



AK5353

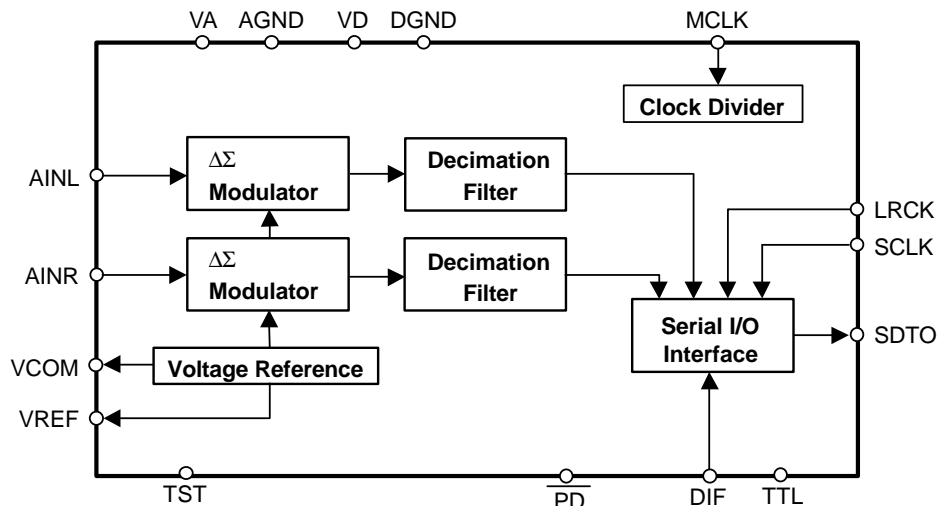
96kHz 24Bit $\Delta\Sigma$ ADC with Single-ended Input

GENERAL DESCRIPTION

The AK5353 is a stereo A/D Converter with wide sampling rate of 4kHz~96kHz and is suitable for multimedia audio system. The AK5353 achieves high accuracy and low cost by using Enhanced dual bit $\Delta\Sigma$ techniques. The AK5353 requires no external components because the analog inputs are single-ended. The audio interface has two formats (MSB justified, I^2S) and can correspond to many systems like Karaoke, surround.

FEATURES

- Stereo $\Delta\Sigma$ ADC
- On-Chip Digital Anti-Alias Filtering
- Single-ended Input
- Digital HPF for DC-Offset cancel
- S/(N+D): 84dB@5V, 80dB@3V for 48kHz
- DR: 96dB@5V, 92dB@3V for 48kHz
- S/N: 96dB@5V, 92dB@3V for 48kHz
- Sampling Rate Ranging from 4kHz to 96kHz
- Master Clock:
 - 256fs/384fs/512fs (~48kHz)
 - 256fs/384fs (~96kHz)
- Low Power Dissipation: 70mW
- Small 16pin TSSOP Package
- Power Supply: 2.7~5.5V (~48kHz)
4.5~5.5V (~96kHz)
- Ta=-40~85°C
- Input level: TTL/CMOS selectable
- Output format: 24bit MSB justified / I^2S selectable



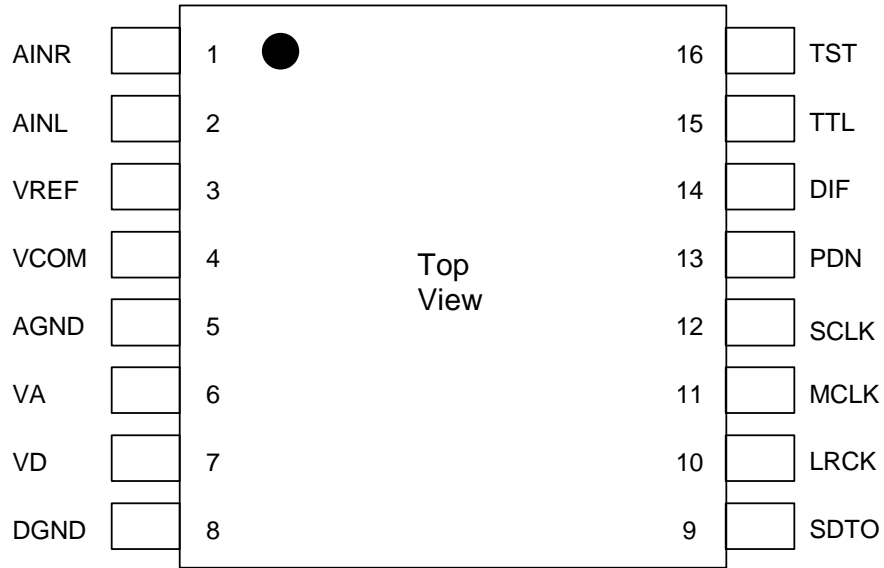
■ Ordering Guide

AK5353VT
AKD5353

-40~+85°C
Evaluation Board

16pin TSSOP

■ Pin Layout



| PIN/FUNCTION | | | |
|--------------|----------|-----|---|
| No. | Pin Name | I/O | Description |
| 1 | AINR | I | Rch Analog Input Pin |
| 2 | AINL | I | Lch Analog Input Pin |
| 3 | VREF | O | Voltage Reference Output Pin Normally connected to AGND with a 0.1uF ceramic capacitor in parallel with an electrolytic capacitor less than 4.7uF. |
| 4 | VCOM | O | Common Voltage Output Pin Normally connected to AGND with a 0.1uF ceramic capacitor in parallel with an electrolytic capacitor less than 4.7uF. |
| 5 | AGND | - | Analog Ground Pin, 0V |
| 6 | VA | - | Analog Power Supply Pin, +2.7~+5.5V |
| 7 | VD | - | Digital Power Supply Pin, +2.7~+5.5V |
| 8 | DGND | - | Digital Ground Pin, 0V |
| 9 | SDTO | O | Serial Data Output Pin Data bits are presented MSB first, in 2 s complement format. This pin is L in the power-down mode. |
| 10 | LRCK | I | Left/Right Channel Select Pin The fs clock is input to this pin. |
| 11 | MCLK | I | Master Clock Input Pin |
| 12 | SCLK | I | Serial Data Input Pin Output data is clocked out on the falling edge of SCLK. |
| 13 | PDN | I | Power-Down Pin When L, the circuit is in power-down mode. The AK5353 should always be reset upon power-up. |
| 14 | DIF | I | Serial Interface Format Pin L : MSB justified, H : I ² S |
| 15 | TTL | I | Digital Input Level Select Pin L : CMOS level (VA,VD=2.7~5.5V), H : TTL level (VA,VD=4.5~5.5V) |
| 16 | TST | I | Test Pin (Internal pull-down pin) This pin should be left floating. |

Note: All input pins except pull-down pins should not be left floating.

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

(AGND, DGND=0V; Note 1)

| Parameter | | Symbol | min | max | Units |
|--|------------------|--------------|------|----------|-------|
| Power Supplies | Analog (VA pin) | VA | -0.3 | 6.0 | V |
| | Digital (VD pin) | VD | -0.3 | 6.0 | V |
| | AGND-DGND | Δ GND | - | 0.3 | V |
| Input Current (any pins except for supplies) | | IIN | - | \pm 10 | mA |
| Analog Input Voltage (AINL, AINR pins) | | VINA | -0.3 | VA+0.3 | V |
| Digital Input Voltage | | VIND | -0.3 | VD+0.3 | V |
| Ambient Temperature | | Ta | -40 | 85 | °C |
| Storage Temperature | | Tstg | -65 | 150 | °C |

Note: 1. All voltages with respect to ground.

2. AGND and DGND must be connected to the same analog ground plane.

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 (fs=48kHz) |
|--|

(AGND, DGND=0V; Note 1)

| Parameter | | Symbol | min | typ | max | Units |
|----------------------------|---------|--------|-----|-----|-----|-------|
| Power Supplies (Note 3) | Analog | VA | 2.7 | 5.0 | 5.5 | V |
| | Digital | VD | 2.7 | 5.0 | VA | V |
| Sampling Rate | | fs | 4 | | 48 | kHz |

Note: 1. All voltages with respect to ground.

3. The power up sequence between VA and VD is not critical.

| |
|--|
| RECOMMENDED OPERATING CONDITIONS (fs=96kHz) |
|--|

(AGND, DGND=0V; Note 1)

| Parameter | | Symbol | min | typ | max | Units |
|----------------------------|---------|--------|-----|-----|-----|-------|
| Power Supplies (Note 3) | Analog | VA | 4.5 | 5.0 | 5.5 | V |
| | Digital | VD | 4.5 | 5.0 | VA | V |
| Sampling Rate | | fs | 4 | | 96 | kHz |

Note: 1. All voltages with respect to ground.

3. The power up sequence between VA and VD is not critical.

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

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| ANALOG CHARACTERISTICS |
|-------------------------------|

(Ta=25°C; VA,VD=5V; fs=48kHz; I/F format=Mode 0; Signal Frequency =1kHz;
Measurement band width=20Hz~20kHz; unless otherwise specified)

| Parameter | | min | typ | max | Units |
|---|-----------------------------|-----|-----|-----|--------|
| ADC Analog Input Characteristics: Analog source impedance=470Ω (BW=40Hz~40kHz at fs=96kHz) | | | | | |
| Resolution | | | | 24 | Bits |
| S/(N+D) (-1dBFS) (Note 4) | fs=48kHz, VA=5V | 76 | 84 | | dB |
| | fs=48kHz, VA=3V | 76 | 84 | | dB |
| | fs=96kHz, VA=5V | - | 84 | | dB |
| DR (-60dBFS) (Note 5) | fs=48kHz, VA=5V, A-weighted | 90 | 96 | | dB |
| | fs=48kHz, VA=3V, A-weighted | 86 | 92 | | dB |
| | fs=96kHz, VA=5V | - | 93 | | dB |
| S/N | fs=48kHz, VA=5V, A-weighted | 90 | 96 | | dB |
| | fs=48kHz, VA=3V, A-weighted | 86 | 92 | | dB |
| | fs=96kHz, VA=5V | - | 93 | | dB |
| Interchannel Isolation | | 78 | 90 | | dB |
| DC Accuracy | | | | | |
| Interchannel Gain Mismatch | | | 0.1 | 0.3 | dB |
| Gain Drift | | | 100 | 150 | ppm/°C |
| Input Voltage | (Note 6) | 2.7 | 3.0 | 3.3 | Vpp |
| Input Resistance | (Note 7) | 40 | 60 | | kΩ |
| Power Supply Rejection | (Note 8) | - | 30 | | dB |
| Power Supplies | | | | | |
| Power Supply Current | | | | | |
| Normal Operation (PDN= H) | (Note 9) | | 14 | 21 | mA |
| VA+VD | | | | | |
| Power-Down Mode (PDN= L) | | | 10 | 100 | μA |
| VA+VD | | | | | |

Note:4. The ratio of the rms value of the signal to the rms sum of all the spectral components less than 20kHz bandwidth, including distortion components.

5. S/(N+D) which is measured with an input signal of -60dB below full-scale.

6. This value is the full scale(0dB) of the input voltage.

Input voltage is proportional to VA. (Vin=0.6xVA)

7. 40kΩ(typ) and 25kΩ(min) at fs=96kHz.

8. PSR is applied to VA,VD with 1kHz, 50mVpp.

9. VA=11mA; VD=3mA@48kHz,5V, 1.5mA@48kHz,3V, 6mA@96kHz,5V (typ).

FILTER CHARACTERISTICS (fs=48kHz)

(Ta=25°C; VA,VD=2.7~5.5V; fs=48kHz)

| Parameter | Symbol | min | typ | max | Units |
|--|--------|------|------|------|-------|
| Digital Filter (Decimation LPF) | | | | | |
| Passband (Note 10) | ±0.1dB | PB | 0 | 18.9 | kHz |
| | -0.2dB | | - | 20.0 | kHz |
| | -1.0dB | | - | 21.8 | kHz |
| | -3.0dB | | - | 23.0 | kHz |
| Stopband (Note 10) | SB | 29.4 | | | kHz |
| Stopband Attenuation | SA | 65 | | | dB |
| Group Delay Distortion | ΔGD | | 0 | | μs |
| Group Delay (Note 11) | GD | - | 17.0 | - | 1/fs |
| Digital Filter (HPF) | | | | | |
| Frequency Response: | -3 dB | FR | - | 4 | Hz |
| | -0.5dB | | - | 11 | Hz |
| | -0.1dB | | - | 24 | Hz |

Note:10. The passband and stopband frequencies scale with fs.

11. The calculating delay time which occurred by digital filtering. This time is from the input of analog signal to setting the 24bit data of both channels to the output register for ADC.

FILTER CHARACTERISTICS (fs=96kHz)

(Ta=25°C; VA,VD=4.5~5.5V; fs=96kHz)

| Parameter | Symbol | min | typ | max | Units |
|--|--------|------|------|------|-------|
| Digital Filter (Decimation LPF) | | | | | |
| Passband (Note 10) | ±0.1dB | PB | 0 | 37.8 | kHz |
| | -0.2dB | | - | 40.0 | kHz |
| | -1.0dB | | - | 43.6 | kHz |
| | -3.0dB | | - | 46.0 | kHz |
| Stopband (Note 10) | SB | 58.8 | | | kHz |
| Stopband Attenuation | SA | 65 | | | dB |
| Group Delay Distortion | ΔGD | | 0 | | μs |
| Group Delay (Note 11) | GD | - | 17.0 | - | 1/fs |
| Digital Filter (HPF) | | | | | |
| Frequency Response: | -3 dB | FR | - | 8 | Hz |
| | -0.5dB | | - | 22 | Hz |
| | -0.1dB | | - | 48 | Hz |

Note:10. The passband and stopband frequencies scale with fs.

11. The calculating delay time which occurred by digital filtering. This time is from the input of analog signal to setting the 24bit data of both channels to the output register for ADC.

DIGITAL CHARACTERISTICS (CMOS level input)

(Ta=25°C; VA,VD=2.7~5.5V; TTL= L)

| Parameter | Symbol | min | typ | Max | Units |
|--|--------|--------|-----|--------|-------|
| High-Level input voltage | VIH | 0.7xVD | - | - | V |
| Low-Level input voltage | VIL | - | - | 0.3xVD | V |
| High-Level output voltage (Iout= -100μA) | VOH | VD-0.5 | - | - | V |
| Low-Level output voltage (Iout= 100μA) | VOL | - | - | 0.5 | V |
| Input leakage current (exclude TST pin) | Iin | - | - | ±10 | μA |

DIGITAL CHARACTERISTICS (TTL level input; except for TTL pin)

(Ta=25°C; VA,VD=4.5~5.5V; TTL= H)

| Parameter | Symbol | min | typ | Max | Units |
|--|--------|--------|-----|--------|-------|
| High-Level input voltage (TTL pin) | VIH | 0.7xVD | - | - | V |
| High-Level input voltage (All pins except for TTL pin) | VIH | 2.2 | - | - | V |
| Low-Level input voltage (TTL pin) | VIL | - | - | 0.3xVD | V |
| Low-Level input voltage (All pins except for TTL pin) | VIL | - | - | 0.8 | V |
| High-Level output voltage (Iout= -100μA) | VOH | VD-0.5 | - | - | V |
| Low-Level output voltage (Iout= 100μA) | VOL | - | - | 0.5 | V |
| Input leakage current (exclude TST pin) | Iin | - | - | ±10 | μA |

| SWITCHING CHARACTERISTICS (VA,VD=4.5~5.5V) | | | | | |
|---|---------------|------------|------------|------------|--------------|
| (Ta=25°C; VA,VD=4.5~5.5V; CL=20pF) | | | | | |
| Parameter | Symbol | min | typ | max | Units |
| Control Clock Frequency | | | | | |
| Master Clock 256fs: | fCLK | 1.024 | 12.288 | 24.576 | MHz |
| Pulse Width Low | tCLKL | 16 | | | ns |
| Pulse Width High | tCLKH | 16 | | | ns |
| 384fs: | fCLK | 1.536 | 18.432 | 36.864 | MHz |
| Pulse Width Low | fCLKL | 10 | | | ns |
| Pulse Width High | fCLKH | 10 | | | ns |
| 512fs: | fCLK | 2.048 | 24.576 | 24.576 | MHz |
| Pulse Width Low | fCLKL | 16 | | | ns |
| Pulse Width High | fCLKH | 16 | | | ns |
| SCLK Frequency | fSLK | | | 6.144 | MHz |
| LRCK Frequency | fs | 4 | 48 | 96 | kHz |
| Serial Interface Timing (Note 12) | | | | | |
| SCLK Period | tSLK | 160 | | | ns |
| SCLK Pulse Width Low | tSLKL | 65 | | | ns |
| Pulse Width High | tSLKH | 65 | | | ns |
| LRCK Edge to SCLK ↑ (Note 13) | tLRSH | 30 | | | ns |
| SCLK ↑ to LRCK Edge (Note 13) | tSHLR | 30 | | | ns |
| LRCK Edge to SDTO Valid (Note 14) | tDLR | | | 50 | ns |
| SCLK ↓ to SDTO Valid | tDSS | | | 50 | ns |
| Power-Down & Reset Timing | | | | | |
| PDN Pulse Width | tPDW | 150 | | | ns |
| PDN ↓ to SDTO delay (Note 15) | tPDV | | 4129 | | 1/fs |

Note: 12. Refer to the operating overview section Serial Data Interface .

13. SCLK rising edge must not occur at the same time as LRCK edge.

14. In case of MSB justified format.

15. These cycles are the number of LRCK rising from PDN falling.

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|---|
| SWITCHING CHARACTERISTICS (VA,VD=2.7~4.5V) |
|---|

(Ta=25°C; VA,VD=2.7~4.5V; CL=20pF)

| Parameter | Symbol | min | typ | max | Units |
|--|--------|-------|------|--------|-------|
| Control Clock Frequency | | | | | |
| Master Clock 256fs: | fCLK | 1.024 | | 12.288 | MHz |
| Pulse Width Low | tCLKL | 32 | | | ns |
| Pulse Width High | tCLKH | 32 | | | ns |
| 384fs: | fCLK | 1.536 | | 18.432 | MHz |
| Pulse Width Low | fCLKL | 21 | | | ns |
| Pulse Width High | fCLKH | 21 | | | ns |
| 512fs: | fCLK | 2.048 | | 24.576 | MHz |
| Pulse Width Low | fCLKL | 16 | | | ns |
| Pulse Width High | fCLKH | 16 | | | ns |
| SCLK Frequency | fSLK | | | 6.144 | MHz |
| LRCK Frequency | fs | 4 | | 48 | kHz |
| Serial Interface Timing (Note 12) | | | | | |
| SCLK Period | tSLK | 160 | | | ns |
| SCLK Pulse Width Low | tSLKL | 65 | | | ns |
| Pulse Width High | tSLKH | 65 | | | ns |
| LRCK Edge to SCLK ↑ (Note 13) | tLRSH | 30 | | | ns |
| SCLK ↑ to LRCK Edge (Note 13) | tSHLR | 30 | | | ns |
| LRCK Edge to SDTO Valid (Note 14) | tDLR | | | 50 | ns |
| SCLK ↓ to SDTO Valid | tDSS | | | 50 | ns |
| Power-Down & Reset Timing | | | | | |
| PDN Pulse Width | tPDW | 150 | | | ns |
| PDN ↓ to SDTO delay (Note 15) | tPDV | | 4129 | | 1/fs |

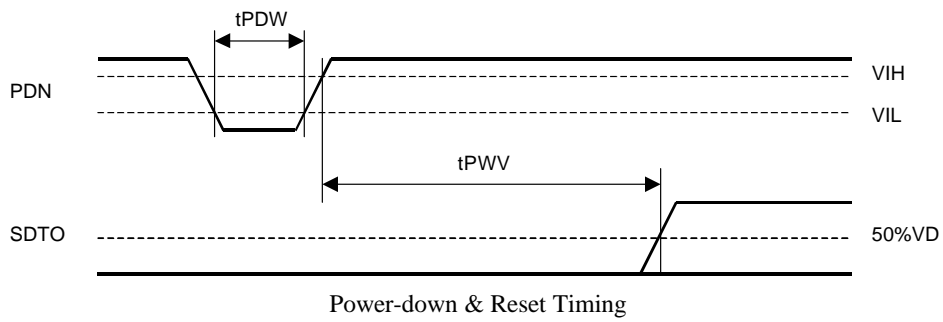
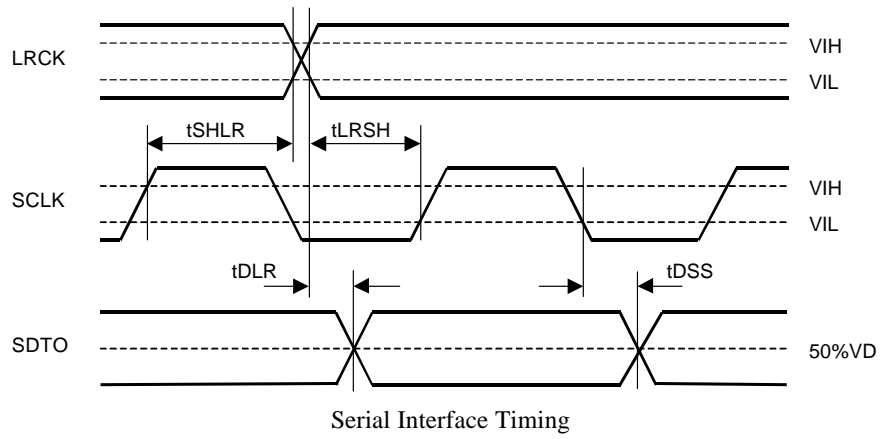
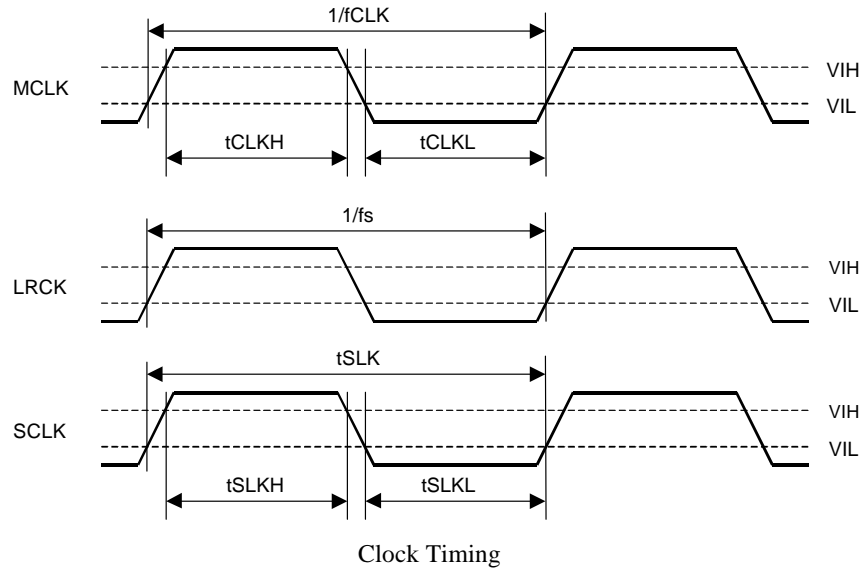
Note: 12. Refer to the operating overview section Serial Data Interface .

13. SCLK rising edge must not occur at the same time as LRCK edge.

14. In case of MSB justified format.

15. These cycles are the number of LRCK rising from PDN falling.

■ Timing Diagram



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|---------------------------|
| OPERATION OVERVIEW |
|---------------------------|

■ System Clock Input

The external clocks which are required to operate the AK5353 are MCLK(256fs/384fs/512fs), LRCK(1fs), SCLK. MCLK should be synchronized with LRCK but the phase is not critical. When 384fs or 512fs clock is input to MCLK pin, the internal master clock becomes 256fs(=384fs*2/3=512fs*1/2). Table 1 illustrates standard audio word rates and corresponding frequencies used in the AK5353.

All external clocks (MCLK,BICK,LRCK) should always be present whenever the AK5353 is in normal operation mode (PDN= H). If these clocks are not provided, the AK5353 may draw excess current and may not possibly operate properly because the device utilizes dynamic refreshed logic internally. If the external clocks are not present, the AK5353 should be in the power-down mode (PDN= L). After exiting reset at power-up etc., the AK5353 is in the power-down mode until MCLK and LRCK are input.

| fs | MCLK | | | SCLK | | |
|---------|------------|------------|------------|-----------|-----------|-----------|
| | 256fs | 384fs | 512fs | 32fs | 64fs | 128fs |
| 32.0kHz | 8.1920MHz | 12.2880MHz | 16.3840MHz | 1.0240MHz | 2.0480MHz | 4.0960MHz |
| 44.1kHz | 11.2896MHz | 16.9344MHz | 22.5792MHz | 1.4112MHz | 2.8224MHz | 5.6448MHz |
| 48.0kHz | 12.2880MHz | 18.4320MHz | 24.5760MHz | 1.5360MHz | 3.0720MHz | 6.1440MHz |
| 96.0kHz | 24.5760MHz | 36.8640MHz | N/A | 3.0720MHz | 6.1440MHz | N/A |

Table 1. Example of System Clock

■ Serial Data Interface

2 kinds of data format can be selected by DIF pin. The data is clocked out via the SDTO pin by SCLK corresponding to the setting of DIF pin. The format of output data is 2 s complement MSB first.

| Mode | DIF | Format |
|------|-----|---|
| 0 | 0 | 24bit, MSB justified, L/R, SCLK ≥48fs (16bit, MSB justified, L/R, SCLK ≥32fs) |
| 1 | 1 | 24bit, I2S, SCLK ≥48fs (16bit, I2S, SCLK ≥32fs) |

Table 2. Audio Serial Interface Formats

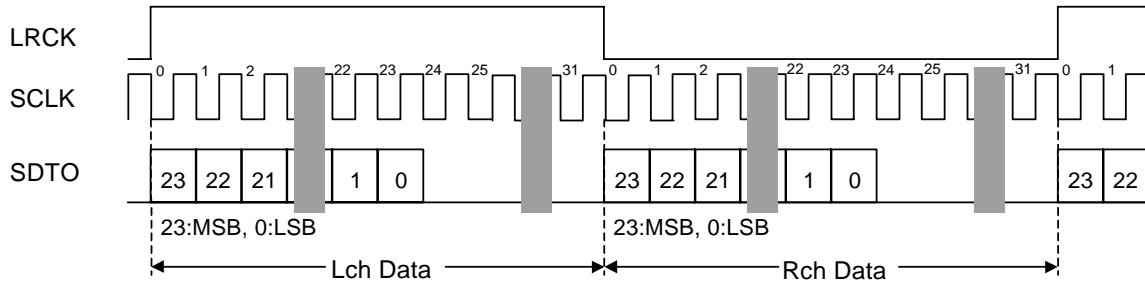


Figure 1. Mode 0 Timing

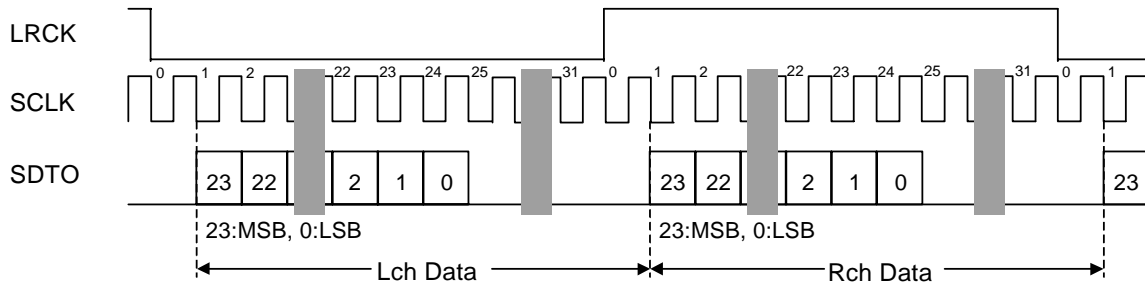
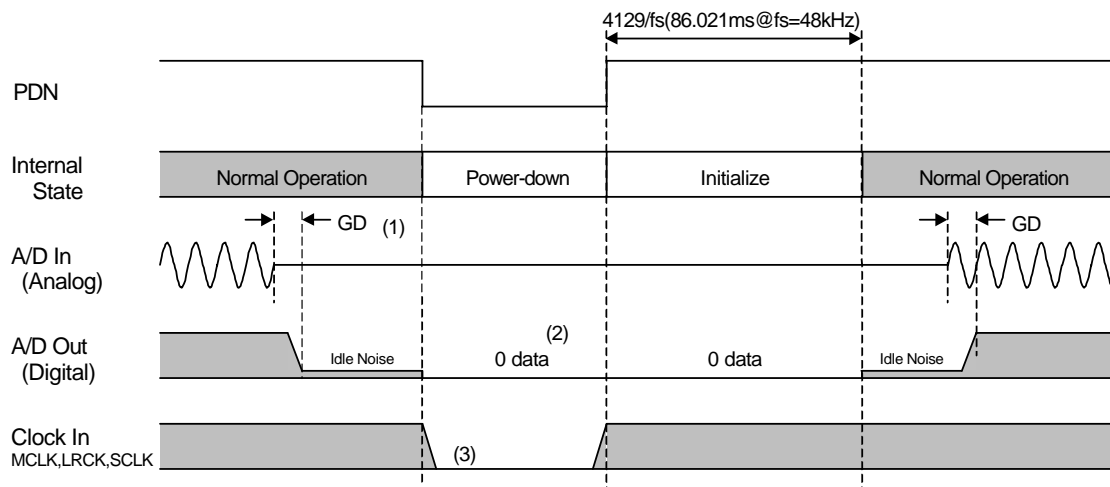


Figure 2. Mode 1 Timing

■ Power down

The AK5353 is placed in the power-down mode by bringing $\overline{\text{PDN}}$ and the digital filter is also reset at the same time. This reset should always be done after power-up. In the power-down mode, the VREF and VCOM are AGND level. An analog initialization cycle starts after exiting the power-down mode. Therefore, the output data SDTO becomes available after 4129 cycles of LRCK clock. During initialization, the ADC digital data outputs of both channels are forced to a 2's complement 0. The ADC outputs settle in the data corresponding to the input signals after the end of initialization (Settling approximately takes the group delay time).



Notes:

- (1) Digital output corresponding to analog input has the group delay (GD).
- (2) A/D output is 0 data at the power-down state.
- (3) When the external clocks (MCLK, SCLK, LRCK) are stopped, the AK5353 should be in the power-down state.

Figure 3. Power-down/up sequence example

■ System Reset

The AK5353 should be reset once by bringing $\overline{\text{PDN}}$ after power-up. The internal timing starts clocking by the rising edge (falling edge at mode1) of LRCK upon exiting from reset.

SYSTEM DESIGN

Figure 4 shows the system connection diagram. An evaluation board is available which demonstrates application circuits, the optimum layout, power supply arrangements and measurement results.

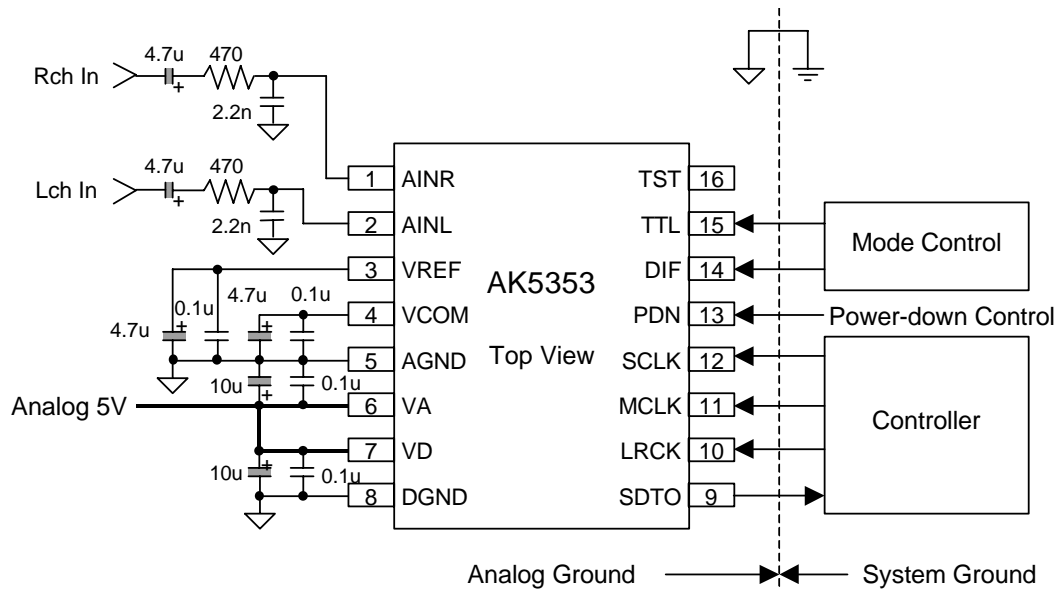


Figure 4. Typical Connection Diagram

Note: The value of electrolytic capacitor at VCOM depends on the low-frequency noise of power supply.

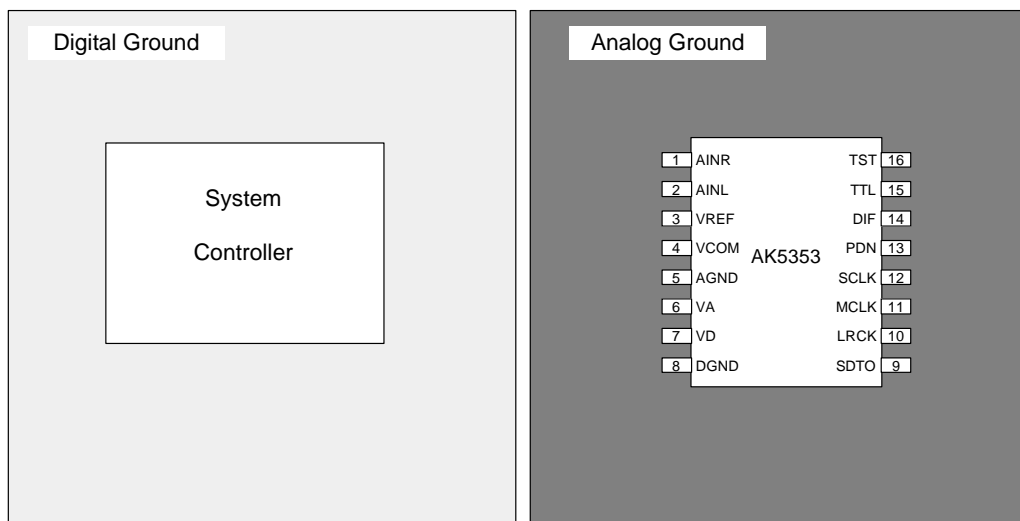


Figure 5. Ground Layout

Note: AGND and DGND must be connected to the same analog ground plane.

1. Grounding and Power Supply decoupling

The AK5353 requires careful attention to power supply and grounding arrangements. VA and VD are usually supplied from analog supply in system. Alternatively if VA and VD are supplied separately, the power up sequence is not critical. **AGND and DGND of the AK5353 must be connected to analog ground plane.** System analog ground and digital ground should be connected together near to where the supplies are brought onto the printed circuit board. Decoupling capacitors should be as near to the AK5353 as possible, with the small value ceramic capacitor being the nearest.

2. On-chip voltage reference

The voltage input to VA sets the analog input range. VREF and VCOM are 55% VA and normally connected to VA with a 0.1uF ceramic capacitor. An electrolytic capacitor 10uF parallel with a 0.1uF ceramic capacitor attached to VREF and VCOM pins eliminates the effects of high frequency noise. No load current may be drawn from these pins. All signals, especially clocks, should be kept away from the VREF and VCOM pins in order to avoid unwanted coupling into the AK5353.

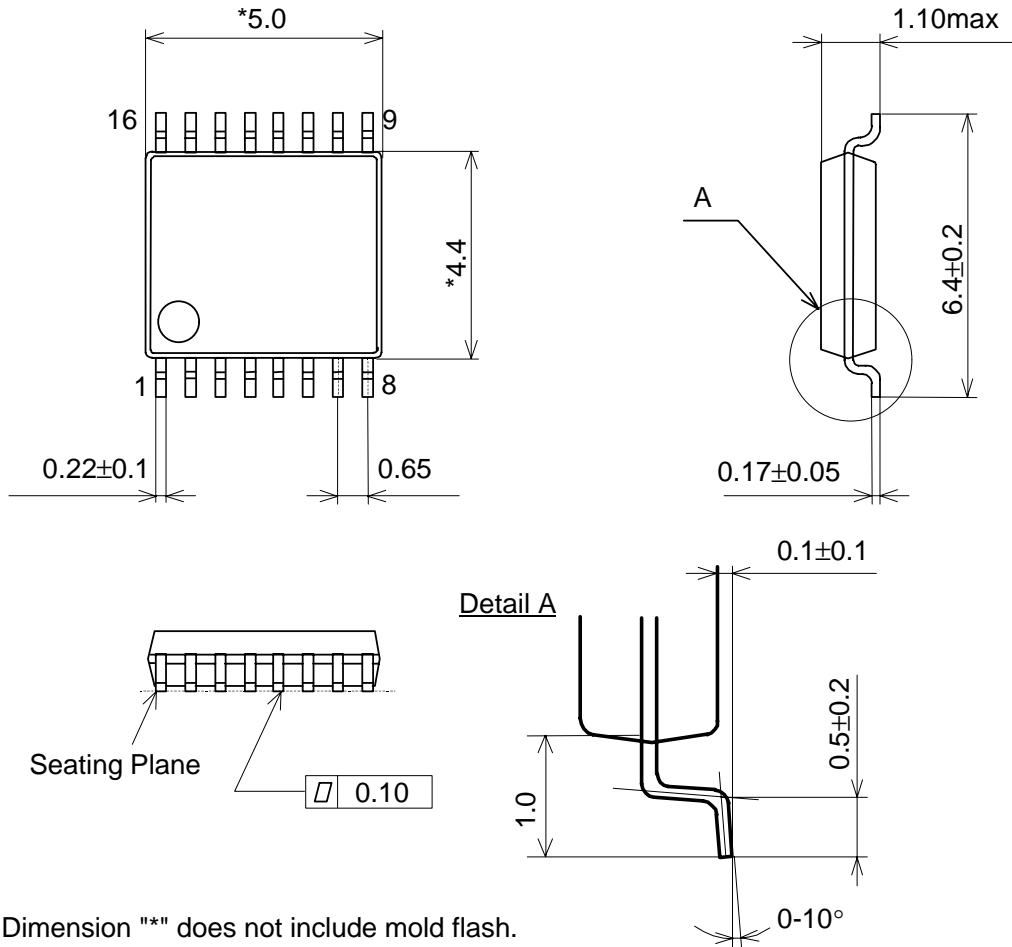
3. Analog Inputs

The ADC inputs are single-ended and internally biased to the common voltage (55%VA) with 100kΩ (typ) resistance. The input signal range scales with the supply voltage and nominally 0.6xVA Vpp. The ADC output data format is 2's complement. The output code is 7FFFFFFH(@24bit) for input above a positive full scale and 800000H(@24bit) for input below a negative full scale. The ideal code is 000000H(@24bit) with no input signal. The DC offset is removed by the internal HPF.

The AK5353 samples the analog inputs at 64fs. The digital filter rejects noise above the stop band except for multiples of 64fs. A simple RC filter (fc=150kHz) may be used to attenuate any noise around 64fs and most audio signals do not have significant energy at 64fs.

PACKAGE

16pin TSSOP (Unit: mm)

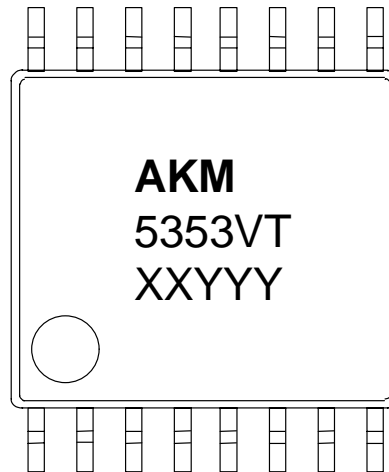


NOTE: Dimension "*" does not include mold flash.

■ Package & Lead frame material

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

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



- 1) Pin #1 indication
- 2) Date Code : XXYYY (5 digits)
 XX: lot#
 YYY: Date Code
- 3) Marketing Code : 5353VT
- 4) Asahi Kasei Logo

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