AsahiKASEI MICRODEVICES

CZ-3906

Fast Response Automotive Grade Coreless Current Sensor

1. General Description

CZ-3906 is an open-type current sensor using Hall sensors, which outputs the analog voltage proportional to the AC/DC current. Group III-V compound semiconductor thin film is used as the Hall sensor, which realizes the high-speed current sensing (100nsec typ.). Coreless ultra-small surface mount package realizes the space-saving. Existing coreless current sensors have an accuracy disadvantage from degradations caused by a disturbed magnetic field. The CZ-3906 has a built-in stray magnetic field reduction function to suppress this effect. The CZ-3906 is suitable for automotive applications such as on-board charger and DC-DC converter. The CZ-3906 is also suitable for other applications requiring isolation and high-speed current sensing using next-generation power devices such as SiC and GaN.

2. Features

- Fast response time : 100ns typ.
- Bandwdth : 4MHz typ.
- AEC-Q100 compliant
- Operating Ambient Temperature : −40~125°C
- Small-sized surface mount package
- Stray magnetic field reduction
- Maximum Primary Current : $40A_{rms}$
- High-accuracy : 0.5%F.S. typ.
- Low variation and low temperature drift of zero-current output voltage
- Low variation and low temperature drift of sensitivity
- Quite small primary conductor resistance : 0.3mΩ typ.
- Isolation Voltage : 3.0 kV_{rms} (AC50Hz, 60s)
- Ratiometric output
- Operated by 5V single power supply

3. Applications

- On Board Charger
- DC-DC converter

And CZ-3906 is suitable for other automotive applications which are required isolation with small size and suppressing the heating.

4. Table of Contents

5. Block Diagram and Functions

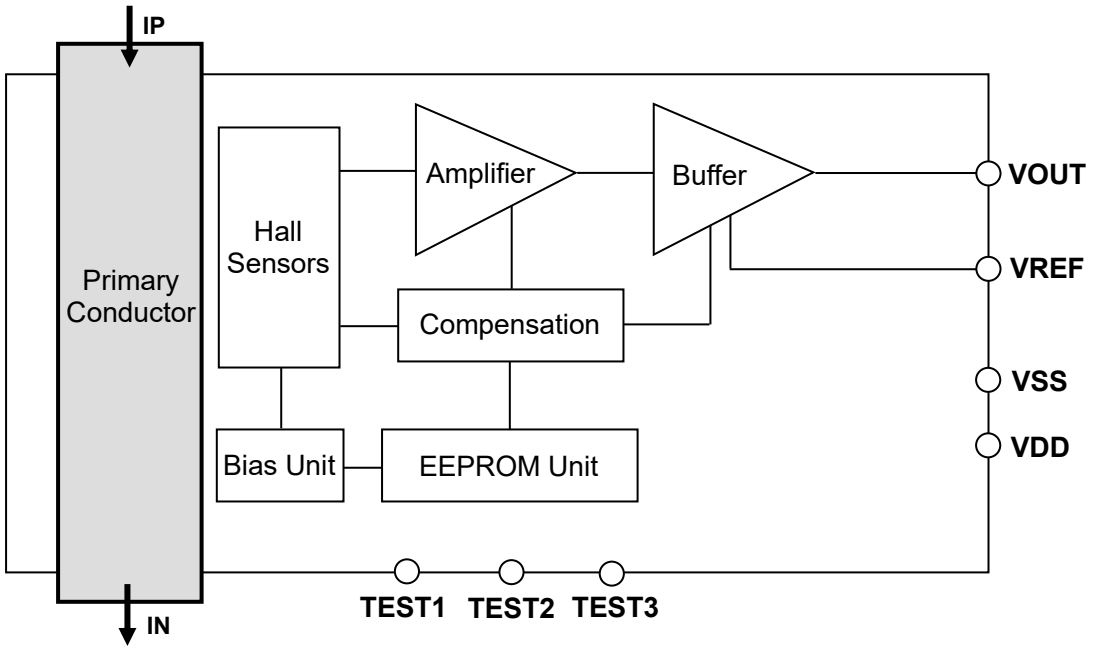
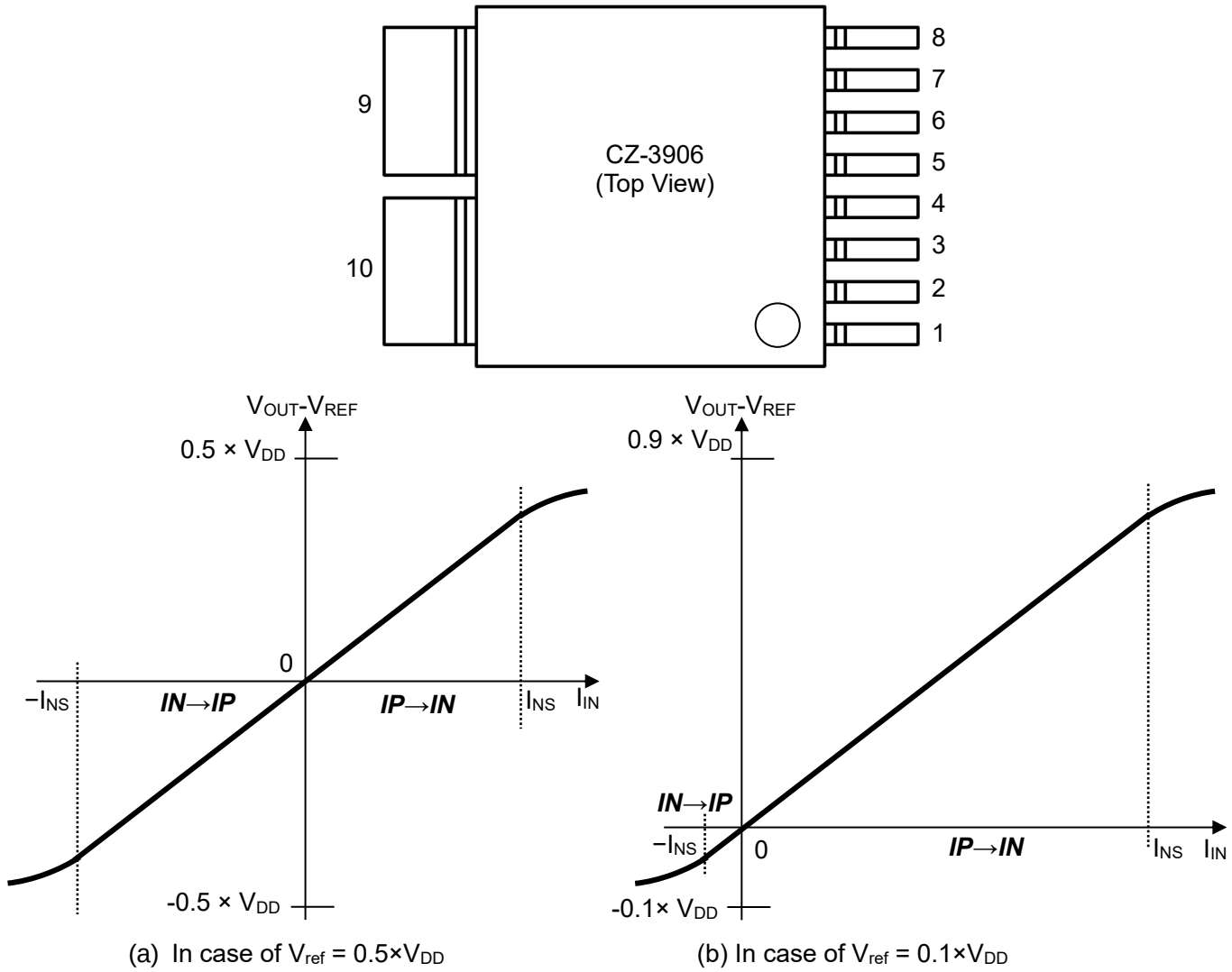


Figure 1. Block diagram of CZ-3906

Table 1. Explanation of circuit blocks

Circuit Block	Function
Primary Conductor	A device has the primary conductor built-in.
Hall Sensors	Hall elements which detect magnetic flux density generated from the measured current.
Amplifier	Amplifier of Hall elements' output.
Buffer	Output buffer with gain. This block outputs the voltage (V_{OUT}) proportional to the current applied to the primary conductor.
Compensation	Compensation circuit which adjusts the temperature drifts of sensitivity and zero-current voltage.
Bias Unit	Drive circuit for Hall elements.
EEPROM Unit	Non-volatile memory for setting adjustment parameters. The parameters are adjusted before the shipment.

6. Pin Configurations and Functions



(a) In case of V_{ref} = 0.5×V_{DD} (b) In case of V_{ref} = 0.1×V_{DD}

Figure 2. Pin configurations and typical output characteristics of CZ-3906

Table 2. Pin configuration and functions of CZ-3906

Pin No.	Pin Name	I/O	Pin Type	Function
1	VSS	GND	Power	Ground pin (GND)
2	VREF	I	Analog	Reference voltage input pin
3	VDD	PWR	Power	Power supply pin (5V)
4	TEST1	-	-	Test pin (This pin must be opened)
5	VOUT	O	Analog	Sensor output pin
6	TEST2	-	-	Test pin (This pin must be opened)
7	TEST3	-	-	Test pin (This pin must be opened)
8	VSS	GND	Power	Ground pin (GND)
9	IN	I	-	Primary conductor pin (-)
10	IP	I	-	Primary conductor pin (+)

7. Absolute Maximum Ratings

Table 3. Absolute maximum ratings

Parameter	Symbol	Min.	Max.	Units	Notes
Supply Voltage	V_{DD}	-0.3	6.5	V	VDD pin
Output Current	I_{OUT}	-10	10	mA	VOUT pin
Input Voltage	V_{REF}	-0.3	V_{DD}+0.3	V	VREF pin
Junction Temperature	T_j	-40	150	°C	
Storage Temperature	T_{STG}	-40	150	°C	

WARNING: Operation at or beyond these limits may result in permanent damage to the device. Normal operation is not guaranteed at these extremes.

8. Recommended Operating Conditions

Table 4. Recommended operating conditions

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Voltage	V_{DD}	4.5	5.0	5.5	V	VDD pin
Sensor Output Load Capacitance	C_{LVOUT}			220	pF	Between VOUT pin and VSS pin
Sensor Output Load Current	I_{LVOUT}	-2		2	mA	VOUT pin
Maximum Primary Current(RMS) (Note 1)	I_{RMSmax}			40	A_{rms}	Continuous DC value or RMS value which can be applied to primary conductor
Operating Ambient Temperature	T_a	-40		125	°C	

WARNING:
Electrical characteristics are not guaranteed when operated at or beyond these conditions.

Note 1. Please determine the Maximum Primary Current(RMS) value considering the thermal resistance and the junction temperature measured in your product design or applications.

9. Electrical Characteristics

Table 5. Electrical characteristics

Conditions (unless otherwise specified): T_a = 25°C, V_{DD} = 5.0V

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Current Consumption	I_{DD}	I_{IN} = 0A, No loads		28	35	mA
Sensitivity (Note 2)	V_h	I_{IN} = ±20A, 500µs	16.4	16.7	17.0	mV/A
Zero-Current Output Voltage (Note 2)	V_{of}	I_{IN} = 0A, V_{of} = V_{OUT} - V_{REF}	-0.02		0.02	V
Reference Input Voltage Range	V_{REF}	External input	0.1 × V_{DD} - 0.05		0.5 × V_{DD} +0.05	V
Linear Sensing Range (Note 3)	I_{NS}	V_{ref} = 0.5 × V_{DD}	-125.6		125.6	A
		V_{ref} = 0.1 × V_{DD}	-7.6		243.6	A
Output Saturation Voltage H (Note 4)	V_{satH}	I_{out} = ±2.0mA	V_{DD} – 0.35			V
Output Saturation Voltage L (Note 4)	V_{satL}	I_{out} = ±2.0mA			0.35	V
Linearity Error (Note 2)	ρ	I_{IN} = ±20A, Current is applied within 500µs, I_{out} = ±2.0mA	-0.3		0.3	%F.S.
Rise Response Time (Note 4)	t_r	I_{IN} 90% to V_{OUT} 90%, C_{LVOUT} = 220pF		100		ns
Fall Response Time (Note 4)	t_f	I_{IN} 10% to V_{OUT} 10%, C_{LVOUT} = 220pF		100		ns
Bandwidth (Note 4)	f_T	-3dB, C_{LVOUT} = 220pF		4		MHz
Input Current Equivalent Noise	I_{Nrms}	I_{IN} = 0A, 100Hz~10MHz		0.1		A_{rms}
Ratiometricity Error of Sensitivity	V_{h-R}	V_{DD} = 4.5V~5.5V	-1.0		1.0	%
Ratiometricity Error of Zero-Current Output Voltage	V_{of-R}	V_{DD} = 4.5V~5.5V I_{IN} = 0A	-0.3		0.3	%F.S.
Power-on Time	t_{on}	I_{IN} = 0A, V_{DD} 4.5V to V_{OUT} within ±10% of Convergence value			10	ms
Stray Magnetic Field Reduction	E_{bc}	Equivalent to Zero-Current output drift -10mT < Stray Magnetic Field < 10mT		0.01		A/mT
Primary Conductor Resistance	R_P			0.3		mΩ
Thermal Resistance junction to ambient	θ_{ja}	Board Layout is Figure 7. $\Delta T=R_p \times I_{IN}^2 \times \theta_{ja}/1000$		45		°C/W
Isolation Voltage (Note 6)	V_{INS}	AC50Hz, 60s	3.0			kV_{rms}
Isolation Resistance (Note 3)	R_{INS}	DC1kV	500			MΩ

Table 6. Temperature drift characteristics

Conditions (unless otherwise specified): T_a = -40°C ~ 125°C, V_{DD} = 5.0V, V_{REF} = 2.5V

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Temperature Drift of Sensitivity (Note 5, Note 7)	$V_{h\text{-}d}$	Variation ratio to V_h (T_a = 25°C)		±0.7		%
Temperature Drift of Zero-current OutputVoltage (Note 5, Note 7)	$V_{of\text{-}d}$	I_{IN} = 0, Variation ratio to V_{of} (T_a = 25°C)		±3		mV
Total Accuracy (Note 5, Note 7)	E_{total}	After correcting of zero-current output voltage (T_a = 25°C)		0.5		%F.S.

Table 7. EEPROM characteristics

Conditions (unless otherwise specified): V_{DD} = 5.0V

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Data Retention (Note 3)	E_{RT}	T_j = 100°C	15			years

Note 2. These values can be drifted by long-term use or reflow process. Please see ’14.Reliability Tests’ for the reference of drift values.

Note 3. These parameters are guaranteed by design and not tested.

Note 4. These parameters are tested to input the equivalent current signal into IC in wafer condition. These characteristics after assembly are guaranteed by design.

Note 5. The typical value is defined as the “average value ± 1σ” of the actual measurement result in a certain lot.

Note 6. These parameters are tested for 1second at 3.6kV_{rms} in mass-production line for all devices.

Note 7. These values can be drifted by long-term use or reflow process.

10. Characteristic Definitions

10.1 Sensitivity(V_h), Zero-current output voltage (V_{of}), and Linearity error (ρ) are defined as below:

Sensitivity(V_h) is defined as the slope of the approximate straight line calculated by the least square method, using the data of output voltage (V_{OUT} -V_{REF}) when the primary current (I_{IN}) is swept within the range of linear sensing range (I_{NS}).
The output voltage (V_{OUT} -V_{REF}) when the primary current (I_{IN}) is 0A is the Zero-Current Output Voltage (V_{of}).

Linearity error (ρ) is defined as the ratio of the maximum error voltage (V_d) to the full scale (F.S.), where V_d is the maximum difference between the output voltage (V_{OUT} -V_{REF}) and the approximate straight line.
Definition formula is shown as below:

$$\rho = V_d / F.S. \times 100$$

Full scale (F.S.) is defined by $V_{satHmin}$ - $V_{satLmax}$

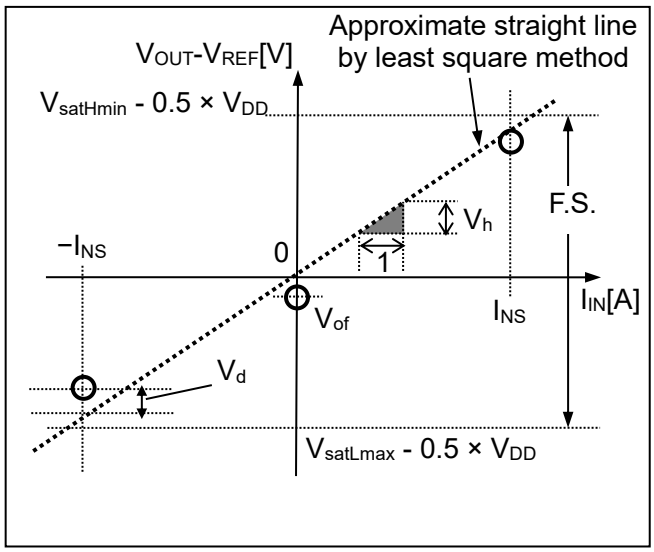


Figure 3. Output characteristics of CZ-3906

10.2 Ratiometric Error of Sensitivity ($V_{h\text{-}R}$) is defined as below:

$$V_{h-R} = 100 \times \frac{\left\{\frac{V_h(V_{DD})}{V_h(5V)} - \frac{V_{DD}}{5}\right\}}{\frac{V_{DD}}{5}}$$

10.3 Ratiometric Error of Zero-Current Output Voltage ($V_{of\text{-}R}$) is defined as below:

$$V_{of-R} = 100 \times \frac{\left(V_{of}(V_{DD}) - \frac{V_{of}(5V) \times V_{DD}}{5}\right)}{F.S.}$$

10.4 Total Accuracy (E_{total}) is defined as below:

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

$$V_{err} = \left(\left|V_{h\_meas} - V_h\right| \times |I_{NS}| + \left|V_{of-d\_meas}\right|\right) + \frac{|\rho_{meas}|}{100} \times \text{F.S.}$$

V_{h_meas} : Measured Sensitivity value [mV/A]
V_h : Sensitivity(Typ.) [mV/A]
V_{of-d_meas}: Measured Temperature Drift of Zero-current Voltage [mV]
ρ_{meas} : Measured Linearity Error [%F.S.]

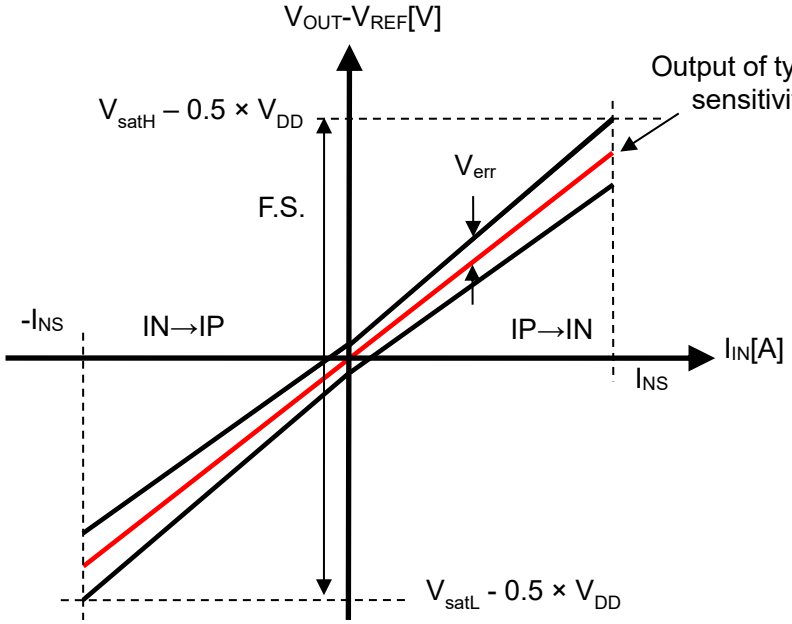


Figure 4. Total Accuracy of CZ-3906

10.5 Rise Response Time t_r [µs] and Fall Response Time t_f [µs]

Rise response time (or fall response time) is defined as the time delay from the 90% (or 10%) of input primary current (I_{IN}) to the 90% (or 10%) of the output voltage (V_{OUT}-V_{REF}) under the pulse input of primary current (Figure 5).

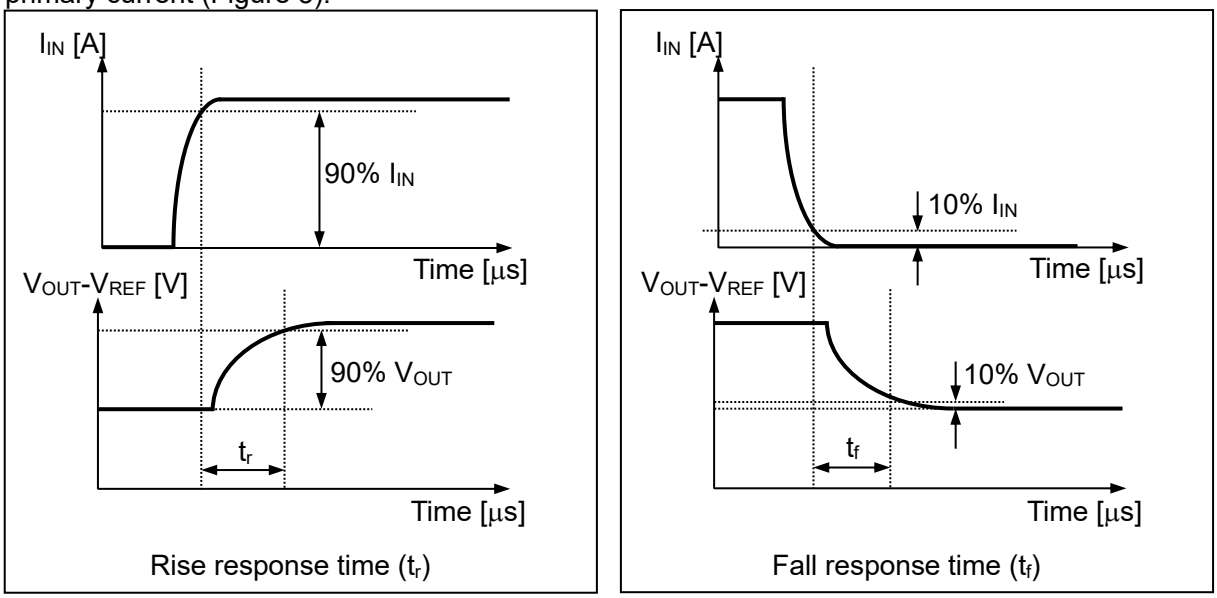


Figure 5. Definition of response time

11. External Circuits Example

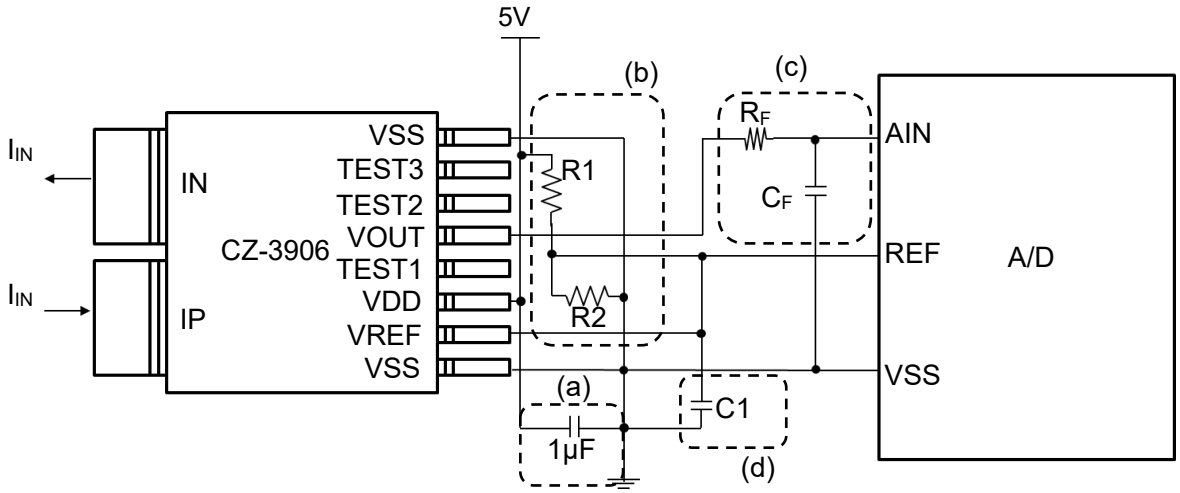


Figure 6. Recommended external circuits

(a) 1µF bypass capacitor should be placed close to CZ-3906.

(b) CZ-3906 has the ratiometric output. Please input the VREF and REF voltage made by dividing the supply voltage of the CZ-3906 with R1 and R2.

(c) Add a low-pass filter if it is necessary. The C_F value should be fixed in consideration of the load condition and the time constant.

(d) Add a stabilizing capacity if it is necessary. The C1 value should be fixed in consideration of the time constant determined by the resistive divider ratio by R1 and R2.

12. Board Layout for Measuring Thermal Resistance

Table 8. Board information

Board Size	45.0mm×40.0mm
Layer number	4
Copper layer thickness	70μm
Board Thickness	1.6mm

·Top pattern(1st) ·Inner pattern(2nd/3rd VSS) ·Bottom pattern(4th)

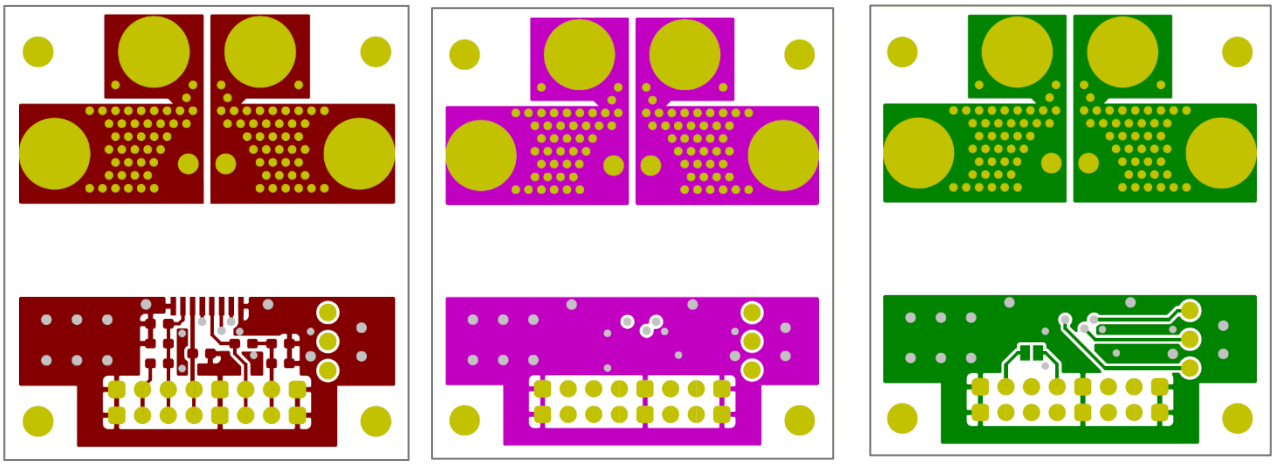
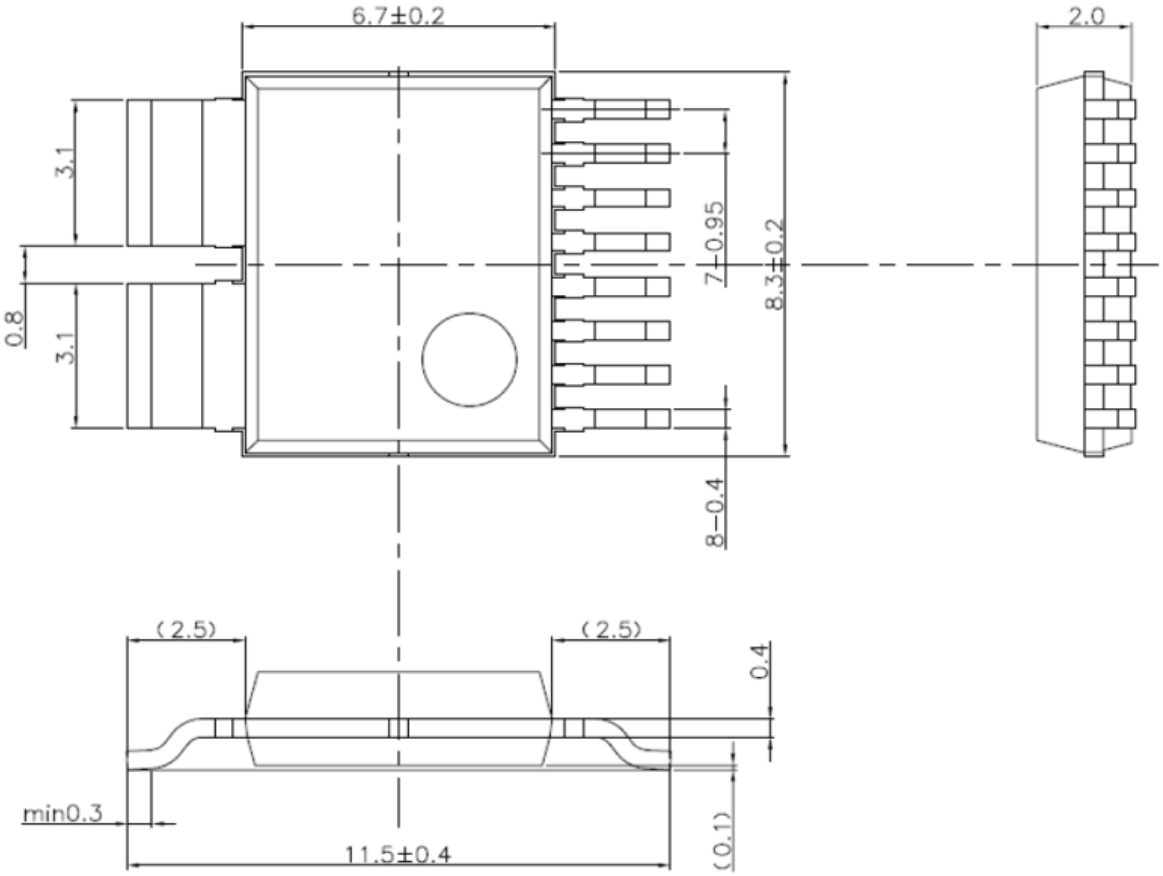


Figure 7. Board layout for measuring thermal resistance of CZ-3906

13. Package

13.1. Outline Dimensions



Unit: mm

The tolerances of dimensions without any mention are ±0.1mm.
( ) is a reference values.

Figure 8. Outline dimensions of CZ-3906

Terminals: Cu
Plating for Terminals: Sn-Bi
RoHS compliant, halogen-free

Table 9. Package characteristics of CZ-3906

Parameter	Symbol	Min	Typ	Max	Units
Creepage distance	Cr	7.2			mm
Clearance distance	Cl	7.2			mm

*Flammability standard is V0. (According to UL94)

*Comparative tracking index (CTI) is 400≤CTI<600. Material Group is Ⅱ.

13.2. Standards

·IEC/UL 62368-1 – Audio/video, information and communication technology equipment – Edition 3. (File No.E359197)
·CSA C22.2 NO. 62368-1:19 – Audio/video, information and communication technology equipment – Edition 3. (File No. E359197)
・UL1577-Non-optical Isolators-Edition 5.(File No. E499004)
・CSA Component Acceptance Service No. 5A - Component Acceptance Service for Optocouplers and Related Devices (File No. E499004)

13.3. Recommended Pad Dimensions

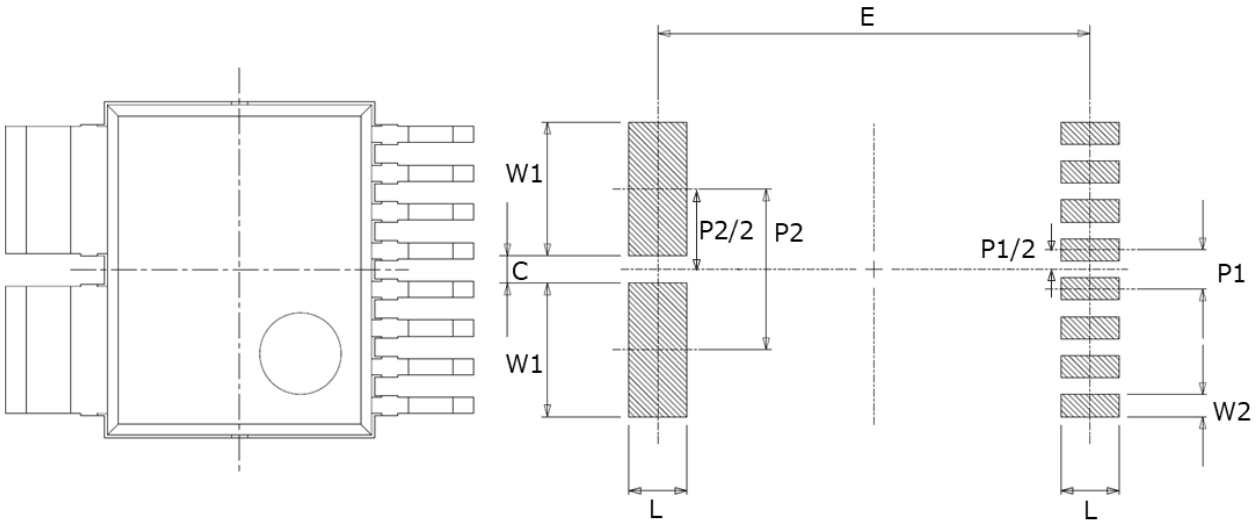


Figure 9. Recommended pad pattern

Table 10. Recommended pad dimensions

L	1.42
E	10.58
W1	3.3
W2	0.54
C	0.66
P1	0.95
P2	3.96

Unit:mm

If two or more trace layers are used as the current paths, please make enough number of through-holes to flow current between the trace layers. In order to make heat dissipation better, it is recommended that Pad on Via should be provided on the pad of the primary conductor.

13.4 Marking

Production information is printed on the package surface by laser marking. Markings consist of 11 characters excluding AKM logo.

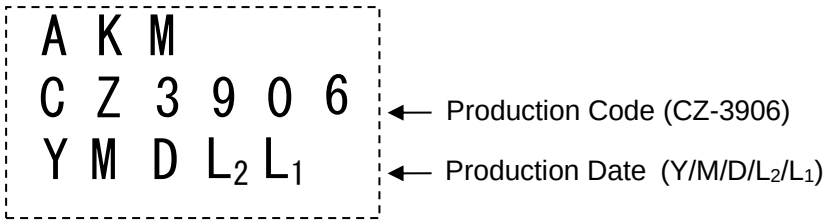


Figure 10. Markings of CZ-3906

Table 11. Production date code table

Year(Y)		Month(M)		Day(D)		Lot number		
Character	Year	Character	Month	Character	Day	Character (L_2)	Character (L_1)	Lot Number
5	2015	C	January	1	1	0	1	01
6	2016	D	February	2	2	0	2	02
7	2017	E	March	3	3	0	3	03
8	2018	F	April	4	4	0	4	04
9	2019	G	May	5	5	0	5	05
A	2020	H	June	6	6	⋮	⋮	⋮
B	2021	J	July	7	7			
C	2022	K	August	8	8	6	7	67
D	2023	L	September	9	9	6	8	68
E	2024	M	October	0	10	6	9	69
F	2025	N	November	A	11	7	0	70
G	2026	P	December	B	12	7	1	71
H	2027			C	13	⋮	⋮	⋮
J	2028			D	14			
K	2029			E	15			
L	2030			F	16			
N	2031			G	17			
P	2032			H	18			
R	2033			J	19			
S	2034			K	20			
T	2035			L	21			
U	2036			N	22			
V	2037			P	23			
W	2038			R	24			
X	2039			S	25			
0	2040			T	26			
1	2041			U	27			
2	2042			V	28			
3	2043			W	29			
4	2044			X	30			
				Y	31			

14. Reliability Tests

Table 12. Test parameters and conditions of reliability tests

No.	Test Parameter	Test Conditions	n	Test Time
1	Temperature Humidity Bias Test	[JEITA EIAJ ED-4701 102] T_a=85°C, 85%RH, continuous operation	77	1000h
2	High Temperature Bias Test	[JEITA EIAJ ED-4701 101] T_a=150°C, continuous operation	77	1000h
3	High Temperature Storage Test	[JEITA EIAJ ED-4701 201] T_a=150°C	45	1000h
4	Temperature Humidity Storage Test	[JEITA EIAJ ED-4701 103] T_a=85°C, 85%RH	77	1000h
5	Low Temperature Operating Test	T_a=−40°C, continuous operation	32	1000h
6	Low Temperature Storage Test	[JEITA EIAJ ED-4701 202] T_a=−65°C	32	1000h
7	Temperature Cycle Test	[JEITA EIAJ ED-4701 105] −65°C ↔ +150°C 30min. ↔ 30min.	77	1000 cycles

Tested samples are pretreated as below before each reliability test:
Desiccation: 125°C / 24h → Moisture Absorption: 60°C / 60%RH / 168h
→ Reflow: 3 times (JEDEC Level 2a)

Criteria:
Products whose drifts between before pretreated and after the reliability tests do not exceed the values below are considered to be in spec.

Sensitivity V_h (T_a = 25°C)	: Within ±2%
Zero-Current Output Voltage V_{of} (T_a = 25°C)	: Within ±20mV
Linearity Error ρ	: Within ±0.5%F.S.
EEPROM data	: Unchanged

15. Precautions

<Storage Environment>

Products should be stored at an appropriate temperature, and at as low humidity as possible by using desiccator . It is recommended to use the products within 4 weeks since packing was opened. This product is a MSL Level 2a product. Keep products away from chlorine and corrosive gas. When stored in an inappropriate environment, it can affect the product properties.

<Long-term Storage>

Long-term storage may result in poor lead solderability and degraded electrical performance even under proper conditions. For those parts, which stored long-term should be checked as for solderability before it is used.
For storage longer than 1 year, it is recommended to store in nitrogen atmosphere. Oxygen of atmosphere oxidizes leads of products, and lead solderability get worse.

<Other Precautions>

1) This product should not be used under the environment with corrosive gas including chlorine or sulfur.
2) This product is lead (Pb) free. All leads are plated with Sn-Bi. Do not store this product alone in high temperature and high humidity environment. Moreover, this product should be mounted on substrate within six months after delivery.
3) This product is damaged when it is used on the following conditions:
- Supply voltage is applied in the opposite way.
- Overvoltage which is larger than the value indicated in the specification.
4) This product will be damaged if it is used for a long time with the current (effective current) which exceeds the current rating. Careful attention must be paid so that maximum effective current is smaller than current rating.
5) The characteristics can be changed by the influences of nearby current and magnetic field and electric field. Please make sure of the mounting position.

As this product contains gallium arsenide, observe the following procedures for safety.
1) Do not alter the form of this product into a gas, powder, liquid, through burning, crushing, or chemical processing.
2) Observe laws and company regulations when discarding this product.

16. Revision History

Date (Y/M/D)	Revision	Reason	Page	Contents
2023/06/30	00	First Edition	-	-

IMPORTANT NOTICE

0. Asahi Kasei Microdevices Corporation (“AKM”) reserves the right to make changes to the information contained in this document without notice. When you consider any use or application of AKM product stipulated in this document (“Product”), please make inquiries the sales office of AKM or authorized distributors as to current status of the Products.
1. All information included in this document are provided only to illustrate the operation and application examples of AKM Products. AKM neither makes warranties or representations with respect to the accuracy or completeness of the information contained in this document nor grants any license to any intellectual property rights or any other rights of AKM or any third party with respect to the information in this document. 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.
2. The Product is neither intended nor warranted for use in equipment or systems that require extraordinarily high levels of quality and/or reliability and/or a malfunction or failure of which may cause loss of human life, bodily injury, serious property damage or serious public impact, including but not limited to, equipment used in nuclear facilities, equipment used in the aerospace industry, medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, devices related to electric power, and equipment used in finance-related fields. Do not use Product for the above use unless specifically agreed by AKM in writing.
3. Though AKM works continually to improve the Product’s quality and reliability, you are responsible for complying with safety standards and for providing adequate designs and safeguards for your hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of the Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption.
4. Do not use or otherwise make available the Product or related technology or any information contained in this document for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). When exporting the Products or related technology or any information contained in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. The Products and related technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.
5. Please contact AKM sales representative for details as to environmental matters such as the RoHS compatibility of the Product. Please use the Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. AKM assumes no liability for damages or losses occurring as a result of noncompliance with applicable laws and regulations.
6. Resale of the Product with provisions different from the statement and/or technical features set forth in this document shall immediately void any warranty granted by AKM for the Product and shall not create or extend in any manner whatsoever, any liability of AKM.
7. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of AKM.

Rev.1