

105 dB, 192 kHz, Multi-Bit Audio A/D Converter

Features

- Advanced multi-bit Delta-Sigma architecture
- 24-bit conversion
- Supports all audio sample rates including 192 kHz
- 105 dB Dynamic Range at 5 V
- -98 dB THD+N
- High pass filter to remove DC offsets
- Analog/digital core supplies from 3.3 V to 5 V
- Supports logic levels between 1.8 V and 5 V
- Linear phase digital anti-alias filtering
- Auto mode selection
- Pin-compatible with the CS5340 and CS5341

General Description

The CS5342 is a complete analog-to-digital (A/D) converter for digital audio systems. It performs sampling, A/D conversion, and anti-alias filtering, generating 24-bit values for both left and right inputs in serial form at sample rates up to 200 kHz per channel.

The CS5342 uses a 5th-order, multi-bit Delta-Sigma modulator followed by digital filtering and decimation, which removes the need for an external anti-alias filter.

The CS5342 is ideal for audio systems requiring wide dynamic range, negligible distortion, and low noise, such as set-top boxes, DVD-karaoke players, DVD recorders, A/V receivers, and automotive applications.

ORDERING INFORMATION

CS5342-CZZ -10° to 70° C 16-pin TSSOP
CDB5342 Evaluation Board

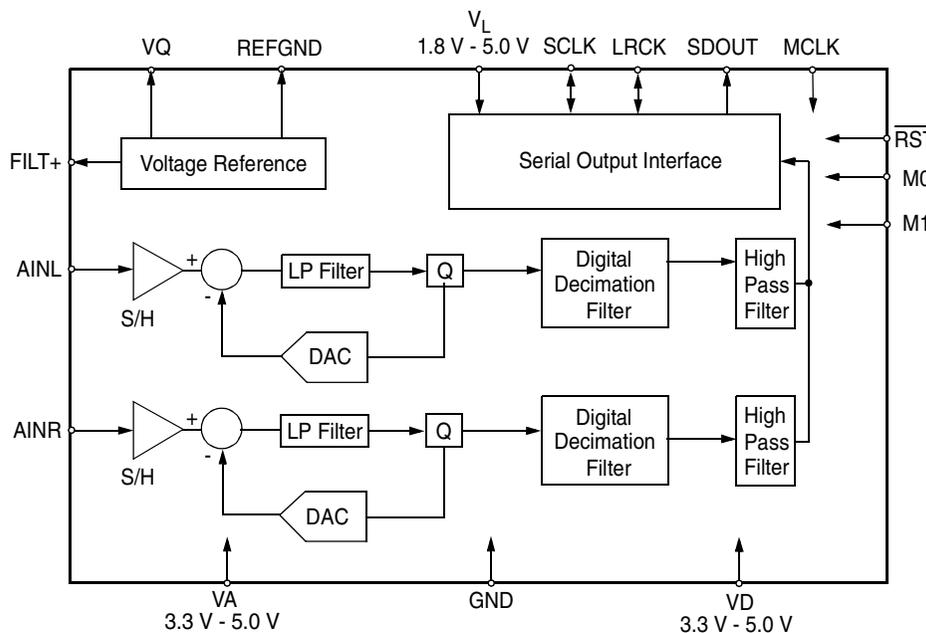


TABLE OF CONTENTS

1 CHARACTERISTICS AND SPECIFICATIONS	4
SPECIFIED OPERATING CONDITIONS	4
ABSOLUTE MAXIMUM RATINGS	4
ANALOG CHARACTERISTICS (CS5342-CZZ)	5
DIGITAL FILTER CHARACTERISTICS.....	7
DC ELECTRICAL CHARACTERISTICS.....	10
DIGITAL CHARACTERISTICS	10
THERMAL CHARACTERISTICS.....	10
SWITCHING CHARACTERISTICS - SERIAL AUDIO PORT	11
2 PIN DESCRIPTION	13
3 TYPICAL CONNECTION DIAGRAM	14
4 APPLICATIONS	15
4.1 Single, Double, and Quad Speed Modes	15
4.2 Operation as Either a Clock Master or Slave	15
4.2.1 Operation as a Clock Master	15
4.2.2 Operation as a Clock Slave	16
4.2.3 Master Clock	17
4.3 Serial Audio Interface	17
4.4 Power-up Sequence	18
4.5 Analog Connections	18
4.6 Grounding and Power Supply Decoupling	18
4.7 Synchronization of Multiple Devices	19
5 PARAMETER DEFINITIONS	20
6 PACKAGE DIMENSIONS	21

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LIST OF FIGURES

Figure 1. Single Speed Mode Stopband Rejection	8
Figure 2. Single Speed Mode Stopband Rejection	8
Figure 3. Single Speed Mode Transition Band (Detail).....	8
Figure 4. Single Speed Mode Passband Ripple	8
Figure 5. Double Speed Mode Stopband Rejection.....	8
Figure 6. Double Speed Mode Stopband Rejection.....	8
Figure 7. Double Speed Mode Transition Band (Detail)	9
Figure 8. Double Speed Mode Passband Ripple	9
Figure 9. Quad Speed Mode Stopband Rejection	9
Figure 10. Quad Speed Mode Stopband Rejection	9
Figure 11. Quad Speed Mode Transition Band (Detail)	9
Figure 12. Quad Speed Mode Passband Ripple.....	9
Figure 13. Master Mode, Left Justified SAI	12
Figure 14. Slave Mode, Left Justified SAI	12
Figure 15. Master Mode, I ² S SAI	12
Figure 16. Slave Mode, I ² S SAI	12
Figure 17. Typical Connection Diagram.....	14
Figure 18. CS5342 Master Mode Clocking	16
Figure 19. Left-Justified Serial Audio Interface	17
Figure 20. I ² S Serial Audio Interface.....	17
Figure 21. CS5342 Recommended Analog Input Buffer.....	18

LIST OF TABLES

Table 1. Speed Modes and the Associated Output Sample Rates (Fs).....	15
Table 2. CS5342 Mode Control.....	15
Table 3. Master Clock (MCLK) Ratios.....	17
Table 4. Master Clock (MCLK) Frequencies for Standard Audio Sample Rates	17

1 CHARACTERISTICS AND SPECIFICATIONS

(All Min/Max characteristics and specifications are guaranteed over the Specified Operating Conditions. Typical performance characteristics and specifications are derived from measurements taken at typical supply voltages and $T_A = 25^\circ\text{C}$.)

SPECIFIED OPERATING CONDITIONS

(GND = 0 V, all voltages with respect to 0 V.)

Parameter		Symbol	Min	Typ	Max	Unit
Power Supplies	Analog	VA	3.1	(Note 1)	5.25	V
	Digital	VD	3.1	3.3	5.25	V
	Logic	VL	1.7	3.3	5.25	V
Ambient Operating Temperature	Commercial (-CZZ)	T_{AC}	-10	-	70	$^\circ\text{C}$

Notes: 1. This part is specified at typical analog voltages of 3.3 V and 5.0 V. See *Analog Characteristics (CS5342-CZZ)* below for details.

ABSOLUTE MAXIMUM RATINGS

(GND = 0 V, All voltages with respect to ground.) (Note 4)

Parameter		Symbol	Min	Max	Units
DC Power Supplies:	Analog	VA	-0.3	+6.0	V
	Logic	VL	-0.3	+6.0	V
	Digital	VD	-0.3	+6.0	V
Input Current	(Note 2)	I_{in}	-	± 10	mA
Analog Input Voltage	(Note 3)	V_{IN}	GND-0.7	VA+0.7	V
Digital Input Voltage	(Note 3)	V_{IND}	-0.7	VL+0.7	V
Ambient Operating Temperature (Power Applied)		T_A	-50	+95	$^\circ\text{C}$
Storage Temperature		T_{stg}	-65	+150	$^\circ\text{C}$

- Notes: 2. Any pin except supplies. Transient currents of up to ± 100 mA on the analog input pins will not cause SRC latch-up.
3. The maximum over/under voltage is limited by the input current.
4. Operation beyond these limits may result in permanent damage to the device. Normal operation is not guaranteed at these extremes.

ANALOG CHARACTERISTICS (CS5342-CZZ) Test conditions (unless otherwise specified):
 Input test signal is a 1 kHz sine wave; measurement bandwidth is 10 Hz to 20 kHz.

Parameter	Symbol	Min	Typ	Max	Unit
VA = 3.3 V					
Single Speed Mode Fs = 48 kHz					
Dynamic Range	A-weighted	96	102	-	dB
	unweighted	93	99	-	dB
Total Harmonic Distortion + Noise (Note 5)	-1 dB	-	-95	-89	dB
	-20 dB	-	-79	-	dB
	-60 dB	-	-39	-	dB
	40 kHz bandwidth	-	-87	-	dB
Double Speed Mode Fs = 96 kHz					
Dynamic Range	A-weighted	96	102	-	dB
	unweighted	93	99	-	dB
	40 kHz bandwidth unweighted	-	96	-	dB
Total Harmonic Distortion + Noise (Note 5)	-1 dB	-	-95	-89	dB
	-20 dB	-	-79	-	dB
	-60 dB	-	-39	-	dB
	40 kHz bandwidth	-	-87	-	dB
Quad Speed Mode Fs = 192 kHz					
Dynamic Range	A-weighted	96	102	-	dB
	unweighted	93	99	-	dB
	40 kHz bandwidth unweighted	-	96	-	dB
Total Harmonic Distortion + Noise (Note 5)	-1 dB	-	-95	-89	dB
	-20 dB	-	-79	-	dB
	-60 dB	-	-39	-	dB
	40 kHz bandwidth	-	-87	-	dB
VA = 5.0 V					
Single Speed Mode Fs = 48 kHz					
Dynamic Range	A-weighted	99	105	-	dB
	unweighted	96	102	-	dB
Total Harmonic Distortion + Noise (Note 5)	-1 dB	-	-98	-92	dB
	-20 dB	-	-82	-	dB
	-60 dB	-	-42	-	dB
	40 kHz bandwidth	-	-95	-	dB
Double Speed Mode Fs = 96 kHz					
Dynamic Range	A-weighted	99	105	-	dB
	unweighted	96	102	-	dB
	40 kHz bandwidth unweighted	-	99	-	dB
Total Harmonic Distortion + Noise (Note 5)	-1 dB	-	-98	-92	dB
	-20 dB	-	-82	-	dB
	-60 dB	-	-42	-	dB
	40 kHz bandwidth	-	-95	-	dB

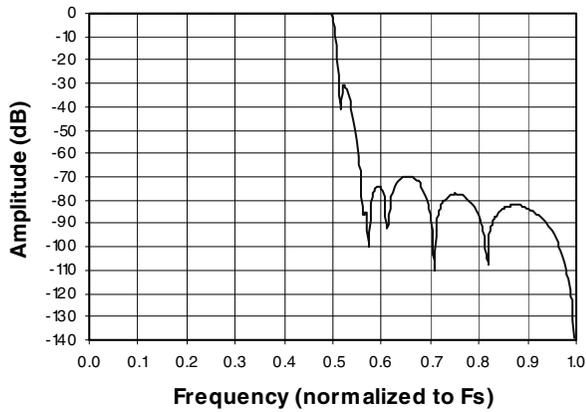
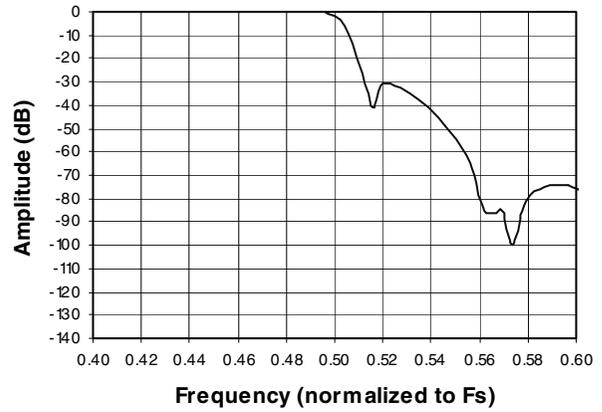
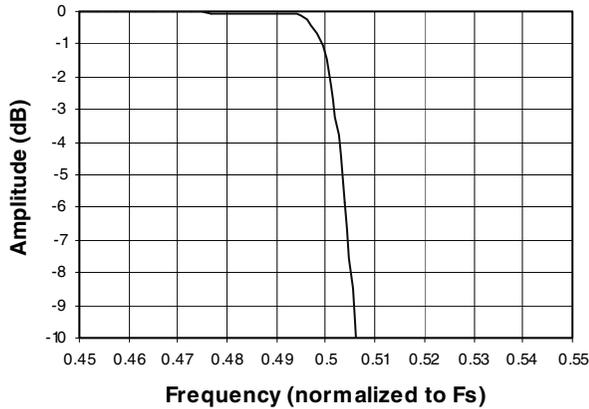
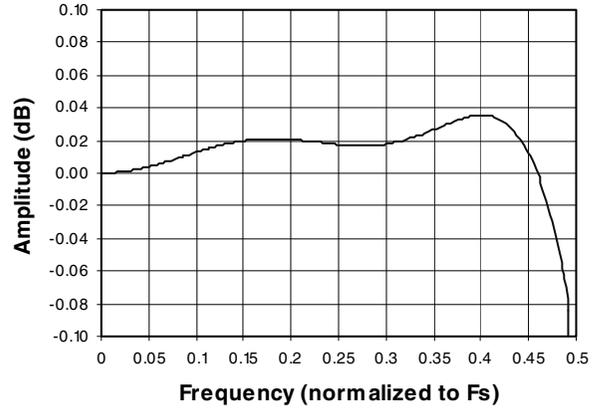
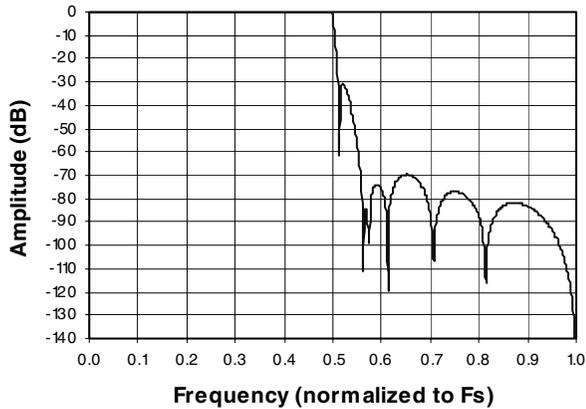
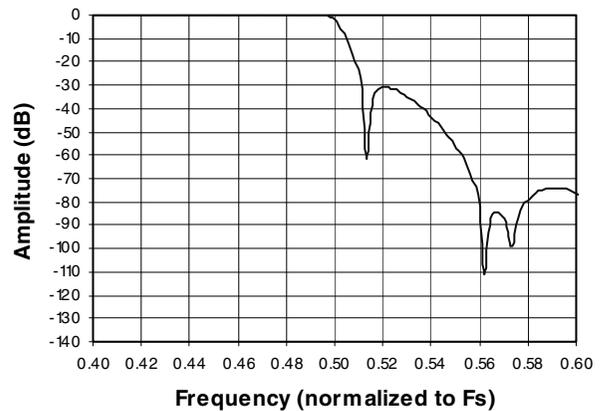
Quad Speed Mode		Fs = 192 kHz				
Dynamic Range	A-weighted		99	105	-	dB
	unweighted		96	102	-	dB
	40 kHz bandwidth unweighted		-	99	-	dB
Total Harmonic Distortion + Noise	(Note 5)	THD+N				
	-1 dB		-	-98	-92	dB
	-20 dB		-	-82	-	dB
	-60 dB		-	-42	-	dB
	40 kHz bandwidth -1 dB		-	-95	-	dB
Dynamic Performance for All Modes						
Interchannel Isolation			-	90	-	dB
Interchannel Phase Deviation			-	0.0001	-	Degree
DC Accuracy						
Interchannel Gain Mismatch			-	0.1	-	dB
Gain Error				-	±5	%
Gain Drift			-	±100	-	ppm/°C
Analog Input Characteristics						
Full-scale Input Voltage			0.53*VA	0.56*VA	0.59*VA	Vpp
Input Impedance			18	-	-	kΩ

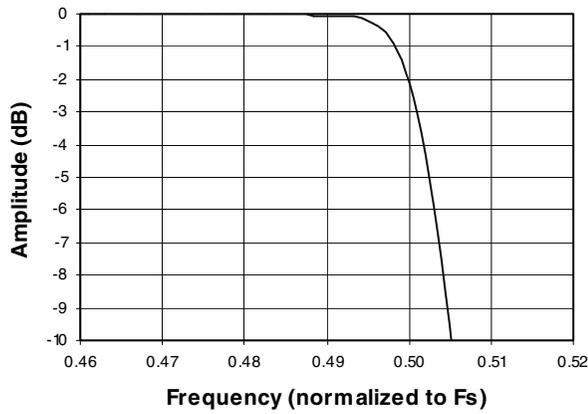
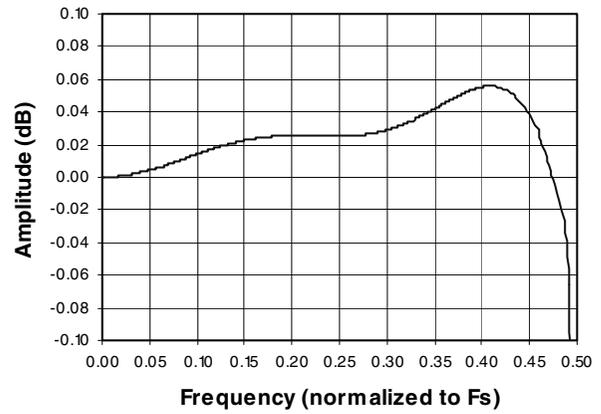
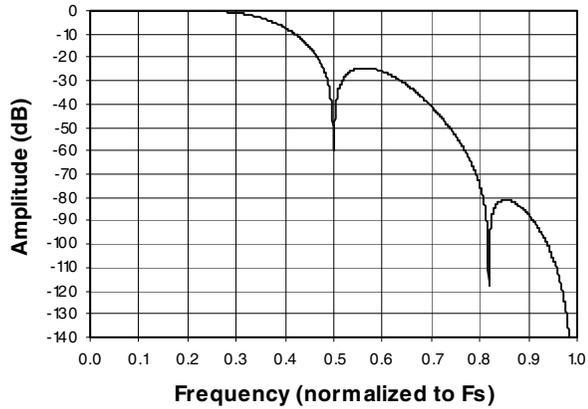
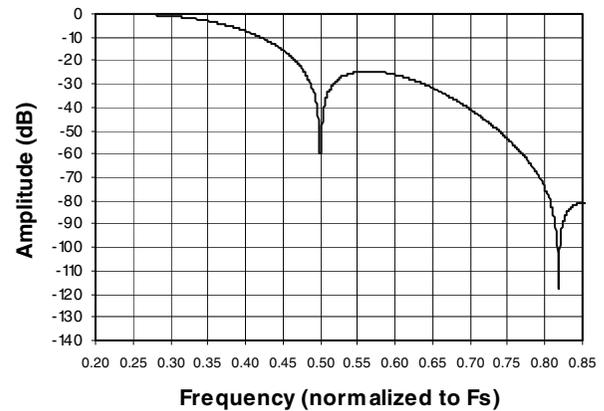
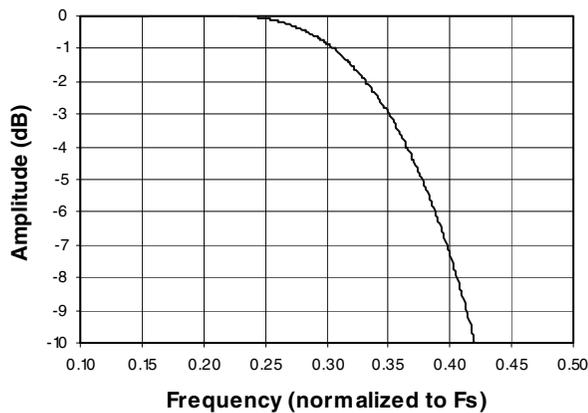
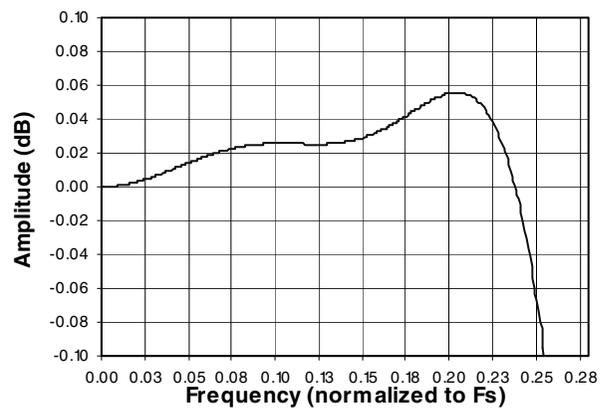
Note: 5. Referred to the typical full-scale input voltage

DIGITAL FILTER CHARACTERISTICS

Parameter	Symbol	Min	Typ	Max	Unit
Single Speed Mode $F_s = 48 \text{ kHz}$					
Passband (-0.1 dB)		0	-	23.5	kHz
Passband Ripple		-	-	0.035	dB
Stopband		27.3	-	-	kHz
Stopband Attenuation		70	-	-	dB
Total Group Delay ($F_s = \text{Output Sample Rate}$)	t_{gd}	-	12/ F_s	-	s
Group Delay Variation vs. Frequency	Δt_{gd}	-	-	0.0	μs
Double Speed Mode $F_s = 96 \text{ kHz}$					
Passband (-0.1 dB)		0	-	47	kHz
Passband Ripple		-	-	± 0.025	dB
Stopband		53.8	-	-	kHz
Stopband Attenuation		69	-	-	dB
Total Group Delay ($F_s = \text{Output Sample Rate}$)	t_{gd}	-	9/ F_s	-	s
Group Delay Variation vs. Frequency	Δt_{gd}	-	-	0.0	μs
Quad Speed Mode $F_s = 192 \text{ kHz}$					
Passband (-0.1 dB)		0	-	50	kHz
Passband Ripple		-	-	± 0.025	dB
Stopband		96	-	-	kHz
Stopband Attenuation		60	-	-	dB
Total Group Delay ($F_s = \text{Output Sample Rate}$)	t_{gd}	-	5/ F_s	-	s
Group Delay Variation vs. Frequency	Δt_{gd}	-	-	0.0	μs
High Pass Filter Characteristics					
Frequency Response -3.0 dB		-	1	-	Hz
-0.13 dB (Note 6)			20	-	Hz
Phase Deviation @ 20Hz (Note 6)		-	10	-	Deg
Passband Ripple		-	-	0	dB

Note: 6. Response shown is for F_s equal to 48 kHz. Filter characteristics scale with F_s .


Figure 1. Single Speed Mode Stopband Rejection

Figure 2. Single Speed Mode Stopband Rejection

Figure 3. Single Speed Mode Transition Band (Detail)

Figure 4. Single Speed Mode Passband Ripple

Figure 5. Double Speed Mode Stopband Rejection

Figure 6. Double Speed Mode Stopband Rejection


Figure 7. Double Speed Mode Transition Band (Detail)

Figure 8. Double Speed Mode Passband Ripple

Figure 9. Quad Speed Mode Stopband Rejection

Figure 10. Quad Speed Mode Stopband Rejection

Figure 11. Quad Speed Mode Transition Band (Detail)

Figure 12. Quad Speed Mode Passband Ripple

DC ELECTRICAL CHARACTERISTICS (GND = 0 V, all voltages with respect to 0 V.
MCLK=12.288 MHz; Master Mode)

Parameter	Symbol	Min	Typ	Max	Unit	
DC Power Supplies:	Positive Analog	VA	3.1	-	5.25	V
	Positive Digital	VD	3.1	-	5.25	V
	Positive Logic	VL	1.7	-	5.25	V
Power Supply Current (Normal Operation)	VA = 5 V	I _A	-	21	23.1	mA
	VA = 3.3 V	I _A	-	18.2	20	mA
	VL, VD = 5 V	I _D	-	15	16.5	mA
	VL, VD = 3.3 V	I _D	-	9	10	mA
Power Supply Current (Power-Down Mode) (Note 7)	VA = 5 V	I _A	-	1.5	-	mA
	VL, VD=5 V	I _D	-	0.4	-	mA
Power Consumption (Normal Operation)	VL, VD, VA = 5 V	-	-	180	198	mW
	VL, VD, VA = 3.3 V	-	-	90	100	mW
	(Power-Down Mode)	-	-	9.5	-	mW
Power Supply Rejection Ratio (1 kHz) (Note 8)	PSRR	-	65	-	-	dB
V _Q Nominal Voltage		-	VA÷2	-	-	V
Output Impedance		-	25	-	-	kΩ
Filt+ Nominal Voltage		-	VA	-	-	V
Output Impedance		-	18	-	-	kΩ
Maximum allowable DC current source/sink		-	0.01	-	-	mA

Notes: 7. Power Down Mode is defined as $\overline{\text{RST}} = \text{Low}$ with all clocks and data lines held static.

8. Valid with the recommended capacitor values on Filt+ and VQ as shown in the Typical Connection Diagram.

DIGITAL CHARACTERISTICS

Parameter	Symbol	Min	Typ	Max	Units
High-Level Input Voltage (% of VL)	V _{IH}	70%	-	-	V
Low-Level Input Voltage (% of VL)	V _{IL}	-	-	30%	V
High-Level Output Voltage at I _o = 100 μA (% of VL)	V _{OH}	70%	-	-	V
Low-Level Output Voltage at I _o = 100 μA (% of VL)	V _{OL}	-	-	15%	V
Input Leakage Current	I _{in}	-	-	±10	μA

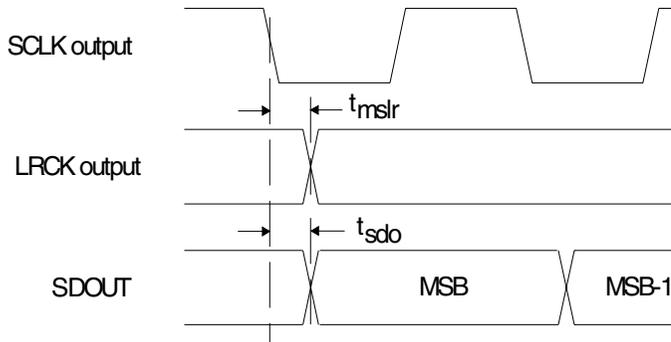
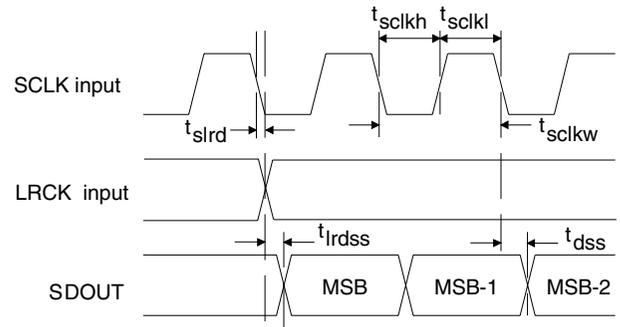
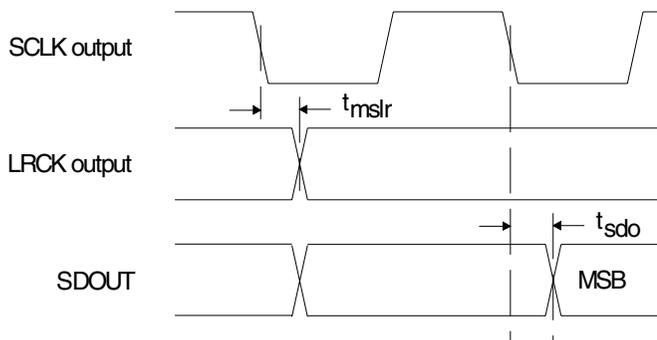
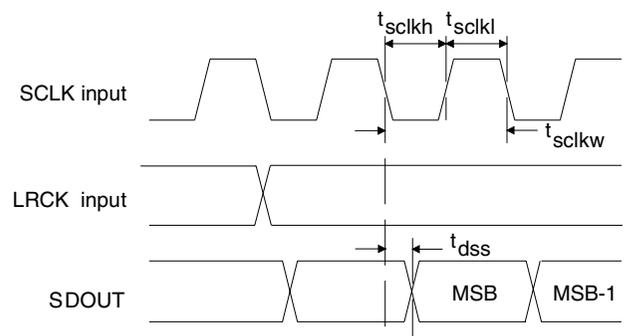
THERMAL CHARACTERISTICS

Parameter	Symbol	Min	Typ	Max	Unit
Allowable Junction Temperature		-	-	135	°C
Junction to Ambient Thermal Impedance	θ _{JA}	-	75	-	°C/W
Ambient Operating Temperature (Power Applied) (-CZZ)	T _A	-10	-	+70	°C

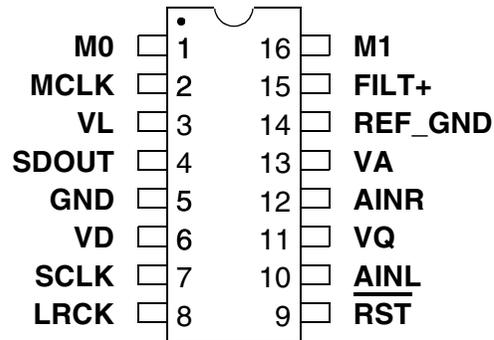
SWITCHING CHARACTERISTICS - SERIAL AUDIO PORT (Logic "0" = GND = 0 V;
Logic "1" = VL, C_L = 20 pF)

Parameter	Symbol	Min	Typ	Max	Unit
MCLK Specifications					
MCLK Period	t _{clkw}	26	-	1302	ns
MCLK Pulse Width High	t _{clkh}	11	-	-	ns
MCLK Pulse Width Low	t _{ckl}	11	-	-	ns
Master Mode					
SCLK falling to LRCK	t _{mslr}	-20	-	20	ns
SCLK falling to SDOOUT valid	t _{sdo}	0	-	32	ns
SCLK Duty Cycle		-	50	-	%
Slave Mode					
Single Speed*					
LRCK Duty Cycle		40	50	60	%
SCLK Period	t _{sclkw}	156	-	-	ns
SCLK High/Low	t _{sclkh}	32	-	-	ns
SCLK falling to SDOOUT valid	t _{dss}	-	-	32	ns
SCLK falling to LRCK edge	t _{slrd}	-20	-	20	ns
Double Speed*					
LRCK Duty Cycle		40	50	60	%
SCLK Period	t _{sclkw}	156	-	-	ns
SCLK High/Low	t _{sclkh}	32	-	-	ns
SCLK falling to SDOOUT valid	t _{dss}	-	-	32	ns
SCLK falling to LRCK edge	t _{slrd}	-20	-	20	ns
Quad Speed*					
LRCK Duty Cycle		40	50	60	%
SCLK Period	t _{sclkw}	78	-	-	ns
SCLK High/Low	t _{sclkh}	32	-	-	ns
SCLK falling to SDOOUT valid	t _{dss}	-	-	32	ns
SCLK falling to LRCK edge	t _{slrd}	-10	-	10	ns

* For a description of Speed Modes, please refer to Table 1 on page 15


Figure 13. Master Mode, Left Justified SAI

Figure 14. Slave Mode, Left Justified SAI

Figure 15. Master Mode, I²S SAI

Figure 16. Slave Mode, I²S SAI

2 PIN DESCRIPTION



Pin Name	#	Pin Description
M0	1	Mode Selection (<i>Input</i>) - Determines the operational mode of the device.
M1	16	
MCLK	2	Master Clock (<i>Input</i>) - Clock source for the delta-sigma modulator and digital filters.
VL	3	Logic Power (<i>Input</i>) - Positive power for the digital input/output.
SDOUT	4	Serial Audio Data Output (<i>Output</i>) - Output for two's complement serial audio data.
GND	5,14	Ground (<i>Input</i>) - Ground reference. Must be connected to analog ground.
VD	6	Digital Power (<i>Input</i>) - Positive power supply for the digital section.
SCLK	7	Serial Clock (<i>Input/Output</i>) - Serial clock for the serial audio interface.
LRCK	8	Left Right Clock (<i>Input/Output</i>) - Determines which channel, Left or Right, is currently active on the serial audio data line.
RST	9	Reset (<i>Input</i>) - The device enters a low power mode when low.
AINL	10	Analog Input (<i>Input</i>) - The full scale analog input level is specified in the Analog Characteristics specification table.
AINR	12	
VQ	11	Quiescent Voltage (<i>Output</i>) - Filter connection for the internal quiescent reference voltage.
VA	13	Analog Power (<i>Input</i>) - Positive power supply for the analog section.
FILT+	15	Positive Voltage Reference (<i>Output</i>) - Positive reference voltage for the internal sampling circuits.

3 TYPICAL CONNECTION DIAGRAM

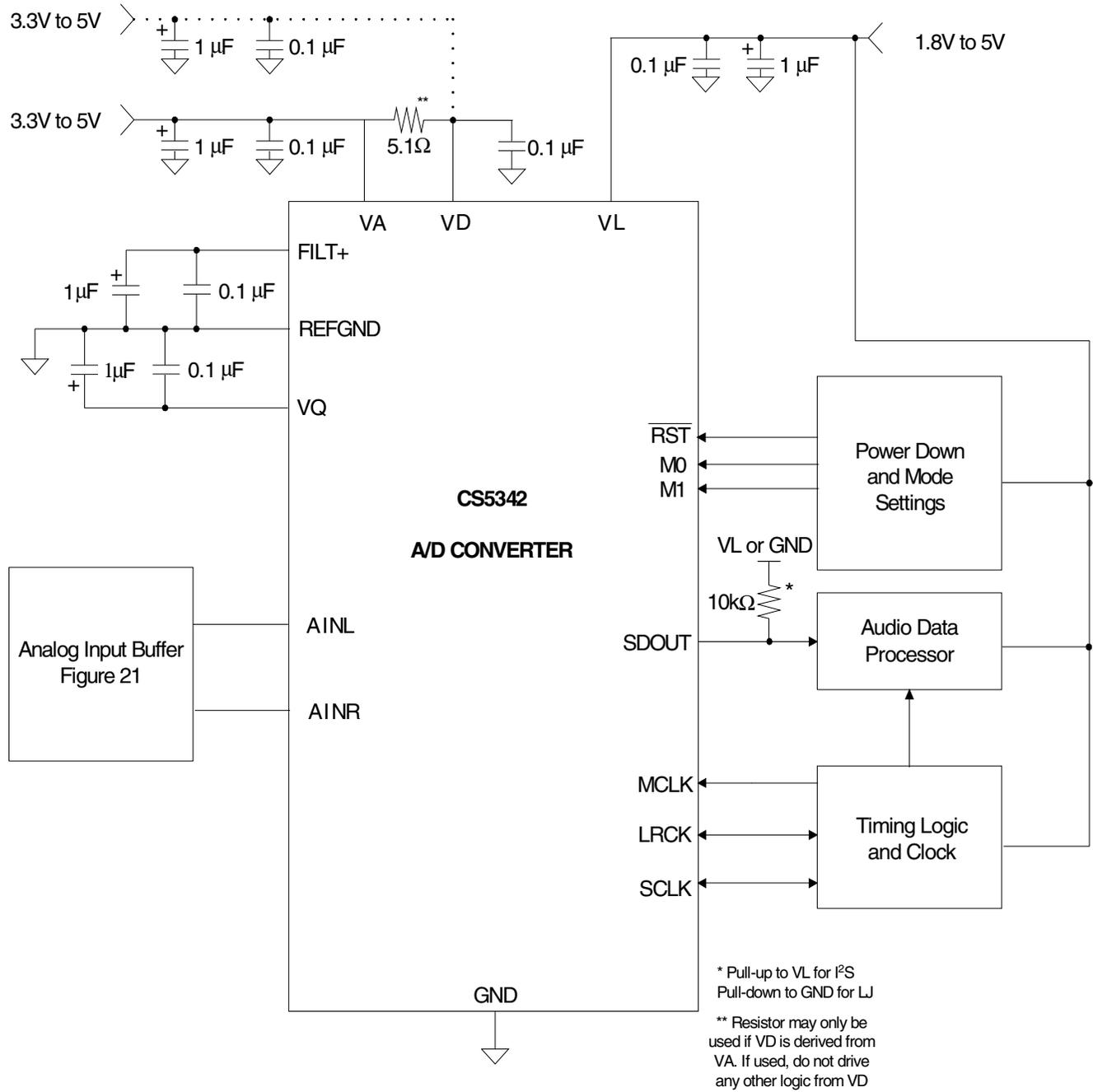


Figure 17. Typical Connection Diagram

4 APPLICATIONS

4.1 Single, Double, and Quad Speed Modes

The CS5342 can support output sample rates from 2 kHz to 200 kHz. The proper speed mode can be determined by the desired output sample rate and the external MCLK/LRCK ratio, as shown in Table 1.

Speed Mode	MCLK/LRCK Ratio	Output Sample Rate Range (kHz)
Single Speed Mode	768x	43 - 50
	384x	2 - 50
Double Speed Mode	384x	86 - 100
	192x	50 - 100
Quad Speed Mode	192x	172 - 200
	96x*	100 - 200

* Quad Speed Mode, 96x only available in Master Mode.

Table 1. Speed Modes and the Associated Output Sample Rates (Fs)

4.2 Operation as Either a Clock Master or Slave

The CS5342 supports operation as either a clock master or slave. As a clock master, the LRCK and SCLK pins are outputs with the left/right and serial clocks synchronously generated on-chip. As a clock slave, the LRCK and SCLK pins are inputs and require the left/right and serial clocks to be externally generated. The selection of clock master or slave is made via the Mode pins as shown in Table 2.

M1 (Pin 16)	M0 (Pin 1)	MODE
0	0	Clock Master, Single Speed Mode
0	1	Clock Master, Double Speed Mode
1	0	Clock Master, Quad Speed Mode
1	1	Clock Slave, All Speed Modes

Table 2. CS5342 Mode Control

4.2.1 Operation as a Clock Master

As a clock master, LRCK and SCLK operate as outputs. The left/right and serial clocks are internally derived from the master clock with the left/right clock equal to F_s and the serial clock equal to $64x F_s$, as shown in Figure 18.

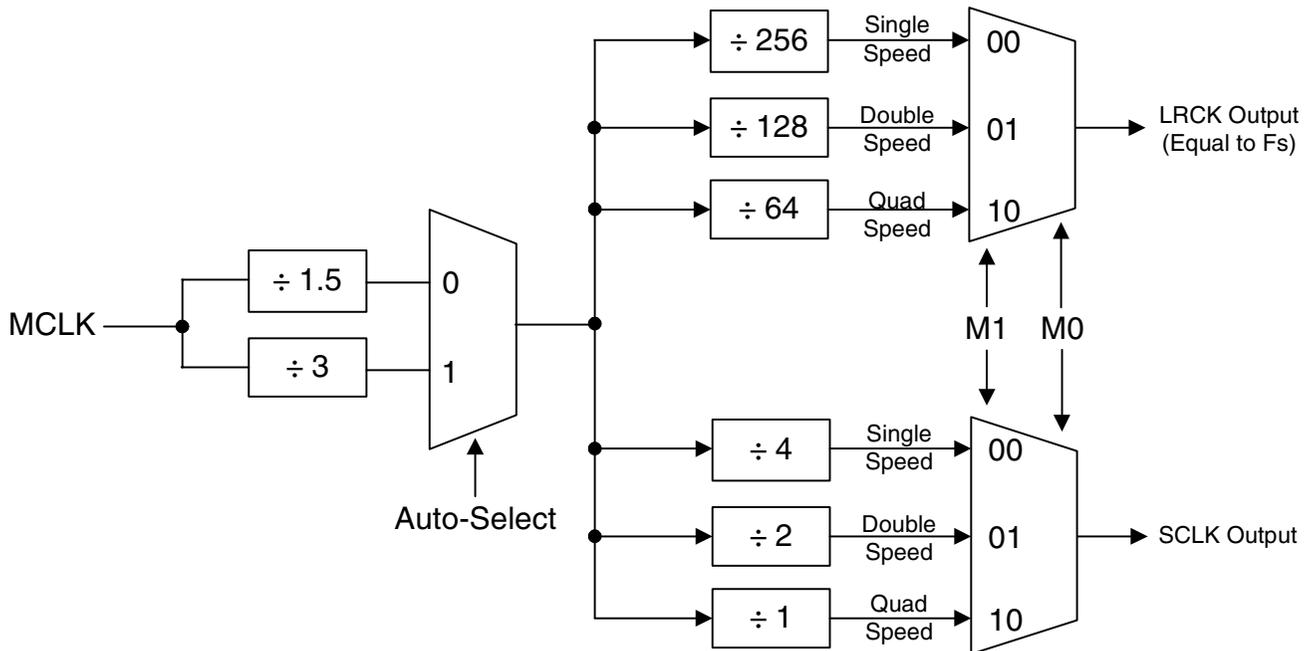


Figure 18. CS5342 Master Mode Clocking

4.2.2 Operation as a Clock Slave

LRCK and SCLK operate as inputs in clock slave mode. It is recommended that the left/right clock be synchronously derived from the master clock and must be equal to F_s . It is also recommended that the serial clock be synchronously derived from the master clock and be equal to $64 \times F_s$ to maximize system performance.

A unique feature of the CS5342 is the automatic selection of either Single, Double or Quad speed mode when operating as a clock slave. The auto-mode select feature negates the need to configure the Mode pins to correspond to the desired mode. The auto-mode selection feature supports all standard audio sample rates from 2 to 200 kHz. However, there are ranges of non-standard audio sample rates that are not supported when operating with a fast MCLK ($768 \times$, $384 \times$, and $96 \times$ for Single, Double, and Quad Speed Modes respectively). Please refer to Table 1 for supported sample rate ranges.

4.2.3 Master Clock

The CS5342 requires a Master clock (MCLK) which runs the internal sampling circuits and digital filters. There is also an internal MCLK divider which is automatically activated based on the frequency of the MCLK. Table 3 shows a listing of the external MCLK/LRCK ratios that are required. Table 4 lists some common audio output sample rates and the required MCLK frequency. Refer to Section 4.1 for details.

	Single Speed Mode	Double Speed Mode	Quad Speed Mode
MCLK/LRCK Ratio	384x, 768x	192x, 384x	96x*, 192x

* Quad Speed, 96x only available in Master Mode.

Table 3. Master Clock (MCLK) Ratios

SAMPLE RATE (kHz)	MCLK (MHz)
32	12.288
44.1	16.9344 33.8688
48	18.432 36.864
64	12.288
88.2	16.9344 33.8688
96	18.432 36.864
192	36.864

Table 4. Master Clock (MCLK) Frequencies for Standard Audio Sample Rates

4.3 Serial Audio Interface

The CS5342 supports both I²S and Left Justified serial audio formats. Upon start-up, the CS5342 will detect the logic level on SDOUT (pin 4). A 10 kΩ pull-up resistor to VL is needed to select I²S format, and a 10 kΩ pull-down resistor to GND is needed to select Left Justified format. Please see Figures 13 through 16 on page 12, for more information on the required timing for the two serial audio interface formats.

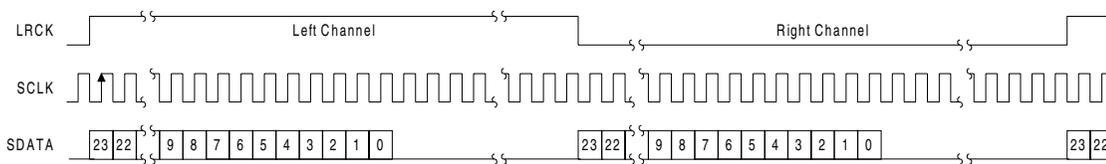


Figure 19. Left-Justified Serial Audio Interface

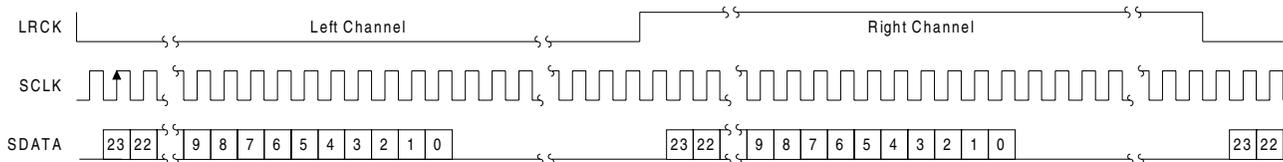


Figure 20. I²S Serial Audio Interface

4.4 Power-up Sequence

Reliable power-up can be accomplished by keeping the device in reset until the power supplies, clocks and configuration pins are stable. It is also recommended that reset be enabled if the analog or digital supplies drop below the minimum specified operating voltages to prevent power glitch related issues.

4.5 Analog Connections

The analog modulator samples the input at 6.144 MHz. The digital filter will reject signals within the stopband of the filter. However, there is no rejection for input signals which are multiples of the input sampling frequency ($n * 6.144 \text{ MHz}$), where $n=0,1,2,\dots$. Refer to Figure 21 on page 18 which shows the suggested filter that will attenuate any noise energy at 6.144 MHz, in addition to providing the optimum source impedance for the modulators. The use of capacitors which have a large voltage coefficient (such as general purpose ceramics) must be avoided since these can degrade signal linearity.

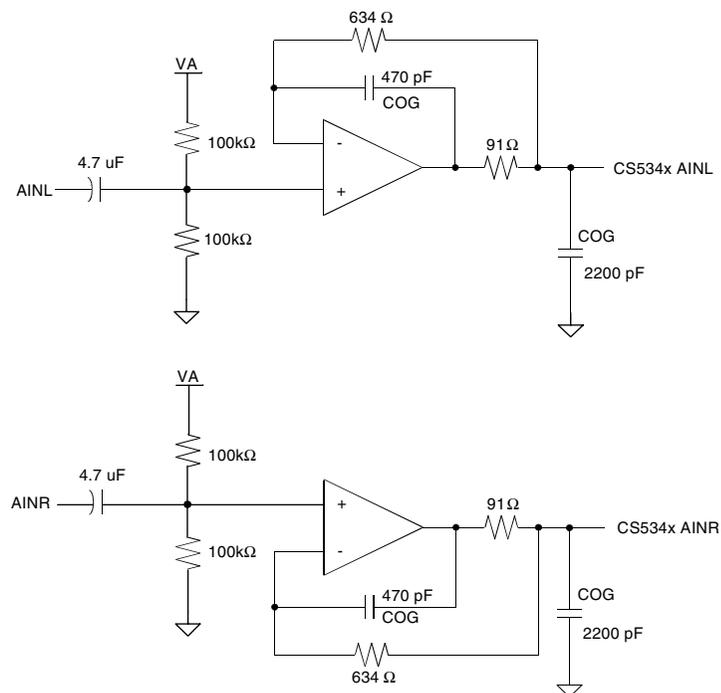


Figure 21. CS5342 Recommended Analog Input Buffer

4.6 Grounding and Power Supply Decoupling

As with any high resolution converter, the CS5342 requires careful attention to power supply and grounding arrangements if its potential performance is to be realized. Figure 17 shows the recommended power arrangements, with VA and VL connected to clean supplies. VD, which powers the digital filter, may be run from the system logic supply or may be powered from the analog supply via a resistor. In this case, no additional devices should be powered from VD. Decoupling capacitors should be as near to the ADC as possible, with the low value ceramic capacitor being the nearest. All signals, especially clocks, should be kept away from the FILTER+ and VQ pins in order to avoid unwanted coupling into the modulators. The FILTER+ and VQ decoupling capacitors, particularly the 0.1 μF , must be positioned to minimize the electrical path from FILTER+ and REF_GND. The CDB5342 evaluation board demonstrates the optimum layout and power supply arrangements. To minimize digital noise, connect the ADC digital outputs only to CMOS inputs.

4.7 Synchronization of Multiple Devices

In systems where multiple ADCs are required, care must be taken to achieve simultaneous sampling. To ensure synchronous sampling, the MCLK and LRCK must be the same for all of the CS5342's in the system. If only one master clock source is needed, one solution is to place one CS5342 in Master mode, and slave all of the other CS5342's to the one master. If multiple master clock sources are needed, a possible solution would be to supply all clocks from the same external source and time the CS5342 reset with the inactive (falling) edge of MCLK. This will ensure that all converters begin sampling on the same clock edge.

5 PARAMETER DEFINITIONS

Dynamic Range

The ratio of the rms value of the signal to the rms sum of all other spectral components over the specified bandwidth. Dynamic Range is a signal-to-noise ratio measurement over the specified bandwidth made with a -60 dBFS signal. 60 dB is added to resulting measurement to refer the measurement to full-scale. This technique ensures that the distortion components are below the noise level and do not affect the measurement. This measurement technique has been accepted by the Audio Engineering Society, AES17-1991, and the Electronic Industries Association of Japan, EIAJ CP-307. Expressed in decibels.

Total Harmonic Distortion + Noise

The ratio of the rms value of the signal to the rms sum of all other spectral components over the specified bandwidth (typically 10 Hz to 20 kHz), including distortion components. Expressed in decibels. Measured at -1 and -20 dBFS as suggested in AES17-1991 Annex A.

Frequency Response

A measure of the amplitude response variation from 10 Hz to 20 kHz relative to the amplitude response at 1 kHz. Units in decibels.

Interchannel Isolation

A measure of crosstalk between the left and right channels. Measured for each channel at the converter's output with no signal to the input under test and a full-scale signal applied to the other channel. Units in decibels.

Interchannel Gain Mismatch

The gain difference between left and right channels. Units in decibels.

Gain Error

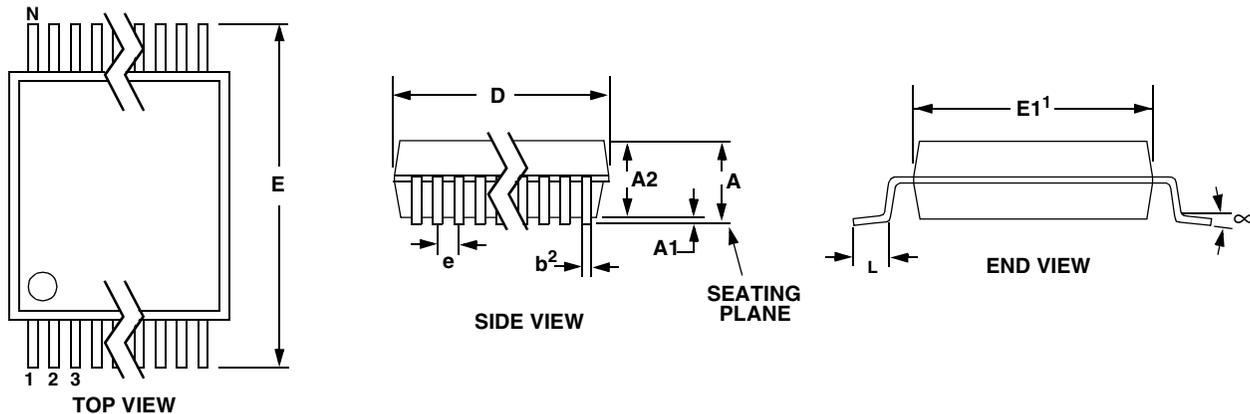
The deviation from the nominal full-scale analog input for a full-scale digital output.

Gain Drift

The change in gain value with temperature. Units in ppm/°C.

Offset Error

The deviation of the mid-scale transition (111...111 to 000...000) from the ideal. Units in mV.

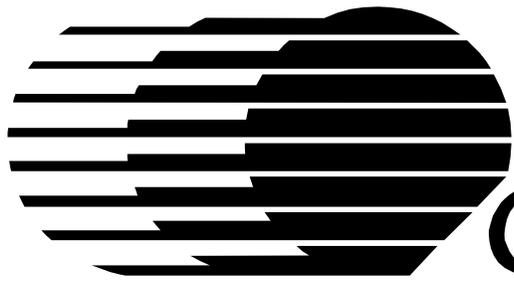
6 PACKAGE DIMENSIONS
16L TSSOP (4.4 mm BODY) PACKAGE DRAWING


DIM	INCHES			MILLIMETERS			NOTE
	MIN	NOM	MAX	MIN	NOM	MAX	
A	--	--	0.043	--	--	1.10	
A1	0.002	0.004	0.006	0.05	--	0.15	
A2	0.03346	0.0354	0.037	0.85	0.90	0.95	
b	0.00748	0.0096	0.012	0.19	0.245	0.30	2,3
D	0.193	0.1969	0.201	4.90	5.00	5.10	1
E	0.248	0.2519	0.256	6.30	6.40	6.50	
E1	0.169	0.1732	0.177	4.30	4.40	4.50	1
e	--	0.026 BSC	--	--	0.065 BSC	--	
L	0.020	0.024	0.028	0.50	0.60	0.70	
∞	0°	4°	8°	0°	4°	8°	

JEDEC #: MO-153

Controlling Dimension is Millimeters

- Notes:
1. "D" and "E1" are reference datums and do not include mold flash or protrusions, but do include mold mismatch and are measured at the parting line, mold flash or protrusions shall not exceed 0.20 mm per side.
 2. Dimension "b" does not include dambar protrusion/intrusion. Allowable dambar protrusion shall be 0.13 mm total in excess of "b" dimension at maximum material condition. Dambar intrusion shall not reduce dimension "b" by more than 0.07 mm at least material condition.
 3. These dimensions apply to the flat section of the lead between 0.10 and 0.25 mm from lead tips.



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