

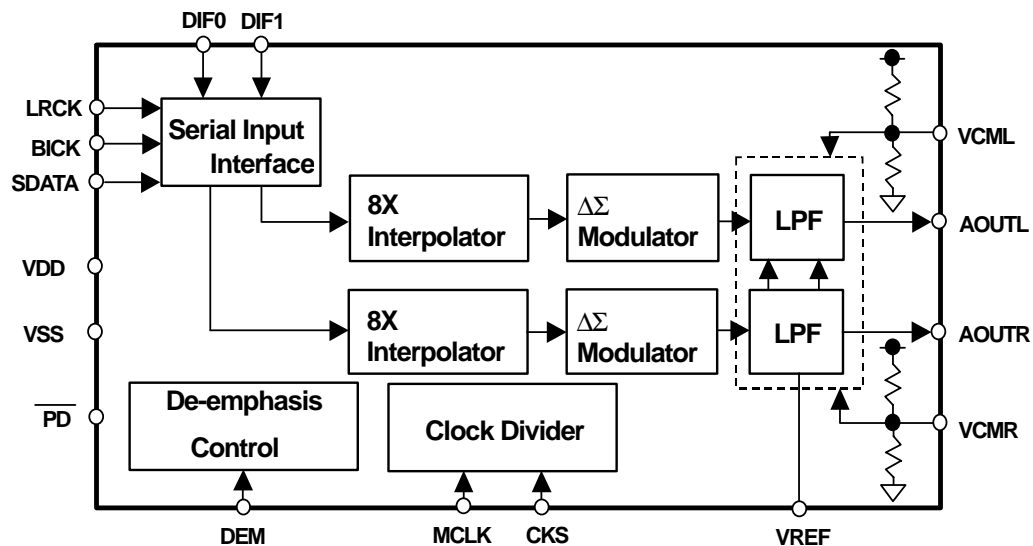


GENERAL DESCRIPTION

The AK4352 is an 18bit low voltage & power stereo DAC for digital audio system. The AK4352 uses the new developed Multi-Bit $\Delta\Sigma$ architecture, this new architecture achieves DR=94dB at low voltage operation. The AK4352 includes post filter with single-ended output and does not need any external parts. The AK4352 is suitable for the portable audio system like MD, etc as low power and small package.

FEATURES

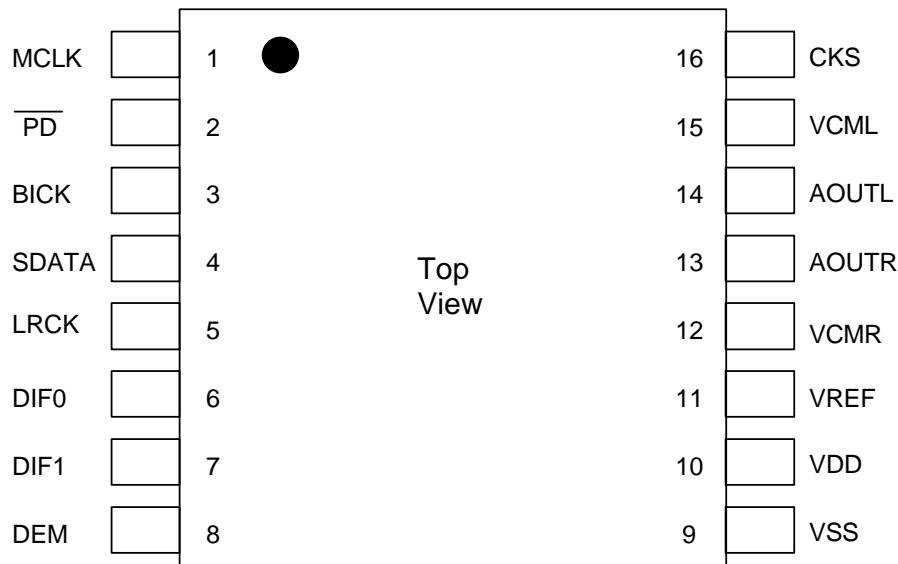
- Multi-Bit $\Delta\Sigma$ DAC
- Sampling Rate Ranging: 8kHz ~ 50kHz
- On chip post filter
- On chip Buffer with Single-ended Output
- On chip Perfect filtering 8 times FIR interpolator
 - Passband: 20kHz
 - Passband Ripple: $\pm 0.06\text{dB}$
 - Stopband Attenuation: 43dB
- Digital Audio I/F format: 2's compliment, MSB first
18bit MSB justified, 16/18bit LSB justified, I²S
- Digital de-emphasis for 44.1kHz sampling
- Master clock: 256fs or 384fs
- THD+N: -83dB@2V, -89dB@3V
- D-Range: 94dB@2V, 96dB@3V
- Output Voltage: 1.10Vpp@2V
- Low Voltage Operation: 2V (1.8 ~ 3.6V)
- Low power Dissipation: 6mW@2V
- Very Small Package: 16pin TSSOP



■ Ordering Guide

AK4352VT -40 ~ +85°C 16pin TSSOP (0.65mm pitch)
 AKD4352 Evaluation Board

■ Pin Layout



PIN/FUNCTION

| No. | Pin Name | I/O | Function |
|-----|------------------------|-----|--|
| 1 | MCLK | I | Master Clock Pin |
| 2 | $\overline{\text{PD}}$ | I | Power-Down Pin When at “L”, the AK4352 is in power-down mode and is held in reset. The AK4352 should always be reset upon power-up. |
| 3 | BICK | I | Serial Bit Input Clock Pin This clock is used to latch audio data. |
| 4 | SDATA | I | Audio Data Input Pin |
| 5 | LRCK | I | L/R Clock Pin This input determines which audio channel is currently being input on SDATA pin. |
| 6 | DIF0 | I | Digital Input Format Pin |
| 7 | DIF1 | I | These pins select one of four input modes. |
| 8 | DEM | I | De-emphasis Enable Pin When at “H”, de-emphasis of fs=44.1kHz is enabled. |
| 9 | VSS | - | Ground Pin |
| 10 | VDD | - | Power Supply Pin |
| 11 | VREF | I | Reference Voltage Input Pin Normally connected to VDD. |
| 12 | VCMR | O | Rch Common Voltage Pin |
| 13 | AOATR | O | Rch Analog Output Pin |
| 14 | AOATL | O | Lch Analog Output Pin |
| 15 | VCML | O | Lch Common Voltage Pin |
| 16 | CKS | I | Master Clock Select Pin “L”: 256fs “H”: 384fs |

Note: All input pins should not be left floating.

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|---------------------------------|
| ABSOLUTE MAXIMUM RATINGS |
|---------------------------------|

(VSS=0V;Note 1)

| Parameter | Symbol | min | max | Units |
|--|--------|------|---------|-------|
| Power Supply | VDD | -0.3 | 4.6 | V |
| Input Current, Any Pin Except Supplies | IIN | - | ±10 | mA |
| Input Voltage | VIND | -0.3 | VDD+0.3 | V |
| Ambient Operating Temperature | Ta | -40 | 85 | °C |
| Storage Temperature | Tstg | -65 | 150 | °C |

Note 1. All voltages with respect to ground.

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

| |
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| RECOMMENDED OPERATING CONDITIONS |
|---|

(VSS=0V;Note 1)

| Parameter | Symbol | min | typ | max | Units |
|----------------------------|--------|-----|-----|-----|-------|
| Power Supply | VDD | 1.8 | 2.0 | 3.6 | V |
| Voltage Reference (Note 2) | VREF | | - | VDD | V |

Note 1. All voltages with respect to ground.

Note 2. Analog output voltage scales with the voltage of VREF.

AOUT (typ.@0dB)=1.10Vpp*VREF/2.

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

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| ANALOG CHARACTERISTICS |
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(Ta=25°C; VDD=2.0V, VREF=VDD; fs=44.1kHz; BICK=64fs; Signal Frequency=1kHz; 18bit Input Data;
Measurement frequency=10Hz ~ 20kHz; RL ≥10kΩ; unless otherwise specified)

| Parameter | min | typ | max | Units |
|---|------|------|------|--------|
| Dynamic Characteristics (Note 3) | | | | |
| THD+N (0dB Output) | | -83 | -74 | dB |
| Dynamic Range (-60dB Output, A-weight) | 88 | 94 | | dB |
| S/N (A-weight) | 88 | 94 | | dB |
| Interchannel Isolation | 90 | 100 | | dB |
| DC Accuracy | | | | |
| Interchannel Gain Mismatch | | 0.1 | 0.5 | dB |
| Gain Drift | - | 60 | - | ppm/°C |
| Output Voltage (Note 4) | 1.02 | 1.10 | 1.18 | Vpp |
| Load Resistance | 10 | | | kΩ |
| Power Supplies | | | | |
| Power Supply Current | | | | |
| Normal Operation ($\overline{PD} = \text{"H"}$) | | | | |
| VDD | | 3.0 | 4.7 | mA |
| Power-Down Mode ($\overline{PD} = \text{"L"}$) | | | | |
| VDD (Note 5) | | 10 | 50 | μA |
| Power Dissipation (VDD) | | | | |
| Normal Operation | | 6.0 | 9.4 | mW |
| Power-Down Mode (Note 5) | | 20 | 100 | μW |
| Power Supply Rejection | - | 50 | - | dB |

Note 3. Measured by AD725C (SHIBASOKU). Averaging mode.

In case of VDD=3.0V,

THD+N: -89dB

DR: 96dB (A-weight)

S/N: 97dB (A-weight)

Note 4. Full-scale voltage (0dB). Output voltage scales with the voltage of VREF.

AOUT (typ. @0dB)=1.10Vpp*VREF/2.

Note 5. In case of power-down mode, all digital input pins including clock pins (MCLK, BICK and LRCK) are held VDD or VSS.

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| FILTER CHARACTERISTICS |
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(Ta=25°C; VDD=1.8 ~ 3.6V; fs=44.1kHz; DEM= "L")

| Parameter | Symbol | min | typ | max | Units |
|---------------------------------------|-----------------|-----|------|--------|-------|
| Digital filter | | | | | |
| Passband | -0.1dB (Note 6) | PB | 0 | 20.0 | kHz |
| | -6.0dB | | - | 22.05 | kHz |
| Stopband | (Note 6) | SB | 24.1 | | kHz |
| Passband Ripple | | PR | | ± 0.06 | dB |
| Stopband Attenuation | | SA | 43 | | dB |
| Group Delay | (Note 7) | GD | - | 14.7 | 1/fs |
| Digital Filter + Analog Filter | | | | | |
| Frequency Response | 0 ~ 20.0kHz | | - | ± 0.2 | dB |

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

For example, PB=0.4535*fs(@-0.1dB), SB=0.546*fs(@-43dB).

Note 7. The calculating delay time which occurred by digital filtering. This time is from setting the 18bit data of both channels to input register to the output of analog signal.

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| DIGITAL CHARACTERISTICS |
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(Ta=25°C; VDD=1.8 ~ 3.6V)

| Parameter | Symbol | min | typ | max | Units |
|--------------------------|--------|--------|-----|--------|-------|
| High-Level Input Voltage | VIH | 75%VDD | - | - | V |
| Low-Level Input Voltage | VIL | - | - | 25%VDD | V |
| Input Leakage Current | Iin | - | - | ± 10 | μA |

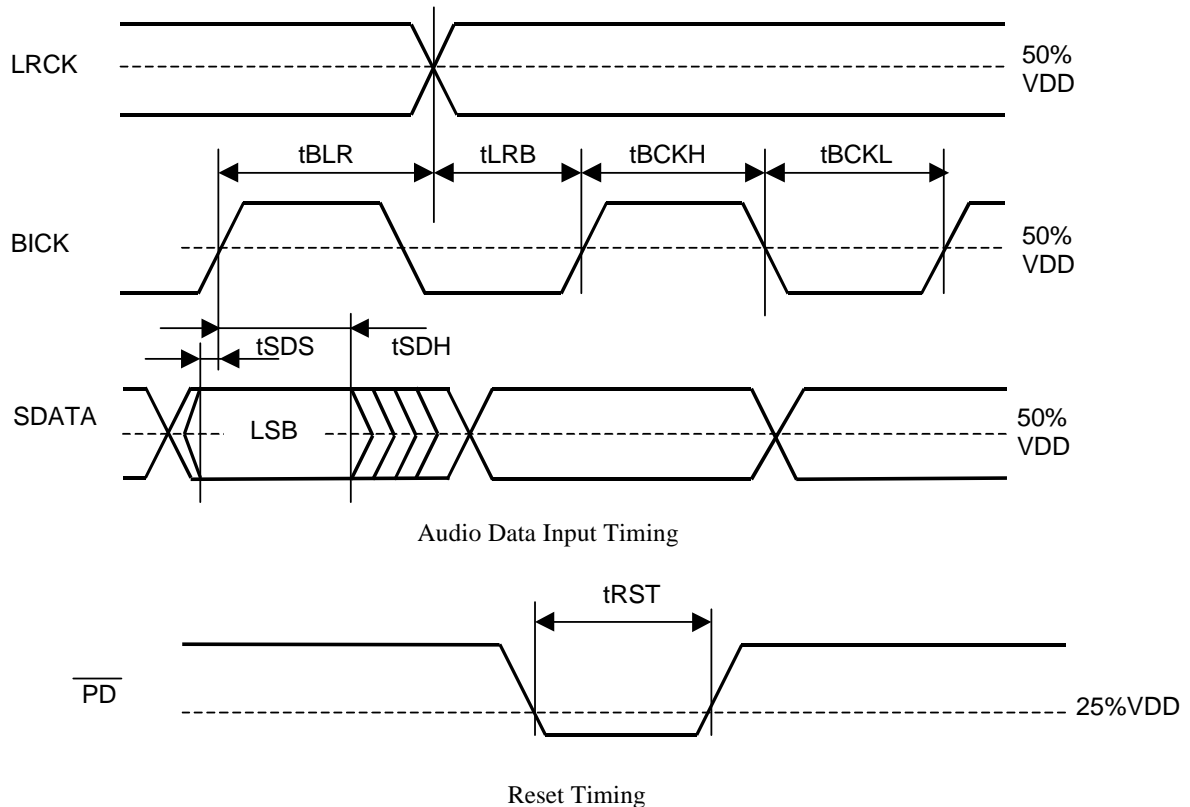
| SWITCHING CHARACTERISTICS | | | | | | |
|--------------------------------|------------------|--------|-------|---------|------|-------|
| (Ta=25°C; VDD=1.8 ~ 3.6V) | | | | | | |
| Parameter | | Symbol | min | typ | max | Units |
| Master Clock Timing | 256fs: | fCLK | 2.048 | 11.2896 | 12.8 | MHz |
| | Pulse Width Low | tCLKL | 28 | | | ns |
| | Pulse Width High | tCLKH | 28 | | | ns |
| | 384fs: | fCLK | 3.072 | 16.9344 | 19.2 | MHz |
| | Pulse Width Low | tCLKL | 23 | | | ns |
| | Pulse Width High | tCLKH | 23 | | | ns |
| LRCK Frequency | | fs | 8 | 44.1 | 50 | kHz |
| Serial Interface Timing | (Note 8) | | | | | |
| BICK Period | | tBCK | 312.5 | | | ns |
| BICK Pulse Width Low | | tBCKL | 100 | | | ns |
| Pulse Width High | | tBCKH | 100 | | | ns |
| BICK rising to LRCK Edge | (Note 9) | tBLR | 50 | | | ns |
| LRCK Edge to BICK rising | (Note 9) | tLRB | 50 | | | ns |
| SDATA Hold Time | | tSDH | 50 | | | ns |
| SDATA Setup Time | | tSDS | 50 | | | ns |
| Reset Timing | | | | | | |
| PD Pulse Width | (Note 10) | tRST | 300 | | | ns |

Note 8. Refer to the operating overview section “Audio Data Interface”.

Note 9. BICK rising edge must not occur at the same time as LRCK edge.

Note 10. The AK4352 can be reset by bringing PD = “L” to “H” only upon power up.

■ Timing Diagram



OPERATION OVERVIEW

■ **System Clock**

The external clocks which are required to operate the AK4352 are MCLK (256fs/384fs) LRCK (fs), BICK (32fs~). The master clock (MCLK) should be synchronized with LRCK but the phase is not critical. The frequency of MCLK is determined by the sampling rate (LRCK) and CKS pin. Setting CKS= "L" selects an MCLK frequency of 256fs while setting CKS= "H" selects 384fs. When the 384fs is selected, the internal master clock becomes 256fs(=384fs*2/3). Table 1 illustrates standard audio word rates and corresponding frequencies used in the AK4352.

All external clocks (MCLK, BICK and LRCK) should always be present whenever the AK4352 is in normal operation mode (PD = "H"). If these clocks are not provided, the AK4352 may draw excess current because the device utilizes dynamic refreshed logic internally. If the external clocks are not present, the AK4352 should be in the power-down mode(PD = "L").

As the AK4352 includes the phase detection circuit for LRCK, the AK4352 adjusts the phase of LRCK automatically when the synchronization is out of phase by changing the clock frequencies. Therefore, the reset is only needed for power-up.

| LRCK (fs) | MCLK | | BICK (64fs) |
|-----------|-----------------|-----------------|-------------|
| | CKS= "L": 256fs | CKS= "H": 384fs | |
| 32.0kHz | 8.1920MHz | 12.2880MHz | 2.0480MHz |
| 44.1kHz | 11.2896MHz | 16.9344MHz | 2.8224MHz |
| 48.0kHz | 12.2880MHz | 18.4320MHz | 3.0720MHz |

Table 1. Examples of System Clock

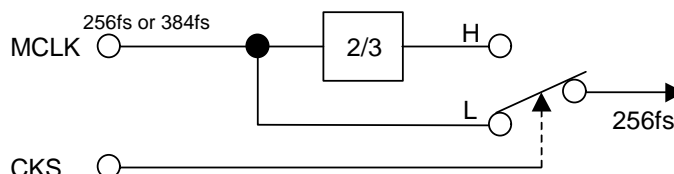


Figure 1. Internal Clock Circuit

■ Audio Serial Interface Format

The AK4352 interfaces with external system by using SDATA, BICK and LRCK pins. Four types of data format are available and one of them is selected by setting DIF0 and DIF1. Format 0 is compatible with existing 16bit DACs and digital filters. Format 1 is an 18bit version of format 0. Format 2 is similar to AKM ADCs and many DSP serial ports. Format 3 is compatible with the I²S serial data protocol. In format 2 and 3, 16bit 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 | BICK | Figure |
|------|------|--------------------------------|---------------|----------|
| 0 | 0 | 0: 16bit LSB Justified | ≥32fs | Figure 2 |
| 0 | 1 | 1: 18bit LSB Justified | ≥36fs | Figure 2 |
| 1 | 0 | 2: 18bit MSB Justified | ≥36fs | Figure 3 |
| 1 | 1 | 3: I ² S Compatible | ≥32fs or 36fs | Figure 4 |

Table 2. Digital Input Formats

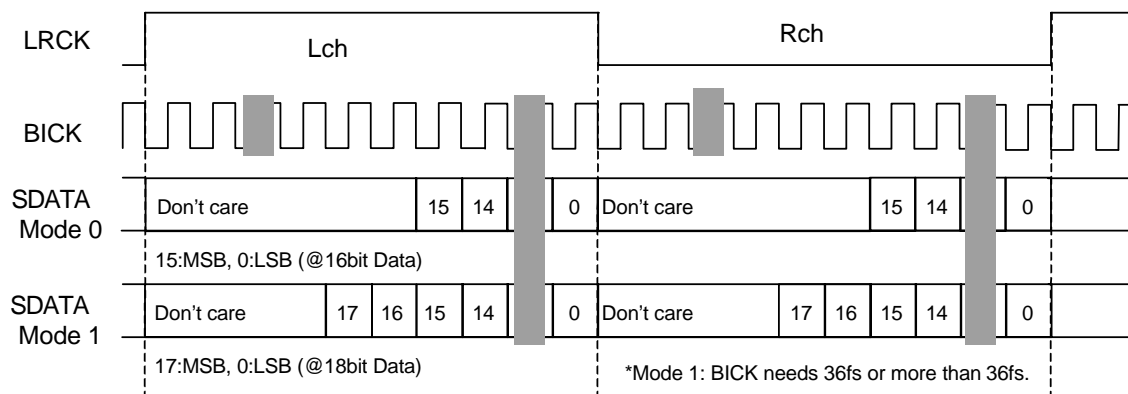


Figure 2. Mode 0,1 Timing

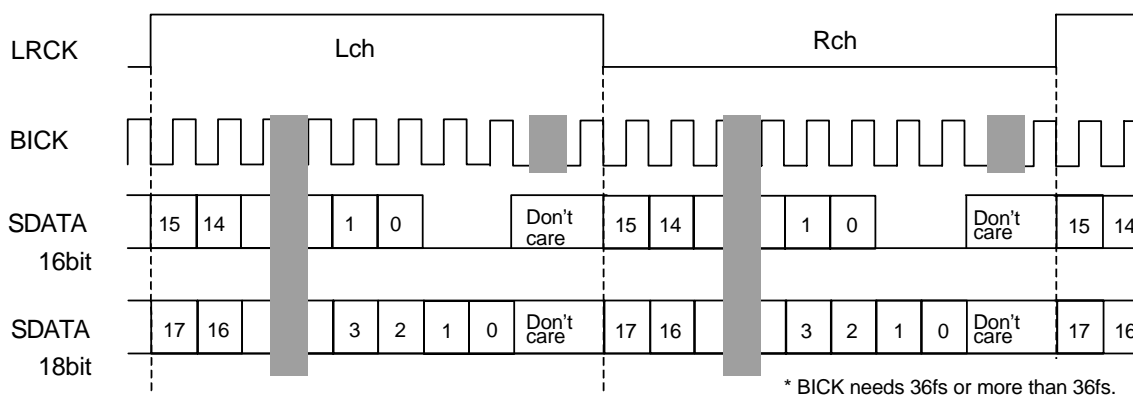


Figure 3. Mode 2 Timing

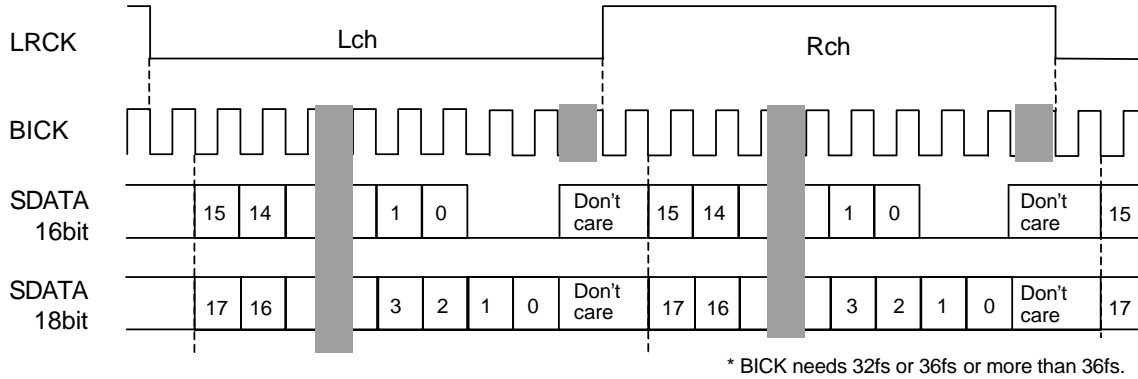


Figure 4. Mode 3 Timing

■ De-emphasis filter

The AK4352 includes the digital de-emphasis filter ($t_c=50/15\mu s$) by IIR filter. This filter corresponds to 44.1kHz sampling. The de-emphasis is enabled by setting DEM pin "H".

■ Power-down

The AK4352 is placed in the power-down mode by bringing \overline{PD} pin "L" and the analog outputs are floating(Hi-Z). Figure 5 shows an example of the system timing at the power-down and power-up.

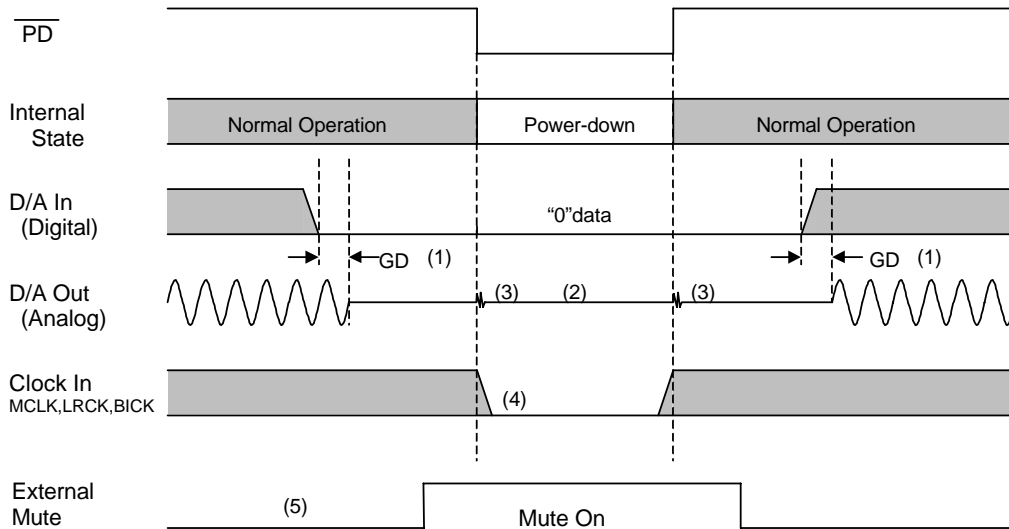


Figure 5. Power-down/up sequence example

Notes:

- (1) Analog output corresponding to digital input have the group delay (GD).
- (2) Analog outputs are floating(Hi-Z) at the power-down mode.
- (3) Click noise occurs at the edges("↑ ↓") of the falling edge of \overline{PD} signal.
- (4) When the external clocks(MCLK,BICK,LRCK) are stopped, the AK4352 should be in the power-down mode.
- (5) Please mute the analog output externally if the click noise(3) influences system application. The timing example is shown in this figure.

■ System Reset

The AK4352 should be reset once by bringing $\overline{\text{PD}} = \text{“L”}$ upon power-up. The internal timing starts clocking by LRCK “↑” upon exiting reset.

SYSTEM DESIGN

Figure 6 shows the system connection diagram. An evaluation board [AKD4352] is available in order to allow an easy study on the layout of a surrounding circuit.

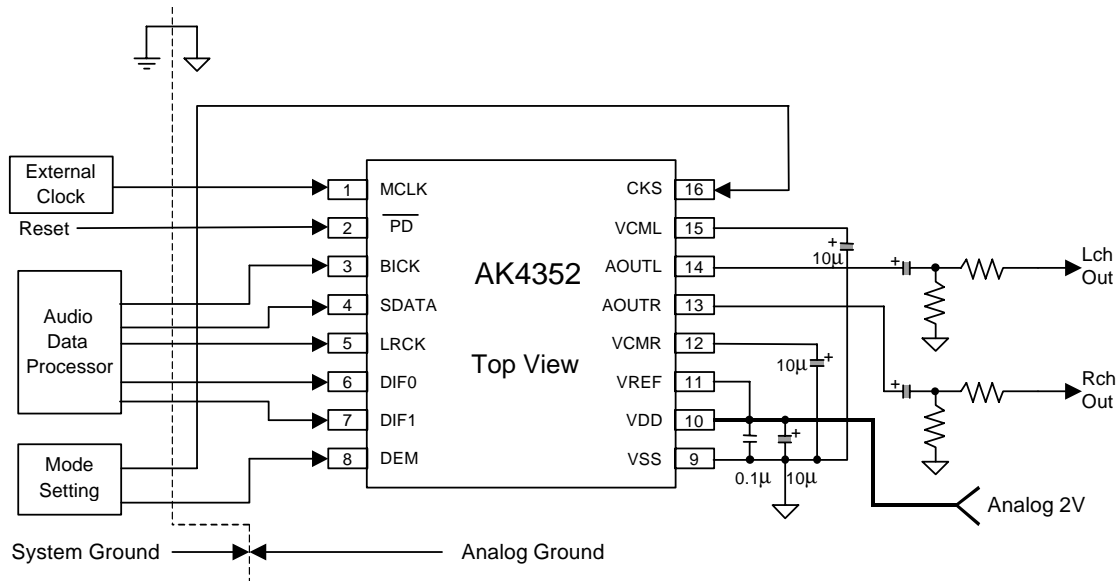


Figure 6. Typical Connection Diagram

Notes:

- LRCK = fs, BICK ≥ 32fs or 36fs, MCLK = 256fs/384fs.
- When AOUT drives some capacitive load, some resistor should be added in series between AOUT and capacitive load.

1. Grounding and Power Supply Decoupling

Figure 6 shows the power supply connection example. VDD is supplied from analog supply in system. Decoupling capacitors for high frequency should be as near to the AK4352 device as possible, with the low value ceramic capacitor between VREF and VSS being the nearest.

2. Voltage Reference

The differential Voltage between VREF and VSS sets the analog output range. VREF pin is normally connected to VDD. An electrolytic capacitor 10 μ F parallel with a 0.1 μ F ceramic capacitor are attached between VREF and VSS pins. VCML and VCMR pins are a signal ground of this chip. An electrolytic capacitor less than 10 μ F parallel with a 0.1 μ F ceramic capacitor attached between VCML, VCMR pins and VSS eliminates the effects of high frequency noise. Especially, the ceramic capacitor should be connected to these pins as near as possible.

No load current may be drawn from VCML and VCMR pins. All signals, especially clocks, should be kept away from the VREF, VCML and VCMR pins in order to avoid unwanted coupling into the AK4352.

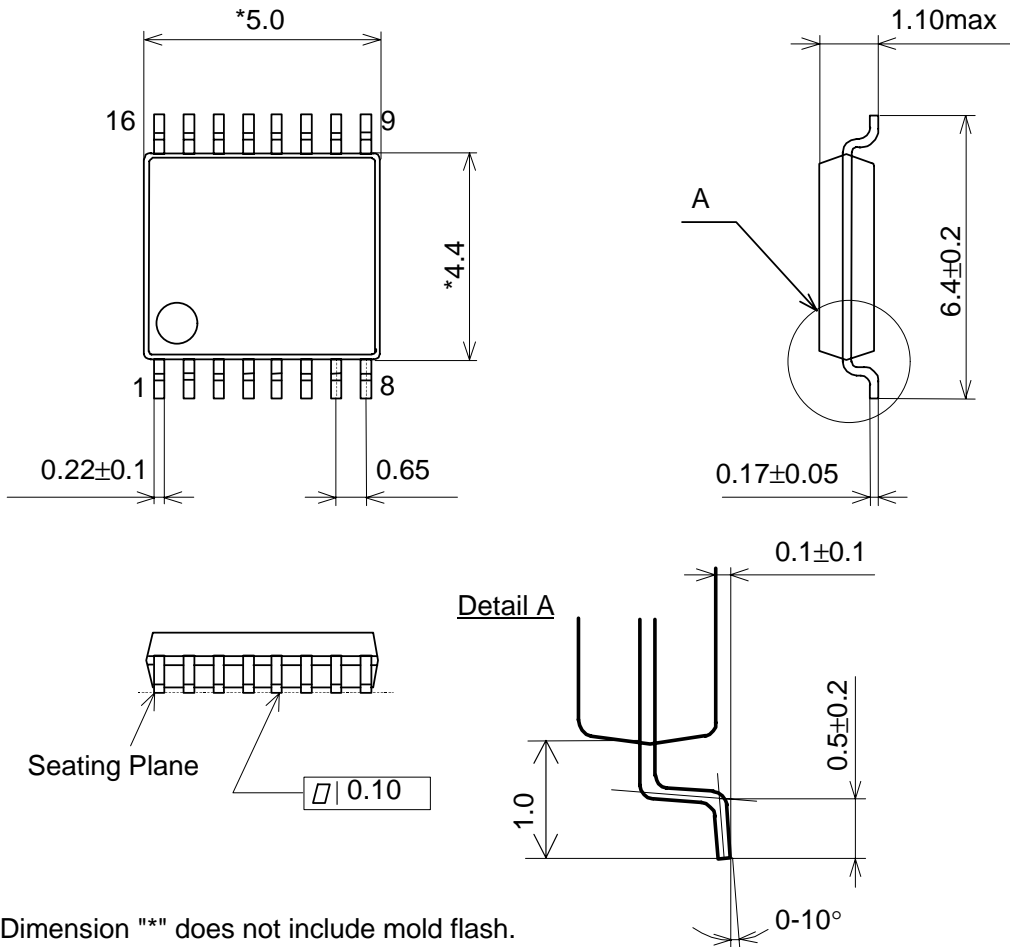
3. Analog Outputs

The analog outputs are single-ended and centered around the VCML, VCMR voltage. The output signal range is typically 1.10Vpp. If the noise generated by the delta-sigma modulator beyond the audio band would be the problem, the attenuation by external filter is required. The output voltage is a positive full scale for 7FFFH(@16bit) and a negative full scale for 8000H(@16bit). The ideal output is VCML, VCMR voltage for 0000H(@16bit).

DC offsets on analog outputs are eliminated by AC coupling since analog outputs have DC offsets of VCML, VCMR voltage + a few mV.

PACKAGE

16pin TSSOP (Unit: mm)

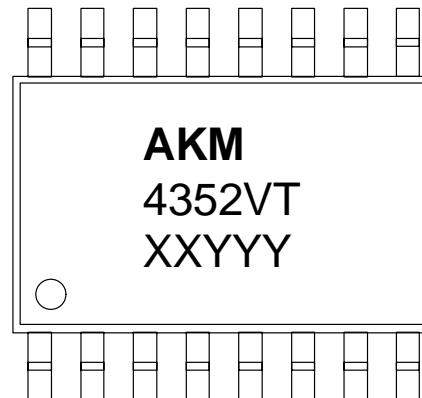


NOTE: Dimension "*" does not include mold flash.

■ Package & Lead frame material

| | |
|-------------------------------|--------------|
| Package molding compound: | Epoxy |
| Lead frame material: | Cu |
| Lead frame surface treatment: | Solder plate |

| |
|----------------|
| MARKING |
|----------------|



Contents of XXYYY

XX: Lot#

YYY: Date Code

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