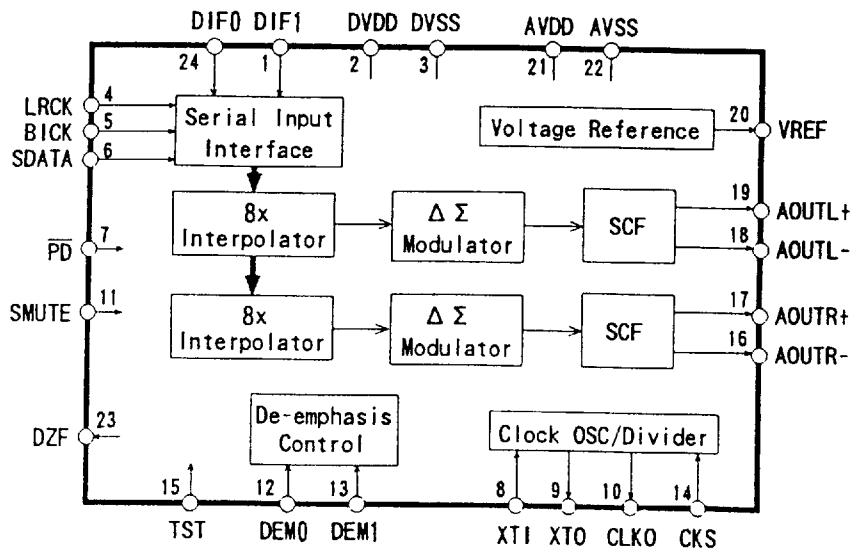


AKM**AK4319****18BIT $\Delta \Sigma$ STEREO DAC****GENERAL DESCRIPTION**

The AK4319 is a high performance 1bit stereo DAC for digital audio systems. A 1bit DAC can achieve monotonicity and low distortion with no adjustment. On chip SCF filter makes the device less affected to the clock jitter and also suppresses the undesirable radio emission noise. The device equips differentially configured output pins, but either of the pins can be used as single-end. The AK4319 achieves lower Out-band noise characteristic (than AK4318) and it is suitable for BS/CS tuner and other digital audio applications.

FEATURES

- ☐ High Performance Stereo 1bit DAC
 - On chip $8 \times$ Interpolation Filter
 - 4th Order $\Delta \Sigma$ DAC
 - On chip Analog Post Filter(SCF)
 - Differential outputs(Single-end use is available)
 - 256/384fs Master Clock available
 - Digital de-emphasis
 - for 32, 44.1, 48kHz sampling
 - Soft mute
 - High Tolerance to Clock Jitter
 - Low Out-band Noise
- ☐ THD+N: -90dB
- ☐ DR: 96dB
- ☐ 24pin SSOP Package



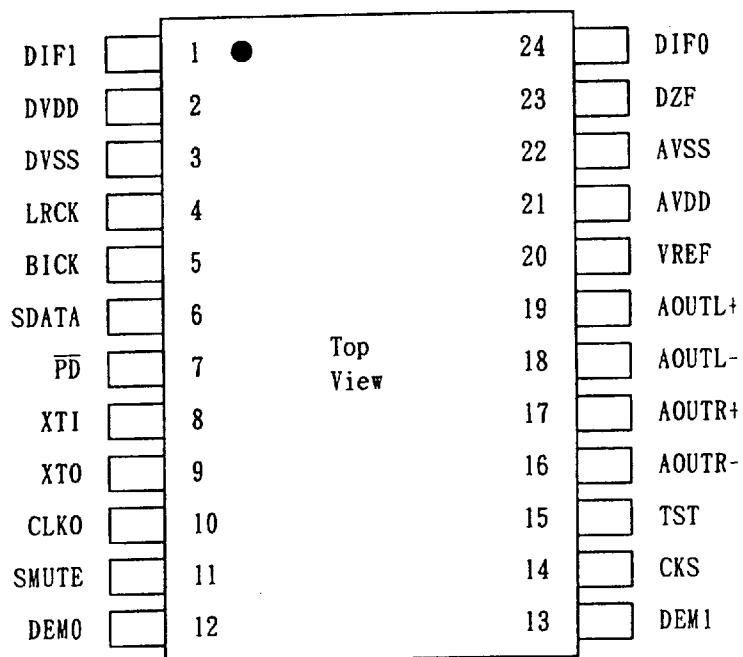
■ Ordering Guide

AK4319-VM
AKD4319

-10 ~ 70 °C
Evaluation Board

24pin SSOP

■ Pin Layout



PIN/FUNCTION			
No.	Pin Name	I/O	Function
2 4	D I F 0	I	Digital Input Format Pins (Pull-down pin)
1	D I F 1		These pins select one of four input modes.
2	D V D D	—	Digital Power Supply Pin, +5V
3	D V S S	—	Digital Ground Pin
4	L R C K	I	L/R Clock Pin This input determines which channel is being input.
5	B I C K	I	Serial Data Clock Pin This clock is used to latch SDATA.
6	S D A T A	I	Serial Data Input Pin 2's complement, MSB-first configuration.
7	P D	I	Power-down Pin Bringing $\overline{PD}$ Pin Low puts the device into power-down mode. Upon returning High, the device initiates internal reset. This input must be brought to Low once to reset after applying power to the device.
8	X T I	I	Master Clock Input Pin A crystal can be connected between this pin and XT0, or an external clock can be input on XTI directly. The frequency of 256fs or 384fs is selected by CKS Pin.
9	X T O	O	Crystal Oscillator Output Pin When an external clock is input to XTI, this pin should be left open.
1 0	C L K O	O	Clock Output pin The inverted X T I clock is output.
1 1	S M U T E	I	Soft Mute Pin (Pull-down pin) "H" initiates the mute cycle and "L" releases it.
1 2	D E M 0	I	De-emphasis Mode Pins
1 3	D E M 1		Major sampling rates(32k, 44.1k, 48k) are supported.
1 4	C K S	I	Master Clock Select Pin (Pull-down pin) "L": CLK=256fs, "H": CLK=384fs
1 5	T S T	I	Test Pin (Pull-down pin) Left open or tied to GND.
1 6	A O U T R -	O	Rch analog negative output pin
1 7	A O U T R +	O	Rch analog positive output pin
1 8	A O U T L -	O	Lch analog negative output pin
1 9	A O U T L +	O	Lch analog positive output pin
2 0	V R E F	O	Voltage Reference Output pin 2.95V (respects to GND) Must be connected to GND through a 0.1uF ceramic cap. along with a 10uF electrolytic capacitor.
2 1	A V D D	—	Analog Power Supply Pin, +5V
2 2	A V S S	—	Analog Ground Pin
2 3	D Z F	O	Zero Input Detect Pin After 8192 LRCK cycles of sequential zero data are input on both L/R channels, this pin goes to "H".

ABSOLUTE MAXIMUM RATINGS

(AVSS,DVSS=0V; Note 1)

Parameter	Symbol	min	max	Units
Power Supplies: Analog	AVDD	-0.3	6.0	V
	DVDD	-0.3	AVDD	V
Input Current, Any Pin Except Supplies	IIN	-	± 10	mA
Input Voltage	VIND	-0.3	AVDD+0.3	V
Ambient Operating Temperature	Ta	-10	70	°C
Storage Temperature	Tstg	-65	150	°C

Note: 1. All voltages with respect to ground.

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 1)

Parameter	Symbol	min	typ	max	Units
Power Supplies: Analog	AVDD	4.5	5.0	5.5	V
	DVDD	4.5	5.0	AVDD	V

Notes:1. All voltages with respect to ground.

* Specifications are subject to change without notice.

* AKM assumes no responsibility for the usage beyond the conditions in this data sheet.

ANALOG CHARACTERISTICS

(Ta=25 °C ; AVDD,DVDD=5.0V; fs=48kHz; Signal Frequency=1kHz; 18bit Input Data;
Differential Outputs; Measurement Bandwidth=10Hz ~ 20kHz; unless otherwise specified)

Parameter	min	typ	max	Units
Dynamic Characteristics				
THD+N (0dB Output) (Note 2)		-90	-84	dB
Dynamic Range (-60dB Output) (Note 3)	88	96		dB
S/N (Note 4)	88	96		dB
Interchannel Isolation	90	100		dB
Interchannel Gain Mismatch		0.1	0.3	dB
DC Accuracy				
Gain Drift		100		ppm/°C
Output Voltage Range (Note 5)	±2.55	±2.76	±2.97	V
Power Supplies				
Power Supply Current				
Normal Operation (PD="H") AVDD		12	18	mA
DVDD		7	11	mA
Power-Down-Mode (PD="L") (All input pins = "L") AVDD+DVDD		10	50	uA
Power Dissipation (AVDD+DVDD)				
Normal Operation		95	145	mW
Power-Down-Mode		0.1		mW
Power Supply Rejection		40		dB

Notes:2. Inverse of S/(N+D).

3. A-weighted. (IEC publ.651)

4. A-weighted. Digital input all zeros.

5. Summation of the differential outputs, (AOUT+)-(AOUT-). RL ≥ 5k Ω

FILTER CHARACTERISTICS

(Ta=25 °C ; AVDD,DVDD=5.0V ± 10%; fs=48kHz; DEM0="1",DEM1="0")

Parameter	Symbol	min	typ	max	Units
Digital Filter					
Passband ±0.06dB (Note 6)	PB	0		21.8	kHz
-6.0dB		0		24.0	kHz
Stopband (Note 6)	SB	26.2			kHz
Passband Ripple	PR			±0.06	dB
Stopband Attenuation	SA	43			dB
Group Delay (Note 7)	GD		14.7		1/fs
2nd Order SCF					
Frequency Response 20kHz			-0.04		dB
24kHz			-0.32		dB
48kHz			-6.0		dB

Note: 6.The passband and stopband frequencies scale with fs.

For example, PB=0.4535*fs(@-0.06dB), SB=0.546*fs.

7.The processing delay time which is consumed in digital filter. This time is measured from setting the 18bit data on the input register to the output of the corresponding analog signal.

DIGITAL CHARACTERISTICS

(Ta=25 °C ; AVDD,DVDD=5.0V ± 10%)

Parameter	Symbol	min	typ	max	Units
High-Level Input Voltage	V _{IH}	2.4	-	-	V
Low-Level Input Voltage	V _{IL}	-	-	0.6	V
XTI input Voltage when it is AC coupled(Note8)	V _{AC}	1	-	-	V _{p-p}
High-Level Output Voltage I _{out} =-100uA	V _{OH}	DVDD-0.5	-	-	V
Low-Level Output Voltage I _{out} =100uA (Note 9)	V _{OL}	-	-	0.5	V
Input Leakage Current (Note 10)	I _{in}	-	-	±10	uA

Note:8.When Not AC coupled, XTI input Voltage is CMOS level.(V_{IH}:70%DVDD,V_{IL}:30%DVDD)

9.Excludes XTO pin.

10.Excludes right listed pins. TST,ZMUTE,SMUTE,DIF0,DIF1,CKS pins are pulled-down internally. (Typ. 90k Ω)

SWITCHING CHARACTERISTICS

(Ta=25 °C ; AVDD,DVDD=5.0V ± 10%; C_L = 20pF)

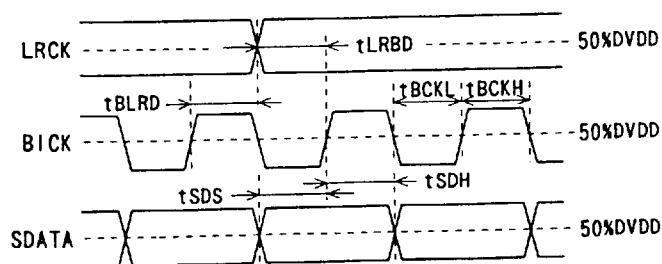
Parameter	Symbol	min	typ	max	Unit
Control Clock Frequency					
Crystal Resonator 256fs:	f _{CLK}	7.10	12.288	13.9	MHz
384fs:	f _{CLK}	10.70	18.432	20.7	MHz
External Clock 256fs:	f _{CLK}	2.56	12.288	13.9	MHz
Pulse Width Low	t _{CLKL}	28			ns
Pulse Width High	t _{CLKH}	28			ns
384fs:	f _{CLK}	3.84	18.432	20.7	MHz
Pulse Width Low	t _{CLKL}	20			ns
Pulse Width High	t _{CLKH}	20			ns
LRCK Frequency	f _s	10	48	54	kHz
Serial Interface Timing (Note 11)					
BICK Period	t _{BCK}	290			ns
BICK Pulse Width Low	t _{BCKL}	100			ns
Pulse Width High	t _{BCKH}	100			ns
BICK rising to LRCK edge (Note 12)	t _{BLRD}	40			ns
LRCK Edge to BICK rising (Note 12)	t _{LRBD}	40			ns
SDATA Hold Time	t _{SDH}	40			ns
SDATA Setup Time	t _{SDS}	40			ns
Reset Timing					
PD Pulse Width (Note 13)	t _{RST}	100			ns

Notes:11. Refer to the operating overview section "Serial Data Interface".

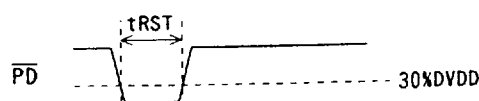
12. Specified L/R edges not to coincide with the rising edges of BICK.

13. PD could be left "L" upon power up.

■ Timing Diagram



Data Input Timing



Reset Timing

OPERATION OVERVIEW

■ System Clock Input

The external clocks of XTI(256fs/384fs), LRCK(fs), BICK(32fs ~) are required to operate the AK4319. The master clock(XTI) should be synchronized with LRCK but there is no need to adjust their phases each other. The XTI is used in the digital interpolation filter and the delta-sigma modulator. The master clock could be generated connecting a crystal oscillator between XTI and XTO, or could be fed to XTI externally with XTO pin left open. XT I could accept not only CMOS compatible clock but also DC isolated 1Vp-p sinusoidal wave. Internal clock is output via CLK0 pin.

The frequency of XTI is determined by the sampling rate fs(LRCK) and the setting of the Clock Select, CKS pin. Setting CKS "L" selects an XTI frequency of 256fs while setting CKS "H" selects 384fs. When the 384fs is selected, the internal masterclock becomes 256fs(=384fs*2/3). Table 1. shows the XTI clock frequency which corresponds to typical audio sampling rate.

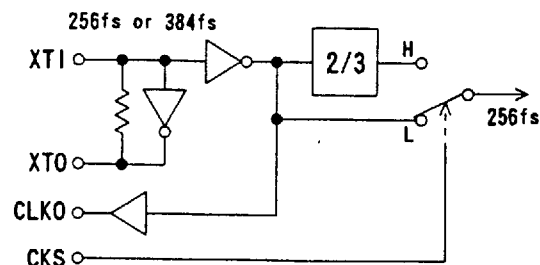


Figure 1. Internal Clock Circuit

LRCK (fs) (kHz)	CKS	XTI (MHz)
32.0	L	8.1920
	H	12.2880
44.1	L	11.2896
	H	16.9344
48.0	L	12.2880
	H	18.4320

Table 1. Example of System Clock

As the AK4319 equipses the phase error detection circuit, the AK4319 is reset by itself automatically when the synchronization between internal timing and external LRCK is missed in case of changing the clock frequencies. Therefore, the reset is not required except only upon power-up. Please refer to the "System Reset" section.

When the device is working ($\overline{\text{PD}}$ ="H"), master clock (CLK) should be presented on the device. The missing of the clock may cause to over currents in the dynamic logic in the device. The device should be put into power-down, before stopping the master clock(CLK).

■ Serial Data Interface

The AK4319 interfaces with external system by using SDATA, BICK and LRCK pins. Four types of data format (Table 2.) are available and one of them is selected by setting DIF0 and DIF1. Format 0 is compatible with existing 16-bit DACs and digital filters. Format1 is an 18-bit version of format0. Format2 is similar to AKM ADCs (AK5339/40/45/89/90) and many DSP serial ports. Format3 is compatible with the I²S serial data protocol. In formats 2 and 3, 16-bit data followed by two zeros also could be input. In all modes, the serial data is MSB-first and 2's complement format.

DIF1	DIF0	Mode	Fig
0	0	0: LSB Justified, 16bit	2
0	1	1: LSB Justified, 18bit	2
1	0	2: MSB Justified, 16-18bit	3
1	1	3: I ² S Compatible	4

Table 2. Digital Input Formats

*Mode 0 or 3 should be selected for the 32fs BICK.

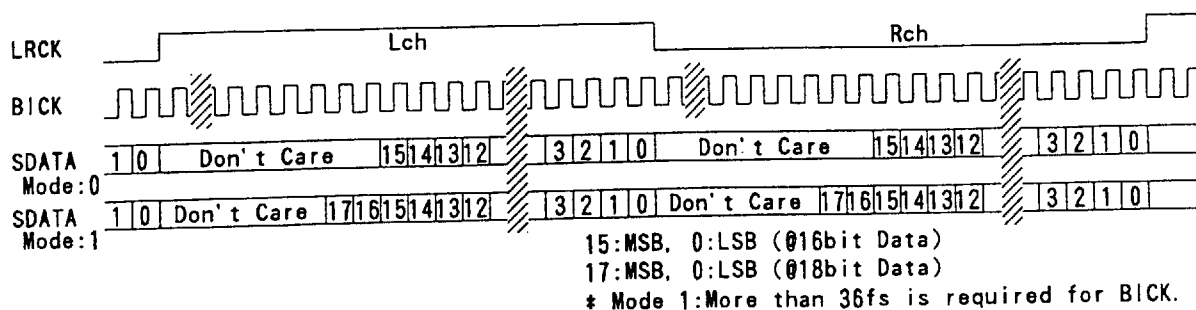


Figure 2. Digital Input Formats 0 & 1

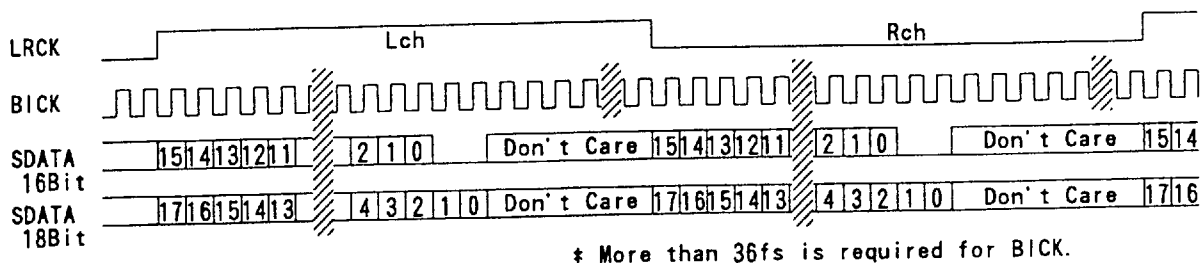


Figure 3. Digital Input Formats 2

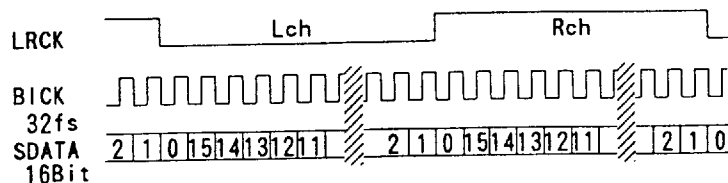
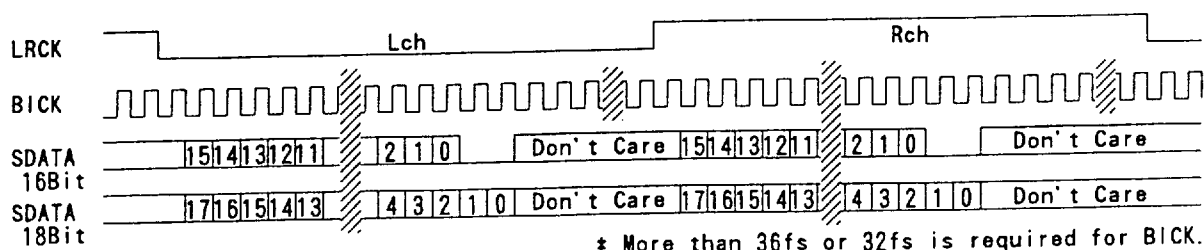


Figure 4. Digital Input Formats 3

■ De-emphasis filter

The AK4319 includes the digital de-emphasis filter ($t_c=50/15\mu s$) based on IIR. The filter is applied to three sampling frequencies (32kHz, 44.1kHz, 48kHz).

The de-emphasis filter selected by DEM0 and DEM1 is enabled for a corresponding input audiodata. The de-emphasis is disabled at DEM0="1" and DEM1="0".

DEM1	DEM0	Mode
0	0	44.1kHz
0	1	OFF
1	0	48kHz
1	1	32kHz

Table 1. De-emphasis filter control

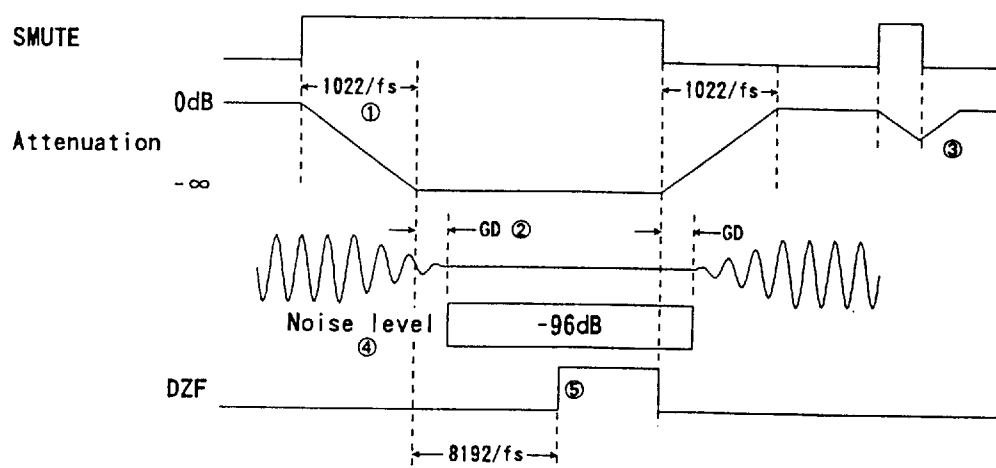
■ Zero detection & Zero mute operation

After the input data at both channels are continuously zeros for 8192 LRCK cycles or when the muting period exceeds 8192+1022 LRCK cycles, DZF goes to "H". DZF goes "L" immediately after non zero data is input or soft mute is released.

■ Soft mute operation

When SMUTE goes "H", the output signal is attenuated into $-\infty$ during 1022 LRCK cycles. SMUTE is returned to "L", the mute condition is released and the output attenuation gradually changes to 0dB during 1022 LRCK cycles. If the soft mute is released within 1022 LRCK cycles, the attenuation is recovered to 0dB with same gradient and cycles.

The soft mute function is effective when changing the signal source without stopping the signal transmission.



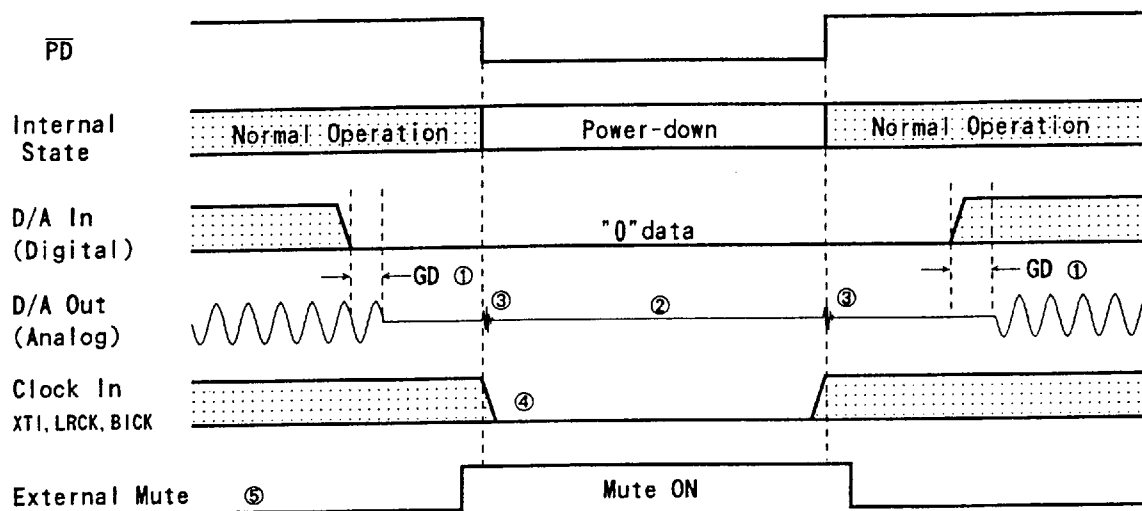
Notes:

- ① The output signal is attenuated into $-\infty$ during 1022 LRCK cycles(1022/fs).
- ② Analog output corresponding to digital input have the group delay(GD).
- ③ If the soft mute is released within 1022 LRCK cycles, the attenuation is recovered to 0dB.
- ④ The noise energy of the 20kHz bandwidth on analog outputs is -96dB when muted.
- ⑤ When the input data at both channels are continuously zeros for 8192 LRCK cycles, DZF goes to "H". DZF goes "L" immediately after non-zero data is input.

Figure 5. Soft mute and zero detection

■ Power-Down

The AK4319 is put in the power-down mode by bringing PD pin "L" and the analog outputs are set to floating(Hi-Z) condition. Figure 6 shows an example of the system timing at the power-down and power-up.



- ① Analog output has the group delay(GD).
- ② When power-down is initiated, analog outputs are set into Hi-Z. Outputs noise level is about -110dB.
- ③ Some -50dB of click noise occurs at the transition (" ↓ ↑ ") of PD pin.
- ④ When the master clock is stopped, the AK4319 should have been in the power-down mode.
- ⑤ If the click noise (③) is a problem, an external mute circuit which generates above timing (⑤) is needed. Please refer to Figure 7.

Figure 6. Power-down/up timing

■ System Reset

The AK4319 should be reset once by bringing PD "L" upon power-up. The internal timing starts clocking after the first " ↑ " of LRCK upon exiting reset.

■ External mute circuit

Some click noise may occur at the transition ("↑ ↓") of PD signal. The click noise of PD signal can be avoided by controlling the external mute circuit using the signal like ⑤ in Figure 6. The S/N of -110dB could be achieved by muting the analog outputs using DZF signal. The external mute circuit example is shown in Figure 7.

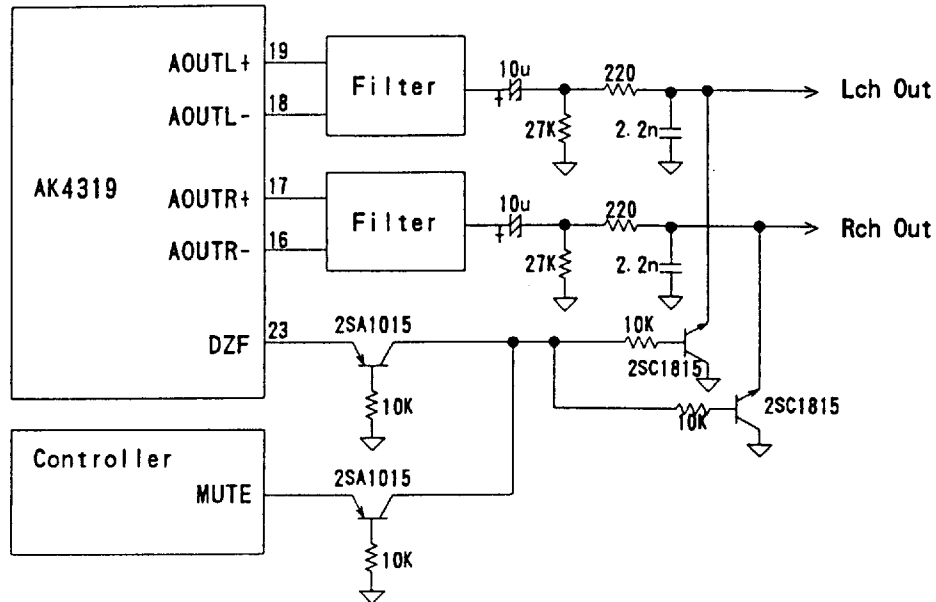


Figure 7. External mute circuit example

SYSTEM DESIGN

Figure 8 shows the system connection diagram. An example of external analog filter is shown in Figure 9. An evaluation board[AKD4318] is available in order to allow an easy study on the layout of a surrounding circuit.

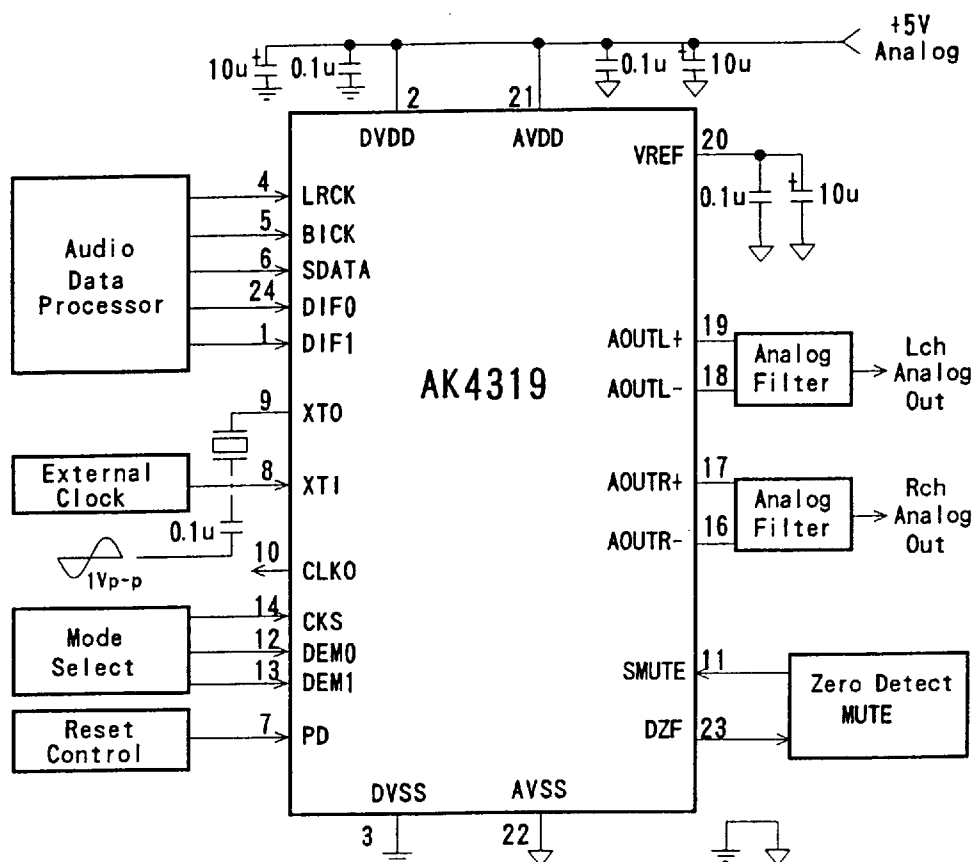


Figure 8. Typical System Connection

■ System design consideration

1. Grounding and Power Supply Decoupling

To minimize the coupling of the digital originated noise, decoupling capacitors should be connected to AVDD and DVDD pins, respectively. Decoupling capacitors should be placed as near to the AK4319 device as possible.

2. On-chip voltage reference

The on-chip voltage reference is output on the VREF pin. An electrolytic capacitor smaller than 10uF in parallel with a 0.1uF ceramic capacitor attached to this pin eliminates the effects of high frequency noise. Especially, the ceramic capacitor should be connected to VREF pin within a few mm as near as possible. No load current may be taken from the VREF output pin. All signals, especially clocks, should be kept away from the VREF pin in order to avoid unwanted coupling into the AK4319.

3. Output analog filter circuit

The analog signals are output from the differential output pins of each channel, therefore they are summed externally. The analog outputs are the differential voltage, $\Delta VAOUT = (AOUT+) - (AOUT-)$ between AOUT+ and AOUT-. The bias voltage ($V_{op}/2$) for this summing circuit is supplied externally. The output signal range is $\pm 1.38V$ ($0.975V_{rms}$, typ) centered at an internal common voltage ($AVDD/2$). If the summing gain is 1, the output range is $\pm 2.76V$ ($1.95V_{rms}$, typ). The input data format is 2's complement. The output voltage ($\Delta VAOUT$) is a positive full scale for 7FFFH (@16bit) and a negative full scale for 8000H (@16bit). The ideal $\Delta VAOUT$ is 0V for 0000H (@16bit). DC offsets on analog outputs are eliminated by AC coupling the signals since DAC outputs have a few mV offsets. The noise generated by the delta-sigma modulator beyond the audio passband is sufficiently attenuated by the high speed over-sampling and by the on-chip SCF filter. However, as the outband noise moves into the audible band at low sampling rate, careful attention is required. On figure 9, the differential outputs of AK4319 are summed by the 1st-order LPF and the $1.95V_{rms}$ output signal range is acquired.

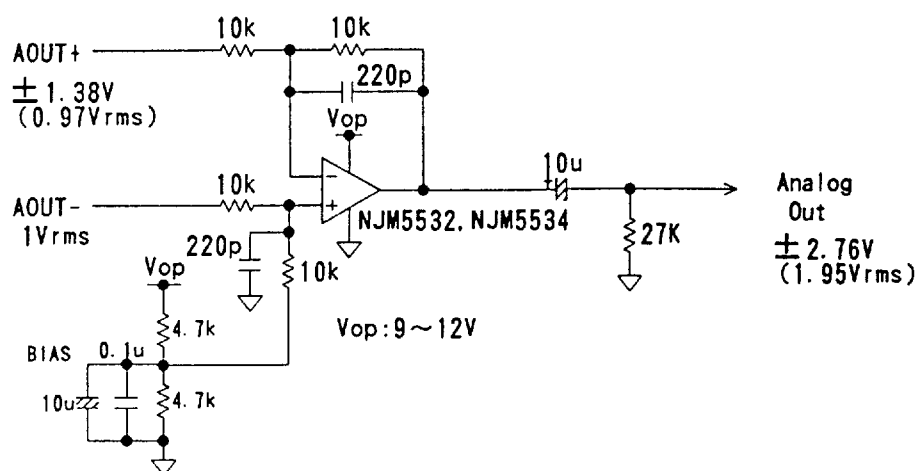


Figure 9. Differential 1st-order LPF example

4. Single-end usage

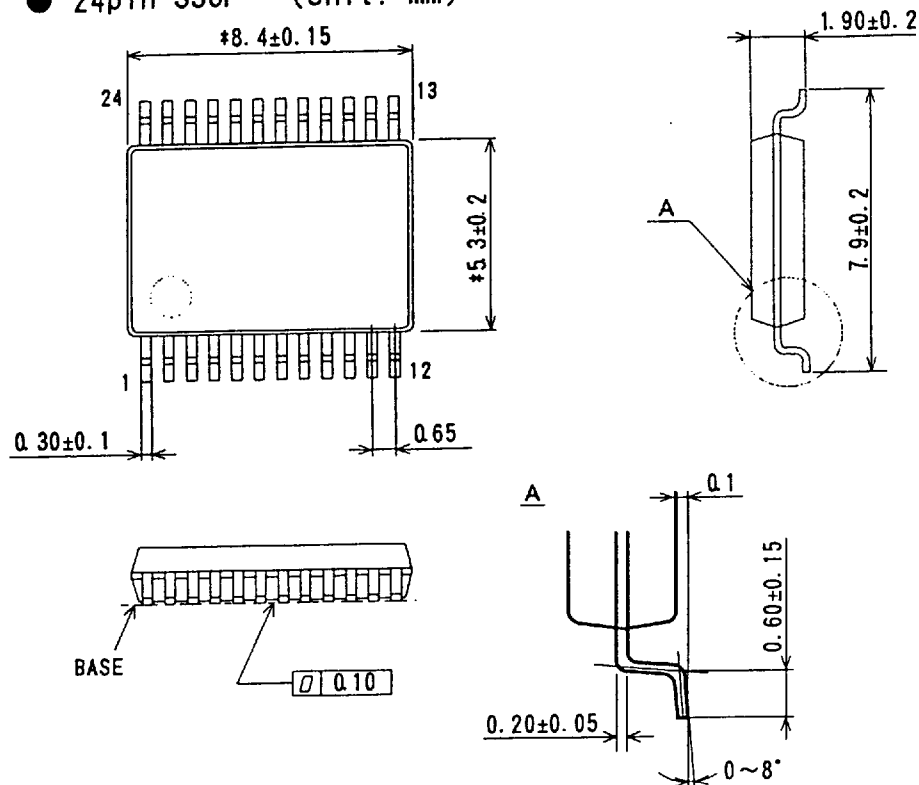
The load impedance for the output pin should be higher than $10k\ \Omega$, and the capacitive load should be less than $20pF$. Hence the output pin can not drive such as line out directly. The output pin which is not used could be left open. When the device is used as a single-end configuration, the analog characteristics (such as THD+N, DR, S/N) may degrade by $1.5 \sim 2dB$. (Experienced on our evaluation board, AKD4319)

For single-end operation, The circuit example of Fig.9 could be modified as follow: DC isolation capacitance is added between AOUT+ and $10k\ \Omega$. Then the $10k\ \Omega$ resistor which is connected to AOUT- is removed. In this case, the output level becomes $0.97V_{rms}$.

With a single-end configuration, the device interfaces directly to external circuit such as volume AMP, which simplifies the circuit.

PACKAGE

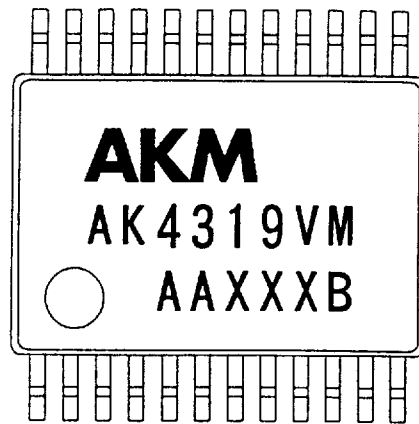
● 24pin SSOP (Unit: mm)



■ Package & Lead frame material

Package molding compound : Epoxy(Black)
 Lead frame material : Cu
 Lead frame surface treatment: Solder plate

MARKING



Contents of A A X X X B

A A : Lot# (alphabet)

X X X B : Date Code (X : numbers, B : alphabet)