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AK4628A

High Performance Multi-channel Audio CODEC

GENERAL DESCRIPTION

The AK4628A is a single chip CODEC that includes two channels of ADC and eight channels of DAC. The ADC outputs 24bit data and the DAC accepts up to 24bit input data. The ADC has the Enhanced Dual Bit architecture with wide dynamic range. The DAC introduces the newly developed Advanced Multi-Bit architecture, and achieves wider dynamic range and lower outband noise. An auxiliary digital audio input interface maybe used instead of the ADC for passing audio data to the primary audio output port. Control may be set directly by pins or programmed through a separate serial interface.

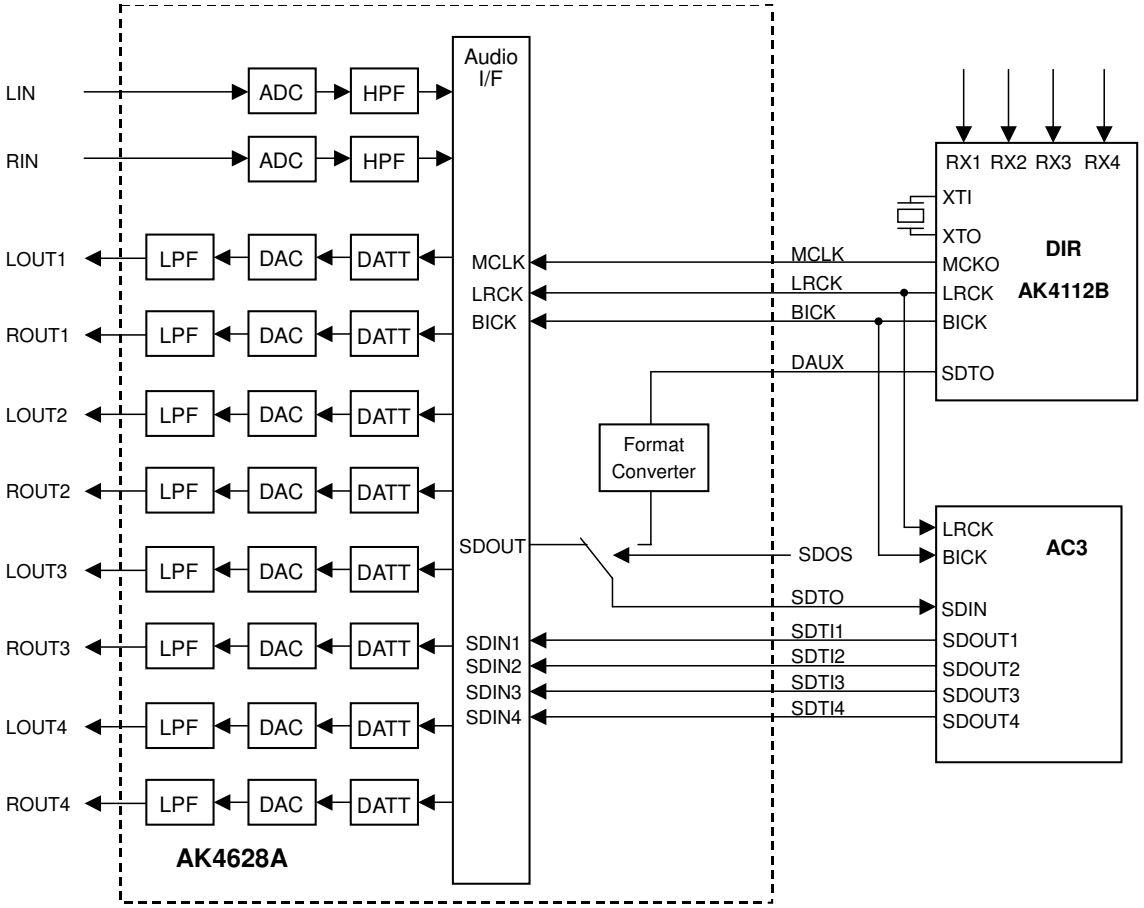
The AK4628A has a dynamic range of 102dB for ADC, 106dB for DAC and is well suited for digital surround for home theater and car audio. An AC-3 system can be built with a IEC60958(SPDIF) receiver such as the AK4112B. The AK4628A is available in a small 44pin LQFP package which will reduce system space.

*AC-3 is a trademark of Dolby Laboratories.

FEATURES

- **2ch 24bit ADC**
  - **64x Oversampling**
  - **Sampling Rate up to 96kHz**
  - **Linear Phase Digital Anti-Alias Filter**
  - **Single-Ended Input**
  - **S/(N+D): 92dB**
  - **Dynamic Range, S/N: 102dB**
  - **Digital HPF for offset cancellation**
  - **I/F format: MSB justified, I^2S or TDM**
  - **Overflow flag**
- **8ch 24bit DAC**
  - **128x Oversampling**
  - **Sampling Rate up to 192kHz**
  - **24bit 8 times Digital Filter**
  - **Single-Ended Outputs**
  - **On-chip Switched-Capacitor Filter**
  - **S/(N+D): 90dB**
  - **Dynamic Range, S/N: 106dB**
  - **I/F format: MSB justified, LSB justified(20bit,24bit), I^2S or TDM**
  - **Individual channel digital volume with 128 levels and 0.5dB step**
  - **Soft mute**
  - **De-emphasis for 32kHz, 44.1kHz and 48kHz**
  - **Zero Detect Function**
- **High Jitter Tolerance**
- **TTL Level Digital I/F**
- **3-wire Serial and I^2C Bus µP I/F for mode setting**
- **Master clock:256fs, 384fs or 512fs for fs=32kHz to 48kHz**
  128fs, 192fs or 256fs for fs=64kHz to 96kHz
  128fs for fs=120kHz to 192kHz
- **Power Supply: 4.5 to 5.5V**
- **Power Supply for output buffer: 2.7 to 5.5V**
- **Small 44pin LQFP**
- **AK4529 Pin Compatible**

■ Block Diagram

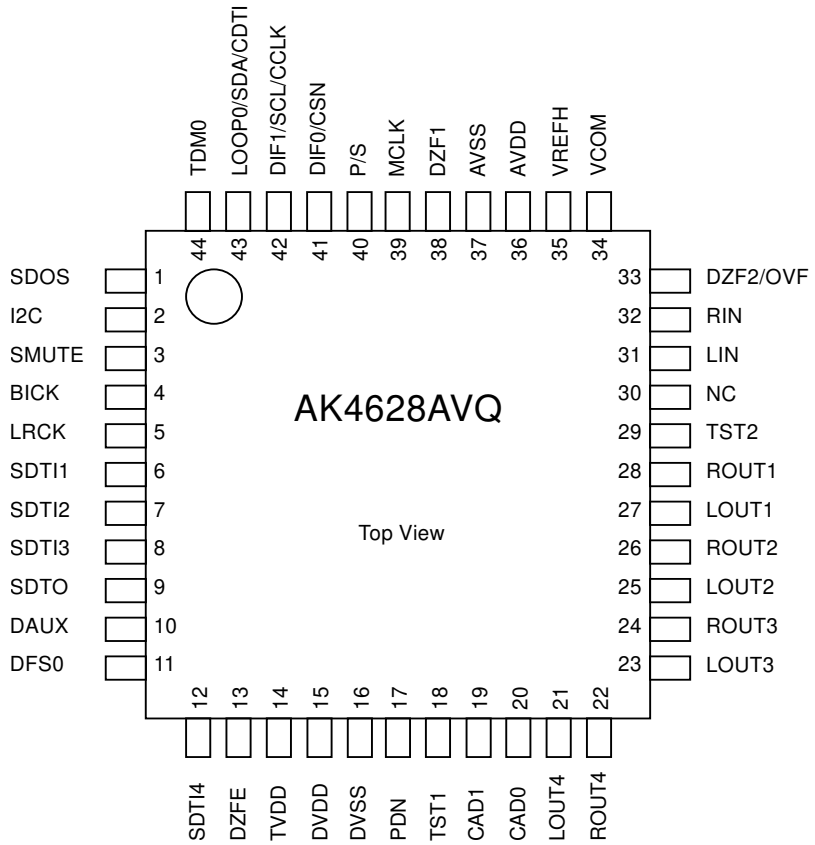


Block Diagram (DIR and AC-3 DSP are external parts)

■ Ordering Guide

AK4628AVQ	-40 ~ +85°C	44pin LQFP(0.8mm pitch)
AKD4628	Evaluation Board for AK4628A	

■ Pin Layout



■ Compatibility with AK4529

1. Functions

Functions	AK4529	AK4628A
DAC Sampling frequency	Up to 96kHz	Up to 192kHz
TDM128 (96kHz)	Not available	Available
Digital Attenuator	256 levels	128 levels
Soft Mute	Soft mute function is independent of Digital attenuator.	Soft mute function is not independent of Digital attenuator.
DAC channel power-down	Not available	Available

2. Pin Configuration

pin#	AK4529	AK4628A
11	DFS	DFS0
18	TST	TST1
29	NC	TST2
44	TDM	TDM0

3. Register

Addr	AK4529	AK4628A
00H	TDM	TDM0
00H	Not available	TDM1
01H	DFS	DFS0
01H	Not available	DFS1
01H	Not available	CKS1, CKS0
09H	Not available	PD4, PD3, PD2, PD1

PIN/FUNCTION

No.	Pin Name	I/O	Function
1	SDOS	I	SDTO Source Select Pin (Note 1) "L": Internal ADC output, "H": DAUX input SDOS pin should be set to "L" when TDM= "1".
2	I2C	I	Control Mode Select Pin "L": 3-wire Serial, "H": I^2C Bus
3	SMUTE	I	Soft Mute Pin (Note 1) When this pin goes to "H", soft mute cycle is initialized. When returning to "L", the output mute releases.
4	BICK	I	Audio Serial Data Clock Pin
5	LRCK	I	Input Channel Clock Pin
6	SDTI1	I	DAC1 Audio Serial Data Input Pin
7	SDTI2	I	DAC2 Audio Serial Data Input Pin
8	SDTI3	I	DAC3 Audio Serial Data Input Pin
9	SDTO	O	Audio Serial Data Output Pin
10	DAUX	I	AUX Audio Serial Data Input Pin
11	DFS0	I	Double Speed Sampling Mode Pin (Note 1) "L": Normal Speed, "H": Double Speed
12	SDTI4	I	DAC4 Audio Serial Data Input Pin
13	DZFE	I	Zero Input Detect Enable Pin "L": mode 7 (disable) at parallel mode, zero detect mode is selectable by DZFM3-0 bits at serial mode "H": mode 0 (DZF1 is AND of all eight channels)
14	TVDD	-	Output Buffer Power Supply Pin, 2.7V~5.5V
15	DVDD	-	Digital Power Supply Pin, 4.5V~5.5V
16	DVSS	-	Digital Ground Pin, 0V
17	PDN	I	Power-Down & Reset Pin When "L", the AK4628A is powered-down and the control registers are reset to default state. If the state of P/S or CAD1-0 changes, then the AK4628A must be reset by PDN.
18	TST1	I	Test Pin This pin should be connected to DVSS.
19	CAD1	I	Chip Address 1 Pin
20	CAD0	I	Chip Address 0 Pin
21	LOUT4	O	DAC4 Lch Analog Output Pin
22	ROUT4	O	DAC4 Rch Analog Output Pin

No.	Pin Name	I/O	Function
23	LOUT3	O	DAC3 Lch Analog Output Pin
24	ROUT3	O	DAC3 Rch Analog Output Pin
25	LOUT2	O	DAC2 Lch Analog Output Pin
26	ROUT2	O	DAC2 Rch Analog Output Pin
27	LOUT1	O	DAC1 Lch Analog Output Pin
28	ROUT1	O	DAC1 Rch Analog Output Pin
29	TST2	I	Test pin (Internal pull-down pin) This pin should be left floating or connected to AVSS.
30	NC	-	No Connect No internal bonding.
31	LIN	I	Lch Analog Input Pin
32	RIN	I	Rch Analog Input Pin
33	DZF2	O	Zero Input Detect 2 Pin (Note 2) When the input data of the group 1 follow total 8192 LRCK cycles with "0" input data, this pin goes to "H". And when RSTN bit is "0", PWDAN pin is "0", this pin goes to "H". It always is in "L" when P/S is "H".
	OVF	O	Analog Input Overflow Detect Pin (Note 3) This pin goes to "H" if the analog input of Lch or Rch overflows.
34	VCOM	O	Common Voltage Output Pin, AVDD/2 Large external capacitor around 2.2μF is used to reduce power-supply noise.
35	VREFH	I	Positive Voltage Reference Input Pin, AVDD
36	AVDD	-	Analog Power Supply Pin, 4.5V~5.5V
37	AVSS	-	Analog Ground Pin, 0V
38	DZF1	O	Zero Input Detect 1 Pin (Note 2) When the input data of the group 1 follow total 8192 LRCK cycles with "0" input data, this pin goes to "H". And when RSTN bit is "0", PWDAN pin is "0", this pin goes to "H". Output is selected by setting DZFE pin when P/S is "H".
39	MCLK	I	Master Clock Input Pin
40	P/S	I	Parallel/Serial Select Pin "L": Serial control mode, "H": Parallel control mode
41	DIF0	I	Audio Data Interface Format 0 Pin in parallel control mode
	CSN	I	Chip Select Pin in 3-wire serial control mode This pin should be connected to DVDD at I^2C bus control mode
42	DIF1	I	Audio Data Interface Format 1 Pin in parallel control mode
	SCL/CCLK	I	Control Data Clock Pin in serial control mode I2C = "L": CCLK (3-wire Serial), I2C = "H": SCL (I^2C Bus)
43	LOOP0	I	Loopback Mode 0 Pin in parallel control mode Enables digital loop-back from ADC to 4 DACs.
	SDA/CDTI	I/O	Control Data Input Pin in serial control mode I2C = "L": CDTI (3-wire Serial), I2C = "H": SDA (I^2C Bus)
44	TDM0	I	TDM I/F Format Mode Pin (Note 1) "L": Normal mode, "H": TDM mode

Notes: 1. SDOS, SMUTE, DFS0, and TDM0 pins are ORed with register data if P/S = "L".
2. The group 1 and 2 can be selected by DZFM3-0 bits if P/S = "L" and DZFE = "L".
3. This pin becomes OVF pin if OVFE bit is set to "1" at serial control mode.
4. All digital input pins except for pull-down should not be left floating.

ABSOLUTE MAXIMUM RATINGS

(AVSS=DVSS=0V; Note 5)

Parameter		Symbol	min	max	Units
Power Supplies	Analog	AVDD	-0.3	6.0	V
	Digital	DVDD	-0.3	6.0	V
	Output buffer	TVDD	-0.3	6.0	V
	|AVSS-DVSS| (Note 6)	ΔGND	-	0.3	V
Input Current (any pins except for supplies)		IIN	-	±10	mA
Analog Input Voltage		VINA	-0.3	AVDD+0.3	V
Digital Input Voltage					
(Expect LRCK, BICK pins)		VIND1	-0.3	DVDD+0.3	V
(LRCK, BICK pins)		VIND2	-0.3	TVDD+0.3	V
Ambient Temperature (power applied)		Ta	-40	85	°C
Storage Temperature		Tstg	-65	150	°C

Notes: 5. All voltages with respect to ground.
6. AVSS and DVSS must be connected to the same analog ground plane.

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

(AVSS=DVSS=0V; Note 5)

Parameter		Symbol	min	typ	max	Units
Power Supplies	Analog	AVDD	4.5	5.0	5.5	V
(Note 7)	Digital	DVDD	4.5	5.0	5.5	V
	Output buffer	TVDD	2.7	5.0	5.5	V

Notes: 5. All voltages with respect to ground.
7. The power up sequence between AVDD, DVDD and TVDD is not critical.
Do not turn off only the AK4628A under the condition that a surrounding device is powered on and the I2C bus is in use.

WARNING: AKM assumes no responsibility for the usage beyond the conditions in this datasheet.

ANALOG CHARACTERISTICS

(Ta=25°C; AVDD=DVDD=TVDD=5V; AVSS=DVSS=0V; VREFH=AVDD; fs=48kHz; BICK=64fs;
Signal Frequency=1kHz; 24bit Data; Measurement Frequency=20Hz~20kHz at 48kHz, 20Hz~40kHz at fs=96kHz, 20Hz~40kHz at fs=192kHz; unless otherwise specified)

Parameter		min	typ	max	Units
ADC Analog Input Characteristics					
Resolution				24	Bits
S/(N+D) (-0.5dBFS)	fs=48kHz	84	92		dB
	fs=96kHz	-	86		dB
DR (-60dBFS)	fs=48kHz, A-weighted	94	102		dB
	fs=96kHz	88	96		dB
	fs=96kHz, A-weighted	93	102		dB
S/N (Note 8)	fs=48kHz, A-weighted	94	102		dB
	fs=96kHz	88	96		dB
	fs=96kHz, A-weighted	93	102		dB
Interchannel Isolation		90	110		dB
DC Accuracy					
Interchannel Gain Mismatch			0.2	0.3	dB
Gain Drift			20	-	ppm/°C
Input Voltage	AIN=0.62xVREFH	2.90	3.10	3.30	Vpp
Input Resistance	(Note 9)	15	25		kΩ
Power Supply Rejection	(Note 10)		50		dB
DAC Analog Output Characteristics					
Resolution				24	Bits
S/(N+D)	fs=48kHz	80	90		dB
	fs=96kHz	78	88		dB
	fs=192kHz	-	88		dB
DR (-60dBFS)	fs=48kHz, A-weighted	95	106		dB
	fs=96kHz	88	100		dB
	fs=96kHz, A-weighted	94	106		dB
	fs=192kHz	-	100		dB
	fs=192kHz, A-weighted	-	106		dB
S/N (Note 11)	fs=48kHz, A-weighted	95	106		dB
	fs=96kHz	88	100		dB
	fs=96kHz, A-weighted	94	106		dB
	fs=192kHz	-	100		dB
	fs=192kHz, A-weighted	-	106		dB
Interchannel Isolation		90	110		dB
DC Accuracy					
Interchannel Gain Mismatch			0.2	0.5	dB
Gain Drift			20	-	ppm/°C
Output Voltage	AOUT=0.6xVREFH	2.75	3.0	3.25	Vpp
Load Resistance		5			kΩ
Power Supply Rejection	(Note 10)		50		dB

Notes:
8. S/N measured by CCIR-ARM is 98dB(@fs=48kHz).
9. Input resistance is 16kΩ typically at fs=96kHz.
10. PSR is applied to AVDD, DVDD and TVDD with 1kHz, 50mVpp. VREFH pin is held a constant voltage.
11. S/N measured by CCIR-ARM is 102dB(@fs=48kHz).

Parameter			min	typ	max	Units
Power Supplies						
Power Supply Current (AVDD+DVDD+TVDD)						
Normal Operation (PDN = "H")						
AVDD	fs=48kHz, 96kHz			45	67	mA
	fs=192kHz			34	51	mA
DVDD+TVDD	fs=48kHz	(Note 12)		18	27	mA
	fs=96kHz			24	36	mA
	fs=192kHz			27	40	mA
Power-down mode (PDN = "L")		(Note 13)		80	200	μA

Notes: 12. TVDD=0.1mA(typ).
13. In the power-down mode. All digital input pins including clock pins (MCLK, BICK, LRCK) are held DVSS.

FILTER CHARACTERISTICS

(Ta=25°C; AVDD=DVDD=4.5~5.5V; TVDD=2.7~5.5V; fs=48kHz)

Parameter			Symbol	min	typ	max	Units
ADC Digital Filter (Decimation LPF):							
Passband	(Note 14)	±0.1dB	PB	0		18.9	kHz
		-0.2dB		-	20.0	-	kHz
		-3.0dB		-	23.0	-	kHz
Stopband			SB	28			kHz
Passband Ripple			PR			±0.04	dB
Stopband Attenuation			SA	68			dB
Group Delay	(Note 15)		GD		16		1/fs
Group Delay Distortion			ΔGD		0		μs
ADC Digital Filter (HPF):							
Frequency Response	(Note 14)	-3dB	FR		1.0		Hz
		-0.1dB			6.5		Hz
DAC Digital Filter:							
Passband	(Note 14)	-0.1dB	PB	0		21.8	kHz
		-6.0dB		-	24.0	-	kHz
Stopband			SB	26.2			kHz
Passband Ripple			PR			±0.02	dB
Stopband Attenuation			SA	54			dB
Group Delay	(Note 15)		GD		19.2		1/fs
DAC Digital Filter + Analog Filter:							
Frequency Response:	0 ~ 20.0kHz		FR		±0.2		dB
	40.0kHz	(Note 16)	FR		±0.3		dB
	80.0kHz	(Note 16)	FR		±1.0		dB

Notes:

14. The passband and stopband frequencies scale with fs.
    For example, 21.8kHz at –0.1dB is 0.454 x fs.
15. The calculating delay time which occurred by digital filtering. This time is from setting the input of analog signal to setting the 24bit data of both channels to the output register for ADC.
    For DAC, this time is from setting the 20/24bit data of both channels on input register to the output of analog signal.
16. 40.0kHz; fs=96kHz , 80.0kHz; fs=192kHz.

DC CHARACTERISTICS

(Ta=25°C; AVDD=DVDD=4.5~5.5V; TVDD=2.7~5.5V)

Parameter	Symbol	min	typ	max	Units
High-Level Input Voltage	VIH	2.2	-	-	V
Low-Level Input Voltage	VIL	-	-	0.8	V
High-Level Output Voltage					
(SDTO, LRCK, BICK pins: Iout=-100μA)	VOH	TVDD-0.5	-	-	V
(DZF1, DZF2/OVF pins: Iout=-100μA)	VOH	AVDD-0.5	-	-	V
Low-Level Output Voltage					
(SDTO, LRCK, BICK,DZF1, DZF2/OVF pins: Iout= 100μA)	VOL	-	-	0.5	V
(SDA pins: Iout= 3mA)	VOL	-	-	0.4	V
Input Leakage Current (Note 17)	Iin	-	-	±10	μA

Note 17: TST2 pin has an internal pull-down device, nominally 100kohm.

SWITCHING CHARACTERISTICS

(Ta=25°C; AVDD=DVDD=4.5~5.5V; TVDD=2.7~5.5V; C_L=20pF)

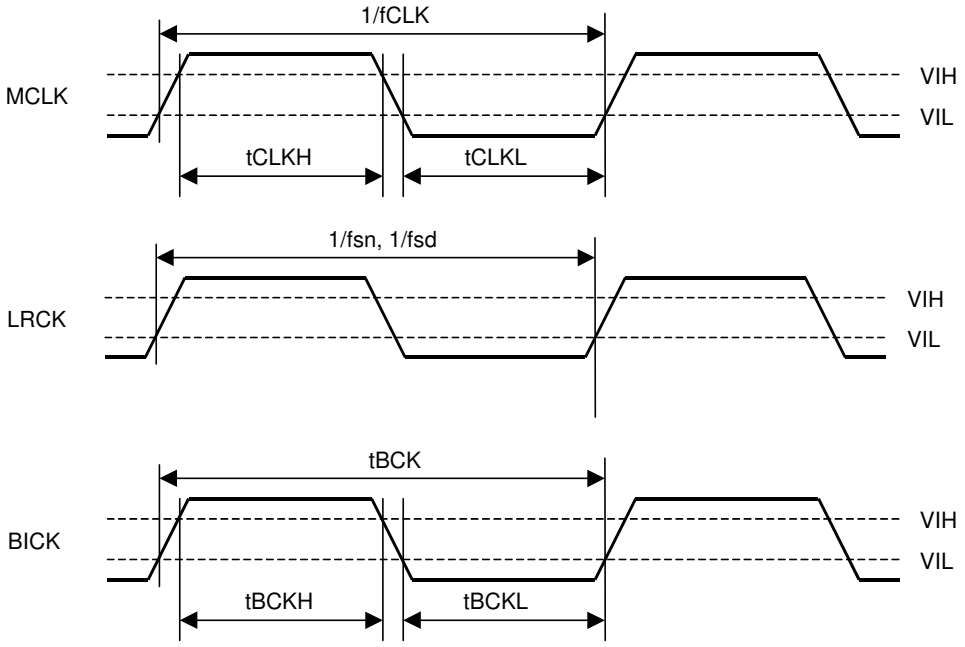
Parameter		Symbol	min	typ	max	Units
Master Clock Timing						
256fsn, 128fsd:		fCLK	8.192		12.288	MHz
Pulse Width Low		tCLKL	27			ns
Pulse Width High		tCLKH	27			ns
384fsn, 192fsd:		fCLK	12.288		18.432	MHz
Pulse Width Low		tCLKL	20			ns
Pulse Width High		tCLKH	20			ns
512fsn, 256fsd:		fCLK	16.384		24.576	MHz
Pulse Width Low		tCLKL	15			ns
Pulse Width High		tCLKH	15			ns
LRCK Timing						
Normal mode (TDM0= "0", TDM1= "0")						
Normal Speed Mode		fsn	32		48	kHz
Double Speed Mode		fsd	64		96	kHz
Quad Speed Mode		fsq	120		192	kHz
Duty Cycle		Duty	45		55	%
TDM256 mode (TDM0= "1", TDM1= "0")						
LRCK frequency		fsn	32		48	kHz
"H" time		tLRH	1/256fs			ns
"L" time		tLRL	1/256fs			ns
TDM128 mode (TDM0= "1", TDM1= "1")						
LRCK frequency		fsn	64		96	kHz
"H" time		tLRH	1/128fs			ns
"L" time		tLRL	1/128fs			ns
Audio Interface Timing						
Normal mode (TDM0= "0", TDM1= "0")						ns
BICK Period		tBCK	81			ns
BICK Pulse Width Low		tBCKL	32			ns
Pulse Width High		tBCKH	32			ns
LRCK Edge to BICK "↑"	(Note 18)	tLRB	20			ns
BICK "↑" to LRCK Edge	(Note 18)	tBLR	20			ns
LRCK to SDTO(MSB)		tLRS			40	ns
BICK "↓" to SDTO		tBSD			40	ns
SDTI1-4,DAUX Hold Time		tSDH	20			ns
SDTI1-4,DAUX Setup Time		tSDS	20			ns
TDM256 mode (TDM0= "1", TDM1= "0")						ns
BICK Period		tBCK	81			ns
BICK Pulse Width Low		tBCKL	32			ns
Pulse Width High		tBCKH	32			ns
LRCK Edge to BICK "↑"	(Note 18)	tLRB	20			ns
BICK "↑" to LRCK Edge	(Note 18)	tBLR	20			ns
BICK "↓" to SDTO		tBSD			20	ns
SDTI1 Hold Time		tSDH	10			ns
SDTI1 Setup Time		tSDS	10			ns
TDM128 mode (TDM0= "1", TDM1= "1")						ns
BICK Period		tBCK	81			ns
BICK Pulse Width Low		tBCKL	32			ns
Pulse Width High		tBCKH	32			ns
LRCK Edge to BICK "↑"	(Note 18)	tLRB	20			ns
BICK "↑" to LRCK Edge	(Note 18)	tBLR	20			ns
BICK "↓" to SDTO		tBSD			20	ns
SDTI1-2 Hold Time		tSDH	10			ns
SDTI1-2 Setup Time		tSDS	10			ns

Notes: 18. BICK rising edge must not occur at the same time as LRCK edge.

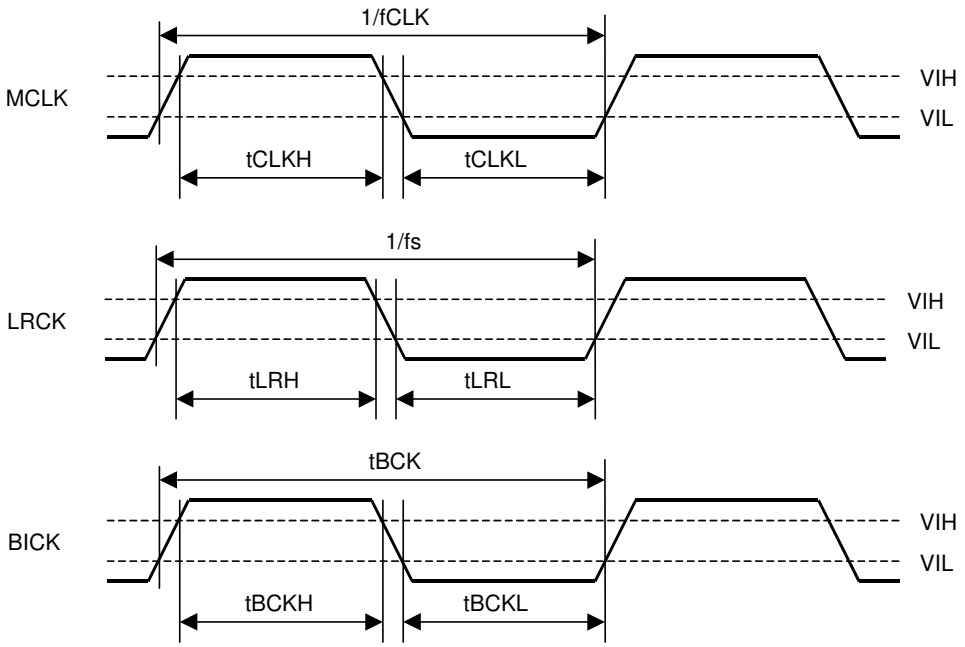
Parameter	Symbol	min	typ	max	Units
Control Interface Timing (3-wire Serial mode):					
CCLK Period	tCCK	200			ns
CCLK Pulse Width Low	tCCKL	80			ns
Pulse Width High	tCCKH	80			ns
CDTI Setup Time	tCDS	40			ns
CDTI Hold Time	tCDH	40			ns
CSN "H" Time	tCSW	150			ns
CSN "↓" to CCLK "↑"	tCSS	50			ns
CCLK "↑" to CSN "↑"	tCSH	50			ns
Control Interface Timing (I^2C Bus mode):					
SCL Clock Frequency	fSCL	-		100	kHz
Bus Free Time Between Transmissions	tBUF	4.7		-	µs
Start Condition Hold Time (prior to first clock pulse)	tHD:STA	4.0		-	µs
Clock Low Time	tLOW	4.7		-	µs
Clock High Time	tHIGH	4.0		-	µs
Setup Time for Repeated Start Condition	tSU:STA	4.7		-	µs
SDA Hold Time from SCL Falling (Note 19)	tHD:DAT	0		-	µs
SDA Setup Time from SCL Rising	tSU:DAT	0.25		-	µs
Rise Time of Both SDA and SCL Lines	tR	-		1.0	µs
Fall Time of Both SDA and SCL Lines	tF	-		0.3	µs
Setup Time for Stop Condition	tSU:STO	4.0		-	µs
Pulse Width of Spike Noise Suppressed by Input Filter	tSP	0		50	ns
Power-down & Reset Timing					
PDN Pulse Width (Note 20)	tPD	150			ns
PDN "↑" to SDTO valid (Note 21)	tPDV		522		1/fs

Notes: 19. Data must be held for sufficient time to bridge the 300 ns transition time of SCL.
20. The AK4628A can be reset by bringing PDN "L" to "H" upon power-up.
21. These cycles are the number of LRCK rising from PDN rising.
22. I^2C-bus is a trademark of NXP B.V.

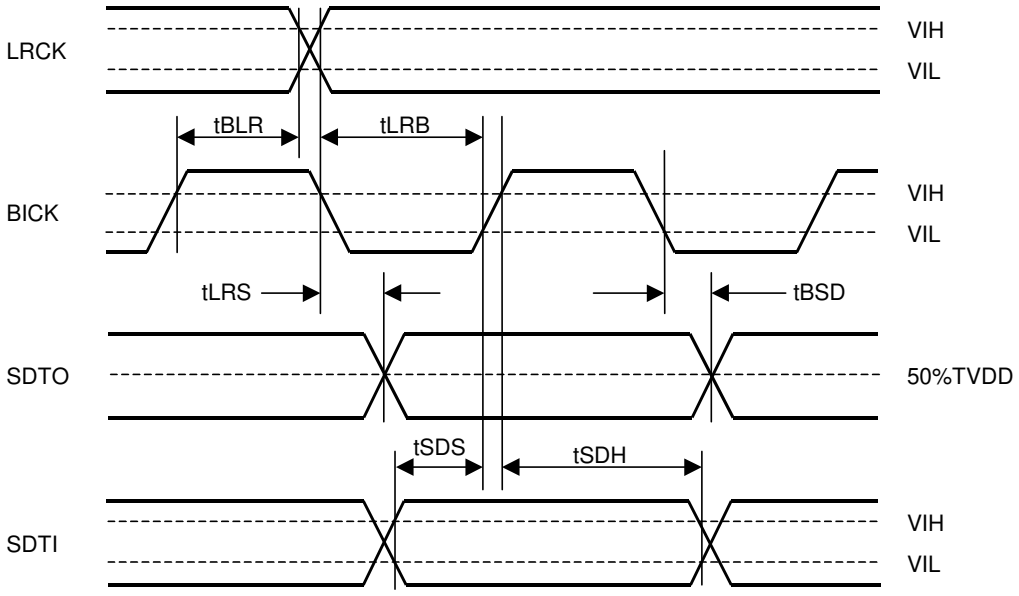
■ **Timing Diagram**



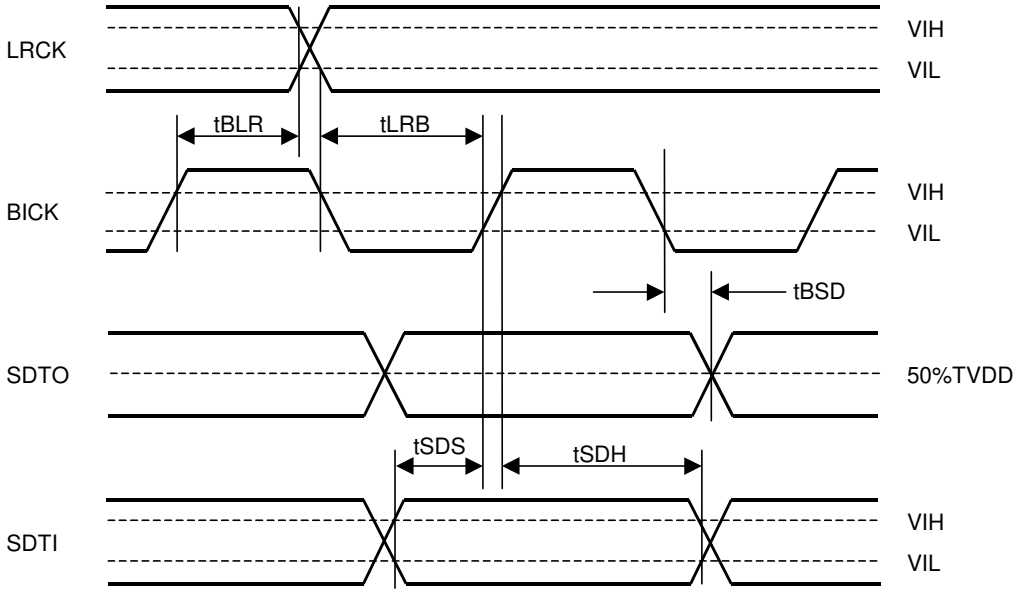
Clock Timing (TDM= "0")



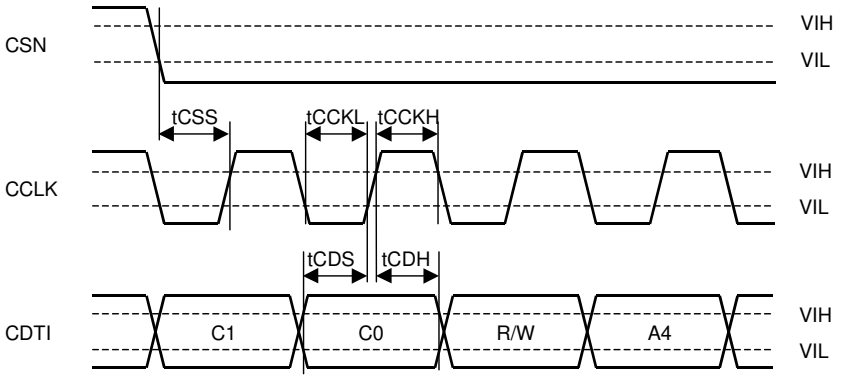
Clock Timing (TDM= "1")



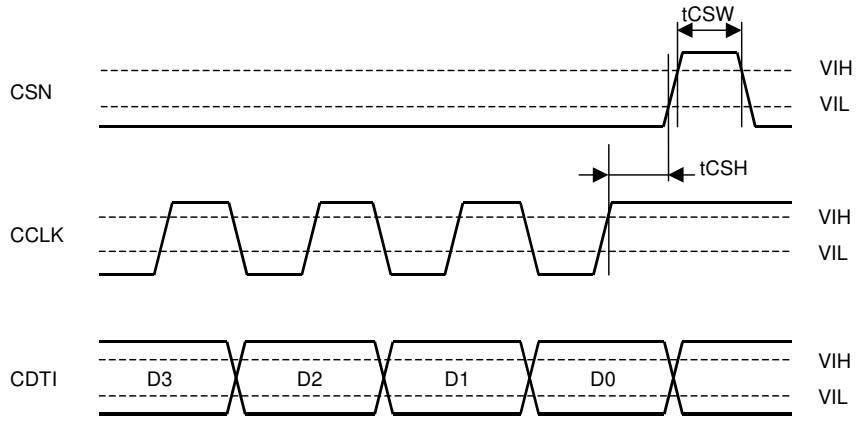
Audio Interface Timing (TDM= "0")



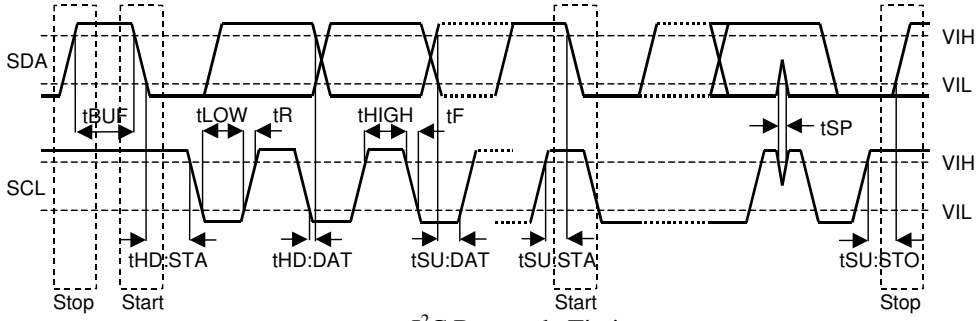
Audio Interface Timing (TDM= "1")



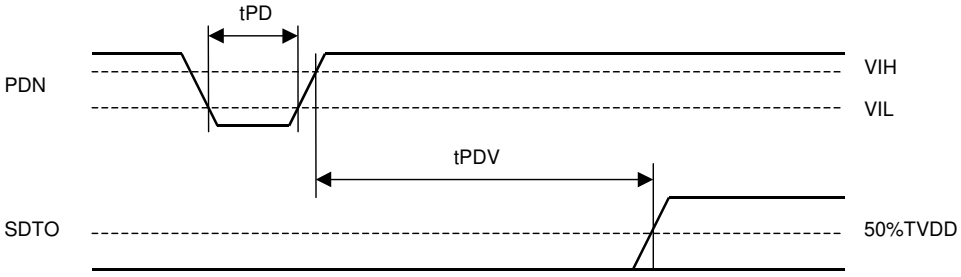
WRITE Command Input Timing (3-wire Serial mode)



WRITE Data Input Timing (3-wire Serial mode)



I^2C Bus mode Timing



Power-down & Reset Timing

OPERATION OVERVIEW

■ System Clock

The external clocks, which are required to operate the AK4628A, are MCLK, LRCK and BICK. MCLK should be synchronized with LRCK but the phase is not critical. There are two methods to set MCLK frequency. In Manual Setting Mode (ACKS = "0": Default), the sampling speed is set by DFS0, DFS1 (Table 1). The frequency of MCLK at each sampling speed is set automatically. (Table 2, 3, 4). In Auto Setting Mode (ACKS = "1"), as MCLK frequency is detected automatically (Table 5), and the internal master clock becomes the appropriate frequency (Table 6), it is not necessary to set DFS.

External clocks (MCLK, BICK) should always be present whenever the AK4628A is in normal operation mode (PDN = "H"). If these clocks are not provided, the AK4628A may draw excess current because the device utilizes dynamic refreshed logic internally. If the external clocks are not present, the AK4628A should be in the power-down mode (PDN = "L") or in the reset mode (RSTN = "0"). After exiting reset at power-up etc., the AK4628A is in the power-down mode until MCLK and LRCK are input.

DFS1	DFS0	Sampling Speed (fs)		
0	0	Normal Speed Mode	32kHz~48kHz	Default
0	1	Double Speed Mode	64kHz~96kHz	
1	0	Quad Speed Mode	120kHz~192kHz	

Table 1. Sampling Speed (Manual Setting Mode)

LRCK	MCLK (MHz)			BICK (MHz)
fs	256fs	384fs	512fs	64fs
32.0kHz	8.1920	12.2880	16.3840	2.0480
44.1kHz	11.2896	16.9344	22.5792	2.8224
48.0kHz	12.2880	18.4320	24.5760	3.0720

Table 2. System Clock Example (Normal Speed Mode @Manual Setting Mode)

LRCK	MCLK (MHz)			BICK (MHz)
fs	128fs	192fs	256fs	64fs
88.2kHz	11.2896	16.9344	22.5792	5.6448
96.0kHz	12.2880	18.4320	24.5760	6.1440

Table 3. System Clock Example (Double Speed Mode @Manual Setting Mode)
(Note: At Double speed mode(DFS1= "0", DFS0 = "1"), 128fs and 192fs are not available for ADC.)

LRCK	MCLK (MHz)			BICK (MHz)
fs	128fs	192fs	256fs	64fs
176.4kHz	22.5792	-	-	11.2896
192.0kHz	24.5760	-	-	12.2880

Table 4. System Clock Example (Quad Speed Mode @Manual Setting Mode)
(Note: At Quad speed mode(DFS1= "1", DFS0 = "0") are not available for ADC.)

MCLK	Sampling Speed
512fs	Normal
256fs	Double
128fs	Quad

Table 5. Sampling Speed (Auto Setting Mode)

LRCK	MCLK (MHz)			Sampling Speed
fs	128fs	256fs	512fs	
32.0kHz	-	-	16.3840	Normal
44.1kHz	-	-	22.5792	
48.0kHz	-	-	24.5760	
88.2kHz	-	22.5792	-	Double
96.0kHz	-	24.5760	-	
176.4kHz	22.5792	-	-	Quad
192.0kHz	24.5760	-	-	

Table 6. System Clock Example (Auto Setting Mode)

■ De-emphasis Filter

The AK4628A includes the digital de-emphasis filter (tc=50/15μs) by IIR filter. De-emphasis filter is not available in Double Speed Mode and Quad Speed Mode. This filter corresponds to three sampling frequencies (32kHz, 44.1kHz, 48kHz). De-emphasis of each DAC can be set individually by register data of DEMA1-C0 (DAC1: DEMA1-0, DAC2: DEMB1-0, DAC3: DEMC1-0, DAC4: DEMD1-0, see “Register Definitions”).

Mode	Sampling Speed	DEM1	DEM0	DEM	
0	Normal Speed	0	0	44.1kHz	
1	Normal Speed	0	1	OFF	Default
2	Normal Speed	1	0	48kHz	
3	Normal Speed	1	1	32kHz	

Table 8. De-emphasis control

■ Digital High Pass Filter

The ADC has a digital high pass filter for DC offset cancel. The cut-off frequency of the HPF is 1.0Hz at fs=48kHz and scales with sampling rate (fs).

■ Audio Serial Interface Format

When TDM= "L", four modes can be selected by the DIF1-0 as shown in Table 8. In all modes the serial data is MSB-first, 2's compliment format. The SDTO is clocked out on the falling edge of BICK and the SDTI/DAUX are latched on the rising edge of BICK.

Figures 1~4 shows the timing at SDOS = "L". In this case, the SDTO outputs the ADC output data. When SDOS = "H", the data input to DAUX is converted to SDTO's format and output from SDTO. Mode 2, 3, 6, 7, 10, 11 in SDTI input formats can be used for 16-20bit data by zeroing the unused LSBs.

Mode	TDM 1	TDM0	DIF1	DIF0	SDTO	SDTI1-4, DAUX	LRCK		BICK		
								I/O		I/O	
0	0	0	0	0	24bit, Left justified	20bit, Right justified	H/L	I	≥ 48fs	I	
1	0	0	0	1	24bit, Left justified	24bit, Right justified	H/L	I	≥ 48fs	I	
2	0	0	1	0	24bit, Left justified	24bit, Left justified	H/L	I	≥ 48fs	I	Default
3	0	0	1	1	24bit, I^2S	24bit, I^2S	L/H	I	≥ 48fs	I	

Table 8. Audio data formats (Normal mode)

The audio serial interface format becomes the TDM mode if TDM0 pin is set to "H". In the TDM256 mode, the serial data of all DAC (eight channels) is input to the SDTI1 pin. The input data to SDTI2-4 pins are ignored. BICK should be fixed to 256fs. "H" time and "L" time of LRCK should be 1/256fs at least. Four modes can be selected by the DIF1-0 as shown in Table 9. In all modes the serial data is MSB-first, 2's compliment format. The SDTO is clocked out on the falling edge of BICK and the SDTI1 are latched on the rising edge of BICK. SDOS and LOOP1-0 should be set to "0" at the TDM mode. TDM128 Mode can be set by TDM1 as show in Table10. In Double Speed Mode, the serial data of DAC (four channels; L1, R1, L2, R2) is input to the SDTI1 pin. Other four data (L3, R3, L4, R4) are input to the SDTI2. TDM0 pin and TDM0 register should be set to "H" if TDM256 Mode is selected. TDM0 pin and TDM0 register, TDM1 register should be set to "H" if Double Speed Mode is selected in TDM128 Mode.

Mode	TDM 1	TDM0	DIF1	DIF0	SDTO	SDTI1	LRCK		BICK	
								I/O		I/O
4	0	1	0	0	24bit, Left justified	20bit, Right justified	↑	I	256fs	I
5	0	1	0	1	24bit, Left justified	24bit, Right justified	↑	I	256fs	I
6	0	1	1	0	24bit, Left justified	24bit, Left justified	↑	I	256fs	I
7	0	1	1	1	24bit, I^2S	24bit, I^2S	↓	I	256fs	I

Table 9. Audio data formats (TDM256 mode)

Mode	TDM 1	TDM0	DIF1	DIF0	SDTO	SDTI1, SDTI2	LRCK		BICK	
								I/O		I/O
8	1	1	0	0	24bit, Left justified	20bit, Right justified	↑	I	128fs	I
9	1	1	0	1	24bit, Left justified	24bit, Right justified	↑	I	128fs	I
10	1	1	1	0	24bit, Left justified	24bit, Left justified	↑	I	128fs	I
11	1	1	1	1	24bit, I^2S	24bit, I^2S	↓	I	128fs	I

Table 10. Audio data formats (TDM128 mode)

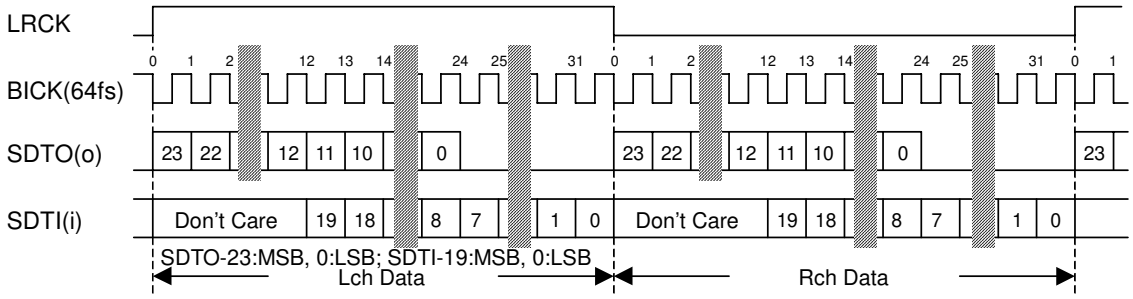


Figure 1. Mode 0 Timing

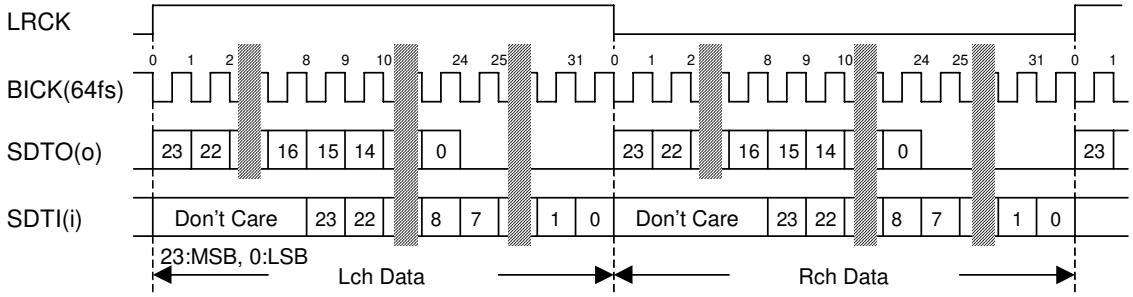


Figure 2. Mode 1 Timing

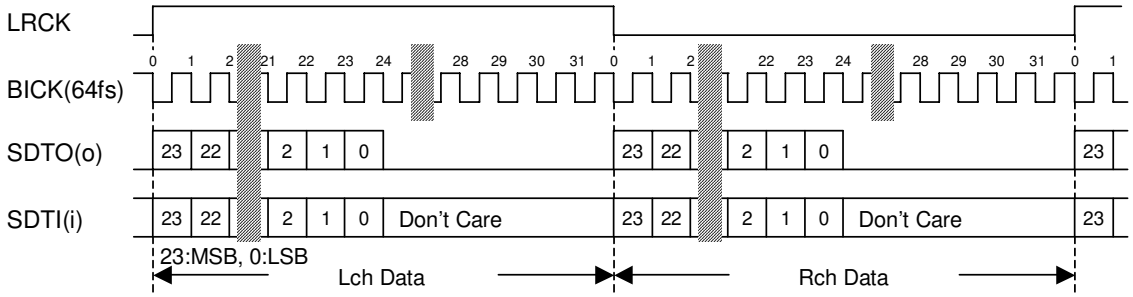


Figure 3. Mode 2 Timing

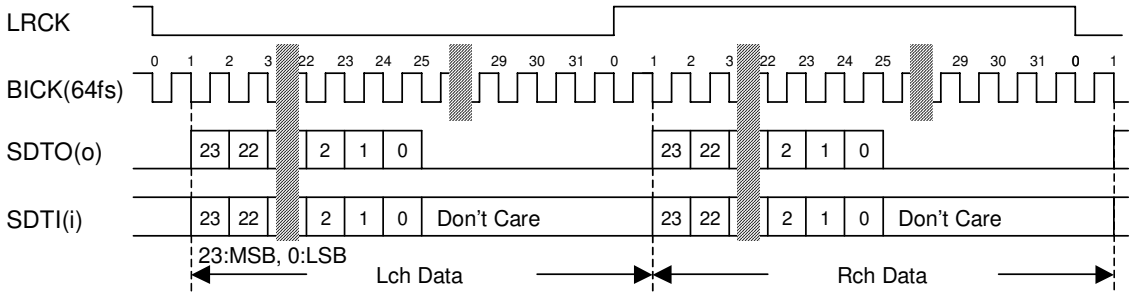


Figure 4. Mode 3 Timing

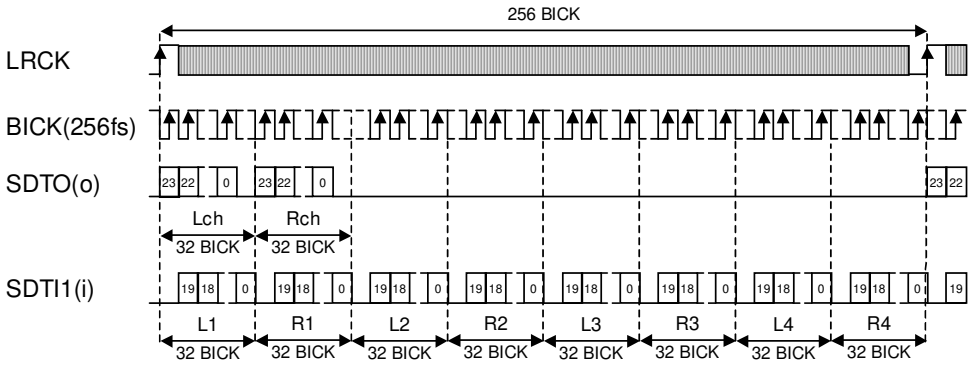


Figure 5. Mode 4 Timing

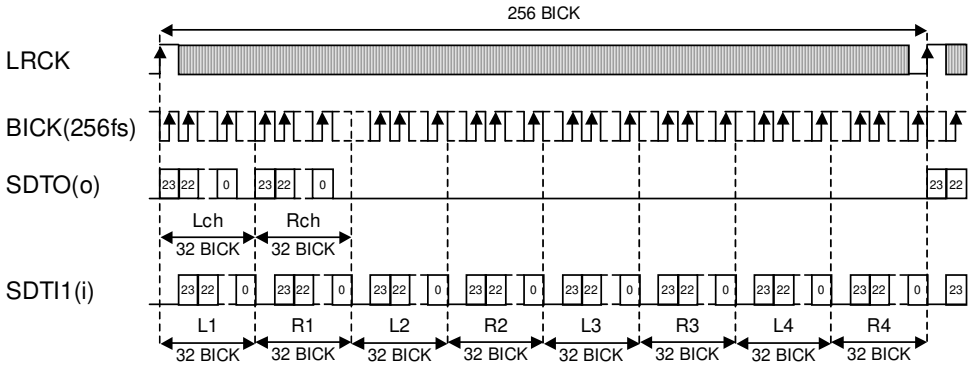


Figure 6. Mode 5 Timing

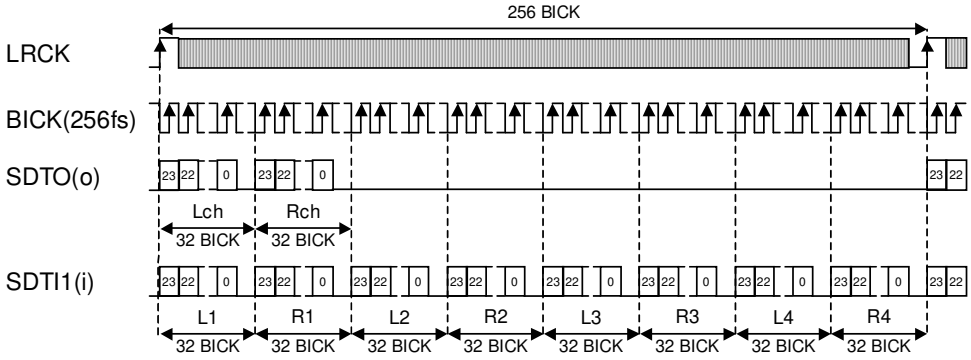


Figure 7. Mode 6 Timing

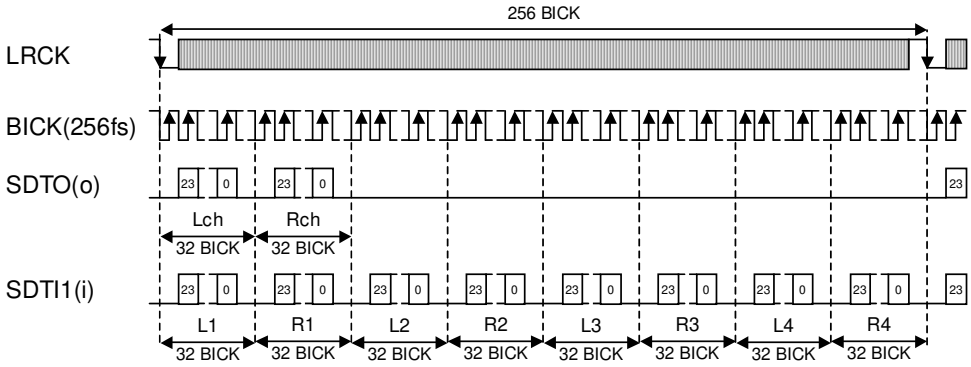


Figure 8. Mode 7 Timing

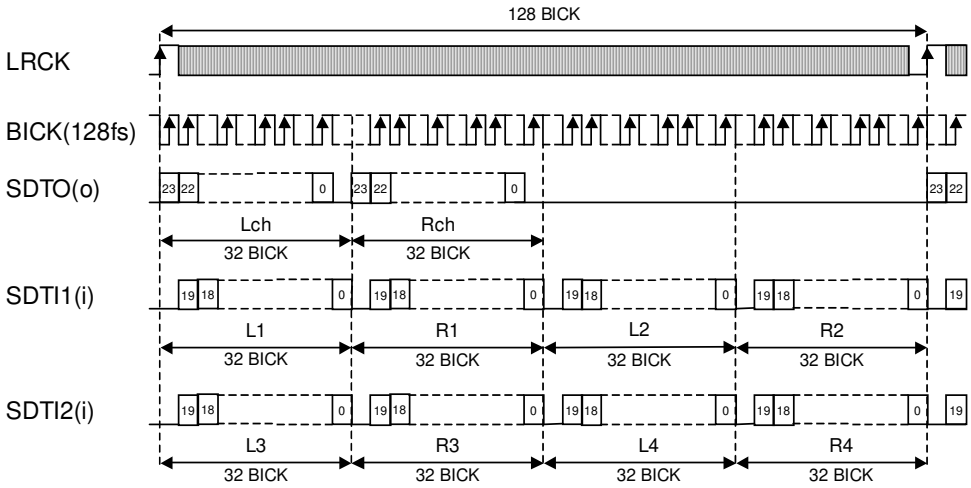


Figure 9. Mode 8 Timing

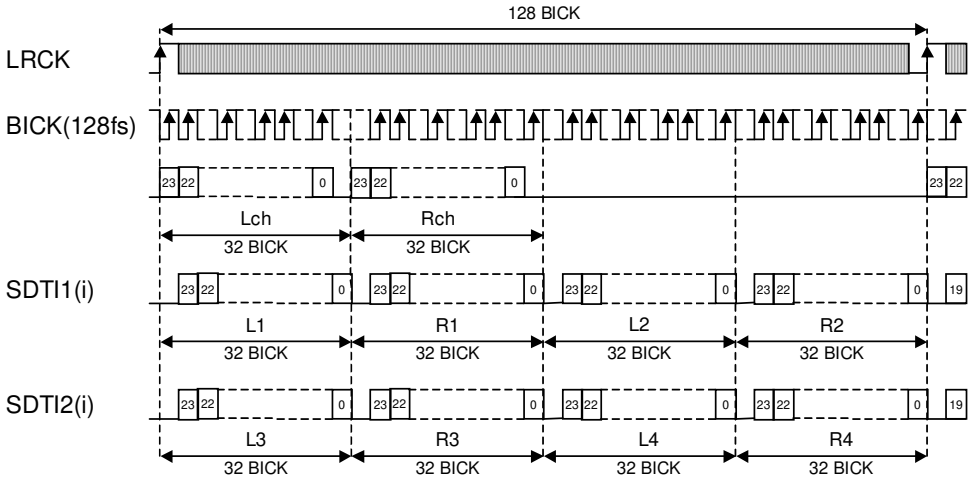


Figure 10. Mode 9 Timing

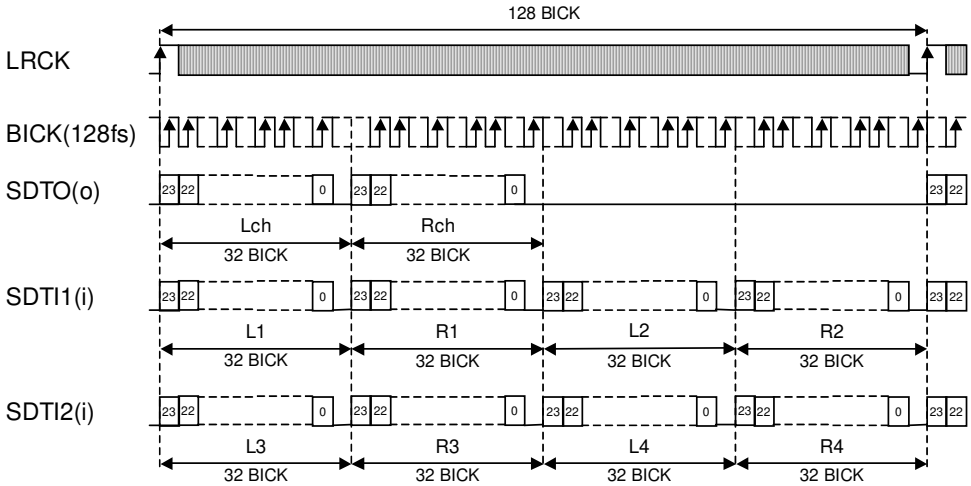


Figure 11. Mode 10 Timing

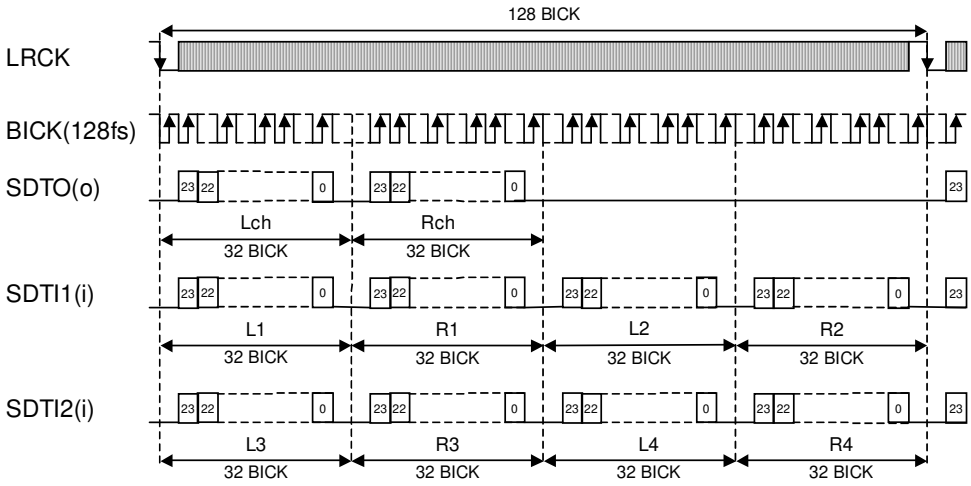


Figure 12. Mode 11 Timing

■ Overflow Detection

The AK4628A has overflow detect function for analog input. Overflow detect function is enable if OVFE bit is set to "1" at serial control mode. OVF pin goes to "H" if analog input of Lch or Rch overflows (more than -0.3dBFS). OVF output for overflowed analog input has the same group delay as ADC (GD = 16/fs = 333μs @fs=48kHz). OVF is "L" for 522/fs (=11.8ms @fs=48kHz) after PDN = "↑", and then overflow detection is enabled.

■ Zero Detection

The AK4628A has two pins for zero detect flag outputs. Channel grouping can be selected by DZFM3-0 bits if P/S = "L" and DZFE = "L" (Table 11). DZF1 pin corresponds to the group 1 channels and DZF2 pin corresponds to the group 2 channels. However DZF2 pin becomes OVF pin if OVFE bit is set to "1". Zero detection mode is set to mode 0 if DZFE= "H" regardless of P/S pin. DZF1 is AND of all eight channels and DZF2 is disabled ("L") at mode 0. Table 12 shows the relation of P/S, DZFE, OVFE and DZF.

When the input data of all channels in the group 1(group 2) are continuously zeros for 8192 LRCK cycles, DZF1(DZF2) pin goes to "H". DZF1(DZF2) pin immediately goes to "L" if input data of any channels in the group 1(group 2) is not zero after going DZF1(DZF2) "H".

Mode	DZFM				AOUT								
	3	2	1	0	L1	R1	L2	R2	L3	R3	L4	R4	
0	0	0	0	0	DZF1	DZF1	DZF1	DZF1	DZF1	DZF1	DZF1	DZF1	
1	0	0	0	1	DZF1	DZF1	DZF1	DZF1	DZF1	DZF2	DZF2	DZF2	
2	0	0	1	0	DZF1	DZF1	DZF1	DZF1	DZF2	DZF2	DZF2	DZF2	
3	0	0	1	1	DZF1	DZF1	DZF1	DZF2	DZF2	DZF2	DZF2	DZF2	
4	0	1	0	0	DZF1	DZF1	DZF2	DZF2	DZF2	DZF2	DZF2	DZF2	
5	0	1	0	1	DZF1	DZF2	DZF2	DZF2	DZF2	DZF2	DZF2	DZF2	
6	0	1	1	0	DZF2	DZF2	DZF2	DZF2	DZF2	DZF2	DZF2	DZF2	
7	0	1	1	1	disable (DZF1=DZF2 = "L")								Default
8	1	0	0	0	DZF1	DZF1	DZF1	DZF1	DZF1	DZF1	DZF1	DZF2	
9	1	0	0	1	DZF1	DZF1	DZF1	DZF1	DZF1	DZF1	DZF2	DZF2	
10	1	0	1	0	disable (DZF1=DZF2 = "L")								
11	1	0	1	1									
12	1	1	0	0									
13	1	1	0	1									
14	1	1	1	0									
15	1	1	1	1									

Table 11. Zero detect control

P/S pin	DZFE pin	OVFE bit	DZF mode	DZF1 pin	DZF2/OVF pin
"H" (parallel mode)	"L"	disable	Mode 7	"L"	"L"
	"H"	disable	Mode 0	AND of 6ch	"L"
"L" (serial mode)	"L"	"0"	Selectable	Selectable	Selectable
		"1"	Selectable	Selectable	OVF output
	"H"	"0"	Mode 0	AND of 6ch	"L"
		"1"	Mode 0	AND of 6ch	OVF output

Table 12. DZF1-2 pins outputs

■ Digital Attenuator

AK4628A has channel-independent digital attenuator (128 levels, 0.5dB step). Attenuation level of each channel can be set by each ATT7-0 bits (Table 13).

ATT7-0	Attenuation Level	
00H	0dB	Default
01H	-0.5dB	
02H	-1.0dB	
:	:	
7DH	-62.5dB	
7EH	-63dB	
7FH	MUTE (-∞)	
	:	
FEH	MUTE (-∞)	
FFH	MUTE (-∞)	

Table 13. Attenuation level of digital attenuator

Transition time between set values of ATT7-0 bits can be selected by ATS1-0 bits (Table 14). Transition between set values is the soft transition. Therefore, the switching noise does not occur in the transition.

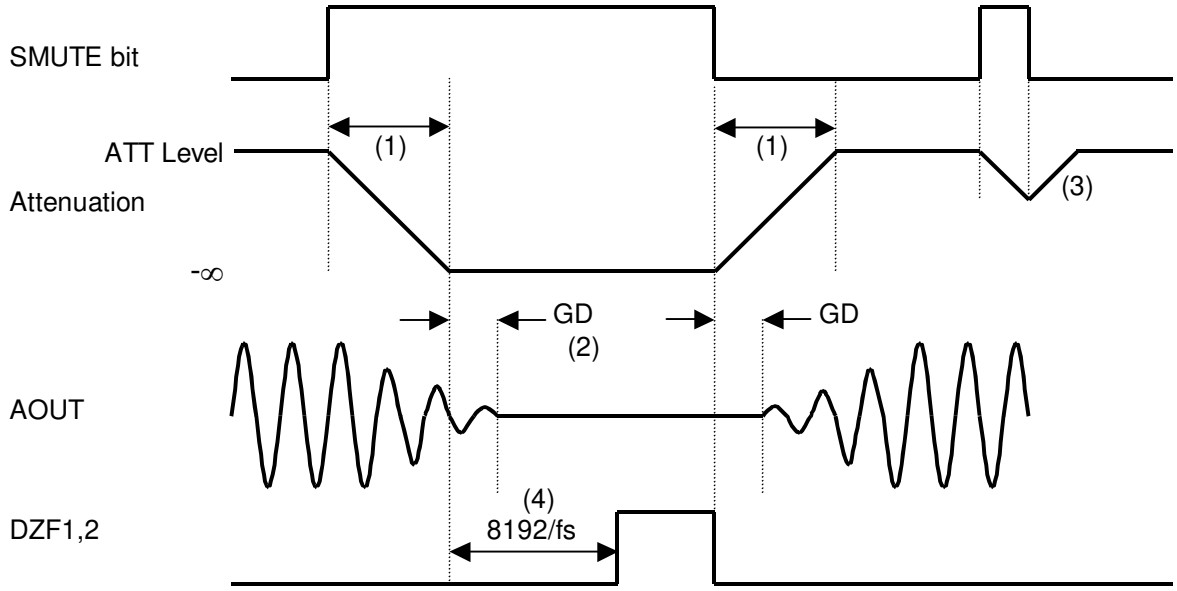
Mode	ATS1	ATS0	ATT speed	
0	0	0	1792/fs	Default
1	0	1	896/fs	
2	1	0	256/fs	
3	1	1	256/fs	

Table 14. Transition time between set values of ATT7-0 bits

The transition between set values is soft transition of 1792 levels in mode 0. It takes 1792/fs (37.3ms@fs=48kHz) from 00H(0dB) to 7FH(MUTE) in mode 0. If PDN pin goes to “L”, the ATTs are initialized to 00H. The ATTs are 00H when RSTN = “0”. When RSTN return to “1”, the ATTs fade to their current value.

■ Soft mute operation

Soft mute operation is performed at digital domain. When the SMUTE pin goes to "H", the output signal is attenuated by -∞ during ATT_DATA×ATT transition time (Table 14) from the current ATT level. When the SMUTE pin is returned to "L", the mute is cancelled and the output attenuation gradually changes to the ATT level during ATT_DATA×ATT transition time. If the soft mute is cancelled before attenuating to -∞ after starting the operation, the attenuation is discontinued and returned to ATT level by the same cycle. The soft mute is effective for changing the signal source without stopping the signal transmission.



Notes:

(1) ATT_DATA×ATT transition time (Table 16). For example, in Normal Speed Mode, this time is 1792LRCK cycles (1792/fs) at ATT_DATA=00H. ATT transition of the soft-mute is from 00H to 7FH

(2) The analog output corresponding to the digital input has a group delay, GD.

(3) If the soft mute is cancelled before attenuating to -∞ after starting the operation, the attenuation is discontinued and returned to ATT level by the same cycle.

(4) When the input data at all the channels of the group are continuously zeros for 8192 LRCK cycles, DZF pin of each channel goes to "H". DZF pin immediately goes to "L" if the input data of either channel of the group are not zero after going DZF "H".

Figure 13. Soft mute and zero detection

■ System Reset

The AK4628A should be reset once by bringing PDN = "L" upon power-up. The AK4628A is powered up and the internal timing starts clocking by LRCK "↑" after exiting reset and power down state by MCLK. The AK4628A is in the power-down mode until MCLK and LRCK are input.