



# CQ-2064

## High-Speed Small-Sized Current Sensor

### Overview

CQ-2064 is an open-type current sensor using a Hall sensor which outputs the analog voltage proportional to the AC/DC current. Quantum well ultra-thin film InAs (Indium Arsenide) is used as the Hall sensor, which enables the high-accuracy and high-speed current sensing. Simple AI-Shell® package with the Hall sensor, magnetic core, and primary conductor realizes the space-saving and high reliability.

### Features

- Bidirectional type
- Electrical isolation between the primary conductor and the sensor signal
- 5V single supply operation
- Ratiometric output
- Low variation and low temperature drift of sensitivity and offset voltage
- Low noise output: 2.1mVrms (max.)
- Fast response time: 1 $\mu$ s (typ.)
- Small-sized package, halogen free

### Functional Block Diagram

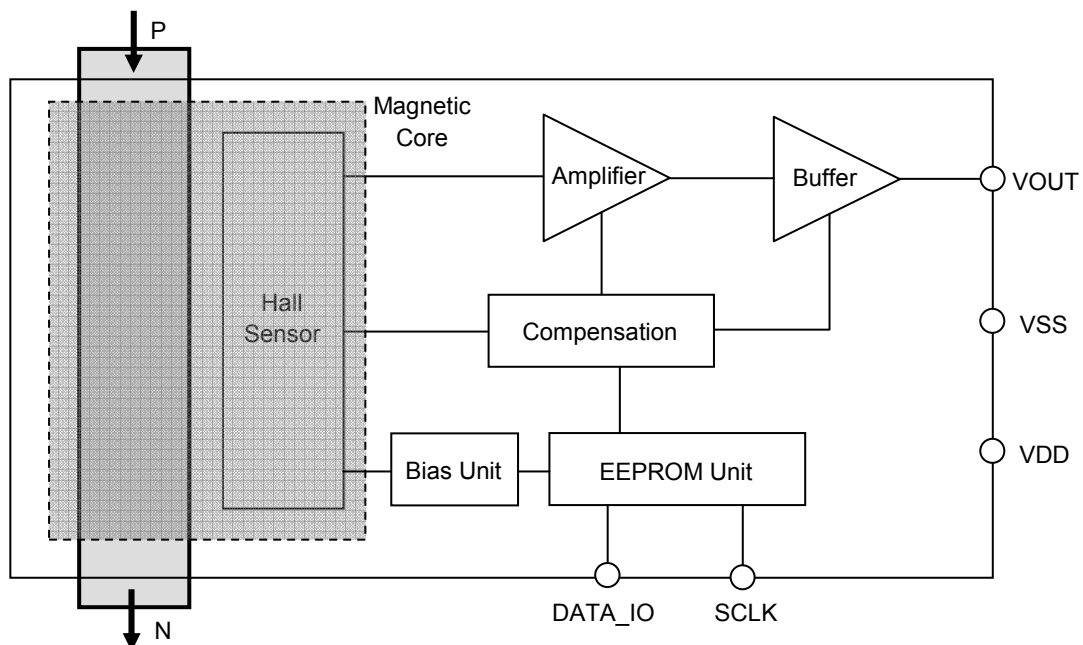


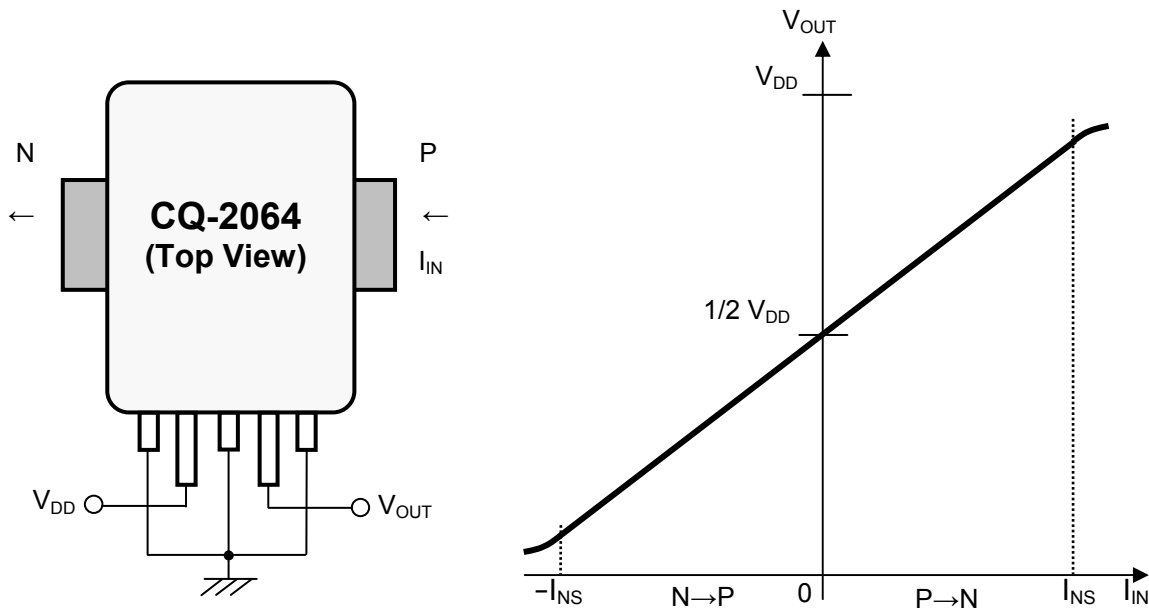
Figure 1. Functional block diagram of CQ-2064

**Circuit Blocks**

**Table 1. Explanation of circuit blocks**

Circuit Block	Function
Hall Sensor	Hall element which detects magnetic flux density generated from the measured current.
Amplifier	Amplifier of Hall element's 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 offset voltage.
Bias Unit	Drive circuit for Hall element.
EEPROM Unit	Non-volatile memory for setting adjustment parameters. The parameters are adjusted before the shipment.
Magnetic Core	Magnetic core which gathers the magnetic flux density to the Hall element.

**Typical Output Characteristics**

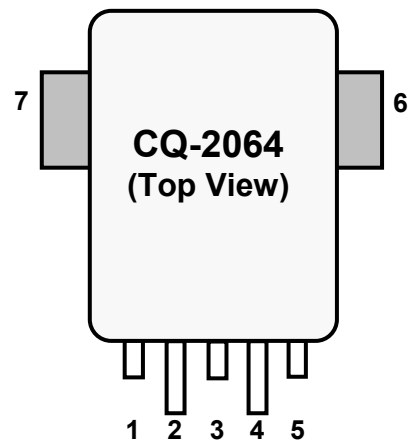


**Figure 2. Typical output characteristics of CQ-2064**

**Pin/Function**

**Table 2. Pin-out description**

No.	Name	I/O	Description
1	DATA_IO	-	Test pin (connect to ground)
2	VDD	-	Power supply pin (5V)
3	VSS	-	Ground pin (0V)
4	VOUT	O	Analog output pin
5	SCLK	-	Test pin (connect to ground)
6	P	I	Primary current pin (+)
7	N	I	Primary current pin (-)



**Figure 3. Pin-out diagram**

**Absolute Maximum Ratings**

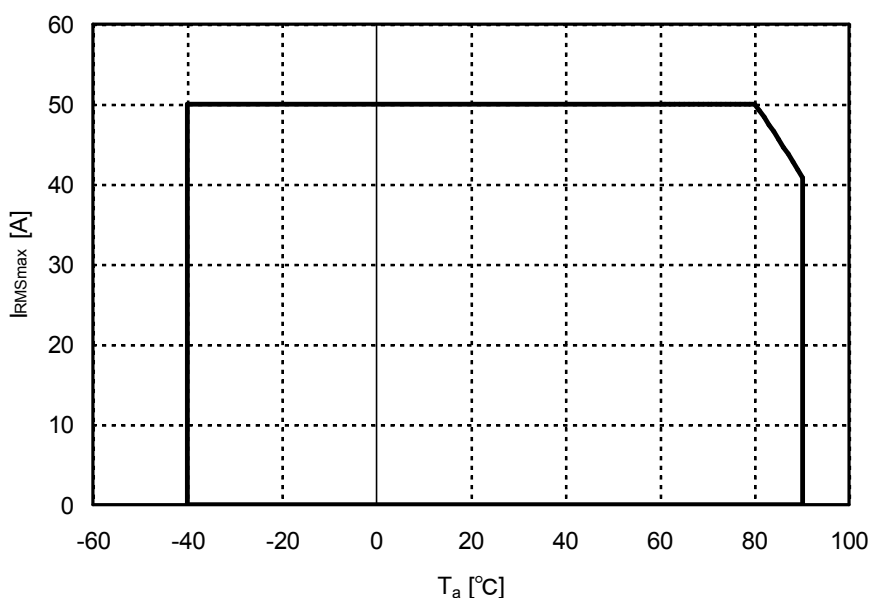
**Table 3. Absolute maximum ratings**

Parameter	Symbol	Min.	Max.	Units	Notes
Supply Voltage	V <sub>DD</sub>	-0.3	6	V	VDD
Analog Output Current	I <sub>OUT</sub>	-1	1	mA	VOUT
Storage Temperature	T <sub>stg</sub>	-40	125	°C	

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

**Primary Current Derating Curve**

Conditions: Mounted on the test board complying with the EIA/JEDEC Standards (EIA/JESD51.)



NOTE) Cooling or thermal radiation will improve the derating curve above.

**Figure 4. Primary current derating curve of CQ-2064**

**Recommended Operating Conditions**

**Table 4. Recommended operating conditions**

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Voltage	V <sub>DD</sub>	4.5	5.0	5.5	V	
Output Current	I <sub>OUT</sub>	-0.5		0.5	mA	VOUT
Output Load Capacitance	C <sub>L</sub>			100	pF	VOUT
Operating Ambient Temperature	T <sub>a</sub>	-40		90	°C	

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

<b>Electrical Characteristics</b>
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**Table 5. Electrical characteristics**Conditions (unless otherwise specified):  $T_a=25^{\circ}\text{C}$ ,  $V_{DD}=5\text{V}$ 

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Maximum Primary Current (RMS)	$I_{RMSmax}$		-50		50	A
Current Consumption	$I_{DD}$	No Loads			9	mA
Sensitivity*	$V_h$		39.2	40.0	40.8	mV/A
Offset Voltage*	$V_{of}$	$I_{IN}=0\text{A}$	2.432	2.500	2.568	V
Linear Sensing Range	$I_{NS}$		-54		54	A
Linearity Error*	$\rho$		-1		1	%F.S.
Rise Response Time	$t_r$	$I_{IN} 90\% \rightarrow V_{OUT} 90\%$ $C_L=100\text{pF}$		1		$\mu\text{s}$
Fall Response Time	$t_f$	$I_{IN} 10\% \rightarrow V_{OUT} 10\%$ $C_L=100\text{pF}$		1		$\mu\text{s}$
Bandwidth	$f_T$	-3dB, $C_L=100\text{pF}$		400		kHz
Output Noise**	$V_{Nrms}$				2.1	mVrms
Temperature Drift of Sensitivity at High Temperature**	$V_{h-dH}$	Variation ratio to $V_h(T_a=35^{\circ}\text{C})$ $T_a=35\sim 90^{\circ}\text{C}$	-2		2	%
Maximum Temperature Drift of Sensitivity at Low Temperature	$V_{h-dLmax}$	Variation ratio to $V_h(T_a=35^{\circ}\text{C})$ $T_a=-40\sim 35^{\circ}\text{C}$		$\pm 2$		%
Maximum Temperature Drift of Offset voltage	$V_{of-dmax}$	Variation from $V_{of}(T_a=35^{\circ}\text{C})$ $T_a=-40\sim 90^{\circ}\text{C}$ , $I_{IN}=0\text{A}$		$\pm 14$		mV
Ratiometricity Error of Sensitivity**	$V_{h-R}$	$V_{DD}=4.5\text{V}\sim 5.5\text{V}$	-1		1	%
Ratiometricity Error of Offset Voltage**	$V_{of-R}$	$V_{DD}=4.5\text{V}\sim 5.5\text{V}$ $I_{IN}=0\text{A}$	-1		1	%
Primary Conductor Resistance	$R_1$			100		$\mu\Omega$
Isolation Voltage**	$V_{INS}$	AC 50/60Hz, 60s	2.5			kV
Isolation Resistance**	$R_{INS}$	DC 1kV	500			M $\Omega$

\* These parameters can drift by the values described in 'Reliability Tests' section over the lifetime of the product.

\*\* These characteristics are guaranteed by design.

<b>Characteristics Definitions</b>
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**(1) Sensitivity  $V_h$  [mV/mT], offset voltage  $V_{of}$  [V]**

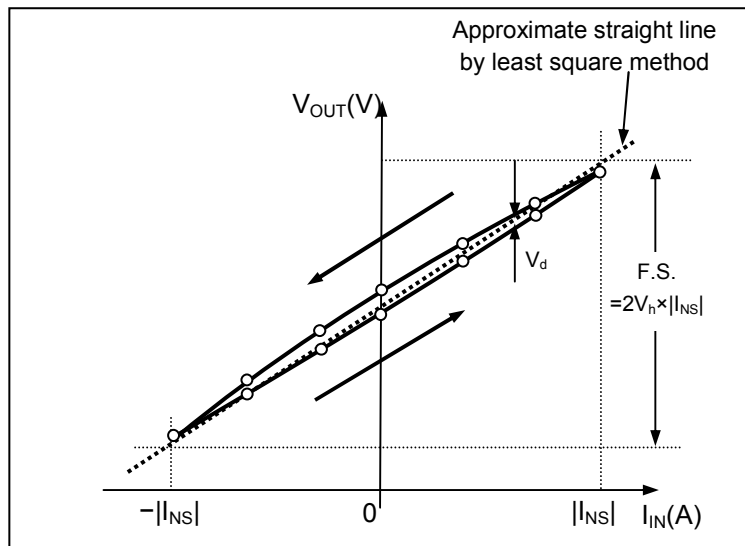
Sensitivity is defined as the slope of the approximate straight line calculated by the least square method, using the data of  $V_{OUT}$  voltage ( $V_{OUT}$ ) when the primary current ( $I_{IN}$ ) is swept within the range of linear sensing range ( $I_{NS}$ ). Offset voltage is defined as the intercept of the approximate straight line above.

**(2) Linearity error  $\rho$  [%F.S.]**

Linearity error 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  $V_{OUT}$  voltage ( $V_{OUT}$ ) and the approximate straight line calculated in the sensitivity and offset voltage definition. Definition formula is shown in below:

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

NOTE) Full scale (F.S.) is defined by the multiplication of the linear sensing range and sensitivity (See Figure 5).



**Figure 5. Output characteristics of CQ-2064**

**(3) Ratiometric error of sensitivity  $V_{h-R}$  [%] and ratiometric error of offset voltage  $V_{of-R}$  [%]**

Output of CQ-2064 is ratiometric, which means the values of sensitivity ( $V_h$ ) and offset voltage ( $V_{of}$ ) are proportional to the supply voltage ( $V_{DD}$ ). Ratiometric error is defined as the difference between the  $V_h$  (or  $V_{of}$ ) and ideal  $V_h$  (or  $V_{of}$ ) when the  $V_{DD}$  is changed from 5.0V to  $V_{DD1}$  ( $4.5V < V_{DD1} < 5.5V$ ). Definition formula is shown in below:

$$V_{h-R} = 100 \times \{ (V_h(V_{DD} = V_{DD1}) / V_h(V_{DD} = 5V)) - (V_{DD1} / 5) \} / (V_{DD1} / 5)$$

$$V_{of-R} = 100 \times \{ (V_{of}(V_{DD} = V_{DD1}) / V_{of}(V_{DD} = 5V)) - (V_{DD1} / 5) \} / (V_{DD1} / 5)$$

**(4) Temperature drift of sensitivity  $V_{h-d}$  [%]**

Temperature drift of sensitivity is defined as the drift ratio of the sensitivity ( $V_h$ ) at  $T_a = T_{a1}$  ( $-40^\circ\text{C} < T_{a1} < 90^\circ\text{C}$ ) to the  $V_h$  at  $T_a = 35^\circ\text{C}$ , and calculated from the formula below:

$$V_{h-d} = 100 \times (V_h(T_{a1}) / V_h(35^\circ\text{C}) - 1)$$

Temperature drift of sensitivity at high temperature ( $V_{h-dH}$ ) is defined as the  $V_{h-d}$  at an arbitrary  $T_{a1}$  ( $35^\circ\text{C} < T_{a1} < 90^\circ\text{C}$ ) and maximum temperature drift of at low temperature range ( $V_{h-dLmax}$ ) is defined as the maximum value of  $|V_{h-d}|$  through  $-40^\circ\text{C} < T_{a1} < 35^\circ\text{C}$ . (continued)

Reference data of the temperature drift of sensitivity of CQ-2064 is shown in Figure 6.

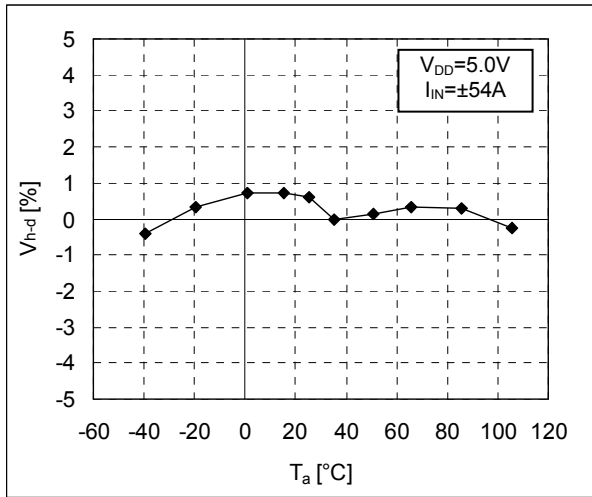
**(5) Temperature drift of offset voltage  $V_{of-d}$  [mV]**

Temperature drift of offset voltage is defined as the drift value between the offset voltage ( $V_{of}$ ) at  $T_a=T_{a1}$  ( $-40^{\circ}\text{C}<T_{a1}<90^{\circ}\text{C}$ ) and the  $V_{of}$  at  $T_a=35^{\circ}\text{C}$ , and calculated from the formula below:

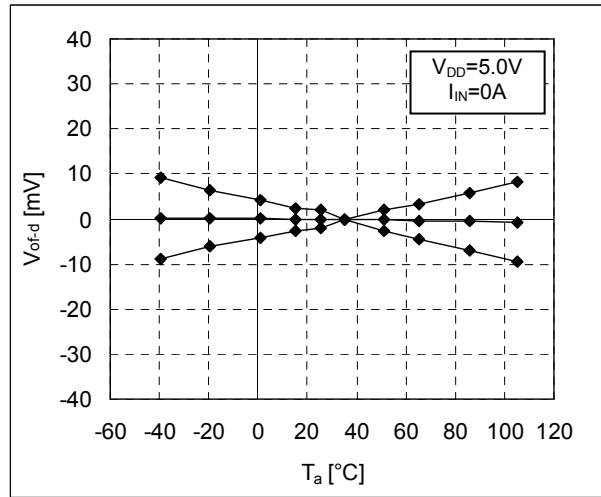
$$V_{of-d} = V_{of}(T_a = T_{a1}) - V_{of}(T_a = 35^{\circ}\text{C})$$

Maximum temperature drift of offset voltage ( $V_{of-dmax}$ ) is defined as the maximum value of  $|V_{h-d}|$  through  $-40^{\circ}\text{C}<T_{a1}<90^{\circ}\text{C}$ .

Reference data of the temperature drift of offset voltage of CQ-2064 is shown in Figure 7.



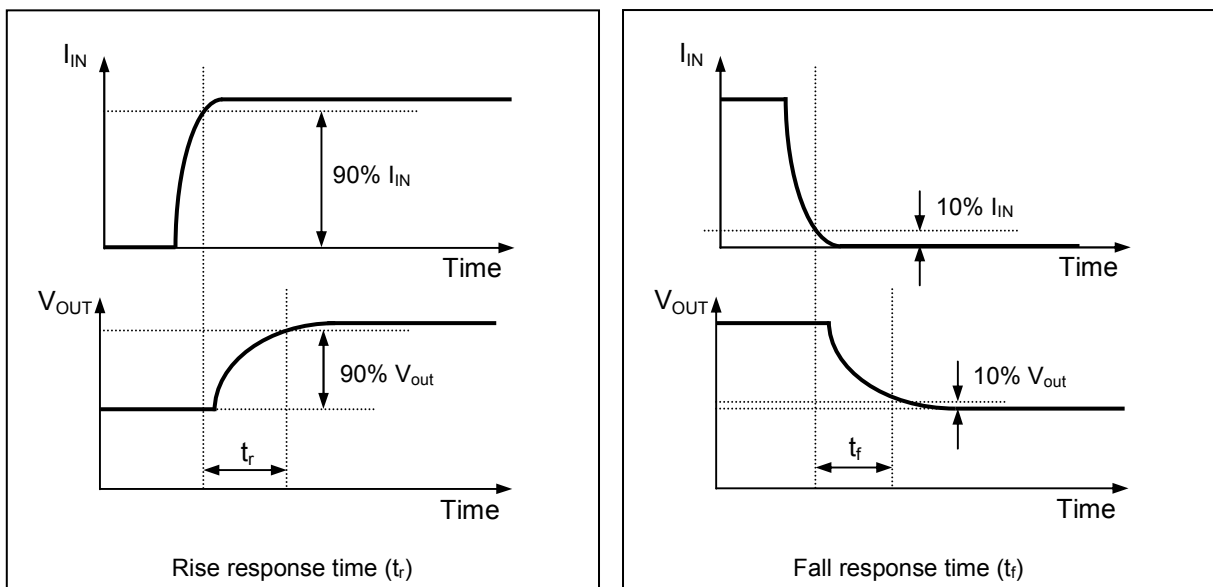
**Figure 6. Temperature drift of sensitivity of CQ-2064 (for reference, n=1)**



**Figure 7. Temperature drift of offset voltage of CQ-2064 (for reference, n=3)**

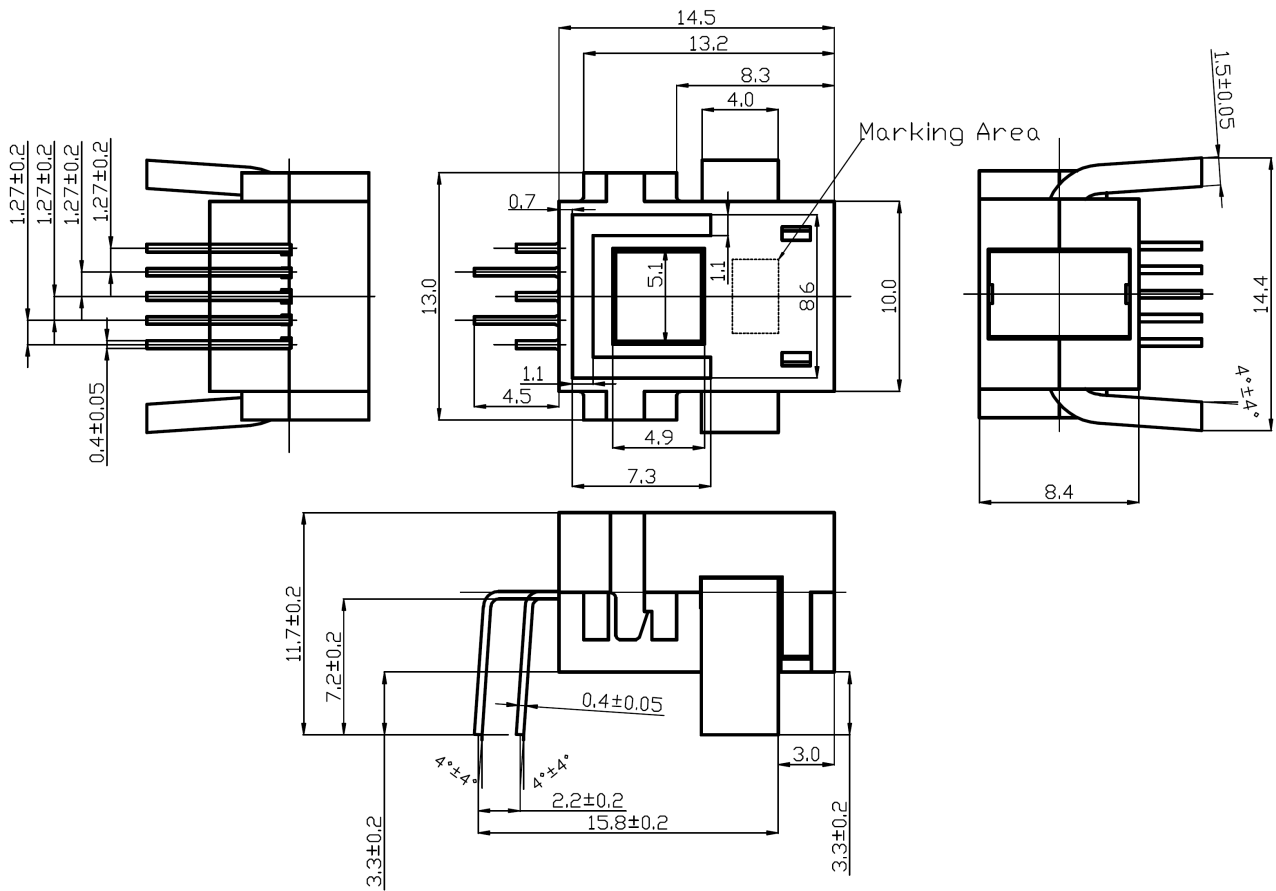
**(6) Rise response time  $t_r$  [ $\mu\text{s}$ ] and fall response time  $t_f$  [ $\mu\text{s}$ ]**

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  $V_{OUT}$  voltage ( $V_{OUT}$ ) under the pulse input of primary current (see Figure 8.)



**Figure 8. Definition of response time**

**Package Dimensions**



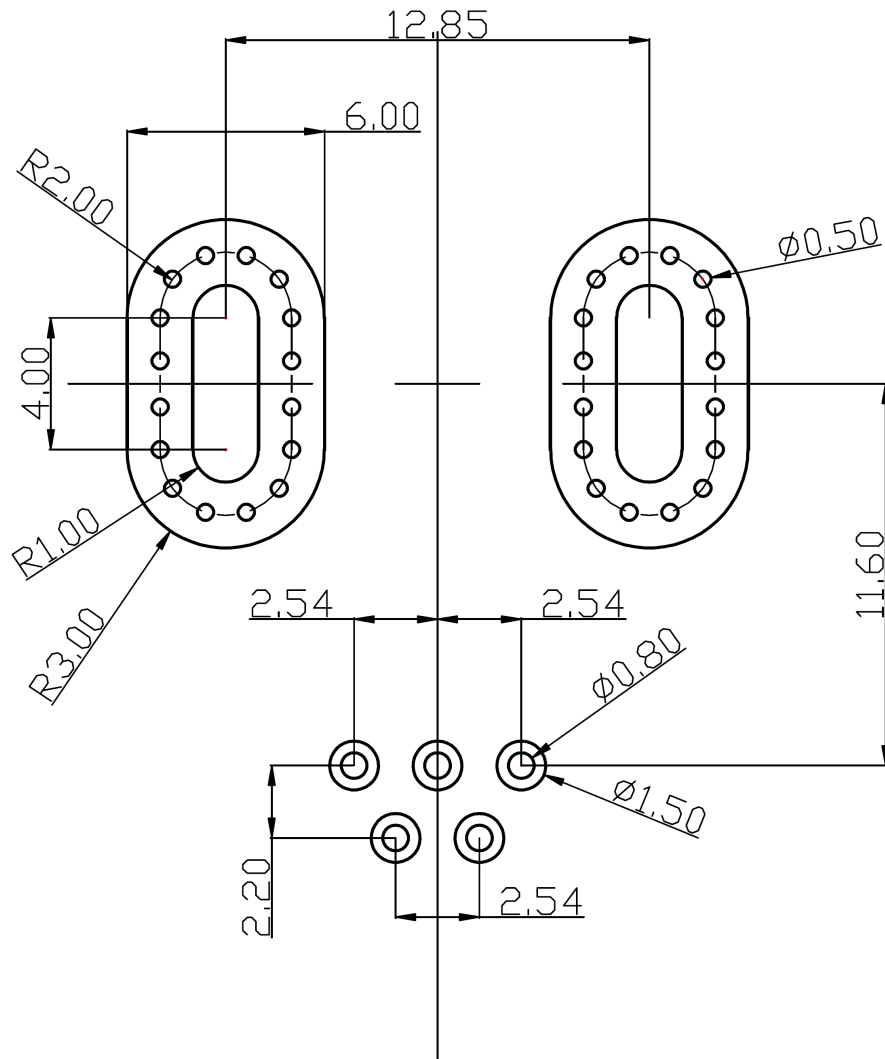
Unit:mm

Note1) The tolerances of dimensions without any mention are ±0.1mm.

Terminals: Cu  
 Plating for Terminals: Sn (100%)  
 RoHS compliant, halogen free

**Figure 9. Package outline**

Recommended Land Pattern (Reference Only)



Unit:mm

**Figure 10. Recommended land pattern of CQ-2064**

Note) If 2 or more trace layers are used as the current path, please make enough number of through-holes to flow current between the trace layers.



Application Circuits

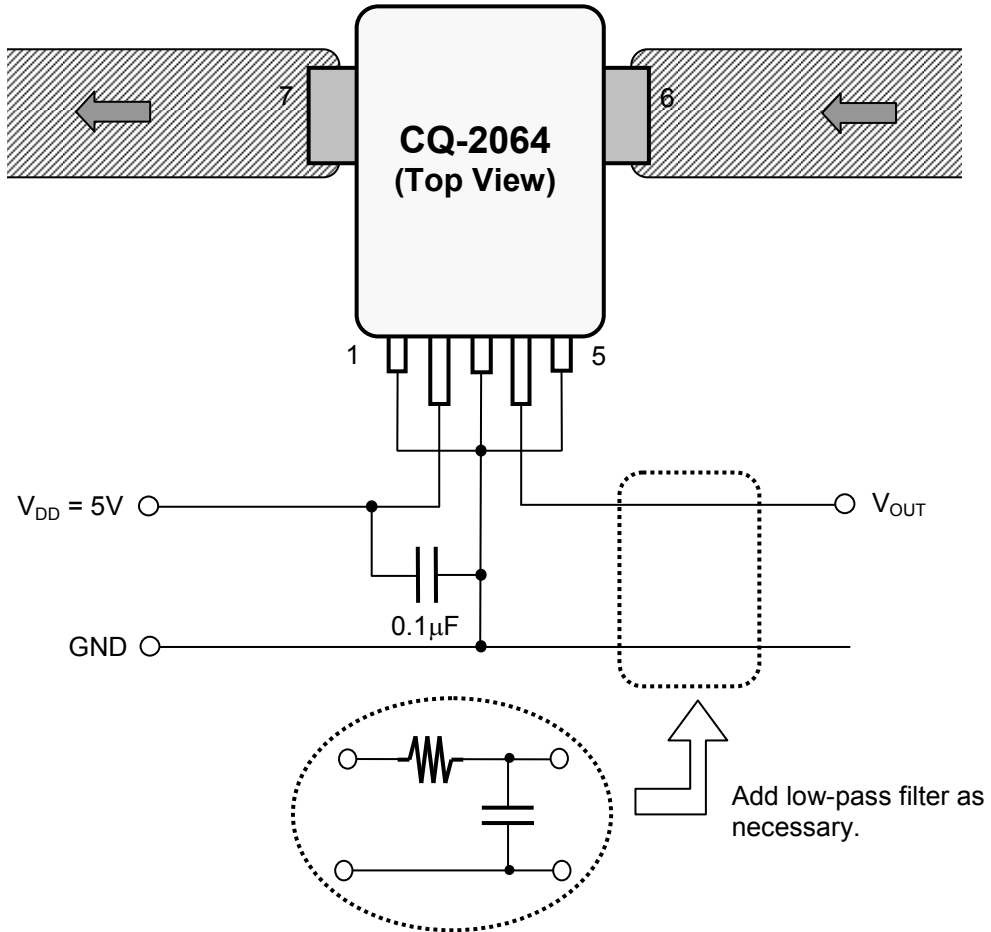
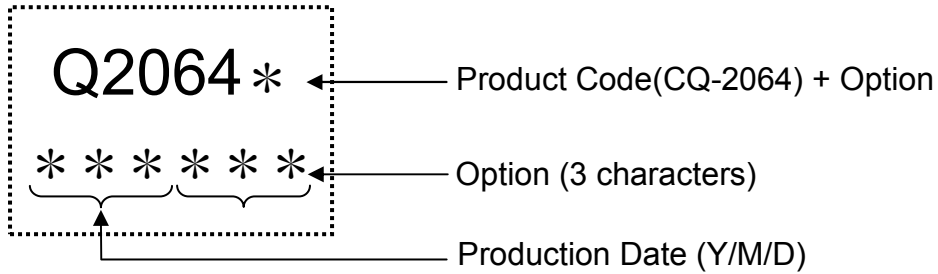


Figure 11. Application Circuits of CQ-2064

**Markings**

Production information is printed on the package surface by laser marking. Markings consist of 12 characters (6 characters × 2 lines).



**Figure 12. Markings of CQ-2064**

**Table 6. Production date code table**

Last Number of Year		Month		Day	
Character	Number	Character	Month	Character	Day
0	0	C	Jan.	1	1
1	1	D	Feb.	2	2
2	2	E	Mar.	3	3
3	3	F	Apr.	4	4
4	4	G	May.	5	5
5	5	H	Jun.	6	6
6	6	J	Jul.	7	7
7	7	K	Aug.	8	8
8	8	L	Sep.	9	9
9	9	M	Oct.	0	10
		N	Nov.	A	11
		P	Dec.	B	12
				C	13
				D	14
				E	15
				F	16
				G	17
				H	18
				J	19
				K	20
				L	21
				N	22
				P	23
				R	24
				S	25
				T	26
				U	27
				V	28
				W	29
				X	30
				Y	31

<b>Reliability Tests</b>
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**Table 7. Test parameters and conditions of reliability test**

No.	Test Parameter	Test Conditions	n	Test Time
1	High Humidity Storage Test	【JEITA EIAJ ED-4701 102】 T <sub>a</sub> =85°C, 85%RH, continuous operation	22	1000h
2	High Temperature Bias Test	【JEITA EIAJ ED-4701 101】 T <sub>a</sub> =125°C, continuous operation	22	1000h
3	High Temperature Storage Test	【JEITA EIAJ ED-4701 201】 T <sub>a</sub> =150°C	22	1000h
4	Low Temperature Storage Test	【JEITA EIAJ ED-4701 202】 T <sub>a</sub> = -55°C	22	1000h
5	Heat Cycle Test	【JEITA EIAJ ED-4701 105】 -40°C ↔ 25°C ↔ 125°C 30min. ↔ 5min. ↔ 30min. Tested in vapor phase	22	100 cycles
6	Vibration Test	【JEITA EIAJ ED-4701 403】 Vibration frequency: 10~55Hz (1min.) Vibration amplitude: 1.5mm (x, y, z directions)	5	2h for each direction

Tested samples are pretreated as below before each reliability test:

Desiccation: 125°C /24h → Moisture Absorption: 85°C/85%RH/168h → Flow: 1 time (260°C, 10s)

Criteria:

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

Sensitivity V <sub>n</sub> (T <sub>a</sub> =25°C)	: Within ±1.5%
Offset Voltage V <sub>of</sub> (T <sub>a</sub> =25°C)	: Within ±100mV
Linearity ρ (T <sub>a</sub> =25°C)	: Within ±1%

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