Burr-Brown Products
from Texas Instruments

PCM2901
PCM2903

SLES034C–MARCH 2002–REVISED NOVEMBER 2007

STEREO AUDIO CODEC WITH USB INTERFACE, SINGLE-ENDED ANALOG INPUT/OUTPUT AND S/PDIF

FEATURES

- PCM2901: Without S/PDIF
- PCM2903: With S/PDIF
- On-Chip USB Interface
  - With Full-Speed Transceivers
  - Fully Compliant With USB 1.1 Specification
  - Certified by USB-IF
  - Partially Programmable Descriptors (1)
  - 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
- 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
    - Pass-Band Ripple = ±0.05 dB
    - Stop-Band Attenuation = –65 dB
  - Single-Ended Voltage Input
  - Antialiasing Filter Included
  - Digital LCF 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
    - Pass-Band Ripple = ±0.1 dB
    - Stop-Band Attenuation = –43 dB
  - Single-Ended Voltage Output
  - Analog LPF Included
- Multifunctions
  - Human Interface Device (HID) Volume ± Control and Mute Control
  - Suspend Flag
- Package: 28-Pin SSOP

(1) The descriptor can be modified by changing a mask.

APPLICATIONS

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

DESCRIPTION

The PCM2901/2903 is TI's single-chip USB stereo audio codec with USB-compliant full-speed protocol controller and S/PDIF (only PCM2903). The USB protocol controller works with no software code, but the USB descriptors can be modified in some areas (for example, vendor ID/product ID). The PCM2901/2903 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 and with 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.

ORDERING INFORMATION

PCM2901						
PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER(1)	TRANSPORT MEDIA
PCM2901E	SSOP-28	28DB	–25°C to 85°C	PCM2901E	PCM2901E	Rails
					PCM2903E/2K	Tape and reel

(1) Models with a slash (/) are available only in tape and reel in the quantities indicated (e.g., /2K indicates 2000 devices per reel). Ordering 2000 pieces of PCM2901E/2K gets a single 2000-piece tape and reel.

PCM2903						
PRODUCT	PACKAGE-LEAD	PACKAGE DESIGNATOR	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER(1)	TRANSPORT MEDIA
PCM2903E	SSOP-28	28DB	–25°C to 85°C	PCM2903E	PCM2903E	Rails
					PCM2903E/2K	Tape and reel

(1) Models with a slash (/) are available only in tape and reel in the quantities indicated (e.g., /2K indicates 2000 devices per reel). Ordering 2000 pieces of PCM2903E/2K gets a single 2000-piece tape and reel.

ABSOLUTE MAXIMUM RATINGS

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

		PCM2901/PCM2903	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, TEST0 (DIN)(2)	–0.3 to 6.5	V
	D+, D–, HID0, HID1, HID2, XTI, XTO, TEST1 (DOUT)(2), $\overline{SSPND}$	–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)		260	°C, 5 s
Package temperature (IR reflow, peak)		250	°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) ( ): PCM2903

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	MIN	TYP	MAX	UNIT
DIGITAL INPUT/OUTPUT						
Host interface		Apply USB Revision 1.1, full speed				
Audio data format		USB isochronous data format				
INPUT LOGIC						
V_{IH}	D+, D–		2		V_{DD}	VDC
High-level input voltage	XTI, HID0, HID1, and HID2		0.7 V_{DD}		V_{DD}	
	SEL0, SEL1		2		5.25	
	DIN (PCM2903)		0.7 V_{DD}		5.25	
V_{IL}	D+, D–		V_{DD}		0.8	VDC
Low-level input voltage	XTI, HID0, HID1, and HID2				0.3 V_{DD}	
	SEL0, SEL1				0.8	
	DIN (PCM2903)				0.3 V_{DD}	
I_{IH}	D+, D–, XTI, SEL0, SEL1	V_{IN} = 3.3 V			±10	µA
High-level input current	HID0, HID1, and HID2	V_{IN} = 3.3 V		50	80	
	DIN (PCM2903)	V_{IN} = 3.3 V		65	100	
I_{IL}	D+, D–, XTI, SEL0, SEL1	V_{IN} = 0 V			±10	µA
Low-level input current	HID0, HID1, and HID2	V_{IN} = 0 V			±10	
	DIN (PCM2903)	V_{IN} = 0 V			±10	
OUTPUT LOGIC						
V_{OH}	D+, D–		2.8			VDC
High-level output voltage	DOUT (PCM2903)	I_{OH} = –4 mA	2.8			
	$\overline{SSPND}$	I_{OH} = –2 mA	2.8			
V_{OL}	D+, D–				0.3	VDC
Low-level output voltage	DOUT (PCM2903)	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

PCM2901
PCM2903
SLES034C–MARCH 2002–REVISED NOVEMBER 2007

TEXAS INSTRUMENTS
www.ti.com

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	MIN	TYP	MAX	UNIT
ADC CHARACTERISTICS						
	Resolution			8, 16		bits
	Audio data channel			1, 2		channel
Clock Frequency						
f_S	Sampling frequencies		8, 11.025, 16, 22.05, 32, 44.1, 48			kHz
DC Accuracy						
	Gain mismatch, channel-to-channel			±1	±5	% of FSR
	Gain error			±2	±10	% of FSR
	Bipolar zero error			±0		% of FSR
Dynamic Performance(1)						
THD+N	Total harmonic distortion plus noise	V_{IN} = –0.5 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}		Vp-p
	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
Digital Filter Performance						
	Pass band				0.454 f_S	Hz
	Stop band		0.563 f_S			Hz
	Pass-band ripple				±0.05	dB
	Stop-band attenuation		–65			dB
t_d	Delay time			17.4/f_S		s
	LCF frquency response	–3 dB		0.078 f_S		MHz

(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

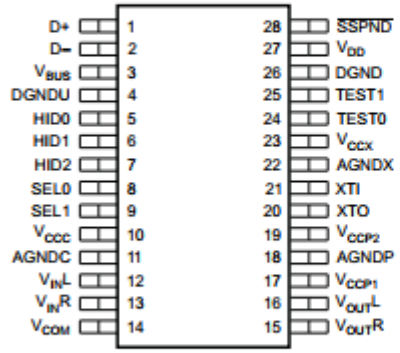
all specifications at T_A = 25°C, V_{CCC} = V_{CCP1} = V_{CCP2} = V_{CCX} = V_{DD} = 3.3 V, f_S = 44.1 kHz, f_{IN} = 1 kHz, 16-bit data, unless otherwise noted

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
DAC CHARACTERISTICS						
	Resolution			8, 16		bits
	Audio data channel			1, 2		channel
Clock Frequency						
f_S	Sampling frequencies			32, 44.1, 48		kHz
DC Accuracy						
	Gain mismatch channel-to-channel			±1	±5	% of FSR
	Gain error			±2	±10	% of FSR
	Bipolar zero error			±2		% of FSR
Dynamic Performance(1)						
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}		Vp-p
	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
Digital Filter Performance						
	Pass band				0.445 f_S	Hz
	Stop band		0.555 f_S			Hz
	Pass-band ripple				±0.1	dB
	Stop-band attenuation		–43			dB
t_d	Delay time			14.3/f_S		s
POWER SUPPLY REQUIREMENTS						
	Voltage range (V_{DD}, V_{CCC}, V_{CCP1}, V_{CCP2}, V_{CCX})		3	3.3	3.6	VDC
	Supply current	ADC, DAC operation		54	70	mA
		Suspend mode(2)		210		µA
P_D	Power dissipation	ADC, DAC operation		178	252	mW
		Suspend mode(2)		0.69		
TEMPERATURE RANGE						
	Operaton temperature		–25		85	°C
θ_{JA}	Thermal resistance			100		°C/W

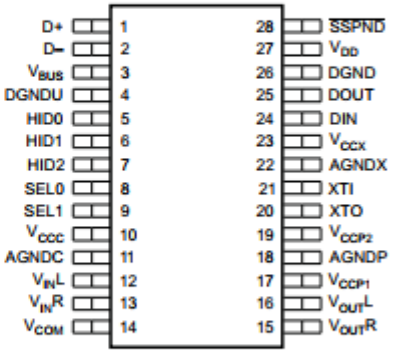
(1) f_{OUT} = 1 kHz, using a System Two audio measuerment system by Audio Precision in RMS mode with a 20-kHz LPF and 400-Hz HPF.
(2) Under USB suspend state

PIN ASSIGNMENTS

PCM2901
(Top View)



PCM2903
(Top View)



P0007-07

PCM2901 TERMINAL FUNCTIONS

TERMINAL		I/O	DESCRIPTION
NAME	NO.		
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
HID0	5	I	HID key state input (mute), active-high (2)
HID1	6	I	HID key state input (volume up), active-high (2)
HID2	7	I	HID key state input (volume down), active-high (2)
SEL0	8	I	Must be set to high (3)
SEL1	9	I	Connected to the USB port of V_{BUS} (3)
$\overline{SSPND}$	28	O	Suspend flag, active-low (Low: suspend, High: operational)
TEST0	24	I	Test pin, must be connected to GND
TEST1	25	O	Test pin, must be left open
V_{BUS}	3	–	Must be connected to V_{DD}
V_{CCC}	10	–	Analog power supply for codec (4)
V_{CCP1}	17	–	Analog power supply for PLL (4)
V_{CCP2}	19	–	Analog power supply for PLL (4)
V_{CCX}	23	–	Analog power supply for oscillator (4)
V_{COM}	14	–	Common for ADC/DAC (V_{CCC}/2) (4)
V_{DD}	27	–	Digital power supply (4)
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 (5)
XTO	20	O	Crystal oscillator output

(1) LV-TTL level
(2) 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.
(3) TTL Schmitt trigger, 5-V tolerant
(4) Connect a decoupling capacitor to GND.
(5) 3.3-V CMO- level input

PCM2901
PCM2903
SLES034C–MARCH 2002–REVISED NOVEMBER 2007

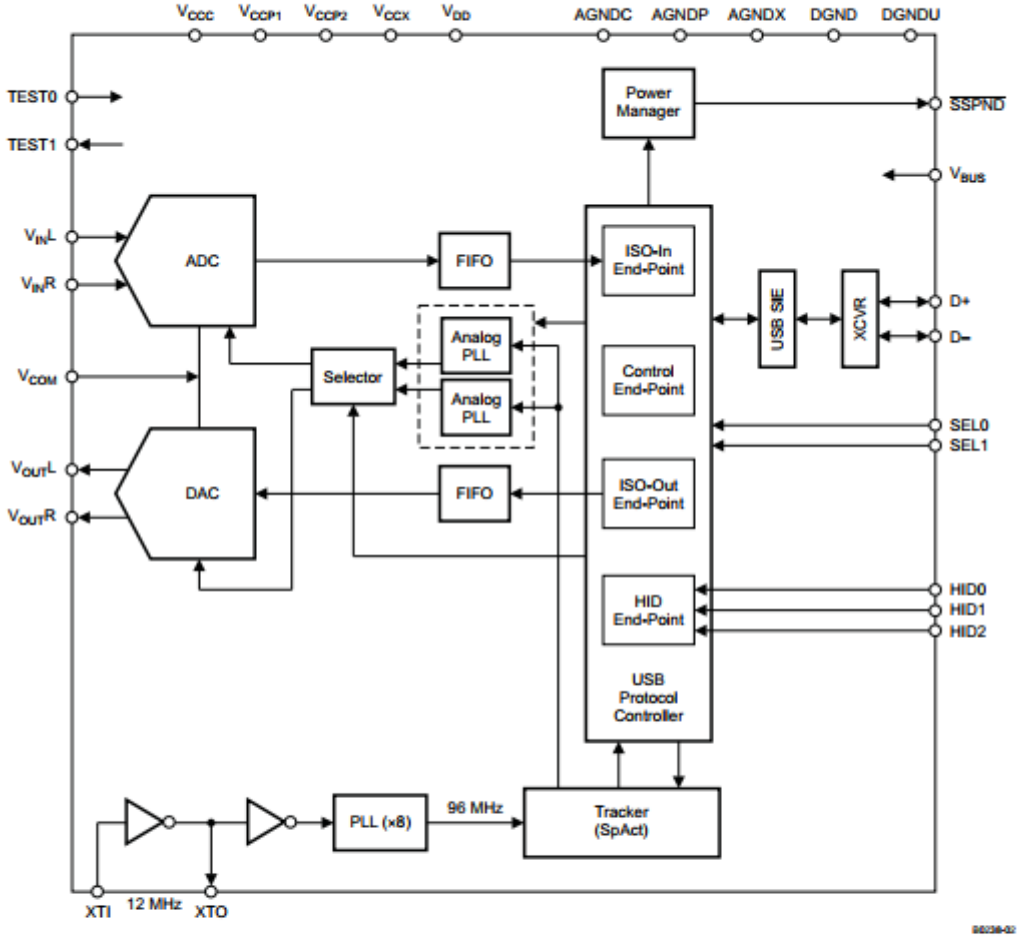
TEXAS INSTRUMENTS
www.ti.com

PCM2903 TERMINAL FUNCTIONS

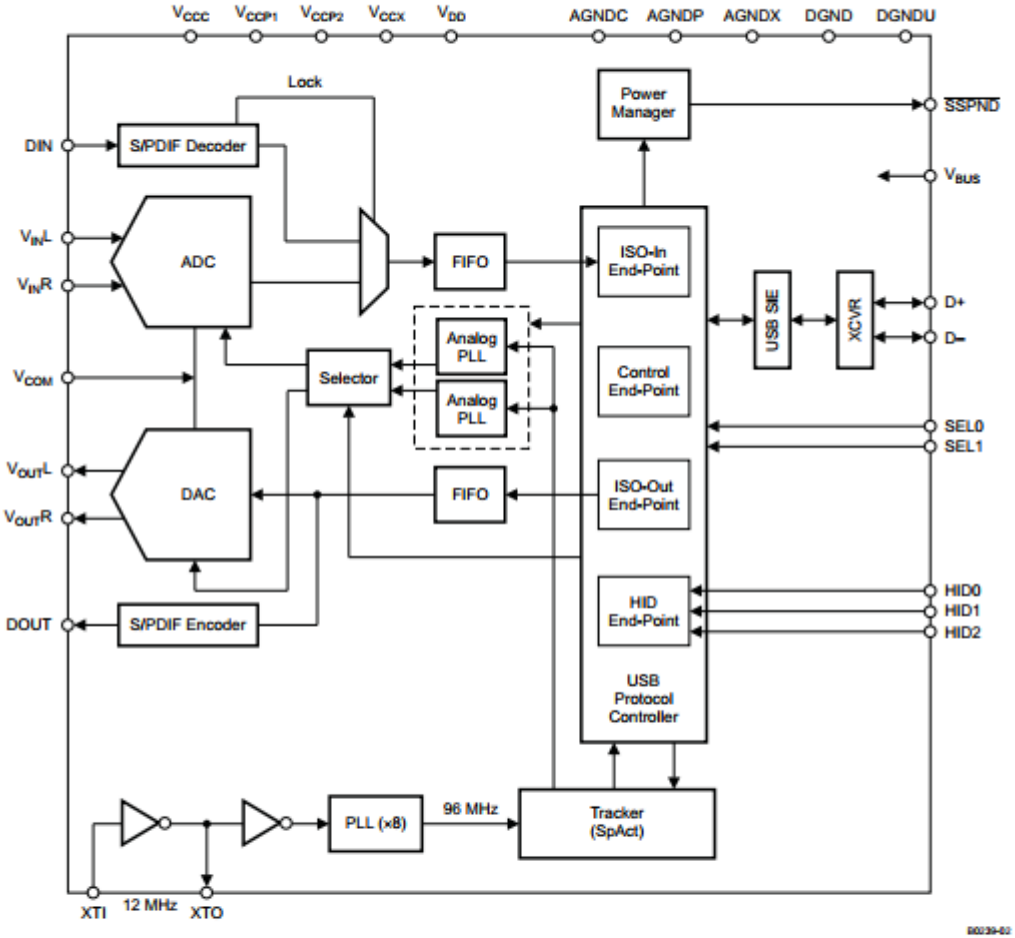
TERMINAL		I/O	DESCRIPTION
NAME	NO.		
AGNDC	11	–	Analog ground for codec
AGNDP	18	–	Analog ground for PLL
AGNDX	22	–	Analog ground for oscillator
D–	2	I/O	USB differential input/output minus (1)
D+	1	I/O	USB differential input/output plus (1)
DGND	26	–	Digital ground
DGNDU	4	–	Digital ground for USB transceiver
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

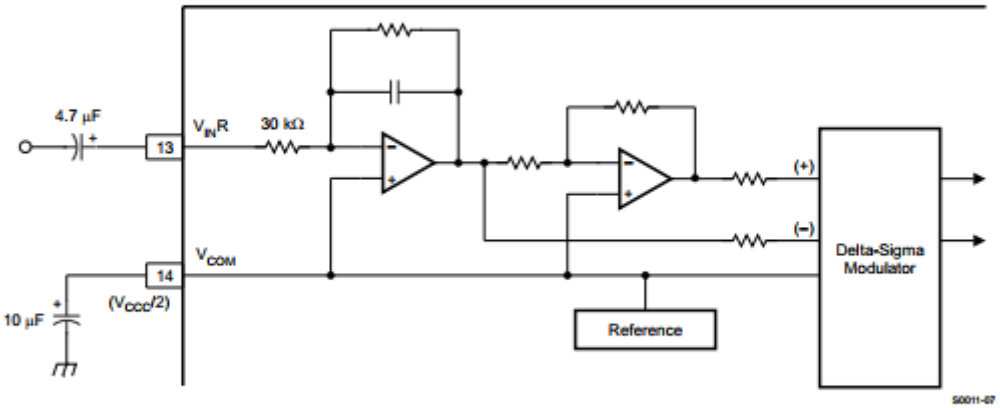
PCM2901 FUNCTIONAL BLOCK DIAGRAM



PCM2903 FUNCTIONAL BLOCK DIAGRAM



PCM2901/2903 BLOCK DIAGRAM OF ANALOG FRONT-END (RIGHT CHANNEL)



TYPICAL CHARACTERISTICS

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.

ADC

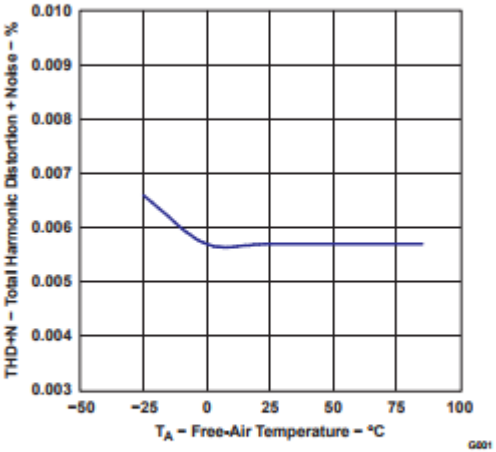


Figure 1.

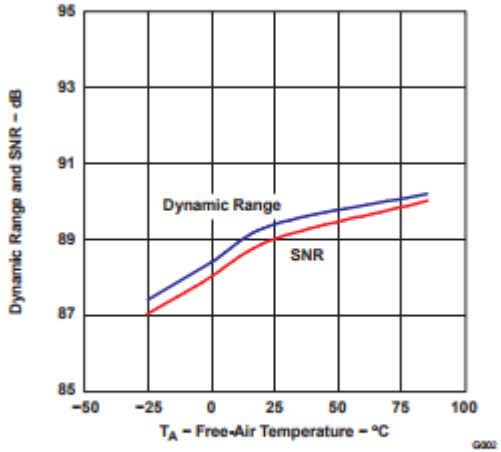


Figure 2.

TYPICAL CHARACTERISTICS (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.

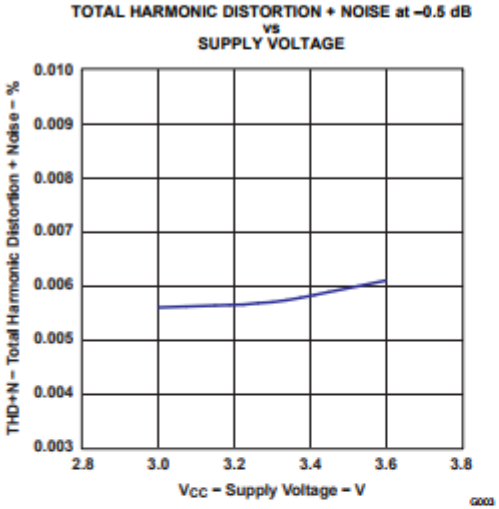


Figure 3.

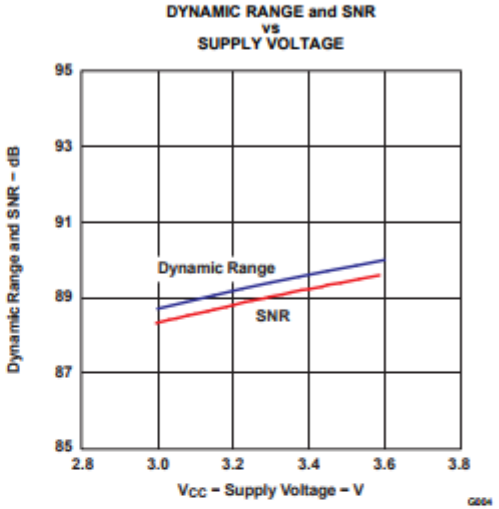


Figure 4.

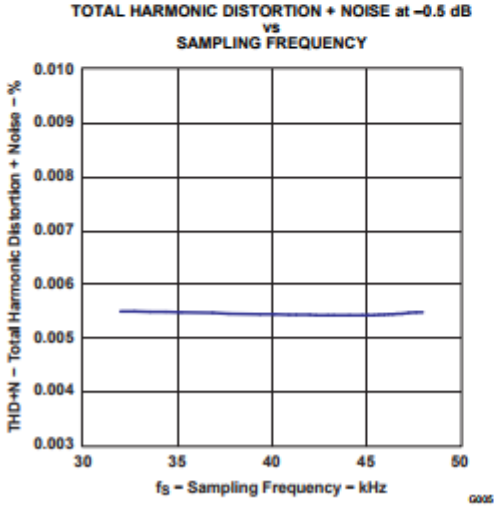


Figure 5.

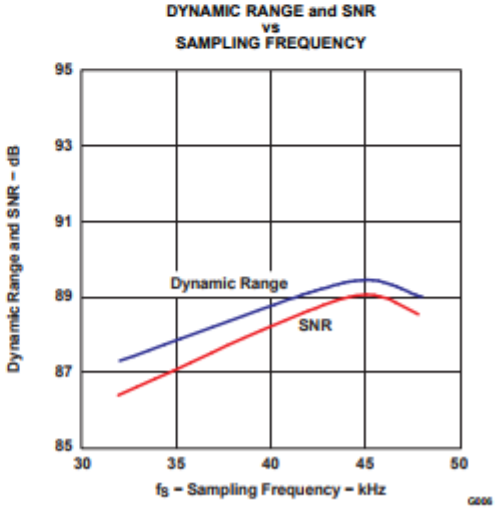


Figure 6.

TYPICAL CHARACTERISTICS (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.

DAC

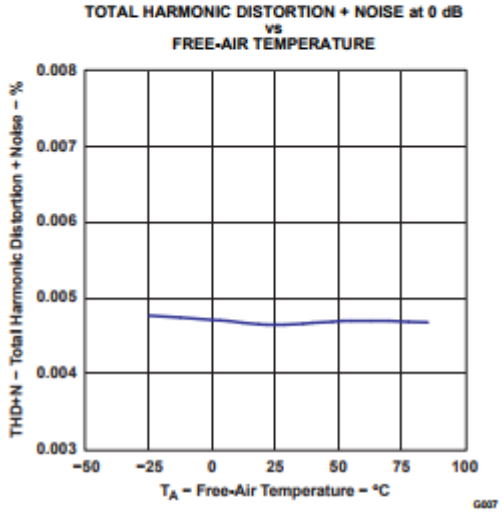


Figure 7.

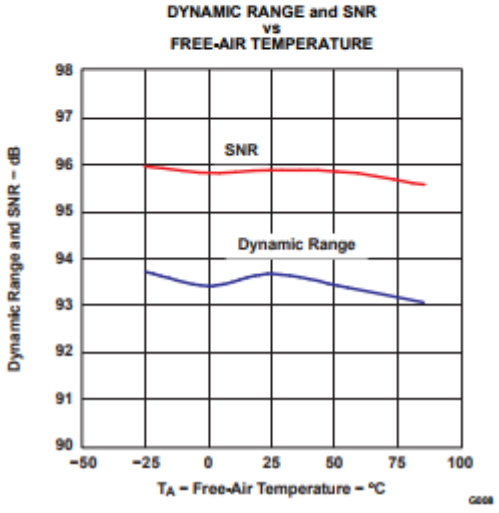


Figure 8.

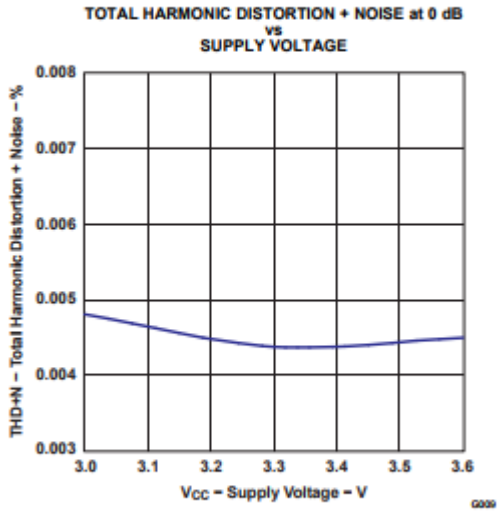


Figure 9.

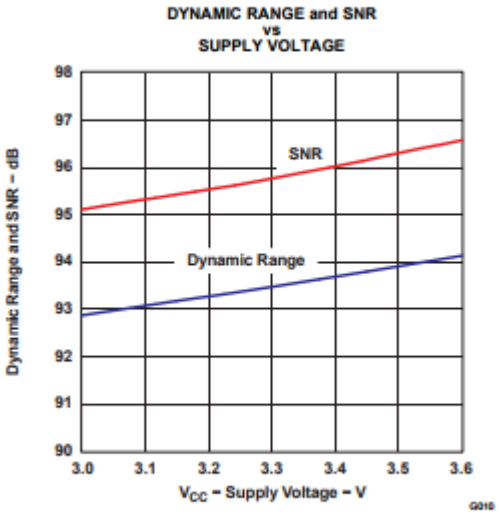


Figure 10.

PCM2901
PCM2903
SLES034C–MARCH 2002–REVISED NOVEMBER 2007

TEXAS INSTRUMENTS
www.ti.com

TYPICAL CHARACTERISTICS (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.

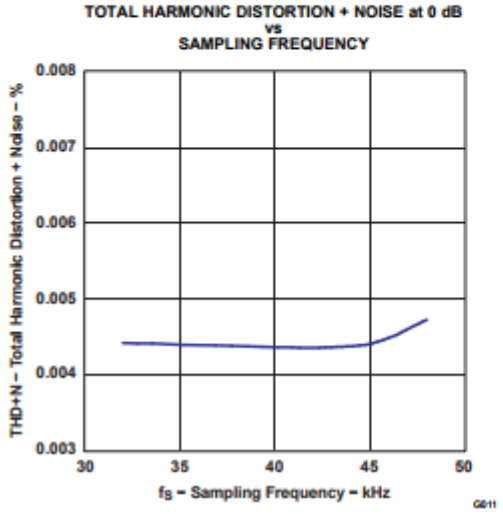


Figure 11.

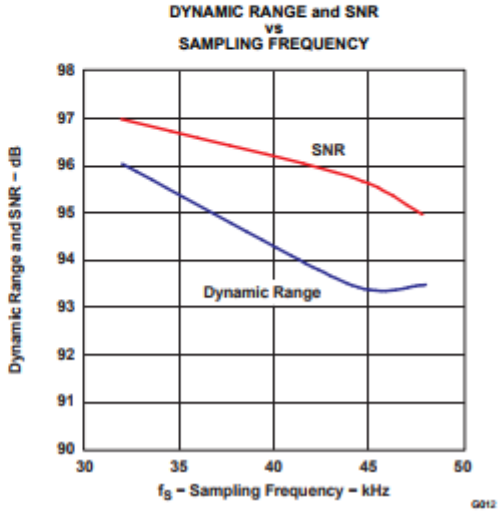


Figure 12.

ADC OUTPUT SPECTRUM

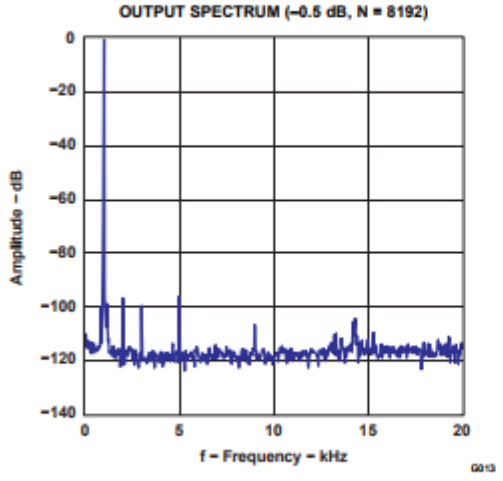


Figure 13.

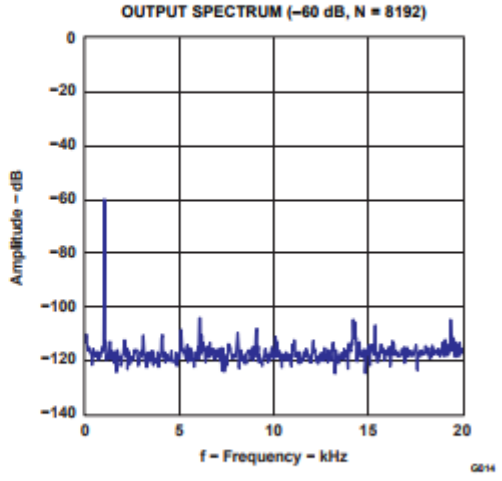


Figure 14.

TYPICAL CHARACTERISTICS (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.

DAC OUTPUT SPECTRUM

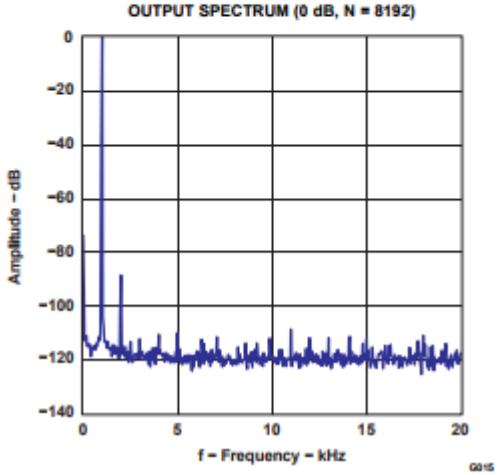


Figure 15.

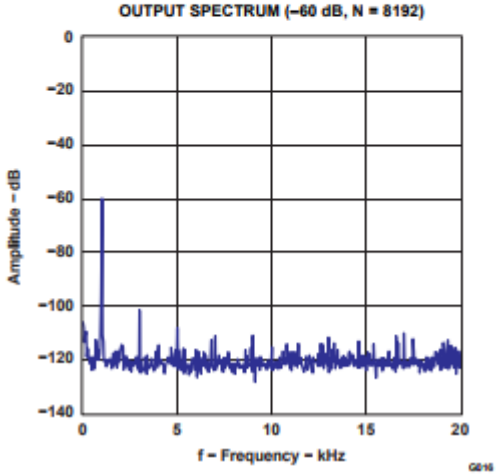


Figure 16.

SUPPLY CURRENT

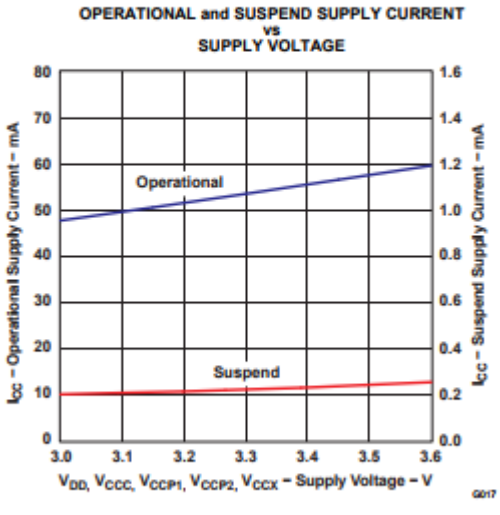


Figure 17.

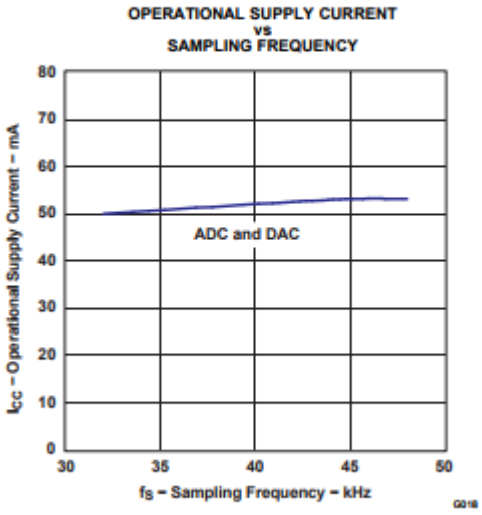


Figure 18.

PCM2901
PCM2903
SLES034C–MARCH 2002–REVISED NOVEMBER 2007

TEXAS INSTRUMENTS
www.ti.com

TYPICAL CHARACTERISTICS (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.

ADC DIGITAL DECIMATION FILTER FREQUENCY RESPONSE

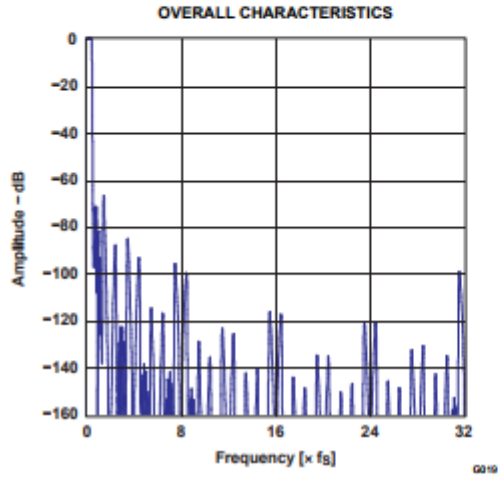


Figure 19.

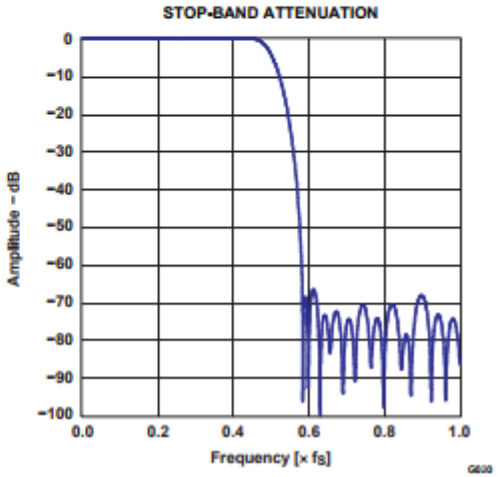


Figure 20.

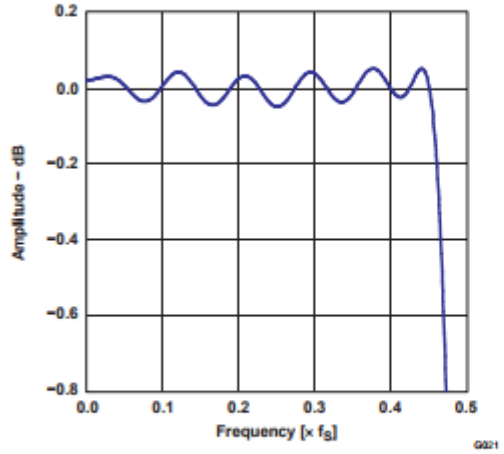


Figure 21.

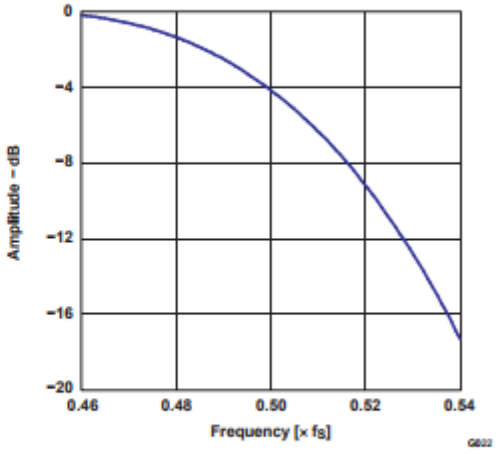


Figure 22.