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## Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



# 114 dB, 192 kHz 6-Channel D/A Converter

## Features

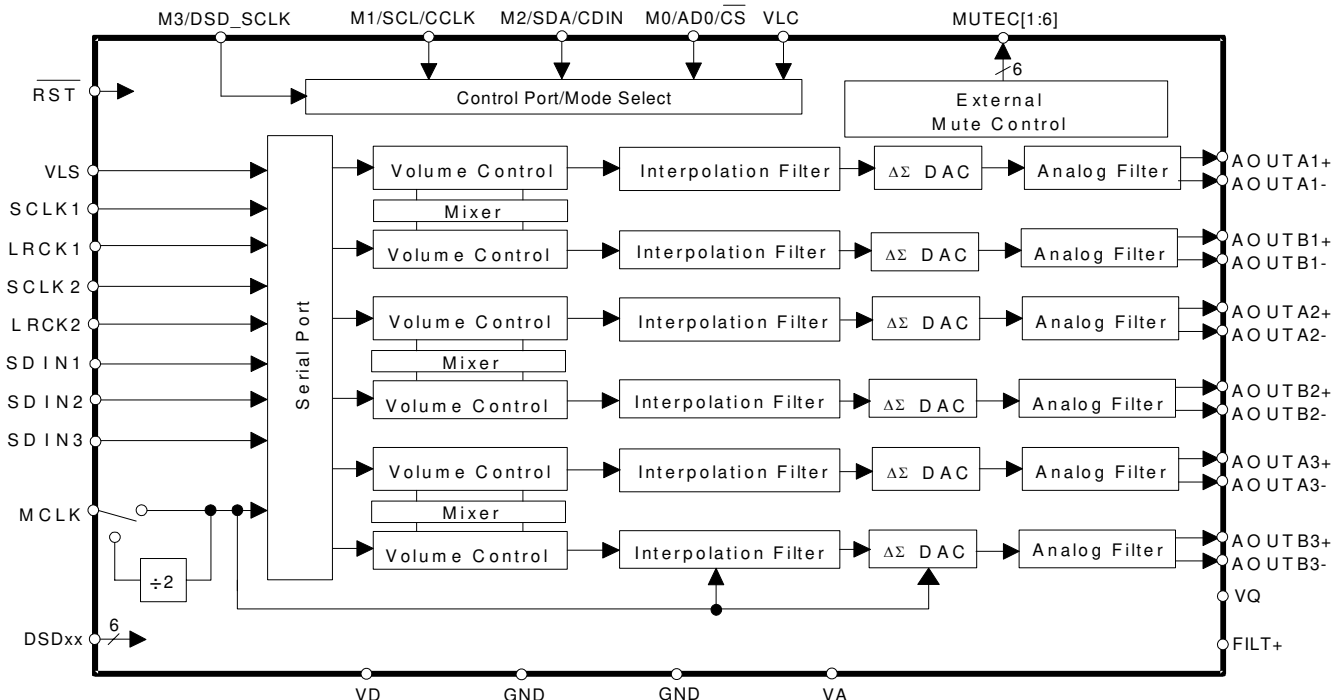
- ◆ 24-bit Conversion
- ◆ Up to 192 kHz Sample Rates
- ◆ 114 dB Dynamic Range
- ◆ -100 dB THD+N
- ◆ Supports PCM or DSD Data Formats
- ◆ Selectable Digital Filters
- ◆ Volume Control with Soft Ramp
  - 1 dB Step Size
  - Zero Crossing Click-free Transitions
- ◆ Dedicated DSD Inputs
- ◆ Low Clock Jitter Sensitivity
- ◆ Simultaneous Support for Two Synchronous Sample Rates for DVD Audio
- ◆  $\mu$ C or Stand-Alone Operation

## Description

The CS4362 is a complete 6-channel digital-to-analog system including digital interpolation, fifth-order delta-sigma digital-to-analog conversion, digital de-emphasis, volume control and analog filtering. The advantages of this architecture include: ideal differential linearity, no distortion mechanisms due to resistor matching errors, no linearity drift over time and temperature and a high tolerance to clock jitter.

The CS4362 is available in a 48-pin LQFP package in Commercial grade (-10°C to +70°C). The CDB4362 Customer Demonstration Board is also available for device evaluation and implementation suggestions. Please see “[Ordering Information](#)” on page 42 for complete details.

The CS4362 accepts PCM data at sample rates from 4 kHz to 192 kHz, DSD audio data, and operates over a wide power supply range. These features are ideal for multi-channel audio systems including DVD players, SACD players, A/V receivers, digital TV’s, mixing consoles, and effects processors.



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# 1. CHARACTERISTICS AND SPECIFICATIONS

## ANALOG CHARACTERISTICS

(Full-Scale Output Sine Wave, 997 Hz; Measurement Bandwidth 10 Hz to 20 kHz, unless otherwise specified; Test load  $R_L = 3\text{ k}\Omega$ ,  $C_L = 100\text{ pF}$ ,  $V_A = 5\text{ V}$ ,  $V_D = 3.3\text{ V}$  (see [Figure 5](#)))

For Single-Speed Mode,  $F_s = 48\text{ kHz}$ ,  $SCLK = 3.072\text{ MHz}$ ,  $MCLK = 12.288\text{ MHz}$ ;

For Double-Speed Mode,  $F_s = 96\text{ kHz}$ ,  $SCLK = 6.144\text{ MHz}$ ,  $MCLK = 12.288\text{ MHz}$ ;

For Quad-Speed Mode,  $F_s = 192\text{ kHz}$ ,  $SCLK = 12.288\text{ MHz}$ ,  $MCLK = 24.576\text{ MHz}$ ;

For Direct Stream Digital Mode,  $F_s = 128 \times 48\text{ kHz}$ ,  $DSD\_SCLK = 6.144\text{ MHz}$ ,  $MCLK = 12.288\text{ MHz}$ ).

Parameters	Symbol	Min	Typ	Max	Unit		
<b>CS4362-KQZ Dynamic Performance - All PCM modes and DSD (Note 1)</b>							
Specified Temperature Range	$T_A$	-10	-	70	°C		
Dynamic Range (Note 2)	24-bit unweighted	105	111	-	dB		
	A-Weighted	108	114	-	dB		
	16-bit unweighted	-	94	-	dB		
	(Note 3) A-Weighted	-	97	-	dB		
Total Harmonic Distortion + Noise	(Note 2)	24-bit 0 dB	THD+N	-	-100	-94	dB
		-20 dB		-	-91	-	dB
		-60 dB		-	-51	-	dB
	(Note 3)	16-bit 0 dB	-	-94	-	dB	
		-20 dB	-	-74	-	dB	
		-60 dB	-	-34	-	dB	
Idle Channel Noise / Signal-to-noise ratio		-	114	-	dB		
Interchannel Isolation	(1 kHz)	-	90	-	dB		

### Notes:

1. CS4362-KQZ parts are tested at 25°C.
2. One-half LSB of triangular PDF dither is added to data.
3. Performance limited by 16-bit quantization noise.

## ANALOG CHARACTERISTICS

(Continued)

Parameters	Symbol	Min	Typ	Max	Units
<b>Analog Output - All PCM modes and DSD</b>					
Full Scale Differential Output Voltage (Note 4)	$V_{FS}$	86% $V_A$	91% $V_A$	96% $V_A$	V <sub>pp</sub>
Quiescent Voltage	$V_Q$	-	50% $V_A$	-	VDC
Max Current from $V_Q$	$I_{QMAX}$	-	1	-	μA
Interchannel Gain Mismatch		-	0.1	-	dB
Gain Drift		-	100	-	ppm/°C
Output Impedance (Note 4)	$Z_{OUT}$	-	100	-	Ω
AC-Load Resistance	$R_L$	3	-	-	kΩ
Load Capacitance	$C_L$	-	-	100	pF

## POWER AND THERMAL CHARACTERISTICS

Parameters	Symbol	Min	Typ	Max	Units
<b>Power Supplies</b>					
Power Supply Current (Note 5) normal operation, $V_A = 5$ V $V_D = 5$ V $V_D = 3.3$ V Interface current, $V_{LC} = 5$ V (Notes 6, 7) $V_{LS} = 5$ V power-down state (all supplies) (Note 8)	$I_A$	-	50	55	mA
	$I_D$	-	38	60	mA
	$I_D$	-	25	40	mA
	$I_{LC}$	-	2	-	μA
	$I_{LS}$	-	84	-	μA
	$I_{pd}$	-	200	-	μA
Power Dissipation (Note 5) $V_A = 5$ V, $V_D = 3.3$ V normal operation power-down (Note 8) $V_A = 5$ V, $V_D = 5$ V normal operation power-down (Note 8)		-	335	410	mW
		-	1	-	mW
		-	440	575	mW
		-	1	-	mW
Package Thermal Resistance multi-layer dual-layer	$\theta_{JA}$	-	48	-	°C/Watt
	$\theta_{JA}$	-	65	-	°C/Watt
	$\theta_{JC}$	-	15	-	°C/Watt
Power Supply Rejection Ratio (Note 9) (1 kHz) (60 Hz)	PSRR	-	60	-	dB
		-	40	-	dB

### Notes:

- $V_{FS}$  is tested under load  $R_L$  and includes attenuation due to  $Z_{OUT}$
- Current consumption increases with increasing FS within a given speed mode and is signal dependant. Max values are based on highest FS and highest MCLK.
- $I_{LC}$  measured with no external loading on the SDA pin.
- This specification is violated when the VLC supply is greater than  $V_D$  and when pin 16 (M1/SDA) is tied or pulled low. Logic tied to pin 16 needs to be able to sink this current.
- Power Down Mode is defined as  $\overline{RST}$  pin = Low with all clock and data lines held static.
- Valid with the recommended capacitor values on FILT+ and VQ as shown in Figures 5 and 6.

**ANALOG FILTER RESPONSE**

Parameter	Fast Roll-Off			Slow Roll-Off (Note 10)			Unit	
	Min	Typ	Max	Min	Typ	Max		
<b>Combined Digital and On-chip Analog Filter Response - Single-Speed Mode (Note 11)</b>								
Passband (Note 12)	to -0.01 dB corner	0	-	.454	0	-	0.417	Fs
	to -3 dB corner	0	-	.499	0	-	0.499	Fs
Frequency Response 10 Hz to 20 kHz	-0.01	-	+0.01	-0.01	-	+0.01		dB
StopBand	.547	-	-	.583	-	-		Fs
StopBand Attenuation (Note 13)	90	-	-	64	-	-		dB
Group Delay	-	12/Fs	-	-	6.5/Fs	-		s
Passband Group Delay Deviation 0 - 20 kHz	-	-	±0.41/Fs	-	-	±0.14/Fs		s
De-emphasis Error (Note 14) (Relative to 1 kHz)	Fs = 32 kHz	-	-	±0.23	-	-	±0.23	dB
	Fs = 44.1 kHz	-	-	±0.14	-	-	±0.14	dB
	Fs = 48 kHz	-	-	±0.09	-	-	±0.09	dB
<b>Combined Digital and On-chip Analog Filter Response - Double-Speed Mode - 96 kHz (Note 11)</b>								
Passband (Note 12)	to -0.01 dB corner	0	-	.430	0	-	.296	Fs
	to -3 dB corner	0	-	.499	0	-	.499	Fs
Frequency Response 10 Hz to 20 kHz	-0.01	-	0.01	-0.01	-	0.01		dB
StopBand	.583	-	-	.792	-	-		Fs
StopBand Attenuation (Note 13)	80	-	-	70	-	-		dB
Group Delay	-	4.6/Fs	-	-	3.9/Fs	-		s
Passband Group Delay Deviation 0 - 20 kHz	-	-	±0.03/Fs	-	-	±0.01/Fs		s
<b>Combined Digital and On-chip Analog Filter Response - Quad-Speed Mode - 192 kHz (Note 11)</b>								
Passband (Note 12)	to -0.01 dB corner	0	-	.105	0	-	.104	Fs
	to -3 dB corner	0	-	.490	0	-	.481	Fs
Frequency Response 10 Hz to 20 kHz	-0.01	-	0.01	-0.01	-	0.01		dB
StopBand	.635	-	-	.868	-	-		Fs
StopBand Attenuation (Note 13)	90	-	-	75	-	-		dB
Group Delay	-	4.7/Fs	-	-	4.2/Fs	-		s
Passband Group Delay Deviation 0 - 20 kHz	-	-	±0.01/Fs	-	-	±0.01/Fs		s
<b>Combined Digital and On-chip Analog Filter Response - DSD Mode (Note 11)</b>								
Passband (Note 12)	to -0.1 dB corner	-	-	-	0	-	20	kHz
	to -3 dB corner	-	-	-	0	-	120	kHz
Frequency Response 10 Hz to 20 kHz	-	-	-	-0.01	-	0.1		dB

**Notes:**

10. Slow Roll-Off interpolation filter is only available in Control Port Mode.
11. Filter response is not tested but is guaranteed by design.
12. Response is clock dependent and will scale with Fs. Note that the response plots (Figures 9 to 32) have been normalized to Fs and can be de-normalized by multiplying the X-axis scale by Fs.
13. Single- and Double-Speed Mode Measurement Bandwidth is from stopband to 3 Fs.  
Quad-Speed Mode Measurement Bandwidth is from stopband to 1.34 Fs.
14. De-emphasis is available only in Single-Speed Mode; Only 44.1 kHz De-emphasis is available in Stand-Alone Mode.



## DIGITAL CHARACTERISTICS

(For KQZ  $T_A = -10^{\circ}\text{C}$  to  $+70^{\circ}\text{C}$ ; VLC = VLS = 1.8 V to 5.5 V)

Parameters	Symbol	Min	Typ	Max	Units
High-Level Input Voltage	Serial Data Port	$V_{IH}$	70% VLS	-	V
	Control Port	$V_{IH}$	70% VLC	-	V
Low-Level Input Voltage	Serial Data Port	$V_{IL}$	-	20% VLS	V
	Control Port	$V_{IL}$	-	20% VLC	V
Input Leakage Current	(Note 7)	$I_{in}$	-	$\pm 10$	$\mu\text{A}$
Input Capacitance			8	-	pF
Maximum MUTE C Drive Current			3	-	mA
MUTE C High-Level Output Voltage		$V_{OH}$	VA	-	V
MUTE C Low-Level Output Voltage		$V_{OL}$	0	-	V

## ABSOLUTE MAXIMUM RATINGS

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

Parameters	Symbol	Min	Max	Units	
DC Power Supply	Analog power	VA	-0.3	6.0	V
	Digital internal power	VD	-0.3	6.0	V
	Serial data port interface power	VLS	-0.3	6.0	V
	Control port interface power	VLC	-0.3	6.0	V
Input Current, Any Pin Except Supplies	$I_{in}$	-	$\pm 10$	mA	
Digital Input Voltage	Serial data port interface	$V_{IND-S}$	-0.3	VLS+ 0.4	V
	Control port interface	$V_{IND-C}$	-0.3	VLC+ 0.4	V
Ambient Operating Temperature (power applied)	$T_A$	-55	125	$^{\circ}\text{C}$	
Storage Temperature	$T_{stg}$	-65	150	$^{\circ}\text{C}$	

**WARNING:** Operation at or beyond these limits may result in permanent damage to the device. Normal operation is not guaranteed at these extremes.

## RECOMMENDED OPERATING CONDITIONS

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

Parameters	Symbol	Min	Typ	Max	Units	
DC Power Supply	Analog power	VA	4.5	5.0	5.5	V
	Digital internal power	VD	3.0	3.3	5.5	V
	Serial data port interface power	VLS	1.8	5.0	5.5	V
	Control port interface power	VLC	1.8	5.0	5.5	V

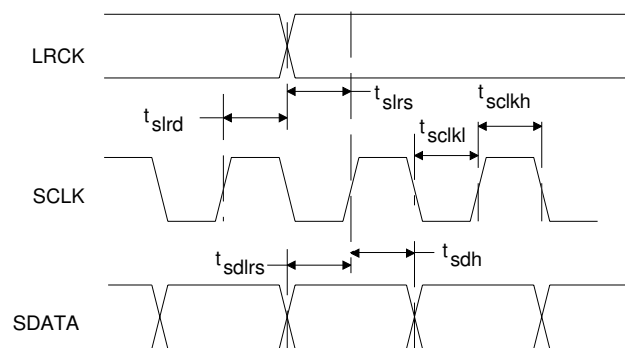
## SWITCHING CHARACTERISTICS

(For KQZ  $T_A = -10^\circ\text{C}$  to  $+70^\circ\text{C}$ ; VLS = 1.8 V to 5.5 V; Inputs: Logic 0 = GND, Logic 1 = VLS,  $C_L = 30$  pF)

Parameters	Symbol	Min	Typ	Max	Units
MCLK Frequency (Note 15)					
Single-Speed Mode		1.024	-	51.2	MHz
Double-Speed Mode		6.400	-	51.2	MHz
Quad-Speed Mode		6.400	-	51.2	MHz
MCLK Duty Cycle		40	50	60	%
Input Sample Rate					
Single-Speed Mode	$F_s$	4	-	50	kHz
Double-Speed Mode	$F_s$	50	-	100	kHz
Quad-Speed Mode	$F_s$	100	-	200	kHz
LRCK Duty Cycle		45	50	55	%
SCLK Pulse Width Low	$t_{sclkl}$	20	-	-	ns
SCLK Pulse Width High	$t_{sclkh}$	20	-	-	ns
SCLK Period	$t_{sclkw}$	$\frac{2}{MCLK}$	-	-	ns
	$t_{sclkw}$	$\frac{4}{MCLK}$	-	-	ns
	(Note 16)				
SCLK rising to LRCK edge delay	$t_{slrd}$	20	-	-	ns
SCLK rising to LRCK edge setup time	$t_{slrs}$	20	-	-	ns
SDATA valid to SCLK rising setup time	$t_{sdrls}$	20	-	-	ns
SCLK rising to SDATA hold time	$t_{sdh}$	20	-	-	ns
LRCK1 to LRCK2 frequency ratio (Note 17)		0.25	1.00	4.00	

### Notes:

15. See Table 5 on page 27 for suggested MCLK frequencies
16. This serial clock is available only in Control Port Mode when the MCLK Divide bit is enabled.
17. The higher frequency LRCK must be an exact integer multiple (1, 2, or 4) of the lower frequency LRCK



**Figure 1. Serial Mode Input Timing**

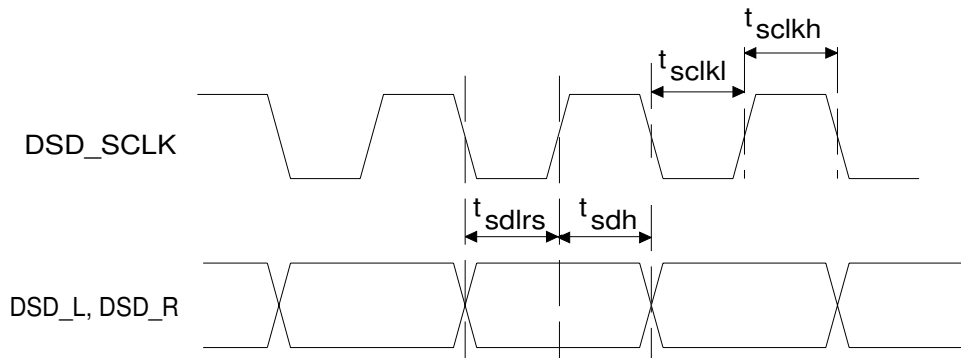
## DSD - SWITCHING CHARACTERISTICS

( $T_A = -10^\circ\text{C}$  to  $70^\circ\text{C}$ ; Logic 0 = GND; VLS = 1.8 V to 5.5 V; Logic 1 = VLS Volts;  $C_L = 30$  pF)

Parameter	Symbol	Min	Typ	Max	Unit
Master Clock Frequency (Note 18)		4.096	-	38.4	MHz
MCLK Duty Cycle (All DSD modes)		40	50	60	%
DSD_SCLK Pulse Width Low	$t_{\text{sckl}}$	20	-	-	ns
DSD_SCLK Pulse Width High	$t_{\text{sckh}}$	20	-	-	ns
DSD_SCLK Frequency (64x Oversampled)		1.024	-	3.2	MHz
(128x Oversampled)		2.048	-	6.4	MHz
DSD_L / _R valid to DSD_SCLK rising setup time	$t_{\text{sdhrs}}$	20	-	-	ns
DSD_SCLK rising to DSD_L or DSD_R hold time	$t_{\text{sdh}}$	20	-	-	ns

**Note:**

18. Min is 4 times 64x DSD or 2 times 128x DSD, and Max is 12 times 64x DSD or 6 times 128x DSD. The proper MCLK to DSD\_SCLK ratio must be set either by the DIF registers or the M0:2 pins



**Figure 2. Direct Stream Digital - Serial Audio Input Timing**

## SWITCHING CHARACTERISTICS - CONTROL PORT - I<sup>2</sup>C<sup>®</sup> FORMAT

(For KQZ T<sub>A</sub> = -10°C to +70°C; VLC = 1.8 V to 5.5 V; Inputs: Logic 0 = GND, Logic 1 = VLC, C<sub>L</sub> = 30 pF)

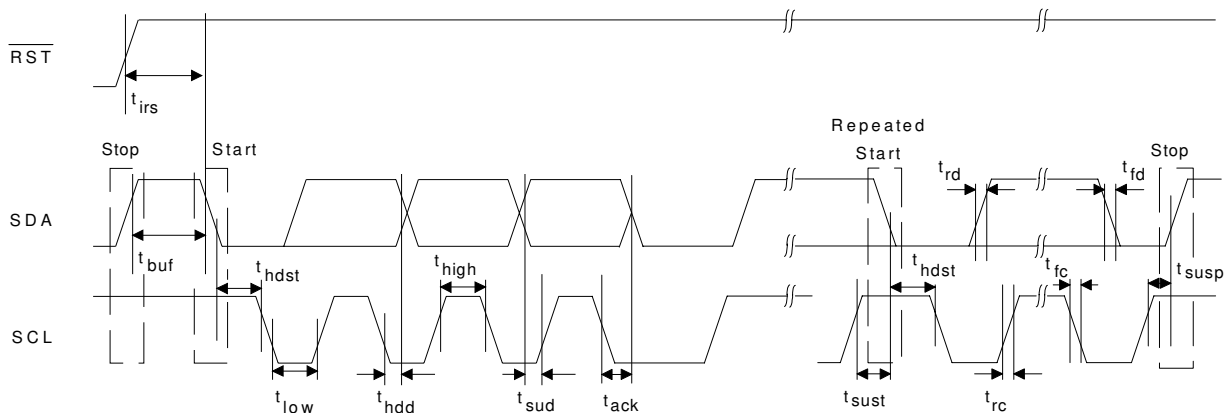
Parameter	Symbol	Min	Max	Unit
SCL Clock Frequency	f <sub>scl</sub>	-	100	kHz
RST Rising Edge to Start	t <sub>irs</sub>	500	-	ns
Bus Free Time Between Transmissions	t <sub>buf</sub>	4.7	-	μs
Start Condition Hold Time (prior to first clock pulse)	t <sub>hdst</sub>	4.0	-	μs
Clock Low time	t <sub>low</sub>	4.7	-	μs
Clock High Time	t <sub>high</sub>	4.0	-	μs
Setup Time for Repeated Start Condition	t <sub>sust</sub>	4.7	-	μs
SDA Hold Time from SCL Falling (Note 19)	t <sub>hdd</sub>	0	-	μs
SDA Setup time to SCL Rising	t <sub>sud</sub>	250	-	ns
Rise Time of SCL and SDA	t <sub>rc</sub> , t <sub>rc</sub>	-	1	μs
Fall Time SCL and SDA	t <sub>fc</sub> , t <sub>fc</sub>	-	300	ns
Setup Time for Stop Condition	t <sub>susp</sub>	4.7	-	μs
Acknowledge Delay from SCL Falling (Note 20)	t <sub>ack</sub>	-	(Note 21)	ns

### Notes:

19. Data must be held for sufficient time to bridge the transition time, t<sub>fc</sub>, of SCL.

20. The acknowledge delay is based on MCLK and can limit the maximum transaction speed.

21.  $\frac{15}{256 \times F_s}$  for Single-Speed Mode,  $\frac{15}{128 \times F_s}$  for Double-Speed Mode,  $\frac{15}{64 \times F_s}$  for Quad-Speed Mode.



**Figure 3. Control Port Timing - I<sup>2</sup>C Format**

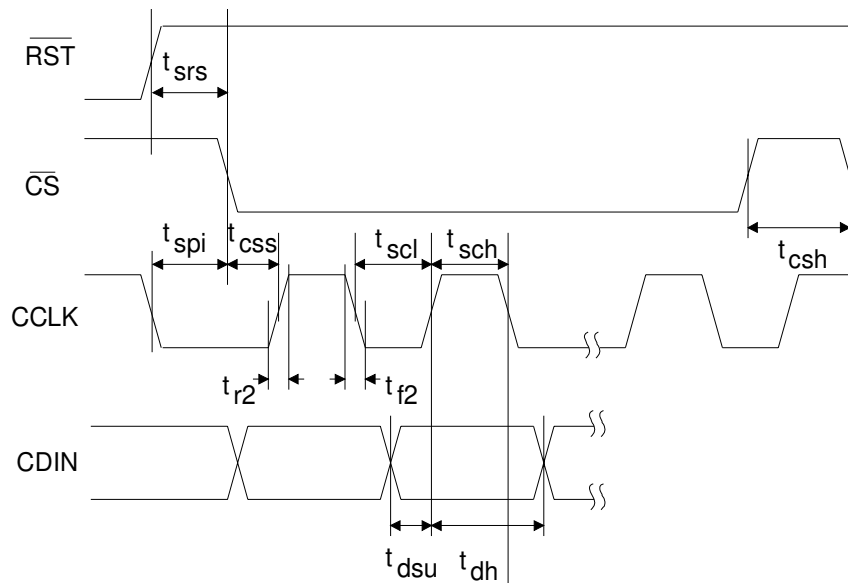
## SWITCHING CHARACTERISTICS - CONTROL PORT - SPI™ FORMAT

(For KQZ  $T_A = -10^\circ\text{C}$  to  $+70^\circ\text{C}$ ; VLC = 1.8 V to 5.5 V; Inputs: Logic 0 = GND, Logic 1 = VLC,  $C_L = 30$  pF)

Parameter	Symbol	Min	Max	Unit
CCLK Clock Frequency	$f_{\text{sclk}}$	-	$\frac{MCLK}{2}$	MHz
$\overline{\text{RST}}$ Rising Edge to $\overline{\text{CS}}$ Falling	$t_{\text{srs}}$	500	-	ns
CCLK Edge to $\overline{\text{CS}}$ Falling <span style="float: right;">(Note 22)</span>	$t_{\text{spi}}$	500	-	ns
$\overline{\text{CS}}$ High Time Between Transmissions	$t_{\text{csh}}$	1.0	-	$\mu\text{s}$
$\overline{\text{CS}}$ Falling to CCLK Edge	$t_{\text{css}}$	20	-	ns
CCLK Low Time	$t_{\text{scl}}$	$\frac{1}{MCLK}$	-	ns
CCLK High Time	$t_{\text{sch}}$	$\frac{1}{MCLK}$	-	ns
CDIN to CCLK Rising Setup Time	$t_{\text{dsu}}$	40	-	ns
CCLK Rising to DATA Hold Time <span style="float: right;">(Note 23)</span>	$t_{\text{dh}}$	15	-	ns
Rise Time of CCLK and CDIN <span style="float: right;">(Note 24)</span>	$t_{r2}$	-	100	ns
Fall Time of CCLK and CDIN <span style="float: right;">(Note 24)</span>	$t_{f2}$	-	100	ns

### Notes:

22.  $t_{\text{spi}}$  only needed before first falling edge of  $\overline{\text{CS}}$  after  $\overline{\text{RST}}$  rising edge.  $t_{\text{spi}} = 0$  at all other times.
23. Data must be held for sufficient time to bridge the transition time of CCLK.
24. For  $F_{\text{SCK}} < 1$  MHz.



**Figure 4. Control Port Timing - SPI Format**

## 2. TYPICAL CONNECTION DIAGRAM

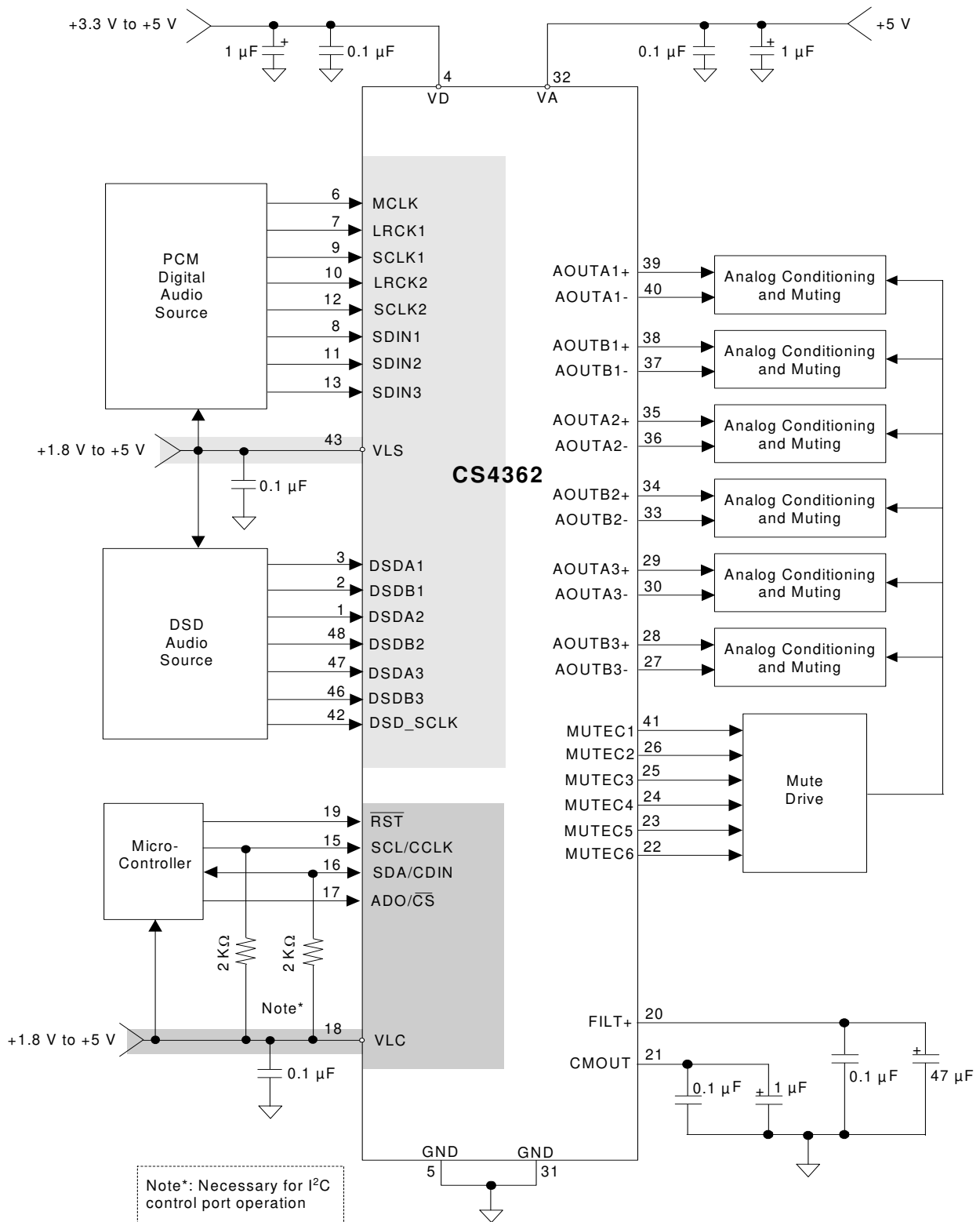


Figure 5. Typical Connection Diagram Control Port

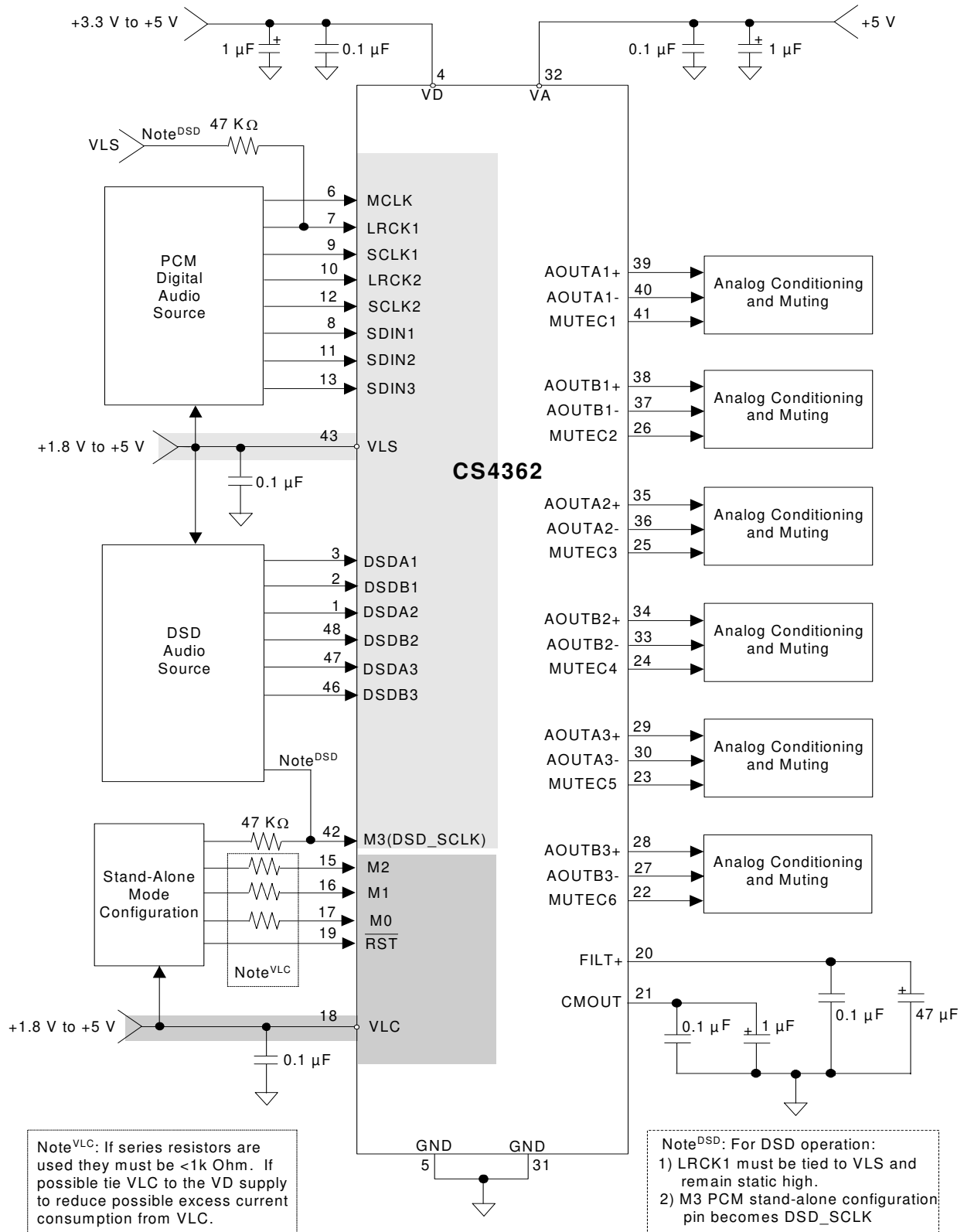


Figure 6. Typical Connection Diagram Stand-Alone

### 3. REGISTER QUICK REFERENCE

Addr	Function	7	6	5	4	3	2	1	0
01h	Mode Control 1 default	CPEN 0	FREEZE 0	MCLKDIV 0	Reserved 0	DAC3_DIS 0	DAC2_DIS 0	DAC1_DIS 0	PDN 1
02h	Mode Control 2 default	Reserved 0	DIF2 0	DIF1 0	DIF0 0	Reserved 0	SDIN3CLK 0	SDIN2CLK 0	SDIN1CLK 0
03h	Mode Control 3 default	SZC1 1	SZC0 0	SNGLVOL 0	RMP_UP 0	MUTE <sup>+/-</sup> 0	AMUTE 1	MUTE <sup>C1</sup> 0	MUTE <sup>C0</sup> 0
04h	Filter Control default	Reserved 0	Reserved 0	Reserved 0	FILT_SEL 0	Reserved 0	DEM1 0	DEM0 0	RMP_DN 0
05h	Invert Control default	Reserved 0	Reserved 0	INV_B3 0	INV_A3 0	INV_B2 0	INV_A2 0	INV_B1 0	INV_A1 0
06h	Mixing Control Pair 1 (AOUTx1) default	P1_A=B 0	P1ATAPI4 0	P1ATAPI3 1	P1ATAPI2 0	P1ATAPI1 0	P1ATAPI0 1	P1FM1 0	P1FM0 0
07h	Vol. Control A1 default	A1_MUTE 0	A1_VOL6 0	A1_VOL5 0	A1_VOL4 0	A1_VOL3 0	A1_VOL2 0	A1_VOL1 0	A1_VOL0 0
08h	Vol. Control B1 default	B1_MUTE 0	B1_VOL6 0	B1_VOL5 0	B1_VOL4 0	B1_VOL3 0	B1_VOL2 0	B1_VOL1 0	B1_VOL0 0
09h	Mixing Control Pair 2 (AOUTx2) default	P2_A=B 0	P2ATAPI4 0	P2ATAPI3 1	P2ATAPI2 0	P2ATAPI1 0	P2ATAPI0 1	P2FM1 0	P2FM0 0
0Ah	Vol. Control A2 default	A2_MUTE 0	A2_VOL6 0	A2_VOL5 0	A2_VOL4 0	A2_VOL3 0	A2_VOL2 0	A2_VOL1 0	A2_VOL0 0
0Bh	Vol. Control B2 default	B2_MUTE 0	B2_VOL6 0	B2_VOL5 0	B2_VOL4 0	B2_VOL3 0	B2_VOL2 0	B2_VOL1 0	B2_VOL0 0
0Ch	Mixing Control Pair 3 (AOUTx3) default	P3_A=B 0	P3ATAPI4 0	P3ATAPI3 1	P3ATAPI2 0	P3ATAPI1 0	P3ATAPI0 1	P3FM1 0	P3FM0 0
0Dh	Vol. Control A3 default	A3_MUTE 0	A3_VOL6 0	A3_VOL5 0	A3_VOL4 0	A3_VOL3 0	A3_VOL2 0	A3_VOL1 0	A3_VOL0 0
0Eh	Vol. Control B3 default	B3_MUTE 0	B3_VOL6 0	B3_VOL5 0	B3_VOL4 0	B3_VOL3 0	B3_VOL2 0	B3_VOL1 0	B3_VOL0 0
12h	Chip Revision default	PART3 1	PART2 1	PART1 1	PART0 0	Reserved -	Reserved -	Reserved -	Reserved -



## 4. REGISTER DESCRIPTION

**Note:** All registers are read/write in I<sup>2</sup>C Mode and write-only in SPI, unless otherwise noted.

### 4.1 Mode Control 1 (address 01h)

7	6	5	4	3	2	1	0
CPEN	FREEZE	MCLKDIV	Reserved	DAC3_DIS	DAC2_DIS	DAC1_DIS	PDN
0	0	0	0	0	0	0	1

#### 4.1.1 Control Port Enable (CPEN)

Default = 0  
 0 - Disabled  
 1 - Enabled

Function:

This bit defaults to 0, allowing the device to power-up in Stand-Alone Mode. The Control Port Mode can be accessed by setting this bit to 1. This will allow the operation of the device to be controlled by the registers and the pin definitions will conform to Control Port Mode. To accomplish a clean power-up, the user should write this bit within 10 ms following the release of Reset.

#### 4.1.2 Freeze Controls (FREEZE)

Default = 0  
 0 - Disabled  
 1 - Enabled

Function:

This function allows modifications to be made to the registers without the changes taking effect until the FREEZE is disabled. To make multiple changes in the Control port registers take effect simultaneously, enable the FREEZE bit, make all register changes, then Disable the FREEZE bit.

#### 4.1.3 Master Clock Divide Enable (MCLKDIV)

Default = 0  
 0 - Disabled  
 1 - Enabled

Function:

The MCLKDIV bit enables a circuit that divides the externally applied MCLK signal by 2 prior to all other internal circuitry.

#### 4.1.4 DAC Pair Disable (DACx\_DIS)

Default = 0  
 0 - DAC Pair x Enabled  
 1 - DAC Pair x Disabled

Function:

When the bit is set, the respective DAC channel pair (AOUTAx and AOUTBx) will remain in a reset state. It is advised that changes to these bits be made while the power-down (PDN) bit is enabled to eliminate the possibility of audible artifacts.

### 4.1.5 Power Down (PDN)

Default = 1  
 0 - Disabled  
 1 - Enabled

Function:

The entire device will enter a low-power state when this function is enabled, and the contents of the control registers are retained in this mode. The power-down bit defaults to 'enabled' on power-up and must be disabled before normal operation in Control Port Mode can occur.

## 4.2 Mode Control 2 (address 02h)

7	6	5	4	3	2	1	0
Reserved	DIF2	DIF1	DIF0	Reserved	SDIN3CLK	SDIN2CLK	SDIN1CLK
0	0	0	0	0	0	0	0

### 4.2.1 Digital Interface Format (DIF)

Default = 000 - Format 0 (Left Justified, up to 24-bit data)

Function:

These bits select the interface format for the serial audio input. The Functional Mode bits determine whether PCM or DSD Mode is selected.

**PCM Mode:** The required relationship between the Left/Right clock, serial clock and serial data is defined by the Digital Interface Format and the options are detailed in [Figures 33 to 38](#).

**Note:** While in PCM Mode, the DIF bits should only be changed when the power-down (PDN) bit is set to ensure proper switching from one mode to another.

DIF2	DIF1	DIF0	DESCRIPTION	Format	FIGURE
0	0	0	Left Justified, up to 24-bit data	0	<a href="#">33</a>
0	0	1	I <sup>2</sup> S, up to 24-bit data	1	<a href="#">34</a>
0	1	0	Right Justified, 16-bit data	2	<a href="#">35</a>
0	1	1	Right Justified, 24-bit data	3	<a href="#">36</a>
1	0	0	Right Justified, 20-bit data	4	<a href="#">37</a>
1	0	1	Right Justified, 18-bit data	5	<a href="#">38</a>
1	1	0	Reserved		
1	1	1	Reserved		

**Table 1. Digital Interface Formats - PCM Mode**

**DSD Mode:** The relationship between the oversampling ratio of the DSD audio data and the required Master clock to DSD data rate is defined by the Digital Interface Format pins. An additional write of 99h to register 00h and 80h to register 1Ah is required to access the modes denoted with \*.

DIF2	DIF1	DIFO	DESCRIPTION	Note
0	0	0	64x oversampled DSD data with a 4x MCLK to DSD data rate	
0	0	1	64x oversampled DSD data with a 6x MCLK to DSD data rate	*
0	1	0	64x oversampled DSD data with a 8x MCLK to DSD data rate	*
0	1	1	64x oversampled DSD data with a 12x MCLK to DSD data rate	*
1	0	0	128x oversampled DSD data with a 2x MCLK to DSD data rate	
1	0	1	128x oversampled DSD data with a 3x MCLK to DSD data rate	*
1	1	0	128x oversampled DSD data with a 4x MCLK to DSD data rate	*
1	1	1	128x oversampled DSD data with a 6x MCLK to DSD data rate	*

**Table 2. Digital Interface Formats - DSD Mode**

#### 4.2.2 Serial Audio Data Clock Source (SDINXCLK)

Default = 0

0 - SDINx clocked by SCLK1 and LRCK1

1 - SDINx clocked by SCLK2 and LRCK2

Function:

The SDINxCLK bit specifies which SCLK/LRCK input pair is used to clock in the data on the given SDINx line. For more details see [“Clock Source Selection” on page 29](#).

#### 4.3 Mode Control 3 (address 03h)

7	6	5	4	3	2	1	0
SZC1	SZC0	SNGLVOL	RMP_UP	Reserved	AMUTE	MUTE1	MUTE0
1	0	0	0	0	1	0	0

##### 4.3.1 Soft Ramp and Zero Cross Control (SZC)

Default = 10

00 - Immediate Change

01 - Zero Cross

10 - Soft Ramp

11 - Soft Ramp on Zero Crossings

Function:

Immediate Change

When Immediate Change is selected all level changes will take effect immediately in one step.

Zero Cross

Zero Cross Enable dictates that signal level changes, either by attenuation changes or muting, will occur on a signal zero crossing to minimize audible artifacts. The requested level change will occur after a timeout period between 512 and 1024 sample periods (10.7 ms to 21.3 ms at 48 kHz sample rate) if the signal does not encounter a zero crossing. The zero cross function is independently monitored and implemented for each channel.

### Soft Ramp

Soft Ramp allows level changes, both muting and attenuation, to be implemented by incrementally ramping, in 1/8 dB steps, from the current level to the new level at a rate of 1 dB per 8 left/right clock periods.

### Soft Ramp on Zero Crossing

Soft Ramp and Zero Cross Enable dictates that signal level changes, either by attenuation changes or muting, will occur in 1/8 dB steps and be implemented on a signal zero crossing. The 1/8 dB level change will occur after a timeout period between 512 and 1024 sample periods (10.7 ms to 21.3 ms at 48 kHz sample rate) if the signal does not encounter a zero crossing. The zero cross function is independently monitored and implemented for each channel.

## **4.3.2 Single Volume Control (SNGLVOL)**

Default = 0  
0 - Disabled  
1 - Enabled

Function:

The individual channel volume levels are independently controlled by their respective Volume Control Bytes when this function is disabled. The volume on all channels is determined by the A1 Channel Volume Control Byte, and the other Volume Control Bytes are ignored when this function is enabled.

## **4.3.3 Soft Volume Ramp-Up After Error (RMP\_UP)**

Default = 0  
0 - Disabled  
1 - Enabled

Function:

An un-mute will be performed after executing a filter mode change, after a LRCK/MCLK ratio change or error, and after changing the Functional Mode. When this feature is enabled, this un-mute is effected, similar to attenuation changes, by the Soft and Zero Cross bits in the Mode Control 3 register. When disabled, an immediate un-mute is performed in these instances.

**Note:** For best results, it is recommended that this feature be used in conjunction with the RMP\_DN bit.

## **4.3.4 MUTE<sub>C</sub> Polarity (MUTE<sub>C</sub>+/-)**

Default = 0  
0 - Active High  
1 - Active Low

Function:

The active polarity of the MUTE<sub>C</sub> pin(s) is determined by this register. When set to 0 (default) the MUTE<sub>C</sub> pins are high when active. When set to 1 the MUTE<sub>C</sub> pin(s) are low when active.

Note: When the on board mute circuitry is designed for active low, the MUTE<sub>C</sub> outputs will be high (un-muted) for the period of time during reset and before this bit is enabled to 1.

### 4.3.5 Auto-Mute (AMUTE)

Default = 1  
 0 - Disabled  
 1 - Enabled

Function:

The Digital-to-Analog converter output will mute following the reception of 8192 consecutive audio samples of static 0 or -1. A single sample of non-static data will release the mute. Detection and muting is done independently for each channel. The quiescent voltage on the output will be retained and the Mute Control pin will go active during the mute period. The muting function is affected, similar to volume control changes, by the Soft and Zero Cross bits in the Mode Control 3 register.

### 4.3.6 Mute Pin Control (MUTEC1, MUTEC0)

Default = 00  
 00 - Six mute control signals  
 01, 10 - One mute control signal  
 11 - Three mute control signals

Function:

Selects how the internal mute control signals are routed to the MUTEC1 through MUTEC6 pins. When set to '00', there is one mute control signal for each channel: AOUT1A on MUTEC1, AOUT1B on MUTEC2, etc. When set to either '01' or '10', there is a single mute control signal on the MUTEC1 pin. When set to '11', there are three mute control signals, one for each stereo pair: AOUT1A and AOUT1B on MUTEC1, AOUT2A and AOUT2B on MUTEC2, and AOUT3A and AOUT3B on MUTEC3.

## 4.4 Filter Control (address 04h)

7	6	5	4	3	2	1	0
Reserved 0	Reserved 0	Reserved 0	FILT_SEL 0	Reserved 0	DEM1 0	DEM0 0	RMP_DN 0

### 4.4.1 Interpolation Filter Select (FILT\_SEL)

Default = 0  
 0 - Fast roll-off  
 1 - Slow roll-off

Function:

This Function allows the user to select whether the interpolation filter has a fast or slow roll off. For filter characteristics please see [Section 1. Characteristics and Specifications](#).

### 4.4.2 De-Emphasis Control (DEM)

Default = 00  
 00 - Disabled  
 01 - 44.1 kHz  
 10 - 48 kHz  
 11 - 32 kHz

Function:

Selects the appropriate digital filter to maintain the standard 15  $\mu$ s/50  $\mu$ s digital de-emphasis filter response at 32, 44.1 or 48 kHz sample rates. (see [Figure 39](#))

De-emphasis is only available in Single-Speed Mode.

#### 4.4.3 **Soft Ramp-Down Before Filter Mode Change (RMP\_DN)**

Default = 0

0 - Disabled

1 - Enabled

Function:

A mute will be performed prior to executing a filter mode change. When this feature is enabled, this mute is effected, similar to attenuation changes, by the Soft and Zero Cross bits in the Mode Control 3 register. When disabled, an immediate mute is performed prior to executing a filter mode change.

**Note:** For best results, it is recommended that this feature be used in conjunction with the RMP\_UP bit.

#### 4.5 **Invert Control (address 05h)**

7	6	5	4	3	2	1	0
Reserved	Reserved	INV_B3	INV_A3	INV_B2	INV_A2	INV_B1	INV_A1
0	0	0	0	0	0	0	0

##### 4.5.1 **Invert Signal Polarity (Inv\_Xx)**

Default = 0

0 - Disabled

1 - Enabled

Function:

When enabled, these bits will invert the signal polarity of their respective channels.

#### 4.6 **Mixing Control Pair 1 (Channels A1 & B1)(address 06h)** **Mixing Control Pair 2 (Channels A2 & B2)(address 09h)** **Mixing Control Pair 3 (Channels A3 & B3)(address 0Ch)**

7	6	5	4	3	2	1	0
Px_A=B	PxATAPI4	PxATAPI3	PxATAPI2	PxATAPI1	PxATAPI0	PxFM1	PxFM0
0	0	1	0	0	1	0	0

##### 4.6.1 **Channel A Volume = Channel B Volume (A=B)**

Default = 0

0 - Disabled

1 - Enabled

Function:

The AOUTAx and AOUTBx volume levels are independently controlled by the A and the B Channel Volume Control Bytes when this function is disabled. The volume on both AOUTAx and AOUTBx are determined by the A Channel Attenuation and Volume Control Bytes (per A-B pair), and the B Channel Bytes are ignored when this function is enabled.

#### 4.6.2 ATAPI Channel Mixing and Muting (ATAPI)

Default = 01001 - AOUTAx=aL, AOUTBx=bR (Stereo)

Function:

The CS4362 implements the channel mixing functions of the ATAPI CD-ROM specification. The ATAPI functions are applied per A-B pair. Refer to [Table 3](#) and [Figure 41](#) for additional information.

ATAPI4	ATAPI3	ATAPI2	ATAPI1	ATAPI0	AOUTAx	AOUTBx
0	0	0	0	0	MUTE	MUTE
0	0	0	0	1	MUTE	bR
0	0	0	1	0	MUTE	bL
0	0	0	1	1	MUTE	$b[(L+R)/2]$
0	0	1	0	0	aR	MUTE
0	0	1	0	1	aR	bR
0	0	1	1	0	aR	bL
0	0	1	1	1	aR	$b[(L+R)/2]$
0	1	0	0	0	aL	MUTE
0	1	0	0	1	aL	bR
0	1	0	1	0	aL	bL
0	1	0	1	1	aL	$b[(L+R)/2]$
0	1	1	0	0	$a[(L+R)/2]$	MUTE
0	1	1	0	1	$a[(L+R)/2]$	bR
0	1	1	1	0	$a[(L+R)/2]$	bL
0	1	1	1	1	$a[(L+R)/2]$	$b[(L+R)/2]$
1	0	0	0	0	MUTE	MUTE
1	0	0	0	1	MUTE	bR
1	0	0	1	0	MUTE	bL
1	0	0	1	1	MUTE	$[(aL+bR)/2]$
1	0	1	0	0	aR	MUTE
1	0	1	0	1	aR	bR
1	0	1	1	0	aR	bL
1	0	1	1	1	aR	$[(bL+aR)/2]$
1	1	0	0	0	aL	MUTE
1	1	0	0	1	aL	bR
1	1	0	1	0	aL	bL
1	1	0	1	1	aL	$[(aL+bR)/2]$
1	1	1	0	0	$[(aL+bR)/2]$	MUTE
1	1	1	0	1	$[(aL+bR)/2]$	bR
1	1	1	1	0	$[(bL+aR)/2]$	bL
1	1	1	1	1	$[(aL+bR)/2]$	$[(aL+bR)/2]$

**Table 3. ATAPI Decode**

### 4.6.3 Functional Mode (FM)

Default = 00

- 00 - Single-Speed Mode (4 to 50 kHz sample rates)
- 01 - Double-Speed Mode (50 to 100 kHz sample rates)
- 10 - Quad-Speed Mode (100 to 200 kHz sample rates)
- 11 - Direct Stream Digital Mode

Function:

Selects the required range of input sample rates or DSD Mode. All DAC pairs set to the same SCLK/LRCK pair ([Section 4.2.2](#)) are required to be set to the same functional mode setting before a speed mode change is accepted. When DSD Mode is selected for any channel pair then all pairs will switch to DSD Mode.

## 4.7 Volume Control (addresses 07h, 08h, 0Ah, 0Bh, 0Dh, 0Eh)

7	6	5	4	3	2	1	0
xx_MUTE	xx_VOL6	xx_VOL5	xx_VOL4	xx_VOL3	xx_VOL2	xx_VOL1	xx_VOL0
0	0	0	0	0	0	0	0

### 4.7.1 Mute (MUTE)

Default = 0

- 0 - Disabled
- 1 - Enabled

Function:

The Digital-to-Analog converter output will mute when enabled. The quiescent voltage on the output will be retained. The muting function is effected, similar to attenuation changes, by the Soft and Zero Cross bits. The MUTE pins will go active during the mute period according to the MUTE<sub>EC</sub> bits.

### 4.7.2 Volume Control (xx\_VOL)

Default = 0 (No attenuation)

Function:

The Digital Volume Control registers allow independent control of the signal levels in 1 dB increments from 0 to -127 dB. Volume settings are decoded as shown in [Table 4](#). The volume changes are implemented as dictated by the Soft and Zero Cross bits. All volume settings less than -127 dB are equivalent to enabling the MUTE bit.

Binary Code	Decimal Value	Volume Setting
0000000	0	0 dB
0010100	20	-20 dB
0101000	40	-40 dB
0111100	60	-60 dB
1011010	90	-90 dB

**Table 4. Example Digital Volume Settings**



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**4.8 Chip Revision (address 12h)**

7	6	5	4	3	2	1	0
PART3	PART2	PART1	PART0	Reserved	Reserved	Reserved	Reserved
1	1	1	0	-	-	-	-

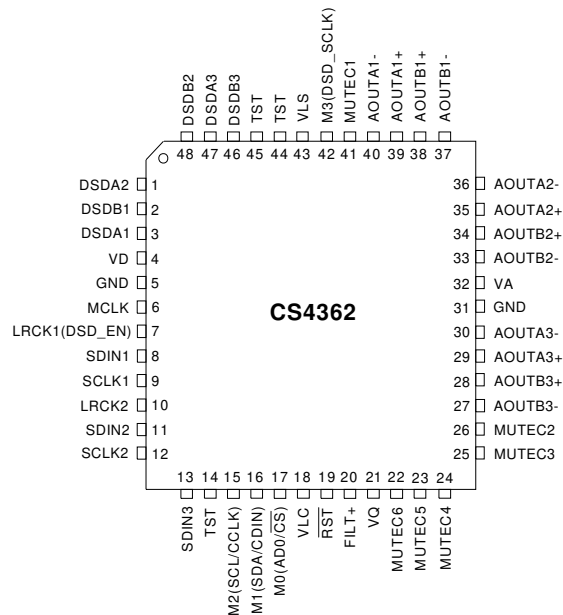
**4.8.1 Part Number ID (PART) [Read Only]**

1110 - CS4362

Function:

This read-only register can be used to identify the model number of the device.

## 5. PIN DESCRIPTION



Pin Name	#	Pin Description
VD	4	<b>Digital Power (Input)</b> - Positive power supply for the digital section. Refer to the Recommended Operating Conditions for appropriate voltages.
GND	5 31	<b>Ground (Input)</b> - Ground reference. Should be connected to analog ground.
MCLK	6	<b>Master Clock (Input)</b> - Clock source for the delta-sigma modulator and digital filters. <a href="#">Table 5</a> illustrates several standard audio sample rates and the required master clock frequencies.
LRCK1 LRCK2	7 10	<b>Left Right Clock (Input)</b> - Determines which channel, Left or Right, is currently active on the serial audio data line. The frequency of the left/right clock must be at the audio sample rate, $F_s$ .
SDIN1 SDIN2 SDIN3	8 11 13	<b>Serial Data Input (Input)</b> - Input for two's complement serial audio data.
SCLK1 SCLK2	9 12	<b>Serial Clock (Input)</b> - Serial clocks for the serial audio interface.
TST	14 44 45	<b>Test</b> - These pins need to be tied to analog ground.
RST	19	<b>Reset (Input)</b> - The device enters a low power mode and all internal registers are reset to their default settings when low.
VA	32	<b>Analog Power (Input)</b> - Positive power supply for the analog section. Refer to the Recommended Operating Conditions for appropriate voltages.
VLS	43	<b>Serial Audio Interface Power (Input)</b> - Determines the required signal level for the serial audio interface. Refer to the Recommended Operating Conditions for appropriate voltages.
VLC	18	<b>Control Port Power (Input)</b> - Determines the required signal level for the control port and stand-alone configuration pins. Refer to the Recommended Operating Conditions for appropriate voltages.