

PCM1841-Q1 Quad Channel, 32-Bit, 192kHz, 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:
 - 123dB, dynamic range enhancer enabled
 - 113dB, dynamic range enhancer disabled
 - THD+N: –98dB
- ADC differential $2V_{RMS}$ full-scale input
- ADC sample rate (f_S) = 8kHz to 192kHz
- Hardware pin control configurations
- Linear-phase or low-latency filter selection
- Flexible audio serial data interface:
 - Controller or target interface selection
 - 32-bits, 4-channel TDM
 - 32-bits, 2-channel TDM
 - 32-bits, 2-channel I²S
 - 32-bits, 2-channel left-justified (LJ)
- Automatic power-down upon loss of audio clocks
- Integrated high-performance audio PLL
- Low-noise MICBIAS 2.75V output
- Single-supply operation: 3.3V
- I/O-supply operation: 3.3V or 1.8V
- Power consumption for 3.3V AVDD supply:
 - 17.0 mW/channel at 16kHz sample rate
 - 18.4 mW/channel at 48kHz sample rate

2 Applications

- [Telematics control unit](#)
- [Automotive head unit](#)
- [Digital cockpit processing unit](#)
- [Automotive display module](#)

3 Description

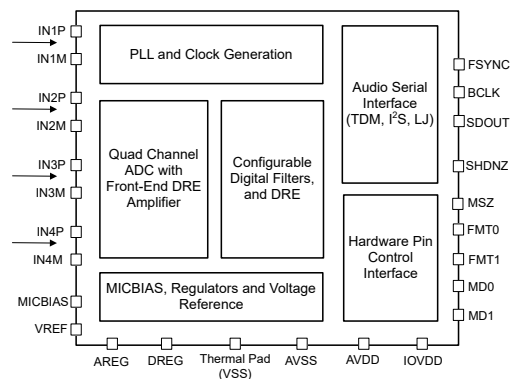
The PCM1841-Q1 is a high-performance, Burr-Brown™ audio analog-to-digital converter (ADC) that supports simultaneous sampling of up to four analog channels. The device supports differential line and microphone inputs with a $2V_{RMS}$ full-scale signal. The device integrates microphone bias voltage, a phase-locked loop (PLL), a DC removal high-pass filter (HPF), and supports sample rates up to 192kHz. The device supports time-division multiplexing (TDM), I²S, or left-justified (LJ) audio formats, selectable with the hardware pin level. Additionally, the PCM1841-Q1 supports controller and target 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 3.3V, make the device an excellent choice for cost-sensitive, space-constrained audio systems in far-field microphone recording applications.

The PCM1841-Q1 is specified from –40°C to +125°C and is offered in a 24-pin VQFN package.

Package Information

PART NUMBER	PACKAGE ⁽¹⁾	PACKAGE SIZE ⁽²⁾	BODY SIZE (NOM)
PCM1841-Q1	RGE (VQFN, 24)	4.00mm x 4.00mm	4.00mm x 4.00mm ⁽³⁾

- (1) For more information, see the [Mechanical, Packaging, and Orderable Information](#).
- (2) The package size (length × width) is a nominal value and includes pins, where applicable.
- (3) Includes 0.5mm pitch.



Simplified Block Diagram



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4 Pin Configuration and Functions

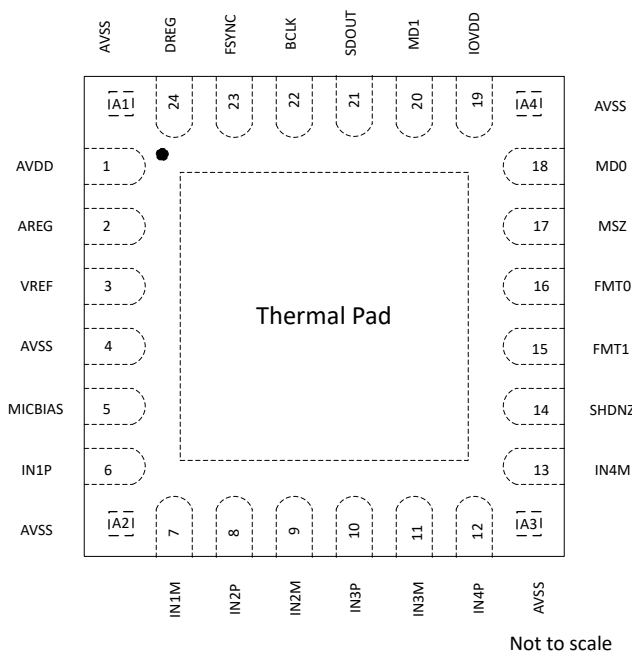


Figure 4-1. RGE Package, 24-Pin VQFN With Exposed Thermal Pad, Top View

Table 4-1. Pin Functions

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

Table 4-1. Pin Functions (continued)

PIN		TYPE ⁽¹⁾	DESCRIPTION
NO.	NAME		
24	DREG	P	Digital regulator output voltage for digital core supply (1.5V, nominal)
A1, A2,A3, A4	AVSS	GND	Analog ground. Short this pin directly to the board ground plane.
Thermal Pad (VSS)		GND	Thermal pad shorted to internal device ground. Short thermal pad directly to board ground plane.

(1) I = input, O = output, P = power, FB = feedback, GND = ground, N/A = not applicable

5 Specifications

5.1 Absolute Maximum Ratings

over the operating ambient temperature range (unless otherwise noted)⁽¹⁾

		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 _A	−40	125	°C
	Junction, T _J	−40	150	
	Storage, T _{slg}	−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.

5.2 ESD Ratings

		VALUE	UNIT
V _(ESD)	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 ⁽¹⁾	±2000
		Charge device model (CDM), per AEC Q100-011	±500

(1) AEC Q100-002 indicates that HBM stressing must be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

5.3 Recommended Operating Conditions

		MIN	NOM	MAX	UNIT
POWER					
AVDD, AREG ⁽¹⁾	Analog supply voltage AVDD to AVSS (AREG is generated using onchip regulator) - AVDD 3.3V operation	3.0	3.3	3.6	V
IOVDD	IO supply voltage to VSS (thermal pad) - IOVDD 3.3V operation	3.0	3.3	3.6	V
	IO supply voltage to VSS (thermal pad) - IOVDD 1.8V operation	1.65	1.8	1.95	
INPUTS					
	Analog input pins voltage to AVSS	0		AVDD	V
	Digital input pins voltage to VSS (thermal pad)	0		IOVDD	V
TEMPERATURE					
T _A	Operating ambient temperature	−40		125	°C
OTHERS					
	Digital input pin used as MCLK input clock frequency			36.864	MHz

5.3 Recommended Operating Conditions (continued)

		MIN	NOM	MAX	UNIT
C _L	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 0.2V.

5.4 Thermal Information

THERMAL METRIC ⁽¹⁾		PCM1841-Q1	UNIT
		RGE (VQFN)	
		24 PINS	
R _{θJA}	Junction-to-ambient thermal resistance	45.6	°C/W
R _{θJC(top)}	Junction-to-case (top) thermal resistance	30	°C/W
R _{θJB}	Junction-to-board thermal resistance	22.5	°C/W
Ψ _{JT}	Junction-to-top characterization parameter	0.8	°C/W
Ψ _{JB}	Junction-to-board characterization parameter	22.4	°C/W
R _{θJC(bot)}	Junction-to-case (bottom) thermal resistance	15	°C/W

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

5.5 Electrical Characteristics

at T_A = 25°C, AVDD = 3.3V, IOVDD = 3.3V, f_{IN} = 1kHz sinusoidal signal, f_S = 48kHz, 32 bit audio data, BCLK = 256 × f_S, TDM target mode (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
ADC CONFIGURATION						
	AC input impedance	Input pins INxP or INxM		2.5		kΩ
ADC PERFORMANCE FOR LINE/MICROPHONE INPUT RECORDING : AVDD 3.3V OPERATION						
	Differential input full-scale AC signal voltage	AC-coupled input		2		V _{RMS}
SNR	Signal-to-noise ratio, A-weighted ^{(1) (2)}	IN1 differential input selected and AC signal shorted to ground, DRE enabled (DRE_LVL = –36dB, DRE_MAXGAIN = 24dB)	115	122		dB
		IN1 differential input selected and AC signal shorted to ground, DRE disabled	106	112		
DR	Dynamic range, A-weighted ⁽²⁾	IN1 differential input selected and –60dB full-scale AC signal input, DRE enabled (DRE_LVL = –36dB, DRE_MAXGAIN = 24dB)		123		dB
		IN1 differential input selected and –60dB full-scale AC signal input, DRE disabled		113		
THD+N	Total harmonic distortion ^{(2) (3)}	IN1 differential input selected and –1dB full-scale AC signal input, DRE enabled (DRE_LVL = –36dB, DRE_MAXGAIN = 24dB)		–98	–80	dB
		IN1 differential input selected and –1dB full-scale AC signal input, DRE disabled		–98		
ADC OTHER PARAMETERS						
	Output data sample rate		7.35		192	kHz
	Output data sample word length				32	Bits
	Interchannel isolation	–1dB full-scale AC-signal input to non measurement channel		–124		dB
	Interchannel gain mismatch	–6dB 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	1kHz sinusoidal signal		0.02		Degrees

5.5 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 target mode (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
	Phase drift	1kHz sinusoidal signal, across temperature range 15°C to 35°C		0.0005		Degrees/ $^\circ\text{C}$
PSRR	Power-supply rejection ratio	100mV _{PP} , 1kHz sinusoidal signal on AVDD, differential input selected, 0dB channel gain		102		dB
CMRR	Common-mode rejection ratio	Differential microphone input selected, 100mV _{PP} , 1kHz signal on both pins and measure level at output		60		dB
MICROPHONE BIAS						
	MICBIAS noise	BW = 20Hz to 20kHz, A-weighted, 1μF capacitor between MICBIAS and AVSS		1.6		μV _{RMS}
	MICBIAS voltage			VREF		V
	MICBIAS current drive				20	mA
	MICBIAS load regulation	Measured up to max load	0	0.6	1.8	%
	MICBIAS over current protection threshold		22			mA
DIGITAL I/O						
$V_{IL(SHDNZ)}$	Low-level digital input logic voltage threshold	SHDNZ pin	−0.3		$0.25 \times IOVDD$	V
$V_{IH(SHDNZ)}$	High-level digital input logic voltage threshold	SHDNZ pin	$0.75 \times IOVDD$		$IOVDD + 0.3$	V
V_{IL}	Low-level digital input logic voltage threshold	All digital pins, IOVDD 1.8V operation	−0.3		$0.3 \times IOVDD$	V
		All digital pins, IOVDD 3.3V operation	−0.3		0.8	
V_{IH}	High-level digital input logic voltage threshold	All digital pins, IOVDD 1.8V or 3.3V operation	$0.7 \times IOVDD$		$IOVDD + 0.3$	V
V_{OL}	Low-level digital output voltage	All digital pins, $I_{OL} = -2\text{mA}$, IOVDD 1.8V operation			0.45	V
		All digital pins, $I_{OL} = -2\text{mA}$, IOVDD 3.3V operation			0.4	
V_{OH}	High-level digital output voltage	All digital pins, $I_{OH} = 2\text{mA}$, IOVDD 1.8V operation	$IOVDD - 0.45$			V
		All digital pins, $I_{OH} = 2\text{mA}$, IOVDD 3.3V operation	2.4			
I_{IH}	Input logic-high leakage for digital inputs	All digital pins, input = IOVDD	−5	0.1	5	μA
I_{IL}	Input logic-low leakage for digital inputs	All digital pins, input = 0V	−5	0.1	5	μA
C_{IN}	Input capacitance for digital inputs	All digital pins		5		pF
TYPICAL SUPPLY CURRENT CONSUMPTION						
I_{AVDD}	Current consumption in hardware shutdown mode	SHDNZ = 0, AVDD = 3.3V, internal AREG		1		μA
I_{IOVDD}		SHDNZ = 0, all external clocks stopped, IOVDD = 3.3V		0.2		
I_{IOVDD}		SHDNZ = 0, all external clocks stopped, IOVDD = 1.8V		0.15		
I_{AVDD}	Current consumption with ADC 4 channel operating at $f_S = 16\text{kHz}$, $BCLK = 256 \times f_S$ and DRE disable	AVDD = 3.3V, internal AREG		21.3		mA
I_{IOVDD}		IOVDD = 3.3V		0.15		
I_{IOVDD}		IOVDD = 1.8V		0.04		
I_{AVDD}	Current consumption with ADC 4 channel operating at $f_S = 48\text{kHz}$, $BCLK = 256 \times f_S$ and DRE disable	AVDD = 3.3V, internal AREG		22.9		mA
I_{IOVDD}		IOVDD = 3.3V		0.25		
I_{IOVDD}		IOVDD = 1.8V		0.1		
I_{AVDD}	Current consumption with ADC 4 channel operating at $f_S = 48\text{kHz}$, $BCLK = 256 \times f_S$ and DRE enable	AVDD = 3.3V, internal AREG		25.0		mA
I_{IOVDD}		IOVDD = 3.3V		0.25		
I_{IOVDD}		IOVDD = 1.8V		0.1		

- (1) Ratio of output level with 1kHz full-scale sine-wave input, to the output level with the AC signal input shorted to ground, measured A-weighted over a 20Hz to 20kHz bandwidth using an audio analyzer.
- (2) All performance measurements done with 20kHz 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.

5.6 Timing Requirements: TDM, I²S or LJ Interface

at T_A = 25°C, IOVDD = 3.3V or 1.8V and 20pF load on all outputs (unless otherwise noted); see Figure 5-1 for timing diagram

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

- (1) The BCLK minimum high or low pulse duration must be higher than 25ns (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.

5.7 Switching Characteristics: TDM, I²S or LJ Interface

at T_A = 25°C, IOVDD = 3.3V or 1.8V and 20pF load on all outputs (unless otherwise noted); see Figure 5-1 for timing diagram

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

- (1) The BCLK output clock frequency must be lower than 18.5MHz (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.

5.8 Timing Diagram

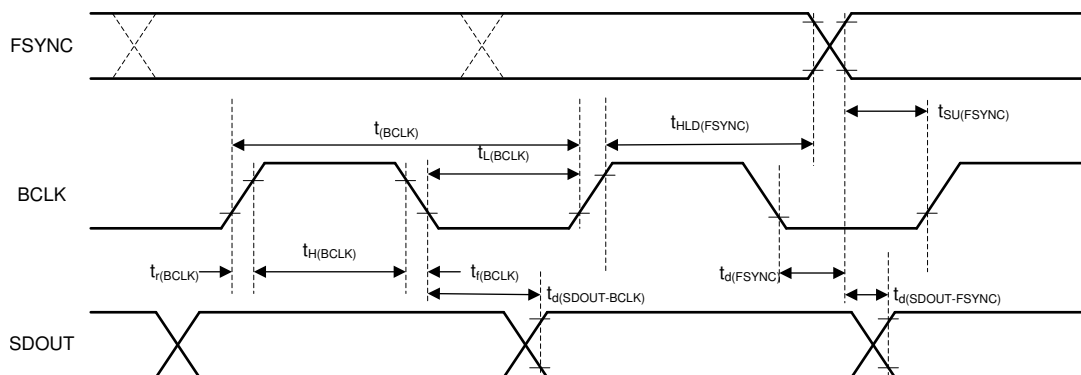


Figure 5-1. TDM, I²S, and LJ Interface Timing Diagram

5.9 Typical Characteristics

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 target mode, PLL on, $DRE_LVL = -36\text{dB}$, channel gain = 0dB , and linear phase decimation filter (unless otherwise noted); all performance measurements are done with a 20kHz , low-pass filter, and an A-weighted filter

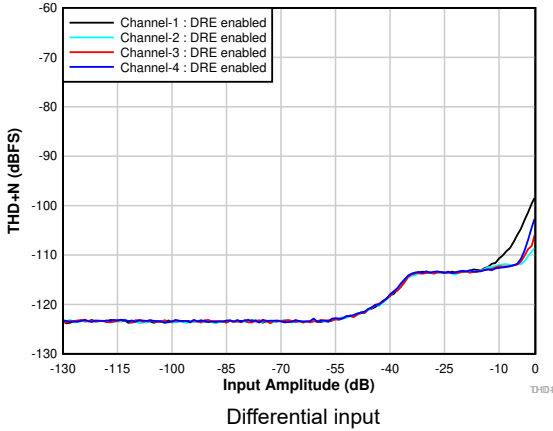


Figure 5-2. THD+N vs Input Amplitude With DRE Enabled

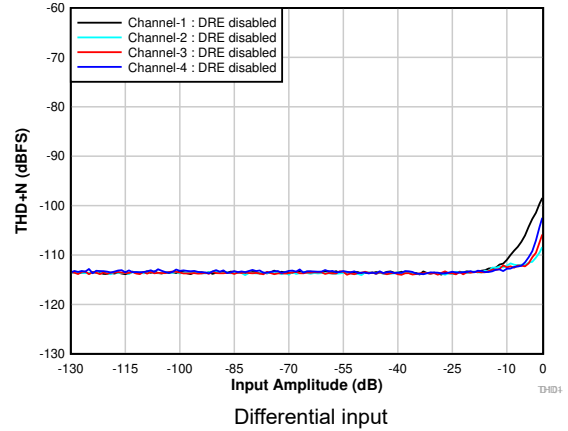


Figure 5-3. THD+N vs Input Amplitude With DRE Disabled

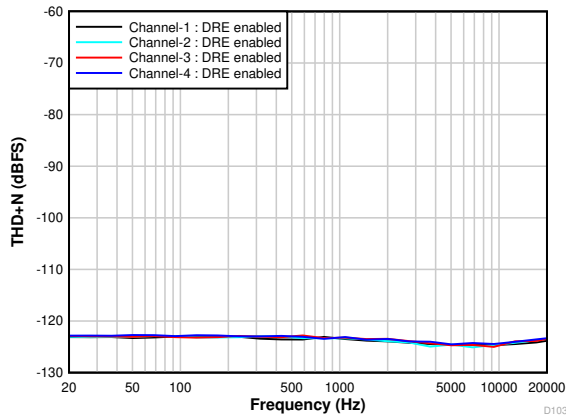


Figure 5-4. THD+N vs Input Frequency With a -60dB Input

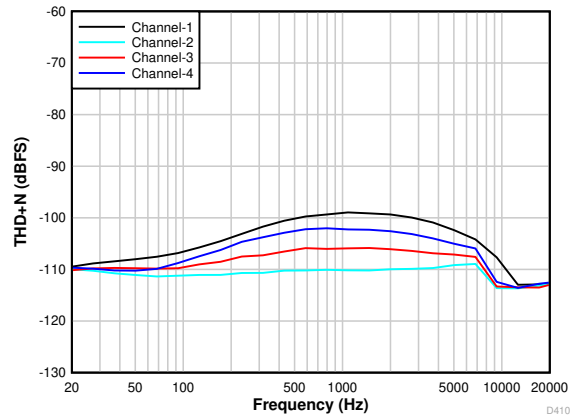


Figure 5-5. THD+N vs Input Frequency With a -1dB Input

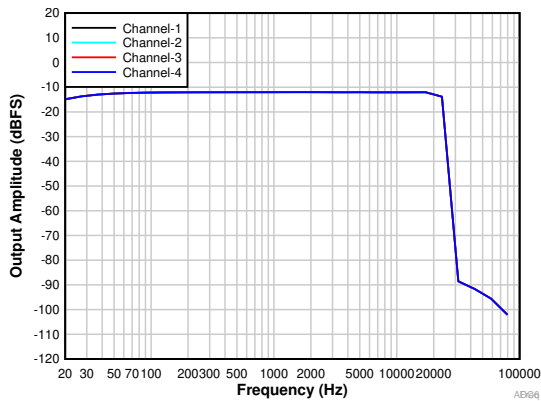


Figure 5-6. Frequency Response With a -12dB Input

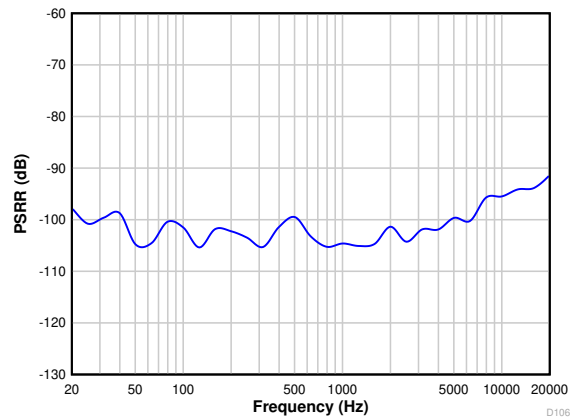


Figure 5-7. Power-Supply Rejection Ratio vs Ripple Frequency With 100mV_{PP} Amplitude

5.9 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 target mode, PLL on, $DRE_LVL = -36\text{dB}$, channel gain = 0dB , and linear phase decimation filter (unless otherwise noted); all performance measurements are done with a 20kHz , low-pass filter, and an A-weighted filter

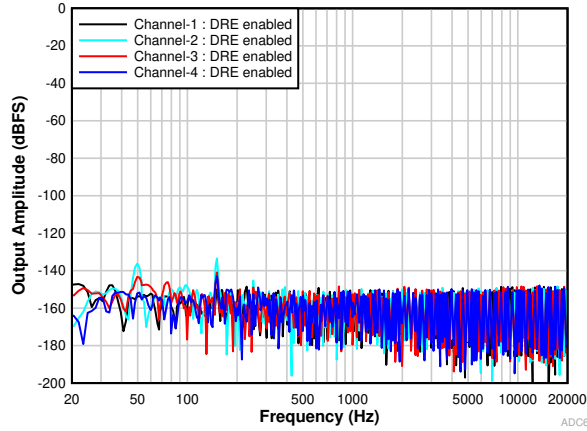


Figure 5-8. FFT With Idle Input With DRE Enabled

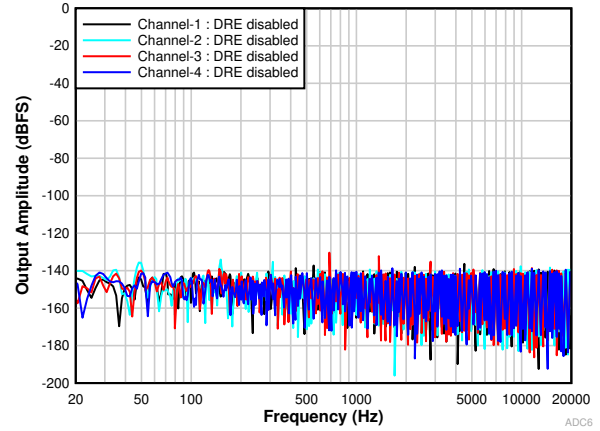


Figure 5-9. FFT With Idle Input With DRE Disabled

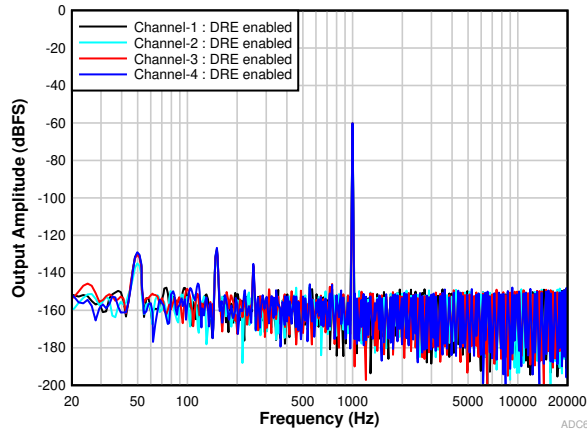


Figure 5-10. FFT With a -60dB Input With DRE Enabled

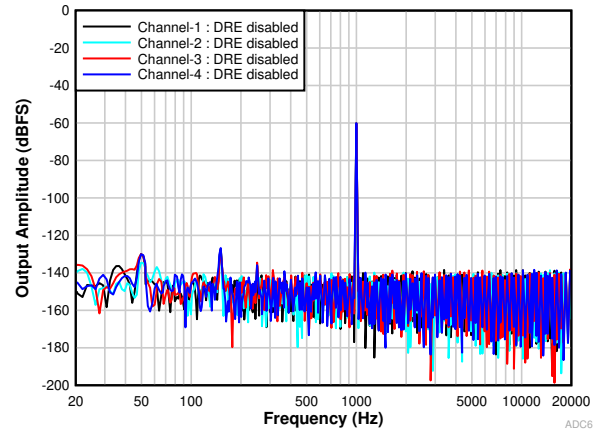


Figure 5-11. FFT With a -60dB Input With DRE Disabled

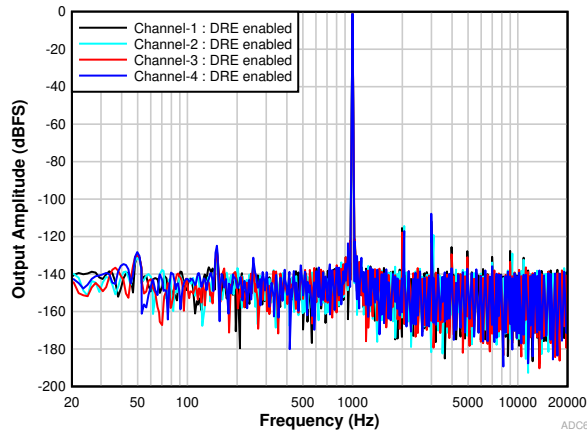


Figure 5-12. FFT With a -1dB Input With DRE Enabled

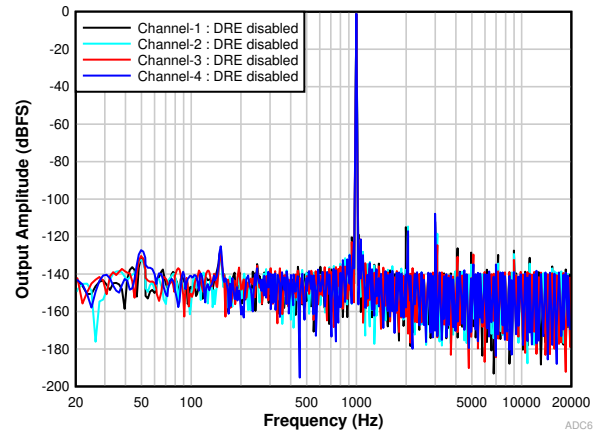


Figure 5-13. FFT With a -1dB Input With DRE Disabled

6 Detailed Description

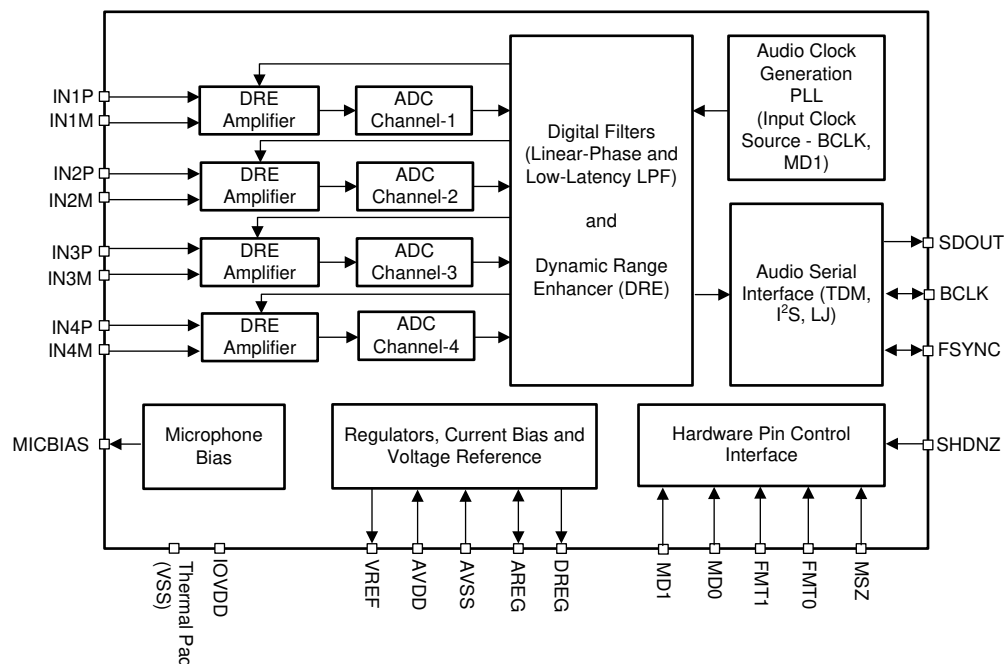
6.1 Overview

The PCM1841-Q1 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 reduce costs, 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 PCM1841-Q1 also supports a power-down and reset function by means of halting the system clock.

The PCM1841-Q1 consists of the following blocks and features:

- Quad-channel, multibit, high-performance delta-sigma ($\Delta\Sigma$) ADC
- Differential audio inputs with a $2V_{RMS}$ full-scale signal
- Low-noise, $1.6\mu V_{RMS}$, microphone bias output
- Hardware pin control operation to select the device features
- Audio bus serial interface controller or target select option
- Audio bus serial interface format select option
- Audio bus serial interface supported up to 192kHz sampling
- Target mode supports dynamic range enhancer (DRE) with 123dB dynamic range
- Target mode supports decimation filters with linear-phase or low-latency filter selection
- Controller 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 3.3V operation

6.2 Functional Block Diagram



6.3 Feature Description

6.3.1 Hardware Control

This device enables simple, pin-controlled hardware select a 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.

6.3.2 Audio Serial Interfaces

Digital audio data flows between the host processor and the PCM1841-Q1 on the digital audio serial interface (ASI), or audio bus. This highly flexible ASI bus includes a TDM mode for multichannel operation, support for I²S or left-justified protocols format, and the pin-selectable controller-target configuration for bus clock lines.

The device supports audio bus controller or target mode of operation using the hardware pin MSZ. FSYNC and BCLK work as input pins in target mode, whereas, FSYNC and BCLK work as output pins generated by the device in controller mode. [Table 6-1](#) shows the controller and target mode selection using the MSZ pin.

Table 6-1. Controller and Target Mode Selection

MSZ	CONTROLLER AND TARGET SELECTION
LOW	Target mode of operation
HIGH	Controller mode of operation

The FMT0 and FMT1 pins can be used to select the bus protocol TDM, I²S, or left-justified (LJ) format. As shown in [Table 6-2](#), these modes are most significant byte (MSB)-first, pulse code modulation (PCM) data format, with the output channel data word-length of 32 bits.

Table 6-2. 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 ² S) mode

6.3.2.1 Time Division Multiplexed Audio (TDM) Interface

The rising edge of FSYNC starts the data transfer in TDM mode (also known as DSP mode) 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 is transmitted on the rising edge of BCLK (except the MSB of slot 0 when TX_OFFSET equals 0). [Figure 6-1](#) to [Figure 6-4](#) illustrate the protocol timing for TDM operation with various configurations.

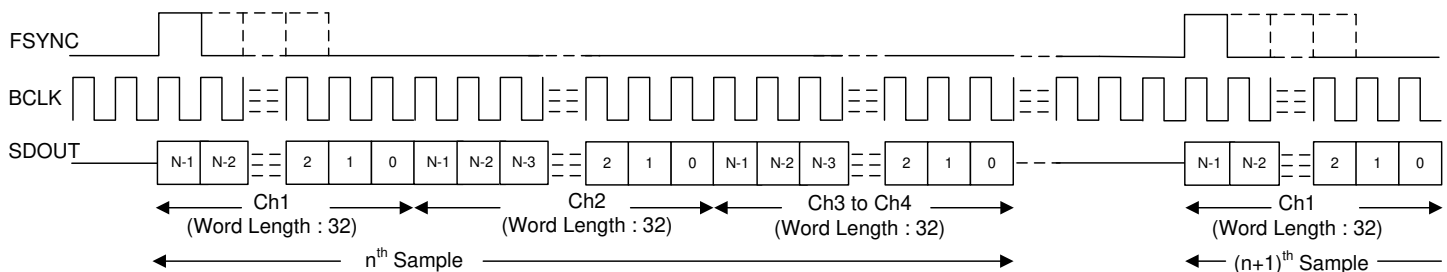


Figure 6-1. TDM Mode Protocol Timing (FMT0 = LOW) In Target Mode

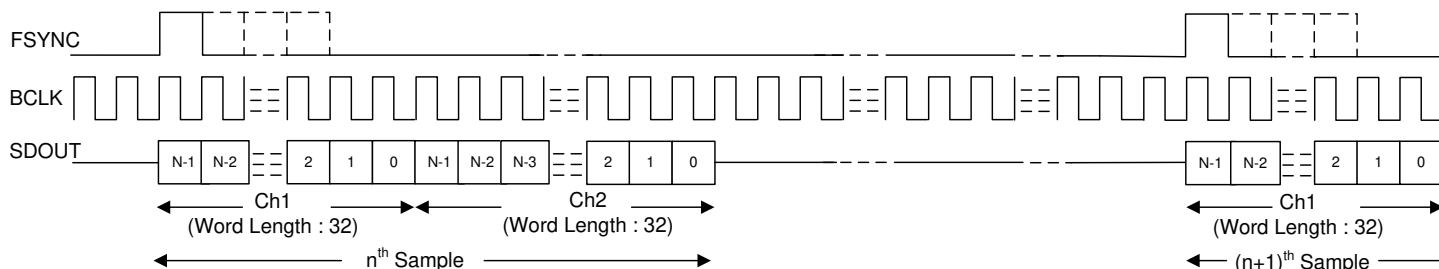


Figure 6-2. TDM Mode Protocol Timing (FMT0 = HIGH) In Target Mode

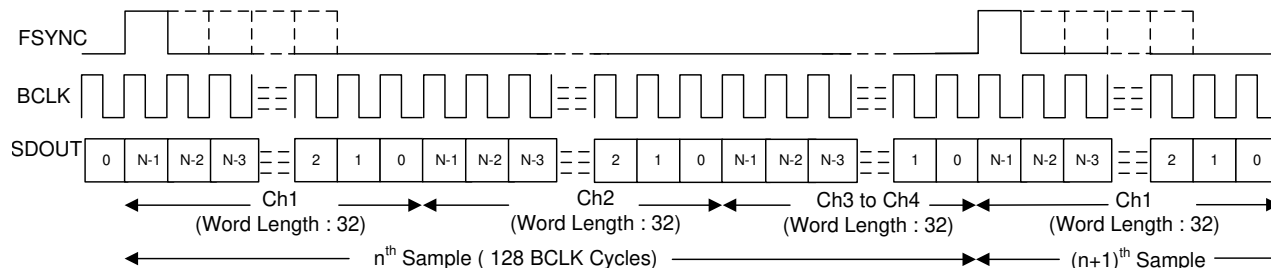


Figure 6-3. TDM Mode Protocol Timing (FMT0 = LOW) In Controller Mode

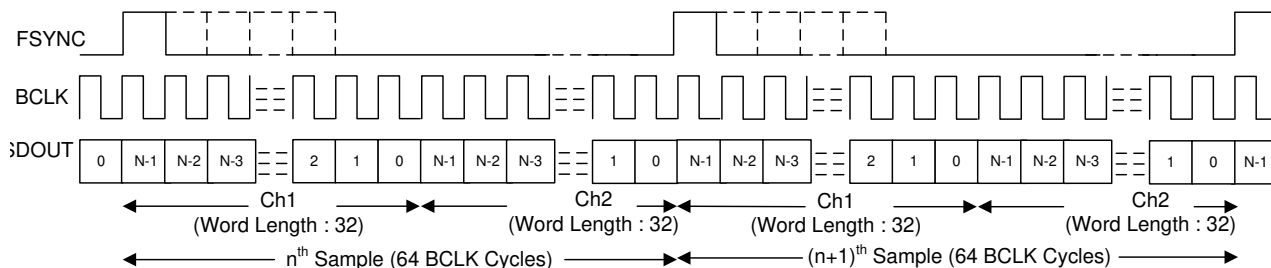


Figure 6-4. TDM Mode Protocol Timing (FMT0 = HIGH) In Controller Mode

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.

6.3.2.2 Inter IC Sound (I²S) Interface

The standard I²S protocol is defined for only two channels: left and right. In I²S 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 controller mode, FSYNC is transmitted on the rising edge of BCLK. [Figure 6-5](#) and [Figure 6-6](#) illustrate the protocol timing for I²S operation in target and controller mode of operation.

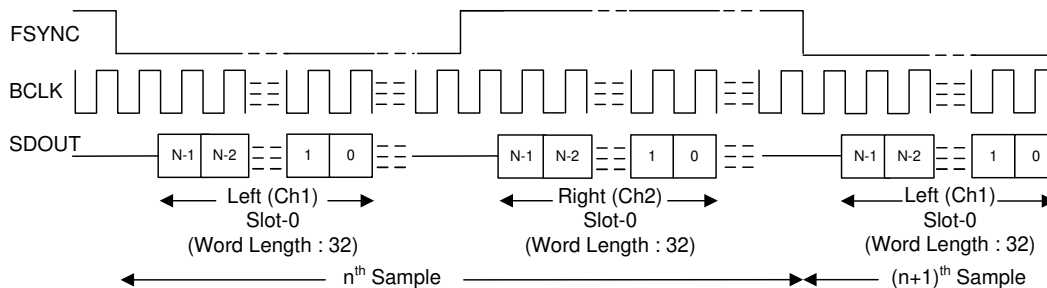


Figure 6-5. I²S Mode Protocol Timing in Target Mode

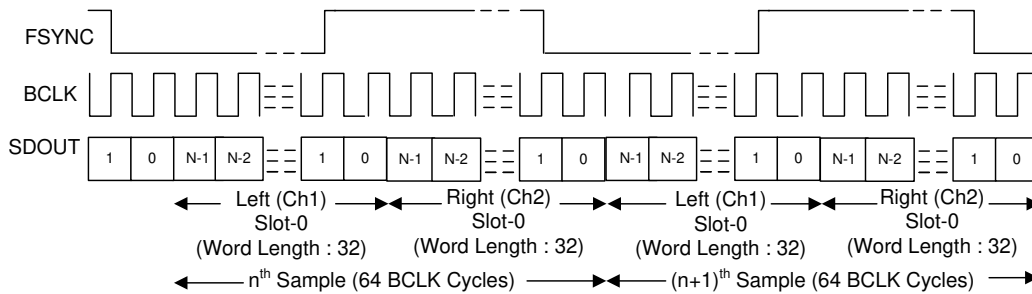


Figure 6-6. I²S Protocol Timing In Controller Mode

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 at least Word length(32-bits) times number of active left channels, BCLK cycles wide. Similarly, the FSYNC high pulse must be at least Word length(32-bits) times number of active right channels, BCLK cycles wide. The device transmits zero data value on SDOUT for the extra unused bit clock cycles.

6.3.2.3 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 controller mode, FSYNC is transmitted on the rising edge of BCLK. [Figure 6-7](#) and [Figure 6-8](#) illustrate the protocol timing for LJ operation in target and controller mode of operation.

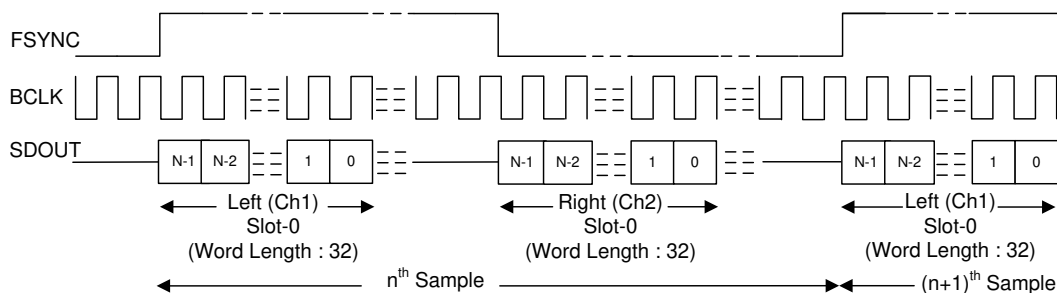


Figure 6-7. LJ Mode Protocol Timing In Target Mode

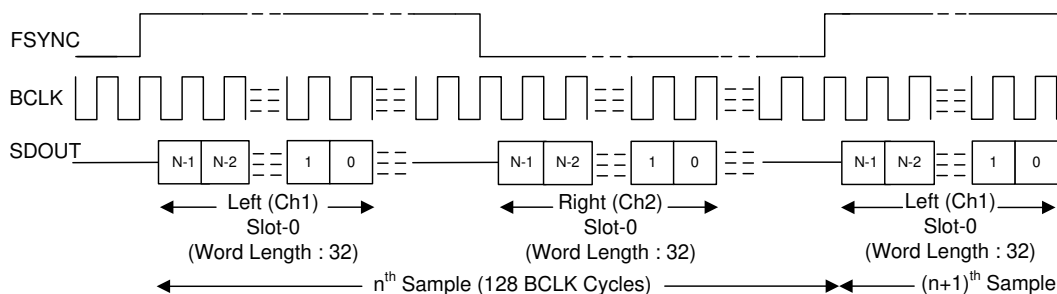


Figure 6-8. LJ Mode Protocol Timing In Controller Mode

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-bit word length of the output channel data. The device FSYNC high pulse must be at least Word length(32-bits) times number of active left channels, BCLK cycles wide. Similarly, the FSYNC low pulse must be at least Word length(32-bits) times number of active right channels, BCLK cycles wide. The device transmits zero data value on SDOUT for the extra unused bit clock cycles.

6.3.3 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 target 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 6-3](#) and [Table 6-4](#) list the supported FSYNC and BCLK frequencies.

Table 6-3. Supported FSYNC (Multiples or Submultiples of 48kHz) and BCLK Frequencies

BCLK TO FSYNC RATIO	BCLK (MHz)						
	FSYNC (8kHz)	FSYNC (16kHz)	FSYNC (24kHz)	FSYNC (32kHz)	FSYNC (48kHz)	FSYNC (96kHz)	FSYNC (192kHz)
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 6-4. Supported FSYNC (Multiples or Submultiples of 44.1kHz) and BCLK Frequencies

BCLK TO FSYNC RATIO	BCLK (MHz)						
	FSYNC (7.35kHz)	FSYNC (14.7kHz)	FSYNC (22.05kHz)	FSYNC (29.4kHz)	FSYNC (44.1kHz)	FSYNC (88.2kHz)	FSYNC (176.4kHz)
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 controller 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 6-5](#) shows the system clock selection for the controller mode using the MD0 pin.

Table 6-5. System Clock Selection for the Controller Mode

MD0	SYSTEM CLOCK SELECTION (Valid for Controller 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 6-7](#) and [Table 6-20](#) for the MD0 and MD1 pin function in the target mode of operation.

6.3.4 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 the 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. For better distortion performance, use the low-voltage coefficient capacitors for AC coupling. The device has the typical input impedance on INxP or INxM as 2.5k Ω on each pin. 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. The device has a quick charge scheme that increases the charging speed of the coupling capacitor at power-up. The default value of the quick-charge timing is set for a coupling capacitor up to 1 μ F.

6.3.5 Reference Voltage

All audio data converters require a DC reference voltage. The PCM1841-Q1 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 μ F capacitor connected from the VREF pin to analog ground (AVSS). The value of this reference voltage, VREF, is set to 2.75V, which in turn supports a 2V_{RMS} differential full-scale input to the device. The required minimum AVDD voltage for this VREF voltage is 3V. Do not connect any external load to a VREF pin.

6.3.6 Microphone Bias

The device integrates a built-in, low-noise, 1.6 μ V_{RMS} microphone bias pin with an output voltage of 2.75V 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 20mA 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 microphones 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.

6.3.7 Signal-Chain Processing

The PCM1841-Q1 signal chain is comprised of very-low-noise, high-performance, low-power analog blocks and highly flexible, programmable digital processing blocks. This high performance and flexibility, combined with a compact package, makes the PCM1841-Q1 excellent for a variety of end-equipments and applications that require multichannel audio capture. Figure 6-9 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.

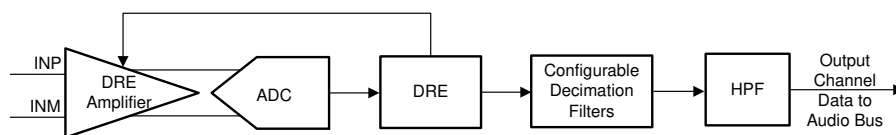


Figure 6-9. Signal-Chain Processing Flowchart

The front-end, dynamic range enhancer (DRE) gain amplifier is very low noise, with a 123dB dynamic range performance. The front-end DRE gain amplifier enables the PCM1841-Q1 to record a far-field audio signal with very high fidelity along with a low-noise and low-distortion, multibit, delta-sigma ADC, in both 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 along 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 80kHz, which allows the high-frequency non-audio signal to be recorded by using a 176.4kHz (or higher) sample rate.

6.3.7.1 Digital High-Pass Filter

The device supports a fixed high-pass filter (HPF) with -3dB cut-off frequency of $0.00002083 \times f_s$ to remove the DC offset component and attenuate the undesired low-frequency noise content in the record data. The HPF is not a channel-independent filter but is globally applicable for all 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 6-6](#) shows the fixed -3dB cutoff frequency value.

Table 6-6. HPF Cutoff Frequency Value

-3dB CUTOFF FREQUENCY VALUE	-3dB CUTOFF FREQUENCY AT 16kHz SAMPLE RATE	-3dB CUTOFF FREQUENCY AT 48kHz SAMPLE RATE
$0.00002083 \times f_s$	0.33Hz	1Hz

6.3.7.2 Configurable Digital Decimation Filters

The device record channel includes a high dynamic range and built-in digital decimation filter to process the oversampled data from the multibit delta-sigma ($\Delta\Sigma$) modulator, which generates digital data at the same Nyquist sampling rate as the FSYNC rate. The decimation filter can be chosen from [Section 6.3.7.2.1](#) and [Section 6.3.7.2.2](#) only in target mode, depending on the required frequency response, group delay, and phase linearity requirements for the target application. The MD0 pin can select the decimation filter option. [Table 6-7](#) shows the decimation filter mode selection for the record channel.

Table 6-7. Decimation Filter Mode Selection for the Record Channel

MD0	DECIMATION FILTER MODE SELECTION (Supported Only in Target Mode)
LOW	Linear phase filters are used for the decimation in target mode. For controller mode, the device always uses linear phase filters for the decimation.
HIGH	Low latency filters are used for the decimation in target mode. For controller mode, the device always uses linear phase filters for the decimation.

6.3.7.2.1 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 [Section 6.3.7.2.1.1](#) through [Section 6.3.7.2.1.7](#).

6.3.7.2.1.1 Sampling Rate: 8kHz or 7.35kHz

Figure 6-10 and Figure 6-11 show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 8kHz or 7.35kHz. Table 6-8 lists the specifications for a decimation filter with an 8kHz or 7.35kHz sampling rate.

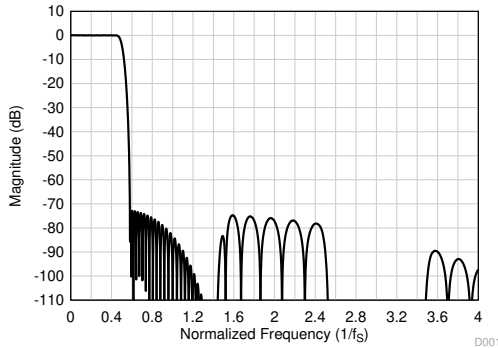


Figure 6-10. Linear Phase Decimation Filter Magnitude Response

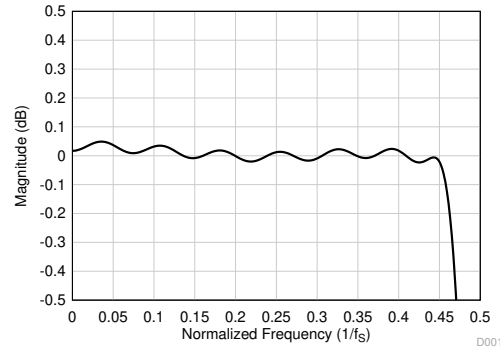


Figure 6-11. Linear Phase Decimation Filter Pass-Band Ripple

Table 6-8. 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		$1/f_s$

6.3.7.2.1.2 Sampling Rate: 16kHz or 14.7kHz

Figure 6-12 and Figure 6-13 show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 16kHz or 14.7kHz. Table 6-9 lists the specifications for a decimation filter with an 16kHz or 14.7kHz sampling rate.

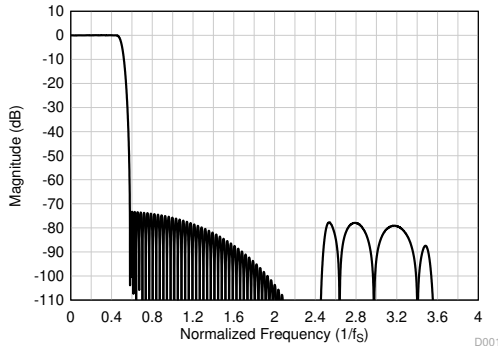


Figure 6-12. Linear Phase Decimation Filter Magnitude Response

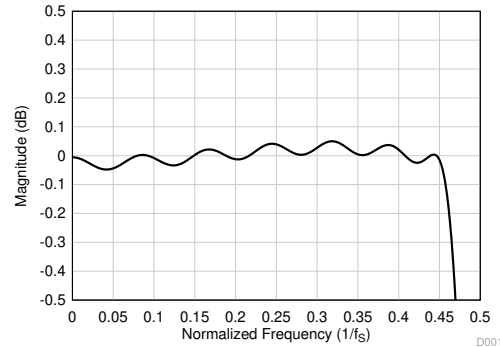


Figure 6-13. Linear Phase Decimation Filter Pass-Band Ripple

Table 6-9. 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			dB
	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		$1/f_s$

6.3.7.2.1.3 Sampling Rate: 24kHz or 22.05kHz

Figure 6-14 and Figure 6-15 show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 24kHz or 22.05kHz. Table 6-10 lists the specifications for a decimation filter with an 24kHz or 22.05kHz sampling rate.

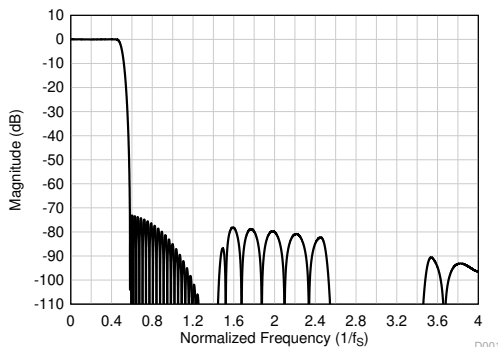


Figure 6-14. Linear Phase Decimation Filter Magnitude Response

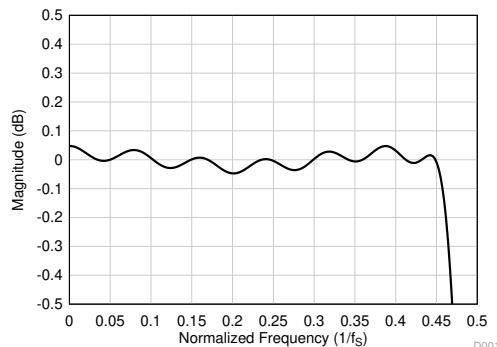


Figure 6-15. Linear Phase Decimation Filter Pass-Band Ripple

Table 6-10. 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			dB
	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		$1/f_s$

6.3.7.2.1.4 Sampling Rate: 32kHz or 29.4kHz

Figure 6-16 and Figure 6-17 show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 32kHz or 29.4kHz. Table 6-11 lists the specifications for a decimation filter with an 32kHz or 29.4kHz sampling rate.

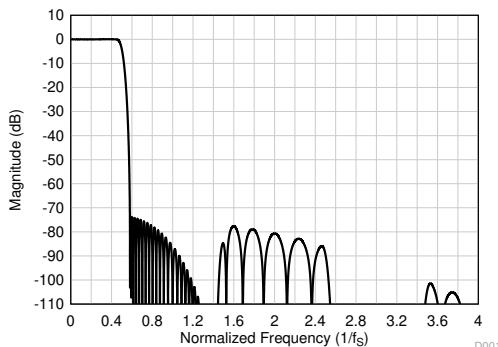


Figure 6-16. Linear Phase Decimation Filter Magnitude Response

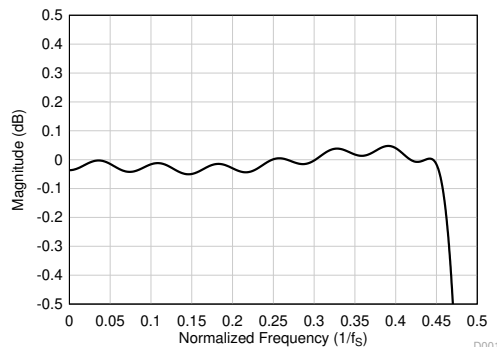


Figure 6-17. Linear Phase Decimation Filter Pass-Band Ripple

Table 6-11. 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			dB
	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		$1/f_s$

6.3.7.2.1.5 Sampling Rate: 48kHz or 44.1kHz

Figure 6-18 and Figure 6-19 show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 48kHz or 44.1kHz. Table 6-12 lists the specifications for a decimation filter with an 48kHz or 44.1kHz sampling rate.

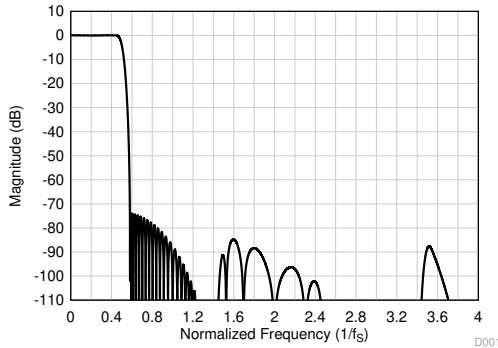


Figure 6-18. Linear Phase Decimation Filter Magnitude Response

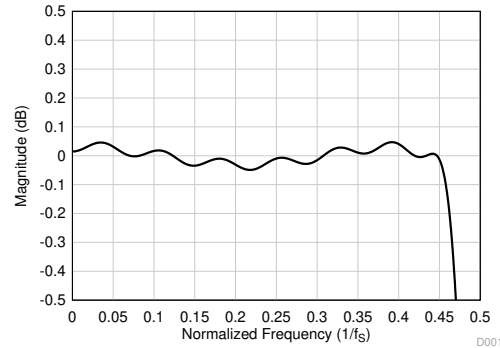


Figure 6-19. Linear Phase Decimation Filter Pass-Band Ripple

Table 6-12. 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			dB
	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		$1/f_s$

6.3.7.2.1.6 Sampling Rate: 96kHz or 88.2kHz

Figure 6-20 and Figure 6-21 show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 96kHz or 88.2kHz. Table 6-13 lists the specifications for a decimation filter with an 96-kHz or 88.2-kHz sampling rate.

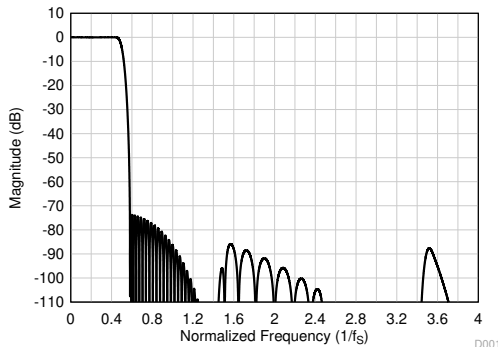


Figure 6-20. Linear Phase Decimation Filter Magnitude Response

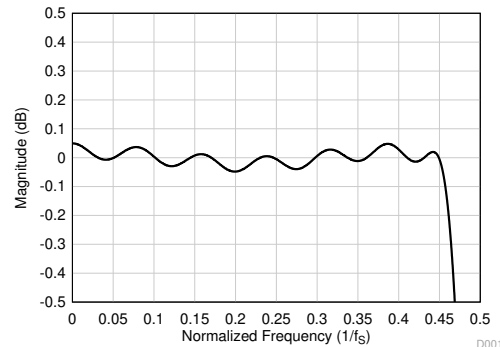


Figure 6-21. Linear Phase Decimation Filter Pass-Band Ripple

Table 6-13. 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			dB
	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		$1/f_s$

6.3.7.2.1.7 Sampling Rate: 192kHz or 176.4kHz

Figure 6-22 and Figure 6-23 show the magnitude response and the pass-band ripple for a decimation filter with a sampling rate of 192kHz or 176.4kHz. Table 6-14 lists the specifications for a decimation filter with an 192kHz or 176.4kHz sampling rate.

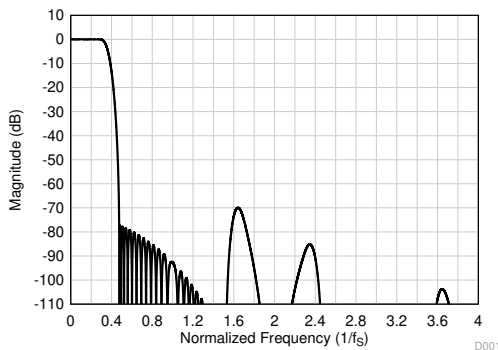


Figure 6-22. Linear Phase Decimation Filter Magnitude Response

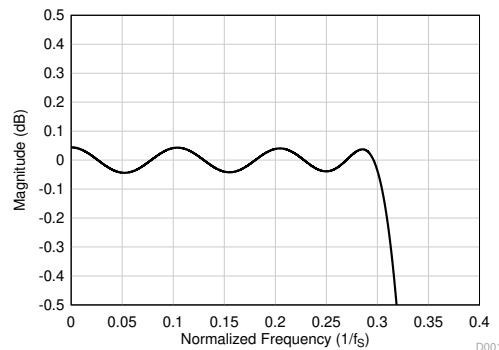


Figure 6-23. Linear Phase Decimation Filter Pass-Band Ripple

Table 6-14. 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			dB
	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		$1/f_s$

6.3.7.2.2 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 PCM1841-Q1 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. Section 6.3.7.2.2.1 through Section 6.3.7.2.2.5 provides the filter performance specifications and various plots for all supported output sampling rates for the low-latency filters.

6.3.7.2.2.1 Sampling Rate: 16kHz or 14.7kHz

Figure 6-24 shows the magnitude response and Figure 6-25 shows the pass-band ripple and phase deviation for a decimation filter with a sampling rate of 16kHz or 14.7kHz. Table 6-15 lists the specifications for a decimation filter with a 16kHz or 14.7kHz sampling rate.

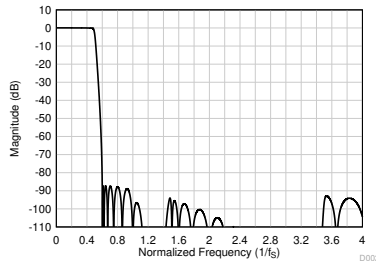


Figure 6-24. Low-Latency Decimation Filter Magnitude Response

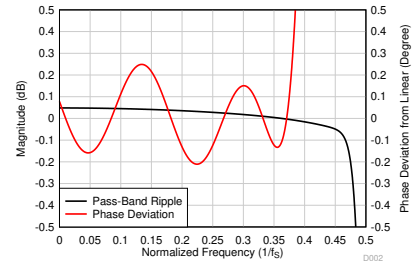


Figure 6-25. Low-Latency Decimation Filter Pass-Band Ripple and Phase Deviation

Table 6-15. 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

6.3.7.2.2.2 Sampling Rate: 24kHz or 22.05kHz

Figure 6-26 shows the magnitude response and Figure 6-27 shows the pass-band ripple and phase deviation for a decimation filter with a sampling rate of 24kHz or 22.05kHz. Table 6-16 lists the specifications for a decimation filter with a 24kHz or 22.05kHz sampling rate.

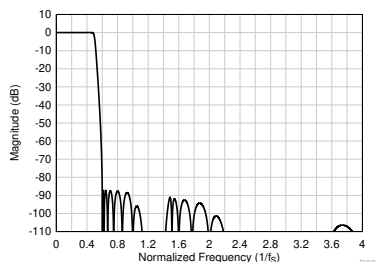


Figure 6-26. Low-Latency Decimation Filter Magnitude Response

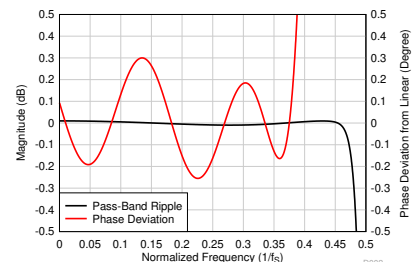


Figure 6-27. Low-Latency Decimation Filter Pass-Band Ripple and Phase Deviation

Table 6-16. 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

6.3.7.2.2.3 Sampling Rate: 32kHz or 29.4kHz

Figure 6-28 shows the magnitude response and Figure 6-29 shows the pass-band ripple and phase deviation for a decimation filter with a sampling rate of 32kHz or 29.4kHz. Table 6-17 lists the specifications for a decimation filter with a 32kHz or 29.4kHz sampling rate.

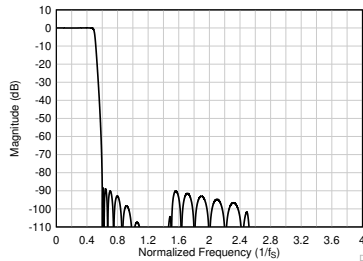


Figure 6-28. Low-Latency Decimation Filter Magnitude Response

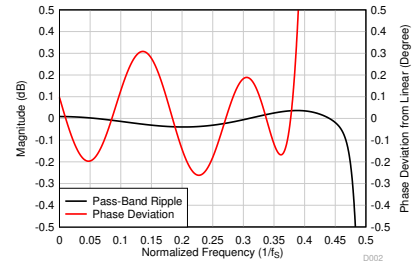


Figure 6-29. Low-Latency Decimation Filter Pass-Band Ripple and Phase Deviation

Table 6-17. 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

6.3.7.2.2.4 Sampling Rate: 48kHz or 44.1kHz

Figure 6-30 shows the magnitude response and Figure 6-31 shows the pass-band ripple and phase deviation for a decimation filter with a sampling rate of 48kHz or 44.1kHz. Table 6-18 lists the specifications for a decimation filter with a 48kHz or 44.1kHz sampling rate.

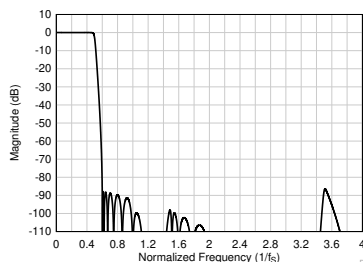


Figure 6-30. Low-Latency Decimation Filter Magnitude Response

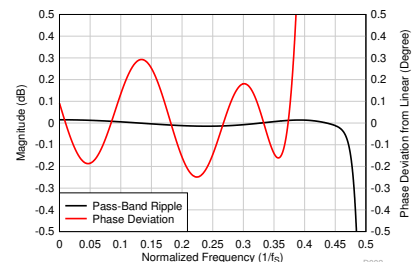


Figure 6-31. Low-Latency Decimation Filter Pass-Band Ripple and Phase Deviation

Table 6-18. 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

6.3.7.2.2.5 Sampling Rate: 96kHz or 88.2kHz

Figure 6-32 shows the magnitude response and Figure 6-33 shows the pass-band ripple and phase deviation for a decimation filter with a sampling rate of 96kHz or 88.2kHz. Table 6-19 lists the specifications for a decimation filter with a 96kHz or 88.2kHz sampling rate.

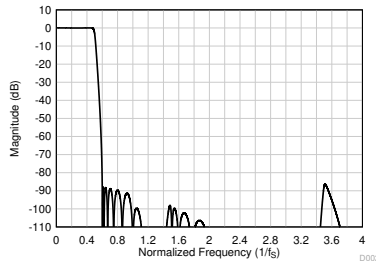


Figure 6-32. Low-Latency Decimation Filter Magnitude Response

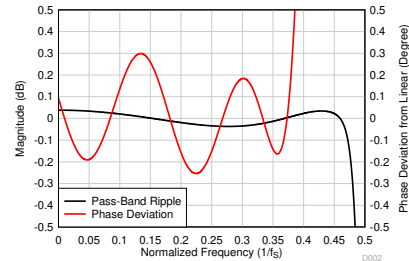


Figure 6-33. Low-Latency Decimation Filter Pass-Band Ripple and Phase Deviation

Table 6-19. 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

6.3.8 Dynamic Range Enhancer (DRE)

The device integrates an ultra-low noise, front-end DRE gain amplifier with 123dB dynamic range performance with a low-noise, low-distortion, multibit delta-sigma ($\Delta\Sigma$) ADC with a 113dB 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 123dB. 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 is enabled only in target mode by driving high to the MD1 pin. Table 6-20 shows the DRE selection for the record channel.

Table 6-20. DRE Selection for the Record Channel

MD1	DRE SELECTION (Supported Only in Target Mode)
LOW	DRE is disabled in target mode. For controller mode, DRE is always disabled.
HIGH	DRE is enabled with DRE_LVL = -36dB and DRE_MAXGAIN = 24dB in target mode. For controller 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 -36dB input signal level. The DRE gain range can be dynamically modulated by using DRE_MAXGAIN, which is fixed to 24dB 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 48kHz.

6.4 Device Functional Modes

6.4.1 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 25ms (typical).

6.4.2 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 20ms (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.

7 Application and Implementation

Note

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

7.1 Application Information

The PCM1841-Q1 is a multichannel, high-performance audio analog-to-digital converter (ADC) that supports output sample rates of up to 192kHz. The device supports up to four analog microphones for simultaneous recording applications.

The PCM1841-Q1 configuration is supported using various hardware pin control options. The device supports a highly flexible, audio serial interface (TDM, I²S, and LJ) to transmit audio data seamlessly in the system across devices.

7.2 Typical Application

Figure 7-1 shows a typical configuration of the PCM1841-Q1 for an application using four analog microelectrical-mechanical system (MEMS) microphones for simultaneous recording operation with a time-division multiplexing (TDM) audio data target interface. For best distortion performance, use input AC-coupling capacitors with a low-voltage coefficient.

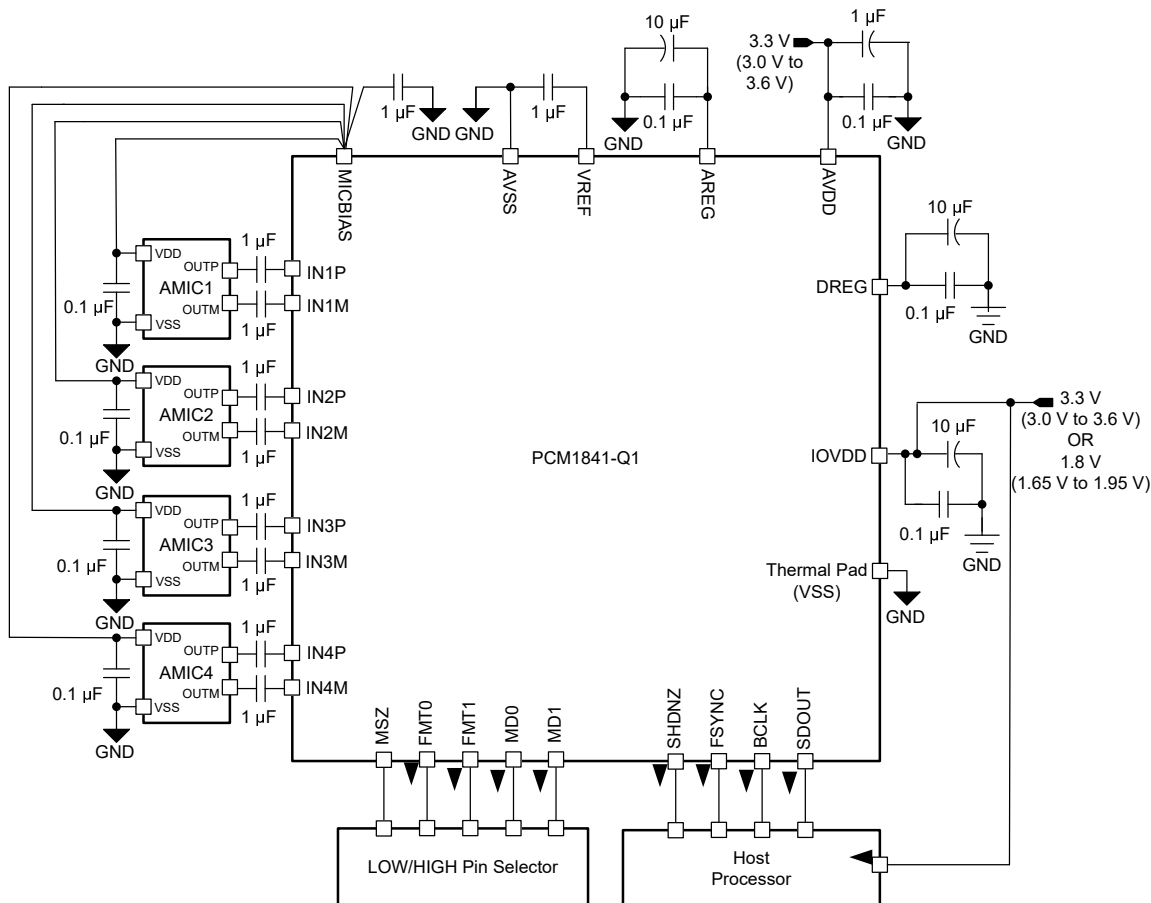


Figure 7-1. Four-Channel Analog Microphone Recording Diagram for 3.3V AVDD Operation

7.2.1 Design Requirements

Table 7-1 lists the design parameters for this application.

Table 7-1. Design Parameters

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

7.2.2 Detailed Design Procedure

This section describes the necessary steps to configure the PCM1841-Q1 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 < 1µA)
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 target 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)

7.2.3 Application Curves

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

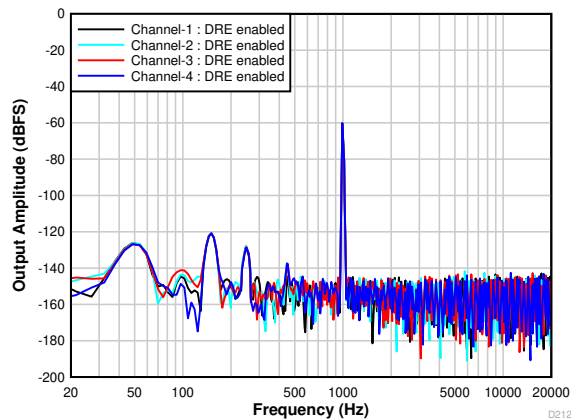


Figure 7-2. FFT With a -60dB Input With DRE Enabled

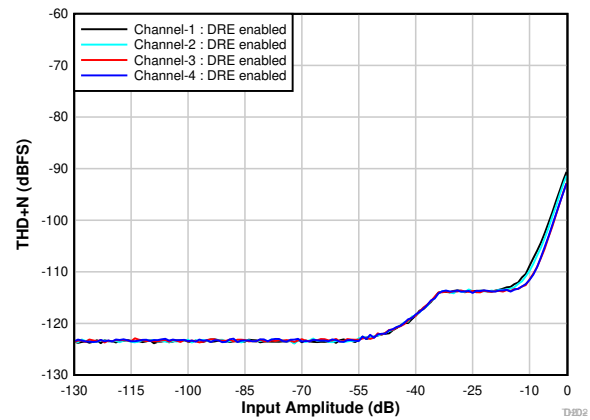


Figure 7-3. THD+N vs Input Amplitude With DRE Enabled

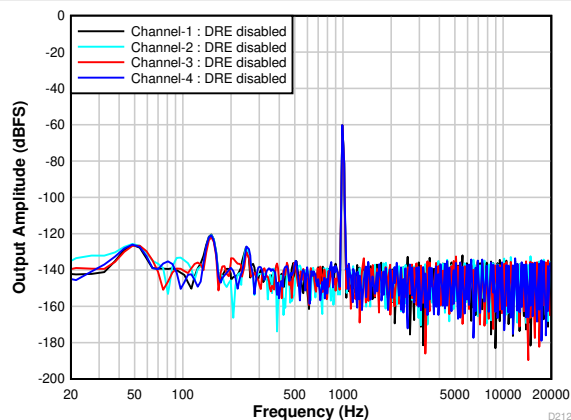


Figure 7-4. FFT With a -60dB Input With DRE Disabled

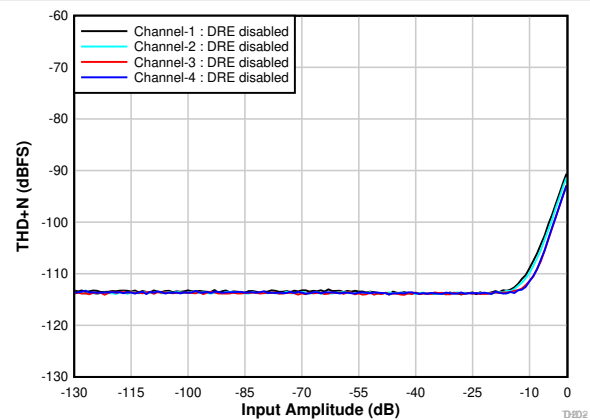


Figure 7-5. THD+N vs Input Amplitude With DRE Disabled

7.3 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 μ s. For the supply power-down requirement, t_3 and t_4 must be at least 10ms. This timing (as shown in Figure 7-6) 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.

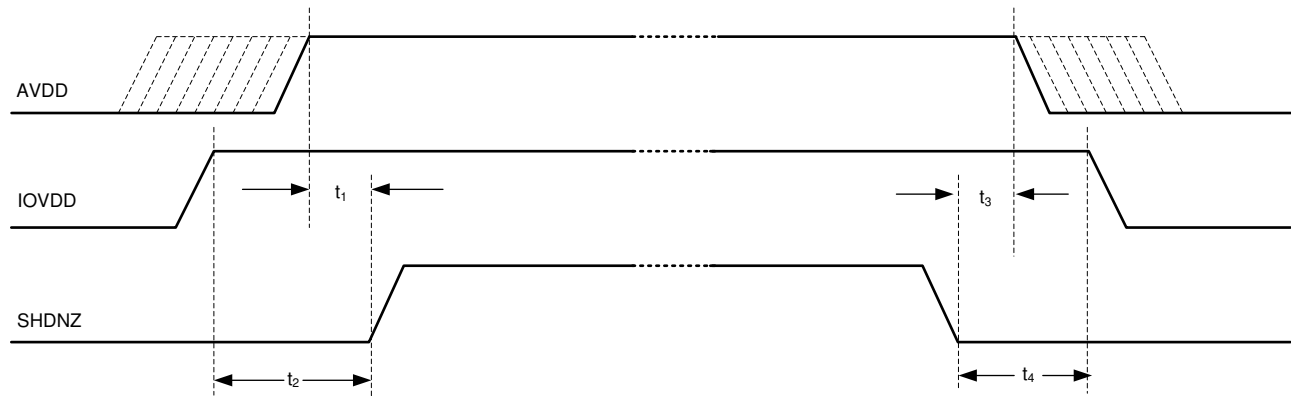


Figure 7-6. Power-Supply Sequencing Requirement Timing Diagram

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

The PCM1841-Q1 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 1.98V in the system, then short the AREG and AVDD pins onboard.

7.4 Layout

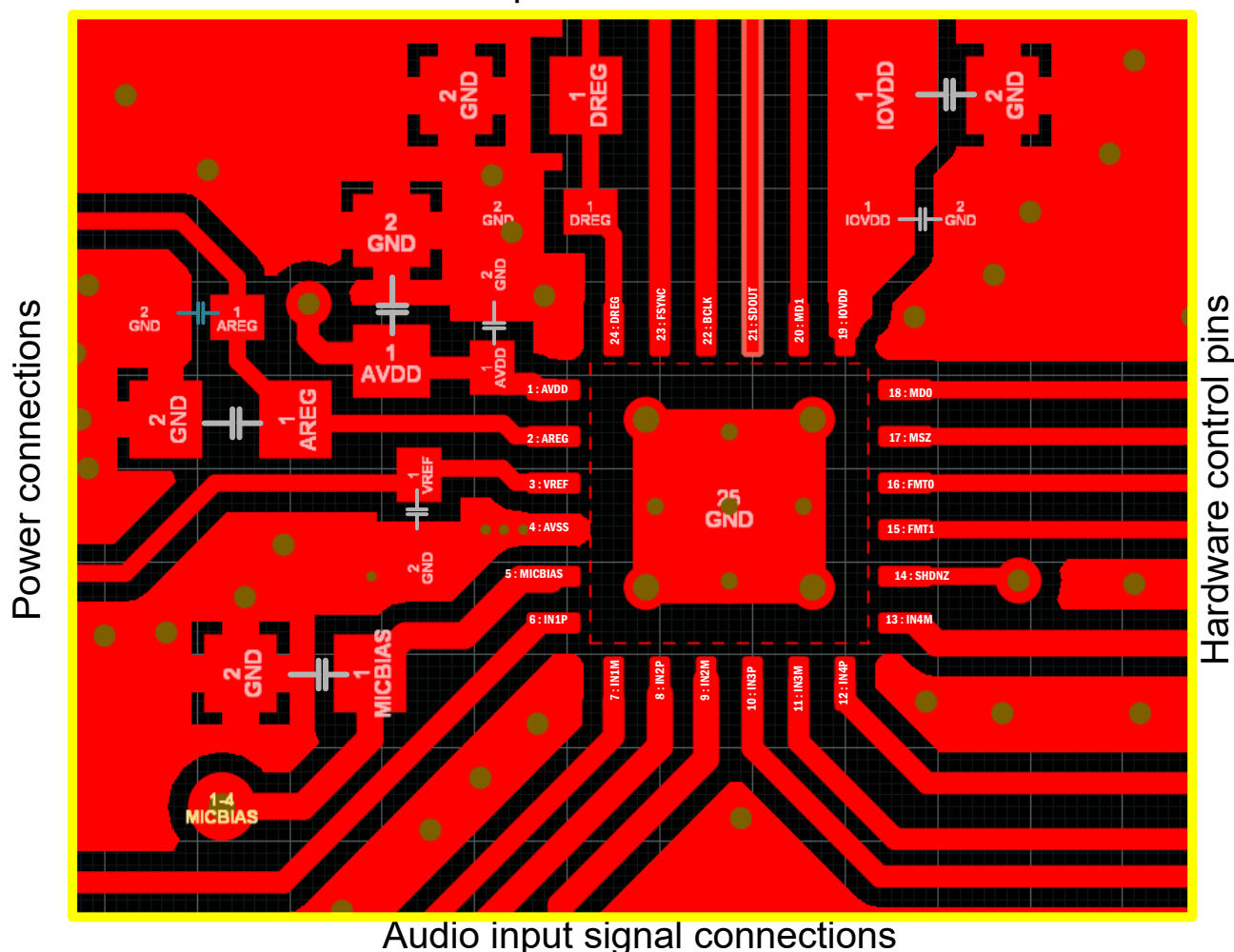
7.4.1 Layout Guidelines

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 maximize 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.

7.4.2 Layout Example

Audio output interface connections



Audio input signal connections

Figure 7-7. Example Layout

8 Device and Documentation Support

8.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](https://www.ti.com). Click on *Notifications* 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.

8.2 Support Resources

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

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8.3 Trademarks

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8.4 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.

8.5 Glossary

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

9 Revision History

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

DATE	REVISION	NOTES
May 2024	*	Initial Release

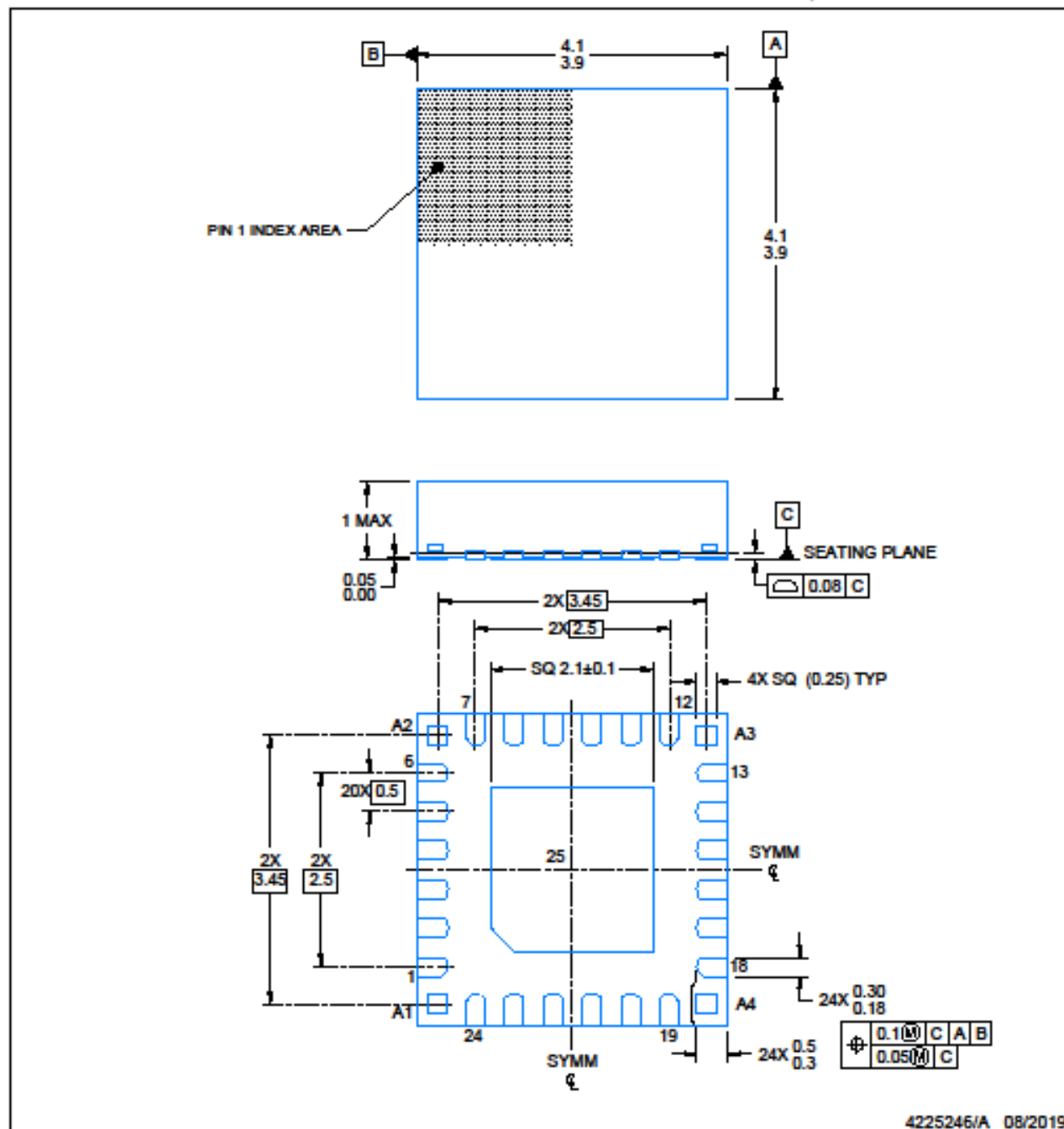
Mechanical, Packaging, and Orderable Information

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.

RGE0024R

PACKAGE OUTLINE VQFN - 1 mm max height

PLASTIC QUAD FLATPACK-NO LEAD



NOTES:

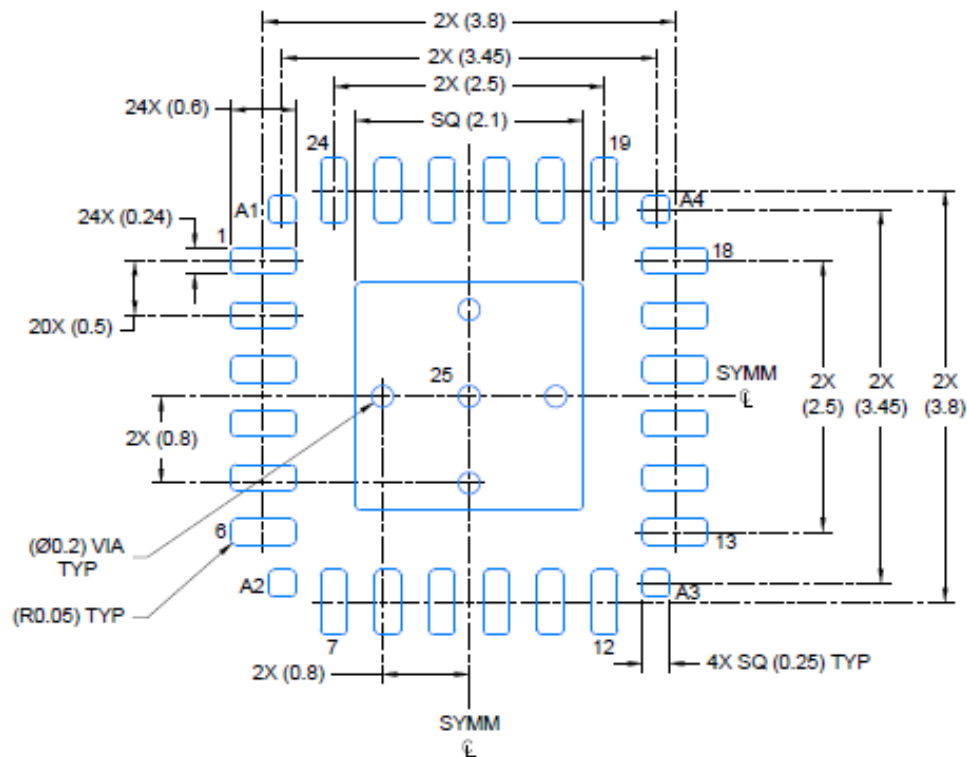
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical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

EXAMPLE BOARD LAYOUT

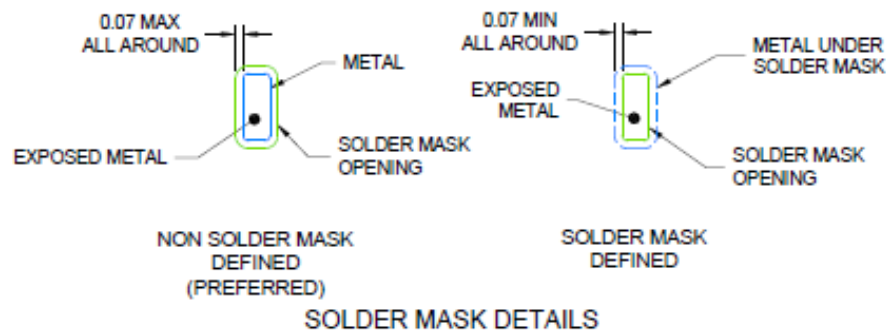
VQFN - 1 mm max height

RGE0024R

PLASTIC QUAD FLATPACK-NO LEAD



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE: 15X



4225246/A 08/2019

NOTES: (continued)

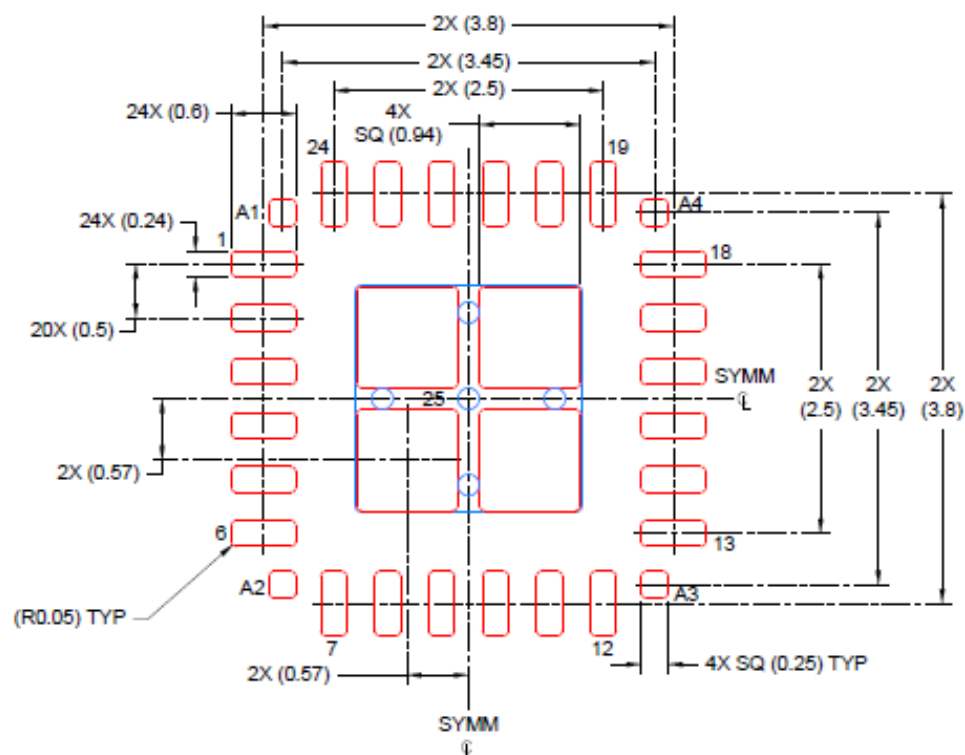
- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/sluea271).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown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

EXAMPLE STENCIL DESIGN

RGE0024R

VQFN - 1 mm max height

PLASTIC QUAD FLATPACK-NO LEAD



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL

EXPOSED PAD
80% PRINTED COVERAGE BY AREA
SCALE: 15X

4225246/A 08/2019

NOTES: (continued)

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

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)
PCM1841QRGERQ1	Active	Production	VQFN (RGE) 24	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	PCM1841 Q1
PCM1841QRGERQ1.A	Active	Production	VQFN (RGE) 24	3000 LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	PCM1841 Q1

⁽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.

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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



*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
PCM1841QRGERQ1	VQFN	RGE	24	3000	330.0	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)
PCM1841QRGERQ1	VQFN	RGE	24	3000	367.0	367.0	35.0

RGE 24

GENERIC PACKAGE VIEW

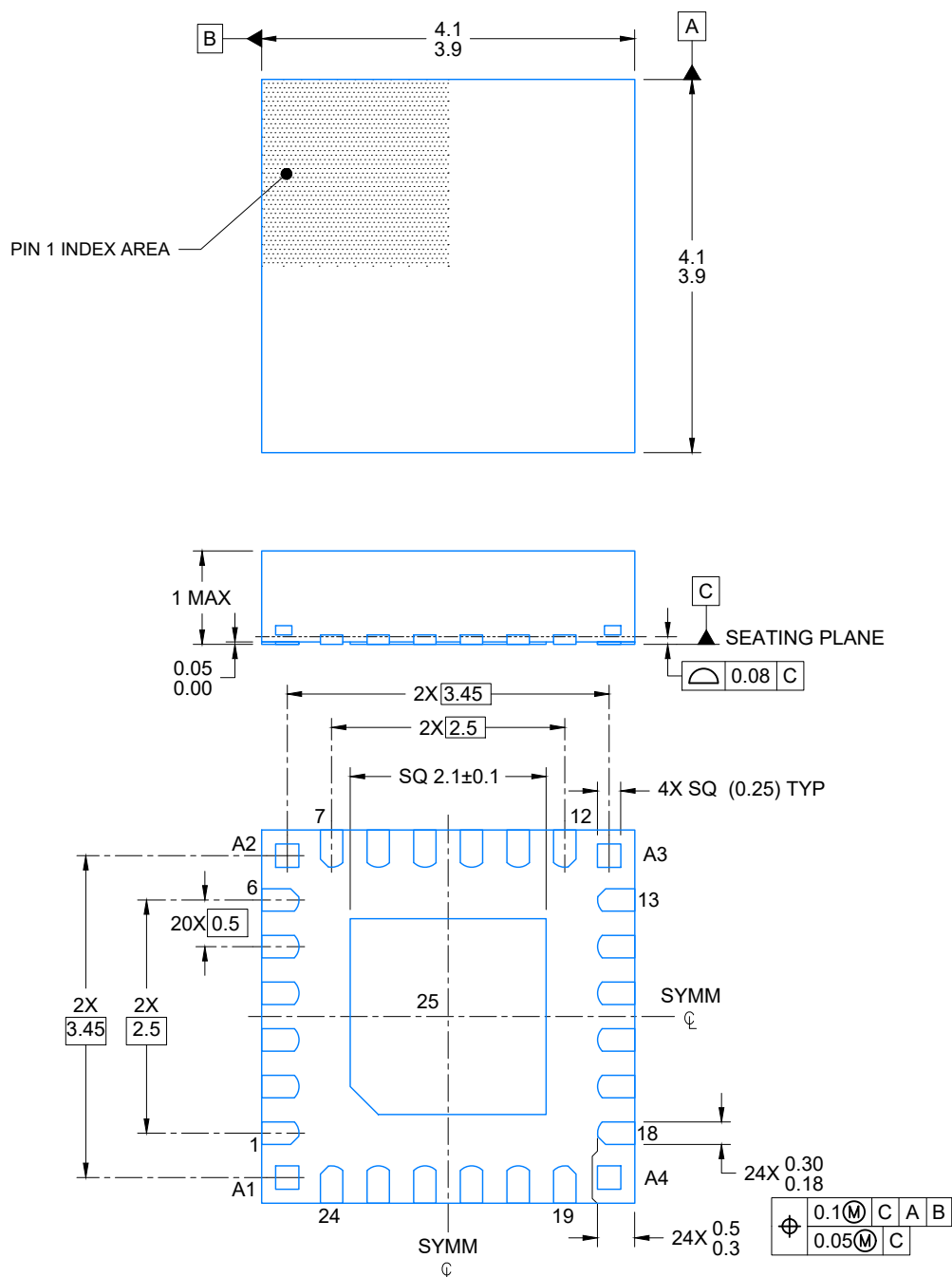
VQFN - 1 mm max height

PLASTIC QUAD FLATPACK - NO LEAD



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

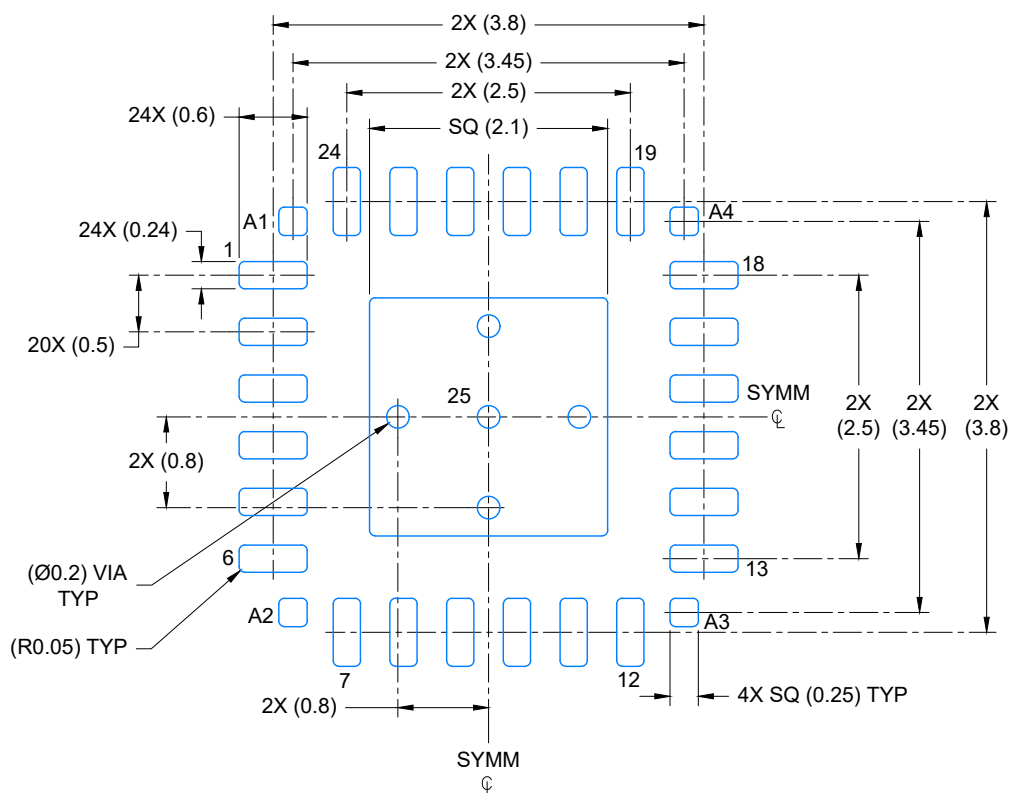
4204104/H



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NOTES:

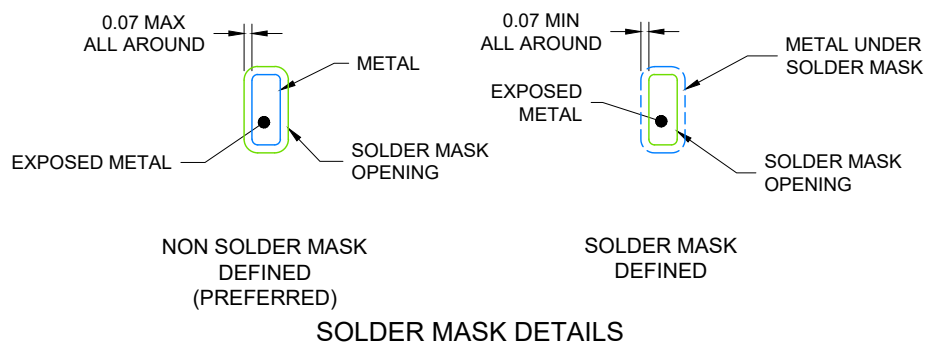
1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. The package thermal pad must be soldered to the printed circuit board for optimal thermal and mechanical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



LAND PATTERN EXAMPLE

EXPOSED METAL SHOWN

SCALE: 15X



4225246/A 08/2019

NOTES: (continued)

- This package is designed to be soldered to a thermal pad on the board. For more information, see Texas Instruments literature number SLUA271 (www.ti.com/lit/slue271).
- Vias are optional depending on application, refer to device data sheet. If any vias are implemented, refer to their locations shown on this view. It is recommended that vias under paste be filled, plugged or tented.

VQFN - 1 mm max height

Technical drawing of a 25-pin connector layout. The drawing shows a central 25-pin connector with dimensions in inches and millimeters. The layout is symmetrical (SYMM) about a vertical centerline (C). The dimensions are as follows:

- Overall width: 2X (3.8)
- Distance from centerline to the first pin: 2X (3.45)
- Distance between the first and last pins: 2X (2.5)
- Distance from the first pin to the centerline: 4X (0.94)
- Distance from the centerline to the last pin: 4X (0.94)
- Distance from the first pin to the centerline: 24X (0.6)
- Distance from the centerline to the last pin: 24X (0.6)
- Distance from the first pin to the centerline: 24X (0.24)
- Distance from the centerline to the last pin: 24X (0.24)
- Distance from the first pin to the centerline: 20X (0.5)
- Distance from the centerline to the last pin: 20X (0.5)
- Distance from the first pin to the centerline: 2X (0.57)
- Distance from the centerline to the last pin: 2X (0.57)
- Distance from the first pin to the centerline: 6 (0.152)
- Distance from the centerline to the last pin: 6 (0.152)
- Distance from the first pin to the centerline: 2X (0.57)
- Distance from the centerline to the last pin: 2X (0.57)
- Distance from the first pin to the centerline: 4X SQ (0.25) TYP
- Distance from the centerline to the last pin: 4X SQ (0.25) TYP
- Distance from the first pin to the centerline: 2X (2.5)
- Distance from the centerline to the last pin: 2X (2.5)
- Distance from the first pin to the centerline: 2X (3.45)
- Distance from the centerline to the last pin: 2X (3.45)
- Distance from the first pin to the centerline: 2X (3.8)
- Distance from the centerline to the last pin: 2X (3.8)

The drawing also includes labels for the pins (A1, A2, A3, A4, 1, 6, 7, 12, 13, 18, 19, 24, 25) and the centerline (C). The text (R0.05) TYP is also present.

EXPOSED PAD
80% PRINTED COVERAGE BY AREA
SCALE: 15X



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