Stereo Audio Codec with USB Interface, Single-Ended Analog Input/Output, and S/PDIF

Check for Samples: PCM2903C

FEATURES

- **On-Chip USB Interface:**
  - **With Full-Speed Transceivers**
  - **Fully Compliant with USB 2.0 Specification**
  - **Certified by USB-IF**
  - **USB Adaptive Mode for Playback**
  - **USB Asynchronous Mode for Record**
  - **Self-Powered**
- **16-Bit Delta-Sigma ADC and DAC**
- **Sampling Rates:**
  - **DAC: 32, 44.1, 48 kHz**
  - **ADC: 8, 11.025, 16, 22.05, 32, 44.1, 48 kHz**
- **On-Chip Clock Generator With Single 12-MHz Clock Source**
- **S/PDIF Input/Output**
- **Single Power Supply:**
  - **3.3 V Typical**
- **Stereo ADC:**
  - **Analog Performance at V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCX} = V_{DD} = 3.3 V:**
    - **THD+N = 0.01%**
    - **SNR = 89 dB**
    - **Dynamic Range = 89 dB**
  - **Decimation Digital Filter:**
    - **Passband Ripple = ±0.05 dB**
    - **Stop-Band Attenuation = –65 dB**
  - **Single-Ended Voltage Input**
  - **Antialiasing Filter Included**
  - **Digital HPF Included**
- **Stereo DAC:**
  - **Analog Performance at V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCX} = V_{DD} = 3.3 V:**
    - **THD+N = 0.005%**
    - **SNR = 96 dB**
    - **Dynamic Range = 93 dB**
  - **Oversampling Digital Filter:**
    - **Passband Ripple = ±0.1 dB**
    - **Stop-Band Attenuation = –43 dB**
  - **Single-Ended Voltage Output**
  - **Analog LPF Included**
- **Multifunctions:**
  - **Human Interface Device (HID) Function:**
    - **Volume and and Mute Controls**
  - **Suspend Flag Function**
- **28-Pin SSOP Package**

APPLICATIONS

- **USB Audio Speaker**
- **USB Headset**
- **USB Monitor**
- **USB Audio Interface Box**

DESCRIPTION

The PCM2903C is Texas Instruments' single-chip, USB, stereo audio codec with a USB-compliant full-speed protocol controller and S/PDIF. The USB protocol controller requires no software code. The PCM2903C employs SpAct™ architecture, TI's unique system that recovers the audio clock from USB packet data. On-chip analog PLLs with SpAct enable playback and record with low clock jitter, as well as independent playback and record sampling rates.

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.

PACKAGE/ORDERING INFORMATION(1)

PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER	TRANSPORT MEDIA, QUANTITY
PCM2903CDB	SSOP-28	DB	–25°C to 85°C	PCM2903C	PCM2903CDB	Rails, 47
					PCM2903CDBR	Tape and Reel, 2000

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or visit the device product folder at www.ti.com.

ABSOLUTE MAXIMUM RATINGS(1)

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

PARAMETER		PCM2903C	UNIT
Supply voltage, V_{CCC}, V_{CCP1}, V_{CCP2}, V_{CCX}, V_{DD}		–0.3 to 4	V
Supply voltage differences, V_{CCC}, V_{CCP1}, V_{CCP2}, V_{CCX}, V_{DD}		±0.1	V
Ground voltage differences, AGNDC, AGNDP, AGNDX, DGND, DGNDU		±0.1	V
Digital input voltage	SEL0, SEL1, DIN	–0.3 to 6.5	V
	D+, D–, HID0, HID1, HID2, XTI, XTO, DOUT, $\overline{\text{SSPND}}$	–0.3 to (V_{DD} + 0.3) < 4	V
Analog input voltage V_{IN}L, V_{IN}R, V_{COM}, V_{OUT}R, V_{OUT}L		–0.3 to (V_{CCC} + 0.3) < 4	V
Input current (any pins except supplies)		±10	mA
Ambient temperature under bias		–40 to +125	°C
Storage temperature, T_{stg}		–55 to +150	°C
Junction temperature T_J		+150	°C
Lead temperature (soldering, 5 s)		+260	°C
Package temperature (IR reflow, peak)		+250	°C

(1) Stresses beyond those listed under A*bsolute 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 is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

THERMAL INFORMATION

THERMAL METRIC(1)		PCM2903C DB (SSOP) 28 PINS	UNITS
θ_{JA}	Junction-to-ambient thermal resistance	64.5	°C/W
θ_{JCtop}	Junction-to-case (top) thermal resistance	24.5	
θ_{JB}	Junction-to-board thermal resistance	25.4	
ψ_{JT}	Junction-to-top characterization parameter	2.0	
ψ_{JB}	Junction-to-board characterization parameter	25.0	
θ_{JCbot}	Junction-to-case (bottom) thermal resistance	N/A	

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

ELECTRICAL CHARACTERISTICS

All specifications at T_A = +25°C, V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCX} = V_{DD} = 3.3 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

PARAMETER			TEST CONDITIONS	PCM2903C MIN	PCM2903C TYP	PCM2903C 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}	High-level input voltage	D+, D–		2		V_{DD}	VDC
		XTI, HID0, HID1, and HID2		0.7 V_{DD}		V_{DD}	
		SEL0, SEL1		2		5.25	
		DIN		0.7 V_{DD}		5.25	
V_{IL}	Low-level input voltage	D+, D–				0.8	VDC
		XTI, HID0, HID1, and HID2				0.3 V_{DD}	
		SEL0, SEL1				0.8	
		DIN				0.3 V_{DD}	
I_{IH}	High-level input current	D+, D–, XTI, SEL0, SEL1	V_{IN} = 3.3 V			±10	µA
		HID0, HID1, and HID2	V_{IN} = 3.3 V		50	80	
		DIN	V_{IN} = 3.3 V		65	100	
I_{IL}	Low-level input current	D+, D–, XTI, SEL0, SEL1	V_{IN} = 0 V			±10	µA
		HID0, HID1, and HID2	V_{IN} = 0 V			±10	
		DIN	V_{IN} = 0 V			±10	
OUTPUT LOGIC							
V_{OH}	High-level output voltage	D+, D–		2.8			VDC
		DOUT	I_{OH} = –4 mA	2.8			
		$\overline{SSPND}$	I_{OH} = –2 mA	2.8			
V_{OL}	Low-level output voltage	D+, D–				0.3	VDC
		DOUT	I_{OL} = 4 mA			0.5	
		$\overline{SSPND}$	I_{OL} = 2 mA			0.5	
CLOCK FREQUENCY							
	Input clock frequency, XTI			11.994	12	12.006	MHz

ELECTRICAL CHARACTERISTICS (continued)

All specifications at T_A = +25°C, V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCX} = V_{DD} = 3.3 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

	PARAMETER	TEST CONDITIONS	PCM2903C MIN	TYP	MAX	UNIT
ADC CHARACTERISTICS						
	Resolution			8, 16		Bits
	Audio data channel			1, 2		Channel
ADC Clock Frequency						
f_S	Sampling frequencies			8, 11.025, 16, 22.05, 32, 44.1, 48		kHz
ADC DC Accuracy						
	Gain mismatch, channel-to-channel			±1	±5	% of FSR
	Gain error			±2	±10	% of FSR
	Bipolar zero error			±0		% of FSR
ADC Dynamic Performance(1)						
THD+N	Total harmonic distortion plus noise	V_{IN} = –1 dB		0.01	0.02	%
		V_{IN} = –60 dB		5		%
	Dynamic range	A-weighted	81	89		dB
SNR	Signal-to-noise ratio	A-weighted	81	89		dB
	Channel separation		80	85		dB
Analog Input						
	Input voltage			0.6 V_{CCC}		V_{PP}
	Center voltage			0.5 V_{CCC}		V
	Input impedance			30		kΩ
	Antialising filter frequency response	–3 dB		150		kHz
		f_{IN} = 20 kHz		–0.08		dB
ADC Digital Filter Performance						
	Passband				0.454 f_S	Hz
	Stop band		0.583 f_S			Hz
	Passband ripple				±0.05	dB
	Stop-band attenuation		–65			dB
t_d	Delay time			17.4/f_S		s
	HPF frequency response	–3 dB		0.078 f_S/1000		Hz

(1) f_{IN} = 1 kHz, using a System Two™ audio measurement system by Audio Precision™ in RMS mode with a 20-kHz LPF and 400-Hz HPF in the calculation.

ELECTRICAL CHARACTERISTICS (continued)

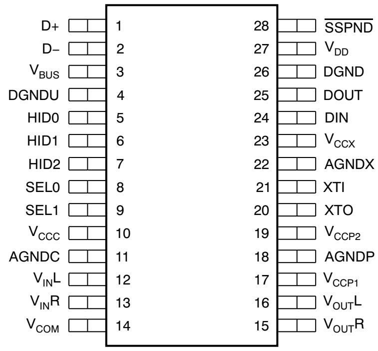
All specifications at T_A = +25°C, V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCX} = V_{DD} = 3.3 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

	PARAMETER	TEST CONDITIONS	PCM2903C MIN	TYP	MAX	UNIT
DAC CHARACTERISTICS						
	Resolution			8, 16		Bits
	Audio data channel			1, 2		Channel
DAC Clock Frequency						
f_S	Sampling frequencies			32, 44.1, 48		kHz
DAC DC Accuracy						
	Gain mismatch channel-to-channel			±1	±5	% of FSR
	Gain error			±2	±10	% of FSR
	Bipolar zero error			±2		% of FSR
DAC Dynamic Performance(2)						
THD+N	Total harmonic distortion plus noise	V_{OUT} = 0 dB		0.005	0.016	%
		V_{OUT} = –60 dB		3		%
	Dynamic range	EIAJ, A-weighted	87	93		dB
SNR	Signal-to-noise ratio	EIAJ, A-weighted	90	96		dB
	Channel separation		86	92		dB
Analog Output						
V_O	Output voltage			0.6 V_{CCC}		V_{PP}
	Center voltage			0.5 V_{CCC}		V
	Load impedance	AC coupling	10			kΩ
	LPF frequency response	–3 dB		250		kHz
		f = 20 kHz		–0.03		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
t_d	Delay time			14.3/f_S		s
POWER-SUPPLY REQUIREMENTS						
V_{DD}, V_{CCC}, V_{CCP1}, V_{CCP2}, V_{CCX}	Voltage range		3	3.3	3.6	VDC
	Supply current	ADC, DAC operation		54	70	mA
		Suspend mode(3)		250		μA
P_D	Power dissipation	ADC, DAC operation		178	252	mW
		Suspend mode(3)		0.83		mW
TEMPERATURE RANGE						
	Operating temperature range		–25		+85	°C
θ_{JA}	Thermal resistance			100		°C/W

(2) f_{OUT} = 1 kHz, using a System Two audio measuerment system by Audio Precision in RMS mode with a 20-kHz LPF and 400-Hz HPF.
(3) Under USB suspend state.

PIN CONFIGURATIONS

DB PACKAGE
SSOP-28
(TOP VIEW)

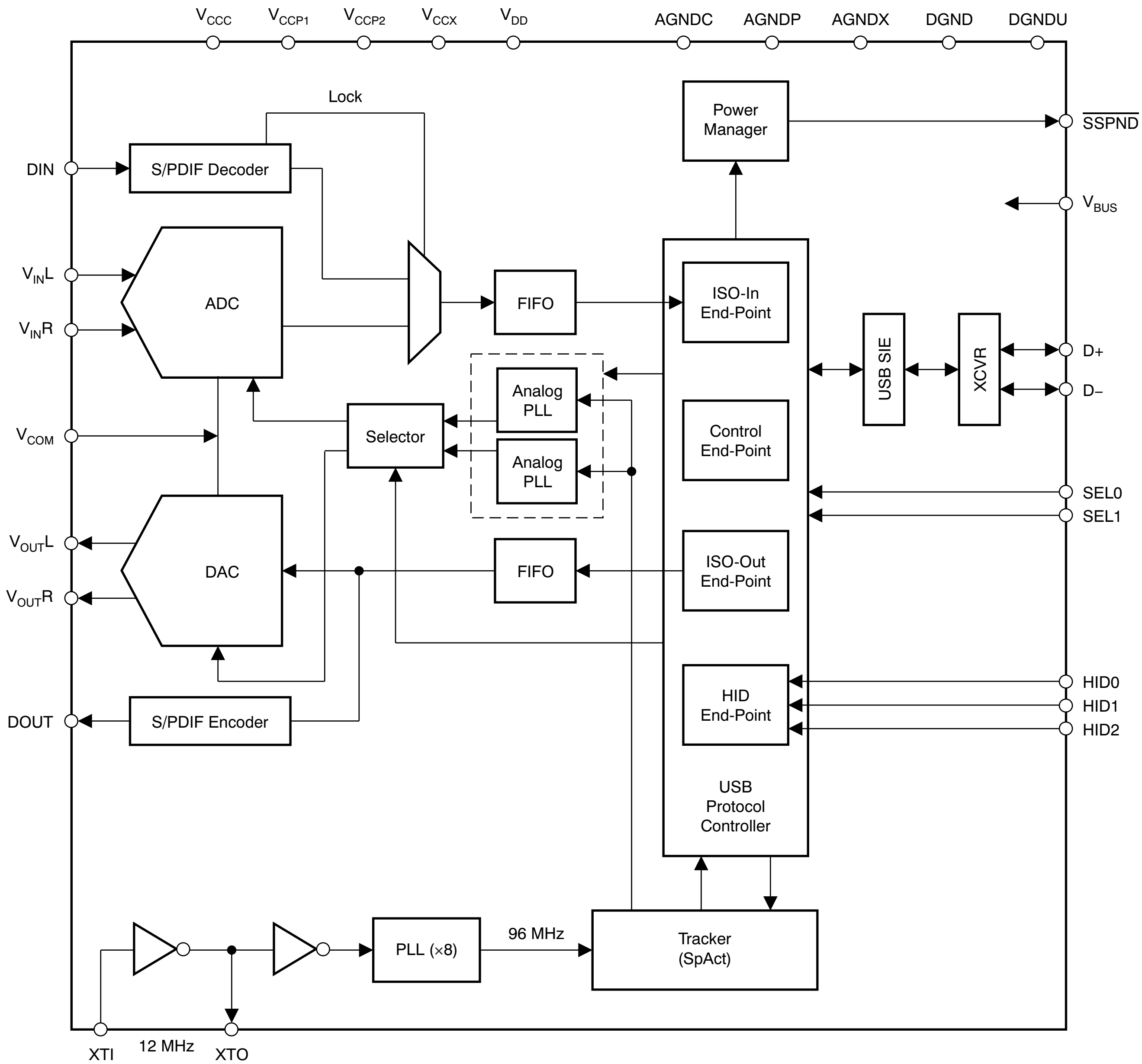


PIN DESCRIPTIONS

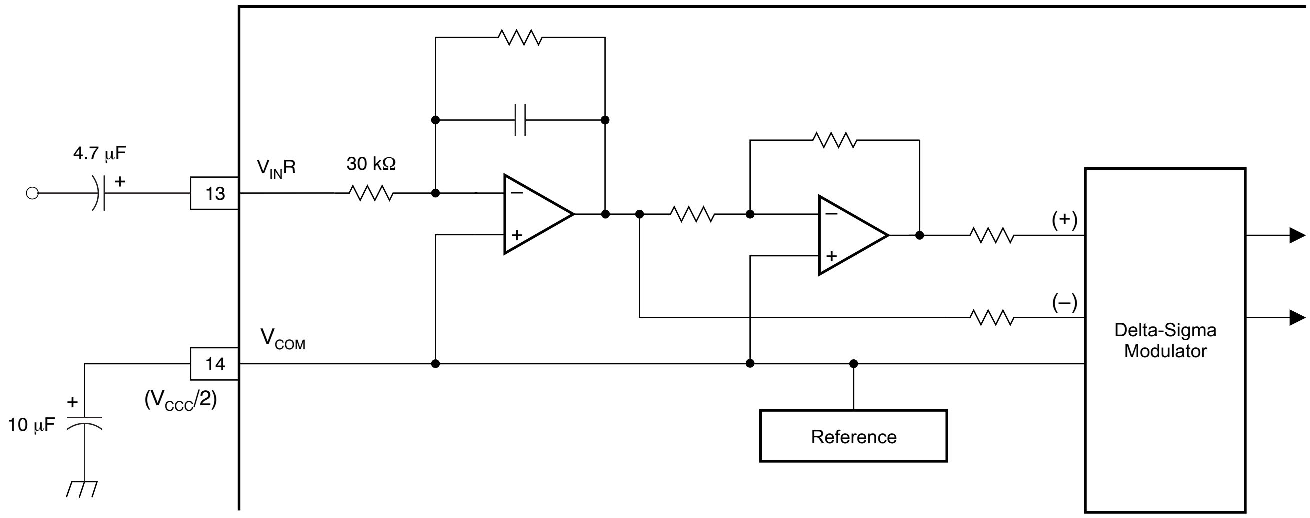
PIN			
NAME	NO.	I/O	DESCRIPTION
AGNDC	11	–	Analog ground for codec
AGNDP	18	–	Analog ground for PLL
AGNDX	22	–	Analog ground for oscillator
D–	2	I/O	USB differential input/output minus(1)
D+	1	I/O	USB differential input/output plus(1)
DGND	26	–	Digital ground
DGNDU	4	–	Digital ground for USB transceiver
DIN	24	I	S/PDIF input (2)
DOUT	25	O	S/PDIF output
HID0	5	I	HID key state input (mute), active-high(3)
HID1	6	I	HID key state input (volume up), active-high(3)
HID2	7	I	HID key state input (volume down), active-high(3)
SEL0	8	I	Must be set to high(4)
SEL1	9	I	Connected to the USB port of V_{BUS} (4)
$\overline{SSPND}$	28	O	Suspend flag, active-low (Low: suspend, High: operational)
V_{BUS}	3	–	Must be connected to V_{DD}
V_{CCC}	10	–	Analog power supply for codec(5)
V_{CCP1}	17	–	Analog power supply for PLL(5)
V_{CCP2}	19	–	Analog power supply for PLL(5)
V_{CCX}	23	–	Analog power supply for oscillator(5)
V_{COM}	14	–	Common for ADC/DAC (V_{CCC}/2) (5)
V_{DD}	27	–	Digital power supply(5)
V_{IN}L	12	I	ADC analog input for L-channel
V_{IN}R	13	I	ADC analog input for R-channel
V_{OUT}L	16	O	DAC analog output for L-channel
V_{OUT}R	15	O	DAC analog output for R-channel
XTI	21	I	Crystal oscillator input(6)
XTO	20	O	Crystal oscillator output

(1) LV-TTL level.
(2) 3.3-V CMOS-level input with internal pulldown, 5-V tolerant.
(3) 3.3-V CMOS-level input with internal pulldown. This pin informs the PC of serviceable control signals such as mute, volume up, or volume down, which have no direct connection with the internal DAC or ADC. See the *Interface #3* and *End-Points* sections.
(4) TTL Schmitt trigger, 5-V tolerant.
(5) Connect a decoupling capacitor to GND.
(6) 3.3-V CMOS-level input.

FUNCTIONAL BLOCK DIAGRAM



BLOCK DIAGRAM OF ANALOG FRONT-END (RIGHT CHANNEL)



TYPICAL CHARACTERISTICS: ADC

All specifications at T_A = +25°C, V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx} = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

TOTAL HARMONIC DISTORTION + NOISE AT –1 dB vs FREE-AIR TEMPERATURE

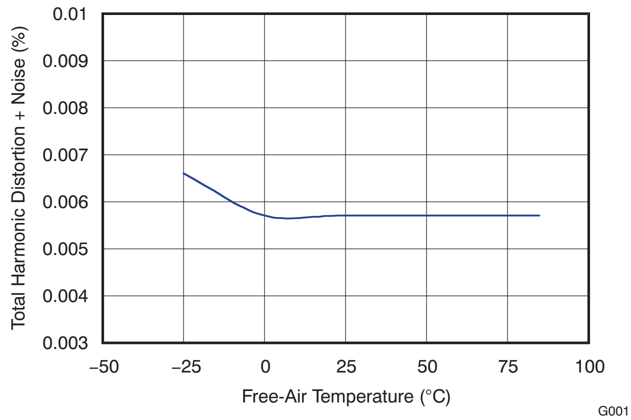


Figure 1.

DYNAMIC RANGE AND SNR vs FREE-AIR TEMPERATURE

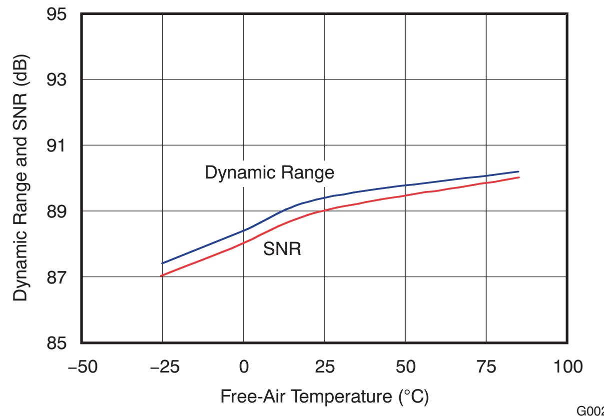


Figure 2.

TOTAL HARMONIC DISTORTION + NOISE AT –1 dB vs SUPPLY VOLTAGE

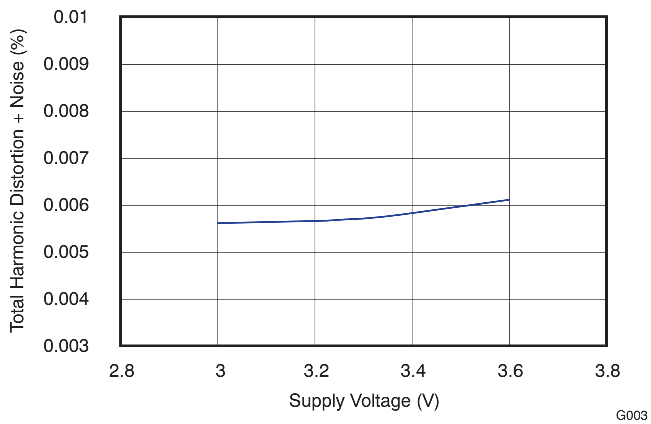


Figure 3.

DYNAMIC RANGE AND SNR vs SUPPLY VOLTAGE

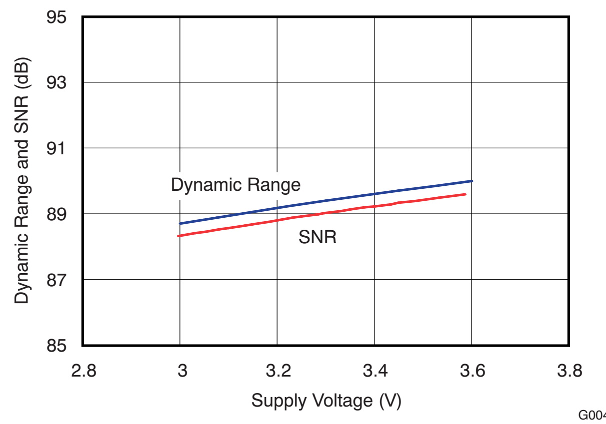


Figure 4.

TYPICAL CHARACTERISTICS: ADC (continued)

All specifications at T_A = +25°C, V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx} = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

TOTAL HARMONIC DISTORTION + NOISE AT –1 dB vs SAMPLING FREQUENCY

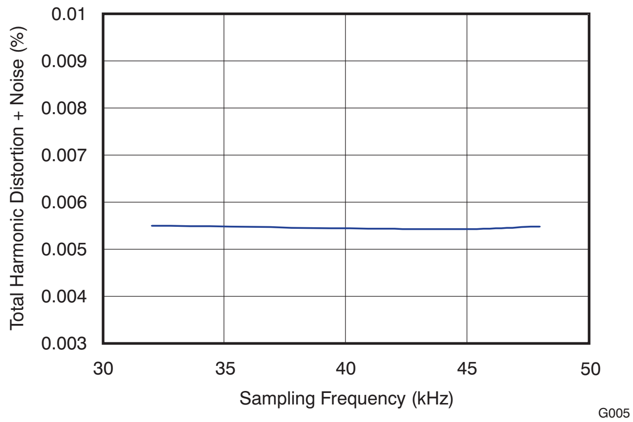


Figure 5.

DYNAMIC RANGE AND SNR vs SAMPLING FREQUENCY

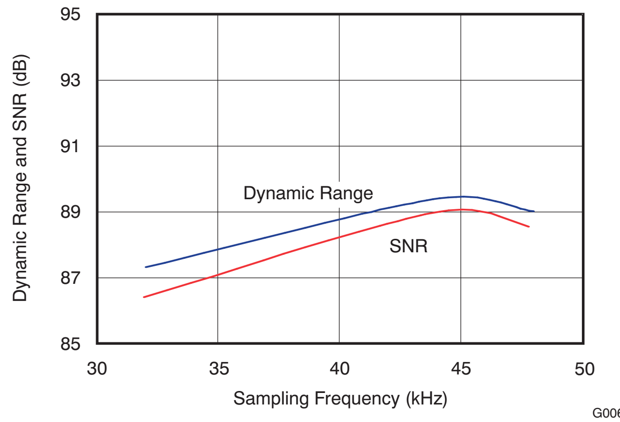


Figure 6.

TYPICAL CHARACTERISTICS: DAC

All specifications at T_A = +25°C, V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx} = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

TOTAL HARMONIC DISTORTION + NOISE AT 0 dB vs FREE-AIR TEMPERATURE

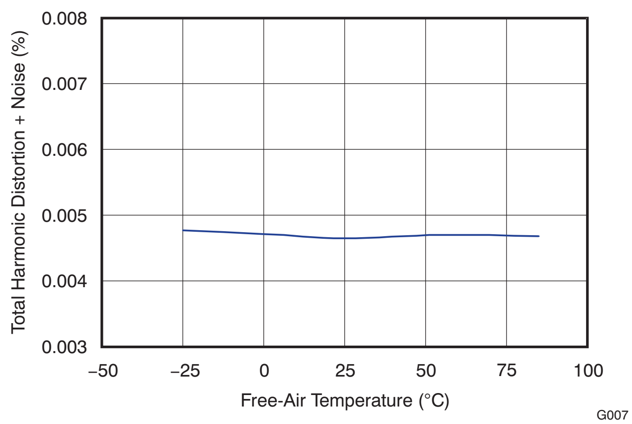


Figure 7.

DYNAMIC RANGE AND SNR vs FREE-AIR TEMPERATURE

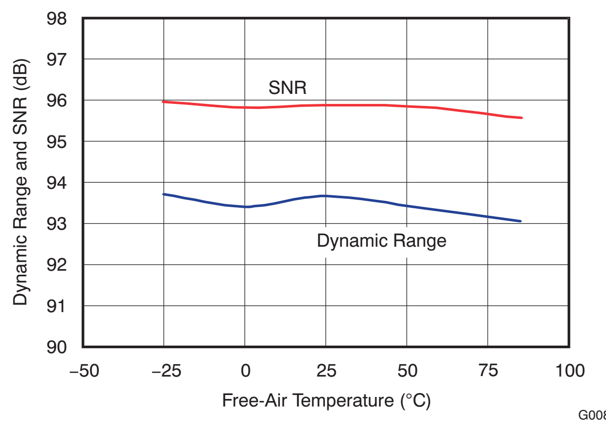


Figure 8.

TYPICAL CHARACTERISTICS: DAC (continued)

All specifications at T_A = +25°C, V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx} = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

TOTAL HARMONIC DISTORTION + NOISE AT 0 dB vs SUPPLY VOLTAGE

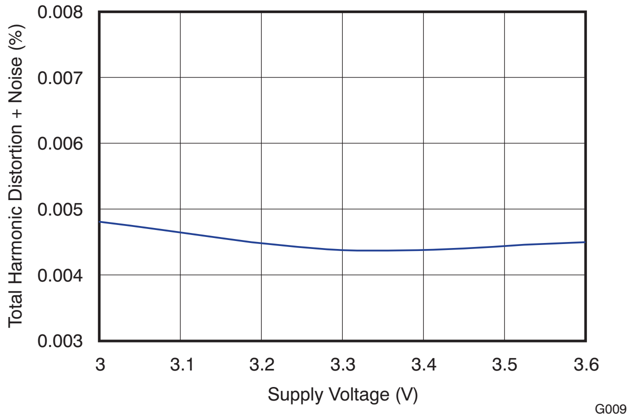


Figure 9.

DYNAMIC RANGE AND SNR vs SUPPLY VOLTAGE

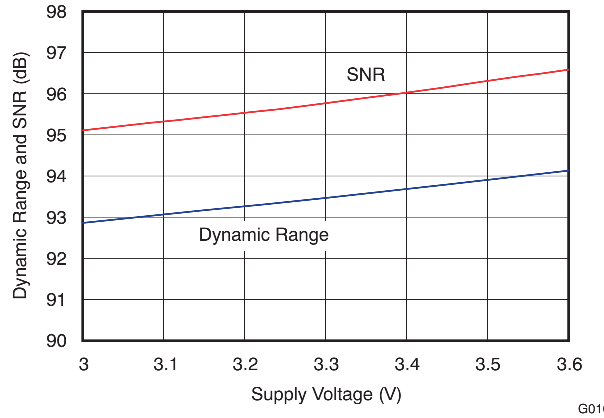


Figure 10.

TOTAL HARMONIC DISTORTION + NOISE AT 0 dB vs SAMPLING FREQUENCY

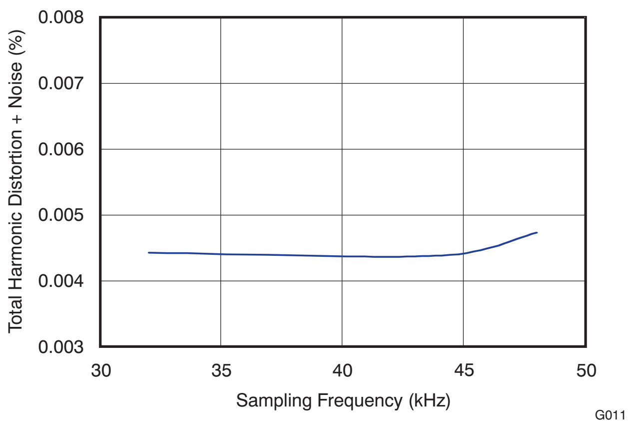


Figure 11.

DYNAMIC RANGE AND SNR vs SAMPLING FREQUENCY

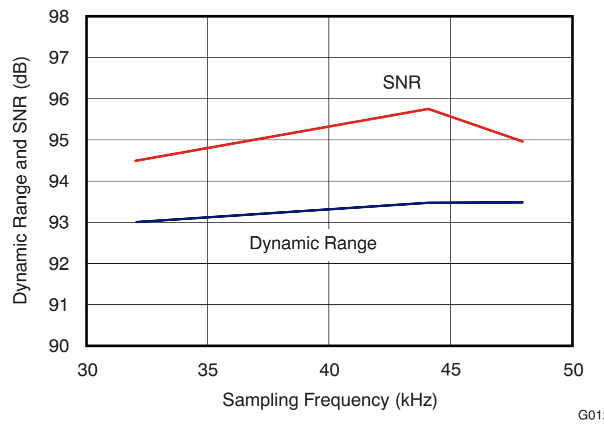


Figure 12.

TYPICAL CHARACTERISTICS: ADC OUTPUT SPECTRUM

All specifications at T_A = +25°C, V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx} = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

OUTPUT SPECTRUM (–1 dB, N = 8192)

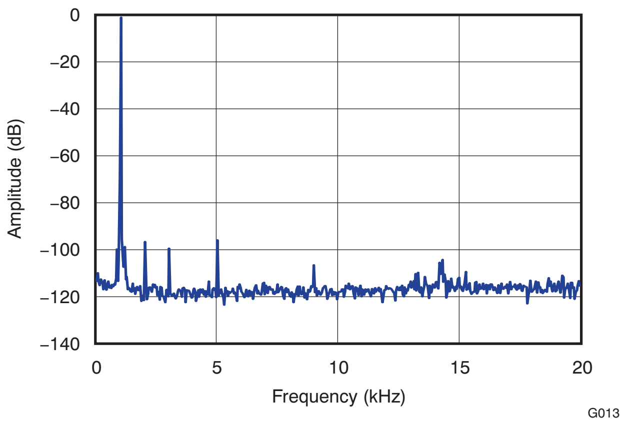


Figure 13.

OUTPUT SPECTRUM (–60 dB, N = 8192)

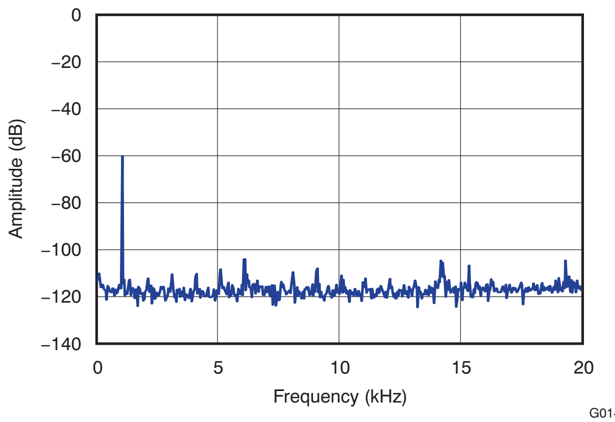


Figure 14.

TYPICAL CHARACTERISTICS: DAC OUTPUT SPECTRUM

All specifications at T_A = +25°C, V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx} = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

OUTPUT SPECTRUM (0 dB, N = 8192)

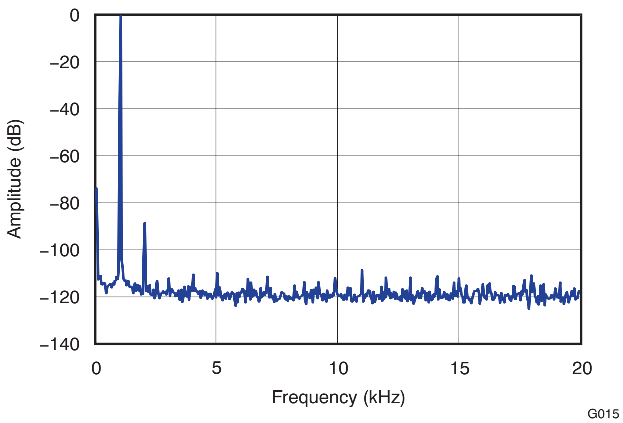


Figure 15.

OUTPUT SPECTRUM (–60 dB, N = 8192)

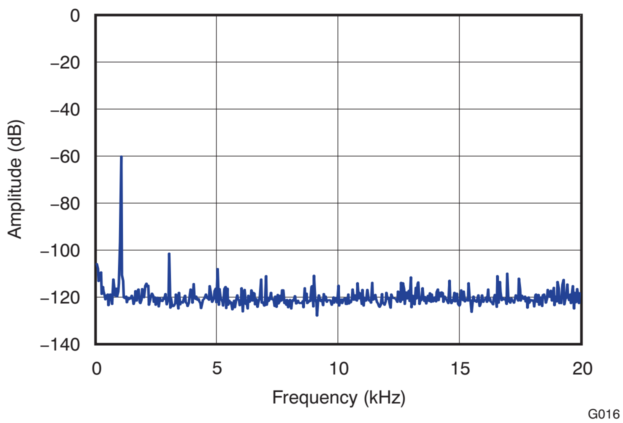


Figure 16.

TYPICAL CHARACTERISTICS: SUPPLY CURRENT

All specifications at T_A = +25°C, $V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx}$ = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

OPERATIONAL AND SUSPEND SUPPLY CURRENT vs SUPPLY VOLTAGE

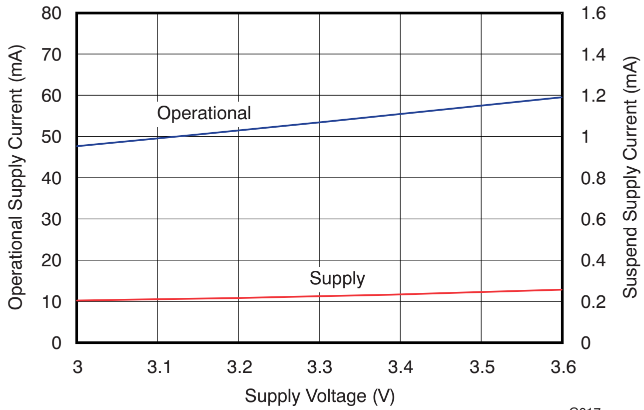


Figure 17.

OPERATIONAL SUPPLY CURRENT vs SAMPLING FREQUENCY

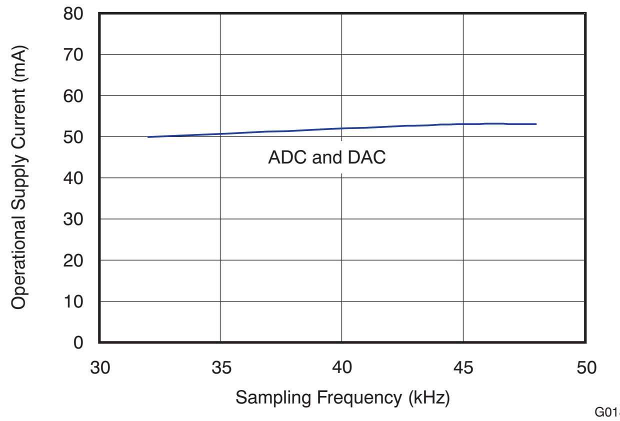


Figure 18.

TYPICAL CHARACTERISTICS: ADC DIGITAL DECIMATION FILTER FREQUENCY RESPONSE

All specifications at T_A = +25°C, $V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx}$ = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

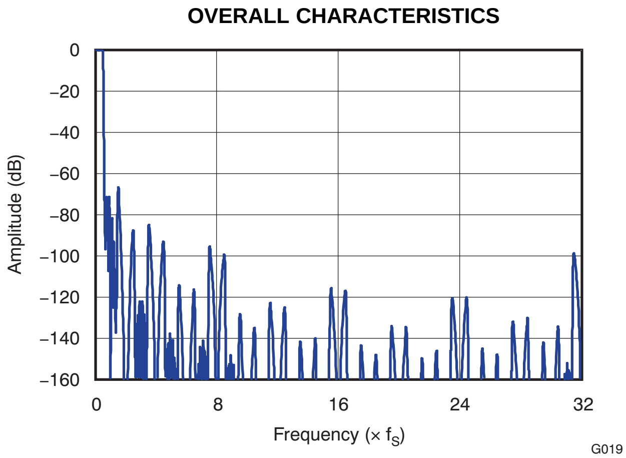


Figure 19.

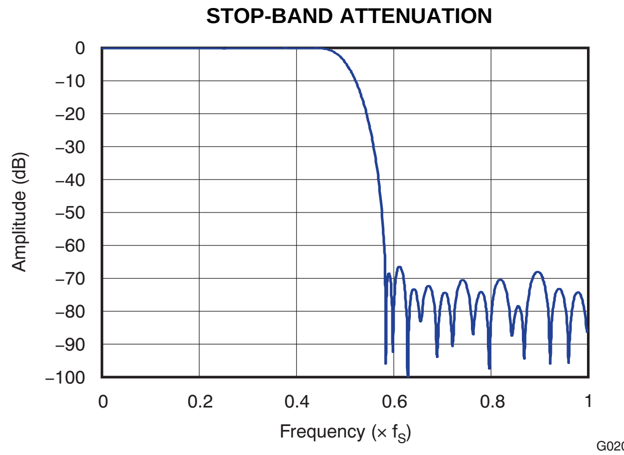


Figure 20.

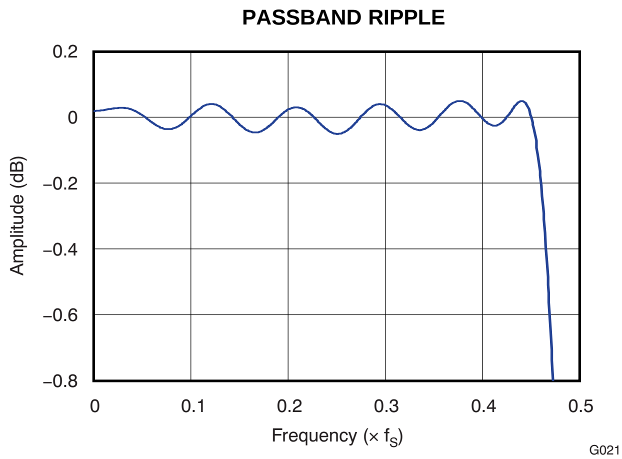


Figure 21.

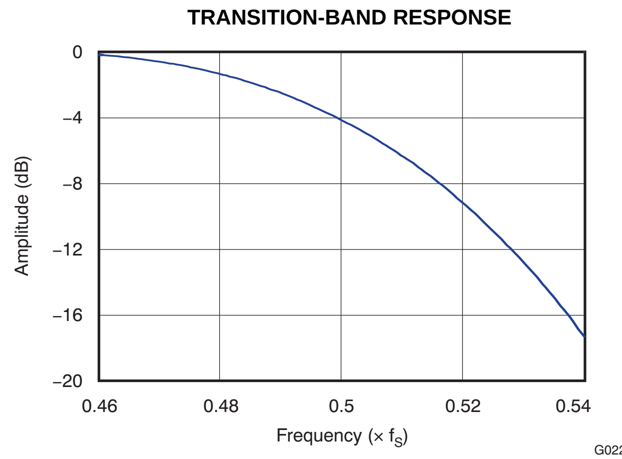


Figure 22.

TYPICAL CHARACTERISTICS: ADC DIGITAL HIGH-PASS FILTER FREQUENCY RESPONSE

All specifications at T_A = +25°C, V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx} = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

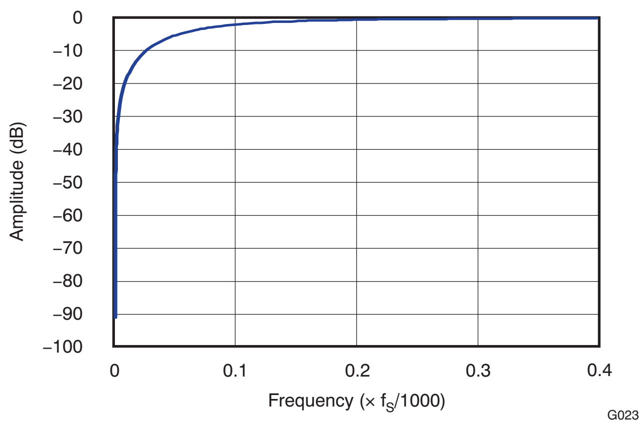


Figure 23.

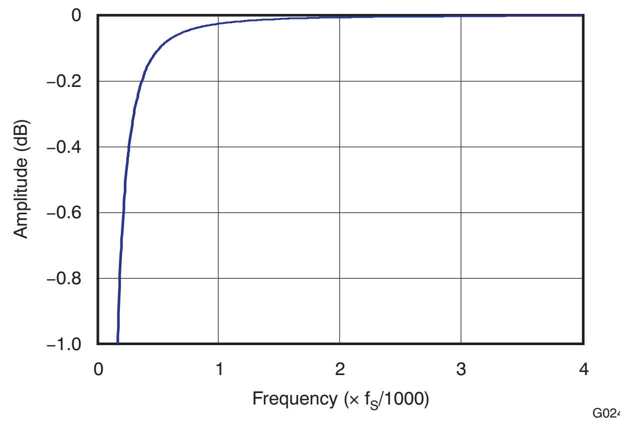


Figure 24.

TYPICAL CHARACTERISTICS: ADC ANALOG ANTIALIASING FILTER FREQUENCY RESPONSE

All specifications at T_A = +25°C, V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx} = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

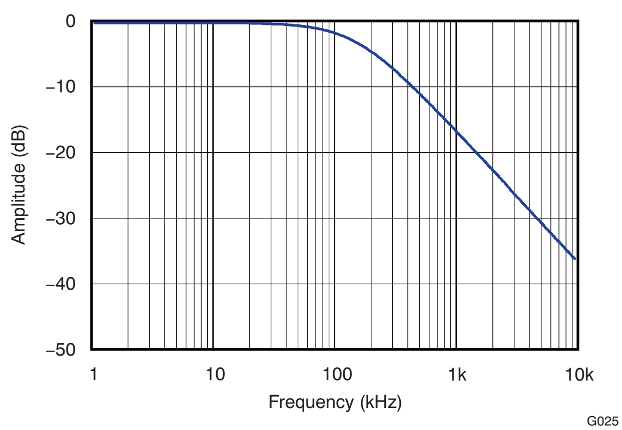


Figure 25.

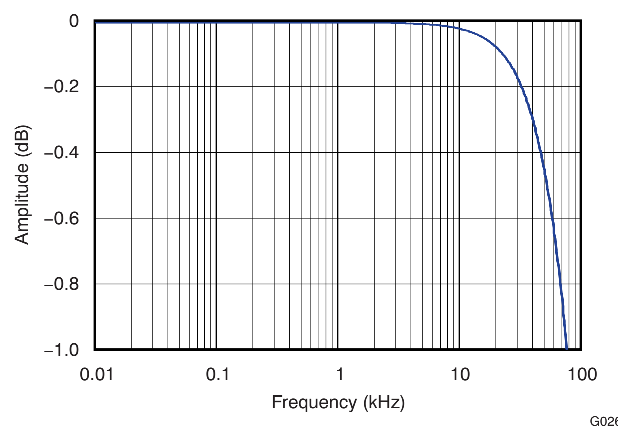


Figure 26.

TYPICAL CHARACTERISTICS: DAC DIGITAL INTERPOLATION FILTER FREQUENCY RESPONSE

All specifications at T_A = +25°C, V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx} = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

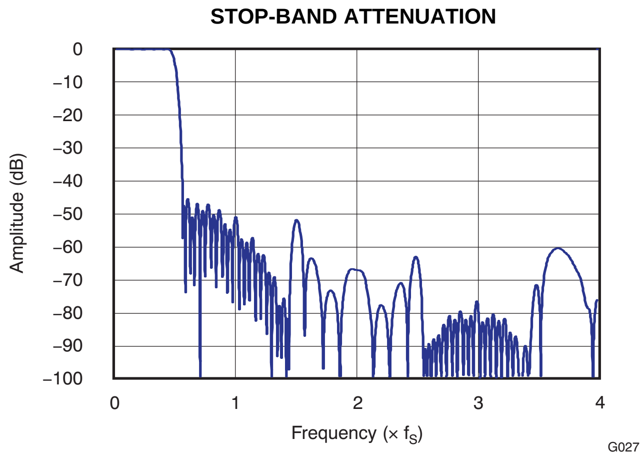


Figure 27.

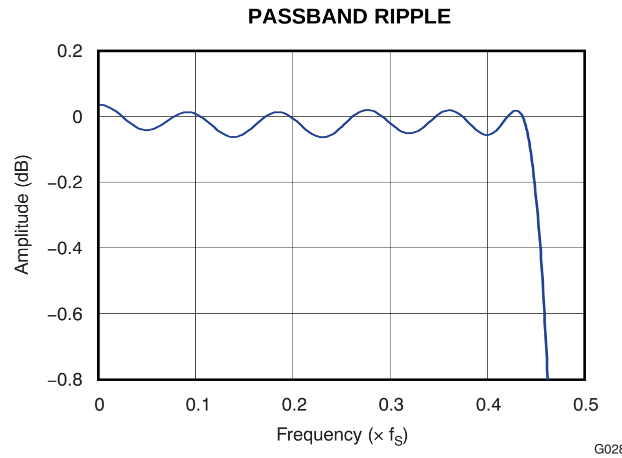


Figure 28.

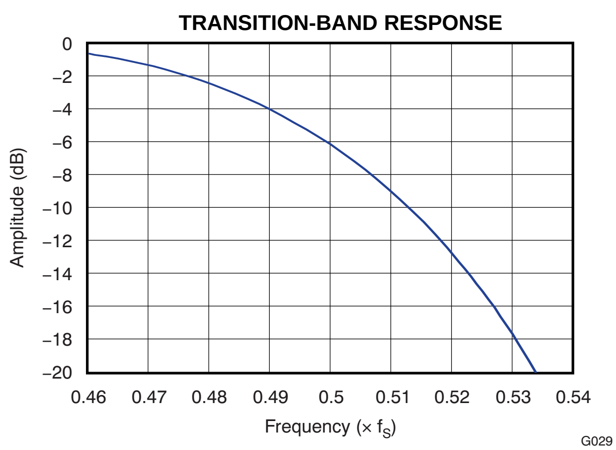


Figure 29.

TYPICAL CHARACTERISTICS: DAC ANALOG FIR FILTER FREQUENCY RESPONSE

All specifications at T_A = +25°C, V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx} = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

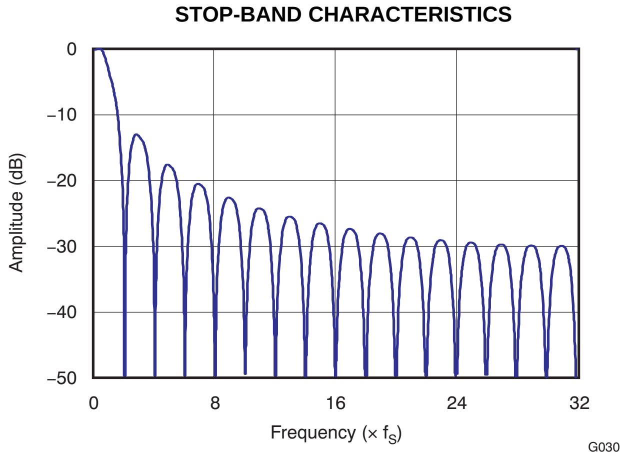


Figure 30.

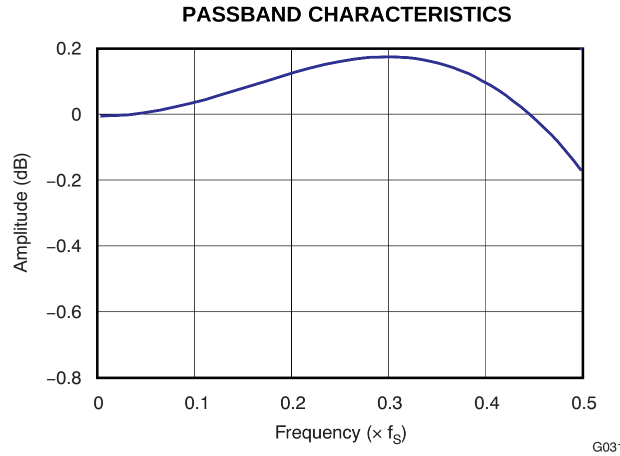


Figure 31.

TYPICAL CHARACTERISTICS: DAC ANALOG LOW-PASS FILTER FREQUENCY RESPONSE

All specifications at T_A = +25°C, V_{DD} = V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCx} = 3.3 V, f_s = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted.

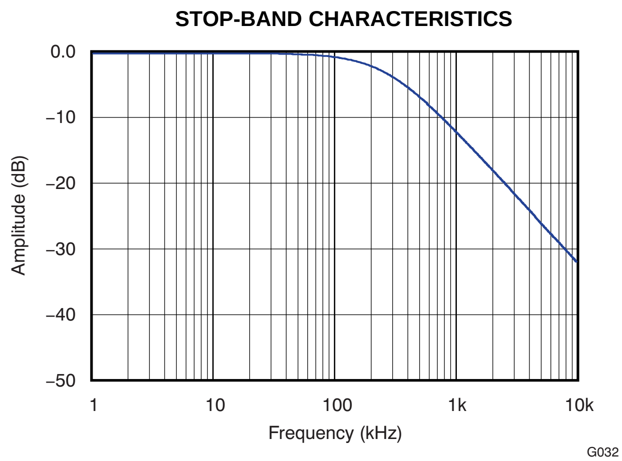


Figure 32.

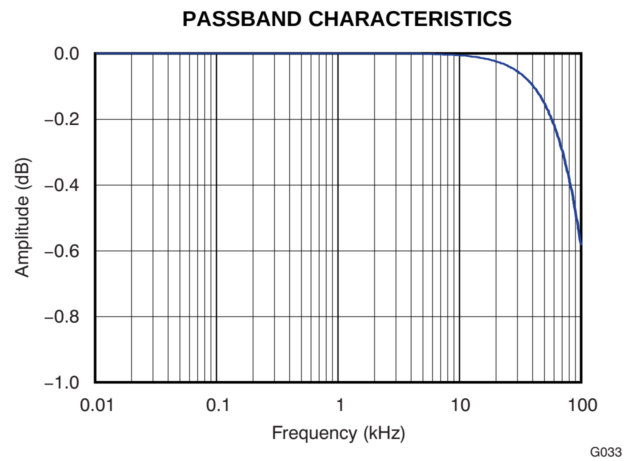


Figure 33.

DETAILED DESCRIPTION

USB INTERFACE

Control data and audio data are transferred to the PCM2903C via D+ (pin 1) and D– (pin 2). All data to and from the PCM2903C are transferred at full speed. The device descriprtor contains the information described in Table 1.

Table 1. Device Descriptor

USB revision	2.0 compliant
Device class	0x00 (device-defined interface level)
Device subclass	0x00 (not specified)
Device protocol	0x00 (not specified)
Max packet size for end-point 0	8 bytes
Vendor ID	0x08BB
Product ID	0x29C3
Device release number	1.0 (0x0100)
Number of configurations	1
Vendor strings	String #1 (see Table 3)
Product strings	String #2 (see Table 3)
Serial number	Not supported

The configuration descriptor contains the information described in Table 2.

Table 2. Configuration Descriptor

Interface	Four interfaces
Power attribute	0xC0 (self-powered, no remote wakeup)
Maximum power	0x0A (20 mA)

The string descriptor contains the information described in Table 3.

Table 3. String Descriptor

#0	0x0409
#1	BurrBrown from Texas Instruments
#2	USB Audio CODEC[(1)]

(1) Ensure that there are two blank spaces between "Audio" and "CODEC"; copying and pasting will not transfer the two blank spaces correctly.

DEVICE CONFIGURATON

Figure 34 illustrates the USB audio function topology. The PCM2903C has four interfaces. Each interface consists of alternative settings.

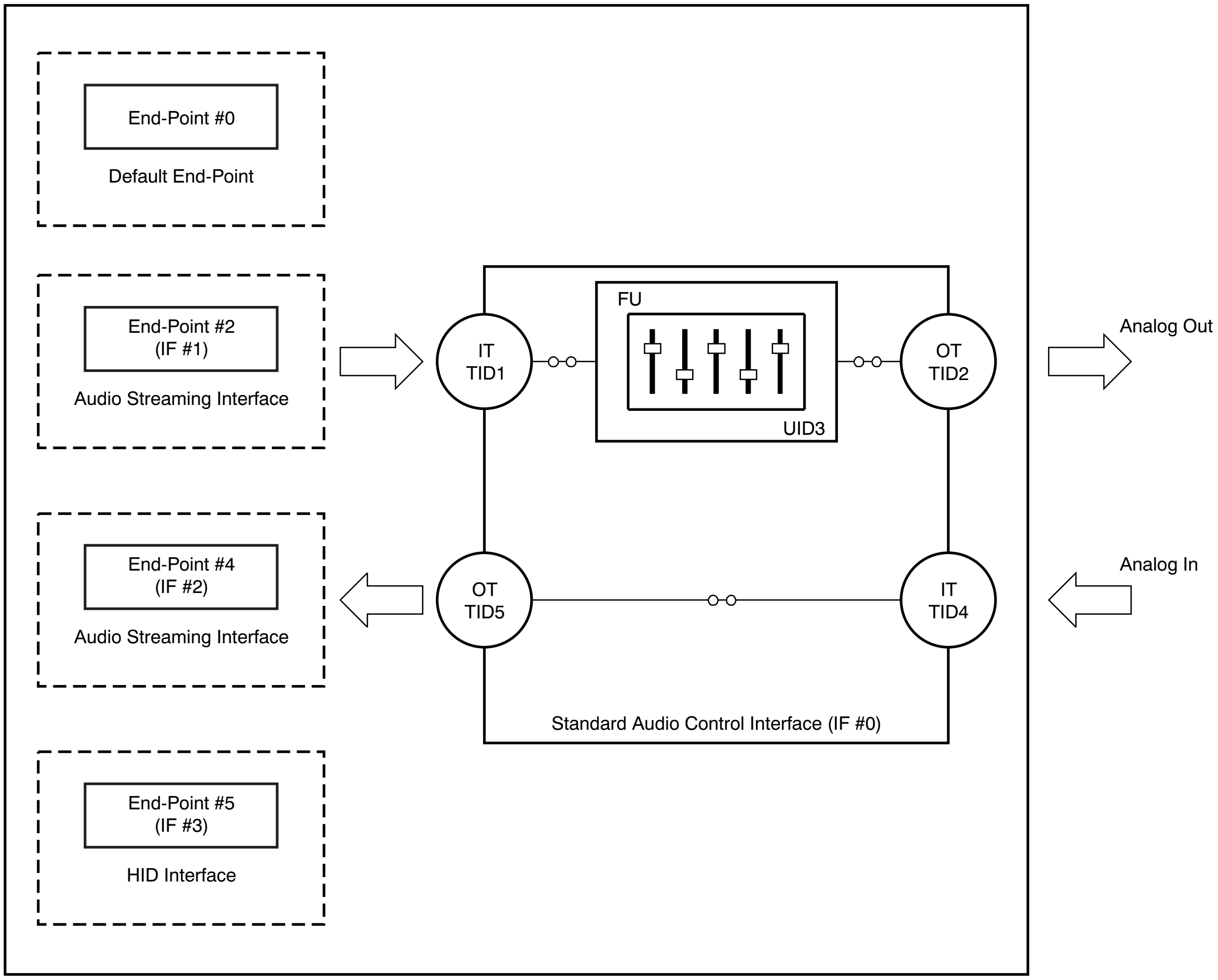


Figure 34. USB Audio Function Topology

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 consists of a single terminal. The PCM2903C has the following five terminals:

- Input terminal (IT #1) for isochronous-out stream
- Output terminal (OT #2) for audio analog output
- Feature unit (FU #3) for DAC digital attenuator
- Input terminal (IT #4) for audio analog input
- Output terminal (OT #5) for isochronous-in stream

Input terminal #1 is defined as *USB stream* (terminal type 0x0101). Input terminal #1 can accept two-channel audio streams consisting of left and right channels. Output terminal #2 is defined as a *speaker* (terminal type 0x0301). Input terminal #4 is defined as a *line connector* (terminal type 0x0603). Output terminal #5 is defined as a *USB stream* (terminal type 0x0101). Output terminal #5 can generate two-channel audio streams composed of left and right channel data. Feature unit #3 supports the following sound control features:

- Volume control
- Mute control

The built-in digital volume controller can be manipulated by an audio class specific request from 0 dB to –64 dB in 1-dB steps. Changes are made by incrementing or decrementing by one step (1 dB) for every $1/f_S$ time interval until the volume level has reached the requested value. Each channel can be set for different values. The master volume control is not supported. A request to the master volume is stalled and ignored. The built-in digital mute controller can be manipulated by audio class-specific request. A master mute control request is acceptable. A request to an individual channel is stalled and ignored.

Interface #1

Interface #1 is the audio streaming data-out interface. Interface #1 has the five alternative settings described in Table 4. Alternative setting #0 is the zero-bandwidth setting.

Table 4. Interface #1 Alternative Settings

ALTERNATIVE SETTING	DATA FORMAT			TRANSFER MODE	SAMPLING RATE (kHz)
00	Zero bandwidth				
01	16-bit	Stereo	Twos complement (PCM)	Adaptive	32, 44.1, 48
02	16-bit	Mono	Twos complement (PCM)	Adaptive	32, 44.1, 48
03	8-bit	Stereo	Twos complement (PCM)	Adaptive	32, 44.1, 48
04	8-bit	Mono	Twos complement (PCM)	Adaptive	32, 44.1, 48

Interface #2

Interface #2 is the audio streaming data-in interface. Interface #2 has the 19 alternative settings described in Table 5. Alternative setting #0 is the zero-bandwidth setting. All other alternative settings are operational settings.

Table 5. Interface #2 Alternative Settings

ALTERNATIVE SETTING	DATA FORMAT			TRANSFER MODE	SAMPLING RATE (kHz)
00	Zero bandwidth				
01	16-bit	Stereo	Twos complement (PCM)	Asynchronous	48
02	16-bit	Mono	Twos complement (PCM)	Asynchronous	48
03	16-bit	Stereo	Twos complement (PCM)	Asynchronous	44.1
04	16-bit	Mono	Twos complement (PCM)	Asynchronous	44.1
05	16-bit	Stereo	Twos complement (PCM)	Asynchronous	32
06	16-bit	Mono	Twos complement (PCM)	Asynchronous	32
07	16-bit	Stereo	Twos complement (PCM)	Asynchronous	22.05
08	16-bit	Mono	Twos complement (PCM)	Asynchronous	22.05
09	16-bit	Stereo	Twos complement (PCM)	Asynchronous	16
0A	16-bit	Mono	Twos complement (PCM)	Asynchronous	16
0B	8-bit	Stereo	Twos complement (PCM)	Asynchronous	16
0C	8-bit	Mono	Twos complement (PCM)	Asynchronous	16
0D	8-bit	Stereo	Twos complement (PCM)	Asynchronous	8
0E	8-bit	Mono	Twos complement (PCM)	Asynchronous	8
0F	16-bit	Stereo	Twos complement (PCM)	Synchronous	11.025
10	16-bit	Mono	Twos complement (PCM)	Synchronous	11.025
11	8-bit	Stereo	Twos complement (PCM)	Synchronous	11.025
12	8-bit	Mono	Twos complement (PCM)	Synchronous	11.025

Interface #3

Interface #3 is the interrupt data-in interface. Alternative setting #0 is the only possible setting for interface #3. Interface #3 consists of the HID consumer control device and reports the status of these three key parameters:

- Mute (0xE209)
- Volume up (0xE909)
- Volume down (0xEA09)

End-Points

The PCM2903C has the following four end-points:

- Control end-point (EP #0)
- Isochronous-out audio data stream end-point (EP #2)
- Isochronous-in audio data stream end-point (EP #4)
- HID end-point (EP #5)

The control end-point is a default end-point. The control end-point is used to control all functions of the PCM2903C by the standard USB request and an USB audio class specific request from the host. The isochronous-out audio data stream end-point is an audio sink end-point, which receives the PCM audio data. The isochronous-out audio data stream end-point accepts the adaptive transfer mode. The isochronous-in audio data stream end-point is an audio source end-point that transmits the PCM audio data. The isochronous-in audio data stream end-point uses asynchronous transfer mode. The HID end-point is an interrupt-in end-point. HID end-point reports HID0, HID1, and HID2 pin status every 32 ms.

The human interface device (HID) pins are defined as consumer control devices. The HID function is designed as an independent end-point from both isochronous-in and -out end-points. Therefore, the result obtained from the HID operation depends on the host software. Typically, the HID function is used as the primary audio-out device.

Clock and Reset

The PCM2903C requires a 12-MHz (±500 ppm) clock for the USB and audio function, which can be generated by a built-in crystal oscillator with a 12-MHz crystal resonator or supplied by an external clock. The 12-MHz crystal resonator must be connected to XTI (pin 21) and XTO (pin 20) with one high (1-MΩ) resistor and two small capacitors, the capacitance of which depends on the load capacitance of the crystal resonator. If the external clock is used, the clock must be supplied to XTI, and XTO must be open.

The PCM2903C has an internal power-on reset circuit, which triggers automatically when V_{DD} (pin 27) exceeds 2.5 V typical (2.7 V to 2.2 V). Approximately 700 μs is required until internal reset release.

Digital Audio Interface

The PCM2903C employs both S/PDIF input and output. Isochronous-out data from the host are encoded to the S/PDIF output and the DAC analog output. Input data are selected as either S/PDIF or ADC analog input. When the device detects an S/PDIF input and successfully locks on the received data, the isochronous-in transfer data source is automatically selected from S/PDIF itself; otherwise, the data source selected is the ADC analog input.

This feature is a customer option. It is the responsibility of the user to implement this feature.

Supported Input/Output Data

The following data formats are accepted by the S/PDIF input and output. All other data formats are unable to use S/PDIF.

- 48-kHz 16-bit stereo
- 44.1-kHz 16-bit stereo
- 32-kHz 16-bit stereo

Any mismatch of the sampling rate between the input S/PDIF signal and the host command is not acceptable. Any mismatch of the data format between the input S/PDIF signal and the host command may cause unexpected results, with the following exceptions:

- Recording in monaural format from stereo data input at the same data rate
- Recording in 8-bit format from 16-bit data input at the same data rate

A combination of these two conditions is not acceptable.

For playback, all possible data-rate sources are converted to 16-bit stereo format at the same source data rate.

Channel Status Information

The channel status information is fixed as consumer application, PCM mode, copyright, and digital/digital converter. All other bits are fixed as 0's except for the sample frequency, which is set automatically according to the data received through the USB.

Copyright Management

Isochronous-in data are affected by the serial copy management system (SCMS). When the control bit indicates that the received digital audio data are original, the input digital audio data are transferred to the host. If the data are indicated as first generation or higher, the transferred data are routed to the analog input.

Digital audio data output is always encoded as original with SCMS control.

INTERFACE SEQUENCE

Power On, Attach, and Playback Sequence

The PCM2903C is ready for setup when the reset sequence has finished and the USB bus is attached. In order to perform certain reset sequences defined in the USB specification, V_{DD}, V_{CCC}, V_{CCP1}, V_{CCP2}, and V_{CCX} must rise up within 10 ms / 3.3 V. After connection has been established by setup, the PCM2903C is ready to accept USB audio data. While waiting, the audio data (idle state) and analog output are set to bipolar zero (BPZ).

When receiving the audio data, the PCM2903C stores the first audio packet, which contained 1-ms audio data, into the internal storage buffer. The PCM2903C starts playing the audio data when detecting the next start of frame (SOF) packet, as illustrated in Figure 35 and Figure 36.

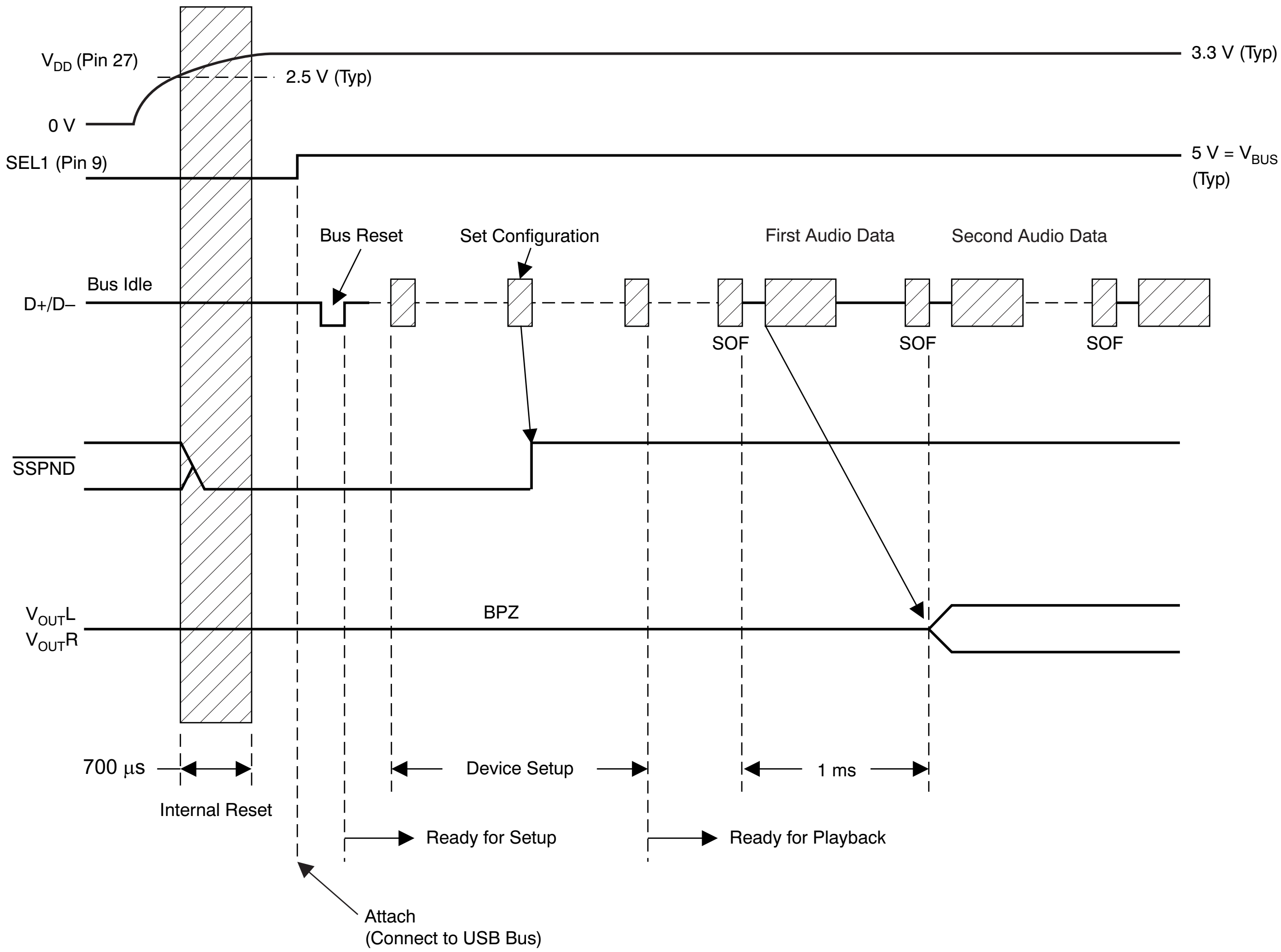


Figure 35. Attach After Power On

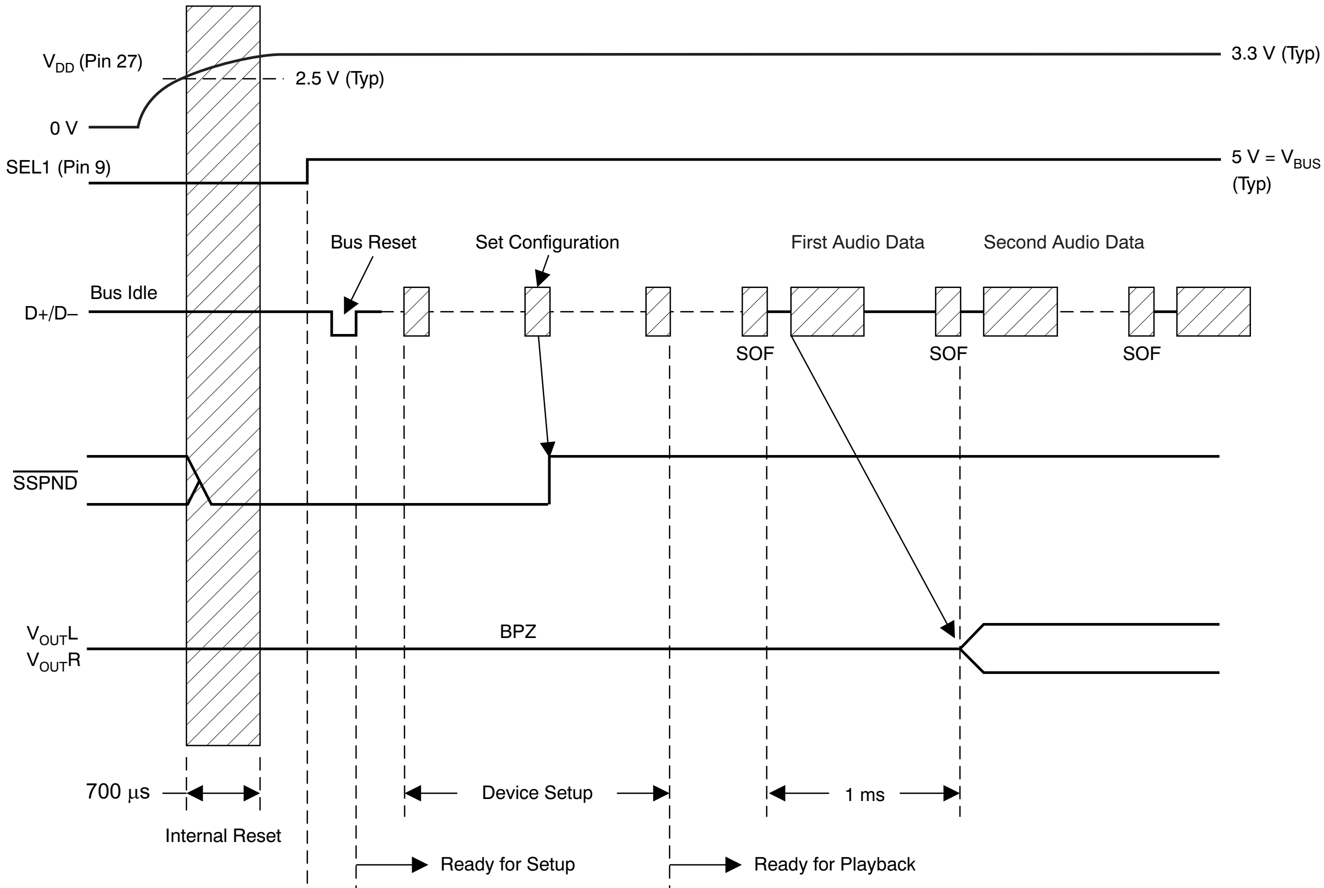


Figure 36. Power-On Under Attach

Play, Stop, and Detach Sequence

When the host finishes or aborts the playback, the PCM2903C stops playing after the last audio data have played, as shown in Figure 37.

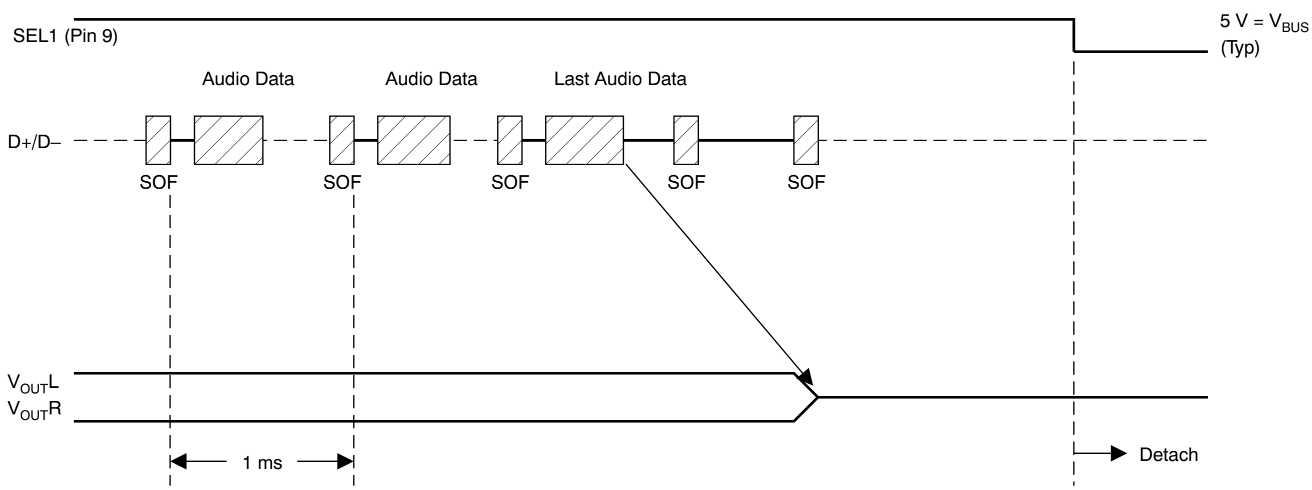


Figure 37. Play, Stop, and Detach Sequence

Record Sequence

The PCM2903C starts the audio capture into the internal memory after receiving the SET_INTERFACE command, as shown in Figure 38.

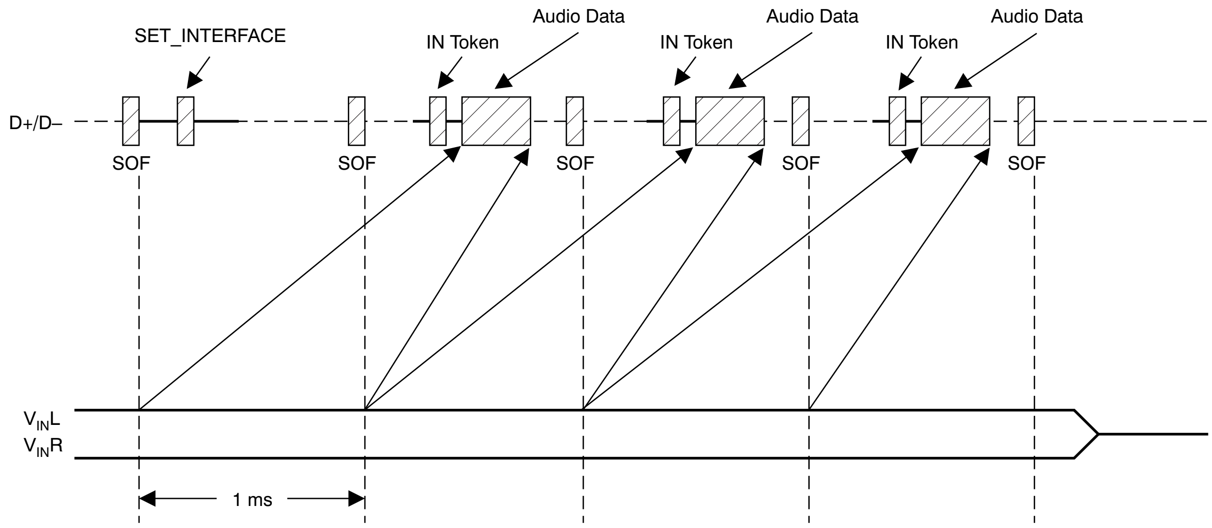


Figure 38. Record Sequence

Suspend and Resume Sequence

The PCM2903C enters the suspend state after it detects a constant idle state on the USB bus (approximately 5 ms), as shown in Figure 39. While the PCM2903C enters the suspend state, the $\overline{\text{SSPND}}$ flag (pin 28) is asserted. The PCM2903C wakes up immediately after detecting a non-idle state on the USB bus.

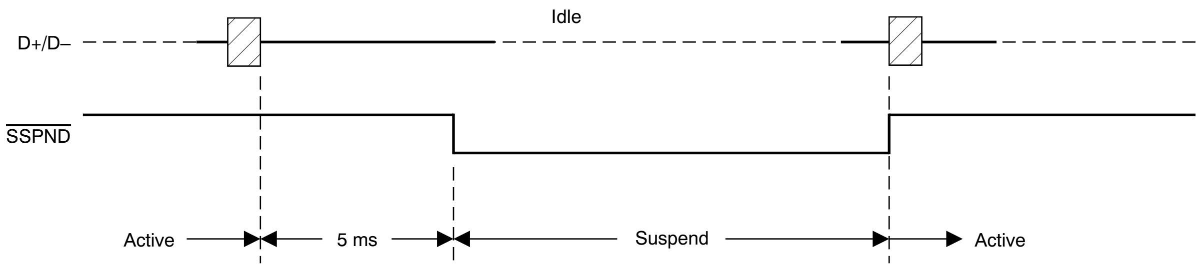
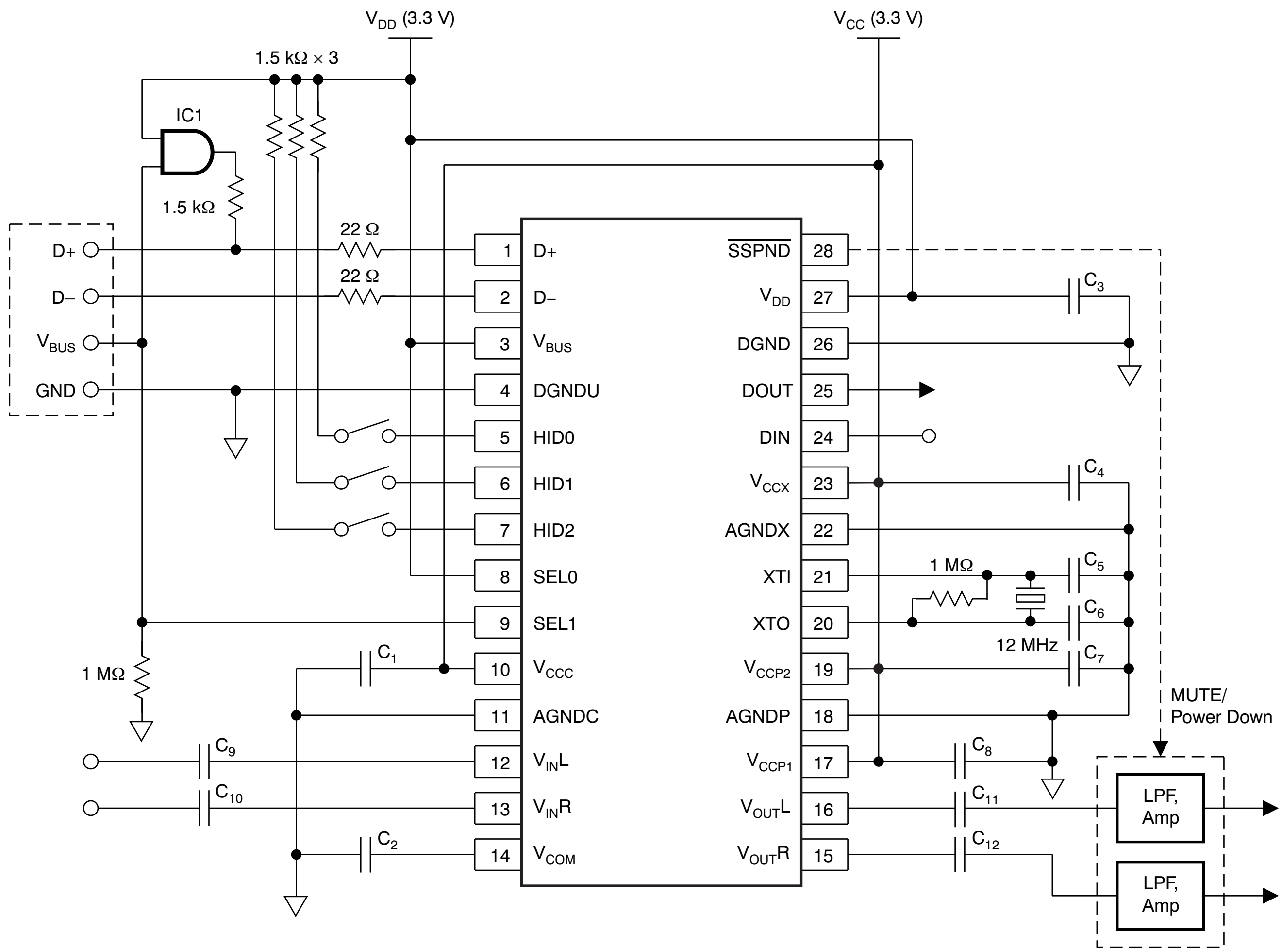


Figure 39. Suspend and Resume Sequence

APPLICATION INFORMATION

TYPICAL CIRCUIT CONNECTION

Figure 40 illustrates a typical circuit connection for a simple application. The circuit illustrated is for information only. The entire board design should be considered to meet the USB specification as a USB-compliant product.



NOTE: IC1 must be driven by V_{DD} with a 5-V tolerant input.
C_1, C_2, C_3, C_4, C_7, C_8: 10 μF
C_5, C_6: 10 pF to 33 pF (depending on crystal resonator)
C_9, C_{10}, C_{11}, C_{12}: The capacitance may vary depending on design.

Figure 40. Self-Powered Configuration

OPERATING ENVIRONMENT

For current information on the PCM2903C operating environment, see Application Report SLAA374, *Updated Operating Environments for PCM270X, PCM290X Applications*, 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)	Samples (Requires Login)
PCM2903CDB	ACTIVE	SSOP	DB	28	50	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	
PCM2903CDBR	ACTIVE	SSOP	DB	28	2000	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.

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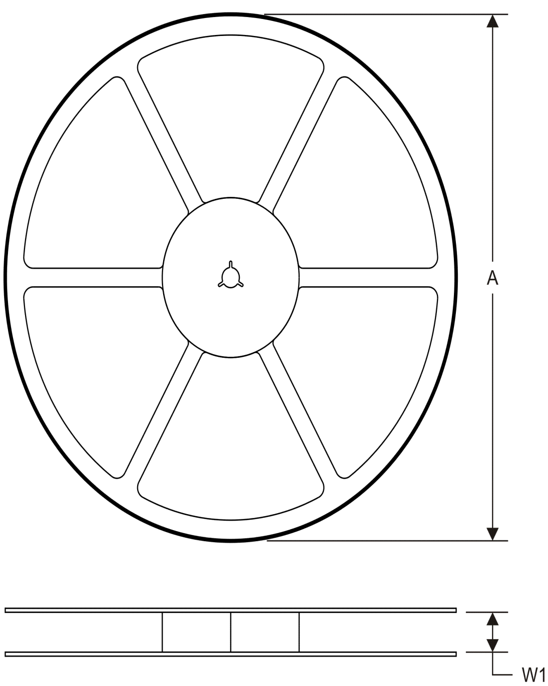
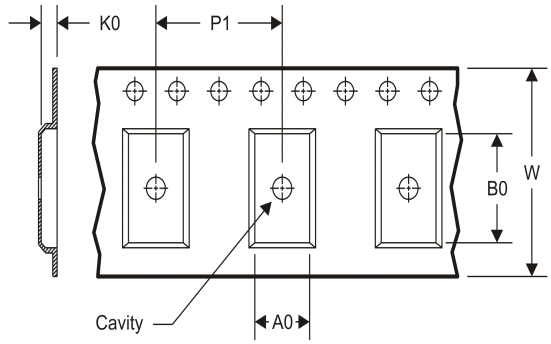
TAPE AND REEL INFORMATION





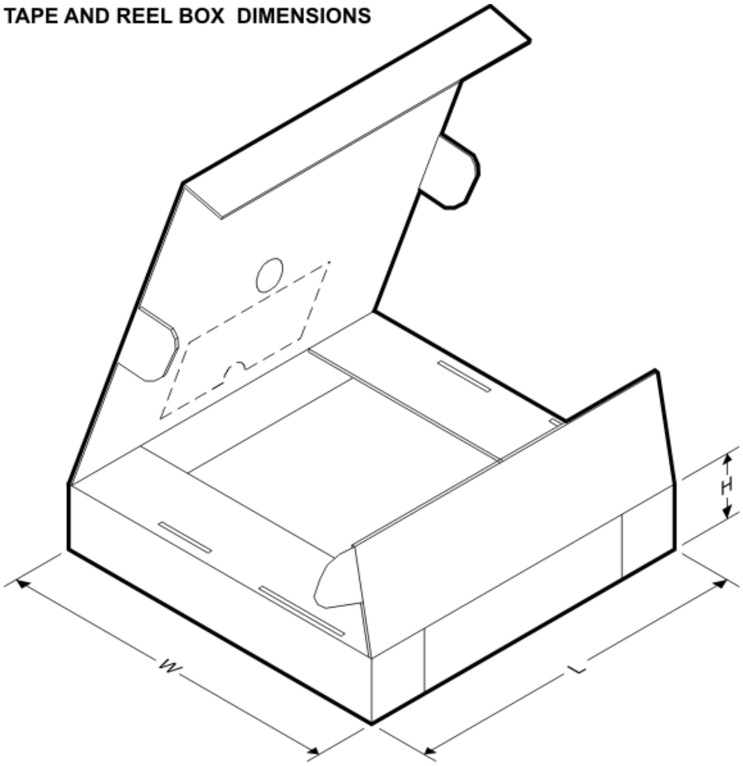
A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

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
PCM2903CDBR	SSOP	DB	28	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS

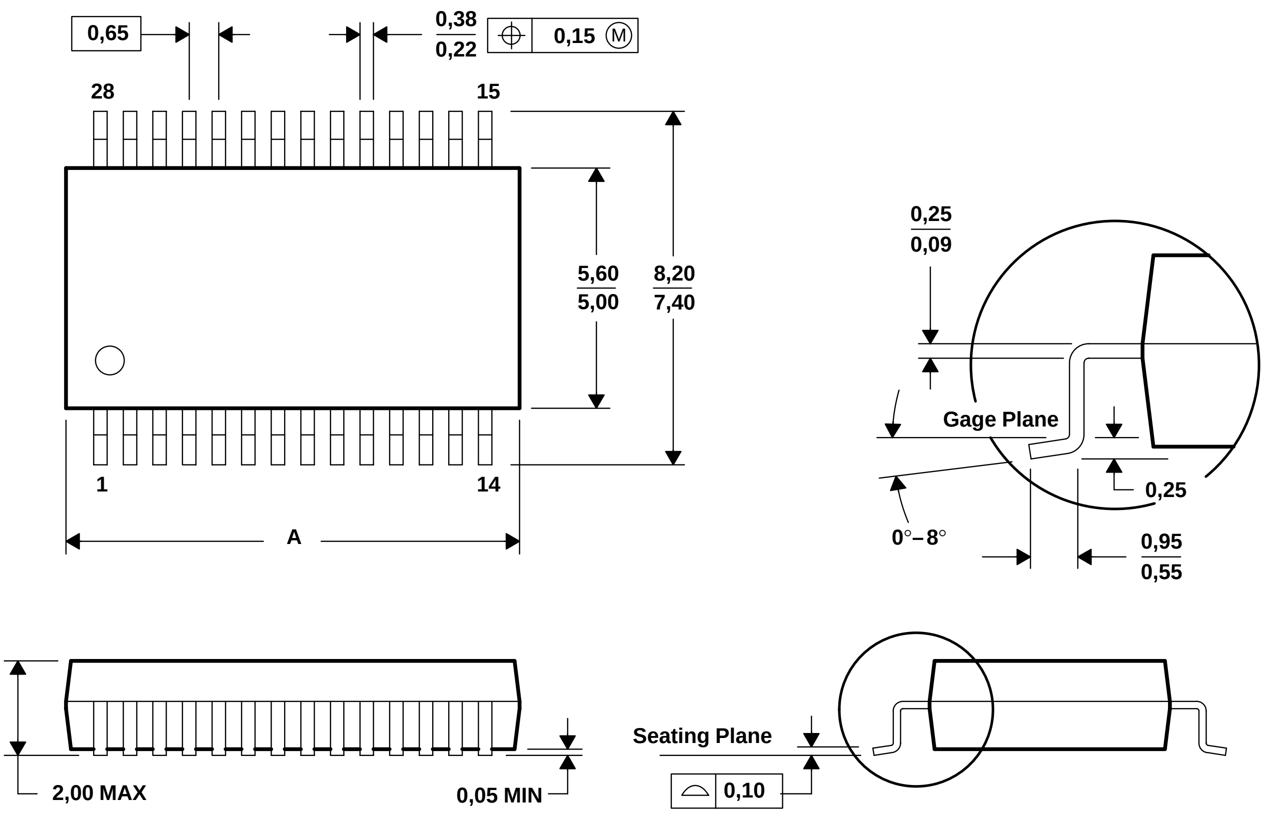


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
PCM2903CDBR	SSOP	DB	28	2000	367.0	367.0	38.0

DB (R-PDSO-G)** **PLASTIC SMALL-OUTLINE**

28 PINS SHOWN



PINS ** / DIM	14	16	20	24	28	30	38
A MAX	6,50	6,50	7,50	8,50	10,50	10,50	12,90
A MIN	5,90	5,90	6,90	7,90	9,90	9,90	12,30

4040065 /E 12/01

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-150