CZ-37xx Application Note

September 23, 2020
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CZ-37xx Application Note (rev.2)
0. Overview

This document is an application note to help use AKM’s current sensor CZ-37xx series effectively.

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

![Figure 1. A trademark of AKM’s coreless current sensor = Currentier](image)

0.1. CZ-37xx

**Part number**  
CZ-370x (x : 0~6) , CZ-372x (x : 0~6)

**Features**  
Creepage, Clearance >8mm  
Capable of 60A_{rms}  
High Accuracy Coreless Current Sensor

**Applications**  
AC Motors, DC Motors, UPS, Low Voltage Drives & Power Conditioners  
Best fit for the applications that need isolation, low heat and small size.

**Market trend**  
To meet safety standard UL61800-5-1 for industrial markets, AKM has developed the coreless current sensor CZ-370x series. A wide line up of measurement ranges from ±5.3A_{pp} to ±180A_{pp}(bipolar) and from -0.4 ~ 10.3A_{pp} to -14.9 ~ 345.2A_{pp}(Unipolar) enables customers to use the same series for different products.

CZ-37xx Application Note (rev.2)  
-3/25-
Details of Features

1. Creepage, Clearance > 8mm

Our unique package design enables us to achieve more than 8mm creepage and clearance in a small configuration. A Working Voltage=600V<sub>rms</sub> (reinforced insulation) helps customers easily design products using these devices.

2. Low heat generation, 60A<sub>rms</sub>/Bipolar: from ±5A<sub>pp</sub> to ±180A<sub>pp</sub>/Bipolar: from ±0.4 ~ 10.3 A<sub>pp</sub> to -14.9 ~ 345.2A<sub>pp</sub>

The CZ-37xx series has primary conductor resistance as low as 0.27mΩ due to AKM’s unique packaging. This will reduce the heat generated by primary current significantly compared to a shunt resistor or similar product from another company, while allowing a continuous current flow of 60A<sub>rms</sub>.

3. High Accuracy

The CZ-370x series is a coreless current sensor with accuracy of 0.5% F.S. (Typ). The built-in stray magnetic field reduction function solves the problem of existing coreless current sensors. The CZ-370x series contributes to the improvement of system efficiency and precise control in a wider range of applications.

Table 1. CZ-37xx series

<table>
<thead>
<tr>
<th>Part #</th>
<th>Linear Sensing Range (A)</th>
<th>Sensitivity (mV/A)</th>
<th>Temperature Drift of Sensitivity (%)&lt;sup&gt;*1&lt;/sup&gt;</th>
<th>Temperature Drift of Zero-current Output (mV)&lt;sup&gt;*1&lt;/sup&gt;</th>
<th>Total Accuracy (%F.S.)&lt;sup&gt;*2&lt;/sup&gt;</th>
<th>Response Time (μs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CZ-3700</td>
<td>±5.3</td>
<td>400</td>
<td>±0.6</td>
<td>±5.4</td>
<td>0.5 (Typ.)</td>
<td>1</td>
</tr>
<tr>
<td>CZ-3701</td>
<td>±10.7</td>
<td>200</td>
<td></td>
<td>±4.4</td>
<td>-0.4~0.8 (Min. Max.)</td>
<td></td>
</tr>
<tr>
<td>CZ-3702</td>
<td>±21.5</td>
<td>100</td>
<td></td>
<td>±3.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZ-3703</td>
<td>±36</td>
<td>60</td>
<td></td>
<td>±3.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZ-3704</td>
<td>±54</td>
<td>40</td>
<td></td>
<td>±3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZ-3705</td>
<td>±86.4</td>
<td>25</td>
<td></td>
<td>±3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZ-3706</td>
<td>±180</td>
<td>12</td>
<td></td>
<td>±3.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZ-3720</td>
<td>-0.4~+10.3</td>
<td>400</td>
<td></td>
<td>±5.4</td>
<td>1.0 (Typ.)</td>
<td></td>
</tr>
<tr>
<td>CZ-3721</td>
<td>-0.8~+20.6</td>
<td>200</td>
<td></td>
<td>±4.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZ-3722</td>
<td>-1.7~+41.3</td>
<td>100</td>
<td></td>
<td>±3.8</td>
<td>-0.9~1.6 (Min. Max.)</td>
<td></td>
</tr>
<tr>
<td>CZ-3723</td>
<td>-2.9~+68.8</td>
<td>60</td>
<td></td>
<td>±3.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZ-3724</td>
<td>-4.4~+103.4</td>
<td>40</td>
<td></td>
<td>±3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZ-3725</td>
<td>-7.1~+165.8</td>
<td>25</td>
<td></td>
<td>±3.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CZ-3726</td>
<td>-14.9~+345.2</td>
<td>12</td>
<td></td>
<td>±3.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*1 Defined as the average value ±3σ of the actual measurement results within a certain lot at T<sub>a</sub>=0~90°C.

*2 The typical value is defined as the average value ±1σ of the actual measurement results within a certain lot at T<sub>a</sub>=0~90°C. The minimum and maximum value are defined as the average value ±3σ of the same.
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 ($T_a$ [°C]) changes from 25°C to $T_{a1}$ (−40°C ≤ $T_{a1}$ ≤ 105°C);

\[
V_{h-d} = 100 \times \left( \frac{V_h(T_a = T_{a1})}{V_h(T_a = 25°C)} - 1 \right)
\]

Figure 2. Temperature Drift of Sensitivity

Figure 2. shows “Average” and “Average ±3σ” of the actual result in a certain lot. This temperature characteristic is the same in CZ-37xx 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 ($T_a$ [°C]) changes from 25°C to $T_{a1}$ (−40°C ≤ $T_{a1}$ ≤ 105°C);

\[
V_{of-d} = V_{of}(T_a = T_{a1}) - V_{of}(T_a = 25°C)
\]
Figure 3 shows “Average” and “Average ±3σ” of the actual result in a certain lot.

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 CZ-37xx (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>CZ-3700</td>
<td>400</td>
<td>±5.3</td>
<td>79</td>
<td>12</td>
<td>30</td>
<td>6.7</td>
</tr>
<tr>
<td>CZ-3701</td>
<td>200</td>
<td>±10.7</td>
<td>40</td>
<td>6</td>
<td>30</td>
<td>7.7</td>
</tr>
<tr>
<td>CZ-3702</td>
<td>100</td>
<td>±21.5</td>
<td>20</td>
<td>3</td>
<td>30</td>
<td>8.7</td>
</tr>
<tr>
<td>CZ-3703</td>
<td>60</td>
<td>±36</td>
<td>12</td>
<td>1.8</td>
<td>30</td>
<td>9.4</td>
</tr>
<tr>
<td>CZ-3704</td>
<td>40</td>
<td>±54</td>
<td>8</td>
<td>1.2</td>
<td>30</td>
<td>10.0</td>
</tr>
<tr>
<td>CZ-3705</td>
<td>25</td>
<td>±86.4</td>
<td>8</td>
<td>1.2</td>
<td>50</td>
<td>10.0</td>
</tr>
<tr>
<td>CZ-3706</td>
<td>12</td>
<td>±180</td>
<td>8</td>
<td>1.2</td>
<td>100</td>
<td>10.0</td>
</tr>
<tr>
<td>CZ-3720</td>
<td>400</td>
<td>-0.4~+10.3</td>
<td>79</td>
<td>12</td>
<td>30</td>
<td>6.7</td>
</tr>
<tr>
<td>CZ-3721</td>
<td>200</td>
<td>-0.8~+20.6</td>
<td>40</td>
<td>6</td>
<td>30</td>
<td>7.7</td>
</tr>
<tr>
<td>CZ-3722</td>
<td>100</td>
<td>-1.7~+41.3</td>
<td>20</td>
<td>3</td>
<td>30</td>
<td>8.7</td>
</tr>
<tr>
<td>CZ-3723</td>
<td>60</td>
<td>-2.9~+68.8</td>
<td>12</td>
<td>1.8</td>
<td>30</td>
<td>9.4</td>
</tr>
<tr>
<td>CZ-3724</td>
<td>40</td>
<td>-4.4~+103.4</td>
<td>8</td>
<td>1.2</td>
<td>30</td>
<td>10.0</td>
</tr>
<tr>
<td>CZ-3725</td>
<td>25</td>
<td>-7.1~+165.8</td>
<td>8</td>
<td>1.2</td>
<td>50</td>
<td>10.0</td>
</tr>
<tr>
<td>CZ-3726</td>
<td>12</td>
<td>-14.9~+345.2</td>
<td>8</td>
<td>1.2</td>
<td>100</td>
<td>10.0</td>
</tr>
</tbody>
</table>
(a) A 0.1μF bypass capacitor should be placed close to VDD and VSS pins of the device.
(b) Add a low-pass filter to VOUT and VREF pins if it is necessary. The R1 and C1 values should be fixed in consideration of the time constant of the filter and load conditions.

Table 3. Example of Current Resolution and Filter Characteristics (CZ-3703, actual result of N=1)

<table>
<thead>
<tr>
<th>C1[nF]</th>
<th>R1[kΩ]</th>
<th>Bandwidth [kHz]</th>
<th>Output Noise [mV_{pp}]</th>
<th>Output Noise [mV_{rms}]</th>
<th>Input Current Equivalent Noise [mA_{rms}]</th>
<th>ENOB [Bits]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Without filter</td>
<td></td>
<td>9.3</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>0.47</td>
<td>3</td>
<td>9.3</td>
<td>1.4</td>
<td>23.5</td>
<td>9.8</td>
</tr>
<tr>
<td>4.7</td>
<td>3</td>
<td>113</td>
<td>5.8</td>
<td>0.9</td>
<td>14.6</td>
<td>10.5</td>
</tr>
<tr>
<td>4.7</td>
<td>10</td>
<td>3.4</td>
<td>1.1</td>
<td>0.2</td>
<td>2.8</td>
<td>12.9</td>
</tr>
</tbody>
</table>

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 4 shows the CZ-37xx series having a strong voltage noise rejection ratio. Figure 6. shows the frequency dependency of the voltage noise rejection ratio.

Table 4. Voltage Noise Rejection Ratio when high frequency sine wave voltage (20V_{pp}) is applied

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>Vout (mV_{pp})</th>
<th>Noise Rejection (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>6</td>
<td>-70.1</td>
</tr>
<tr>
<td>10</td>
<td>15</td>
<td>-62.7</td>
</tr>
<tr>
<td>15</td>
<td>35</td>
<td>-55.3</td>
</tr>
<tr>
<td>20</td>
<td>53</td>
<td>-51.6</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 CZ-37xx. (reference)

1.7. Variation of the Primary Conductor Resistance

The primary conductor resistance of CZ-37xx varies from 0.21mΩ to 0.30mΩ (reference) at 25°C.

1.8. Inductance of the Primary Conductor

The Primary Conductor Inductance of CZ-37xx is about 3nH (reference) at 25°C.
1.9. Thermal Resistance
The thermal resistance ($\theta_{ja}$) of CZ-37xx is 32°C/W when using the board shown in Figure 8.

Table 5. Thermal Resistance measurement board

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Board size</td>
<td>68.58mm×63.5mm</td>
</tr>
<tr>
<td>Number of layer</td>
<td>4 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>

- Face (1st layer)
- Inner (2nd/3rd layer: VSS)
- Tail (4th layer)

Figure 8. Thermal Resistance measurement board

1.10. Response Time
Figure 9. shows the actual performance of the typical pulse response waveform. The part used was CZ-3704 ($V_h$=40mV/A), Input current $I_{in}$=25A. Rise and fall response time is about 0.5μs.

Figure 9. Rise response waveform (left), fall response waveform (right).
1.11. dV/dt Noise, dI/dt Noise

Figure 10. shows the dV/dt noise of CZ-37xx output voltage ($V_{OUT} - V_{REF}$), when 1kV is applied to the primary conductor at the rise time of 1μs. The yellow line shows the input voltage waveform and the pink line shows the output voltage waveform. The convergence time is as short as 2μs. Please avoid this noise by adjusting the capture timing.

![Figure 10. dV/dt noise waveform (left: rise waveform, right: fall waveform)](image)

Figure 11. shows the output voltage ($V_{OUT} - V_{REF}$) of CZ-37xx, when a 25A 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 2μs.

![Figure 11. dI/dt noise waveform](image)
2. Board Design Guidelines

2.1. External Circuits Example

In this subsection, we show three examples of the external circuit when using CZ37xx. 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) CZ-37xx + ADC(5V)

(a) A 0.1μF bypass capacitor should be placed close to VDD and VSS pins of CZ-37xx.
(b) Add a low-pass filter to VOUT and VREF pins if it is necessary. The R1 and C1 values should be fixed in consideration of the time constant of the filter and load conditions.

Case2) CZ-37xx + ADC(3.3V)

(a) 0.1μF bypass capacitor should be placed close to VDD and VSS pins of CZ-37xx.
(b) Add a low-pass filter to VOUT and VREF pins if it is necessary. The R1, R2 and C1 values should be fixed in consideration of the time constant and the resistive divider ratio.
Case3) CZ-37xx + Amplifier

![Diagram of External Circuit Example 3]

Figure 15. External Circuit Example 3

(a) 0.1μF bypass capacitor should be placed close to VDD and VSS pins of CZ-37xx.
(b) R1 and R2 are resistors that decides the gain. 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 CZ-37xx wider in the width and shorter in the length to make the trace resistance small and to prevent overheating.

Please refer to Figure 16. for the recommended footprint.

![Footprint Diagram]

Figure 16. CZ-37xx recommended footprint
2.2.2. The Configuration of the Trace

We recommend extending straight to right and left as shown in Figure 17(a). If this is not possible due to board layout limitations, we recommend extending away from the signal paths as shown in Figure 17(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 Figure 17(c). It may degrade the withstand voltage as stated in section 2.3.4.

We also 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 17. How to trace the primary conductor of CZ-37xx](image)

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 Figure 18, the output of the CZ-37xx increases as current flows from right to left, and decreases from left to right.

![Figure 18. The relationship between the output of CZ-37xx and the direction of the primary current](image)
2.3 Trace of the signal paths
Please refer to the followings for pin names of CZ-37xx.

![Figure 19. CZ-37xx Pin configuration](image)

<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>IP</td>
<td>I</td>
<td>–</td>
<td>Primary conductor pin (+)</td>
</tr>
<tr>
<td>2</td>
<td>IN</td>
<td>I</td>
<td>–</td>
<td>Primary conductor pin (-)</td>
</tr>
<tr>
<td>3</td>
<td>VSS</td>
<td>GND</td>
<td>Power</td>
<td>Ground pin (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>VREF*</td>
<td>O</td>
<td>Analog</td>
<td>Reference output pin</td>
</tr>
<tr>
<td>6</td>
<td>VOUT</td>
<td>O</td>
<td>Analog</td>
<td>Sensor output pin</td>
</tr>
<tr>
<td>7</td>
<td>VDD</td>
<td>PWR</td>
<td>Power</td>
<td>Power supply pin (5V)</td>
</tr>
<tr>
<td>8</td>
<td>TEST2</td>
<td>—</td>
<td>–</td>
<td>Test pin (Recommended external connection: OPEN)</td>
</tr>
<tr>
<td>9</td>
<td>TEST3</td>
<td>—</td>
<td>–</td>
<td>Test pin (Recommended external connection: OPEN)</td>
</tr>
<tr>
<td>10</td>
<td>VSS</td>
<td>GND</td>
<td>Power</td>
<td>Ground pin (GND)</td>
</tr>
</tbody>
</table>

*VREF pin is output pin, cannot input voltage

2.3.1. Length and width of the signal paths
We recommend making the traces of VDD, VOUT and VREF 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 0.1µF by-pass capacitor between VDD and VSS 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 VOUT and VREF pins 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 VSS pin of CZ-37xx to the GND of signal line.

2.3.4. Insulation design

The package of CZ-37xx is compliant with safety standard UL61800-5-1. The clearance and creepage between the primary conductor and the signal paths are more than 8mm. The Comparative Tracking Index (CTI) of the CZ-37xx package resin is 600V, and the Material Group is I. Table 8 shows the Working Voltage of CZ-37xx.

In order to maximize the insulation withstanding voltage of CZ-37xx, 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 8mm by adding a slit in the board as shown in Figure 20.

<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>2100</td>
</tr>
<tr>
<td>Reinforced Isolation</td>
<td>1200</td>
</tr>
</tbody>
</table>

(Vrms)

Figure 20. Example to increase the creepage
2.4 Thermal design

2.4.1. Thermal design (Compliant with UL61800-5-1)

The CZ-37xx is capable of 60A_{rms} continuous current, even larger current in case of transitional. When CZ-37xx is used under conditions compliant with UL61800-5-1, please ensure the case temperature (T_c) is kept lower than 130°C from heating by the primary current. Please refer to the Figure21. for the position to measure T_c.

![Figure 21. Position to measure package case temperature](source)

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 CZ-37xxx’s lead frame. Because it nearly equals to the temperature of the sensor inside the package.

2.4.3. Heating Measurement(reference)

Figure 21.,22. show the results of Tc 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 19.

**Maximum operation temperature**: T_c<130°C

The size of wire which is connected to the board is selected according to the standard of the amount of current.

- 30～90A : 14sq, AWG5.8, Diameter: 4.2mm
- 120～150A : 30sq, AWG2.5, Diameter: 6.2mm

CZ-37xx Application Note (rev.2)
180A : 50sq, AWG0.3, Diameter: 8.0mm

Figure 21. Relationship between CZ-37xx Case temperature and amount of input current (left: 30~120A, right: 150A)

Figure 22. Relationship between CZ-37xx Case temperature and amount of input current (180A)

2.5. Stray Magnetic Field Reduction Function

There are two Hall elements inside CZ-37xx connected in a differential manner. By detecting the difference of these two Hall elements' outputs, CZ-37xx reduces the effects of stray magnetic fields as a built-in common-mode rejection function. When the same magnetic field is applied to both Hall elements, this magnetic field is deemed to be the stray and is reduced from the output of CZ-37xx by the ratio of Stray Magnetic Field Reduction ($E_{bc}$: 0.01A/mT Typ.).

Example: When a stray magnetic field of 1mT is applied to the CZ-37xx, the output will have additional error of 0.01A=10mA equivalent.

- CZ-3700: Sensitivity=400mV/A, Error=10mA → Output error=4mV
- CZ-3706: Sensitivity=12mV/A, Error=10mA → Output error=0.12mV

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On the other hand, when different magnetic fields are applied to each Hall element, this will appear as output error. For example, a current carrying trace that runs close the CZ-37xx may cause this. The extent of the error will depend on the layout of the current trace, actual current, distance from the CZ-37xx, and the part number (sensitivity). Figure 22 shows some simulated examples of output error by the nearby current.

![Figure 23. Examples of nearby current lines](image)

Figure 23. Examples of nearby current lines

![Figure 24. Output Error by nearby current](image)

Figure 24. Output Error by nearby current
3. Useful Tips

3.1 Supply Voltage

The CZ-37xx 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 13. shows an example of the external circuit where a 5V A/D converter is connected. Figure 14 shows the case where a 3.3V A/D is used. The supply voltage of the CZ-37xx 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.

Table 8. shows the VDD dependence of VREF voltage. Figure 25 shows the output voltage of the CZ-3702 (Sensitivity $V_h=100\text{mV/A}$) as an example ratiometric output.

<table>
<thead>
<tr>
<th>VDD(V)</th>
<th>VREF(V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5</td>
<td>2.25</td>
</tr>
<tr>
<td>5.0</td>
<td>2.50</td>
</tr>
<tr>
<td>5.5</td>
<td>2.75</td>
</tr>
</tbody>
</table>

Figure 25. Output voltage of the CZ-3702 vs Input current with different VDD. (Left: $V_{OUT}$, Right: $V_{OUT}-V_{REF}$)

3.2 Calibration of Zero-Current Output in initialization

The Zero-Current Output of the CZ-37xx 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 Power up
Figure 22 shows a recommended example of the power up sequence. In the power up sequence, if the time from \( V_{DD}=3.7V \) to \( V_{DD}=5V \) is less than 0.4msec, the output will be stabilized after 1.2msec (typ.) from the time \( V_{DD}=3.7V \). If it takes 0.4msec or more, it may take longer to stabilize the output. Please check the time needed to stabilize the output in that case.

![Figure 22. Recommended example of the power up sequence](image)

3.4 Magnetic parts around
The CZ-37xx output can be affected by magnetic devices (mechanical relays, transformers, etc.) that are nearby. In the case where magnetic devices must be placed close to the CZ-37xx, please check the effect on sensitivity or other characteristics and make sure any effects are understood and mitigated as much as possible.

3.5 Storage Environment
CZ-37xx 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 4week.
3.6 Sensitivity and Zero-Current Output Drift by Reflow

Solder reflow can cause the Sensitivity and Zero-Current Output of CZ-37xx 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 27. and Table.10 show the recommended reflow temperature profile. AKM recommends subjecting the CZ-37xx to a reflow process a maximum of three (3) times.

### Table 9. Reflow Conditions

<table>
<thead>
<tr>
<th></th>
<th>T&lt;sub&gt;s&lt;/sub&gt;</th>
<th>T&lt;sub&gt;s&lt;/sub&gt;-5°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preheat/Soak</td>
<td>T&lt;sub&gt;s&lt;/sub&gt;</td>
<td>150°C</td>
</tr>
<tr>
<td></td>
<td>T&lt;sub&gt;s&lt;/sub&gt;-max</td>
<td>200°C</td>
</tr>
<tr>
<td></td>
<td>T&lt;sub&gt;s&lt;/sub&gt;-min to T&lt;sub&gt;s&lt;/sub&gt;-max</td>
<td>60~120s</td>
</tr>
<tr>
<td>Liquidous Temperature</td>
<td>T&lt;sub&gt;L&lt;/sub&gt;</td>
<td>217°C</td>
</tr>
<tr>
<td></td>
<td>T&lt;sub&gt;L&lt;/sub&gt;-max</td>
<td>60~150s</td>
</tr>
<tr>
<td>Ramp-up Rate</td>
<td>T&lt;sub&gt;L&lt;/sub&gt; to T&lt;sub&gt;p&lt;/sub&gt;</td>
<td>3°C/s max.</td>
</tr>
<tr>
<td>Peak Package Body Temp</td>
<td>T&lt;sub&gt;p&lt;/sub&gt;</td>
<td>260°C max.</td>
</tr>
<tr>
<td></td>
<td>T&lt;sub&gt;p&lt;/sub&gt;-max</td>
<td>30s max.</td>
</tr>
<tr>
<td>Ramp-down Rate</td>
<td>T&lt;sub&gt;p&lt;/sub&gt; to T&lt;sub&gt;L&lt;/sub&gt;</td>
<td>6°C/s max.</td>
</tr>
<tr>
<td>Time 25°C to Peak Temp</td>
<td>25°C to T&lt;sub&gt;p&lt;/sub&gt;</td>
<td>8min max.</td>
</tr>
</tbody>
</table>

![Figure 23. Reflow profile](image-url)
3.6 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. CZ-37xx 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 CZ-37xx 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 \( I_{\text{NS}} \).

3.7 Safety Standard

CZ-37xx is certified as IEC/UL-62368-1,UL-1577 by the international certification organization.

- IEC/UL 62368-1, 2nd Ed, 2014-12-01 (Audio/video, information and communication technology equipment Part 1: Safety requirements)
- CAN/CSA C22.2 No. 62368-1-14, 2nd Ed-(Audio/video, information and communication technology equipment Part 1: Safety requirements)
- CSA Component Acceptance Service No. 5A – Component Acceptance Service for Optocouplers and Related Devices (File No. E499004)

3.8 Other information

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

akm.com  Search

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