

|                                                                                   |                                    |
|-----------------------------------------------------------------------------------|------------------------------------|
|  | <h1 style="margin: 0;">AK4223</h1> |
| <h2 style="margin: 0;">6:2 Audio Switch and 6:2 Video Switch</h2>                 |                                    |

|                            |
|----------------------------|
| <b>GENERAL DESCRIPTION</b> |
|----------------------------|

The AK4223 is an AV switch with 6:2 audio and 6:2 video switches. High performances with low power consumption are achieved by CMOS process. Integrated differential input circuits in audio and video blocks can separate the external ground noise. In audio block, a differential input circuit, audio LPF and 0dB/-6dB gain amplifier are integrated eliminating the needs for external LPF for audio outputs. In video block, an input clamp circuit, 6dB amplifier and video driver are integrated, and they also eliminate the need for external circuits. The AK4223 is offered in a space saving small 48-pin LQFP package, ideal for car navigation applications.

|                 |
|-----------------|
| <b>FEATURES</b> |
|-----------------|

**1. Audio Section**

- Selector with 6 inputs and 2 outputs
- Differential Input Circuit for Ground Noise Canceling
- LPF Circuit for Audio signals
- Output Gain Control: 0dB ~ - 6dB, -1dB Step
- S/(N+D): 90dB (@0dBV)
- Dynamic Range: 94dB
- Channel-Independent Mute Function

**2. Video Section**

- Selector with 6 inputs and 2 outputs
- Six Composite Signal Inputs
- On-Chip Sync-tip Clamp Circuit
- Video Drivers for Composite Signal Output (+6dB/+3dB/0dB/-3dB)
- Output Gain Control: -1dB ~ +1dB, 0.1dB Step
- LPF Circuit for Video signals (Bandwidth: 6MHz)
- S/N: 65dB
- Channel-Independent Mute Function

**3. Control Section**

- Serial  $\mu$ P I/F (I<sup>2</sup>C)

**4. Power Supply: 7.5V ~ 9.5V****5. Ta = -40 ~ 85 °C****6. Package: 48pin LQFP**

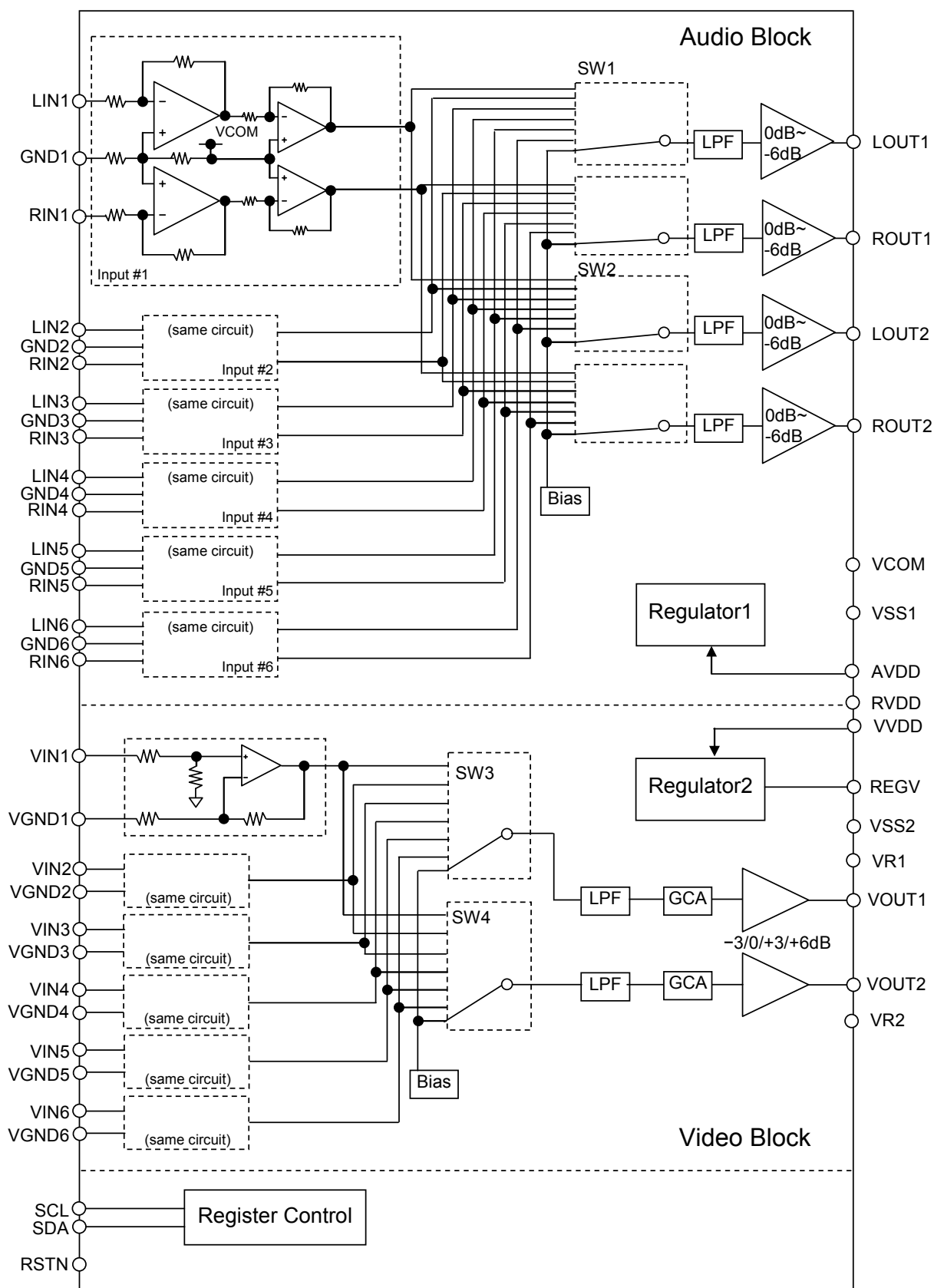


Figure 1. AK4223 Block Diagram



## PIN/FUNCTION

| No. | Pin Name | I/O | Function                                                                                                                                                            |
|-----|----------|-----|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1   | VIN6     | I   | Video Signal Input Pin 6.                                                                                                                                           |
| 2   | VGND5    | I   | Video GND Input Pin 5.                                                                                                                                              |
| 3   | VIN5     | I   | Video Signal Input Pin 5.                                                                                                                                           |
| 4   | VGND4    | I   | Video GND Input Pin 4.                                                                                                                                              |
| 5   | VIN4     | I   | Video Signal Input Pin 4.                                                                                                                                           |
| 6   | VGND3    | I   | Video GND Input Pin 3.                                                                                                                                              |
| 7   | VIN3     | I   | Video Signal Input Pin 3.                                                                                                                                           |
| 8   | VGND2    | I   | Video GND Input Pin 2.                                                                                                                                              |
| 9   | VIN2     | I   | Video Signal Input Pin 2.                                                                                                                                           |
| 10  | VGND1    | I   | Video GND Input Pin 1.                                                                                                                                              |
| 11  | VIN1     | I   | Video Signal Input Pin 1.                                                                                                                                           |
| 12  | VR2      | O   | Video Signal Clamp Reference Pin 2.<br>Normally connected to VSS2 with a 0.1μF capacitor.                                                                           |
| 13  | VOUT2    | O   | Video Signal Output Pin 2.                                                                                                                                          |
| 14  | VOUT1    | O   | Video Signal Output Pin 1.                                                                                                                                          |
| 15  | VR1      | O   | Video Signal Clamp Reference Pin 1.<br>Normally connected to VSS2 with a 0.1μF capacitor.                                                                           |
| 16  | REGV     | O   | Regulator Output Pin for the power supply of Video Core Circuit. 5.0V (typ)<br>For stability of the regulator, this pin must connect to VSS2 with a 10μF capacitor. |
| 17  | RSTN     | I   | Reset Mode Pin<br>“L”: Reset mode (All registers are initialized to their default values.)<br>“H”: Normal operation                                                 |
| 18  | VVDD     | -   | Power Supply Pin: 7.5V~9.5V                                                                                                                                         |
| 19  | AVDD     | -   | Power Supply Pin: 7.5V~9.5V                                                                                                                                         |
| 20  | RVDD     | -   | Power Supply Pin: 7.5V~9.5V                                                                                                                                         |
| 21  | ROUT2    | O   | Audio Signal Output Pin ROUT 2.                                                                                                                                     |
| 22  | LOUT2    | O   | Audio Signal Output Pin LOUT 2.                                                                                                                                     |
| 23  | ROUT1    | O   | Audio Signal Output Pin ROUT 1.                                                                                                                                     |
| 24  | LOUT1    | O   | Audio Signal Output Pin LOUT 1.                                                                                                                                     |
| 25  | RIN6     | I   | Audio Signal Input Pin RIN 6.                                                                                                                                       |
| 26  | GND6     | I   | Audio GND Input Pin GND 6.                                                                                                                                          |
| 27  | LIN6     | I   | Audio Signal Input Pin LIN 6.                                                                                                                                       |
| 28  | RIN5     | I   | Audio Signal Input Pin RIN 5.                                                                                                                                       |
| 29  | GND5     | I   | Audio GND Input Pin GND 5.                                                                                                                                          |
| 30  | LIN5     | I   | Audio Signal Input Pin LIN 5.                                                                                                                                       |
| 31  | RIN4     | I   | Audio Signal Input Pin RIN 4.                                                                                                                                       |
| 32  | GND4     | I   | Audio GND Input Pin GND 4.                                                                                                                                          |
| 33  | LIN4     | I   | Audio Signal Input Pin LIN 4.                                                                                                                                       |
| 34  | RIN3     | I   | Audio Signal Input Pin RIN 3.                                                                                                                                       |
| 35  | GND3     | I   | Audio GND Input Pin GND 3.                                                                                                                                          |
| 36  | LIN3     | I   | Audio Signal Input Pin LIN 3.                                                                                                                                       |
| 37  | VSS1     | -   | Audio Ground Pin                                                                                                                                                    |
| 38  | RIN2     | I   | Audio Signal Input Pin RIN 2.                                                                                                                                       |
| 39  | GND2     | I   | Audio GND Input Pin GND 2.                                                                                                                                          |
| 40  | LIN2     | I   | Audio Signal Input Pin LIN 2.                                                                                                                                       |

## PIN/FUNCTION (Continued)

| No. | Pin Name | I/O | Function                                                                                 |
|-----|----------|-----|------------------------------------------------------------------------------------------|
| 41  | RIN1     | I   | Audio Signal Input Pin RIN 1.                                                            |
| 42  | GND1     | I   | Audio GND Input Pin GND 1.                                                               |
| 43  | LIN1     | I   | Audio Signal Input Pin LIN 1.                                                            |
| 44  | VCOM     | O   | Audio VCOM Voltage Pin.<br>Normally connected to VSS1 with a 1μF electrolytic capacitor. |
| 45  | SDA      | I/O | Control Data Pin.                                                                        |
| 46  | SCL      | I   | Control Data Clock Pin.                                                                  |
| 47  | VSS2     | -   | Video Ground Pin.                                                                        |
| 48  | VGND6    | I   | Video GND Input Pin 6.                                                                   |

### ■ Handling of Unused Pin

The unused I/O pins should be processed appropriately as below.

| Classification       | Pin Name                  | Setting                               |
|----------------------|---------------------------|---------------------------------------|
| Audio Inputs         | LIN1-6, RIN1-6, GND1-6    | These pins must be open.              |
| Video Input          | VIN1-6, VGND1-6           | These pins must be connected to VSS2. |
| Audio, Video Outputs | LOUT1-2, ROUT1-2, VOUT1-2 | These pins must be open.              |

**ABSOLUTE MAXIMUM RATINGS**(VSS1=VSS2 =0V; [Note 1](#))

| Parameter                                    | Symbol               | min  | max      | Unit |
|----------------------------------------------|----------------------|------|----------|------|
| Power Supply                                 | AVDD<br>VVDD<br>RVDD | -0.3 | +14.0    | V    |
| Input Current (any pins except for supplies) | IIN                  | -    | ±10      | mA   |
| Audio Input Voltage                          | VINA                 | -0.3 | AVDD+0.3 | V    |
| Video Input Voltage                          | VINV                 | -0.3 | 5.5      | V    |
| Digital Input Voltage                        | VIND                 | -0.3 | 5.5      | V    |
| Ambient Operating Temperature                | Ta                   | -40  | 85       | °C   |
| Storage Temperature                          | Tstg                 | -65  | 150      | °C   |

Note 1. All voltages with respect to ground.

Note 2. VSS1 and VSS2 must be connected to the same analog ground plane.

Note 3. AVDD and RVDD must be the same voltage.

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**

(VSS1=VSS2 = 0V)

| Parameter    | Symbol               | min | typ | max | Unit |
|--------------|----------------------|-----|-----|-----|------|
| Power Supply | AVDD<br>VVDD<br>RVDD | 7.5 | 9.0 | 9.5 | V    |

Note 3. AVDD and RVDD must be the same voltage.

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

**ELECTRICAL CHARACTERISTICS**

(Ta=25°C; AVDD= RVDD= VVDD= 9.0V; VSS1= VSS2 = 0V)

| <b>Power Supplies</b>                                         |     |     |     |      |
|---------------------------------------------------------------|-----|-----|-----|------|
| Parameter                                                     | min | typ | max | Unit |
| Power Supply (AVDD+RVDD+VVDD)                                 |     |     |     |      |
| Normal Operation ( <a href="#">Note 4</a> ), (RSTN pin = “H”) |     | 33  | 50  | mA   |
| Power-Down Mode ( <a href="#">Note 5</a> ), (RSTN pin = “L”)  |     | 2.1 | 3.1 | μA   |

Note 4. No input, No load.

Note 5. This is the value without analog inputs when all digital input pins are fixed to VSS1 or VSS2.

**ANALOG CHARACTERISTICS (Audio)**

(Ta=25°C; AVDD= RVDD= VVDD= 9.0V; VSS1=VSS2= 0V; Signal Frequency=1kHz, Measurement Frequency= 20Hz~20kHz, unless otherwise specified)

| Parameter                                          | Conditions               | min  | typ  | max  | Unit   |
|----------------------------------------------------|--------------------------|------|------|------|--------|
| S/(N+D) (Note 6)                                   | Input=0dBV               | 82   | 90   |      | dB     |
| DR (0dBV reference) (Note 6)                       | Input=-60dBV, A-weighted | 88   | 94   |      | dB     |
| S/N (0dBV reference) (Note 6)                      | A-weighted               | 88   | 94   |      | dB     |
| Input Impedance                                    |                          | 70   | 100  |      | kΩ     |
| Input Voltage (Note 7)                             |                          |      |      | 2    | Vrms   |
| Gain                                               | 0dB                      | -0.4 | 0    | +0.4 | dB     |
|                                                    | -6dB                     | -6.4 | -6.0 | -5.6 | dB     |
| AGCA step (Note 6)                                 |                          | -    | 1.0  | -    | dB     |
| Interchannel Isolation (Note 8)                    |                          | -    | 100  |      | dB     |
| LPF Frequency Response<br>Input=1Vrms, 0dB at 1kHz | Response at 24kHz        | -2   | -0.5 | -    | dB     |
|                                                    | Response at 96kHz        | -    | -24  | -    | dB     |
| Interchannel Gain Mismatch                         |                          |      | 0.2  | -    | dB     |
| Gain Drift                                         |                          |      | 20   | -    | ppm/°C |
| Load Resistance (Note 9)                           | R1 (Figure 2)            | 300  |      |      | Ω      |
|                                                    | R1+R2 (Figure 2)         | 5    |      |      | kΩ     |
| Load Capacitance                                   | C1 (Figure 2)            |      |      | 1.5  | nF     |
|                                                    | C2 (Figure 2)            |      |      | 30   | pF     |
| Power Supply Rejection                             | (Note 10)                | -    | 74   |      | dB     |
| CMRR                                               | f=1kHz, 1Vp-p input      | 35   | 45   |      | dB     |

Note 6. This is a value when AGCA=0dB.

Note 7. The Input Voltage meets S/(N+D)>82dB.

Note 8. Between all channels of LIN1-6 and RIN1-6.

Note 9. The output resistance of audio output (LOUT1-2 and ROUT1-2) are less than 10Ω (typ).

Note 10. Applied to AVDD, RVDD and VVDD with a sine wave (1kHz, 50mVpp).

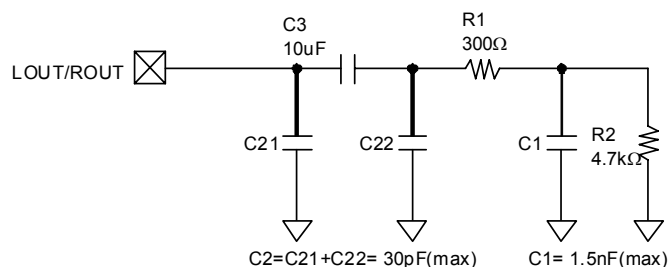


Figure 2. Load Resistance R1, R2 and Load Capacitance C1, C2

**ANALOG CHARACTERISTICS (Video)**

(Ta = 25°C; AVDD= RVDD= VVDD= 9.0V; VSS1= VSS2 = 0V; VGAIN= +6dB, VGCA=0dB; VR1/2 bit="0"; unless otherwise specified.)

| Parameter                                                       | Conditions                                                                      |      | min  | typ  | max    | Unit |
|-----------------------------------------------------------------|---------------------------------------------------------------------------------|------|------|------|--------|------|
| Sync tip clamp level<br>(Note 11)                               | VGAIN=+3dB, +6dB                                                                |      |      |      | 200    | mV   |
|                                                                 | VGAIN=-3dB, 0dB                                                                 |      |      |      | 500    | mV   |
| Gain<br>Input=0.3Vp-p, 100kHz                                   | VGCA=+1dB                                                                       | 6dB  | -    | 7    | -      | dB   |
|                                                                 |                                                                                 | 3dB  | -    | 4    | -      | dB   |
|                                                                 |                                                                                 | 0dB  | -    | 1    | -      | dB   |
|                                                                 |                                                                                 | -3dB | -    | -2   | -      | dB   |
|                                                                 | VGCA=0dB                                                                        | 6dB  | 5.6  | 6    | 6.4    | dB   |
|                                                                 |                                                                                 | 3dB  | 2.6  | 3    | 3.4    | dB   |
|                                                                 |                                                                                 | 0dB  | -0.4 | 0    | 0.4    | dB   |
|                                                                 |                                                                                 | -3dB | -3.4 | -3   | -2.6   | dB   |
|                                                                 | VGCA=-1dB                                                                       | 6dB  | -    | 5    | -      | dB   |
|                                                                 |                                                                                 | 3dB  | -    | 2    | -      | dB   |
|                                                                 |                                                                                 | 0dB  | -    | -1   | -      | dB   |
|                                                                 |                                                                                 | -3dB | -    | -4   | -      | dB   |
| VGCA step                                                       |                                                                                 | -    | 0.1  | -    | dB     |      |
| Frequency Response<br>Input=0.3Vpp, Sin Wave<br>(0dB at 100kHz) | Response at 6MHz                                                                | -1.0 |      | +1.0 | dB     |      |
|                                                                 | Response at 27MHz                                                               | -    | -35  | -    | dB     |      |
| Group Delay Distortion                                          | GD3MHz – GD6MHz                                                                 |      | 10   | 40   | ns     |      |
| Input Impedance                                                 |                                                                                 |      | 300  |      | kΩ     |      |
| Input Signal                                                    |                                                                                 |      |      | 1.5  | Vpp    |      |
| Inter channel Isolation                                         | f=4.43MHz, 1Vpp input                                                           | -    | 52   |      | dB     |      |
| S/N                                                             | Reference Level = 0.7Vp-p,<br>BW= 100kHz to 6MHz.                               | -    | 65   |      | dB     |      |
| Differential Gain                                               | 0.7Vpp 5steps modulated staircase.<br>Chrominance & burst are 280mVpp, 4.43MHz. |      | +0.4 | -    | %      |      |
| Differential Phase                                              | 0.7Vpp 5steps modulated staircase.<br>Chrominance & burst are 280mVpp, 4.43MHz. |      | +1   | -    | Degree |      |
| Load Resistance                                                 | VR1/2 bit = “0”, R1+R2 (Figure 4)                                               | 140  | 150  | 160  | Ω      |      |
|                                                                 | VR1/2 bit = “1”, R1 (Figure 5)                                                  | 100  | -    | -    | kΩ     |      |
| Load Capacitance                                                | VR1/2 bit = “0”, (Figure 4)<br>C1                                               |      |      | 1.5  | nF     |      |
|                                                                 | C2                                                                              |      |      | 15   | pF     |      |
|                                                                 | VR1/2 bit = “1”, (Figure 5)<br>C1+C2                                            |      |      | 15   | pF     |      |
| CMRR                                                            | f=20kHz, 1Vp-p input                                                            | 34   | 55   |      | dB     |      |

Note 11. At the measurement point A in Figure 3. Idling DC output level is 200mV(max) when VGAIN=+6dB or +3db, and 500mV(max) when VGAIN=0dB or -3dB.

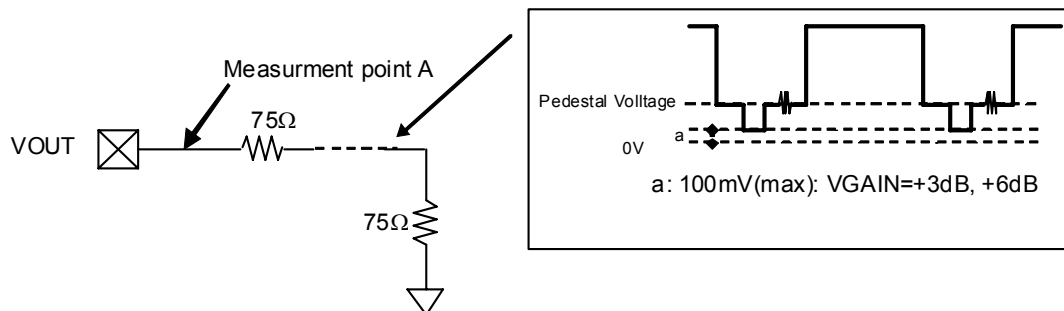


Figure 3. Measurement Point

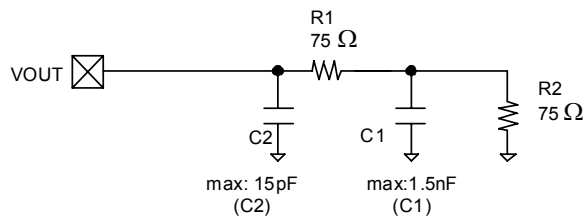


Figure 4. Load Resistance R1+R2 and Load Capacitance C1/C2 (VR1/2 bit = "0")

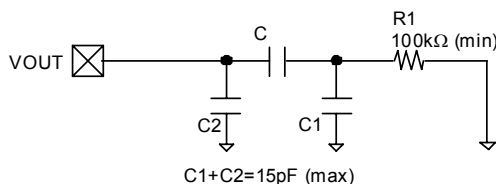


Figure 5. Load Resistance R1+R2 and Load Capacitance C1/C2 (VR1/2 bit = "1")

### DC CHARACTERISTICS

(Ta=-40~85°C; AVDD=RVDD=VVD= 7.5~9.5V)

| Parameter                                        | Symbol | min | typ | max | Unit |
|--------------------------------------------------|--------|-----|-----|-----|------|
| High-Level Input Voltage (RSTN,SCL,SDA,CAD pins) | VIH    | 2.7 | -   | 5.5 | V    |
| Low-Level Input Voltage (RSTN,SCL,SDA,CAD pins)  | VIL    | -   | -   | 0.8 | V    |
| Low-Level Output Voltage (SDA pin: Iout=3mA)     | VOL    | -   | -   | 0.4 | V    |
| Input Leakage Current                            | Iin    | -   | -   | ±10 | μA   |

### SWITCHING CHARACTERISTICS

(Ta= 25°C; AVDD =RVDD= VVD= 9.0V)

|                                                        |         |     |  |     |     |
|--------------------------------------------------------|---------|-----|--|-----|-----|
| <b>Control Interface Timing (I<sup>2</sup>C Bus)</b>   |         |     |  |     |     |
| SCL Clock Frequency                                    | fSCL    | -   |  | 400 | kHz |
| Bus Free Time Between Transmissions                    | tBUF    | 1.3 |  | -   | μs  |
| Start Condition Hold Time (prior to first clock pulse) | tHD:STA | 0.6 |  | -   | μs  |
| Clock Low Time                                         | tLOW    | 1.3 |  | -   | μs  |
| Clock High Time                                        | tHIGH   | 0.6 |  | -   | μs  |
| Setup Time for Repeated Start Condition                | tSU:STA | 0.6 |  | -   | μs  |
| SDA Hold Time from SCL Falling (Note 13)               | tHD:DAT | 0   |  | -   | μs  |
| SDA Setup Time from SCL Rising                         | tSU:DAT | 0.1 |  | -   | μs  |
| Rise Time of Both SDA and SCL Lines                    | tR      | -   |  | 0.3 | μs  |
| Fall Time of Both SDA and SCL Lines                    | tF      | -   |  | 0.3 | μs  |
| Setup Time for Stop Condition                          | tSU:STO | 0.6 |  | -   | μs  |
| Pulse Width of Spike Noise Suppressed by Input Filter  | tSP     | 0   |  | 50  | ns  |
| Capacitive load on bus                                 | Cb      | -   |  | 400 | pF  |
| <b>Power-down &amp; Reset Timing</b>                   |         |     |  |     |     |
| RSTN Reject Pulse Width                                | tRPD    |     |  | 15  | ns  |
| RSTN Pulse Width (Note 14)                             | tPD     | 150 |  |     | ns  |

Note 12. I<sup>2</sup>C-bus is a trademark of NXP B.V.

Note 13. Data must be held long enough to bridge the 300ns-transition time of SCL.

Note 14. The AK4223 can be reset by setting the RSTN pin = "L" when powered up.

■ Timing Diagram

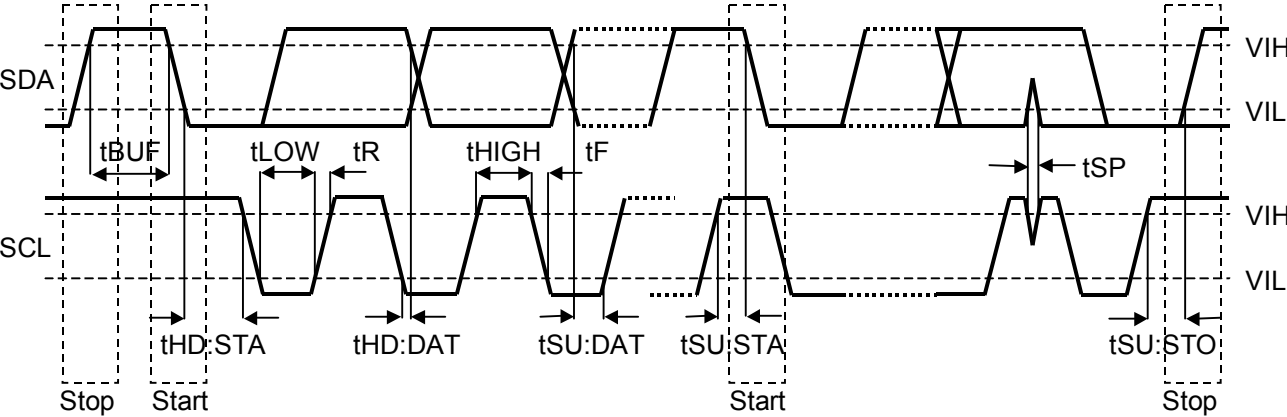


Figure 6. I²C Bus mode Timing

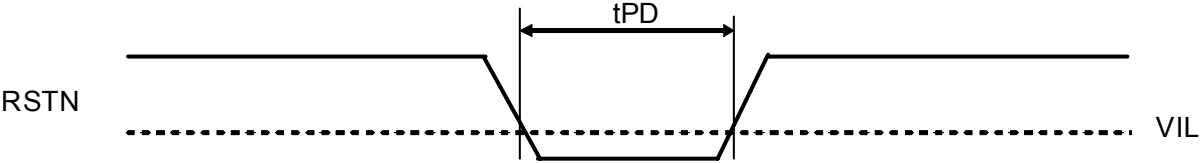


Figure 7. Reset Mode Timing

## OPERATION OVERVIEW

### ■ Power Up/Down

The AK4223 can be reset by bringing the RSTN pin = “L” upon power-up. In reset mode, internal resistors are initialized and the audio and video circuits are in power-down state outputting Hi-Z signals. The RSTN pin must be “L” to execute this reset when power up the AK4223.

### ■ Audio and Video Signal Inputs

#### 1. Audio Signal Input

The ground noise is cancelled by the differential input with the same ground for L and R channels. The output of LIN and RIN are the same phase. LIN1-6, RIN1-6 and GND1-6 pins must be AC coupled with a  $0.47\mu\text{F}$  capacitor.

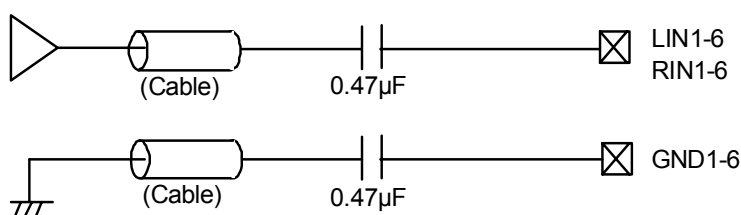


Figure 8. Audio Input Circuit (Differential)

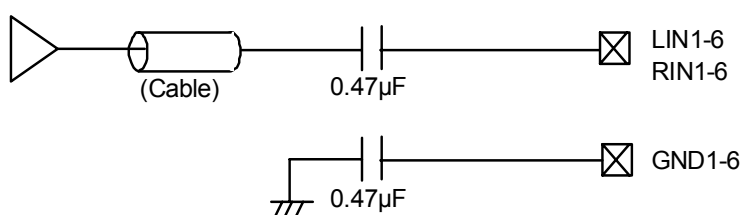


Figure 9. Audio Input Circuit (Single-ended)

#### 2. Video Signal Input

Sync-tip output level is fixed by the internal clamp circuit. VIN1-6 pins must be input via a  $0.1\mu\text{F}$  capacitor for AC coupling.

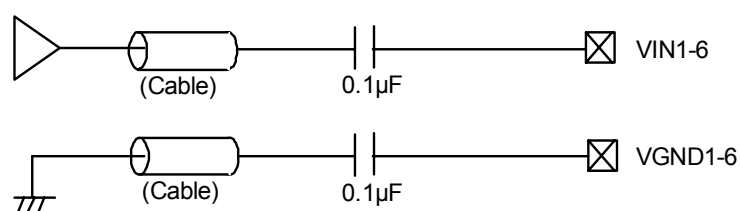


Figure 10. Video Input Circuit (Differential)

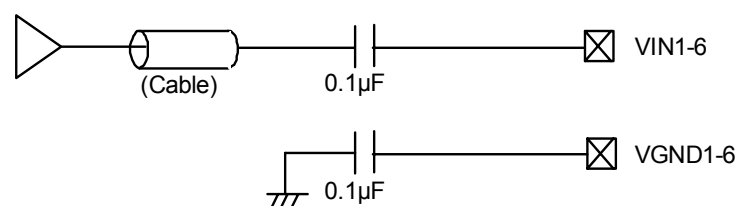


Figure 11. Video Input Circuit (Single-ended)

## ■ Input Selector

The AK4223 has 6:2 input selectors for audio input, and 6:2 input selectors for video input. The audio input selectors are set by ASEL12-10bits and ASEL22-20 bits, and the video input selectors are set by VSEL12-10bits and VSEL22-20 bits.

| ASEL12 bit | ASEL11 bit | ASEL10 bit | Input Selector                  |           |
|------------|------------|------------|---------------------------------|-----------|
| 0          | 0          | 0          | Off ( <a href="#">Note 15</a> ) | (default) |
| 0          | 0          | 1          | LIN1 / RIN1                     |           |
| 0          | 1          | 0          | LIN2 / RIN2                     |           |
| 0          | 1          | 1          | LIN3 / RIN3                     |           |
| 1          | 0          | 0          | LIN4 / RIN4                     |           |
| 1          | 0          | 1          | LIN5 / RIN5                     |           |
| 1          | 1          | 0          | LIN6 / RIN6                     |           |
| 1          | 1          | 1          | (Reserved)                      |           |

Table 1. Audio Input Selector 1 (LOUT1/ROUT1)

| ASEL22 bit | ASEL21 bit | ASEL20 bit | Input Selector                  |           |
|------------|------------|------------|---------------------------------|-----------|
| 0          | 0          | 0          | Off ( <a href="#">Note 15</a> ) | (default) |
| 0          | 0          | 1          | LIN1 / RIN1                     |           |
| 0          | 1          | 0          | LIN2 / RIN2                     |           |
| 0          | 1          | 1          | LIN3 / RIN3                     |           |
| 1          | 0          | 0          | LIN4 / RIN4                     |           |
| 1          | 0          | 1          | LIN5 / RIN5                     |           |
| 1          | 1          | 0          | LIN6 / RIN6                     |           |
| 1          | 1          | 1          | (Reserved)                      |           |

Table 2. Audio Input Selector 2 (LOUT2/ROUT2)

Note 15. The audio outputs become 3.9V(typ., Gain=0dB) when input selectors are OFF.

| VSEL12 bit | VSEL11 bit | VSEL10 bit | Input Selector                  |           |
|------------|------------|------------|---------------------------------|-----------|
| 0          | 0          | 0          | Off ( <a href="#">Note 16</a> ) | (default) |
| 0          | 0          | 1          | VIN1                            |           |
| 0          | 1          | 0          | VIN2                            |           |
| 0          | 1          | 1          | VIN3                            |           |
| 1          | 0          | 0          | VIN4                            |           |
| 1          | 0          | 1          | VIN5                            |           |
| 1          | 1          | 0          | VIN6                            |           |
| 1          | 1          | 1          | (Reserved)                      |           |

Table 3. Video Input Selector 1 (VOUT1)

| VSEL22 bit | VSEL21 bit | VSEL20 bit | Input Selector                  |           |
|------------|------------|------------|---------------------------------|-----------|
| 0          | 0          | 0          | Off ( <a href="#">Note 16</a> ) | (default) |
| 0          | 0          | 1          | VIN1                            |           |
| 0          | 1          | 0          | VIN2                            |           |
| 0          | 1          | 1          | VIN3                            |           |
| 1          | 0          | 0          | VIN4                            |           |
| 1          | 0          | 1          | VIN5                            |           |
| 1          | 1          | 0          | VIN6                            |           |
| 1          | 1          | 1          | (Reserved)                      |           |

Table 4. Video Input Selector 2 (VOUT2)

Note 16. The video outputs become sync tip level when input selectors are OFF.

## ■ Audio Output Level Setting

AGCA12-10 bits control the audio output level of the L/ROUT1 pin, and AGCA22-20 bits controls the audio output level of the L/ROUT2 pin. (Table 5, Table 6)

| AGCA12 bit | AGCA11 bit | AGCA10 bit | L/ROUT1 GAIN [dB] | Output DC Level[V typ] | STEP |
|------------|------------|------------|-------------------|------------------------|------|
| 0          | 0          | 0          | 0 (default)       | 3.9                    | 1dB  |
| 0          | 0          | 1          | -1                | 3.7                    |      |
| 0          | 1          | 0          | -2                | 3.5                    |      |
| 0          | 1          | 1          | -3                | 3.4                    |      |
| 1          | 0          | 0          | -4                | 3.2                    |      |
| 1          | 0          | 1          | -5                | 3.1                    |      |
| 1          | 1          | 0          | -6                | 3.0                    |      |
| 1          | 1          | 1          | Reserved          | -                      |      |

Table 5. L/ROUT1 Output Level Setting

| AGCA22 bit | AGCA21 bit | AGCA20 bit | L/ROUT2 GAIN [dB] | Output DC Level[V typ] | STEP |
|------------|------------|------------|-------------------|------------------------|------|
| 0          | 0          | 0          | 0 (default)       | 3.9                    | 1dB  |
| 0          | 0          | 1          | -1                | 3.7                    |      |
| 0          | 1          | 0          | -2                | 3.5                    |      |
| 0          | 1          | 1          | -3                | 3.4                    |      |
| 1          | 0          | 0          | -4                | 3.2                    |      |
| 1          | 0          | 1          | -5                | 3.1                    |      |
| 1          | 1          | 0          | -6                | 3.0                    |      |
| 1          | 1          | 1          | Reserved          | -                      |      |

Table 6. L/ROUT2 Output Level Setting

## ■ Audio Output Mute Select

The AK4223 has a channel independent mute function for audio outputs. AMUTE1/2 bits control L/ROUT1 and L/ROUT2 outputs mute. (Table 7, Table 8)

| AMUTE1 bit | L/ROUT1 Output | (default) |
|------------|----------------|-----------|
| 0          | Normal Output  |           |
| 1          | Mute           |           |

Table 7. L/ROUT1 Output Mute Control

| AMUTE2 bit | L/ROUT2 Output | (default) |
|------------|----------------|-----------|
| 0          | Normal Output  |           |
| 1          | Mute           |           |

Table 8. L/ROUT2 Output Mute Control

## ■ Video Output Level Setting

VGAIN11-10 bits control the video output level of the VOUT1 pin, and VGAIN21-20 bits control the video output level of the VOUT2 pin. (Table 9, Table 10)

| VGAIN11 bit | VGAIN10 bit | VOUT1 output Level | VOUT1 Sync Tip Level (max) | (default) |
|-------------|-------------|--------------------|----------------------------|-----------|
| 0           | 0           | +6dB               | 200mV                      |           |
| 0           | 1           | 0dB                | 500mV                      |           |
| 1           | 0           | +3dB               | 200mV                      |           |
| 1           | 1           | -3dB               | 500mV                      |           |

Table 9.VOUT1 Output Level Setting

| VGAIN21 bit | VGAIN20 bit | VOUT2 output Level | VOUT2 Sync Tip Level (max) | (default) |
|-------------|-------------|--------------------|----------------------------|-----------|
| 0           | 0           | +6dB               | 200mV                      |           |
| 0           | 1           | 0dB                | 500mV                      |           |
| 1           | 0           | +3dB               | 200mV                      |           |
| 1           | 1           | -3dB               | 500mV                      |           |

Table 10.VOUT2 Output Level Setting

VGCA14-10 bits finely tune the video output levels of VOUT1, and VGCA24-20 bits tune VOUT2. (Table 11, Table 12)

| VGCA14-10 bit | VOUT1 GAIN [dB] | STEP  |
|---------------|-----------------|-------|
| 00000         | -1.0            | 0.1dB |
| 00001         | -0.9            |       |
| 00010         | -0.8            |       |
| ⋮             | ⋮               |       |
| 01010         | 0 (default)     |       |
| ⋮             | ⋮               |       |
| 10010         | +0.8            |       |
| 10011         | +0.9            |       |
| 10100         | +1.0            |       |
| others        | Reserved        |       |

Table 11. Video Output Level (VOUT1) Fine Tuning Setting

| VGCA24-20 bit | VOUT2 GAIN [dB] | STEP  |
|---------------|-----------------|-------|
| 00000         | -1.0            | 0.1dB |
| 00001         | -0.9            |       |
| 00010         | -0.8            |       |
| ⋮             | ⋮               |       |
| 01010         | 0 (default)     |       |
| ⋮             | ⋮               |       |
| 10010         | +0.8            |       |
| 10011         | +0.9            |       |
| 10100         | +1.0            |       |
| others        | Reserved        |       |

Table 12. Video Output Level (VOUT2) Fine Tuning Setting

## ■ Video Output Driver

VR1 and VR2 bits control the video output driver of the VOUT1 and VOUT2 pins respectively. VR1 and VR2 bits should be set to “0” when driving 150Ω resistance.

| VR1 bit | VOUT1            | (default) |
|---------|------------------|-----------|
| 0       | 150Ω Drive       |           |
| 1       | min. 100kΩ Drive |           |

Table 13. VOUT1 Output Driver Setting

| VR2 bit | VOUT2            | (default) |
|---------|------------------|-----------|
| 0       | 150Ω Drive       |           |
| 1       | min. 100kΩ Drive |           |

Table 14. VOUT2 Output Driver Setting

## ■ Video Output Mute Setting

The AK4223 has a channel independent mute function of the video output. VMUTE1 and VMUTE2 bits mute (Sync tip clamp level) VOUT1 and VOUT2 outputs respectively. (Table 15, Table 16)

| VMUTE1 bit | VOUT1 Output  | (default) |
|------------|---------------|-----------|
| 0          | Normal Output |           |
| 1          | Mute          |           |

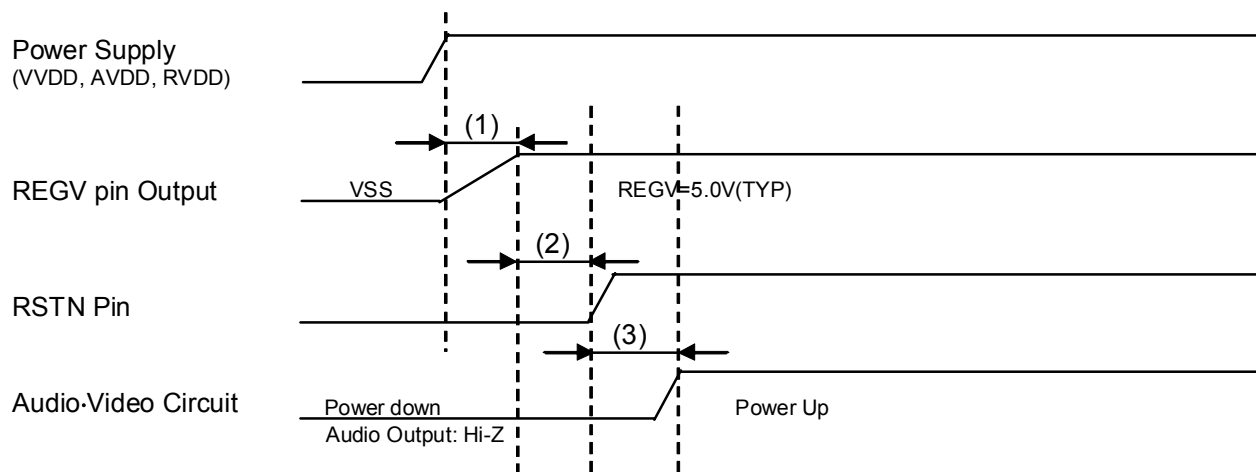
Table 15. VOUT1 Output Mute Control

| VMUTE2 bit | VOUT2 Output  | (default) |
|------------|---------------|-----------|
| 0          | Normal Output |           |
| 1          | Mute          |           |

Table 16. VOUT2 Output Mute Control

## ■ System Reset

The RSTN pin must be set to “L” when power up the AK4223. The AK4223 powers up in reset state. The REGV pin starts outputting (typ. 5.0V) when power is supplied to the device. This reset is released by setting the RSTN pin to “H”. Figure 12 shows the reset sequence.



Notes:

(1) Time that the REGV output reaches 95% of the maximum value. (typ. 800 $\mu$ s, max. 5ms)

(2) Reset Time (min. 150ns)

(3) Time to be in a normal operation after reset release. (Video Output: typ. 100ms, Audio Output: typ. 170ms)

\*The required time to be in a normal operation of audio outputs is proportional to the capacity of an external capacitor at the VCOM pin. This typical value 170ms is for when the external capacitor is 1.0 $\mu$ F.

Figure 12 System Reset Diagram

■ Control Interface

The AK4223 supports the fast-mode I<sup>2</sup>C-bus system (max: 400kHz).

2-1. WRITE Operation

Figure 13 shows the data transfer sequence for the I<sup>2</sup>C-bus mode. All commands are preceded by a START condition. A HIGH to LOW transition on the SDA line while SCL is HIGH indicates a START condition (Figure 19). After the START condition, a slave address is sent. This address is 7 bits long followed by the eighth bit that is a data direction bit (R/W). The most significant seven bits of the slave address are fixed as “0010000”. If the slave address matches that of the AK4223, the AK4223 generates an acknowledge and the operation is executed. The master must generate the acknowledge-related clock pulse and release the SDA line (HIGH) during the acknowledge clock pulse (Figure 20). A R/W bit value of “1” indicates that the read operation is to be executed. A “0” indicates that the write operation is to be executed.

The second byte consists of the control register address of the AK4223. The format is MSB first, and those most significant 3-bits are fixed to zeros (Figure 15). The data after the second byte contains control data. The format is MSB first, 8bits (Figure 16). The AK4223 generates an acknowledge after each byte has been received. A data transfer is always terminated by a STOP condition generated by the master. A LOW to HIGH transition on the SDA line while SCL is HIGH defines a STOP condition (Figure 19).

The AK4223 can perform more than one byte write operation per sequence. After receipt of the third byte the AK4223 generates an acknowledge and awaits the next data. The master can transmit more than one byte instead of terminating the write cycle after the first data byte is transferred. After receiving each data packet the internal 8-bit address counter is incremented by one, and the next data is automatically taken into the next address. If the address exceeds 06H prior to generating the stop condition, the address counter will “roll over” to 00H and the previous data will be overwritten.

The data on the SDA line must remain stable during the HIGH period of the clock. The HIGH or LOW state of the data line can only change when the clock signal on the SCL line is LOW (Figure 21) except for the START and STOP conditions.

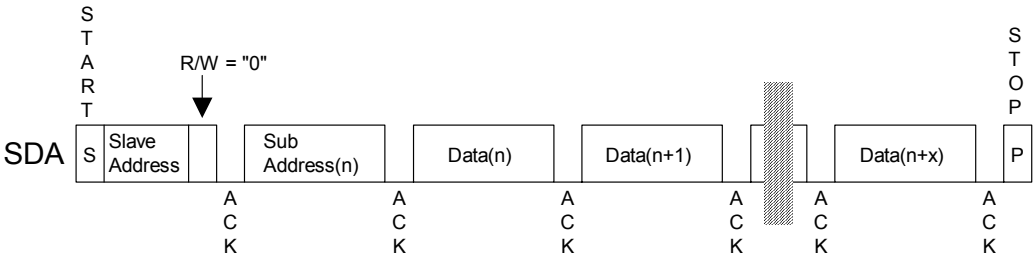


Figure 13. Data Transfer Sequence at the I<sup>2</sup>C-Bus Mode

|   |   |   |   |   |   |   |     |
|---|---|---|---|---|---|---|-----|
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | R/W |
|---|---|---|---|---|---|---|-----|

Figure 14. The First Byte

|   |   |   |   |   |    |    |    |
|---|---|---|---|---|----|----|----|
| 0 | 0 | 0 | 0 | 0 | A2 | A1 | A0 |
|---|---|---|---|---|----|----|----|

Figure 15. The Second Byte

|    |    |    |    |    |    |    |    |
|----|----|----|----|----|----|----|----|
| D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|----|----|----|----|----|----|----|----|

Figure 16. Byte Structure after the second byte

## 2-2. READ Operations

Set the R/W bit = "1" for the READ operation of the AK4223. After transmission of data, the master can read the next address's data by generating an acknowledge instead of terminating the write cycle after the receipt of the first data word. After receiving each data packet the internal 5-bit address counter is incremented by one, and the next data is automatically taken into the next address. If the address exceeds 06H prior to generating a stop condition, the address counter will "roll over" to 00H and the previous data will be overwritten.

The AK4223 supports two basic read operations: CURRENT ADDRESS READ and RANDOM ADDRESS READ.

### 2-2-1. CURRENT ADDRESS READ

The AK4223 contains an internal address counter that maintains the address of the last word accessed, incremented by one. Therefore, if the last access (either a read or write) were to address "n", the next CURRENT READ operation would access data from the address "n+1". After receipt of the slave address with R/W bit set to "1", the AK4223 generates an acknowledge, transmits 1-byte of data to the address set by the internal address counter and increments the internal address counter by 1. If the master does not generate an acknowledge to the data but instead generates a stop condition, the AK4223 ceases transmission.

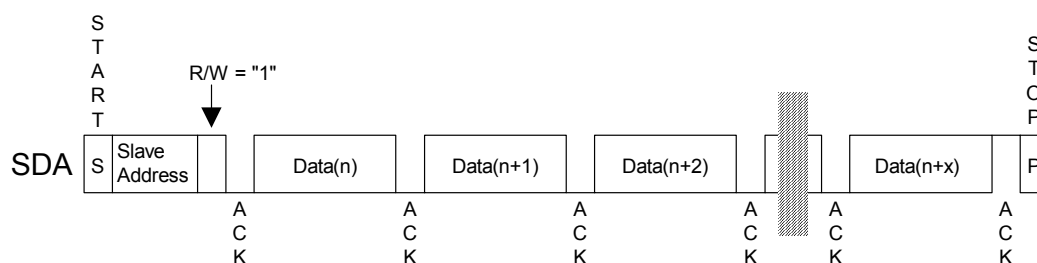


Figure 17. CURRENT ADDRESS READ

### 2-2-2. RANDOM ADDRESS READ

The random read operation allows the master to access any memory location at random. Prior to issuing the slave address with the R/W bit set to "1", the master must first perform a "dummy" write operation. The master issues a start request, a slave address (R/W bit = "0") and then the register address to read. After the register address is acknowledged, the master immediately reissues the start request and the slave address with the R/W bit set to "1". The AK4223 then generates an acknowledge, 1 byte of data and increments the internal address counter by 1. If the master does not generate an acknowledge to the data but instead generates a stop condition, the AK4223 ceases transmission.

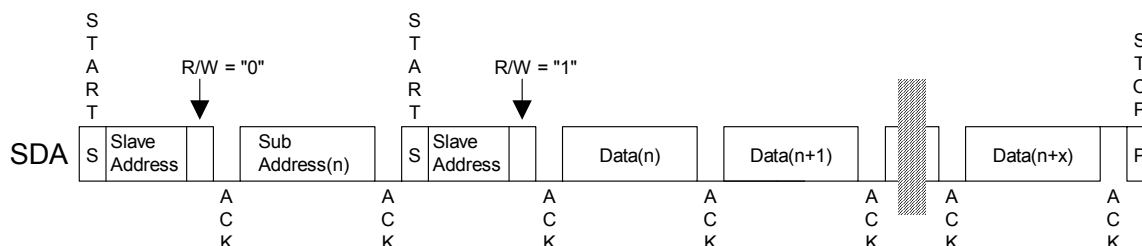


Figure 18. RANDOM ADDRESS READ

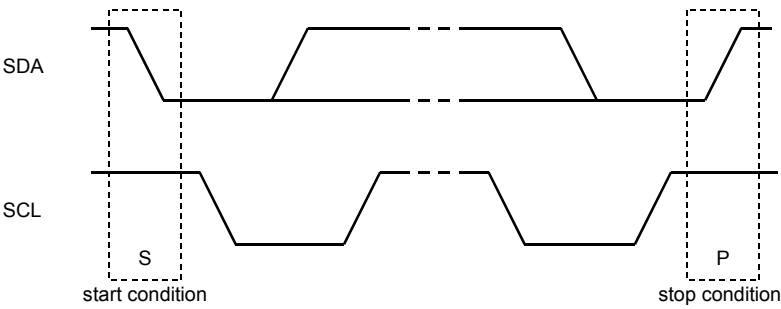


Figure 19. START and STOP Conditions

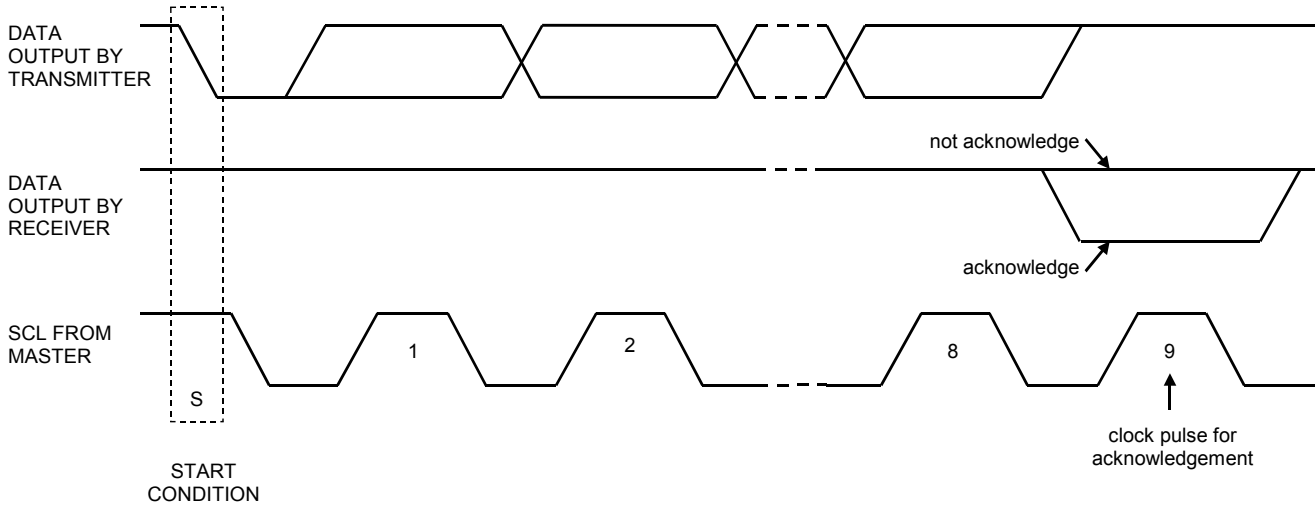


Figure 20. Acknowledge on the I<sup>2</sup>C-Bus

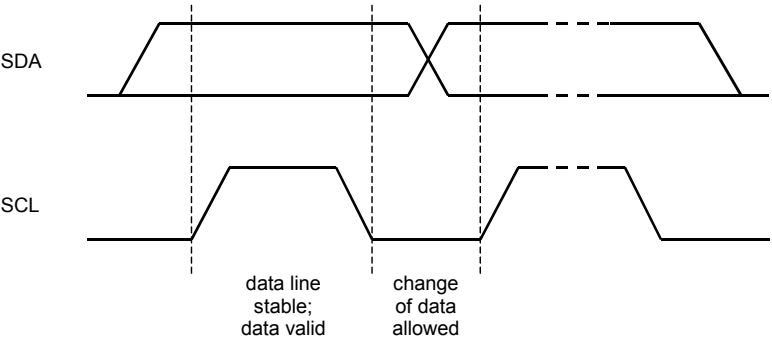


Figure 21. Bit Transfer on the I<sup>2</sup>C-Bus

## ■ Register Map

| Addr | Register Name           | D7 | D6     | D5     | D4     | D3      | D2      | D1      | D0      |
|------|-------------------------|----|--------|--------|--------|---------|---------|---------|---------|
| 00H  | Control                 | 0  | 0      | VMUTE2 | VMUTE1 | 0       | 0       | AMUTE2  | AMUTE1  |
| 01H  | Input Selector Control1 | 0  | ASEL22 | ASEL21 | ASEL20 | 0       | ASEL12  | ASEL11  | ASEL10  |
| 02H  | Input Selector Control2 | 0  | VSEL22 | VSEL21 | VSEL20 | 0       | VSEL12  | VSEL11  | VSEL10  |
| 03H  | Output Level Control1   | 0  | AGCA22 | AGCA21 | AGCA20 | 0       | AGCA12  | AGCA11  | AGCA10  |
| 04H  | Output Level Control2   | 0  | VR2    | VR1    | 0      | VGAIN21 | VGAIN20 | VGAIN11 | VGAIN10 |
| 05H  | Output Level Control3   | 0  | 0      | 0      | VGCA14 | VGCA13  | VGCA12  | VGCA11  | VGCA10  |
| 06H  | Output Level Control4   | 0  | 0      | 0      | VGCA24 | VGCA23  | VGCA22  | VGCA21  | VGCA20  |

Note: Do not write any data to the register over 07H.

When the PDN pin changes to “L”, the registers are initialized to their default values.

The bits defined as 0 must contain a “0” value.

## ■ Register Definitions

| Addr | Register Name | D7 | D6 | D5     | D4     | D3 | D2 | D1     | D0     |
|------|---------------|----|----|--------|--------|----|----|--------|--------|
| 00H  | Control       | 0  | 0  | VMUTE2 | VMUTE1 | 0  | 0  | AMUTE2 | AMUTE1 |
|      | Default       | 0  | 0  | 0      | 0      | 0  | 0  | 0      | 0      |

AMUTE2-1: Audio Output Mute Control ([Table 7](#), [Table 8](#))

0: Normal Operation (default)

1: Mute

VMUTE2-1: Video Output Mute Control ([Table 15](#), [Table 16](#))

0: Normal Operation (default)

1: Mute

| Addr | Register Name           | D7 | D6     | D5     | D4     | D3 | D2     | D1     | D0     |
|------|-------------------------|----|--------|--------|--------|----|--------|--------|--------|
| 01H  | Input Selector Control1 | 0  | ASEL22 | ASEL21 | ASEL20 | 0  | ASEL12 | ASEL11 | ASEL10 |
|      | Default                 | 0  | 0      | 0      | 0      | 0  | 0      | 0      | 0      |

ASEL12-10: Audio Input Selector 1 Control ([Table 1](#))

The LOUT1/ROUT2 pin outputs 3.9V (typ., Gain=0dB) at the default setting “000”.

ASEL22-20: Audio Input Selector 2 Control ([Table 2](#))

The LOUT2/ROUT2 pin outputs 3.9V (typ., Gain=0dB) at the default setting “000”.

| Addr | Register Name           | D7 | D6     | D5     | D4     | D3 | D2     | D1     | D0     |
|------|-------------------------|----|--------|--------|--------|----|--------|--------|--------|
| 02H  | Input Selector Control2 | 0  | VSEL22 | VSEL21 | VSEL20 | 0  | VSEL12 | VSEL11 | VSEL10 |
|      | Default                 | 0  | 0      | 0      | 0      | 0  | 0      | 0      | 0      |

VSEL12-10: Video Input Selector 1 Control ([Table 3](#))

The video output is sync tip clamp level at the default setting “000”.

VSEL22-20: Video Input Selector 2 Control ([Table 4](#))

The video output is sync tip clamp level at the default setting “000”.

| Addr | Register Name         | D7 | D6     | D5     | D4     | D3 | D2     | D1     | D0     |
|------|-----------------------|----|--------|--------|--------|----|--------|--------|--------|
| 03H  | Output Level Control1 | 0  | AGCA22 | AGCA21 | AGCA20 | 0  | AGCA12 | AGCA11 | AGCA10 |
|      | Default               | 0  | 0      | 0      | 0      | 0  | 0      | 0      | 0      |

AGCA11-10: Audio Output L/ROUT1 Level Control ([Table 5](#))

000: 0dB (default)

001: -1dB

010: -2dB

...

110: -6dB

111: Reserved

AGCA21-20: Audio Output L/ROUT2 Level Control ([Table 6](#))

000: 0dB (default)

001: -1dB

010: -2dB

...

110: -6dB

111: Reserved

| Addr | Register Name         | D7 | D6  | D5  | D4 | D3      | D2      | D1      | D0      |
|------|-----------------------|----|-----|-----|----|---------|---------|---------|---------|
| 04H  | Output Level Control2 | 0  | VR2 | VR1 | 0  | VGAIN21 | VGAIN20 | VGAIN11 | VGAIN10 |
|      | Default               | 0  | 0   | 0   | 0  | 0       | 0       | 0       | 0       |

VGAIN11-10: Video Output1 Level Control ([Table 9](#))

00: +6dB (default)

01: 0dB

10: +3dB

11: -3dB

VGAIN21-20: Video Output2 Level Control ([Table 10](#))

00: +6dB (default)

01: 0dB

10: +3dB

11: -3dB

VR1: Video Output1 Load Resistance

0: Drive 150Ω (default)

1: Drive 100kΩ (min)

VR2: Video Output2 Load Resistance

0: Drive 150Ω (default)

1: Drive 100kΩ (min)

| Addr | Register Name         | D7 | D6 | D5 | D4     | D3     | D2     | D1     | D0     |
|------|-----------------------|----|----|----|--------|--------|--------|--------|--------|
| 05H  | Output Level Control3 | 0  | 0  | 0  | VGCA14 | VGCA13 | VGCA12 | VGCA11 | VGCA10 |
|      | Default               | 0  | 0  | 0  | 0      | 1      | 0      | 1      | 0      |

VGCA14-10: Video Output1 Level Control ([Table 11](#))

The video output is +6dB (when VGAIN11-10 bits = “00”), 0dB (when VGAIN11-10 bits = “01”), +3dB (when VGAIN11-10 bits=“10”) and -3dB (when VGAIN11-10 bits = “11”) at the default setting “01010”.

| Addr | Register Name         | D7 | D6 | D5 | D4     | D3     | D2     | D1     | D0     |
|------|-----------------------|----|----|----|--------|--------|--------|--------|--------|
| 06H  | Output Level Control4 | 0  | 0  | 0  | VGCA24 | VGCA23 | VGCA22 | VGCA21 | VGCA20 |
|      | Default               | 0  | 0  | 0  | 0      | 1      | 0      | 1      | 0      |

VGCA24-20: Video Output2 Level Control ([Table 12](#))

The video output is +6dB (when VGAIN21-20 bits = “00”), 0dB (when VGAIN21-20 bits = “01”), +3dB (when VGAIN21-20 bits=“10”) and -3dB (when VGAIN21-20 bits = “11”) at the default setting “01010”.

## SYSTEM DESIGN

Figure 22 shows a system connection diagram. An evaluation board [AKD4223] is available which demonstrates the optimum layout, power supply arrangements and measurement results.

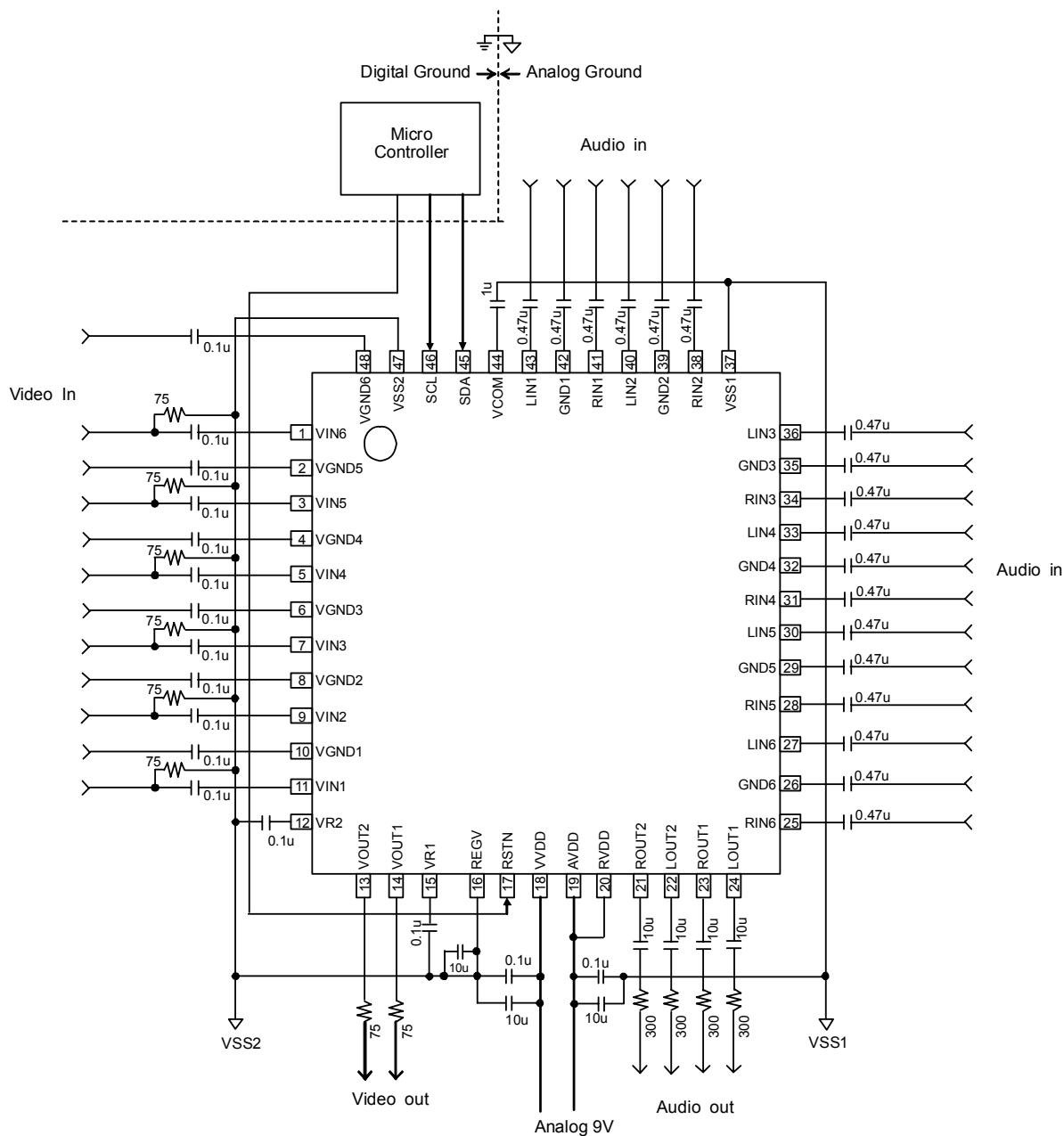


Figure 22. Typical Connection Diagram

## 1. Grounding and Power Supply Decoupling

The AK4223 requires careful attention to power supply and grounding arrangements. AVDD, VVDD and RVDD are usually supplied from the analog power supply in the system. Alternatively if AVDD, VVDD and RVDD are supplied separately, AVDD and RVDD must be powered-up at the same time. The power up sequence between AVDD/RVDD and VVDD is not critical. VSS1 and VSS2 must be connected to the 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 close to the power supply pin of AK4223 as possible.

## 2. Voltage Reference

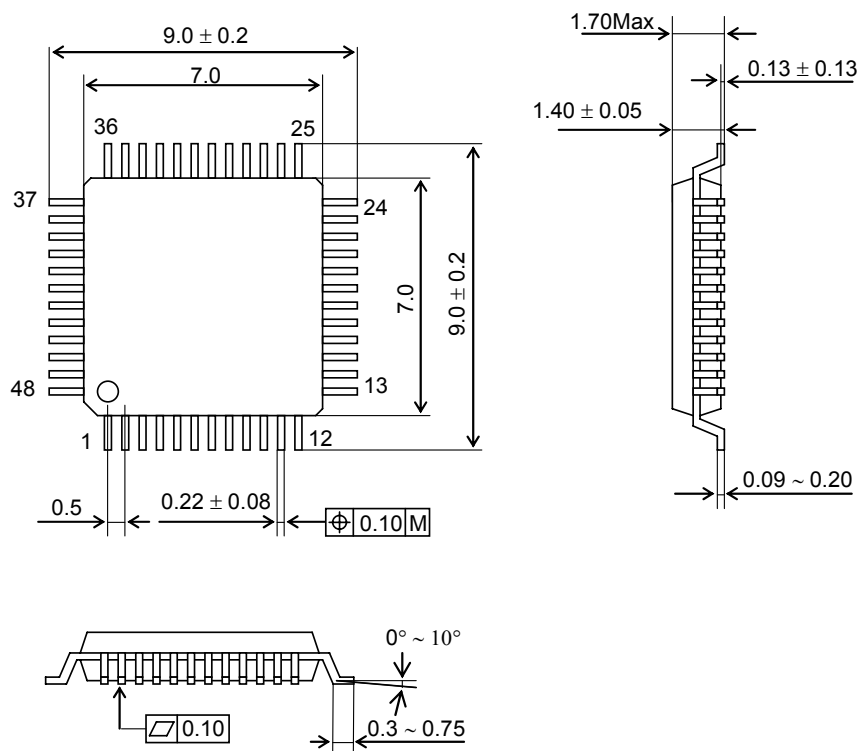
VCOM is a signal ground of this chip. An 1 $\mu$ F electrolytic capacitor attached between VCOM and VSS1 eliminates the effects of high frequency noise. No load current may be drawn from the VCOM pin. To avoid coupling to the AK4223, all signals and especially clock signals should be kept away as far as possible from the VCOM pin.

## 3. Notes for Drawing a Board

Analog input and output pins should be as short as possible in order to avoid unwanted coupling into the AK4223. The unused pins should be open.

|                |
|----------------|
| <b>PACKAGE</b> |
|----------------|

## 48pin LQFP (Unit: mm)

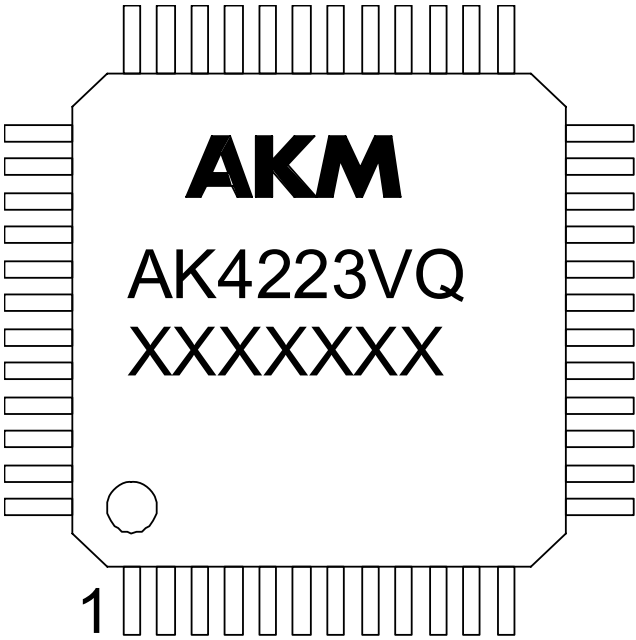
**■ Package & Lead Frame Material**

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

**RoHS Compliance**

\*All integrated circuits from Asahi Kasei Microdevices Corporation (AKM) assembled in “lead-free” packages are fully compliant with RoHS.

MARKING



XXXXXXXX: Date code identifier

REVISION HISTORY

| Date (Y/M/D) | Revision | Reason              | Page | Contents                          |
|--------------|----------|---------------------|------|-----------------------------------|
| 10/10/22     | 00       | First Edition       |      |                                   |
| 13/08/05     | 01       | Figure Modification | 2    | FEATURES<br>Figure 1 was changed. |

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