pin (as system clock, MCLK) as the reference input clock source with supported system clock frequency option of either  $256 \times f_s$  or  $512 \times f_s$  as configured using the MD0 pin. [Table 5](#) shows the system clock selection for the master mode using the MD0 pin.

**Table 5. System Clock Selection for the Master Mode**

MD0	SYSTEM CLOCK SELECTION (Valid for Master Mode Only)
LOW	System clock with frequency $256 \times f_s$ connected to pin MD1 as MCLK
HIGH	System clock with frequency $512 \times f_s$ connected to pin MD1 as MCLK

See [Table 7](#) and [Table 20](#) for the MD0 and MD1 pin function in the slave mode of operation.

### 7.3.4 Input Channel Configurations

The device consists of four pairs of analog input pins (INxP and INxM) as differential inputs for the recording channel. The device supports simultaneous recording of up to four channels using the high-performance multichannel ADC. The input source for the analog pins can be from electret condenser analog microphones, micro electrical-mechanical system (MEMS) analog microphones, or line-in (auxiliary) inputs from the system board.

The voice or audio signal inputs must be capacitively coupled (AC-coupled) to the device and for best distortion performance, use the low-voltage coefficient capacitors for AC coupling. The device has the typical input impedance on INxP or INxM as 2.5 k $\Omega$  on each pins. The value of the coupling capacitor in AC-coupled mode must be chosen so that the high-pass filter formed by the coupling capacitor and the input impedance do not affect the signal content. Before proper recording can begin, this coupling capacitor must be charged up to the common-mode voltage at power-up. To enable quick charging, the device has quick charge scheme to speed up the charging of the coupling capacitor at power-up. The default value of the quick-charge timing is set for a coupling capacitor up to 1  $\mu$ F.

### 7.3.5 Reference Voltage

All audio data converters require a DC reference voltage. The PCM1840 achieves low-noise performance by internally generating a low-noise reference voltage. This reference voltage is generated using a band-gap circuit with high PSRR performance. This audio converter reference voltage must be filtered externally using a minimum 1- $\mu$ F capacitor connected from the VREF pin to analog ground (AVSS). The value of this reference voltage, VREF, is set to 2.75 V, which in turn supports a 2- $V_{RMS}$  differential full-scale input to the device. The required minimum AVDD voltage for this VREF voltage is 3 V. Do not connect any external load to a VREF pin.

### 7.3.6 Microphone Bias

The device integrates a built-in, low-noise, 1.6- $\mu$ V<sub>RMS</sub> microphone bias pin with an output voltage of 2.75 V that can be used in the system for biasing electret-condenser microphones or providing the supply to the MEMS analog or digital microphone. The integrated bias amplifier supports up to 20 mA of load current that can be used for multiple microphones and is designed to provide a combination of high PSRR, and low noise bias voltages to bias microphone for high-end audio applications. When using this MICBIAS pin for biasing or supplying to multiple microphones, avoid any common impedance on the board layout for the MICBIAS connection to minimize coupling across microphones.



### 7.3.7 Signal-Chain Processing

The PCM1840 signal chain is comprised of very-low-noise, high-performance, and low-power analog blocks and highly flexible and programmable digital processing blocks. The high performance and flexibility combined with a compact package makes the PCM1840 optimized for a variety of end-equipments and applications that require multichannel audio capture. Figure 22 shows a conceptual block diagram that highlights the various building blocks used in the signal chain, and how the blocks interact in the signal chain.

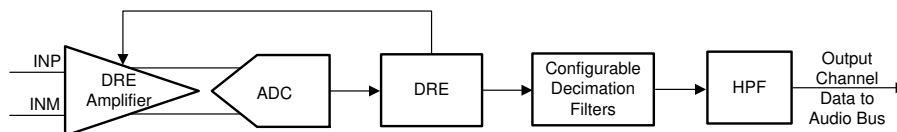


Figure 22. Signal-Chain Processing Flowchart

The front-end dynamic range enhancer (DRE) gain amplifier is very low noise, with a 123-dB dynamic range performance. Along with a low-noise and low-distortion, multibit, delta-sigma ADC, the front-end DRE gain amplifier enables the PCM1840 to record a far-field audio signal with very high fidelity, both in quiet and loud environments. Moreover, the ADC architecture has inherent antialias filtering with a high rejection of out-of-band frequency noise around multiple modulator frequency components. Therefore, the device prevents noise from aliasing into the audio band during ADC sampling. Further on in the signal chain, an integrated, high-performance multistage digital decimation filter sharply cuts off any out-of-band frequency noise with high stop-band attenuation.

The device supports an input signal bandwidth up to 80 kHz, which allows the high-frequency non-audio signal to be recorded by using a 176.4-kHz (or higher) sample rate.

#### 7.3.7.1 Digital High-Pass Filter

To remove the DC offset component and attenuate the undesired low-frequency noise content in the record data, the device supports a fixed high-pass filter (HPF) with  $-3$ -dB cut-off frequency of  $0.00025 \times f_s$ . The HPF is not a channel-independent filter but is globally applicable for all the ADC channels. This HPF is constructed using the first-order infinite impulse response (IIR) filter, and is efficient enough to filter out possible DC components of the signal. Table 6 shows the fixed  $-3$ -dB cutoff frequency value. Figure 23 shows a frequency response plot for the HPF filter.

Table 6. HPF Cutoff Frequency Value

-3-dB CUTOFF FREQUENCY VALUE	-3-dB CUTOFF FREQUENCY AT 16 kHz SAMPLE RATE	-3-dB CUTOFF FREQUENCY AT 48 kHz SAMPLE RATE
$0.00025 \times f_s$	4 Hz	12 Hz

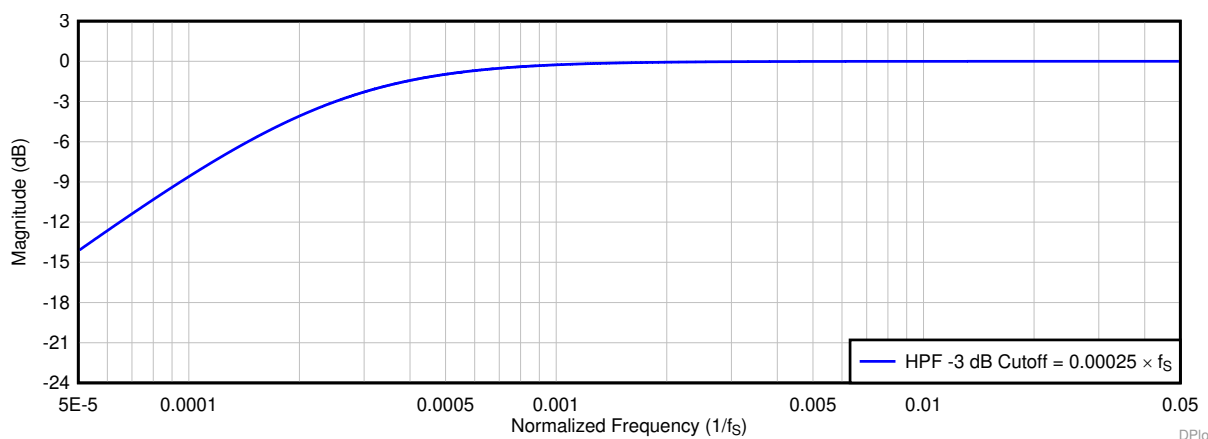


Figure 23. HPF Filter Frequency Response Plot

### 7.3.7.2 Configurable Digital Decimation Filters

The device record channel includes a high dynamic range, built-in digital decimation filter to process the oversampled data from the multibit delta-sigma ( $\Delta\Sigma$ ) modulator to generate digital data at the same Nyquist sampling rate as the FSYNC rate. The decimation filter can be chosen from two different types only in slave mode, depending on the required frequency response, group delay, and phase linearity requirements for the target application. The selection of the decimation filter option can be done by the MD0 pin. Table 7 shows the decimation filter mode selection for the record channel.

**Table 7. Decimation Filter Mode Selection for the Record Channel**

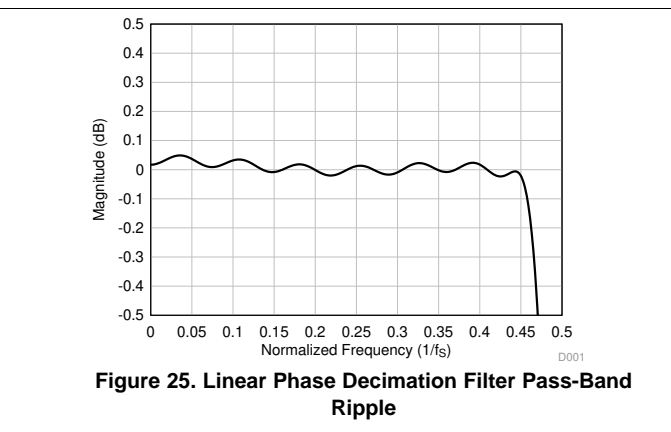
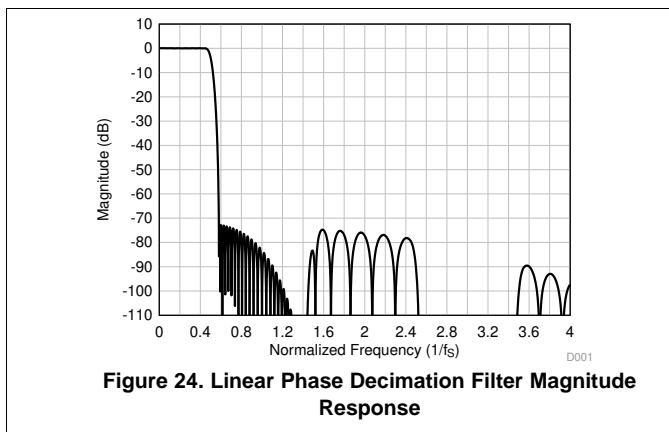
MD0	DECIMATION FILTER MODE SELECTION (Supported Only in Slave Mode)
LOW	Linear phase filters are used for the decimation in slave mode. For master mode, the device always use linear phase filters for the decimation.
HIGH	Low latency filters are used for the decimation in slave mode. For master mode, the device always use linear phase filters for the decimation.

#### 7.3.7.2.1 Linear Phase Filters

The linear phase decimation filters are the default filters set by the device and can be used for all applications that require a perfect linear phase with zero-phase deviation within the pass-band specification of the filter. The filter performance specifications and various plots for all supported output sampling rates are listed in this section.

##### 7.3.7.2.1.1 Sampling Rate: 8 kHz or 7.35 kHz

Figure 24 and Figure 25 respectively show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 8 kHz or 7.35 kHz. Table 8 lists the specifications for a decimation filter with an 8-kHz or 7.35-kHz sampling rate.

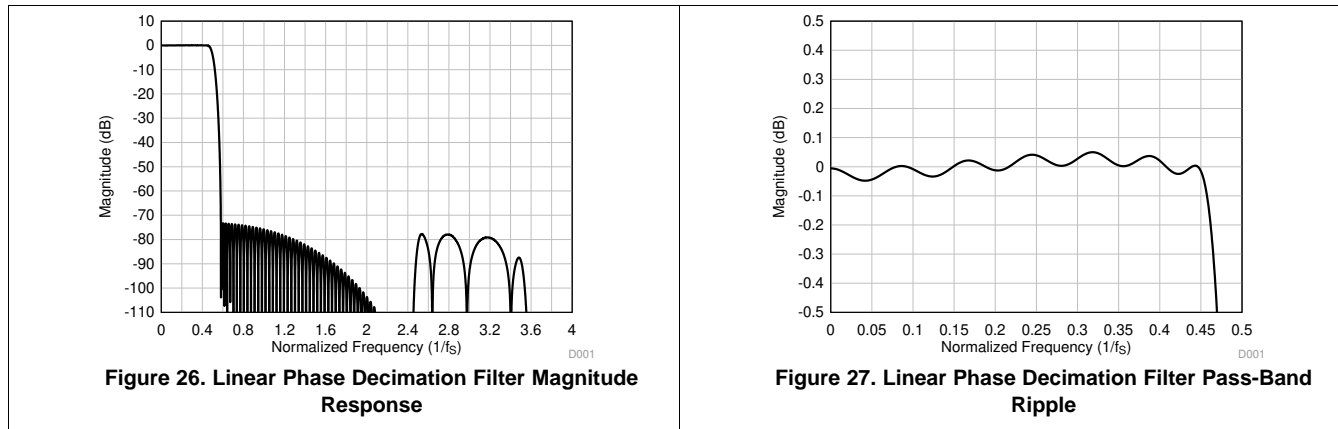


**Table 8. Linear Phase Decimation Filter Specifications**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.454 \times f_s$	-0.05		0.05	dB
Stop-band attenuation	Frequency range is $0.58 \times f_s$ to $4 \times f_s$	72.7			dB
	Frequency range is $4 \times f_s$ onwards	81.2			
Group delay or latency	Frequency range is 0 to $0.454 \times f_s$		17.1		$1/f_s$

**7.3.7.2.1.2 Sampling Rate: 16 kHz or 14.7 kHz**

Figure 26 and Figure 27 respectively show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 16 kHz or 14.7 kHz. Table 9 lists the specifications for a decimation filter with an 16-kHz or 14.7-kHz sampling rate.

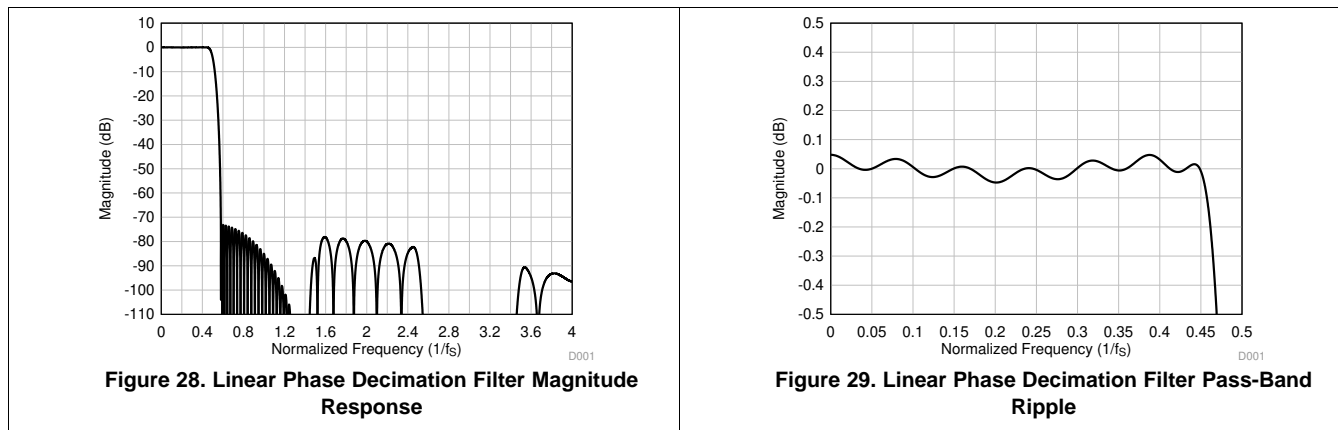


**Table 9. Linear Phase Decimation Filter Specifications**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.454 \times f_s$	-0.05		0.05	dB
Stop-band attenuation	Frequency range is $0.58 \times f_s$ to $4 \times f_s$	73.3			
	Frequency range is $4 \times f_s$ onwards	95.0			
Group delay or latency	Frequency range is 0 to $0.454 \times f_s$		15.7		$1/f_s$

**7.3.7.2.1.3 Sampling Rate: 24 kHz or 22.05 kHz**

Figure 28 and Figure 29 respectively show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 24 kHz or 22.05 kHz. Table 10 lists the specifications for a decimation filter with an 24-kHz or 22.05-kHz sampling rate.

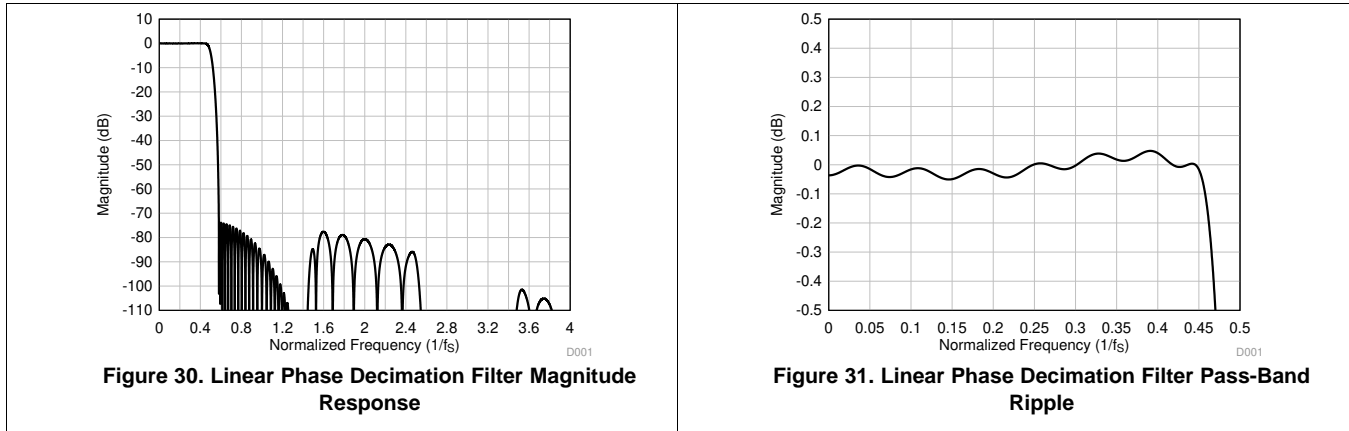


**Table 10. Linear Phase Decimation Filter Specifications**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.454 \times f_s$	-0.05		0.05	dB
Stop-band attenuation	Frequency range is $0.58 \times f_s$ to $4 \times f_s$	73.0			
	Frequency range is $4 \times f_s$ onwards	96.4			
Group delay or latency	Frequency range is 0 to $0.454 \times f_s$		16.6		$1/f_s$

**7.3.7.2.1.4 Sampling Rate: 32 kHz or 29.4 kHz**

Figure 30 and Figure 31 respectively show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 32 kHz or 29.4 kHz. Table 11 lists the specifications for a decimation filter with an 32-kHz or 29.4-kHz sampling rate.

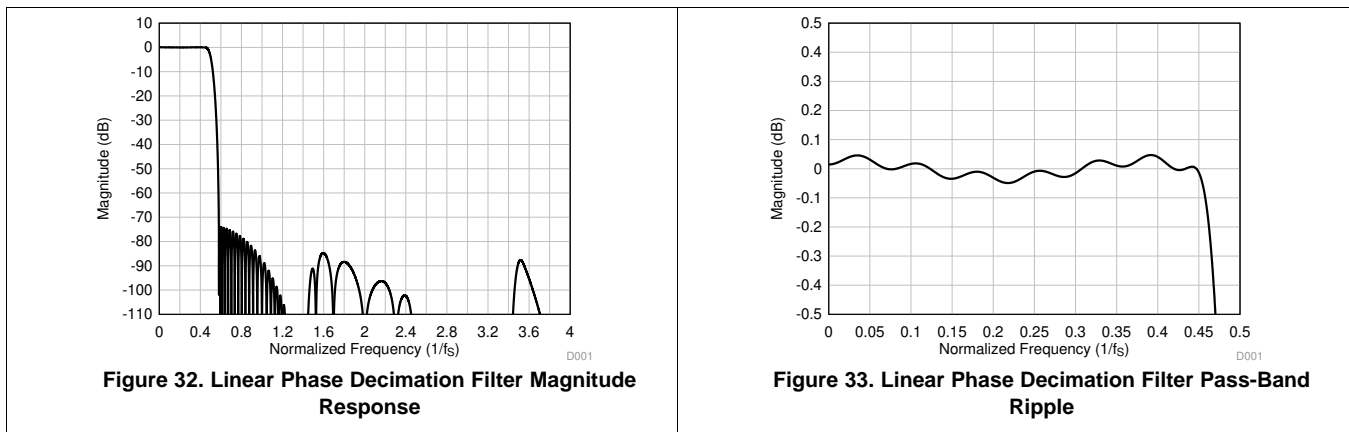


**Table 11. Linear Phase Decimation Filter Specifications**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.454 \times f_s$	-0.05		0.05	dB
Stop-band attenuation	Frequency range is $0.58 \times f_s$ to $4 \times f_s$	73.7			
	Frequency range is $4 \times f_s$ onwards	107.2			
Group delay or latency	Frequency range is 0 to $0.454 \times f_s$		16.9		$1/f_s$

**7.3.7.2.1.5 Sampling Rate: 48 kHz or 44.1 kHz**

Figure 32 and Figure 33 respectively show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 48 kHz or 44.1 kHz. Table 12 lists the specifications for a decimation filter with an 48-kHz or 44.1-kHz sampling rate.



**Table 12. Linear Phase Decimation Filter Specifications**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.454 \times f_s$	-0.05		0.05	dB
Stop-band attenuation	Frequency range is $0.58 \times f_s$ to $4 \times f_s$	73.8			
	Frequency range is $4 \times f_s$ onwards	98.1			
Group delay or latency	Frequency range is 0 to $0.454 \times f_s$		17.1		$1/f_s$

7.3.7.2.1.6 Sampling Rate: 96 kHz or 88.2 kHz

Figure 34 and Figure 35 respectively show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 96 kHz or 88.2 kHz. Table 13 lists the specifications for a decimation filter with an 96-kHz or 88.2-kHz sampling rate.

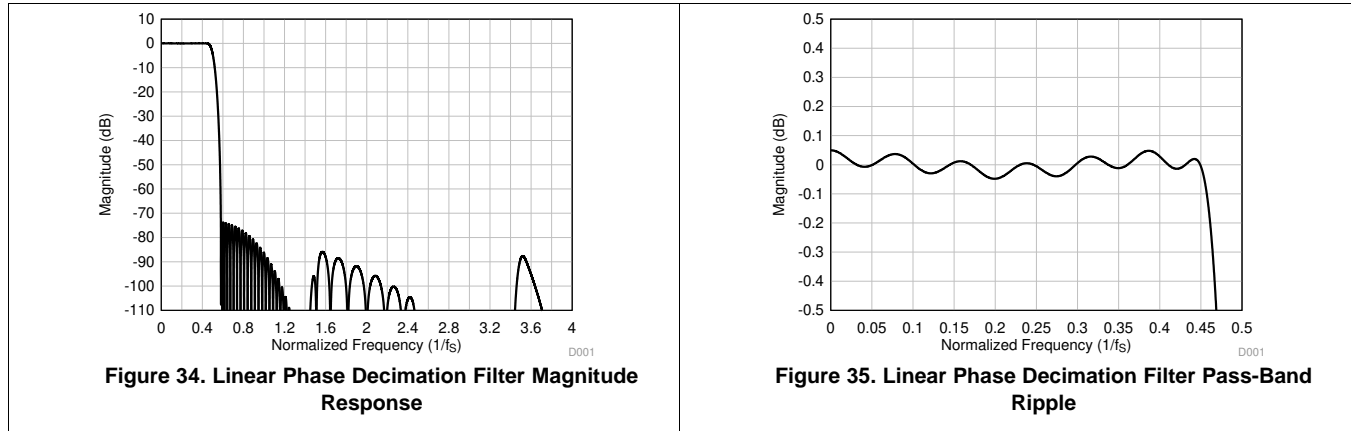


Table 13. Linear Phase Decimation Filter Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.454 \times f_s$	-0.05		0.05	dB
Stop-band attenuation	Frequency range is $0.58 \times f_s$ to $4 \times f_s$	73.6			
	Frequency range is $4 \times f_s$ onwards	97.9			
Group delay or latency	Frequency range is 0 to $0.454 \times f_s$		17.1		$1/f_s$

7.3.7.2.1.7 Sampling Rate: 192 kHz or 176.4 kHz

Figure 36 and Figure 37 respectively show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 192 kHz or 176.4 kHz. Table 14 lists the specifications for a decimation filter with an 192-kHz or 176.4-kHz sampling rate.

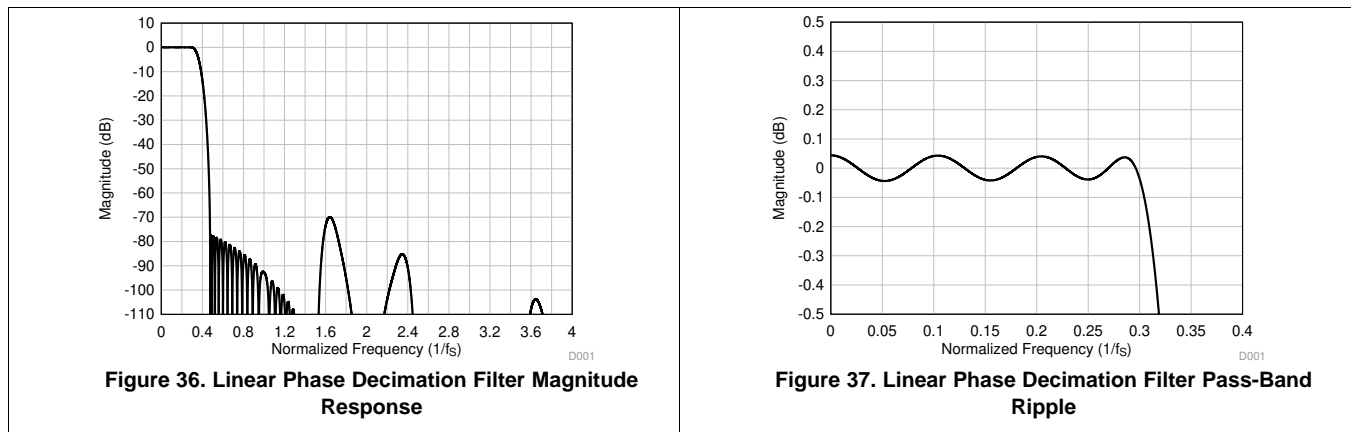


Table 14. Linear Phase Decimation Filter Specifications

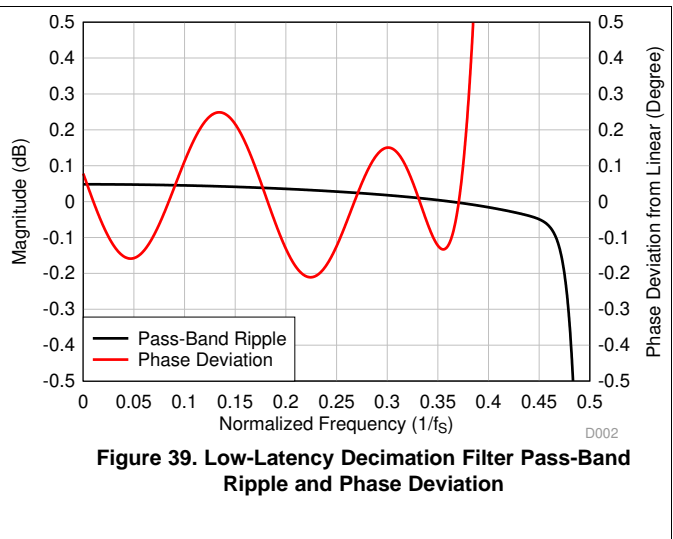
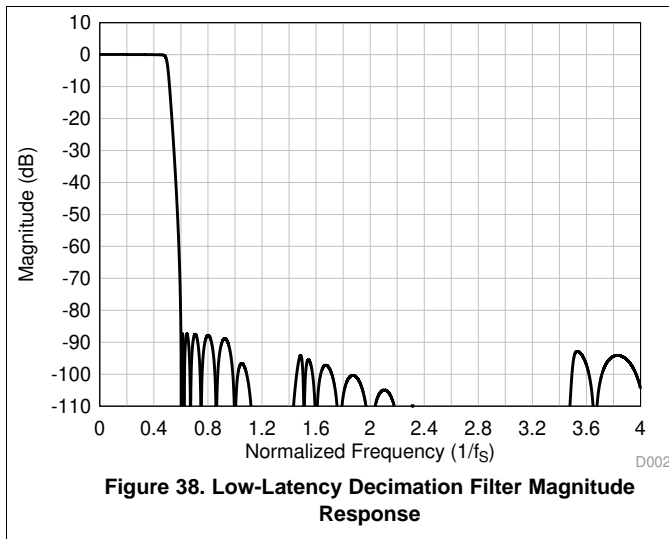
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.3 \times f_s$	-0.05		0.05	dB
Stop-band attenuation	Frequency range is $0.473 \times f_s$ to $4 \times f_s$	70.0			
	Frequency range is $4 \times f_s$ onwards	111.0			
Group delay or latency	Frequency range is 0 to $0.3 \times f_s$		11.9		$1/f_s$

### 7.3.7.2.2 Low-Latency Filters

For applications where low latency with minimal phase deviation (within the audio band) is critical, the low-latency decimation filters on the PCM1840 can be used. The device supports these filters with a group delay of approximately seven samples with an almost linear phase response within the  $0.365 \times f_s$  frequency band. This section provides the filter performance specifications and various plots for all supported output sampling rates for the low-latency filters.

#### 7.3.7.2.2.1 Sampling Rate: 16 kHz or 14.7 kHz

Figure 38 shows the magnitude response and Figure 39 shows the pass-band ripple and phase deviation for a decimation filter with a sampling rate of 16 kHz or 14.7 kHz. Table 15 lists the specifications for a decimation filter with a 16-kHz or 14.7-kHz sampling rate.



**Table 15. Low-Latency Decimation Filter Specifications**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.451 \times f_s$	-0.05		0.05	dB
Stop-band attenuation	Frequency range is $0.61 \times f_s$ onwards	87.3			dB
Group delay or latency	Frequency range is 0 to $0.363 \times f_s$		7.6		$1/f_s$
Group delay deviation	Frequency range is 0 to $0.363 \times f_s$	-0.022		0.022	$1/f_s$
Phase deviation	Frequency range is 0 to $0.363 \times f_s$	-0.21		0.25	Degrees

7.3.7.2.2 Sampling Rate: 24 kHz or 22.05 kHz

Figure 40 shows the magnitude response and Figure 41 shows the pass-band ripple and phase deviation for a decimation filter with a sampling rate of 24 kHz or 22.05 kHz. Table 16 lists the specifications for a decimation filter with a 24-kHz or 22.05-kHz sampling rate.

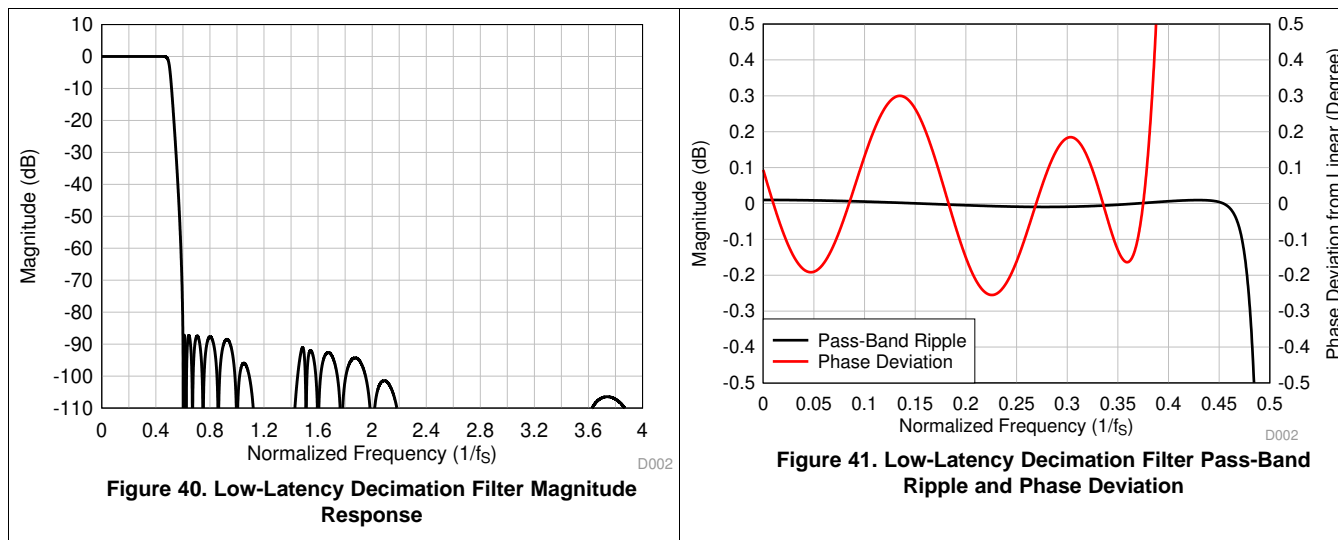
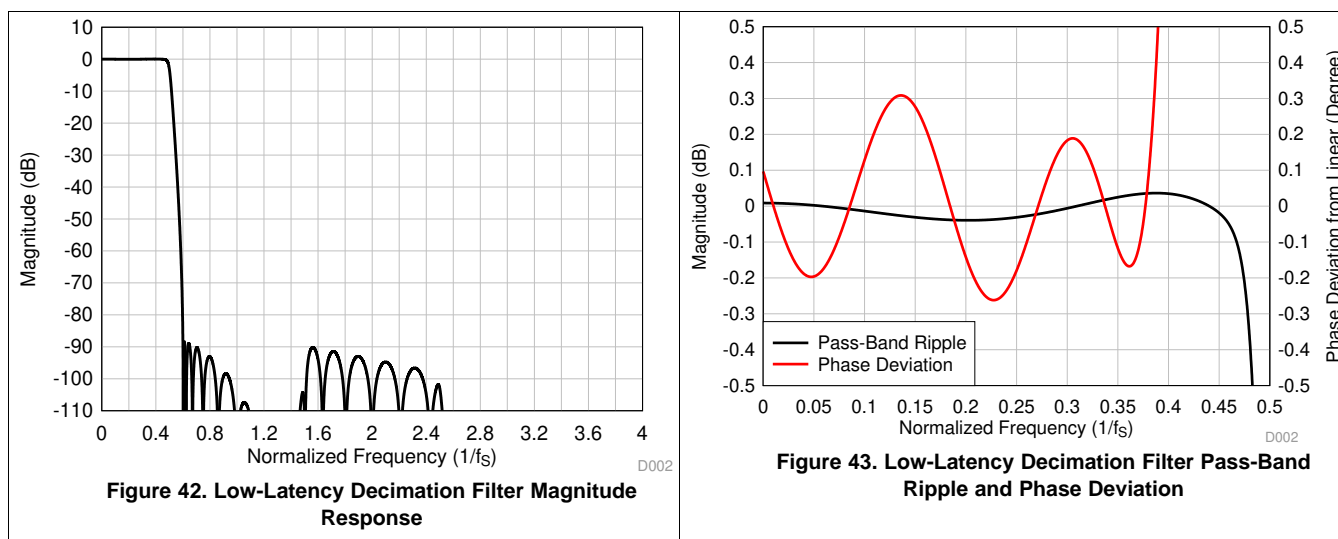


Table 16. Low-Latency Decimation Filter Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.459 \times f_s$	-0.01		0.01	dB
Stop-band attenuation	Frequency range is $0.6 \times f_s$ onwards	87.2			dB
Group delay or latency	Frequency range is 0 to $0.365 \times f_s$		7.5		$1/f_s$
Group delay deviation	Frequency range is 0 to $0.365 \times f_s$	-0.026		0.026	$1/f_s$
Phase deviation	Frequency range is 0 to $0.365 \times f_s$	-0.26		0.30	Degrees

7.3.7.2.3 Sampling Rate: 32 kHz or 29.4 kHz

Figure 42 shows the magnitude response and Figure 43 shows the pass-band ripple and phase deviation for a decimation filter with a sampling rate of 32 kHz or 29.4 kHz. Table 17 lists the specifications for a decimation filter with a 32-kHz or 29.4-kHz sampling rate.

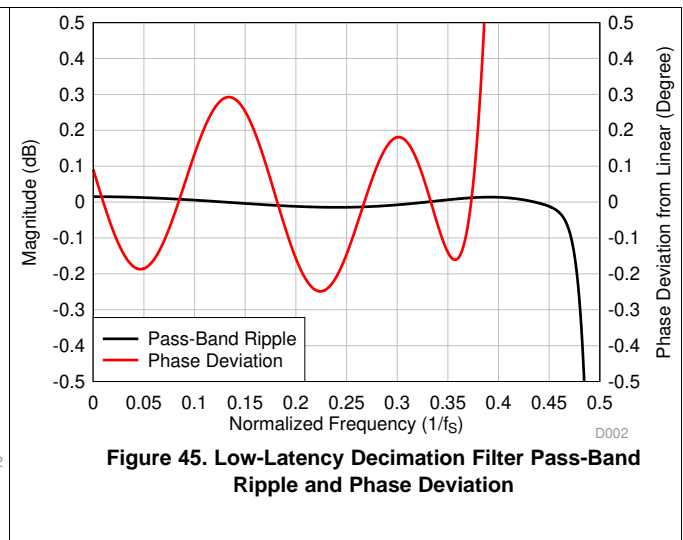
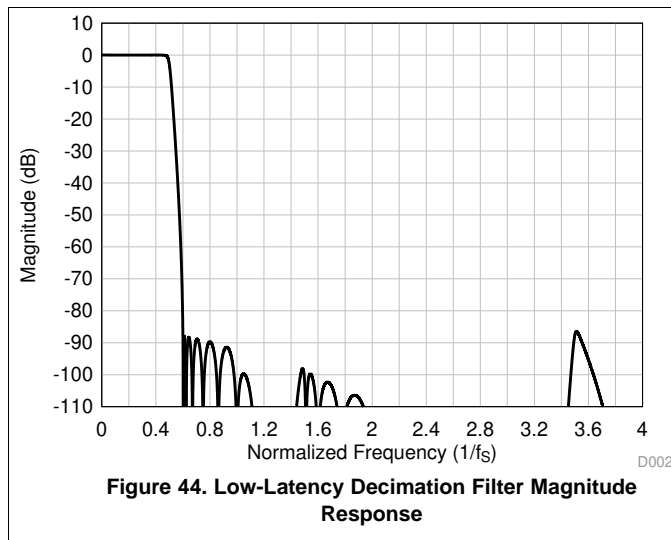


**Table 17. Low-Latency Decimation Filter Specifications**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.457 \times f_S$	-0.04		0.04	dB
Stop-band attenuation	Frequency range is $0.6 \times f_S$ onwards	88.3			dB
Group delay or latency	Frequency range is 0 to $0.368 \times f_S$		8.7		$1/f_S$
Group delay deviation	Frequency range is 0 to $0.368 \times f_S$	-0.026		0.026	$1/f_S$
Phase deviation	Frequency range is 0 to $0.368 \times f_S$	-0.26		0.31	Degrees

**7.3.7.2.2.4 Sampling Rate: 48 kHz or 44.1 kHz**

Figure 44 shows the magnitude response and Figure 45 shows the pass-band ripple and phase deviation for a decimation filter with a sampling rate of 48 kHz or 44.1 kHz. Table 18 lists the specifications for a decimation filter with a 48-kHz or 44.1-kHz sampling rate.



**Table 18. Low-Latency Decimation Filter Specifications**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.452 \times f_S$	-0.015		0.015	dB
Stop-band attenuation	Frequency range is $0.6 \times f_S$ onwards	86.4			dB
Group delay or latency	Frequency range is 0 to $0.365 \times f_S$		7.7		$1/f_S$
Group delay deviation	Frequency range is 0 to $0.365 \times f_S$	-0.027		0.027	$1/f_S$
Phase deviation	Frequency range is 0 to $0.365 \times f_S$	-0.25		0.30	Degrees



7.3.7.2.2.5 Sampling Rate: 96 kHz or 88.2 kHz

Figure 46 shows the magnitude response and Figure 47 shows the pass-band ripple and phase deviation for a decimation filter with a sampling rate of 96 kHz or 88.2 kHz. Table 19 lists the specifications for a decimation filter with a 96-kHz or 88.2-kHz sampling rate.

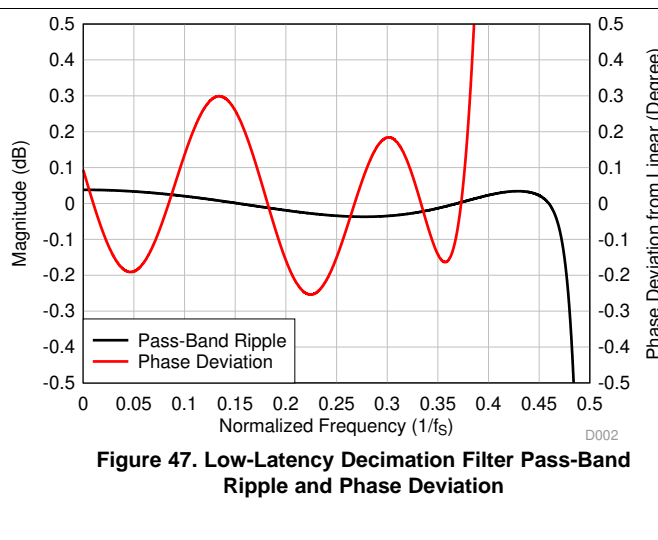
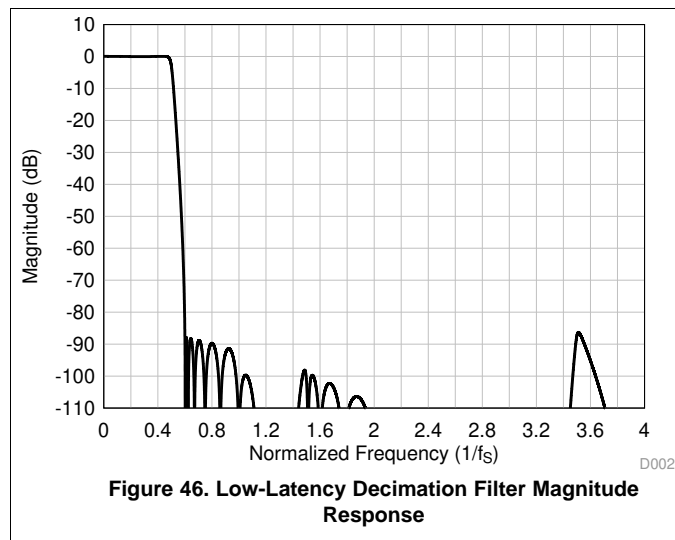


Table 19. Low-Latency Decimation Filter Specifications

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
Pass-band ripple	Frequency range is 0 to $0.466 \times f_s$	-0.04		0.04	dB
Stop-band attenuation	Frequency range is $0.6 \times f_s$ onwards	86.3			dB
Group delay or latency	Frequency range is 0 to $0.365 \times f_s$		7.7		$1/f_s$
Group delay deviation	Frequency range is 0 to $0.365 \times f_s$	-0.027		0.027	$1/f_s$
Phase deviation	Frequency range is 0 to $0.365 \times f_s$	-0.26		0.30	Degrees

### 7.3.8 Dynamic Range Enhancer (DRE)

The device integrates an ultra-low noise front-end DRE gain amplifier with 123-dB dynamic range performance with a low-noise, low-distortion, multibit delta-sigma ( $\Delta\Sigma$ ) ADC with a 108-dB dynamic range. The dynamic range enhancer (DRE) is a digitally assisted algorithm to boost the overall channel performance. The DRE monitors the incoming signal amplitude and accordingly adjusts the internal DRE amplifier gain automatically. The DRE achieves a complete-channel dynamic range as high as 123 dB. At a system level, the DRE scheme enables far-field, high-fidelity recording of audio signals in very quiet environments and low-distortion recording in loud environments.

The DRE can be enable only in slave mode by driving high to the MD1 pin. [Table 20](#) shows the DRE selection for the record channel.

**Table 20. DRE Selection for the Record Channel**

MD1	DRE SELECTION (Supported Only in Slave Mode)
LOW	DRE is disabled in slave mode. For master mode, DRE is always disabled.
HIGH	DRE is enabled with DRE_LVL = -36 dB and DRE_MAXGAIN = 24 dB in slave mode. For master mode, DRE is always disabled.

This algorithm is implemented with very low latency and all signal chain blocks are designed to minimize any audible artifacts that may occur resulting from dynamic gain modulation. The target signal threshold level, DRE\_LVL, at which DRE is triggered is fixed to the -36-dB input signal level. The DRE gain range can be dynamically modulated by using DRE\_MAXGAIN, which is fixed to 24 dB to maximize the benefit of the DRE in real-world applications and to minimize any audible artifacts.

Enabling the DRE for processing increases the power consumption of the device because of increased signal processing. Therefore, disable the DRE for low-power critical applications. Furthermore, the DRE is not supported for output sample rates greater than 48 kHz.

## 7.4 Device Functional Modes

### 7.4.1 Hardware Shutdown

The device enters hardware shutdown mode when the SHDNZ pin is asserted low or the AVDD supply voltage is not applied to the device. In hardware shutdown mode, the device consumes the minimum quiescent current from the AVDD supply. If the SHDNZ pin is asserted low when the device is in active mode, the device ramps down volume on the record data, powers down the analog and digital blocks, and puts the device into hardware shutdown mode in 25 ms (typical).

### 7.4.2 Active Mode

In the hardware shutdown state, when the SHDNZ pin goes high, the device starts the internal boot-up sequence and then enters into active mode in less than 20 ms (typical). Assert the SHDNZ pin high only when the IOVDD supply settles to a steady voltage level and all hardware control pins (MSZ, MD0, MD1, FMT0, and FMT1) are driven to the voltage level for the device desired mode of operation.

In active mode, when the audio clocks are available, the device powers up all the ADC channels and starts transmitting the data over the audio serial interface. If the clocks are stopped then the device auto powers down the ADC channels.

## 8 Application and Implementation

### NOTE

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

### 8.1 Application Information

The PCM1840 is a multichannel, high-performance audio analog-to-digital converter (ADC) that supports output sample rates of up to 192 kHz. The device supports up to four analog microphones for simultaneous recording applications.

The PCM1840 configuration is supported using various hardware pin control options. The device supports a highly flexible, audio serial interface (TDM, I<sup>2</sup>S, and LJ) to transmit audio data seamlessly in the system across devices.

### 8.2 Typical Application

Figure 48 shows a typical configuration of the PCM1840 for an application using four analog microelectrical-mechanical system (MEMS) microphones for simultaneous recording operation with a time-division multiplexing (TDM) audio data slave interface. For best distortion performance, use input AC-coupling capacitors with a low-voltage coefficient.

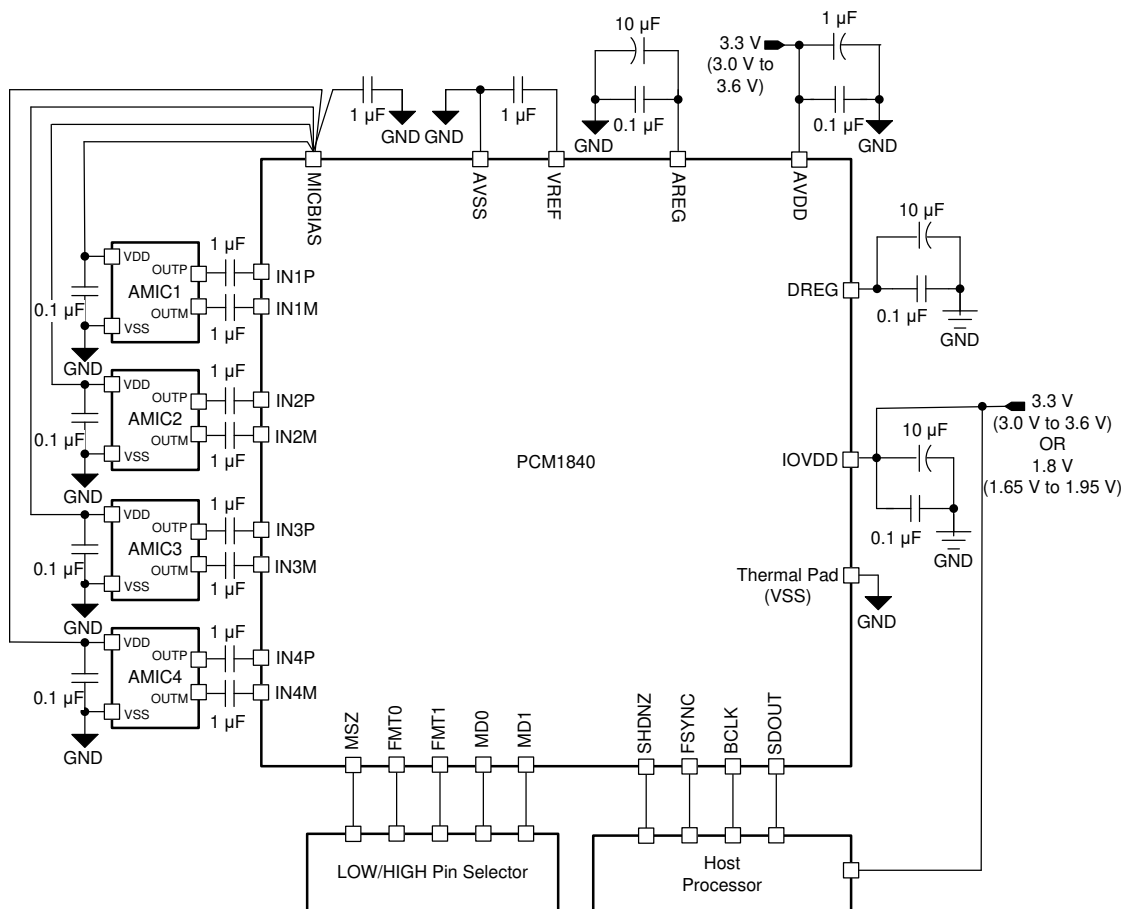


Figure 48. Four-Channel Analog Microphone Recording Diagram for 3.3-V AVDD Operation

## Typical Application (continued)

### 8.2.1 Design Requirements

Table 21 lists the design parameters for this application.

**Table 21. Design Parameters**

KEY PARAMETER	SPECIFICATION: 3.3-V AVDD OPERATION
AVDD	3.3 V
AVDD supply current consumption	> 23 mA (PLL on, four-channel recording, $f_s = 48$ kHz)
IOVDD	1.8 V or 3.3 V
Maximum MICBIAS current	10 mA (MICBIAS voltage is the same as VREF)

### 8.2.2 Detailed Design Procedure

This section describes the necessary steps to configure the PCM1840 for this specific application. The following steps provide a sequence of items that must be executed in the time between powering the device up and reading data from the device or transitioning from one mode to another mode of operation.

1. Apply power to the device:
  - a. Power-up the IOVDD and AVDD power supplies, keeping the SHDNZ pin voltage low
  - b. The device now goes into hardware shutdown mode (ultra-low-power mode < 1  $\mu$ A)
2. Transition from hardware shutdown mode to active mode whenever required for the recording operation:
  - a. Connect the MSZ, FMT0, and FMT1 pins voltage low to configure the device in 4-channel TDM slave mode
  - b. Release SHDNZ only when the IOVDD and AVDD power supplies settle to the steady-state operating voltage
  - c. Apply FSYNC and BCLK with the desired output sample rates and the BCLK to FSYNC ratio
 

This specific step can be done at any point in the sequence after step a

See the [Phase-Locked Loop \(PLL\) and Clock Generation](#) section for supported sample rates and the BCLK to FSYNC ratio
  - d. The device recording data are now sent to the host processor via the TDM audio serial data bus
3. Assert the SHDNZ pin low to enter hardware shutdown mode (again) at any time
4. Follow step 2 onwards to exit hardware shutdown mode (again)

### 8.2.3 Application Curves

Measurements are done on the EVM by feeding the device analog input signal using audio precision and with a 3.3-V AVDD supply.

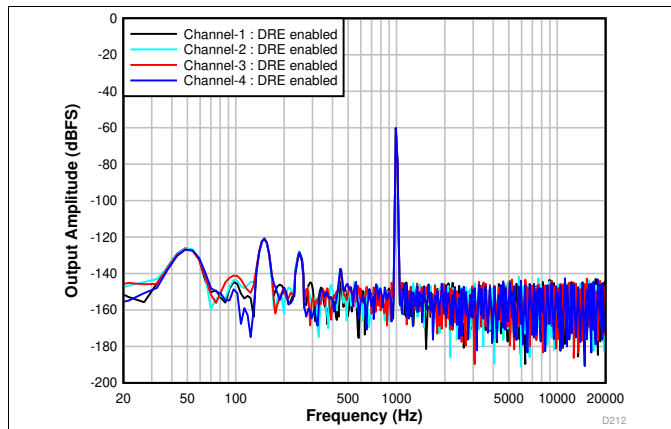


Figure 49. FFT With a -60-dBr Input With DRE Enabled

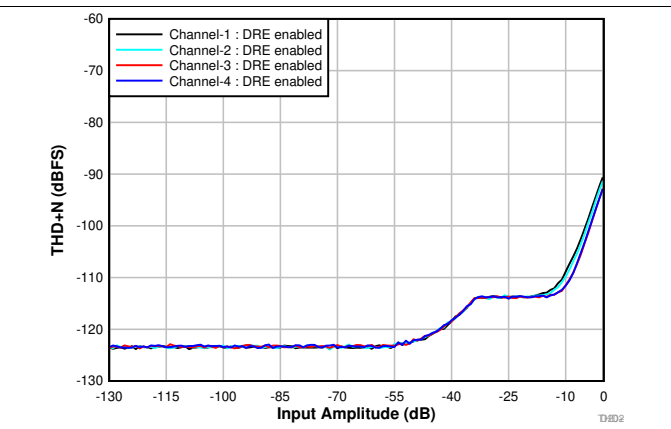


Figure 50. THD+N vs Input Amplitude With DRE Enabled

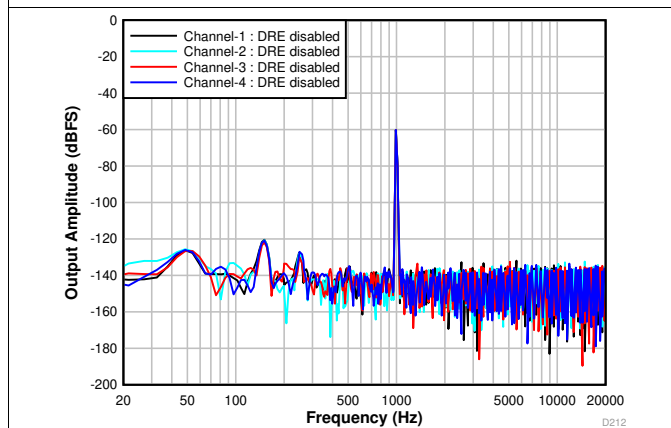


Figure 51. FFT With a -60-dBr Input With DRE Disabled

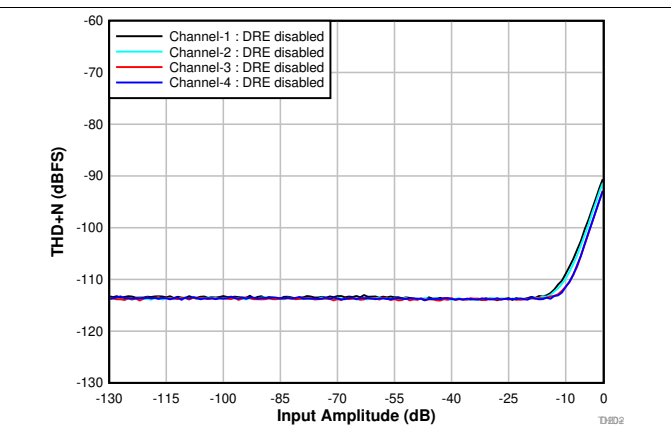
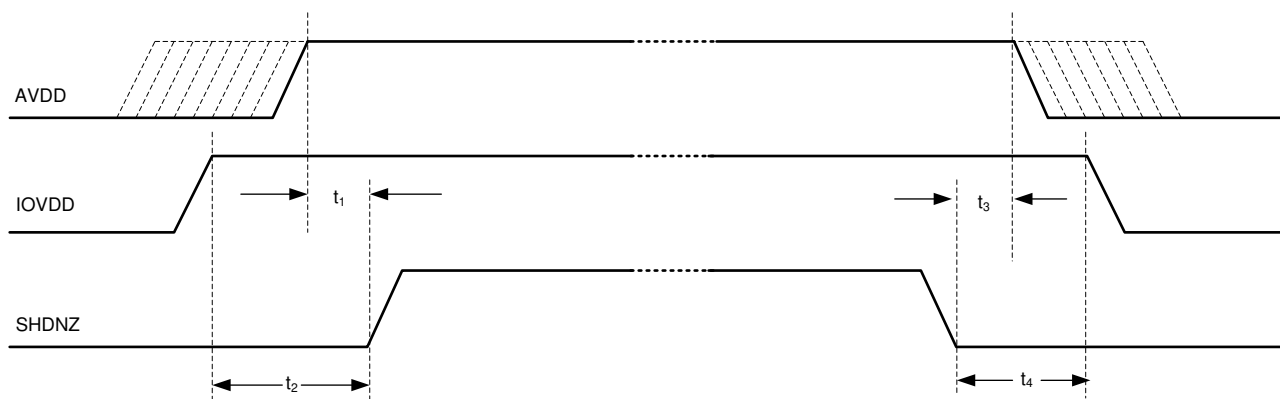


Figure 52. THD+N vs Input Amplitude With DRE Disabled

## 9 Power Supply Recommendations

The power-supply sequence between the IOVDD and AVDD rails can be applied in any order. However, keep the SHDNZ pin low until the IOVDD supply voltage settles to a stable and supported operating voltage range. After all supplies are stable, set the SHDNZ pin high to initialize the device. Assert the SHDNZ pin high only when all hardware control pins (MSZ, MD0, MD1, FMT0, and FMT1) are driven to the voltage level for the device desired mode of operation.

For the supply power-up requirement,  $t_1$  and  $t_2$  must be at least 100  $\mu\text{s}$ . For the supply power-down requirement,  $t_3$  and  $t_4$  must be at least 10 ms. This timing (as shown in Figure 53) allows the device to ramp down the volume on the record data, power down the analog and digital blocks, and put the device into hardware shutdown mode.



**Figure 53. Power-Supply Sequencing Requirement Timing Diagram**

Make sure that the supply ramp rate is slower than 1 V/ $\mu\text{s}$  and that the wait time between a power-down and a power-up event is at least 100 ms.

The PCM1840 supports a single AVDD supply operation by integrating an on-chip digital regulator, DREG, and an analog regulator, AREG. However, if the AVDD voltage is less than 1.98 V in the system, then short the AREG and AVDD pins onboard.

## 10 Layout

### 10.1 Layout Guidelines

Each system design and printed circuit board (PCB) layout is unique. The layout must be carefully reviewed in the context of a specific PCB design. However, the following guidelines can optimize the device performance:

- Connect the thermal pad to ground. Use a via pattern to connect the device thermal pad, which is the area directly under the device, to the ground planes. This connection helps dissipate heat from the device.
- The decoupling capacitors for the power supplies must be placed close to the device pins.
- Route the analog differential audio signals differentially on the PCB for better noise immunity. Avoid crossing digital and analog signals to prevent undesirable crosstalk.
- The device internal voltage references must be filtered using external capacitors. Place the filter capacitors near the VREF pin for optimal performance.
- Directly tap the MICBIAS pin to avoid common impedance when routing the biasing or supply traces for multiple microphones to avoid coupling across microphones.
- Directly short the VREF and MICBIAS external capacitors ground terminal to the AVSS pin without using any vias for this connection trace.
- Place the MICBIAS capacitor (with low equivalent series resistance) close to the device with minimal trace impedance.
- Use ground planes to provide the lowest impedance for power and signal current between the device and the decoupling capacitors. Treat the area directly under the device as a central ground area for the device, and all device grounds must be connected directly to that area.

### 10.2 Layout Example

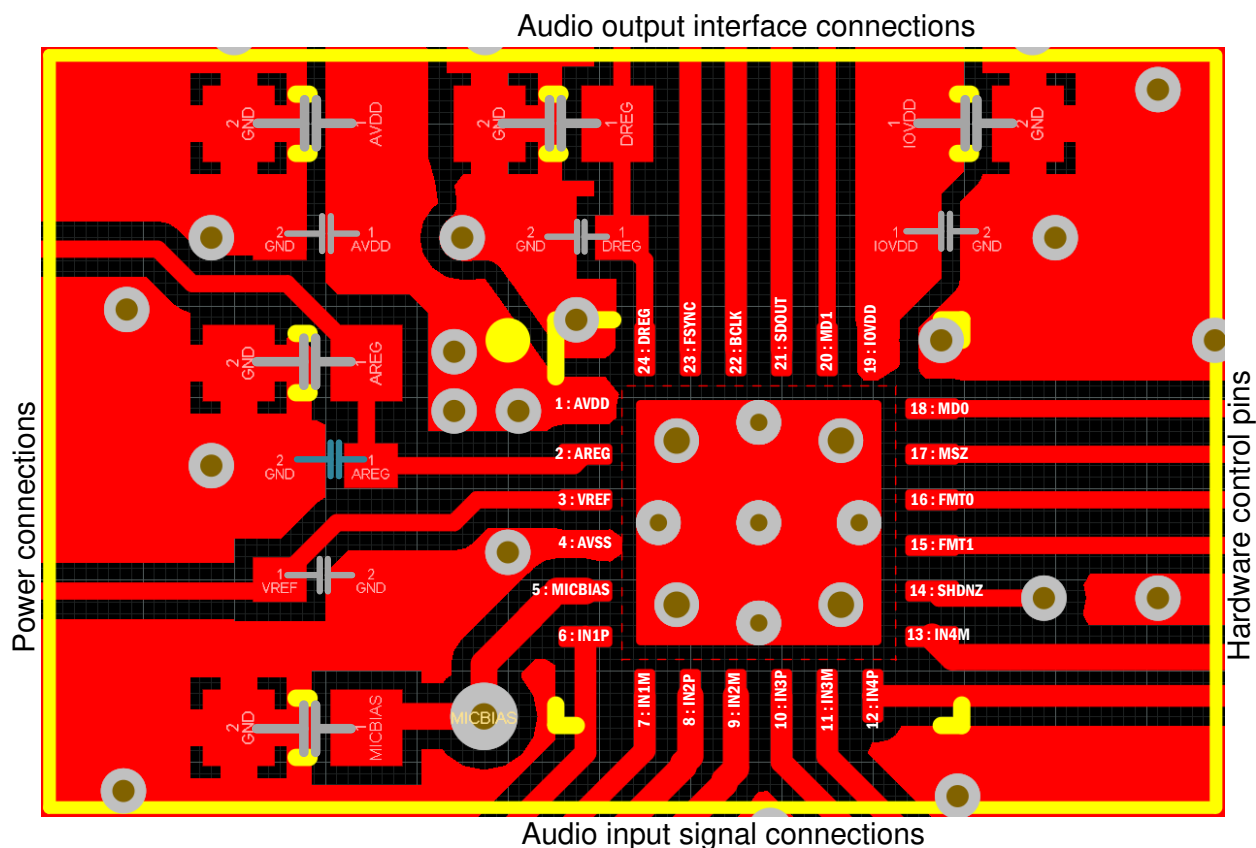


Figure 54. Example Layout

## 11 Device and Documentation Support

### 11.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. In the upper right corner, click on *Alert me* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 11.2 Community Resources

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

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's [Terms of Use](#).

### 11.3 Trademarks

Burr-Brown, E2E are trademarks of Texas Instruments. All other trademarks are the property of their respective owners.

### 11.4 Electrostatic Discharge Caution



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

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

### 11.5 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 part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
<a href="#">PCM1840IRTWR</a>	Active	Production	WQFN (RTW)   24	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	PCM1840
PCM1840IRTWR.A	Active	Production	WQFN (RTW)   24	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	PCM1840
PCM1840IRTWRG4	Active	Production	WQFN (RTW)   24	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	PCM1840
PCM1840IRTWRG4.A	Active	Production	WQFN (RTW)   24	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	PCM1840
<a href="#">PCM1840IRTWT</a>	Active	Production	WQFN (RTW)   24	250   SMALL T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	PCM1840
PCM1840IRTWT.A	Active	Production	WQFN (RTW)   24	250   SMALL T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	PCM1840

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

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

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

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

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

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

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

**Important Information and Disclaimer:** The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and 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. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.



**TAPE AND REEL INFORMATION**

**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
PCM1840IRTWR	WQFN	RTW	24	3000	330.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2
PCM1840IRTWRG4	WQFN	RTW	24	3000	330.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2
PCM1840IRTWT	WQFN	RTW	24	250	180.0	12.4	4.25	4.25	1.15	8.0	12.0	Q2

**TAPE AND REEL BOX DIMENSIONS**


\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PCM1840IRTWR	WQFN	RTW	24	3000	367.0	367.0	35.0
PCM1840IRTRG4	WQFN	RTW	24	3000	367.0	367.0	35.0
PCM1840IRWT	WQFN	RTW	24	250	210.0	185.0	35.0

## GENERIC PACKAGE VIEW

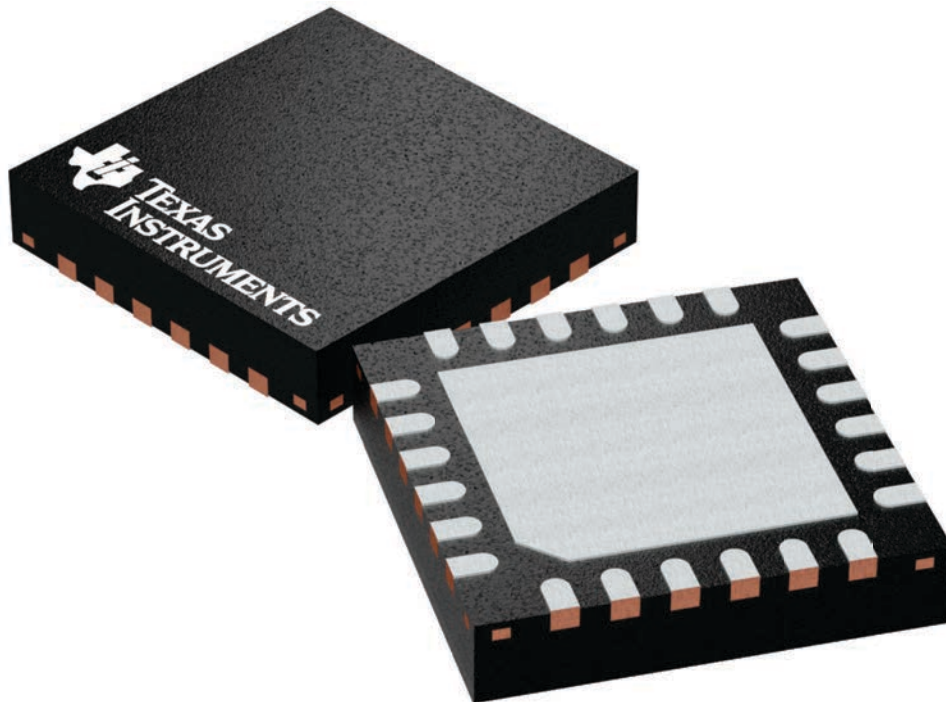
**RTW 24**

**WQFN - 0.8 mm max height**

4 x 4, 0.5 mm pitch

PLASTIC QUAD FLATPACK - NO LEAD

This image is a representation of the package family, actual package may vary.  
Refer to the product data sheet for package details.



4224801/A

RTW (S-PWQFN-N24)

PLASTIC QUAD FLATPACK NO-LEAD



4206244/C 07/11

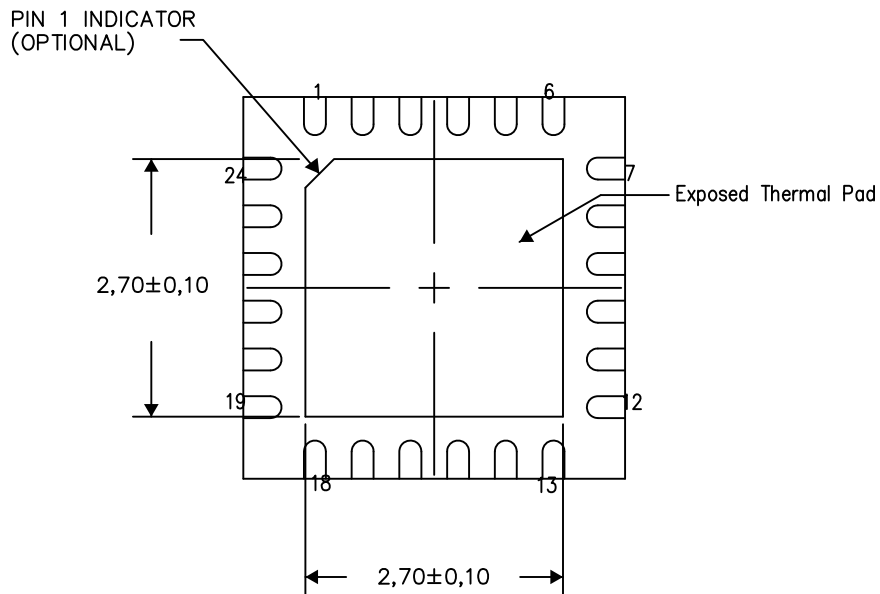
- NOTES:
- All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
  - This drawing is subject to change without notice.
  - Quad Flatpack, No-Leads (QFN) package configuration.
  - The package thermal pad must be soldered to the board for thermal and mechanical performance.
  - See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
  - Falls within JEDEC MO-220.

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No-Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at [www.ti.com](http://www.ti.com).

The exposed thermal pad dimensions for this package are shown in the following illustration.



Bottom View

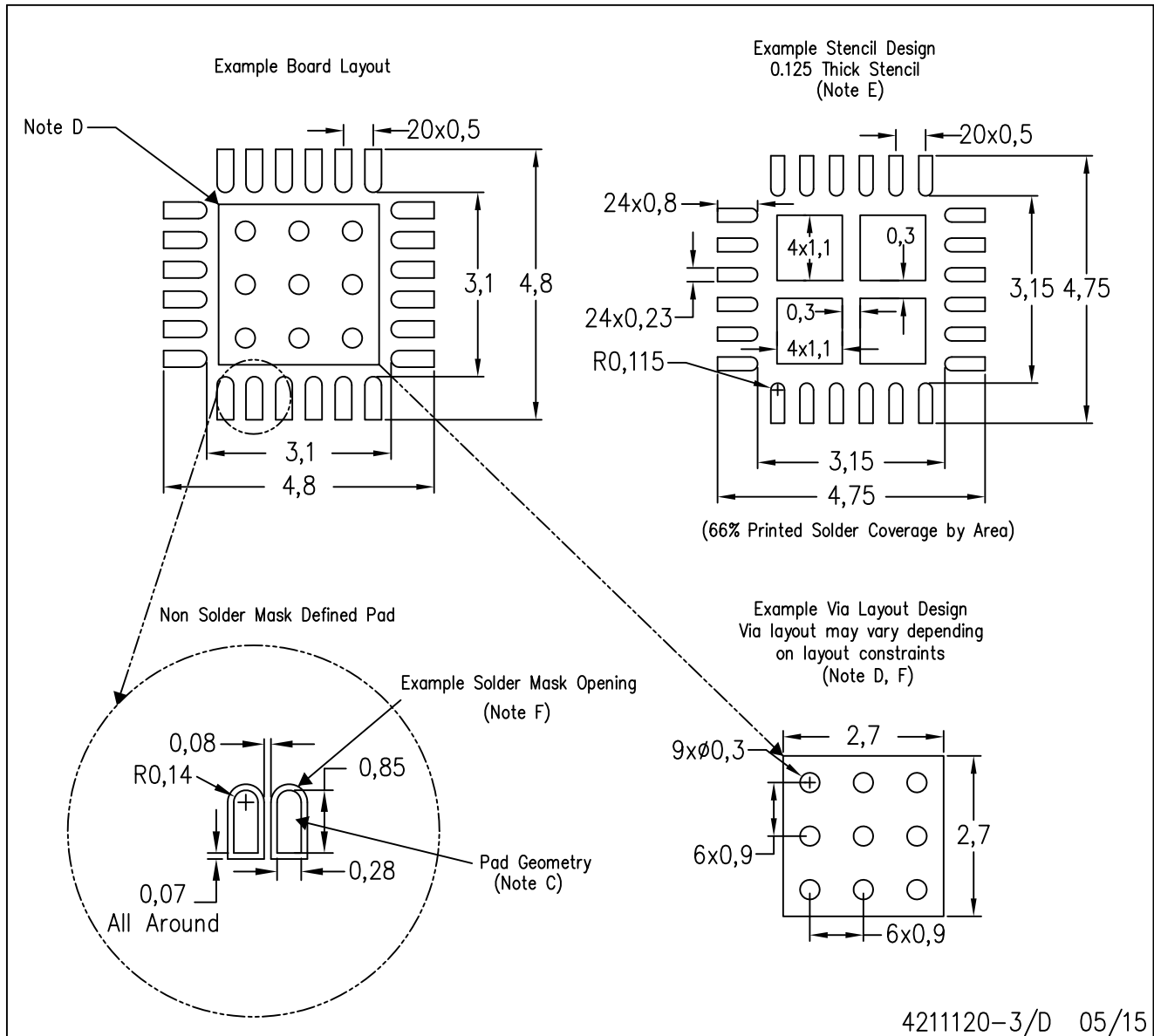
Exposed Thermal Pad Dimensions

4206249-5/P 05/15

NOTES: A. All linear dimensions are in millimeters

RTW (S-PWQFN-N24)

PLASTIC QUAD FLATPACK NO-LEAD



- NOTES:
- All linear dimensions are in millimeters.
  - This drawing is subject to change without notice.
  - Publication IPC-7351 is recommended for alternate designs.
  - This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat-Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at [www.ti.com](http://www.ti.com) <<http://www.ti.com>>.
  - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
  - Customers should contact their board fabrication site for recommended solder mask tolerances and via tenting recommendations for vias placed in the thermal pad.



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