AK310x Application Note
Table of Contents

0. Overview .......................................................................................................... 3
  0.1. AK310x ........................................................................................................ 3
1. Electrical Characteristics of the current sensor ...................................................... 5
  1.1. Temperature Drift of Sensitivity .................................................................... 5
  1.2. Temperature Drift of Zero-current Output ......................................................... 5
  1.3. Temperature dependency of Total Accuracy ..................................................... 6
  1.4. Resolution of measured current (Output Noise) ................................................ 7
  1.5. Voltage Noise Rejection Ratio ........................................................................ 7
  1.6. Temperature Drift of the Primary Conductor Resistance .................................. 8
  1.7. Variation of the Primary Conductor Resistance ............................................... 8
  1.8. Inductance of the Primary Conductor ............................................................. 8
  1.9. Evaluation board ............................................................................................ 9
  1.10. Response Time .............................................................................................. 9
  1.11. Frequency Characteristic ............................................................................. 10
  1.12. dV/dt Noise, dI/dt Noise .............................................................................. 11
2. Board Design Guidelines ................................................................................... 12
  2.1. External Circuits Example .............................................................................. 12
  2.2. Trace of the Primary Current ......................................................................... 14
  2.3 Trace of the signal paths .................................................................................. 16
  2.4 Thermal design ............................................................................................... 18
  2.5. Stray Magnetic Field Reduction Function ....................................................... 20
3. Useful Tips ..................................................................................................... 22
  3.1 Supply Voltage ............................................................................................... 22
  3.2 Calibration of Zero-Current Output in initialization .......................................... 22
  3.3 Magnetic parts around .................................................................................... 22
  3.4 Heat Generation .............................................................................................. 23
  3.5 Storage Environment ...................................................................................... 23
  3.6 Sensitivity and Zero-Current Output Drift by Reflow ....................................... 23
  3.7 Maximum Primary Current and Linear Sensing Range ................................... 24
  3.8 Safety Standard .............................................................................................. 25
  3.9 Other information ........................................................................................... 25
Disclaimer .......................................................................................................... 26
0. Overview

This document is an application note to help use AKM’s current sensor AK310x series effectively.

This document consists of three sections;
1. Electric characteristics of the current sensor
2. Board design guideline
3. Useful tips

![Figure1. A trademark of AKM coreless current sensor](image)

0.1. AK310x

**Part number**  
AK310x (x : 1/2/3/H)

**Features**  
Ultra-low Noise Coreless Current Sensor

**Applications**  
Audio Systems, Industrial Motors

Also, AK310x is suitable for applications requiring quite small current resolution, and current measurement with isolation.

**Market trend**  
AKM has developed ultra-low noise coreless current sensors for improving audio quality of large sized speakers such as subwoofers. The AK310X series is suitable for a system which controls voicecoil motion in speakers (Motional Feedback) by current feedback. This series can be used for controlling industrial motors, since it is certified to UL safety standards.
1. Achieving Ultra-Low Noise
Although conventional current sensors had large noise, the AK310X series reduces the noise extremely to combine with a signal processing IC and an ultra-high sensitivity Hall element. It achieves the world’s best noise performance of \(-108\text{dBm}/\sqrt{\text{Hz}}\).*

*According to AKM’s research as of the date of releasing this product.

2. Ultra-Low Impedance
The dumping factor of the speaker is almost unaffected because the AK310X series can measure the current with a 1.6mΩ impedance. This series is suitable for motional feedback system.

3. Ultra-small Package Certified to Safety Standard
The AK310X series adopts an ultra-small coreless package, (D/W/H: 7.6mm×7.9mm×1.15mm).
It is certified to IEC/UL60950 and planned to be certified to IEC/UL1577, suitable for various industrial applications such as AC motors and general-purpose inverters.

### Table 1. AK310x series

<table>
<thead>
<tr>
<th>Part #</th>
<th>Linear Sensing Range (A)</th>
<th>Sensitivity (mV/A)</th>
<th>Output Noise (dBm/√Hz)</th>
<th>Temperature Drift of Sensitivity (%)</th>
<th>Temperature Drift of Zero-current Output Voltage (mV)</th>
<th>Total Accuracy (%F.S.)</th>
<th>Response Time (µs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK3101</td>
<td>±10.7</td>
<td>195</td>
<td>-102</td>
<td>±2.7</td>
<td>±1.6</td>
<td>1.5 (Typ.)</td>
<td>2</td>
</tr>
<tr>
<td>AK3102</td>
<td>±21</td>
<td>100</td>
<td>-108</td>
<td>±2.7</td>
<td>±0.9</td>
<td>1.5 (Typ.)</td>
<td></td>
</tr>
<tr>
<td>AK3103</td>
<td>±35</td>
<td>60</td>
<td>-108</td>
<td>±2.7</td>
<td>±0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AK310H</td>
<td>±42</td>
<td>50</td>
<td>-108</td>
<td>±2.7</td>
<td>±0.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*1 Defined as the average value ±1σ of the actual measurement results within a certain lot at Ta=-40~90°C.
*2 The typical value is defined as the average value ±1σ of the actual measurement results within a certain lot at Ta=-40~90°C.
1. Electrical Characteristics of the current sensor

1.1. Temperature Drift of Sensitivity

Temperature Drift of Sensitivity \((V_{h-d} \ [%])\) is defined as the change rate of Sensitivity \(V_h \ [mV/A]\) when Operating Ambient Temperature \((T_a \ [\degree C])\) changes from 35°C to \(T_{a1}(-40\degree C \leq T_{a1} \leq 90\degree C)\);

\[
V_{h-d} = 100 \times \left( \frac{V_h(T_a = T_{a1})}{V_h(T_a = 35\degree C)} \right)
\]

![Figure 2. Temperature Drift of Sensitivity](image)

Figure 2. shows “Average” and “Average ±3σ” of the actual result in a certain lot. This temperature characteristic is the same in AK310x series.

Please be noted that there is a difference between the definition of “Average” and that of “Typical” in the datasheet. “Typical” equals “Average” ±1σ.

1.2. Temperature Drift of Zero-current Output

Temperature Drift of Zero-current Output \((V_{of-d} \ [mV])\) is defined as the change of Zero-current Output \(V_{of} \ [V]\) when Operating Ambient Temperature \((T_a \ [\degree C])\) changes from 35°C to \(T_{a1}(-40\degree C \leq T_{a1} \leq 90\degree C)\);

\[
V_{of-d} = V_{of}(T_a = T_{a1}) - V_{of}(T_a = 35\degree C)
\]

![Figure 3. Temperature Drift of Zero-current Output](image)
Figure 3. Temperature Drift of Zero-current Output

Figure 3. shows “Average” and “Average ±3σ” of the actual result in a certain lot. Please note that there is a difference between the definition of “Average” and that of “Typical” in the datasheet. “Typical” equals “Average” ±1σ.

1.3. Temperature dependency of Total Accuracy

Total Accuracy ($E_{\text{total}}$) is defined as follows;

$$E_{\text{total}} = 100 \times \frac{V_{\text{err}}}{F.S.}$$

$$V_{\text{err}} = |V_{h-\text{meas}} - V_h| \times |I_{NS}| + |V_{of-d}| + |\rho_{\text{meas}}| \times F.S.$$  

- $V_{h-\text{meas}}$: Measured Sensitivity [mV/A]
- $V_h$: Typical Sensitivity [mV/A]
- $V_{of-d}$: Measured Drift of Zero-current Output [mV]
- $\rho_{\text{meas}}$: Measured Linearity Error [%F.S.]

Figure 4. Temperature dependency of Total Accuracy

Figure 4. shows “Average” and “Average +3σ” of the actual results within a certain lot. Please note that there is a difference between the definition of “Average” and that of “Typical” in the datasheet. “Typical” equals “Average” ±1σ.
1.4. Resolution of measured current (Output Noise)

Output noise affects the resolution of the measured current. It is possible to reduce the output noise by filter, and to increase the resolution depending on the filter characteristic.

**Table 2. Current resolution of AK310x (without filter, typical datasheet values)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AK3101</td>
<td>195</td>
<td>±10.7</td>
<td>4.6</td>
<td>0.70</td>
<td>3.6</td>
<td>10.7</td>
</tr>
<tr>
<td>AK3102</td>
<td>100</td>
<td>±21</td>
<td>2.3</td>
<td>0.35</td>
<td>3.5</td>
<td>11.8</td>
</tr>
<tr>
<td>AK3103</td>
<td>60</td>
<td>±35</td>
<td>2.3</td>
<td>0.35</td>
<td>5.8</td>
<td>11.8</td>
</tr>
<tr>
<td>AK310H</td>
<td>50</td>
<td>±42</td>
<td>2.3</td>
<td>0.35</td>
<td>7.0</td>
<td>11.8</td>
</tr>
</tbody>
</table>

![Figure 5. External Circuits Example](image)

(a) A 1.0μF bypass capacitor should be placed close to VDD and VSS pins of the device.
(b) Add a low-pass filter to VOUT pin if it is necessary. The R1 and C1 values should be fixed in consideration of the time constant of the filter and load conditions.

1.5. Voltage Noise Rejection Ratio

The Voltage Noise Rejection Ratio of the Primary Conductor was calculated by measuring the output while a high frequency sine wave voltage was applied as the input noise to the primary conductor. Table 3. shows the AK310x series having a strong voltage noise rejection ratio. Figure 6. shows the frequency dependency of the voltage noise rejection ratio.

**Table 3. Voltage Noise Rejection Ratio when high frequency sine wave voltage**

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Vout (mVpp)</th>
<th>Noise Rejection (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>7.2</td>
<td>-68.7</td>
</tr>
<tr>
<td>10</td>
<td>8.4</td>
<td>-67.4</td>
</tr>
<tr>
<td>15</td>
<td>22.1</td>
<td>-59.0</td>
</tr>
<tr>
<td>20</td>
<td>28.1</td>
<td>-57.0</td>
</tr>
</tbody>
</table>
1.6. Temperature Drift of the Primary Conductor Resistance

Figure 7. shows the temperature drift of the primary conductor resistance of AK310x. (reference)

1.7. Variation of the Primary Conductor Resistance

The primary conductor resistance of AK310x varies from 1.2m Ω to 2.1m Ω (reference) at 25°C.

1.8. Inductance of the Primary Conductor

The Primary Conductor Inductance of AK310x is about 2.7nH (reference) at 25°C.
1.9. Evaluation board

Figure 8. shows the evaluation board which is used for derating curve of AK310x shown in Chapter “3.4 Heat Generation”. Table 4. shows the condition of AK310x evaluation board.

<table>
<thead>
<tr>
<th>Board size</th>
<th>43.1mm×46.9mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of layer</td>
<td>2 layers</td>
</tr>
<tr>
<td>Copper layer thickness</td>
<td>70μm/layer</td>
</tr>
<tr>
<td>Board thickness</td>
<td>1.6mm</td>
</tr>
</tbody>
</table>

Table 4. Evaluation board

![Figure 8. AK310x evaluation board](image)

1.10. Response Time

The response time of AK310x is typically 2μs with a load capacitance of 100pF. Figure 9. shows the typical pulse response waveform.

Part #: AK3101  \( V_{ih} = 195 \text{mV/A} \)

\( I_{IN} = 10 \text{A}, \) Rise and fall response time is about 2.0μs.

![Figure 9. Rise response waveform (left), fall response waveform (right).](image)
1.11. Frequency Characteristic

The graph in Figure 10. shows the typical frequency characteristics of the AK310x.

![Gain Characteristic](image1)

![Phase Characteristic](image2)

**Figure 10. Frequency Response of the AK310X**
(a) Gain Characteristic
(b) Phase Characteristic
1.12. dV/dt Noise, dI/dt Noise

Figure 11. shows the dV/dt noise property of AK310x output voltage (V_{OUT}), when 1kV is applied to the primary conductor at the rise time of 3μs. The yellow line shows the input voltage waveform and the green line shows the output voltage waveform. The convergence time is as short as 3μs. Please avoid this noise by adjusting the capture timing.

Figure 11. dV/dt noise waveform (left: rise waveform, right: fall waveform)

Figure 12. shows the output voltage (V_{OUT}) of AK310x, when a 10A pulse is applied to the primary conductor with a pulse width of 1μs. The yellow line shows the input current waveform and the green line shows the output voltage waveform. The convergence time is as short as 3μs.

Figure 12. dI/dt noise waveform
2. Board Design Guidelines

2.1. External Circuits Example

In this subsection, we show three examples of the external circuit when using AK310x. These are just examples and there are other possible circuits. Please evaluate your external circuit by yourself.

Case1) Connecting a 5V A/D converter in the subsequent stage
Case2) Connecting a 3.3V A/D converter in the subsequent stage
Case3) Connecting an amplifier to change the reference voltage of the output or to change the sensitivity

Case1) AK310x+ADC(5V)

(a) 1.0μF bypass capacitor should be placed close to V_{DD} and V_{SS} pins of AK310x.
(b) Add a low-pass filter to V_{OUT} pin if it is necessary. The R_{1} and C_{1} values should be fixed in consideration of the time constant of the filter.

Figure 14. External Circuit Example 1
Case 2) AK310x + ADC (3.3V)

(a) 1.0μF bypass capacitor should be placed close to VDD and VSS pins of AK310x.
(b) Add a low-pass filter to VOUT and A/D converter REF pin, if it is necessary. The R1, R2 and C1 values should be fixed in consideration of the time constant of the filter and the resistive divider ratio.

Case 3) AK310x + Amplifier

(a) 1.0μF bypass capacitor should be placed close to VDD and VSS pins of AK310x.
(b) R1 and R2 are resistors that decides the gain. The R0 value should be fixed in consideration of the load condition. The R1 and R2 values should be fixed in consideration of the gain.
2.2. Trace of the Primary Current
2.2.1. Width and Length of the Primary Current Trace

Please design the trace of the primary current for AK310x wider in the width and shorter in the length to make the trace resistance small and to prevent overheating. And, please refer to Figure 17. and Table 5 for the recommended footprint.

![Figure 17. AK310x recommended land pattern](image)

Table 5. AK310x recommended land pattern dimensions

<table>
<thead>
<tr>
<th>Unit</th>
<th>Dimension (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>1.42</td>
</tr>
<tr>
<td>E</td>
<td>7.62</td>
</tr>
<tr>
<td>W1</td>
<td>3.60</td>
</tr>
<tr>
<td>W2</td>
<td>0.35</td>
</tr>
<tr>
<td>C</td>
<td>0.30</td>
</tr>
<tr>
<td>P</td>
<td>0.65</td>
</tr>
</tbody>
</table>

Unit: mm
2.2.2. The Configuration of the Trace

We recommend extending straight to right and left as shown in the Figure 18(a). If this is not possible due to board layout limitations, we recommend extending away from the signal paths as shown in the Figure 18(b). The sensitivity may differ 1% at maximum between these two traces. Please evaluate the trace design in the actual environment in order to achieve the highest possible accuracy.

We do not recommend extending toward the signal paths as shown in the Figure 18(c). It may degrade the withstand voltage as stated in section 2.3.4.

We do not recommend running current-carrying traces beneath the current sensor. The output may fluctuate due to stray magnetic fields. Refer to section 2.5. Please evaluate carefully if this is not avoidable.

![Figure 18. How to trace the primary conductor of AK310x](image)

(a) Straight (recommended)  (b) Away from the signal paths (recommended)  (c) Toward the signal paths (Not recommended)

2.2.3. Direction of the primary current

The user needs to know the direction of the current flow in the primary conductor to detect the correct output. In case of the trace shown in the Figure 19, the output of the AK310x decreases as current flows from right to left and increases from left to right.

![Figure 19. The relationship between the output of AK310x and the direction of the primary current](image)

(a) $V_{OUT} < 1/2 \times V_{DD}$  (b) $V_{OUT} > 1/2 \times V_{DD}$
2.3 Trace of the signal paths

Please refer to the followings for pin names of AK310x.

![Figure 20. AK310x Pin configuration](image)

Table 6. Pin functions of AK310x

<table>
<thead>
<tr>
<th>Pin No.</th>
<th>Pin name</th>
<th>I/O</th>
<th>Type</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>VSS1</td>
<td>GND</td>
<td>-</td>
<td>Ground pin (GND)</td>
</tr>
<tr>
<td>2</td>
<td>VSS1</td>
<td>GND</td>
<td>-</td>
<td>Ground pin (GND)</td>
</tr>
<tr>
<td>3</td>
<td>N.C.</td>
<td>-</td>
<td>-</td>
<td>N.C. pin (Recommended external connection: GND)</td>
</tr>
<tr>
<td>4</td>
<td>TEST1</td>
<td>-</td>
<td>-</td>
<td>Test pin (Recommended external connection: GND)</td>
</tr>
<tr>
<td>5</td>
<td>VDD1</td>
<td>I</td>
<td>PWR</td>
<td>Power supply pin (5V)</td>
</tr>
<tr>
<td>6</td>
<td>VDD2</td>
<td>I</td>
<td>PWR</td>
<td>Power supply pin (5V)</td>
</tr>
<tr>
<td>7</td>
<td>TEST2</td>
<td>-</td>
<td>-</td>
<td>Test pin (Recommended external connection: GND)</td>
</tr>
<tr>
<td>8</td>
<td>VOUT</td>
<td>O</td>
<td>Analog</td>
<td>Sensor output pin</td>
</tr>
<tr>
<td>9</td>
<td>TEST3</td>
<td>-</td>
<td>-</td>
<td>Test pin (Recommended external connection: GND)</td>
</tr>
<tr>
<td>10</td>
<td>N.C.</td>
<td>-</td>
<td>-</td>
<td>N.C. pin (Recommended external connection: GND)</td>
</tr>
<tr>
<td>11</td>
<td>VSS2</td>
<td>GND</td>
<td>-</td>
<td>Ground pin (GND)</td>
</tr>
<tr>
<td>12</td>
<td>VSS2</td>
<td>GND</td>
<td>-</td>
<td>Ground pin (GND)</td>
</tr>
<tr>
<td>13</td>
<td>IN</td>
<td>I</td>
<td>-</td>
<td>Primary conductor pin (−)</td>
</tr>
<tr>
<td>14</td>
<td>IP</td>
<td>I</td>
<td>-</td>
<td>Primary conductor pin (+)</td>
</tr>
</tbody>
</table>
2.3.1. Length and width of the signal paths
We recommend making the traces of \( V_{DD} \) and \( V_{OUT} \) signals as wide and short as possible to avoid electrical noise from external capacitive coupling.

2.3.2. Noise filtering
In order to reduce the noise superimposed on the power line, we recommend placing a 1\( \mu \)F by-pass capacitor between \( V_{DD} \) and \( V_{SS} \) pins as close to those pins as possible. By adding an electrolytic capacitor with larger capacitance in parallel, it will reduce the effect of the instant voltage drop of the power supply.
In case that large noise is superimposed on the output, adding a low pass filter to the \( V_{OUT} \) pin may provide improvement. When adding a low pass filter, please consider the time constant to meet the required response time.

2.3.3. Connection to GND
Generally, in an inverter circuit board, GND of power line and that of signal line are isolated from each other in order to avoid malfunction of the MCU due to noise. Please connect the \( V_{SS} \) pin of AK310x to the GND of signal line.

2.3.4. Insulation design
The clearance and creepage between the primary conductor and the signal paths are more than 5mm. The Comparative Tracking Index (CTI) of the AK310x package resin is 600V, The Material Group is I. Table 7 shows the Working Voltage of AK310x.
In order to maximize the insulation withstanding voltage of AK310x, please keep enough distance between traces of the primary conductor and the signal paths. In case that there is a specific standard required for the system, please design the clearance and creepage to meet that requirement.
If the creepage is shorter than the requirement, it is possible to increase to more than 5mm by adding a slit in the board as shown in Figure 21.

<table>
<thead>
<tr>
<th>Working Voltage</th>
<th>Pollution Degree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Basic Isolation</td>
<td>1450</td>
</tr>
<tr>
<td>Reinforced Isolation</td>
<td>825</td>
</tr>
</tbody>
</table>
2.4 Thermal design

2.4.1. Thermal design

The AK310x is capable of 20A_{rms} continuous current, even larger current in case of transitional. When AK310x is used under conditions compliant with safety standard, please ensure the case temperature (T_c) is kept lower than 130°C from heating by the primary current. Please refer to the Figure 22. for the position to measure T_c.

If the heat dissipation is not enough, using “pad on vias” at the primary conductor pads may help. These can increase heat dissipation without increasing the trace area by thermally connecting the primary conductors to an inner and outer layers directly.

2.4.2. Junction temperature (T_j) estimation

T_j can be estimated the temperature from AK310x’s lead frame. Because it nearly equals to the temperature of the sensor inside the package.

2.4.3. Improvement of heat dissipation

These can increase heat dissipation without increasing the trace area by thermally connecting the primary conductors to an inner or outer thermal layer directly. If the heat dissipation is not enough, using thermal vias may help.

AK310x Application Note (rev.1)
2.4.4. Heating Measurement (reference)

Figure 23 and Figure 24 show the results of $T_c$ measurement used by figure 8” Evaluation board”. This result is a reference data. $T_c$ is changed much by the board layout and the heat dissipation. Please confirm it in your evaluation environment.

Measurement Condition
Measurement Temperature: at RT. (about 25°C)
Position to measure $T_c$: Refer to Figure 22.
Maximum operation temperature: $T_c < 130^\circ$C

The size of wire which is connected to the board is selected according to the standard of the amount of current.
14sq., AWG5.8, Diameter: 4.2mm

Figure 23. Relationship between AK310x Case temperature and amount of input current (left: 10~35A, right: 42A)

Figure 24. Relationship between AK310x Case temperature and amount of input current (60A)
2.5. Stray Magnetic Field Reduction Function
AK310x can be detected the primary current by detecting the magnetic flux density of primary current. Therefore, AK310x is affected by external magnetic field, and this will appear as output error. In this section, we show about the situation affected by nearby current lines.

Figure 25. defines the distance from nearby current lines.
Figure 26. shows the relationship between “output error” and “distance A/B”.

Example:
In case of the nearby current is 20A and its output error keep less than 400mA, AK310x keep the clearance more than 6mm (Distance A) and 5mm (Distance B).
*Distance B is not only defined as the line on the left of AK310x package but also the line on the right of AK310x package.

Figure 25. the definition of distance from nearby current lines to AK310x
Figure 26. the relationship between “output error” and “distance A/B”
3. Useful Tips

3.1 Supply Voltage
The AK310x has a ratiometric output. This means that the output of the current sensor changes proportionally to the supply power voltage. A ratiometric output is suitable for applications where the output is converted to digital using an A/D converter and where fluctuation of the power supply voltage causes reference error of the A/D converter. Figure 14 shows an example of the external circuit where a 5V A/D converter is connected. Figure 15 shows the case where a 3.3V A/D converter is used. The supply voltage of the AK310x and the reference voltage of the A/D converter fluctuate at the same ratio. This will avoid the effects of the fluctuation of the power supply to the A/D converter output.

Figure 27 shows the output voltage of the AK3103 (Sensitivity $V_h=60$ mV/A) as an example ratiometric output.

![Output voltage of the AK3103 vs Input Current with different $V_{DD}$.](image)

3.2 Calibration of Zero-Current Output in initialization
The Zero-Current Output of the AK310x may drift over time within the values defined in datasheet Section 14. Therefore, in order to minimize this drift, we strongly recommend calibrating the Zero-Current Output by software after the power-up time of the system when the measured current is zero.

3.3 Magnetic parts around
The AK310x output can be affected by magnetic devices (mechanical, lays, transformers, etc.) that are nearby. In the case where magnetic devices must be placed close to the AK310x, please check the effect on sensitivity or other characteristics and make sure any effects are understood and mitigated as much as possible.
3.4 Heat Generation
AK310x must be used under the condition within the derating curve shown in Figure 28. If AK310x are placed near the electric parts which produce much heat such as IPM, confirm that the ambient temperature does not exceed beyond the derating curve. (e.g. if the maximum primary current is 10A, the ambient temperature must not exceed 90°C)

![Derating curve of AK310x](image)

Figure 28. Derating curve of AK310x

3.5 Storage Environment
AK310x is the condition of MSL2a (JEDEC J-STD-020). Please store under the following conditions.

[Storage term]
Within 1 year after delivery (Before and after unpacking the moisture-proof packing.)
[Before unpacking the moisture-proof packing]
5~40°C, less than 90%RH
[After unpacking the moisture-proof packing]
5~30°C, 60%RH or less, less than 168 hours (1 week).

3.6 Sensitivity and Zero-Current Output Drift by Reflow
Solder reflow can cause the Sensitivity and Zero-Current Output of AK310x to drift. Section 9 of the datasheet shows the variation of the shipment test results by AKM. The reflow process can induce drift within the values defined in Section 14 of the datasheet. Regarding Zero-Current Output drift, we recommend calibrating according to Section 3.2 of this document.

Figure 29. and Table.8 show the recommended reflow temperature profile. AKM recommends subjecting the AK310x to a reflow process a maximum of three (3) times.
3.7 Maximum Primary Current and Linear Sensing Range

Maximum Primary Current ($I_{\text{RMSmax}}$) is the maximum current that can be flowed through the primary conductor continuously. It depends on the cross-sectional area of the primary conductor. AK310x can be damaged if it is used in conditions where the DC current or the root-mean-square value of AC current exceeds $I_{\text{RMSmax}}$ for an extended period of time. In the case of pulsed current, it is possible to apply currents larger than $I_{\text{RMSmax}}$.

Linear Sensing Range ($I_{\text{NS}}$) is the current range where we guarantee the linearity of Ak310x output. If the primary current is beyond $I_{\text{NS}}$, the output will saturate. However, it will return to normal once the primary current is back within $I_{\text{NS}}$. 

Table 8. Reflow Conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preheat/Soak</td>
<td>$T_{\text{min}}$ 150°C</td>
</tr>
<tr>
<td></td>
<td>$T_{\text{max}}$ 200°C</td>
</tr>
<tr>
<td></td>
<td>$T_{\text{min to max}}$ 60–120s</td>
</tr>
<tr>
<td>Liquidus Temperature</td>
<td>$T_{L}$ 217°C</td>
</tr>
<tr>
<td></td>
<td>$t_{L}$ 60–150s</td>
</tr>
<tr>
<td>Ramp-up Rate</td>
<td>$T_{L}$ to $T_{p}$ 3°C/s max.</td>
</tr>
<tr>
<td>Peak Package Body Temperature</td>
<td>$T_{p}$ 260°C max.</td>
</tr>
<tr>
<td></td>
<td>$t_{p}$ 30s max.</td>
</tr>
<tr>
<td>Ramp-down Rate</td>
<td>$T_{p}$ to $T_{L}$ 6°C/s max.</td>
</tr>
<tr>
<td>Time 25°C to Peak Temperature</td>
<td>25°C to $T_{p}$ 8min max.</td>
</tr>
</tbody>
</table>

Figure 29. Reflow profile
3.8 Safety Standard
AK310x is certified as IEC/UL60950, by the international certification organization.

- CAN/CSA C22.2 No.62368-1-14 -Audio/video, Information and Communication Technology Equipment- 2nd Ed,(File No.E359197)

3.9 Other information
Please check our website akm.com for datasheets, selection guide, and more.

http://www.akm.com/jp/ja
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