AUDIO CODEC WITH USB INTERFACE, MONO MICROPHONE INPUT AND STEREO HEADPHONE OUTPUT

FEATURES

- On-Chip USB Interface:
  - With Full-Speed Transceivers
  - Fully Compliant with USB 2.0 Specification
  - Certified By USB-IF
  - Partially Programmable Descriptors
  - Adaptive Isochronous Transfer for Playback
  - Asynchronous Isochronous Transfer for Record
  - Bus Powered
- 16-Bit Delta-Sigma ADC and DAC
- Sampling Rate:
  - 8, 11.025, 16, 22.05, 32, 44.1, 48 kHz
- On-Chip Clock Generator:
  - With Single 6-MHz Clock Source
- Mono ADC with Microphone Input
  - Analog Performance at V_{BUS} = 5 V:
    - THD+N: 0.01%
    - SNR: 92 dB
    - Dynamic Range: 90 dB
  - Decimation Digital Filter
    - Passband Ripple: ±0.05 dB
    - Stop-Band Attenuation: –65 dB
  - Single-Ended Voltage Input
  - Antialiasing Filter Included
  - Digital HPF Included
  - Microphone Bias, Microphone Amplifier, and Input PGA
- Stereo DAC With Headphone Output
  - Analog Performance at V_{BUS} = 5.0 V:
    - THD+N: 0.01% (R_L > 10 kΩ)
    - THD+N: 0.02% (R_L = 32 Ω)
    - SNR: 92 dB
    - Dynamic Range: 90 dB
    - PO: 13 mW (R_L = 32 Ω)
    - PO: 25 mW (R_L = 16 Ω)
  - Oversampling Digital Filter
    - Passband Ripple: ±0.1 dB
    - Stop-Band Attenuation: –43 dB
    - Single-Ended Voltage Output
    - Analog LPF Included
    - Sidetone PGA, Output PGA, and HP Amplifier
- Multifunctions:
  - Suspend, Playback, and Record Status Flag
  - Microphone Amplifier, Mute, and Gain Control
- Pop/Click Noise-Free
- Single Power-Supply: 5 V Typ (V_{BUS})
- Package: 32-Pin TQFP

APPLICATIONS

- USB Headset
- USB Headphone
- USB Speaker
- USB Featured Consumer Audio Product
- USB Audio Interface Box
- USB Monitor
- Video Conference System

DESCRIPTION

The PCM2912A is the Texas Instruments single-chip, USB stereo audio codec with a USB 2.0-compliant full-speed protocol controller and an analog front-end (AFE) function for headset applications. The USB protocol controller works with no software code, but USB descriptors can be modified on request(1). The PCM2912A employs SpAct™ architecture, TI's unique system that recovers the audio clock from USB packet data. On-chip analog PLLs with SpAct enables independent playback and record sampling rates with low clock jitters.

(1) The descriptor can be modified by changing a mask; contact your local representative for details.

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.

ABSOLUTE MAXIMUM RATINGS(1)(2)

Over operating free-air temperature range (unless otherwise noted).

PARAMETER		PCM2912A	UNIT
Supply voltage	V_{BUS}	–0.3 to +6.5	V
Ground voltage differences: BGND, PGND, AGND, HGND, DGND		±0.1	V
Input voltage : V_{CCP}, V_{CCA}, V_{CCL}, V_{CCR}, V_{DD}		–0.3 to 4	V
Digital input voltage	$\overline{PLAY}$, $\overline{REC}$.	–0.3 to 6.5	V
	D+, D–, XTI, XTO, MMUTE, TEST0, TEST1, POWER, MAMP, $\overline{SSPND}$	–0.3 to 4	V
Analog input voltage	MBIAS, V_{IN}, V_{COM1}, V_{COM2}, $V_{OUT}L$, $V_{OUT}R$, FR, FL	–0.3 to 4	V
Input current (any pins except supplies)		±10	mA
Ambient temperature under bias		–40 to +125	°C
Storage temperature		–55 to +150	°C
Junction temperature		+150	°C

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

(2) All voltage values are with respect to network ground terminal.

RECOMMENDED OPERATING CONDITIONS

Over operating free-air temperature range (unless otherwise noted).

PARAMETER		MIN	NOM	MAX	UNIT
V_{BUS}	Supply voltage	4.35	5.00	5.25	V
	Analog input voltage, full scale (–0 dB)		0.43 V_{CCA}		V_{PP}
	Digital input logic family		TTL		
	Digital input clock frequency	5.997	6.000	6.003	MHz
	Analog output load resistance	32			Ω
	Analog output load capacitance			100	pF
	Digital output load capacitance			10	pF
T_A	Operating free-air temperature	–25		+70	°C

ELECTRICAL CHARACTERISTICS

All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

PARAMETER		TEST CONDITIONS	PCM2912A MIN	PCM2912A TYP	PCM2912A MAX	UNIT
DIGITAL INPUT/OUTPUT						
	Host interface	Apply USB revision 2.0, full-speed				
	Audio data format	USB isochronous data format				
INPUT LOGIC						
V_{IH}	Input logic level		2		3.3	VDC
V_{IL}					0.8	
I_{IH} (1)(2)	Input logic current	V_{IN} = 3.3 V			±10	µA
I_{IL} (1)(2)		V_{IN} = 0 V			±10	
I_{IH} (3)		V_{IN} = 3.3 V		65	100	µA
I_{IL} (3)		V_{IN} = 0 V			±10	
OUTPUT LOGIC						
V_{OH} (1)	Output logic level	I_{OH} = –10 mA	2.9			VDC
V_{OL} (1)		I_{OL} = 10 mA			0.3	
V_{OH} (4)		I_{OH} = –2 mA	2.8			
V_{OL} (4)		I_{OL} = 2 mA			0.5	
V_{OL} (5)		I_{OL} = 8 mA			0.5	
I_{OH} (5)	Output leak current	V_{IN} = 5 V			±10	µA
CLOCK FREQUENCY						
	Input clock frequency, XTI		5.997	6.000	6.003	MHz
MICROPHONE BIAS						
	Output voltage			0.75 V_{CCA}		VDC
	Output current			2		mA
	Output noise	R_L = 1 kΩ		5		μV_{RMS}

(1) Pins 3, 4: D–, D+.
(2) Pins 8, 23, 24, 27, 28: XTI, MAMP, POWER, TEST1, TEST0
(3) Pin 30: MMUTE
(4) Pins 7, 29: $\overline{\text{XTO}}$, $\overline{\text{SSPND}}$
(5) Pins 31, 32: $\overline{\text{REC}}$, $\overline{\text{PLAY}}$.

ELECTRICAL CHARACTERISTICS (continued)

All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

PARAMETER		TEST CONDITIONS	PCM2912A MIN	PCM2912A TYP	PCM2912A MAX	UNIT
ANALOG-TO-DIGITAL CONVERTER (ADC) CHARACTERISTICS						
	Resolution			16		Bits
	Audio data channel			1		Channel
	Sampling frequency			8, 11.025, 16, 22.05, 32, 44.1, 48		kHz
ADC Dynamic Performance(6)						
THD+N	Total harmonic distortion plus noise	V_{IN} = –1 dB of 0.43 V_{CCA}		0.01	0.02	%
	Dynamic range	A-weighted	82	90		dB
SNR	Signal-to-noise ratio	A-weighted	84	92		dB
ADC DC Accuracy						
	Gain error			±2	±10	% of FSR
	Bipolar zero error			±0		% of FSR
Analog Input						
	Input voltage			0.43 V_{CCA}		V_{PP}
	Center voltage			0.5 V_{CCA}		V
	Antialiasing filter frequency response	–3 dB		150		kHz
		f_{IN} = 20 kHz		–0.08		dB
Microphone Amplifier						
	Gain		0		20	dB
	Input impedance			20		kΩ
Input PGA						
	Gain range		–12		30	dB
	Gain step size			1		dB
ADC Digital Filter Performance						
	Passband				0.454 f_S	Hz
	Stop band		0.583 f_S			Hz
	Passband ripple				±0.02	dB
	Stop-band attenuation		–65			dB
	Delay time			17.4/f_S		s
	HPF frequency response	–3 dB		0.078 f_S/1000		Hz

(6) f_{IN} = 1 kHz, using Audio Precision™ System Two™, RMS mode with 20-kHz LPF, 400-Hz HPF in calculation. Mic amp = 0 dB, PGA = 0 dB.

ELECTRICAL CHARACTERISTICS (continued)

All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

PARAMETER		TEST CONDITIONS	PCM2912A MIN	PCM2912A TYP	PCM2912A MAX	UNIT
DIGITAL-TO-ANALOG CONVERTER (DAC) CHARACTERISTICS						
	Resolution			16		Bits
	Audio data channel			1, 2		Channel
	Sampling frequency			8, 11.025, 16, 22.05, 32, 44.1, 48		kHz
DAC Dynamic Performance(7)						
THD+N	Total harmonic distortion plus noise	R_L > 10 kΩ, V_{OUT} = 0 dB of 0.6 V_{CCA}		0.01	0.02	%
		R_L = 32 Ω, V_{OUT} = 0 dB of 0.55 V_{CCA}		0.02	0.05	%
	Dynamic range	EIAJ, A-Weighted	82	90		dB
SNR	Signal-to-noise ratio	EIAJ, A-Weighted	84	92		dB
	Channel separation	R_L > 10 kΩ	80	88		dB
DAC DC Accuracy						
	Gain mismatch channel-to-channel			±2	±10	% of FSR
	Gain error			±2	±10	% of FSR
	Bipolar zero error			±3		% of FSR
Analog Output						
	Output voltage	R_L > 10 kΩ		0.6 V_{CCA}		V_{PP}
		R_L = 32 Ω		0.55 V_{CCA}		
	Center voltage			0.5 V_{CCA}		V
	Output power	R_L = 32 Ω		13		mW
		R_L = 16 Ω		25		
	Load impedance (AC coupling)	Line	10			kΩ
		Headphone	16	32		Ω
	LPF frequency response	–3 dB		140		kHz
		f = 20 kHz		–0.1		dB
Sidetone Programmable Attenuator						
	Gain range		–76		0	dB
	Gain step size			1		dB
Output Programmable Attenuator						
	Gain range		–76		0	dB
	Gain step size			1		dB
Analog Loopback Performance(8)						
THD+N	Total harmonic distortion plus noise	R_L > 10 kΩ, V_{IN} = 0 dB of 0.43 V_{CCA}		0.01	0.02	%
		R_L = 32 Ω, V_{IN} = 0 dB of 0.43 V_{CCA}		0.02	0.05	%
	Dynamic range	EIAJ, A-weighted	82	90		dB
SNR	Signal-to-noise ratio	EIAJ, A-weighted	84	92		dB
DAC Digital Filter Performance						
	Passband				0.445 f_S	Hz
	Stop band		0.555 f_S			Hz
	Passband ripple				±0.1	dB
	Stop-band attenuation		–43			dB
	Delay time			14.3/f_S		s

(7) f_{OUT} = 1 kHz, using Audio Precision System Two, RMS mode with 20-kHz LPF, 400-Hz HPF. Output attenuator = 0 dB, Sidetone = Mute.
(8) MIC Amp = 0 dB, Sidetone attenuator = 0 dB, Output attenuator = 0 dB.

ELECTRICAL CHARACTERISTICS (continued)

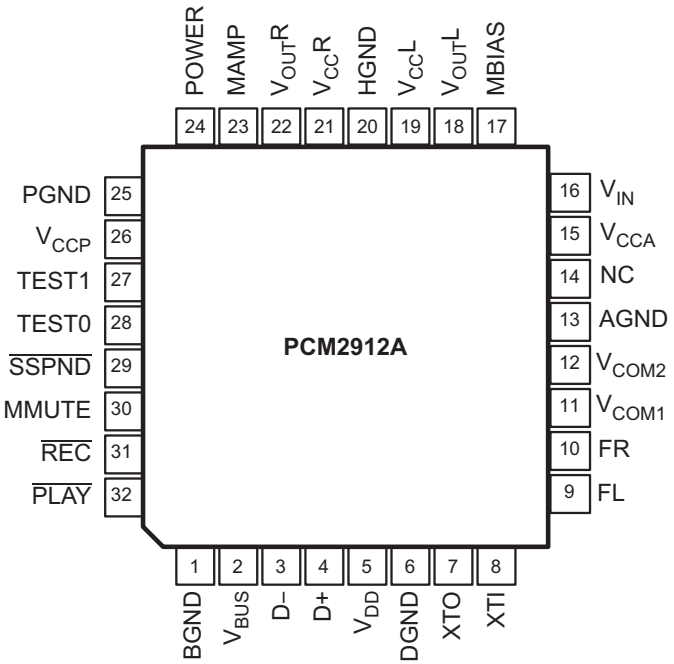
All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

PARAMETER		TEST CONDITIONS	PCM2912A			UNIT
			MIN	TYP	MAX	
POWER-SUPPLY REQUIREMENTS						
V_{BUS}	Voltage range	Bus-powered	4.35	5.0	5.25	VDC
	Supply current	ADC, DAC operation (R_L = 32 Ω)		85	100	mA
		Suspend mode(9)		220	300	µA
	Power dissipation	ADC, DAC Operation		425	500	mW
		Suspend mode(9)		0.8	1	mW
V_{CCP},V_{CCL}, V_{CCR},V_{CCA}, V_{DD}	Internally-generated power supply voltage(10)		3	3.3	3.6	VDC
TEMPERATURE RANGE						
	Operation temperature		–25		+85	°C
θ_{JA}	Thermal resistance	32-pin TQFP		80		°C/W

(9) Under USB suspend state
(10) Pins 5, 15, 19, 21, 26: V_{DD}, V_{CCA}, V_{CCL}, V_{CCR}, V_{CCP}.

PIN ASSIGNMENTS

PJT PACKAGE
TQFP-32
(TOP VIEW)

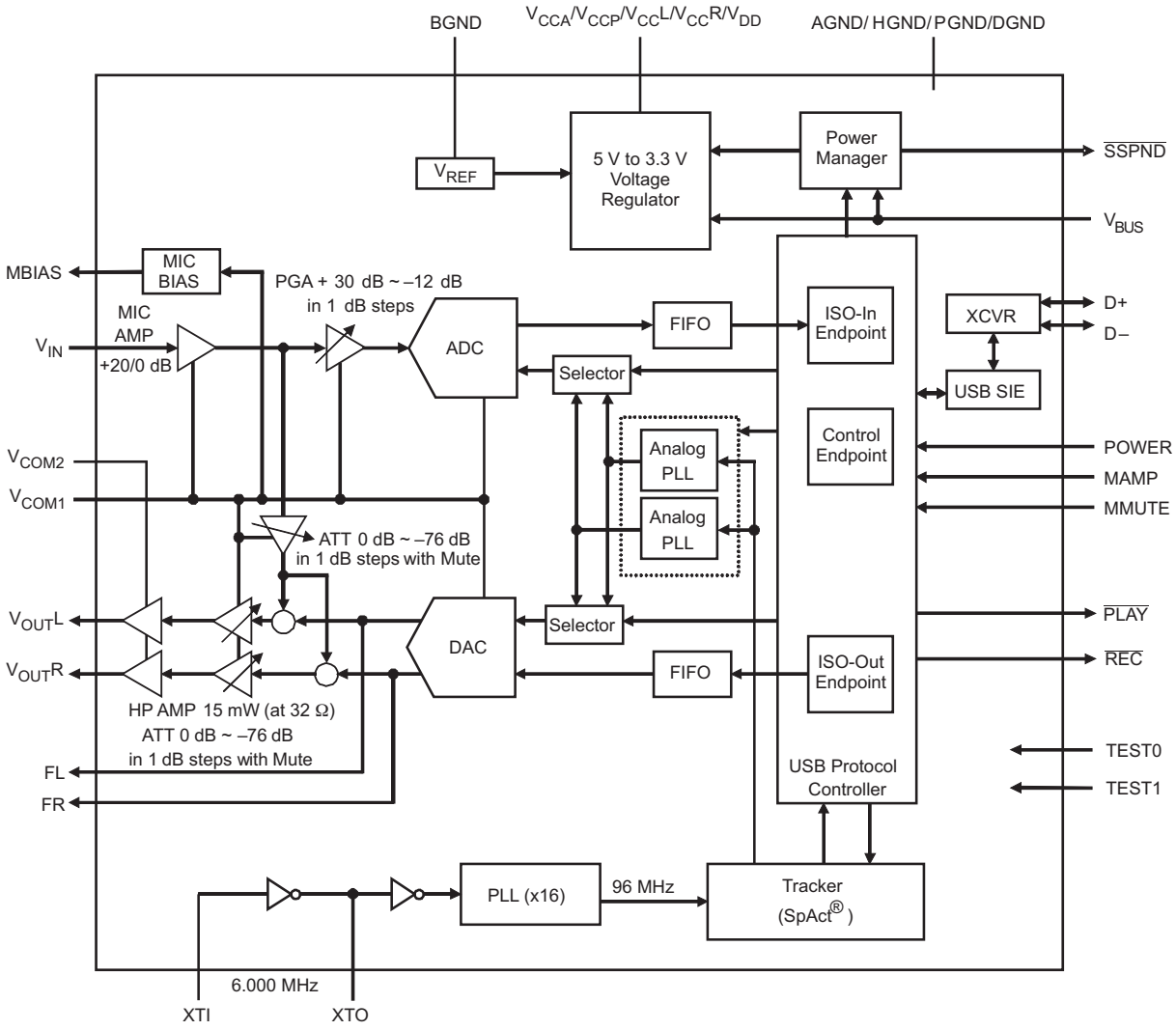


TERMINAL FUNCTIONS

TERMINAL		I/O	DESCRIPTIONS
NAME	PJT		
BGND	1	—	Reference for internal regulator.
V_{BUS}	2	—	Connect to USB power (V_{BUS})
D–	3	I/O	USB differential input/output minus (1)
D+	4	I/O	USB differential input/output plus (1)
V_{DD}	5	—	Digital power supply (2)
DGND	6		Digital ground
XTO	7	O	Crystal oscillator output
XTI	8	I	Crystal oscillator input (3)
FL	9	—	External filter pin of L-channel (optional)
FR	10	—	External filter pin of R-channel (optional)
V_{COM1}	11	—	Common voltage for ADC, DAC, and analog front-end (V_{CCA}/2). Decoupling capacitor should be connected to AGND.
V_{COM2}	12	—	Common voltage for headphone (V_{CCA}/2). Decoupling capacitor should be connected to AGND.
AGND	13	—	Analog ground
NC	14	—	Not connected
V_{CCA}	15	—	Analog power supply
V_{IN}	16	I	ADC microphone input
MBIAS	17	O	Microphone bias output (0.75 V_{CCA})
V_{OUT}L	18	O	Headphone output for L-channel
V_{CC}L	19	—	Analog power supply for headphone amplifier of L-channel (2)
HGND	20	—	Analog ground for headphone amplifier
V_{CC}R	21	—	Analog power supply for headphone amplifier of R-channel (2)
V_{OUT}R	22	O	Headphone output for R-channel
MAMP	23	I	Microphone preamplifier gain control (LOW: Preamplifier off, HIGH: Preamplifier on = +20 dB) (3)
POWER	24	I	Power consumption declaration select pin (LOW: 100 mA, HIGH: 500 mA) (3)
PGND	25	—	Analog ground for microphone bias, microphone amplifier, and PGA
V_{CCP}	26	—	Analog power supply for PLL (2)
TEST1	27	I	Test pin. Must be set to HIGH (3)
TEST0	28	I	Test pin. Must be set to LOW (3)
$\overline{\text{SSPND}}$	29	O	Suspend flag (LOW: Suspend, HIGH: Operational state)
MMUTE	30	I	Microphone mute control, active HIGH (LOW: Mute off, HIGH: Mute on) (4)
$\overline{\text{REC}}$	31	O	Status output for record (LOW: Record, FLASH: Mute on recode, HIGH: Stop) (5)
$\overline{\text{PLAY}}$	32	O	Status output for playback (LOW: Playback, FLASH: Mute on playback, HIGH: Stop) (5)

(1) LV-TTL level
(2) Connect decouple capacitor to corresponding ground.
(3) 3.3-V CMOS level input.
(4) 3.3-V CMOS level input with internal pulldown.
(5) 5-V tolerant, open-drain.

FUNCTIONAL BLOCK DIAGRAM



TYPICAL CHARACTERISTICS: INTERNAL FILTER

All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

ADC Digital Decimation Filter Frequency Response

OVERALL CHARACTERISTIC

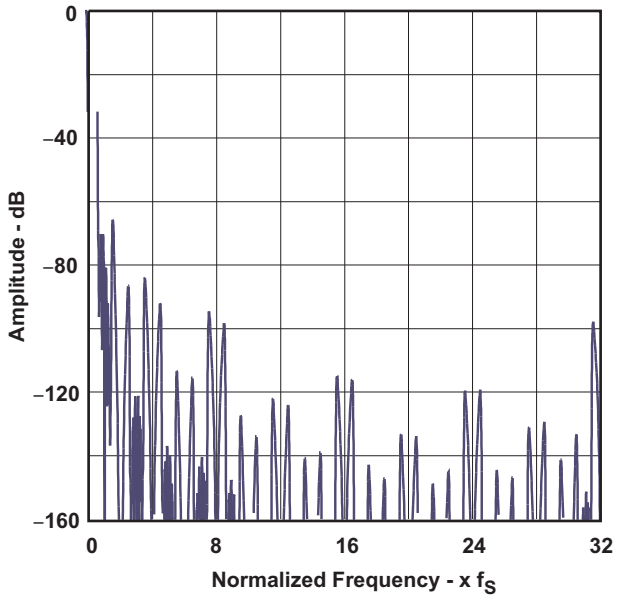


Figure 1.

STOP BAND ATTENUATION

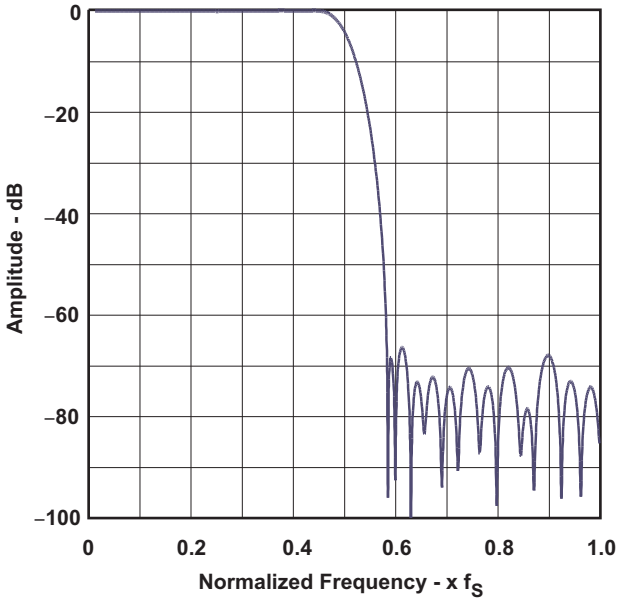


Figure 2.

PASSBAND RIPPLE

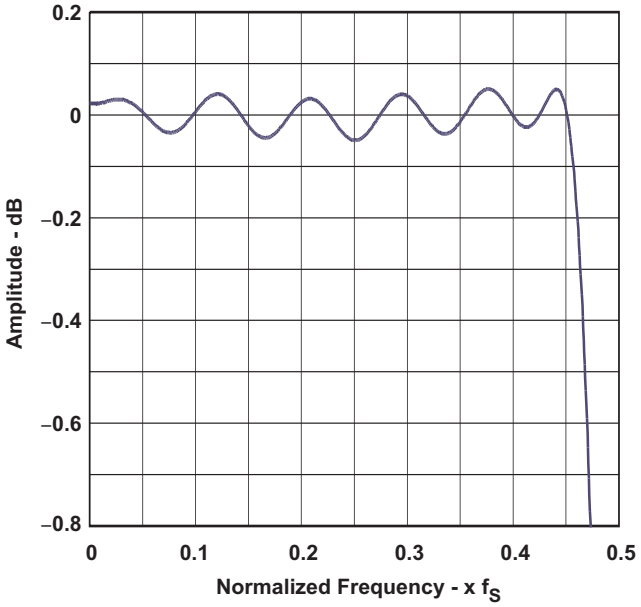


Figure 3.

TRANSIENT BAND RESPONSE

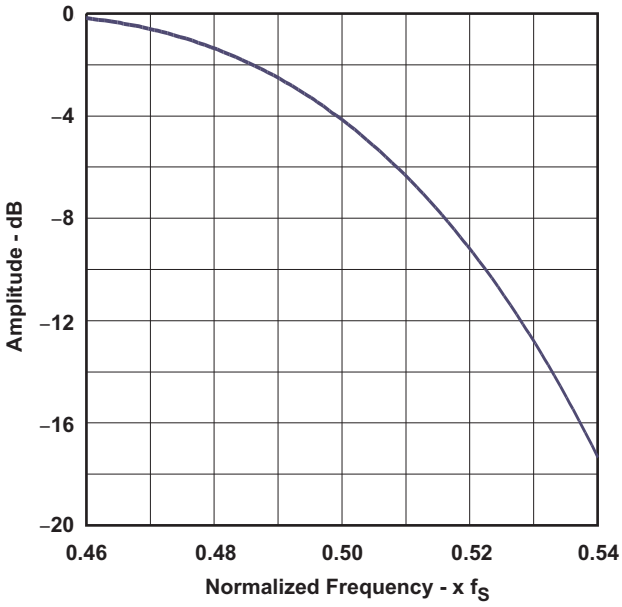


Figure 4.

TYPICAL CHARACTERISTICS: INTERNAL FILTER (continued)

All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

ADC Digital High-Pass Filter Frequency Response

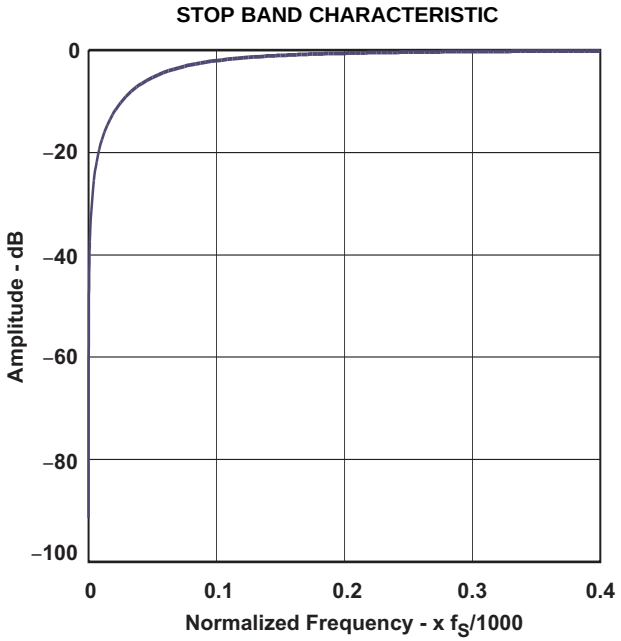


Figure 5.

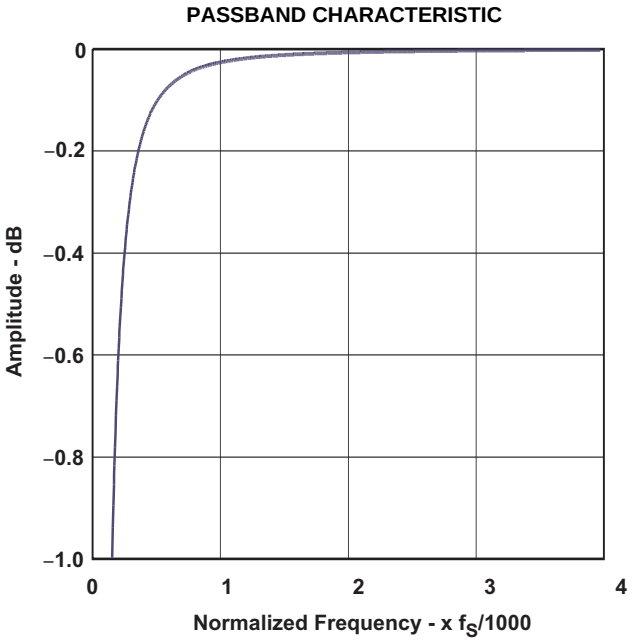


Figure 6.

ADC Analog Antialiasing Filter Frequency Response

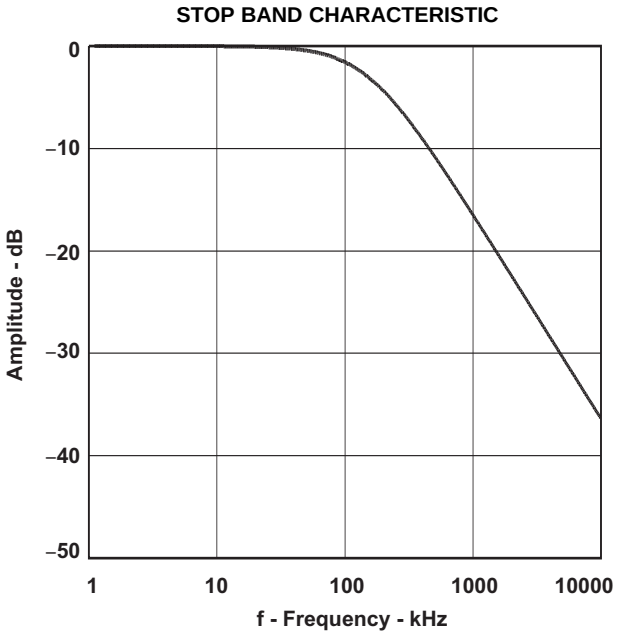


Figure 7.

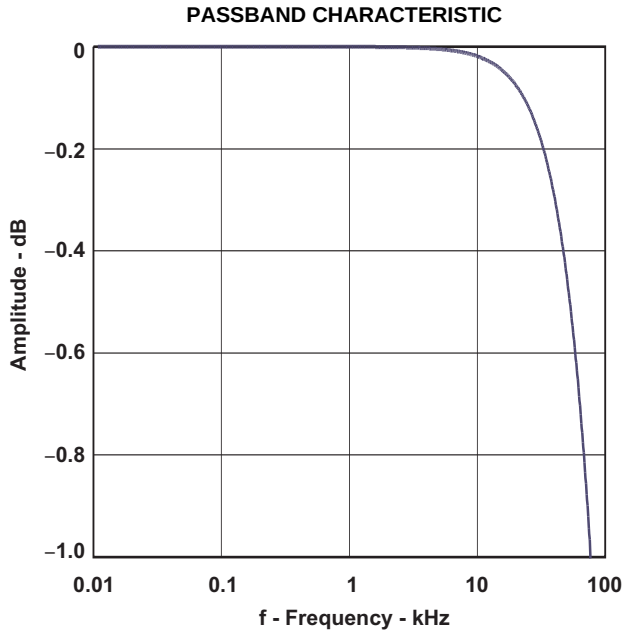


Figure 8.

TYPICAL CHARACTERISTICS: INTERNAL FILTER (continued)

All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

DAC Digital Interpolation Filter Frequency Response

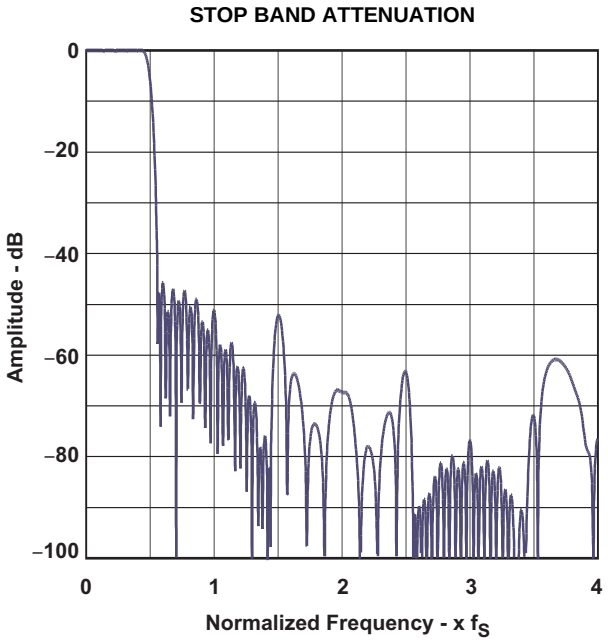


Figure 9.

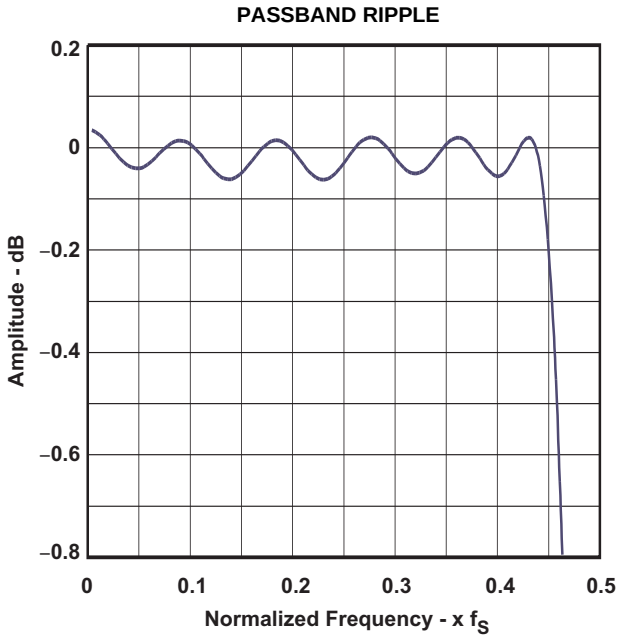


Figure 10.

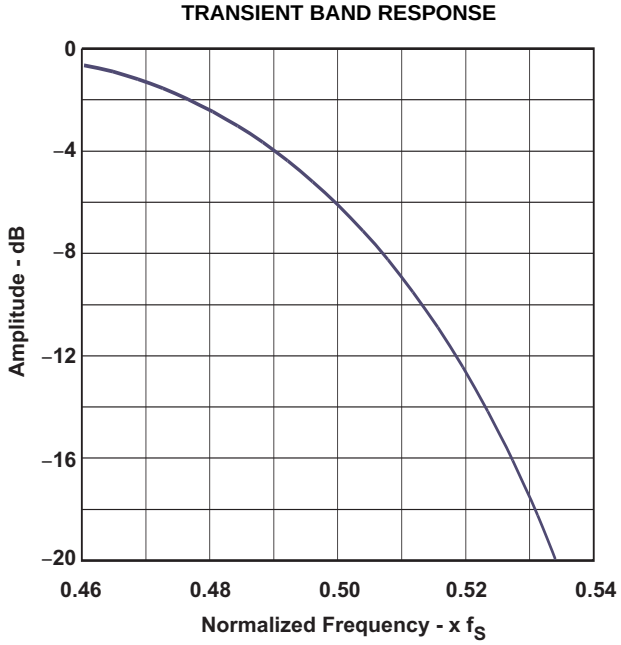


Figure 11.

TYPICAL CHARACTERISTICS: INTERNAL FILTER (continued)

All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

DAC Analog FIR Filter Frequency Response

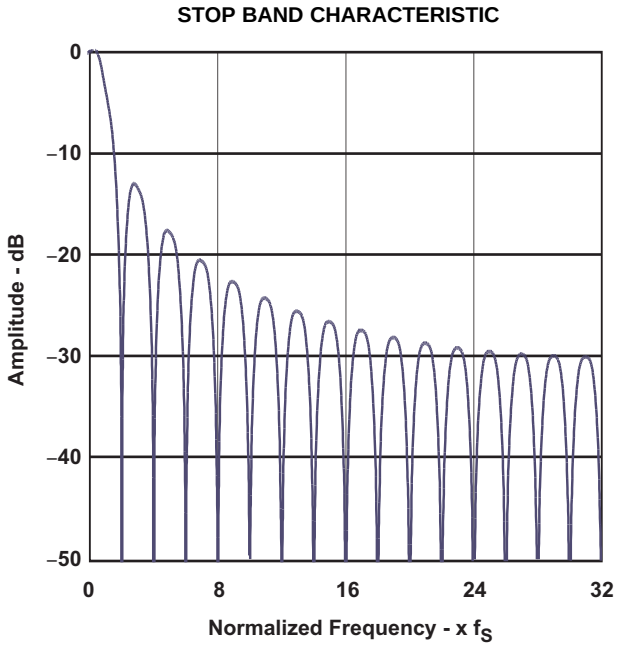


Figure 12.

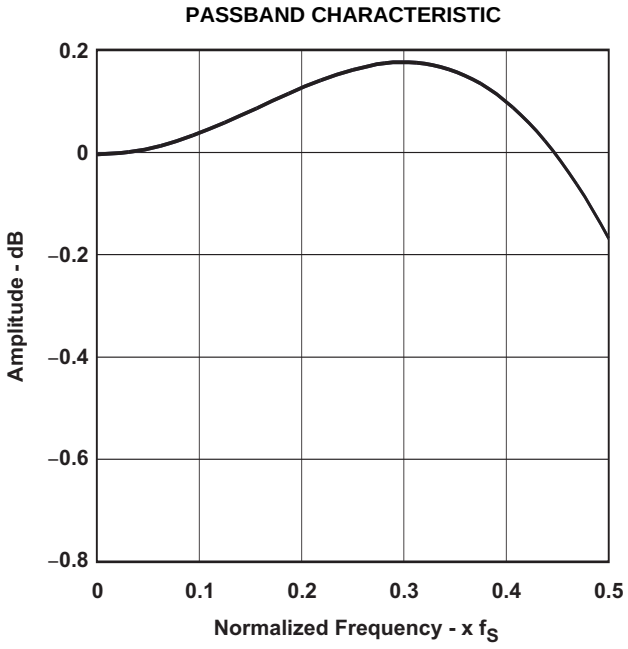


Figure 13.

DAC Analog Low-Pass Filter Frequency Response

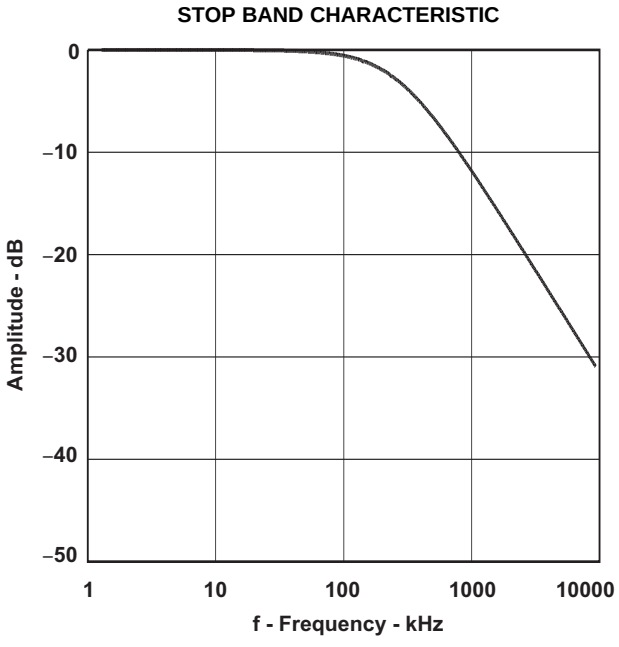


Figure 14.

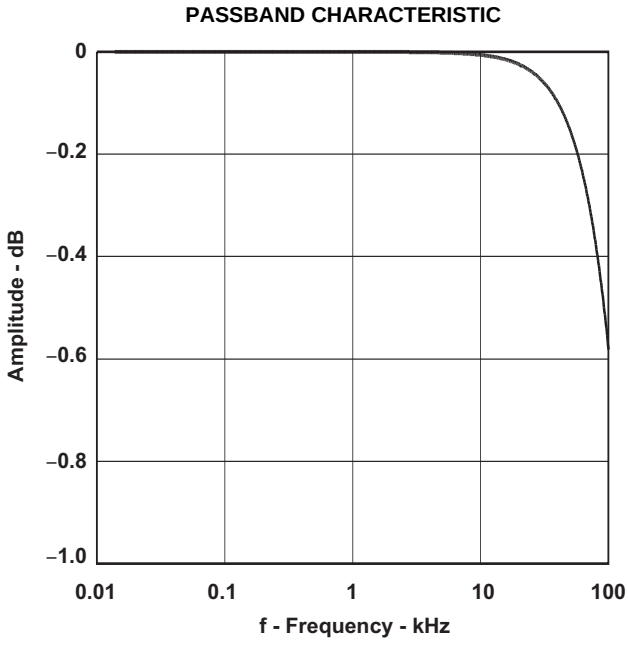


Figure 15.

TYPICAL CHARACTERISTICS

All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

ADC

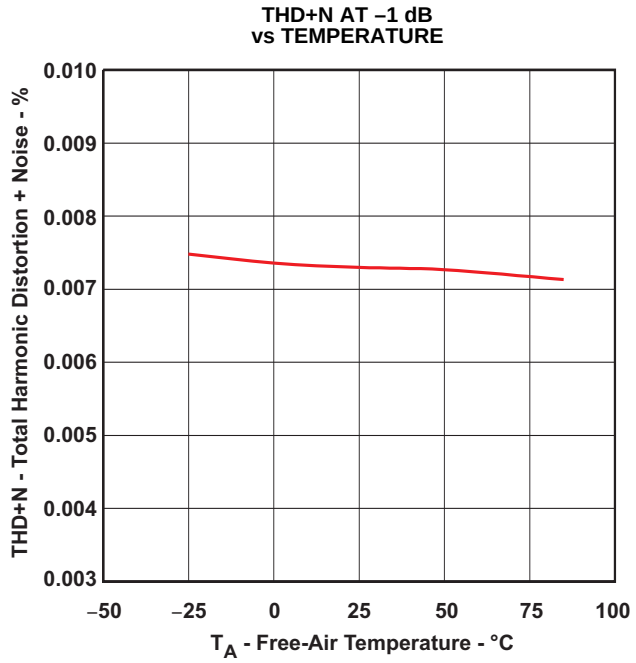


Figure 16.

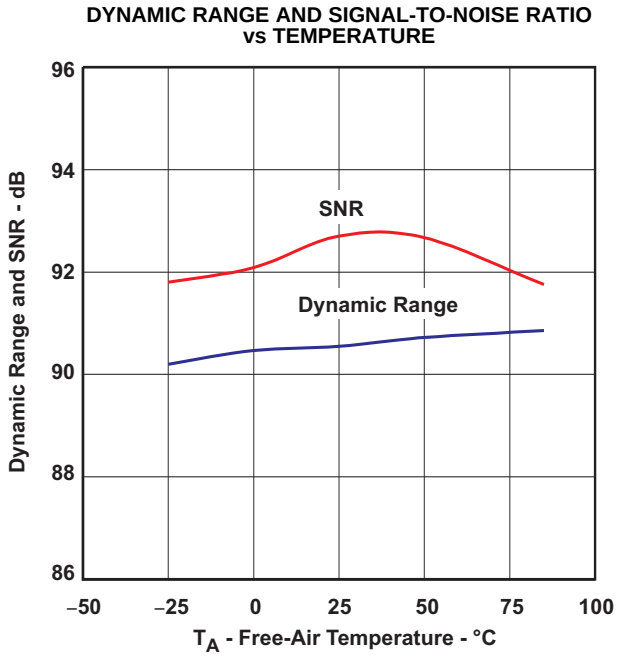


Figure 17.

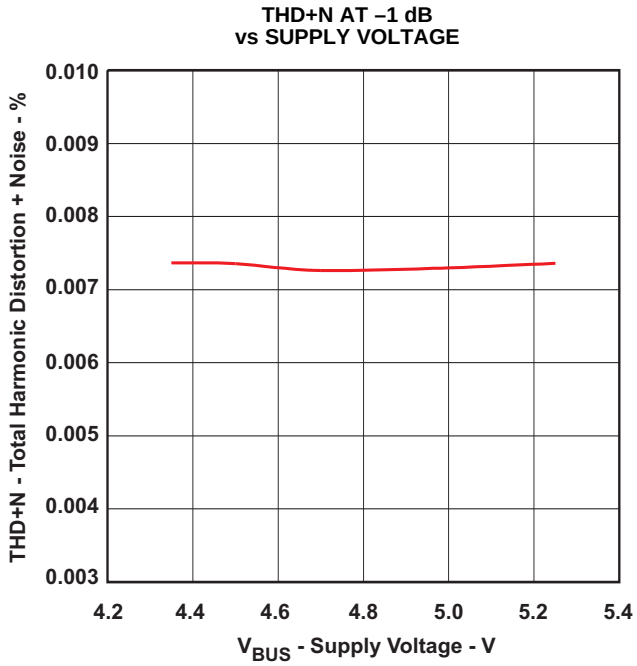


Figure 18.

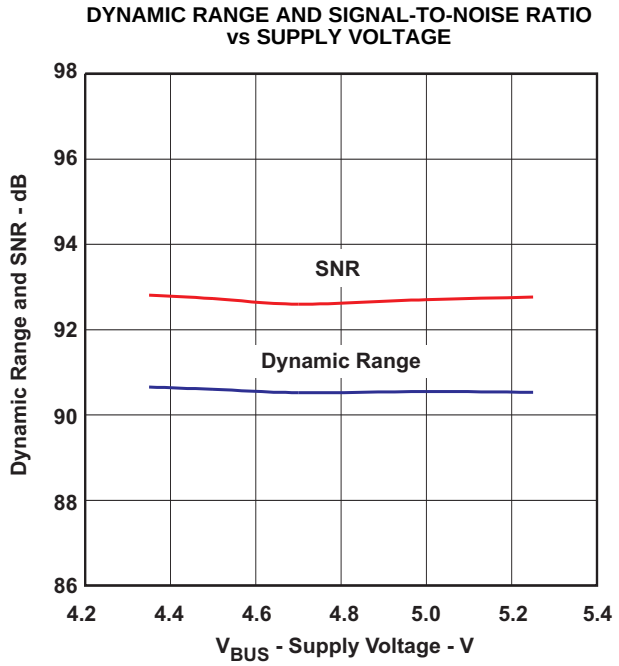


Figure 19.

TYPICAL CHARACTERISTICS (continued)

All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

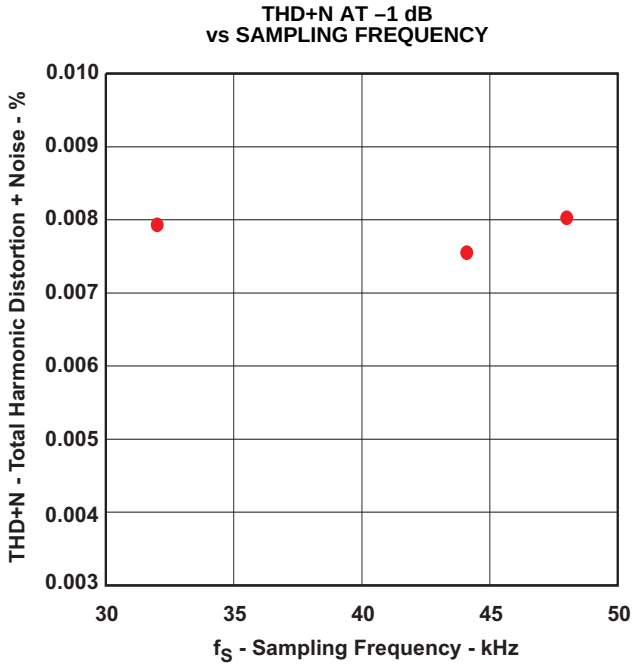


Figure 20.

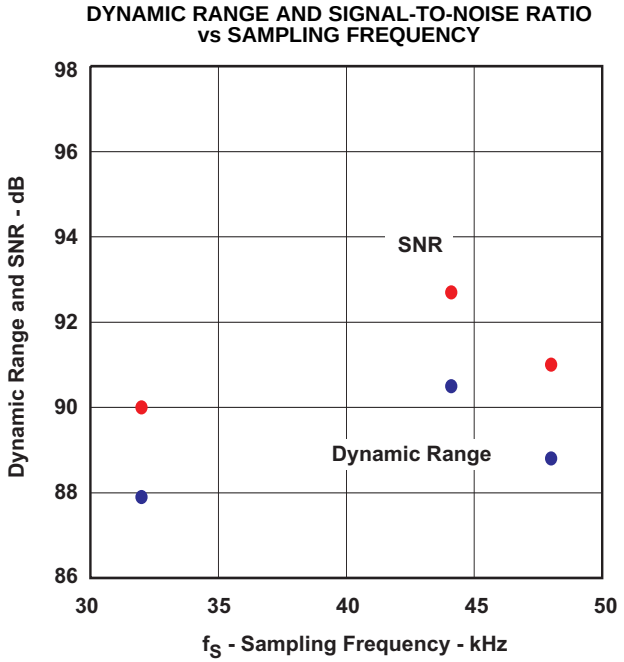


Figure 21.

DAC

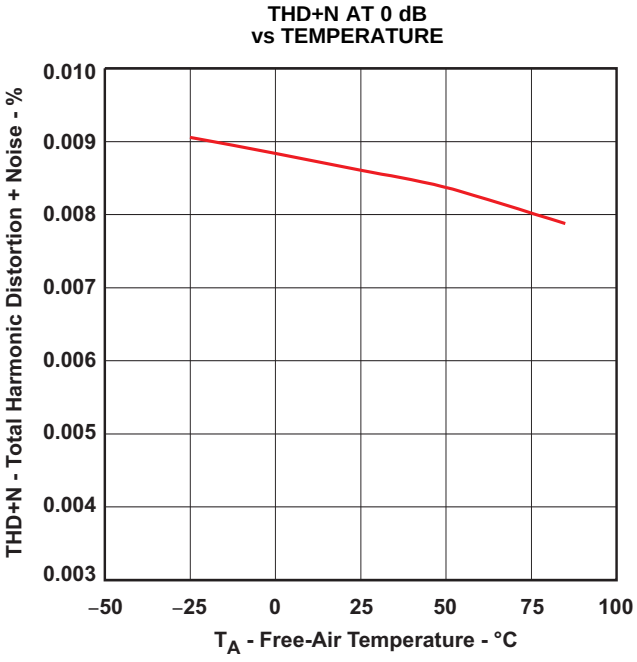


Figure 22.

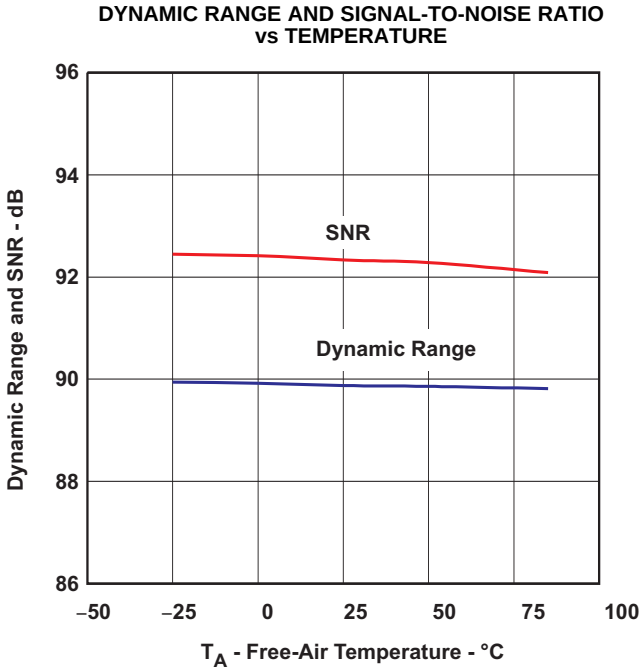


Figure 23.

TYPICAL CHARACTERISTICS (continued)

All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

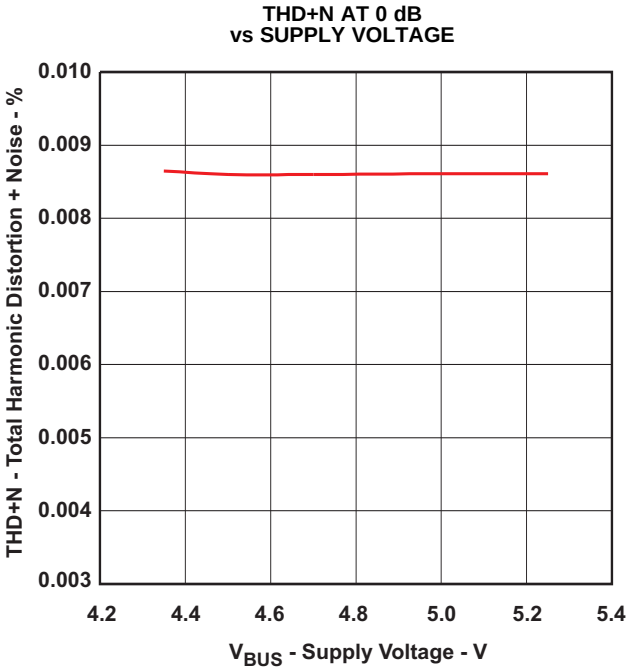


Figure 24.

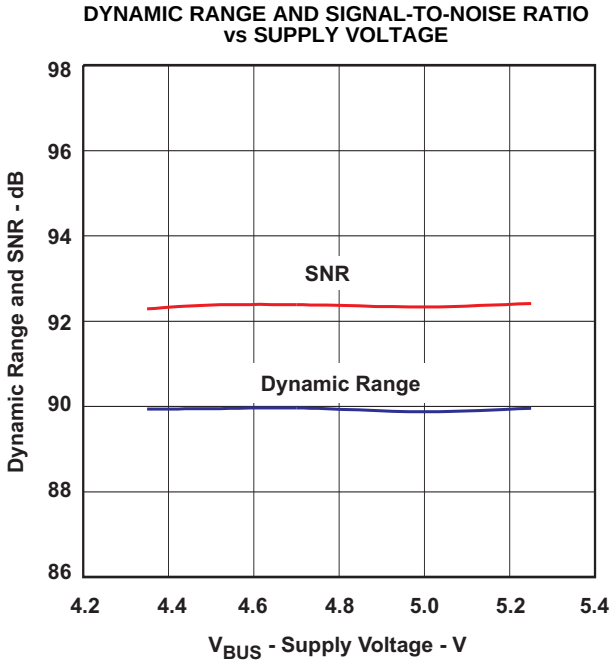


Figure 25.

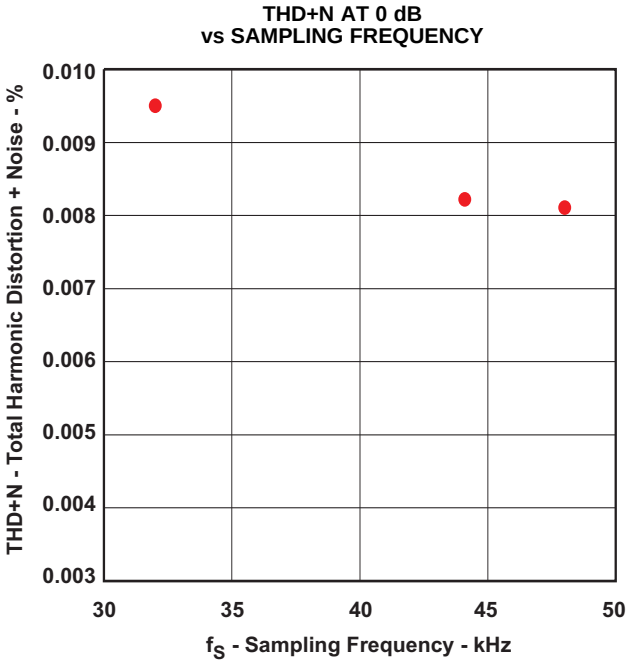


Figure 26.

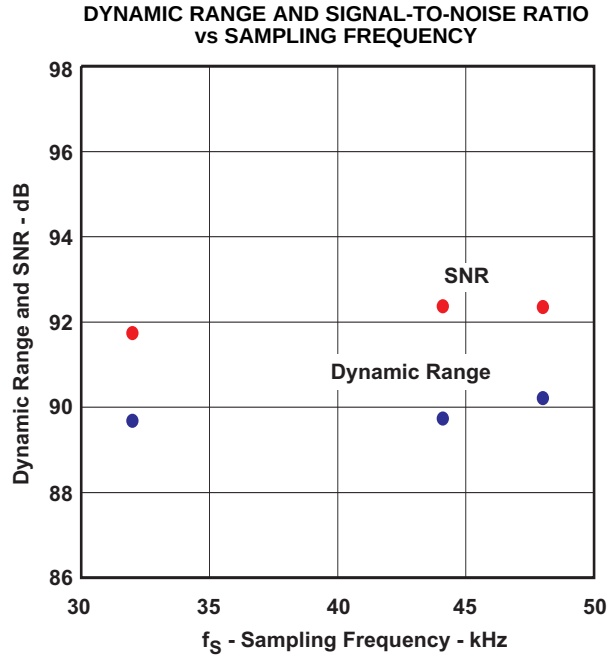


Figure 27.

TYPICAL CHARACTERISTICS (continued)

All specifications at T_A = +25°C, V_{BUS} = 5 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, and 16-bit data, unless otherwise noted.

Supply Current

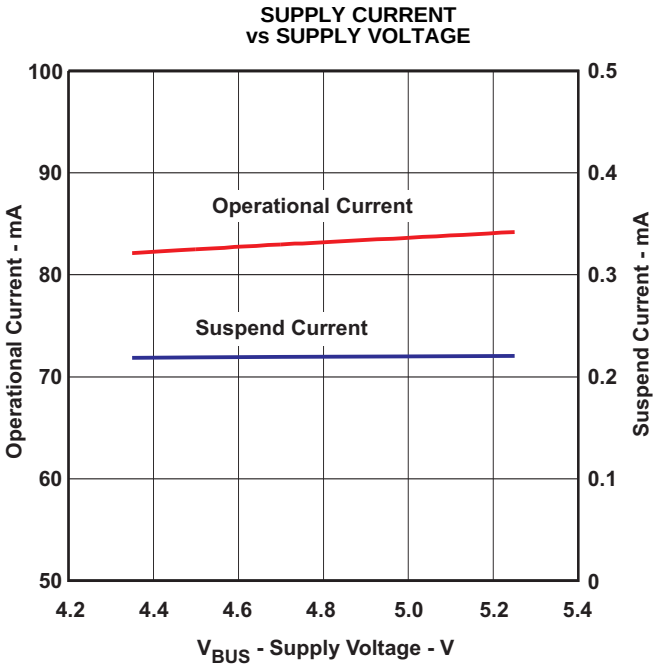


Figure 28.

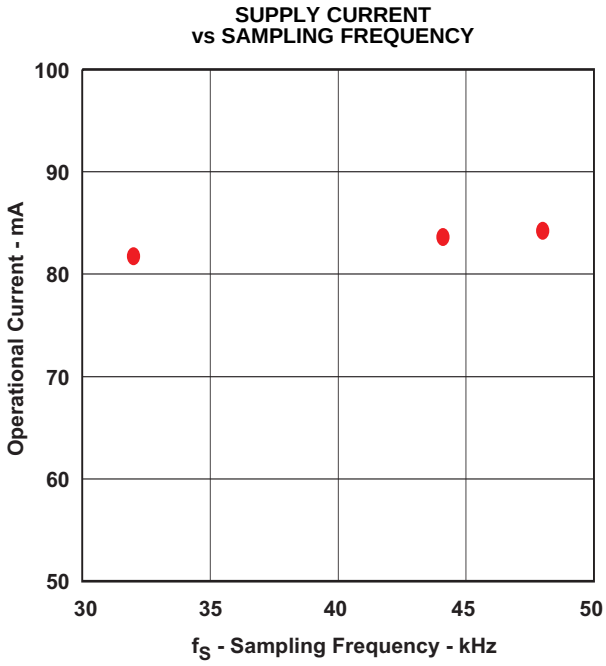


Figure 29.

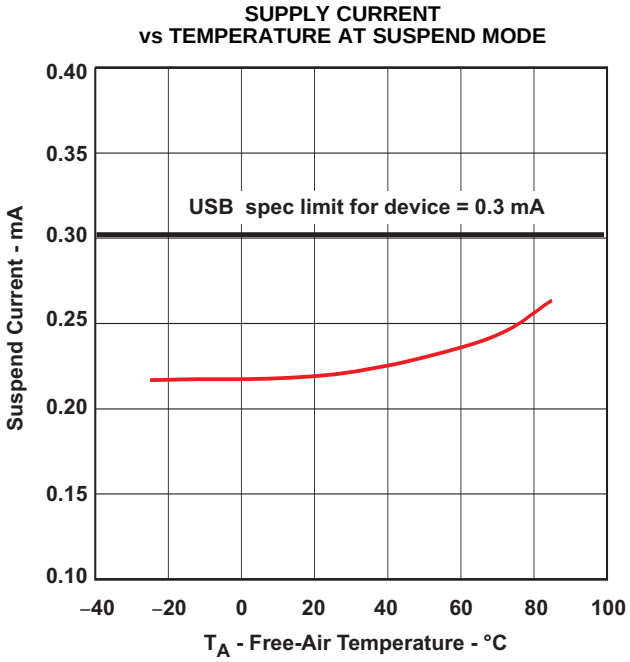


Figure 30.

GENERAL DESCRIPTION

USB INTERFACE

Control data and audio data are transferred to the PCM2912A via D+ (pin 4) and D– (pin 3). All data transferred to/from the PCM2912A are performed at full speed. Table 1 summarizes the device descriptor. The device descriptor can be modified on request.

Table 1. Device Descriptor

USB revision	2.0 compliant
Device class	0x00 (device defined in interface level)
Device sub class	0x00 (not specified)
Device protocol	0x00 (not specified)
Max packet size for endpoint 0	8-byte
Vendor ID	0x08BB
Product ID	0x2912
Device release number	0x0100 (1.00)
Number of configurations	1
Vendor string	String #1 (refer to Table 3)
Product string	String #2 (refer to Table 3)
Serial number	Not supported

Table 2 lists the configuration descriptor. The configuration descriptor can be modified on request.

Table 2. Configuration Descriptor

Interface	Three interfaces
Power attribute	0x80 (Bus powered, no remote wakeup)
Max power	0x32 (100 mA at POWER = Low) / 0xFA (500mA at POWER = High)

Table 3 summarizes the string descriptor. The string descriptor can be modified on request.

Table 3. String Descriptor

#0	0x0409
#1	Burr-Brown from TI
#2	USB audio CODEC

Device Configuration

Figure 31 illustrates the USB audio function topology. The PCM2912A has three interfaces. Each interface is constructed with some alternative settings.

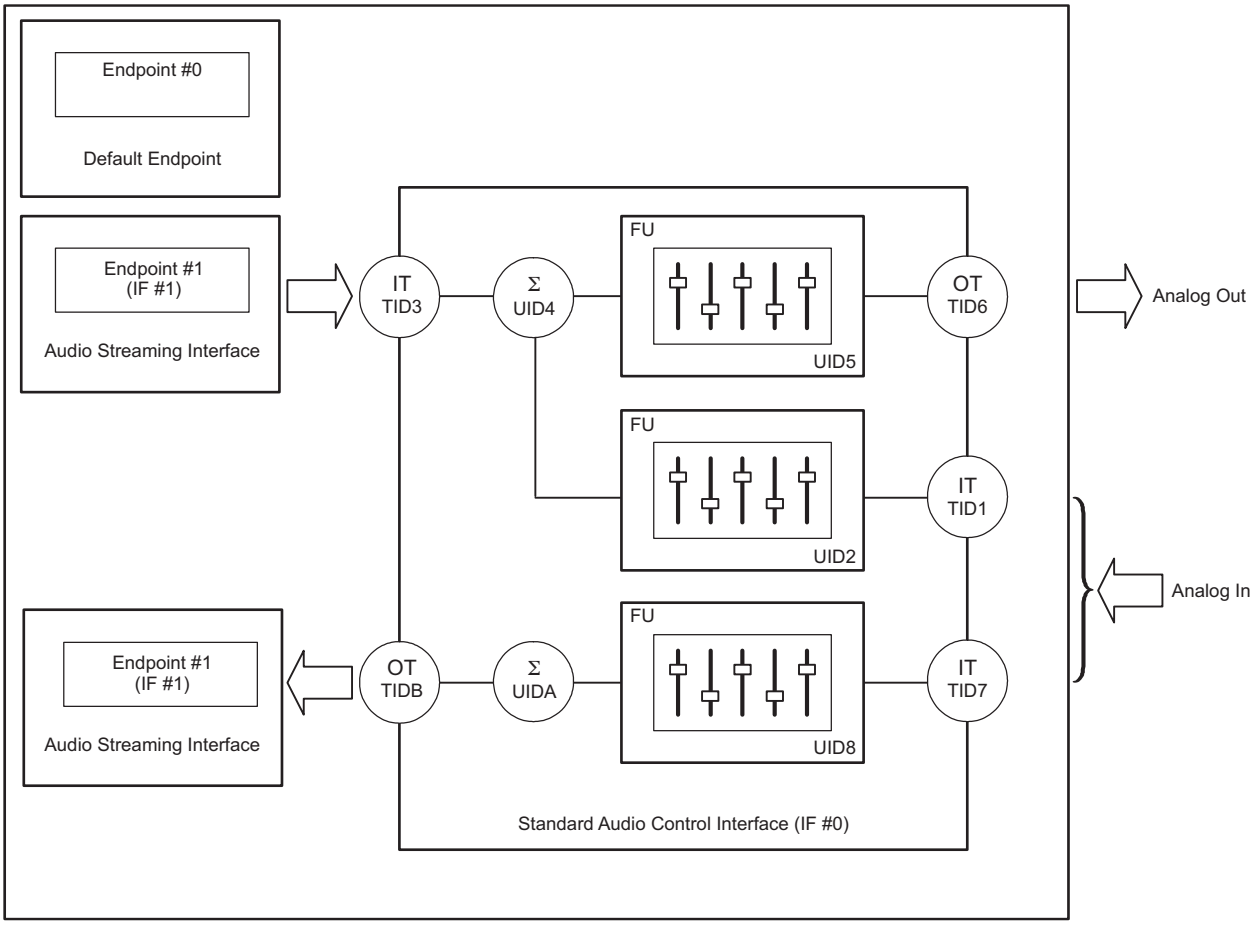


Figure 31. USB Audio Function Topology

Interface #0

Interface #0 is the control interface. Alternative setting #0 is the only possible setting for interface #0. Alternative setting #0 describes the standard audio control interface. The audio control interface is constructed with a series of terminal connections. The PCM2912A has the following 10 terminals:

- Input terminal (Terminal ID#1) for audio analog input for sidetone
- Feature unit (Unit ID#2) for sidetone PGA
- Input terminal (Terminal ID#3) for isochronous out stream
- Mixer unit (Unit ID#4) for sidetone mixing
- Feature unit (Unit ID#5) for analog output PGA
- Output terminal (Terminal ID#6) for audio analog output
- Input terminal (Terminal ID#7) for audio analog input
- Feature unit (Unit ID#8) for analog input PGA
- Mixer unit (Unit ID#A) for analog input
- Output terminal (Terminal ID#B) for isochronous in stream

Input terminal #3 is defined as *USB stream* (terminal type 0x0101). Input terminal #3 can accept two-channel audio streams constructed by the left and right channels. Output terminal #6 is defined as a *speaker* (terminal type 0x0301). Input terminals #1 and #7 are defined as *Microphone* (terminal type 0x0201). Physically, these two input terminals are the same input, but logically duplicated. Output terminal B is defined as a *USB stream* (terminal type 0x0101). Output terminal B is a single-channel audio stream. Mixer unit #4 multiplexes the analog input (sidetone) and the audio data of the digital-to-analog converter (DAC). Mixer unit A is placed in front of output terminal B. Mixer unit A has no impact on recording data. Mixer units #4 and A do not have programming capability.

Feature unit #5 supports the following sound control features for analog outputs:

- Volume control
- Mute control

The built-in volume controller can be manipulated by an audio-class-specific request from 0 dB to –76 dB in steps of 1 dB. An individual (L and R) channel can be set for different values. The built-in mute controller can be manipulated by an audio-class-specific request. Only the master mute control request is acceptable.

Feature unit #2 supports the following sound control features for analog input (sidetone):

- Volume control
- Mute control

The built-in volume controller can be manipulated by an audio-class-specific request from 0 dB to –76 dB in 1-dB steps. Only the master volume control is acceptable. The built-in mute controller can be manipulated by audio-class-specific request. Only the master mute control request is acceptable.

Feature unit #8 supports the following sound control features for analog input (microphone record input):

- Volume control
- Mute control

The built-in analog volume controller can be manipulated by an audio-class-specific request from +30 dB to –12 dB in 1-dB steps. The built-in mute controller can be manipulated by an audio-class-specific request. Only the master mute control request is acceptable.

Interface #1

Interface #1 is the audio streaming interface for data output. Table 4 lists the three alternative settings for Interface #1. Alternative setting #0 is the zero bandwidth setting. All other alternative settings are operational settings.

Table 4. Interface #1 Alternative Settings

ALTERNATIVE SETTING	DATA FORMAT			TRANSFER MODE	SAMPLING RATE (kHz)
00	Zero Bandwidth				
01	16 bit	Stereo	2s complement (PCM)	Adaptive	8, 11.025, 16, 22.05, 32, 44.1, 48
02	16 bit	Mono	2s complement (PCM)	Adaptive	8, 11.025, 16, 22.05, 32, 44.1, 48

Interface #2

Interface #2 is the audio streaming interface for data output. Table 5 shows the two alternative settings for Interface #2. Alternative setting #0 is the Zero Band Width setting. Alternative setting #1 is an operational setting.

Table 5. Interface #2 Alternative Settings

ALTERNATIVE SETTING	DATA FORMAT			TRANSFER MODE	SAMPLING RATE (kHz)
00	Zero Bandwidth				
01	16 bit	Mono	2s complement (PCM)	Asynchronous	8, 11.025, 16, 22.05, 32, 44.1, 48

Endpoints

The PCM2912A has the following three endpoints:

- Control endpoint (EP #0)
- Isochronous out audio data stream endpoint (EP #1)
- Isochronous in audio data stream endpoint (EP #2)

The control endpoint is the default endpoint. The control endpoint controls all functions of the PCM2912A by the standard USB request and USB audio class-specific request from the host. The isochronous out audio data stream endpoint is an audio sink endpoint, which receives the PCM audio data. The isochronous out audio data stream endpoint accepts the asynchronous transfer mode. The isochronous in audio data stream endpoint is an audio source endpoint, which transmits the PCM audio data. The isochronous in audio data stream endpoint uses synchronous transfer mode.

Internal Regulator

All required power sources are generated by five internal regulators.

Each regulator generates 3.3 V (typical, without load) from V_{BUS} (pin 2). Each regulator has an output pin and a ground return pin (as described in Table 6); this pair must be decoupled with an appropriate capacitor. Note that this capacitance affects inrush-current limitation. One band-gap reference circuit supplies reference voltage for all regulators. BGND (pin 1) is provided for reference ground of the band-gap reference.

Table 6. Internal Regulator Summary

SUPPLIED CIRCUIT	OUTPUT	RETURN
Digital	V_{DD} (pin 5)	DGND (pin 6)
Analog	V_{CCA} (pin 15)	AGND (pin 13)
Headphone (L-ch)	V_{CCL} (pin 19)	HGND (pin 20)
Headphone (R-ch)	V_{CCR} (pin 21)	HGND (pin 20)
PLL	V_{CCP} (pin 26)	PGND (pin 25)

Clock and Reset

The PCM2912A requires a 6-MHz (±500 ppm) clock for USB function and audio function, which can be generated from a built-in crystal oscillator with a 6-MHz crystal resonator. The 6-MHz crystal resonator must be connected to XTI (pin 8) and XTO (pin 7) with one high (1-MΩ) resistor and two small capacitors, whose capacitance depends on the load capacitance of the crystal resonator. An external clock can be supplied through XTI; if an external clock is supplied, XTO must be left open. Because there is no clock disabling signal, using the external clock supply is not recommended. $\overline{SSPND}$ (pin 29) is unable to use clock disabling.

The PCM2912A has an internal power-on-reset circuit, which works automatically when V_{BUS} (pin 2) exceeds 2.5 V, typical (2.2 V to 2.7 V), and approximately 700 µs is required until the internal reset is released.

DAC

The PCM2912A has a stereo delta-sigma DAC that uses a 64-f_S oversampling technique with an 8-f_S oversampling digital filter. DAC outputs are provided through the headphone amplifier; $V_{OUT}L$ (pin 18) and $V_{OUT}R$ (pin 22) provide 13 mW at 32 Ω and 0.6 $V_{CC}L/V_{CC}R$ V_{PP} at a 10-kΩ load.

ADC

The PCM2912A has a mono delta-sigma ADC that uses a 64-f_S oversampling technique with a 1/64-f_S decimation digital filter. The microphone input, V_{IN} (pin 16), is fed to the ADC through a +20-dB microphone amplifier and the PGA, which has +30 dB to –12 dB in 1-dB steps.

Microphone Bias

The PCM2912A has a microphone bias generator, which provides a low-noise, 0.75-V_{CCA}, 2-mA source current output with appropriate output impedance for electret-microphone driving. This output, MBIAS (pin 17), should be bypassed to AGND (pin 13) through an appropriate capacitor to reduce the output noise level.

Microphone Amplifier

The PCM2912A has a low-noise, single-ended, mono microphone amplifier with a mute function that is controlled by MUTE (pin 30). The signal gain is selectable by MAMP (pin 23). The noise level at the input node is 5 μV_{RMS}, and the input impedance is 20 kΩ.

Input PGA

The PCM2912A also has a low-noise input, programmable gain amplifier (PGA) for the microphone amplifier output/ADC input, with a gain range of +30 dB to –12 dB in 1dB/step.

Sidetone Programmable Attenuator

The PCM2912A has a low-noise, sidetone programmable attenuator with a mute function for the sidetone signal path (microphone amplifier output to output PGA input), and a gain range of 0 dB to –76 dB in 1 dB/step.

Output Programmable Attenuator

The PCM2912A has a low-noise output programmable attenuator with a mute function for mixed signal, which affects DAC output signal and sidetone signal. The output PGA gain range is 0 dB to –76 dB in 1 dB/step.

V_{COM1} and V_{CCM2}

V_{COM2} (pin 12) is provided for the center voltage of the headphone amplifier. V_{COM1} (pin 11) is provided for the center voltage of all other analog circuits. Each V_{COM} pin must be decoupled with an appropriate capacitor. Because the headphone output is disconnected when entering the suspend state, determining the capacitance is important to prevent pop noise, especially for V_{COM2} (pin 12). The equivalent resistance of V_{COM2} is 500 kΩ, and V_{COM1} is 15 kΩ.

Filter Pins

FL (pin 9) and FR (pin 10) are provided to make a low-pass filter (LPF) to decrease the DAC outband noise, as shown in Figure 32. This filter is optional.

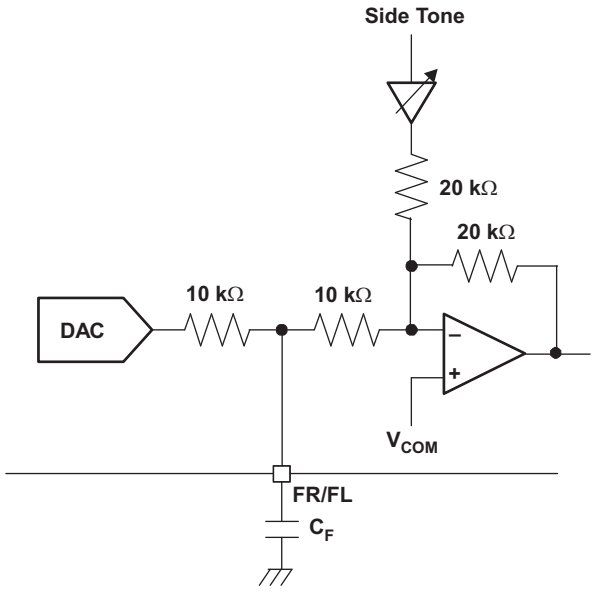


Figure 32. Filter Circuit

INTERFACE SEQUENCE

Power-On, Attach, and Play Back Sequence

The PCM2912A is ready for setup when the reset sequence has finished and the USB bus is attached. After a connection has been established, the PCM2912A is ready to accept USB audio data. While waiting for the audio data (that is, in an idle state), the analog output is set to bipolar zero (BPZ).

When receiving the audio data, the PCM2912A stores the first audio packet, which contains 1-ms audio data, into the internal storage buffer. The PCM2912A starts playing the audio data when the subsequent Start of Frame (SOF) packet is detected, as shown in Figure 33.

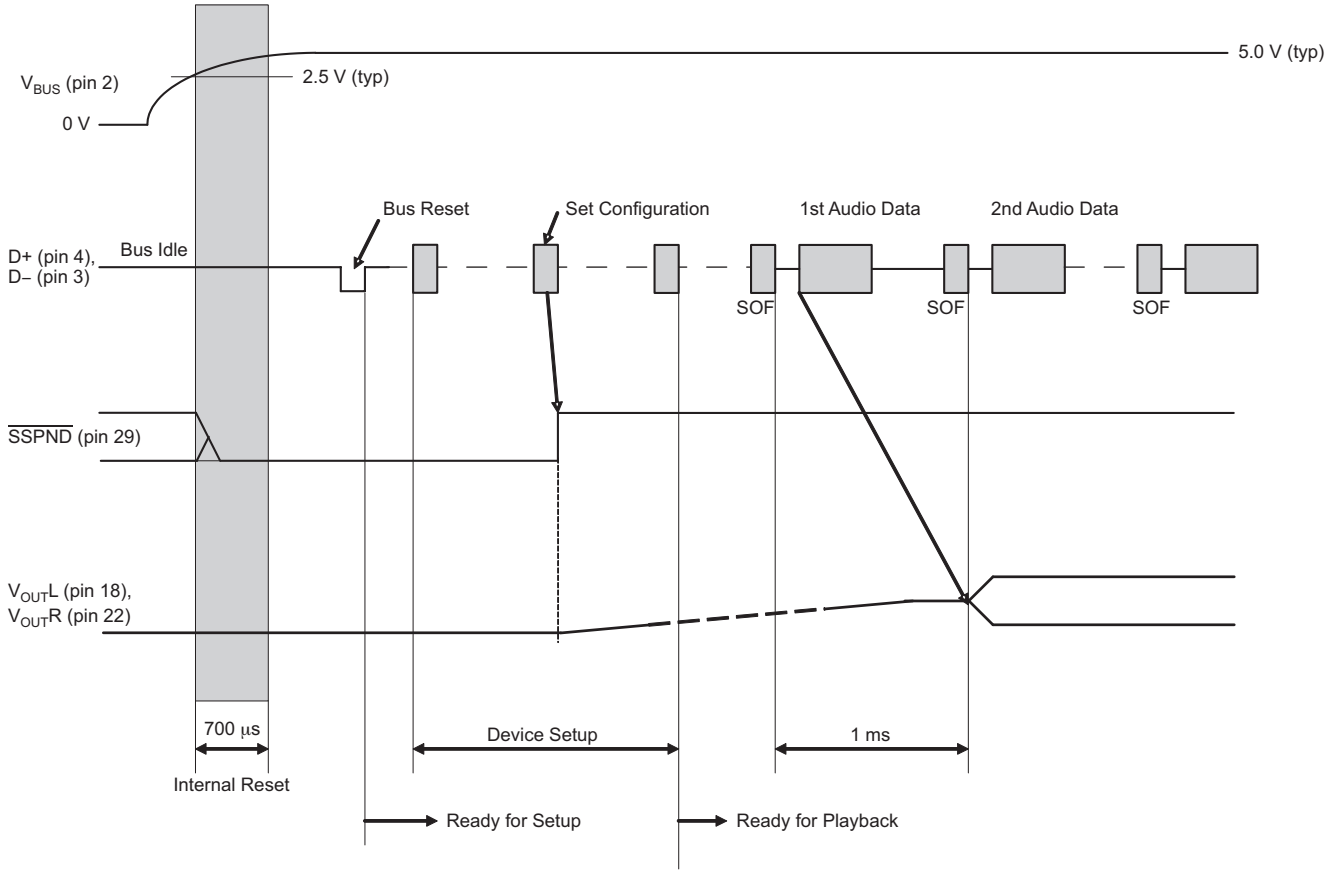


Figure 33. Initial Sequence

Play, Stop, and Detach Sequence

When the host finishes or aborts the play back process, the PCM2912A stops playing after last audio data has played, as shown in Figure 34.

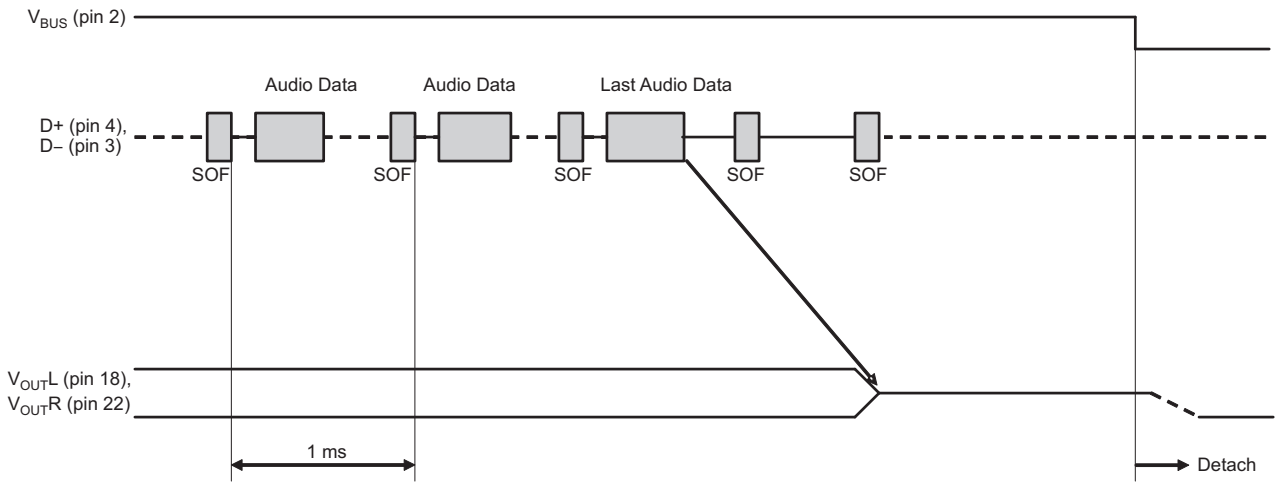


Figure 34. Play, Stop, and Detach

Record Sequence

Figure 35 illustrates how the PCM2912A records the audio into the internal memory after receiving the SET_INTERFACE command.

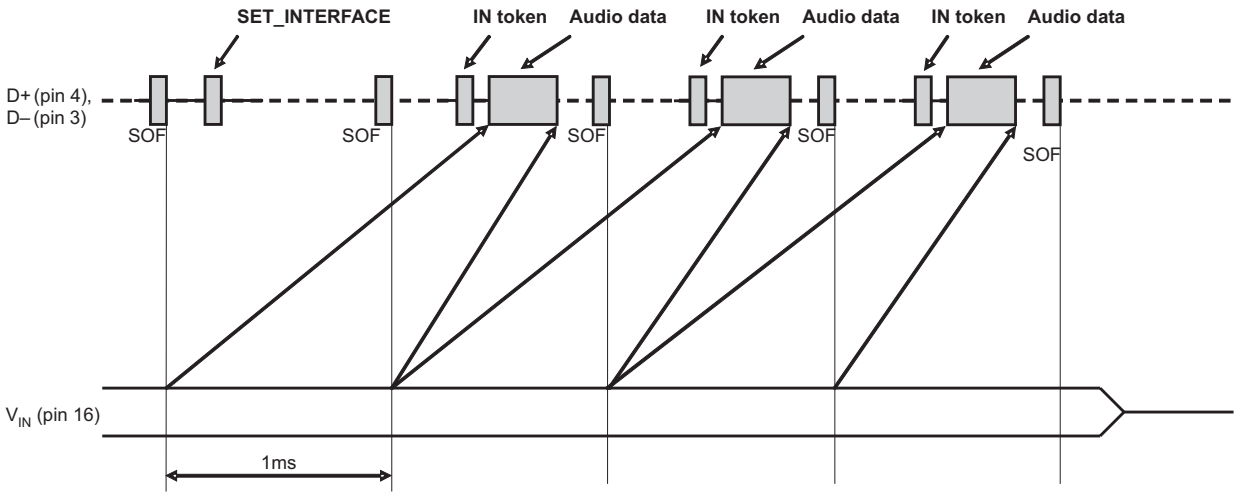


Figure 35. Record Sequence

Suspend and Resume Sequence

The PCM2912A enters a suspend state when it sees a constant idle state on the USB bus after approximately 5 ms. When the PCM2912A enters the suspend state, the $\overline{\text{SSPND}}$ flag (pin 29) is asserted. The PCM2912A wakes up immediately after detecting the non-idle state on the USB bus. Figure 36 illustrates these actions.

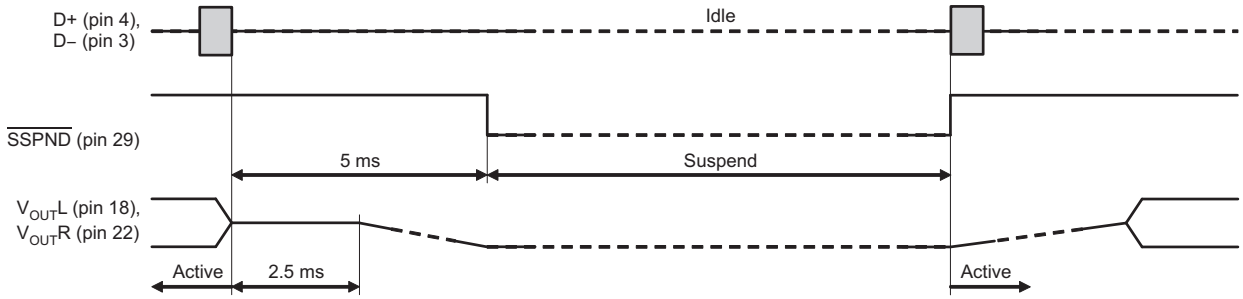
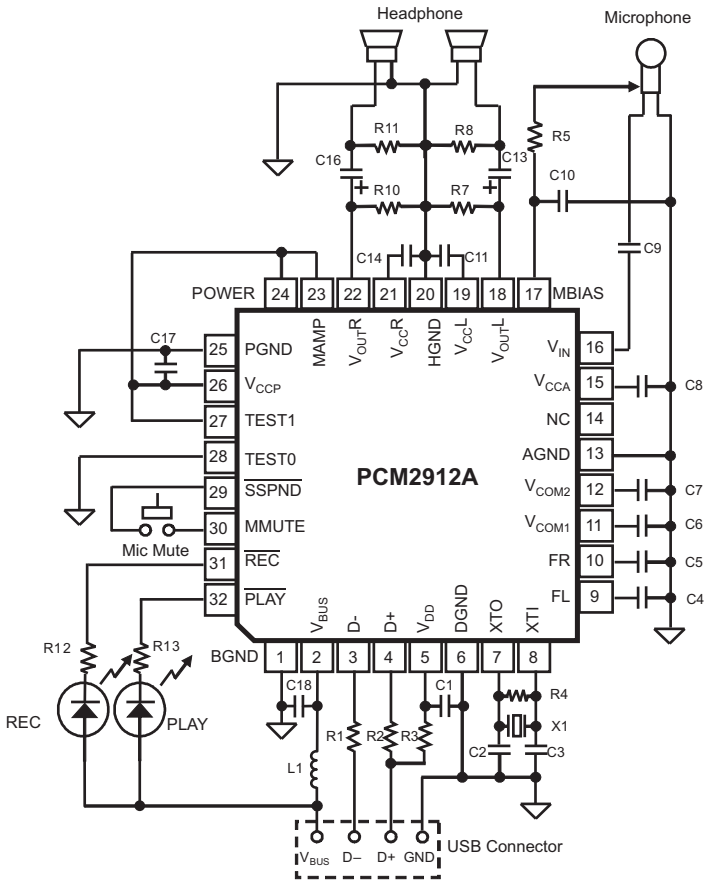


Figure 36. Suspend and Resume

TYPICAL CIRCUIT CONNECTION

A bus-powered (Hi-power), +20-dB microphone amplifier application example is shown in Figure 37.



NOTE: X_1: 6-MHz crystal resonator
C_1, C_8, C_{11}, C_{14}, C_{17}, C_{18}: 1 µF ceramic
C_2, C_3: 10 pF to 33 pF (depending on load capacitance of crystal resonator)
C_4, C_5: 100 pF ceramic
C_6, C_{10}: 3.3 µF
C_7: 0.1 µF
C_9: 0.22 µF electrolytic (depending on required frequency response for microphone input)
C_{13}, C_{16}: 100 µF electrolytic (depending on required frequency response for headphone output)
R_1, R_2: 22 Ω to 33 Ω
R_3: 1.5 kΩ
R_4: 1 MΩ
R_5: 1 kΩ (depending on microphone characteristic)
R_7, R_8, R_{10}, R_{11}: 3.3 kΩ
R_{12}, R_{13}: 820 Ω (depending on LED drive current)
L_1: 1 µH (DC resistance < 0.6 Ω)
It is possible to change maximum power if total power of actual application does not require over 100 mA (set POWER = *low* to configure as *low-power* device).

Figure 37. USB Headset Application

NOTE:

The circuit in Figure 37 is for information only. Total board design should be considered in order to meet the USB specification as a USB-compliant product.

RELATED DOCUMENTATION FROM TEXAS INSTRUMENTS

For additional information concerning the PCM2912A device, see the TI application report, Operating Envronments for PCM2912 Applications (SLAA387), available for download from www.ti.com.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
PCM2912APJT	ACTIVE	TQFP	PJT	32	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
PCM2912APJTR	ACTIVE	TQFP	PJT	32	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

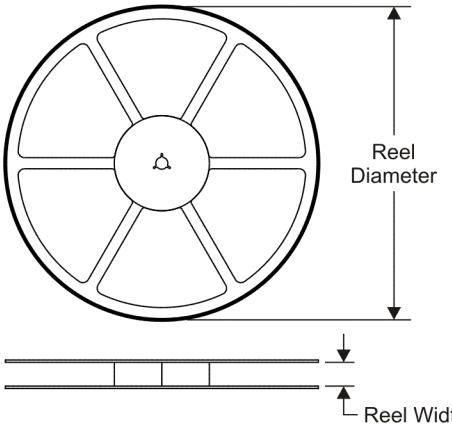
(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers,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

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

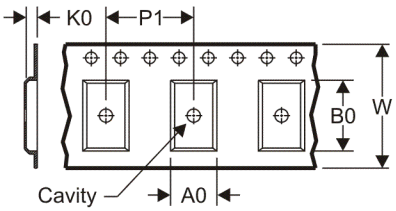
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

TAPE AND REEL INFORMATION

REEL DIMENSIONS

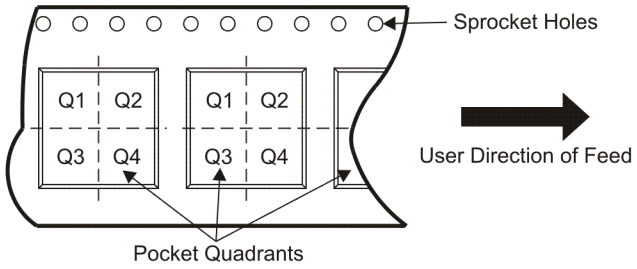


TAPE DIMENSIONS



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

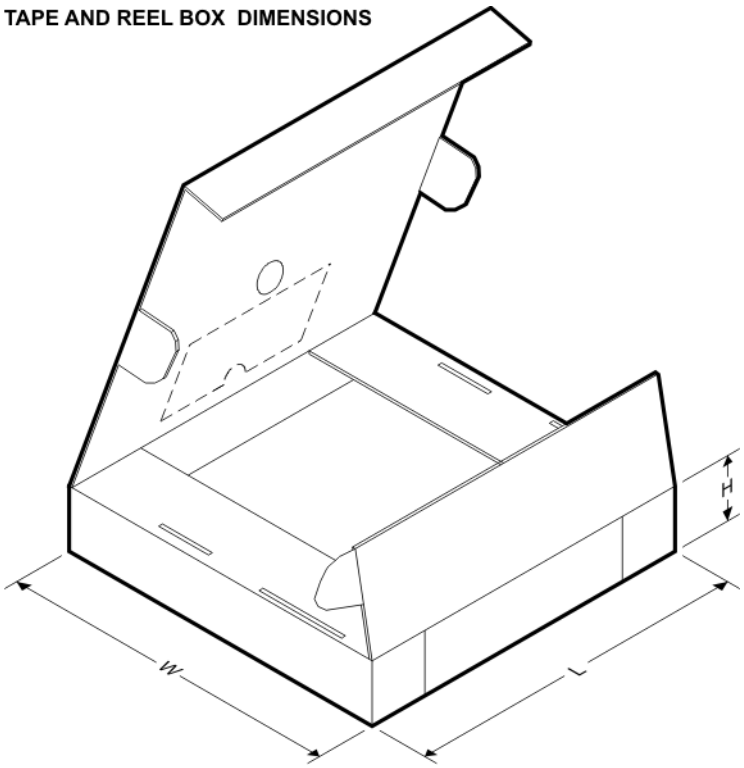
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
PCM2912APJTR	TQFP	PJT	32	1000	330.0	16.4	9.6	9.6	1.5	12.0	16.0	Q2

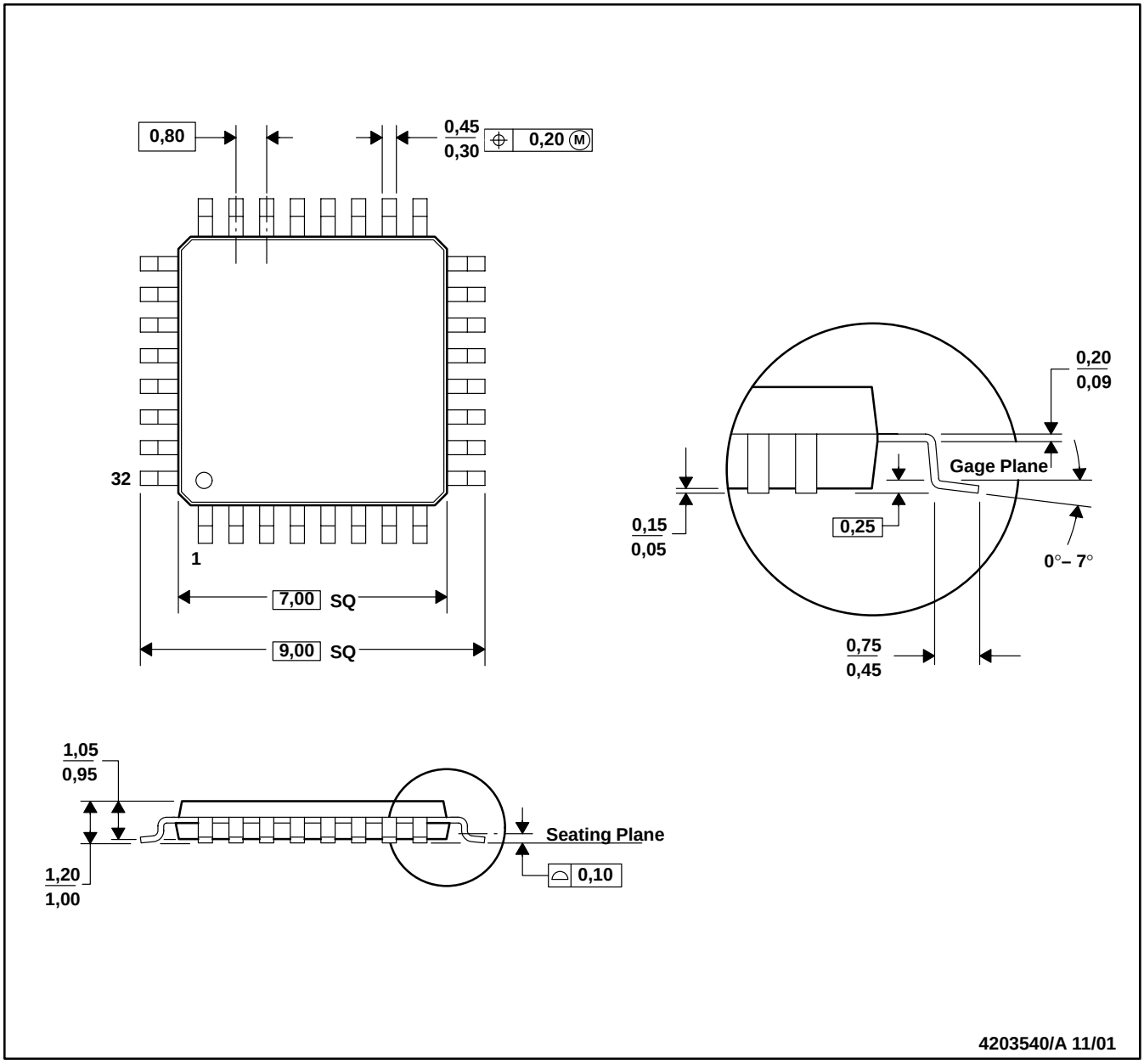
TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PCM2912APJTR	TQFP	PJT	32	1000	346.0	346.0	33.0

PJT (S-PQFP–N32) **PLASTIC QUAD FLATPACK**



NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-026

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