June 1, 2022

CZ-3Axx Application Note

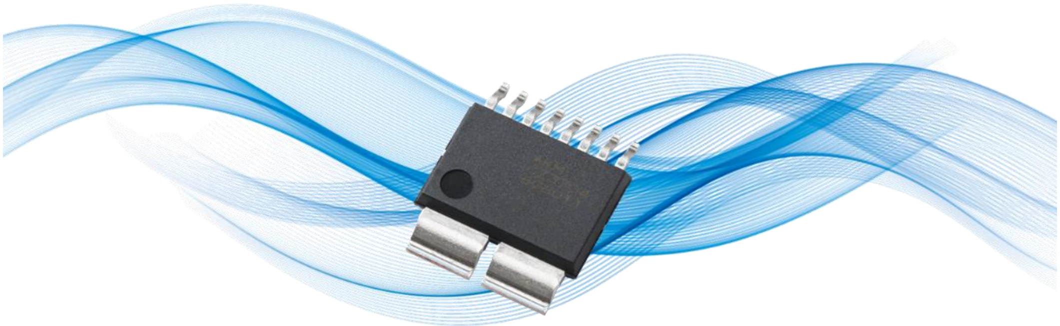
Table of contents

0. Overview

This document is an application note to help use AKM's current sensor CZ-3Axx series effectively.

This document consists of three sections;

1. Electric characteristics of the current sensor
2. Board design guideline
3. Useful tips



anticipate the current flow

Currentier™

Figure 1. A trademark of AKM coreless current sensor = Currentier

0.1. CZ-3Axx

Part number	CZ-3A0x (x : 1～7), CZ-3AGx (x : 1～7)
Features	Creepage, Clearance >8mm
	Capable of 50Arms
	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-3Axx series. A wide line up of measurement ranges from ±12.9App to ±129.1App (CZ-3A0x) and ±11.6App to ±116.6App (CZ-3AGx) enables customers to use the same series for different products.

Details of Feature

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=600Vrms (reinforced insulation) helps customers easily design products using these devices.

2. Low heat generation,50Arms,

CZ-3A0x:±12.9～±129.1App, CZ-3AGx: ±11.6~±116.6App

The CZ-3Axx 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 50Arms.

３． High Accuracy

The CZ-3Axx series is a highly accurate coreless current sensor with accuracy of 0.2% F.S.(Typical). The built-in stray magnetic field reduction function solves the problem of existing coreless current sensors. The CZ-3Axx series contributes to the improvement of system efficiency and precise control in a wider range of applications.

３． Non-ratiometric

This means that the output of the current sensor(Sensitivity and Zero-current voltage) is constant, even if the supply power voltage changed. CZ-3Axx can detect without error, under the condition the supply power voltage is not stable.

Table1. CZ-3Axx series

Part #	Linear Sensing Range (A)	Sensitivity (mV/A)	Input Voltage (V)	Output Voltage (V)	Temperature Drift of Sensitivity (%)*1	Temperature Drift of Zero-current Output Voltage (mV)*1	Total Accuracy (%F.S.)*2	Response Time (μs)
CZ-3A01	±12.9	120	3.3	3.3	±0.6	±2.8	0.2 (Typ) 0.4 (Max)	1
CZ-3A02	±15.5	100						
CZ-3A03	±22.1	70						
CZ-3A04	±32.2	48						
CZ-3A05	±64.5	24						
CZ-3A06	±103.3	15						
CZ-3A07	±129.1	12						
CZ-3AG1	±11.6	120	5.0	3.0	±0.6	±2.8	0.2 (Typ) 0.4 (Max)	1
CZ-3AG2	±14.0	100						
CZ-3AG3	±20.0	70						
CZ-3AG4	±29.1	48						
CZ-3AG5	±58.3	24						
CZ-3AG6	±93.3	15						
CZ-3AG7	±116.6	12						

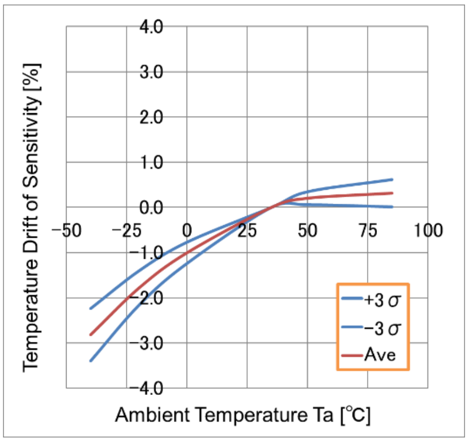
*1 Defined as the average value ±3σ of the actual measurement results within a certain lot at Ta=35～90℃.

*2 The typical value is defined as the average value ±1σ of the actual measurement results within a certain lot at Ta=35～90℃. 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 ($V_{h\text{-}d}$ [%]) is defined as the change rate of Sensitivity (V_h [mV/A]) when Operating Ambient Temperature (T_a [°C]) changes from 35°C to Ta1(−40°C ≤ Ta1 ≤ 85°C);



$$V_{h-d} = 100 \times \left(\frac{V_h(T_a = T_{a1})}{V_h(T_a = 35°C)} - 1\right)$$

Figure2. Temperature Drift of Sensitivity

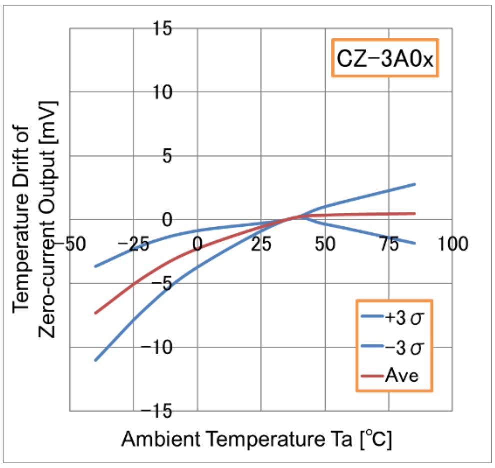
Figure 2. shows “Average” and “Average ±3σ” of the actual result in a certain lot. This temperature characteristic is the same in CZ-3Axx series.

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 ($V_{of\text{-}d}$ [mV]) is defined as the change of Zero-current Output (V_{of} [V]) when Operating Ambient Temperature (Ta [°C]) changes from 35°C to Ta1(−40°C ≤ Ta1 ≤ 85°C);

$$V_{of\text{-}d} = V_{of}(T_a = T_{a1}) - V_{of}(T_a = 35°C)$$



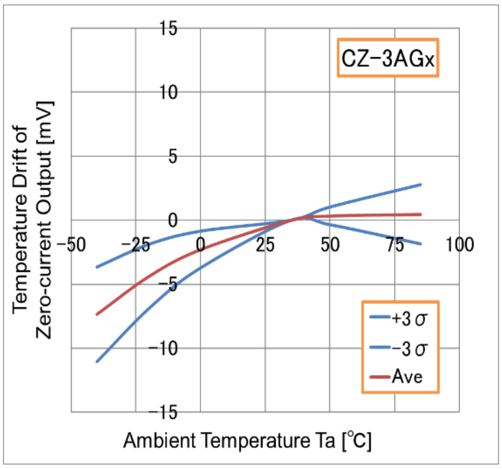


Figure 3. Temperature Drift of Zero-current Output

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 (Etotal) is defined as follows;

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

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

V_{h-meas} : Measured Sensitivity [mV/A]

V_h : Typical Sensitivity [mV/A]

V_{of-d} : Measured Drift of Zero-current Output [mV]

ρ_{meas} : Measured Linearity Error [%F.S.]

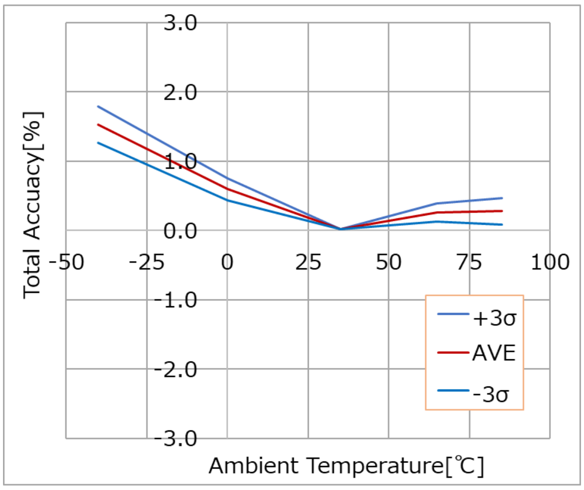


Figure 4. Temperature dependency of Total Accuracy

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-3Axx (without filter, typical datasheet values)

Part #	Sensitivity [mV/A]	Linear Sensing Range [A]	Output noise [mV_{pp}]	Output noise [mV_{rms}]	Input Current Equivalent Noise [mA_{rms}]	ENOB [Bits]
CZ-3A01	120	±12.9	28	4.2	35	7.7
CZ-3A02	100	±15.5	23	3.5	35	8.0
CZ-3A03	70	±22.1	16	2.5	35	8.5
CZ-3A04	48	±32.2	14	2.2	45	8.7
CZ-3A05	25	±64.5	7	1.1	45	9.7
CZ-3A06	15	±103.3	7	1.1	70	9.7
CZ-3A07	12	±129.1	7	1.0	85	9.8
CZ-3AG1	120	±11.6	16	2.4	20	8.5
CZ-3AG2	100	±14	13	2.0	20	8.7
CZ-3AG3	70	±20	9	1.4	20	9.2
CZ-3AG4	48	±29.1	8	1.2	25	9.4
CZ-3AG5	25	±58.3	7	1.1	45	9.6
CZ-3AG6	15	±93.3	7	1.1	70	9.5
CZ-3AG7	12	±116.6	7	1.0	85	9.7

Table 3. Example of Current Resolution and Filter Characteristics (CZ-3A01, actual result of N=1)

C_1[nF]	R_1[kΩ]	Bandwidth [kHz]	Output noise [mV_{pp}]	Output noise [mV_{rms}]	Input Current Equivalent Noise [mA_{rms}]	ENOB [Bits]
Without filter			30.6	3.5	29.1	8.0
0.47	3	113	17.6	8.7	17.6	8.7
4.7	3	11	7.5	10.0	7.5	10.0
4.7	10	3.4	4.8	10.6	4.8	10.6

Table 4. Example of Current Resolution and Filter Characteristics (CZ-3AG1, actual result of N=1)

C_1[nF]	R_1[kΩ]	Bandwidth [kHz]	Output noise [mV_{pp}]	Output noise [mV_{rms}]	Input Current Equivalent Noise [mA_{rms}]	ENOB [Bits]
Without filter			21.0	2.4	20.4	8.4
0.47	3	113	15.4	8.8	15.4	8.8
4.7	3	11	7.6	9.8	7.6	9.8
4.7	10	3.4	4.7	10.5	4.7	10.5

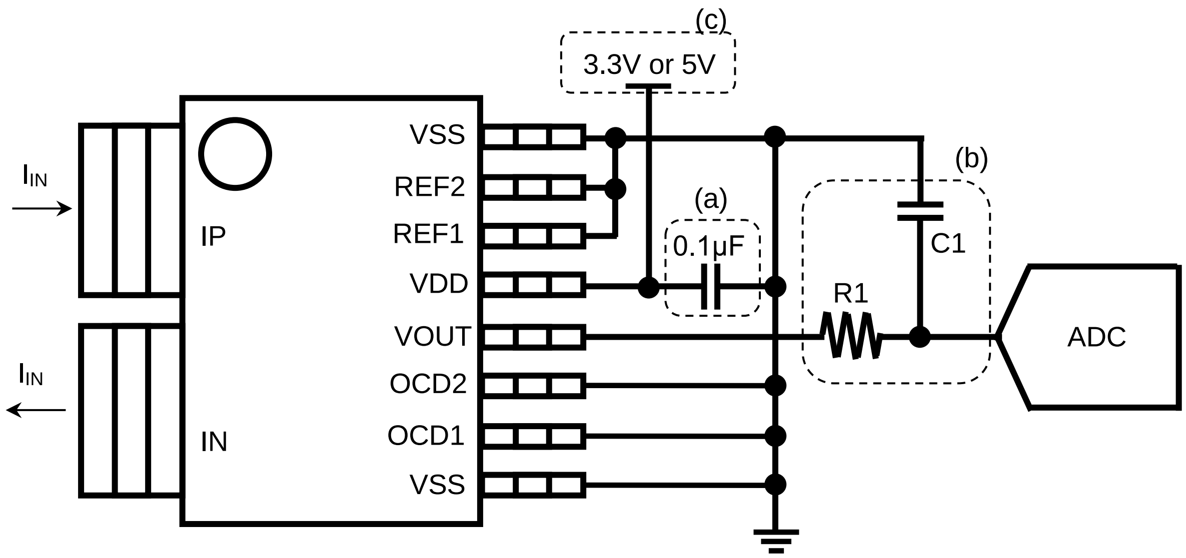


Figure 5. External Circuits Example

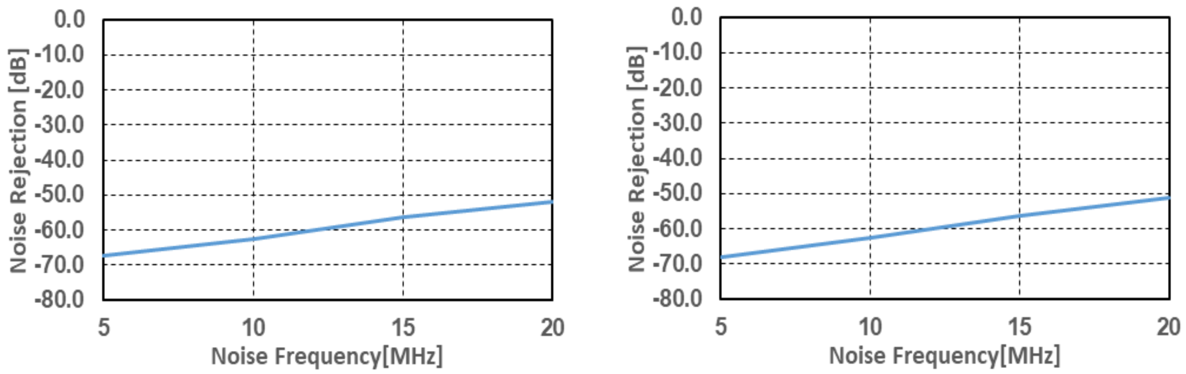
(a) 0.1μF bypass capacitor should be placed close to VDD and VSS pins of the device.
(b) Add a low-pass filter to VOUT pin, if it is necessary. The R1 and C1 values should be fixed in consideration of the time constant of the filter and load conditions.
(c) 3.3V should be applied in case of CZ-3A0x. 5V should be applied in case of CZ-3AGx.

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 5 shows the CZ-3Axx series having a strong voltage noise rejection ratio. Figure 6. shows the frequency dependency of the voltage noise rejection ratio.

Table 5. Voltage Noise Rejection Ratio when high frequency sine wave voltage

	Frequency (MHz)	Vout (mV_{pp})	Noise Rejection (dB)
CZ-3A0x	5	8.8	-67.2
	10	15.3	-62.4
	15	35.0	-56.1
	20	55.2	-52.1
CZ-3AGx	5	7.9	-68.0
	10	15.0	-62.5
	15	34.4	-56.2
	20	60.6	-51.1



(a) CZ-3A0x (b) CZ-3AGx

Figure 6. CZ-3Axx Noise Frequency vs Voltage Noise Rejection Ratio

1.6. Temperature Drift of the Primary Conductor Resistance

Figure 7. shows the temperature drift of the primary conductor resistance of CZ-3Axx. (reference)

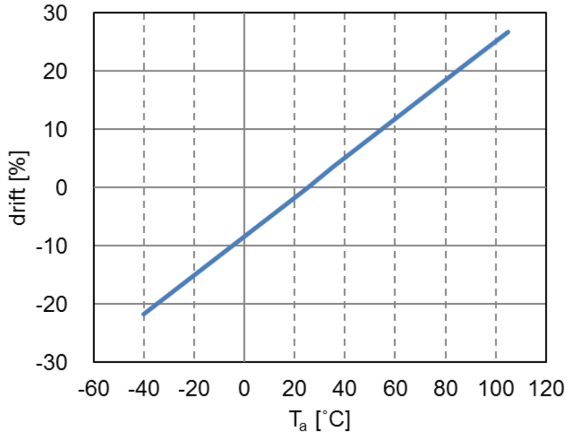


Figure 7. CZ-3Axx Temperature Drift of the Primary Conductor Resistance (normalized at 25℃)

1.7. Variation of the Primary Conductor Resistance

The primary conductor resistance of CZ-3Axx varies from 0.21mΩ to 0.30mΩ (reference) at 25°C.

1.8. Inductance of the Primary Conductor

The primary conductor inductance of CZ-3Axx is about 3nH (reference) at 25°C.

1.9. Thermal Resistance

The thermal resistance (θja) of CZ-3Axx is 32°C/W when using the board shown in Figure 8.

Table 6. Thermal Resistance measurement board

Board size	68.6mm×59.7mm
Number of layer	4 layers
Copper layer thickness	70µm/layer
Board thickness	1.6mm

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

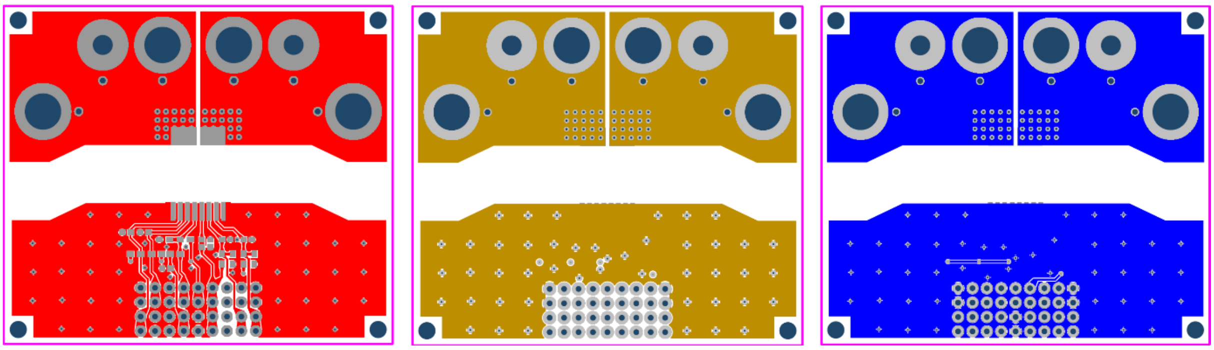


Figure 8. Thermal Resistance measurement board

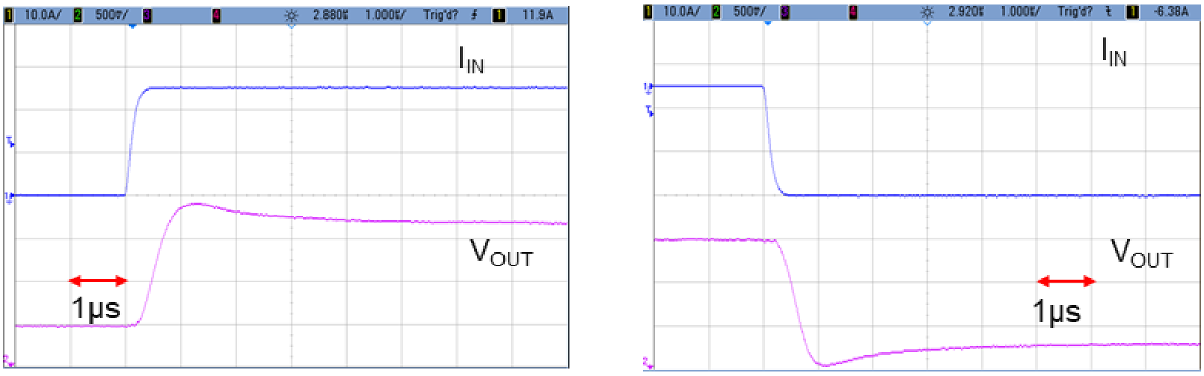
1.10. Response Time

The response time of CZ-3A0x is typically 1µs and the response time of CZ-3G0x is typically 3.6µs with a load capacitance of 1000pF.

Figure 9. shows the typical pulse response waveform. Rise and fall response time of CZ-3A0x is about 0.8µs and rise and fall response time of CZ-3AGx is about 2.4µs with a load capacitance of 1000pF.

The conditions are written as below.

- Part# : CZ-3A04(Vh=48mV/A)
- Input current＝25A



<u>The conditions are written as below.</u>

- Part# : CZ-3AG4(Vh=48mV/A)
- Input current＝25A

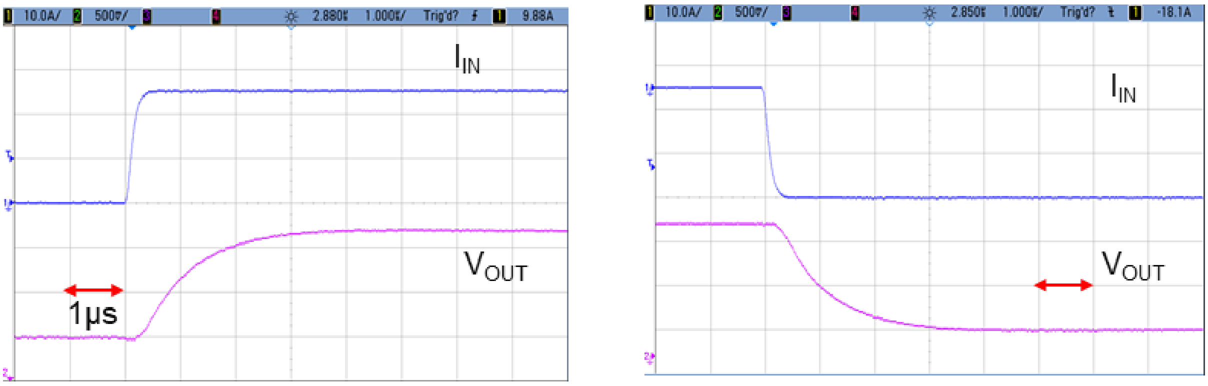
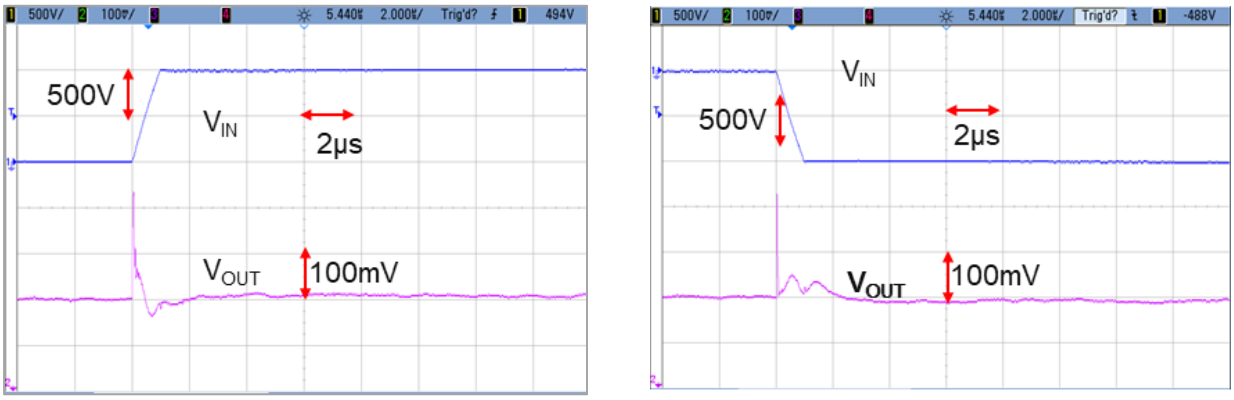


Figure 9. Rise response waveform (left), fall response waveform (right).

1.11. dV/dt Noise, dI/dt Noise

Figure 10. shows the dV/dt noise property of CZ-3Axx output voltage (V_{OUT}), when 1kV is applied to the primary conductor at the rise time of 1μs. The yellow line shows the input voltage waveform and the green line shows the output voltage waveform. The convergence time of CZ-3A0x is as short as 2μs. The convergence time of CZ-3AGx is as short as 3μs. Please avoid this noise by adjusting the capture timing.

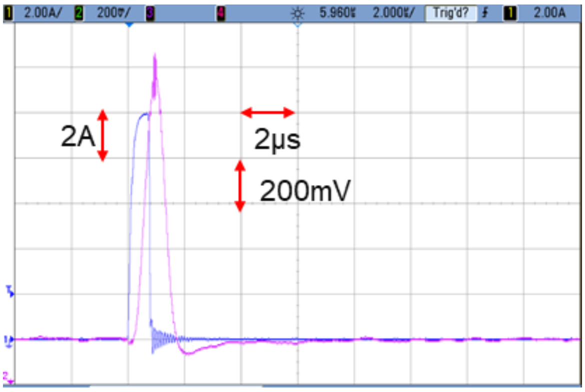


(a)CZ-3A0x

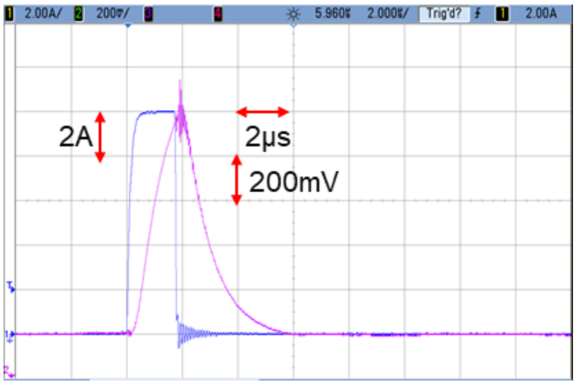
(b)CZ-3AGx

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

Figure 11(a). shows the output voltage (V_{OUT}) of CZ-3A0x, when a 10A pulse is applied to the primary conductor with a pulse width of 1μs.
Figure 11(b). shows the output voltage (V_{OUT}) of CZ-3AGx, when a 10A pulse is applied to the primary conductor with a pulse width of 2μs.
The yellow line shows the input current waveform and the green line shows the output voltage waveform.
The convergence time of CZ-3A0x is as short as 2μs.
The convergence time of CZ-3AGx is as short as 3μs.



(a)CZ-3A0x



(b)CZ-3AGx

Figure 11. dI/dt noise waveform

1.12. OCD(Over Current Detection)

OCD function is operated as below. (refer to Figure12.)

(1) After the I_{IN}[A] has exceeded the overcurrent detection threshold (I_{OCDTH}) for overcurrent response time (t_{RSOCD}) , overcurrent detection output voltage (V_{OCD})will be logical low.

(2) When the I_{IN}[A] decreases below the value (I_{OCDTH} - I_{OCDHY}) which is defined by difference between the overcurrent detection threshold (I_{OCDTH}) and overcurrent detection threshold hysteresis (I_{OCDHY}), overcurrent detection output voltage (V_{OCD})goes high within the overcurrent recovery time (t_{RCOCD}).

(3) If the I_{IN}[A] goes up more than the overcurrent detection threshold (I_{OCDTH}) and then decreases below the value (I_{OCDTH} - I_{OCDHY}) for less than overcurrent response time (t_{RSOCD}), the overcurrent detection output voltage (V_{OCD}) does not change.

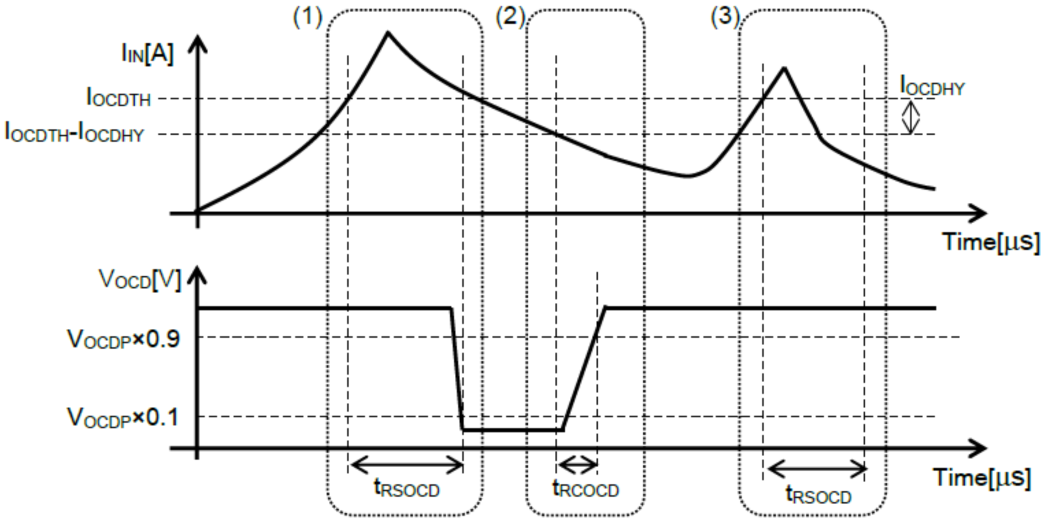


Figure 12. OCD function of CZ-3Axx series

Figure13. shows the typical OCD response time of CZ-3A01.

The conditions are written as below.

- Part # : CZ-3A01
- Input current=15A
- V_{REF1}=300mV, V_{REF2}=1400mV
- I_{OCDTH1}= 14.5A, I_{OCDTH2}=14.6A
- ROCD=1kΩ、CLOCD=1000pF
- Pull up voltage＝3.3V

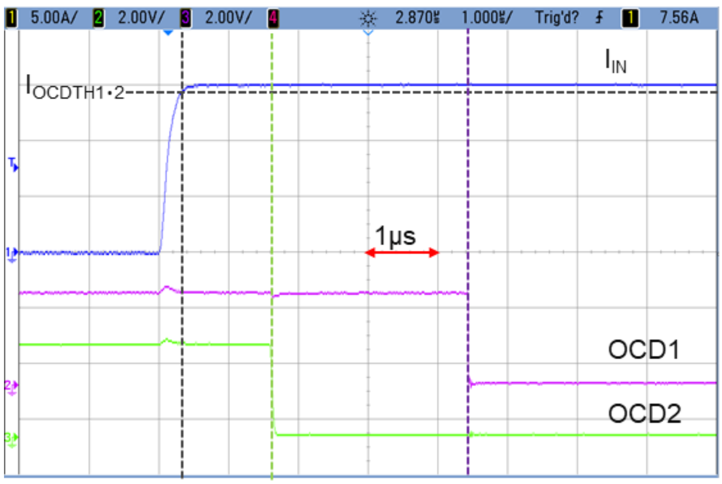


Figure 13. OCD1 and OCD2 response time of CZ-3A01

OCD threshold is defined as below.

VREF1 [mV] = 2500 - $|I_{OCDTH1}|$[A] × "Constant１"

VREF2 [mV] = 2500 － $|I_{OCDTH2}|$[A] × "Constant2"

※1 VREF1 [mV] = 300~1620[mV]

※2 VREF2 [mV] = 300~1400[mV]

Table7. Parameter for VREF setting

P/N	Constant1	Constant2	Threshold Current Value[A]		OCD response time[μs]	
			$\|I_{OCDTH1}\|$	$\|I_{OCDTH2}\|$	t_{RSOCD1}	t_{RSOCD2}
CZ-3A01	1056/7	528/7	5.9~14.5	14.6~29.1	4.5	1.5
CZ-3A02	880/7	440/7	7.0~17.5	17.5~35.0	4.5	1.5
CZ-3A03	88/1	44/1	10.0~25.0	25.0~50.0	4.5	1.5
CZ-3A04	2112/35	1056/35	14.6~36.4	36.5~72.9	4.5	1.5
CZ-3A05	1056/35	528/35	29.2~72.9	73.0~145.8	4.5	1.5
CZ-3A06	132/7	66/7	46.7~116.6	116.7~233.3	4.5	1.5
CZ-3A07	528/35	264/35	58.4~145.8	145.9~291.6	4.5	1.5
CZ-3AG1	1056/7	528/7	5.9~14.5	14.6~29.1	5.5	2.5
CZ-3AG2	880/7	440/7	7.0~17.5	17.5~35.0	5.5	2.5
CZ-3AG3	88/1	44/1	10.0~25.0	25.0~50.0	5.5	2.5
CZ-3AG4	2112/35	1056/35	14.6~36.4	36.5~72.9	5.5	2.5
CZ-3AG5	1056/35	528/35	29.2~72.9	73.0~145.8	5.5	2.5
CZ-3AG6	132/7	66/7	46.7~116.6	116.7~233.3	5.5	2.5
CZ-3AG7	528/35	264/35	58.4~145.8	145.9~291.6	5.5	2.5

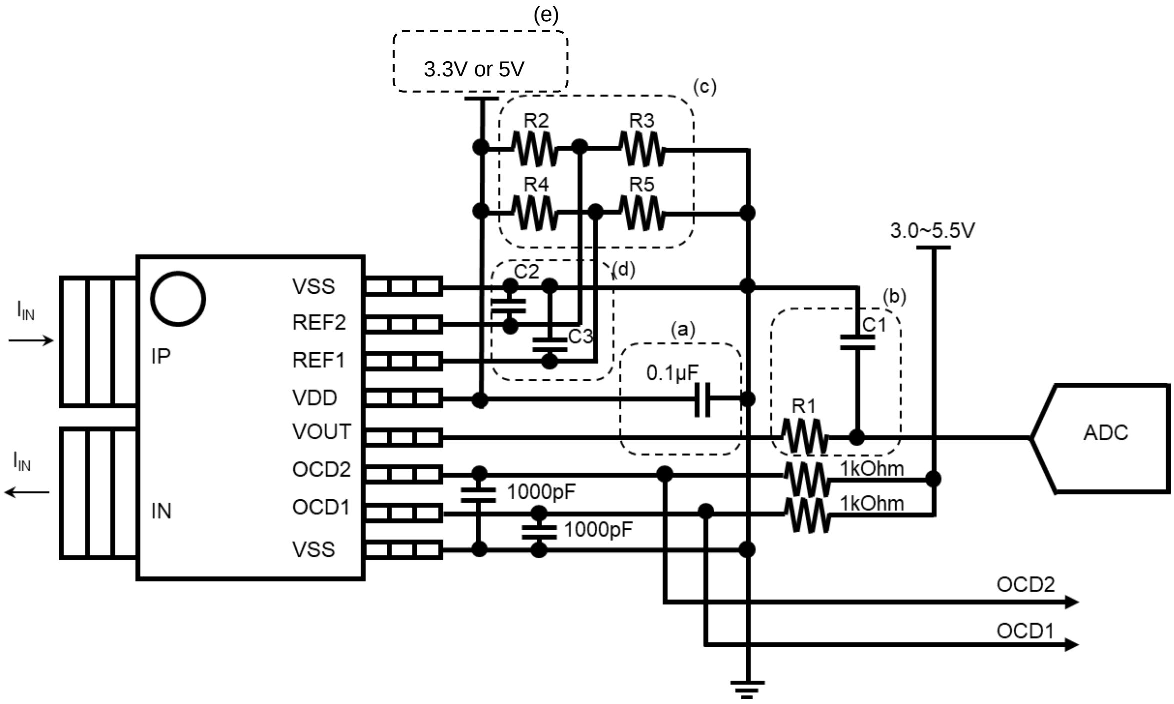


Figure 14. External Circuit Example

(a) 0.1uF bypass capacitor should be placed close to CZ-3Axx.
(b) Add a low-pass filter if it is necessary. The R1 and C1 values should be fixed in consideration of the time constant of the filter and load conditions.
(c) Overcurrent detection thresholds are decided by the input voltage of REF1 and REF2 pin. R2, R3, R4 and R5 values determined according to the overcurrent detection thresholds. (see datasheet chapter 10.5)
(d) Add capacitors if necessary. The C2 and C3 values should be fixed in consideration of the time constant values which are decided by ratio of C2 to R2 and R3 or C3 to R4 and R5.
(e) 3.3V should be applied in case of CZ-3A0x. 5V should be applied in case of CZ-3AGx.

※If overcurrent detection function is not required. Connect VSS and both REF1 pin and OCD1 pin or both REF2 pin and OCD2 pin.

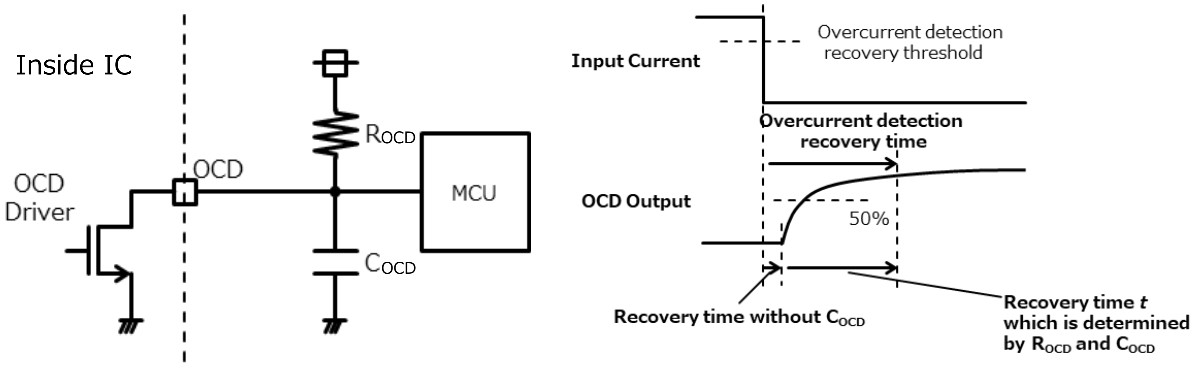


Figure 15. Recovery time adjustment circuit example and recovery time

When the open-drain output pull-up resistors R_{OCD} and C_{OCD} are connected and the OCD output is input to the microcontroller in the later stage as shown in Figure 15, the recovery time from Low to High of the OCD output that is input to the microcontroller can be obtained by the following equation.

The recovery time t = - R_{OCD} × C_{OCD} × LN(1 - Convergence rate)

Example) If a 10us delay is added at a point where the convergence rate is 50%.

$$t = -R \times C \times \ln(1 - 0.5) \geq 10us$$

$$R \times C \geq 14.4\ us$$

∴ If C=1000pF, R≧14.3kΩ

∴ If C=100pF, R≧143kΩ

As shown above, any desired recovery time can be set, so please make use of this function in your design.

※Please note that the capacitance of C to be used should not exceed Max. 1000pF, and R should not be less than Min. 0.6kΩ.

2. Board Design Guidelines

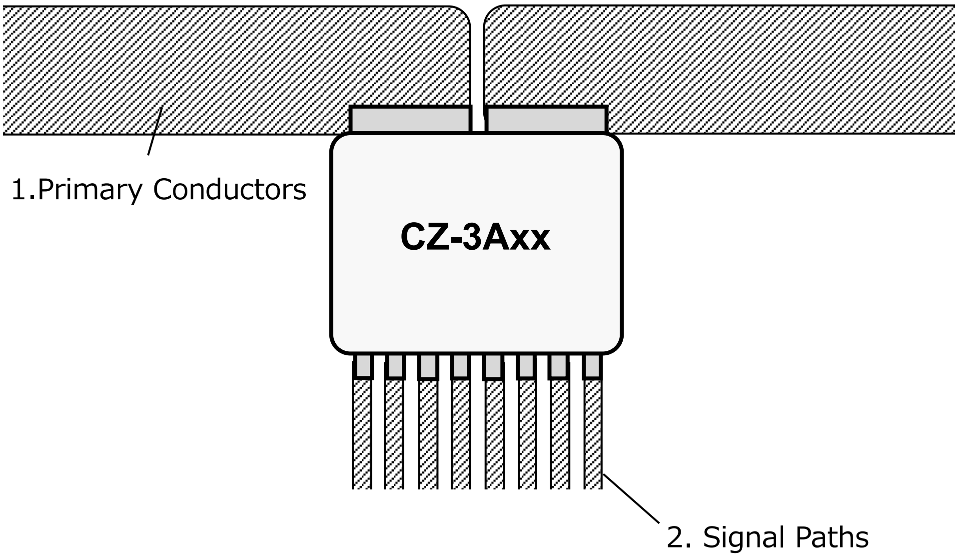


Figure 16. Board layout names in this section

2.1. External Circuits Example

In this subsection, we show two examples of the external circuit when using CZ-3Axx. These are just examples and there are other possible circuits. Please evaluate your external circuit by yourself. This example shows the case of OCD not in use. If you think about using OCD function, please refer to figure14.

Case1) Connecting a 3V A/D converter in the subsequent stage
Case2) Connecting an amplifier to change the reference voltage of the output or to change the sensitivity

Case1) CZ-3Axx+ADC(3V)

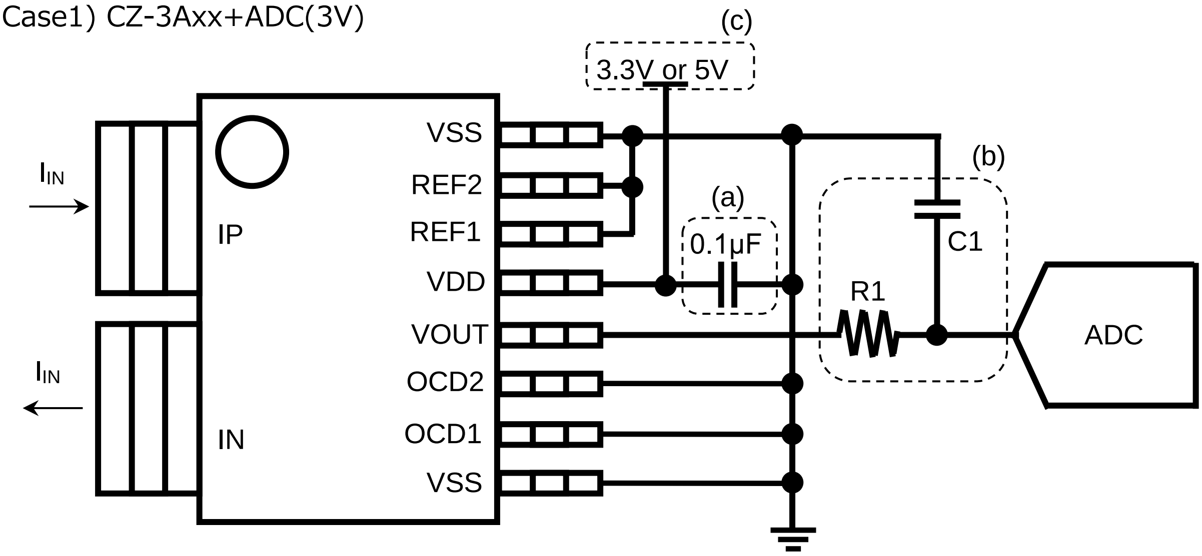


Figure 17. External Circuit Example 1

(a) 0.1μF bypass capacitor should be placed close to VDD and VSS pins of CZ-3Axx.
(b) Add a low-pass filter to the VOUT pins if necessary. The R1 and C1 values should be fixed in consideration of the time constant of the filter and load conditions.
(c) 3.3V should be applied in case of CZ-3A0x. 5V should be applied in case of CZ-3AGx.

Case2) CZ-3Axx+Amplifier

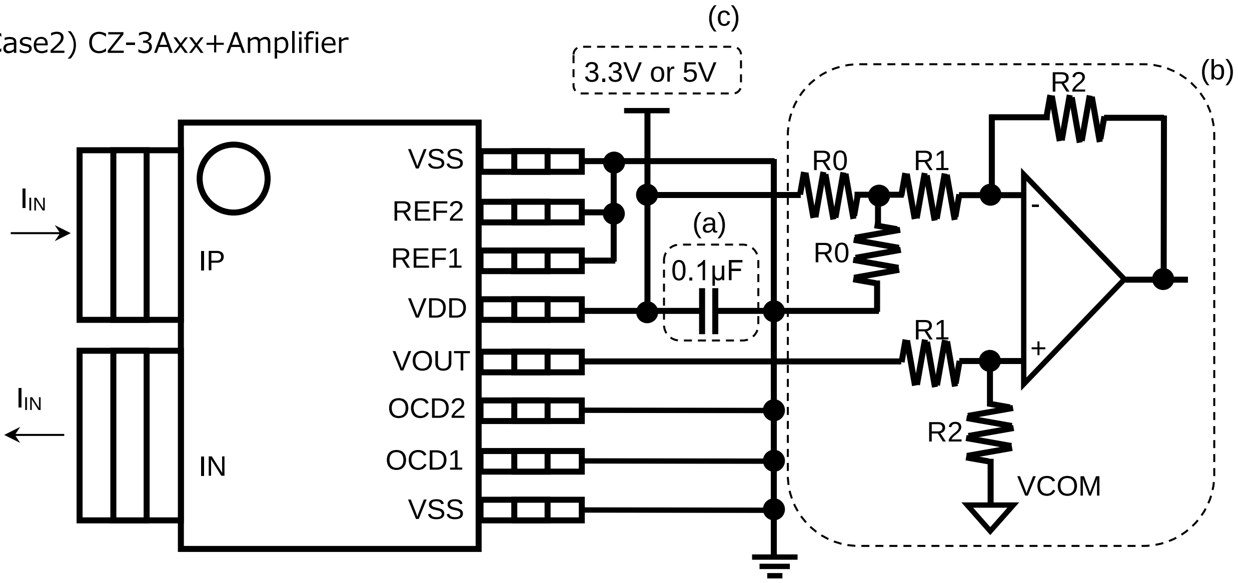


Figure 18. External Circuit Example 2

(a) 0.1μF bypass capacitor should be placed close to VDD and VSS pins of CZ-3Axx.
(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.
(c) 3.3V should be applied in case of CZ-3A0x. 5V should be applied in case of CZ-3AGx.

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-3Axx wider in the width and shorter in the length to make the trace resistance small and to prevent overheating.

Please refer to Figure19. and Figure 8. for the recommended footprint.

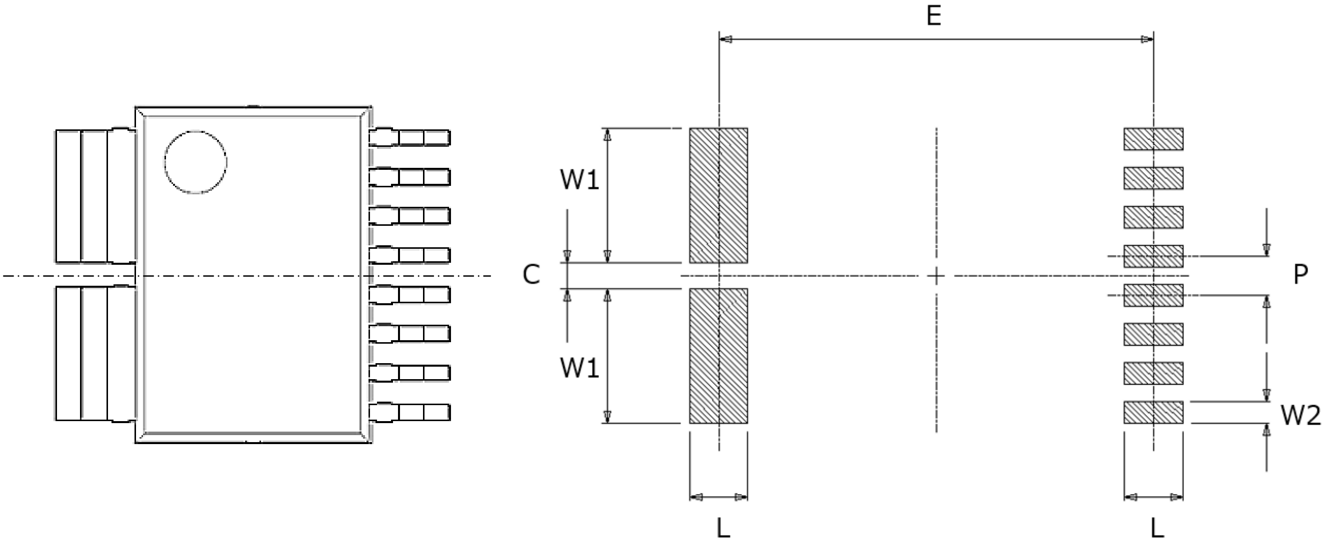


Figure 19. CZ-3Axx recommended land pattern

Table 8. CZ-3Axx recommended land pattern dimensions

L	1.59
E	11.79
W1	4.44
W2	0.64
C	0.66
P	1.27

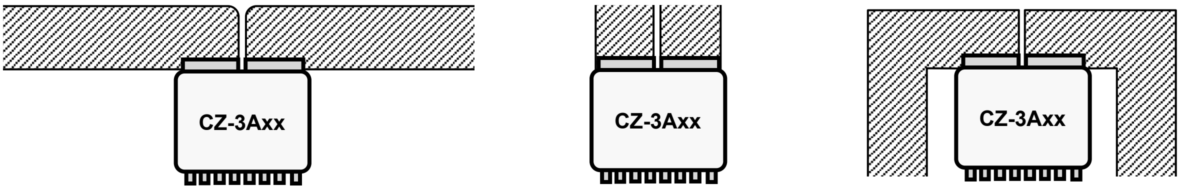
Unit : mm

2.2.2. The Configuration of the Trace

We recommend extending straight to right and left as shown in the Figure20(a). If this is not possible due to board layout limitations, we recommend extending away from the signal paths as shown in the Figure20(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 Figure20(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.

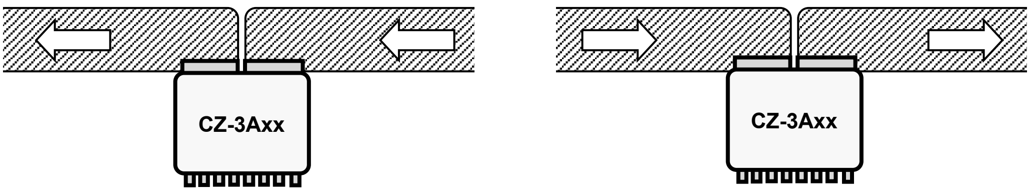


(a) Straight (recommended) (b) Away from the signal paths (recommended) (c) Toward the signal paths (Not recommended)

Figure 20. How to trace the primary conductor of CZ-3Axx

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 21, the output of the CZ-3Axx decreases as current flows from right to left, and increases from left to right.



(a) CZ-3A0x: V_{OUT} > 1.65V
CZ-3AGx: V_{OUT} > 1.5V

(b) CZ-3A0x: V_{OUT} < 1.65V
CZ-3AGx: V_{OUT} < 1.5V

Figure 21. The relationship between the output of CZ-3Axx and the direction of the primary current

2.3 Trace of the signal paths

Please refer to the followings for pin names of CZ-3Axx.

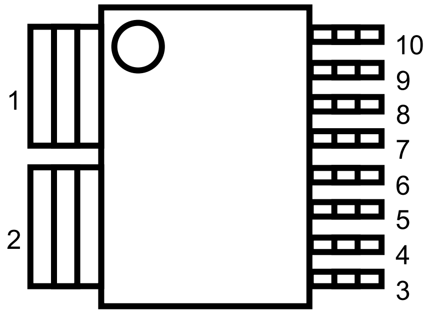


Figure 22. CZ-3Axx Pin Configuration

Table 9. Pin functions of CZ-3Axx

Pin No.	Pin Name	I/O	Type	機能
1	IP	I	-	Primary conductor pin (+)
2	IN	I	-	Primary conductor pin (−)
3	VSS	GND	-	Ground pin (GND)
4	OCD1	O	Digital	The overcurrent detection output pin1, open drain output Normal output: H, Overcurrent Detection: L
5	OCD2	O	Digital	The overcurrent detection output pin2, open drain output Normal output: H, Overcurrent Detection: L
6	VOUT	O	Analog	Sensor output pin
7	VDD	PWR	Power	Power supply pin
8	REF1	I	Analog	Analog input pin to adjust the overcurrent threshold 1
9	REF2	I	Analog	Analog input pin to adjust the overcurrent threshold 2
10	VSS	GND	-	Ground pin (GND)

2.3.1. Length and width of the signal paths

We recommend making the traces of VDD and VOUT 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 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 VSS pin of CZ-3Axx to the GND of signal line.

2.3.4. Insulation design

The package of CZ-3Axx is compliant with safety standard UL61800-5-1. The clearance and creepage between the primary conductor and the signal paths is more than 8mm. The Comparative Tracking Index (CTI) of the CZ-3Axx package resin is 400V, the Material Group is Ⅱ. Table 9 shows the Working Voltage of CZ-3Axx.

In order to maximize the insulation withstanding voltage of CZ-3Axx, 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 the creepage by adding a slit in the board as shown in Figure 23.

Table 10. Working Voltage

Working Voltage	Pollution Degree			
	1	2	3	
Basic Isolation	2100	1118	561	(Vrms)
Reinforced Isolation	1200	557	281	

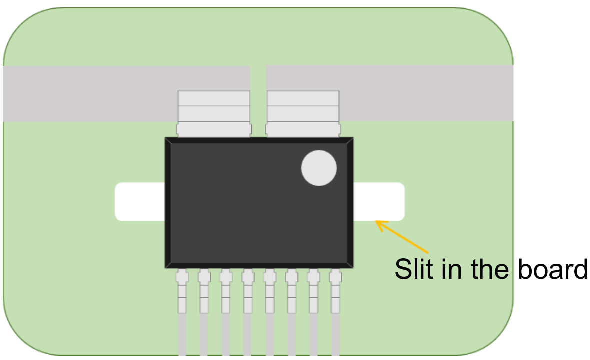


Figure 23. Example to increase the creepage

2.4 Thermal design

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

The CZ-3Axx is capable of 50A_{rms} continuous current, even larger current in case of transitional. When CZ-3Axx is used under conditions compliant with UL61800-5-1, please ensure the case temperature (T_c) is kept lower than 130℃ from heating by the primary current. Please refer to the Figure24. for the position to measure T_c.

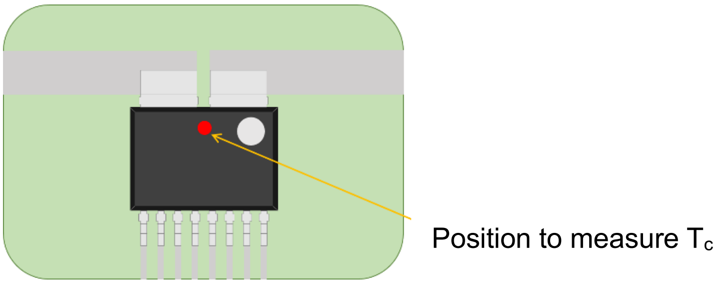


Figure24. Position to measure package case temperature

2.4.2. Junction temperature (Tj) estimation

T_j can be estimated the temperature from CZ-3Axx's lead frame. Because it nearly equals to the temperature of the sensor inside the package.

2.4.3. Improvement of heat dissipation

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 or outer thermal layer directly.

2.4.4. Heating Measurement(reference)

Figure25 and Figure26 shows the results of T_c measurement used by Figure8 "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℃）
Position to measure T_c : Refer to Figure23.
Maximum operation temperature : T_c<130℃

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

180A :50sq, AWG0.3, Diameter:8.0mm

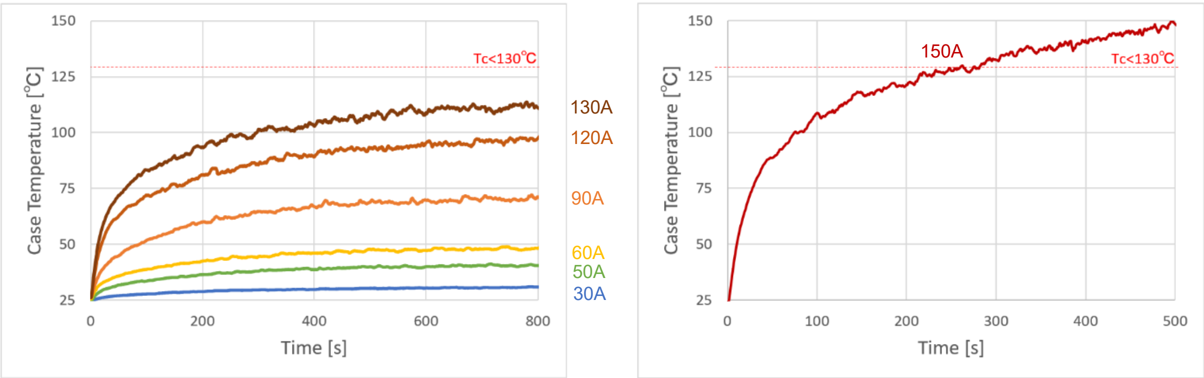


Figure25. Relationship between CZ-3Axx Case temperature and amount of input current (left: 30~130A, right: 150A)

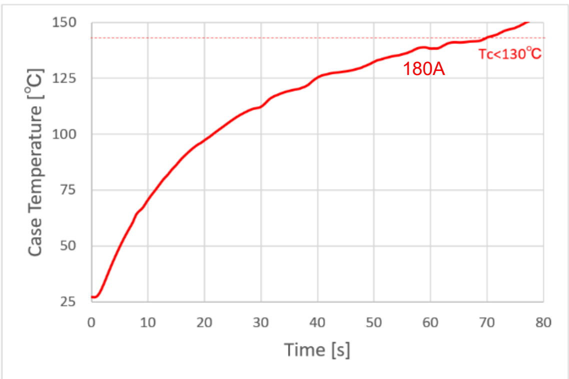


Figure26. Relationship between CZ-3Axx Case temperature and amount of input current(180A)

2.5. Stray Magnetic Field Reduction Function

There are two Hall elements inside CZ-3Axx connected in a differential manner. By detecting the difference of these two Hall elements' outputs, CZ-3Axx 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-3Axx by the ratio of Stray Magnetic Field Reduction (Ebc: 0.01A/mT Typ.).

Example: When a stray magnetic field of 1mT is applied to the CZ-3Axx, the output will have additional error of 0.01A=10mA equivalent.

- CZ-3A01: Sensitivity=120mV/A, Error=10mA → Output error=1.2mV
- CZ-3A07: Sensitivity=12mV/A, Error=10mA → Output error=0.12mV

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-3Axx may cause this. The extent of the error will depend on the layout of the current trace, actual current, distance from the CZ-3Axx, and the part number (sensitivity). Figure 28 shows some simulated examples of output error by the nearby current.

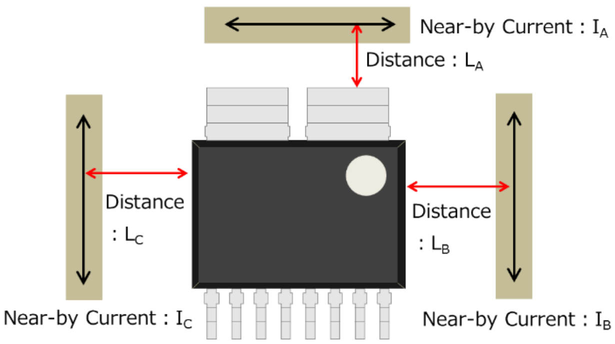


Figure 27. Examples of nearby current lines

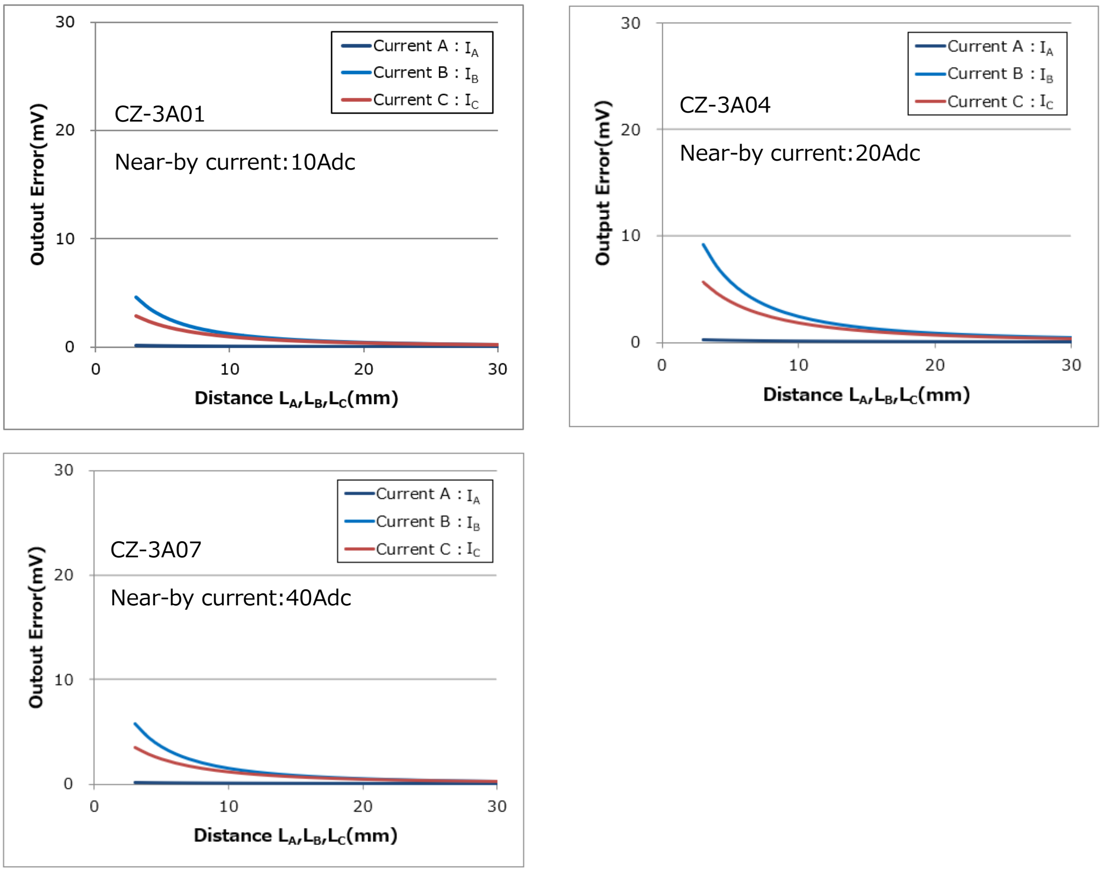


Figure28. Output Error by nearby current

3. Useful Tips

3.1 Calibration of Zero-Current Output in initialization

The Zero-Current Output of the CZ-3Axx 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.

3.2 Power up sequence

Figure 29. shows a recommended example of the power up sequence.

In the power up sequence of CZ-3A0x, if the time from VDD=2.75V to VDD=3.3V is less than 0.87msec, the output will be stabilized after 0.87msec(typ.) from the time VDD=2.75V. If it takes 0.87msec or more, it may take longer to stabilize the output.

In the power up sequence of CZ-3AGx, if the time from VDD=2.75V to VDD=5.0V is less than 0.79msec, the output will be stabilized after 0.79msec(typ.) from the time VDD=2.75V. If it takes 0.79msec or more, it may take longer to stabilize the output.

Please check the time needed to stabilize the output in that case.

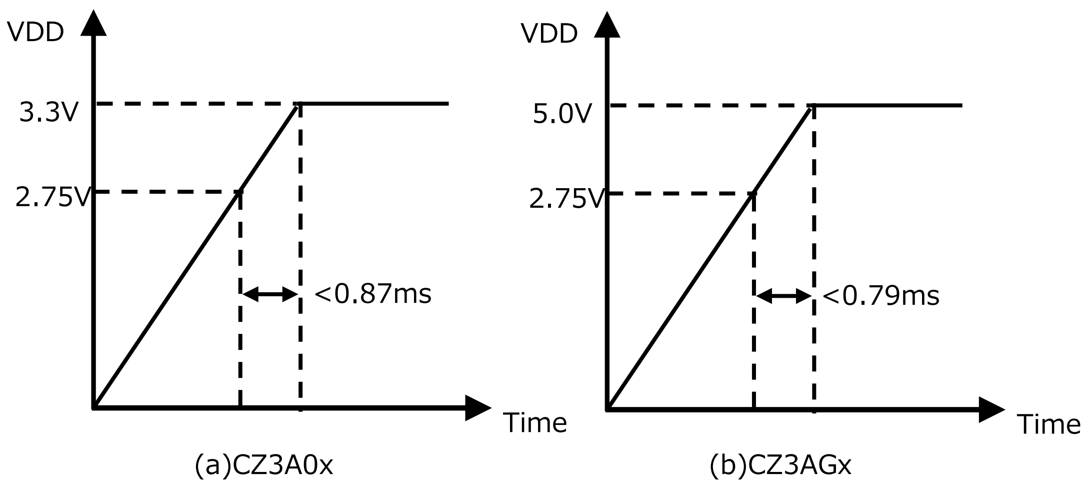


図 29. Recommended example of the power up sequence

3.3 Magnetic parts around

The CZ-3Axx 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 CZ-3Axx, please check the effect on sensitivity or other characteristics and make sure any effects are understood and mitigated as much as possible.

3.4 Storage Environment

CZ-3Axx is the condition of MSL2a(JEDEC J-STD-020). Please store in accordance with 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 4weeks.

3.5 Sensitivity and Zero-Current Output Drift by Reflow

Solder reflow can cause the Sensitivity and Zero-Current Output of CZ-3Axx 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 3.1 of this document.

Figure 30. and Table.11 show the recommended reflow temperature profile. AKM recommends subjecting the CZ-3Axx to a reflow process a maximum of three (3) times.

Table11. Reflow Conditions

Preheat/Soak	T_{smin}	150°C
	T_{smax}	200°C
	T_{smin} to T_{smax}	60~120s
Liquidous Temperature	T_L	217°C
	t_L	60~150s
Ramp-up Rate	T_L to T_p	3°C/s max.
Peak Package Body Temperature	T_p	260°C max.
	t_p	30s max.
Ramp-down Rate	T_p to T_L	6°C/s max.
Time 25°C to Peak Temperature	25°C to T_p	8min max.

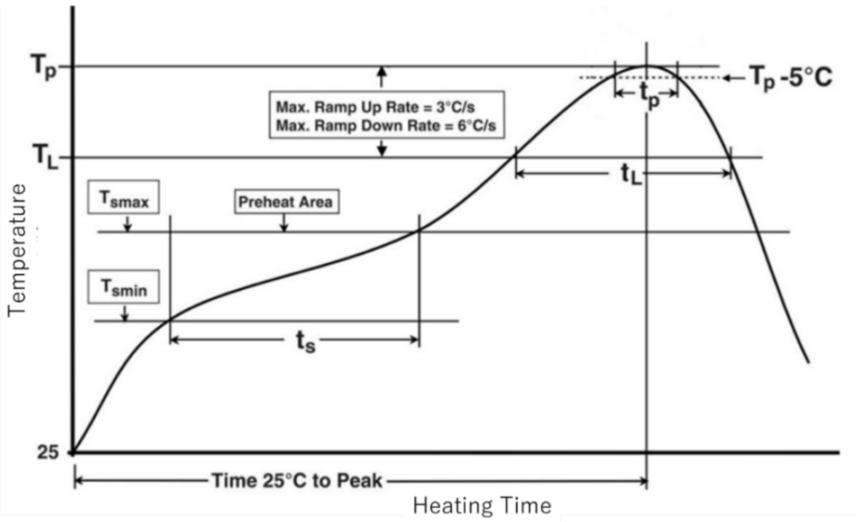


Figure 30. Reflow profile

3.6 Maximum Primary Current and Linear Sensing Range

Maximum Primary Current (I_{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-3Axx can be damaged if it is used in conditions where the DC current or the root-mean-square value of AC current exceeds I_{RMSmax} for an extended period of time. In the case of pulsed current, it is possible to apply currents larger than I_{RMSmax}.

Linear Sensing Range (I_{NS}) is the current range where we guarantee the linearity of CZ-3Axx output. If the primary current is beyond I_{NS}, the output will saturate. However, it will return to normal once the primary current is back within I_{NS}.

3.7 Safety Standard

CZ-3Axx is certified as IEC/UL-62368, 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) (FileNo.E359197)
・CAN/CSA C22.2 No. 62368-1-14, 2nd Ed-(Audio/video, information and communication technology equipment Part 1: Safety requirements)(FileNo.E359197)
・UL1577－Optical Isolators－Edition 5.(File No. E499004)
・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 検索

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

Disclaimer

All information included in this document are provided only to illustrate the operation and application examples of AKM Products. You are fully responsible for use of such information contained in this document in your product design or applications. AKM ASSUMES NO LIABILITY FOR ANY LOSSES INCURRED BY YOU OR THIRD PARTIES ARISING FROM THE USE OF SUCH INFORMATION IN YOUR PRODUCT DESIGN OR APPLICATIONS.