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CQ-320B

High-Speed Response Coreless Current Sensor

1. General Description

CQ-320B 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. Coreless surface mount package realizes the space-saving.

2. Features

- Small-sized surface mount package: VSOP-24
- High isolation voltage: 3.0kV (50/60Hz, 60s)
- Compliant to safety standards of IEC/UL-60950 and UL-508
- Ultra-fast response time: 0.5μs (typ.)
- Low variation and low temperature drift of sensitivity and zero-current output voltage
- No output hysteresis
- Low noise output: 1.2mVrms (typ.)
- Uni-directional type
- 3.3V single power supply
- Ratiometric output
- Halogen free

3. Table of Contents

4. Block Diagram and Functions

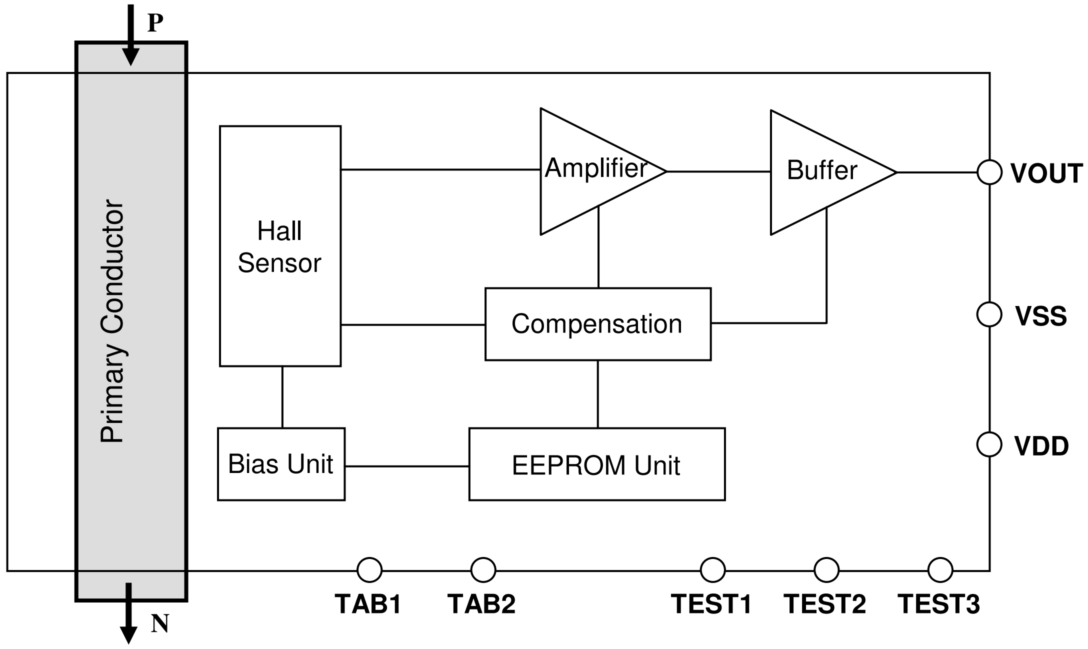


Figure 1. Functional block diagram of CQ-320B.

Table 1. Explanation of circuit blocks.

Circuit Block	Function
Primary Conductor	Conductor which measured current is applied.
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 zero-current output voltage.
Bias Unit	Drive circuit for Hall element.
EEPROM Unit	Non-volatile memory for setting adjustment parameters. The parameters are adjusted before the shipment.

5. Pin Configurations and Functions

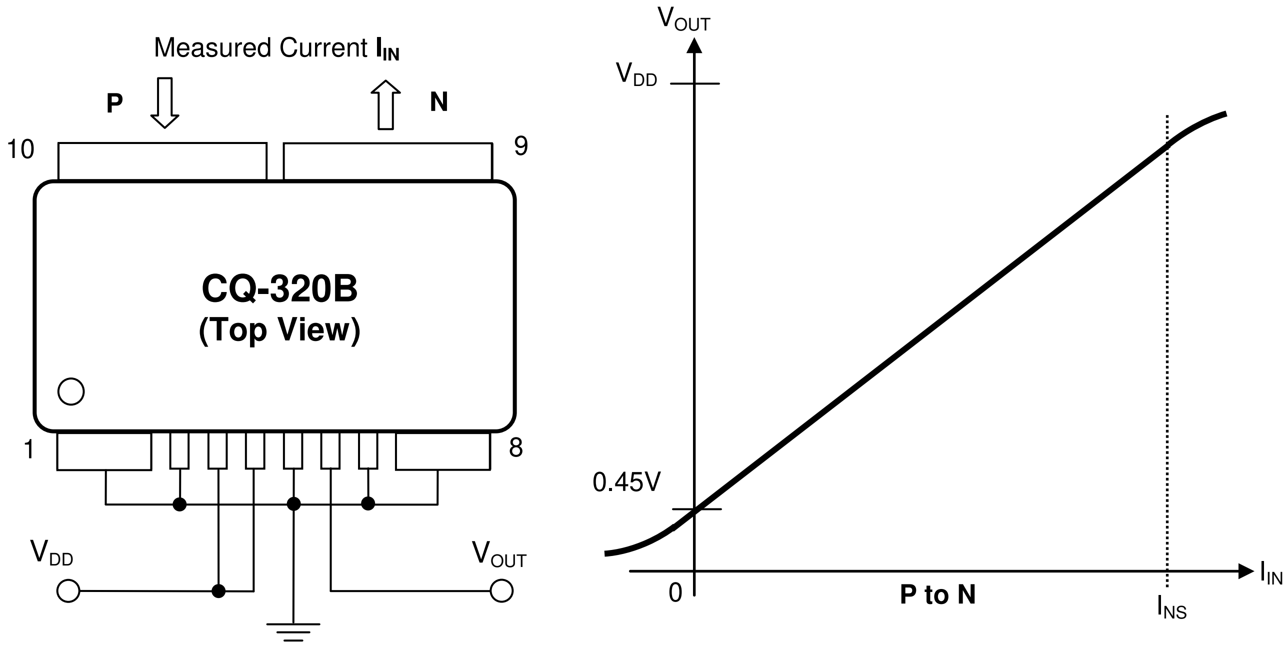


Figure 2. Pin assignment and typical output characteristics of CQ-320B.

Table 2. Pin configuration and functions of CQ-320B.

No.	Pin Name	I/O	Function
1	TAB1	-	Radiation pin, recommended to connect to GND
2	TEST1	-	Test pin, recommended to connect to GND
3	VDD	PWR	Power supply pin, 3.3V
4	TEST2	-	Test pin, recommended to connect to VDD
5	VSS	GND	Ground pin (GND)
6	VOUT	O	Analog output pin
7	TEST3	-	Test pin, recommended to connect to GND
8	TAB2	-	Radiation pin, recommended to connect to GND
9	N	I	Primary conductor pin
10	P	I	Primary conductor pin

6. Safety Standards

- IEC/UL 60950-1 – Information Technology Equipment – Edition 2. (File No.E359197)
- CSA C22.2 NO. 60950-1-07 – Information Technology Equipment – Edition 2. (File No. E359197)
- UL 508 – Industrial Control Equipment – Edition 17. (File No. E353882)

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
Analog Output Current	I_{OUT}	−1	1	mA	VOUT pin
Storage Temperature	T_{stg}	−40	125	°C	

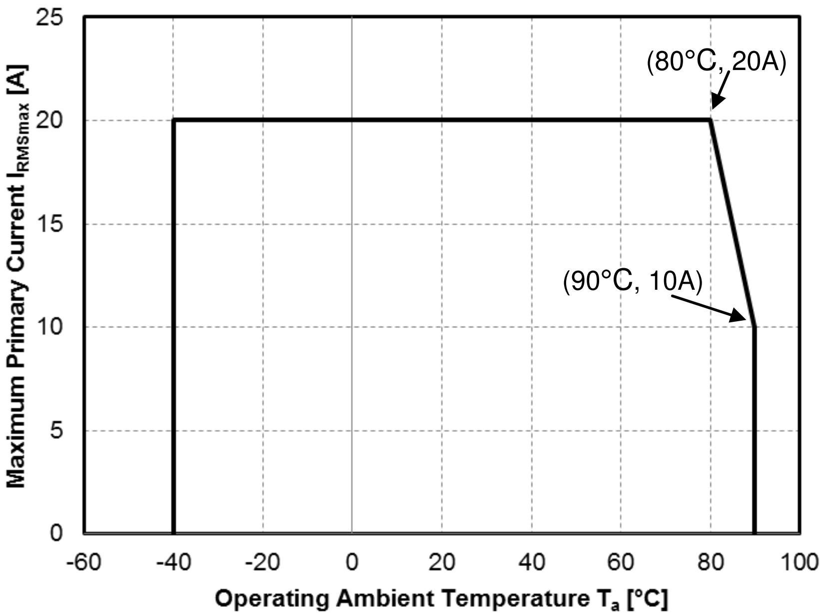
WARNING: Operation at or beyond these limits may result in permanent damage to the device. Normal operation is not guaranteed at these extremes.

8. Recommended Operating Conditions

Table 4. Recommended operating conditions.

Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Supply Voltage	V_{DD}	2.7	3.3	3.63	V	
Analog Output Current	I_{OUT}	−0.5		0.5	mA	VOUT pin
Output Load Capacitance	C_L			100	pF	VOUT pin
Maximum Primary Current (RMS)	I_{RMSmax}	−20		20	A	DC value or RMS value which can be applied to primary conductor see Figure 3
Operating Ambient Temperature	T_a	−40		90	°C	see Figure 3

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



Conditions: Mounted on the test board shown in Figure 12. V_{DD} = 3.3V.

Figure 3. Primary current derating curve of CQ-320B.

Cooling or thermal radiation will improve the derating curve above.

9. Electrical Characteristics

Table 5. Electrical characteristics.

Conditions (unless otherwise specified): T_a = 35°C, V_{DD} = 3.3V

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Units
Current Consumption	I_{DD}	No loads		6.2	9.6	mA
Sensitivity (Note 1, Note 2, Note 3)	V_h	See paragraph 10.1	118.8	120.0	121.2	mV/A
Zero-Current Output Voltage (Note 1, Note 2)	V_{of}	See paragraph 10.1	0.436	0.45	0.464	V
Linear Sensing Range	I_{NS}		−1.1		20.9	A
Output Saturation Voltage H	V_{satH}	I_{OUT} = −0.5mA	V_{DD} −0.3			V
Output Saturation Voltage L	V_{satL}	I_{OUT} = +0.5mA			0.3	V
Linearity Error (Note 1, Note 2)	ρ	See paragraph 10.2	−0.6		0.6	%F.S.
Rise Response Time	t_r	C_L = 100pF, see paragraph 10.5		0.5		µs
Fall Response Time	t_f	C_L = 100pF, see paragraph 10.5		0.5		µs
Bandwidth	f_T	−3dB, C_L = 100pF		1000		kHz
Output Noise	V_{Nrms}	100Hz to 4MHz		1.2		mVrms
Temperature Drift of Sensitivity (Note 2)	$V_{h\text{-}dmax}$	T_a = −40 to 90°C Reference temperature T_a = 35°C		±0.7		%
Temperature Drift of Zero-Current Output Voltage (Note 2)	$V_{of\text{-}dmax}$	T_a = −40 to 90°C Reference temperature T_a = 35°C		±9		mV
Ratiometricity Error of Sensitivity (Note 2)	$V_{h\text{-}R}$	V_{DD} = 2.97V to 3.63V	−1.0		1.0	%
Ratiometricity Error of Zero-Current Output Voltage (Note 2)	$V_{of\text{-}R}$	V_{DD} = 2.97V to 3.63V,	−0.8		0.8	%F.S.
Primary Conductor Resistance (Note 4)	R_1			1.6		mΩ
Total Accuracy (Note 5)	E_{TO}	T_a = −40 to 90°C		±1.9		%F.S.
Isolation Voltage(Note 6)	V_{INS}	AC 50/60Hz, 60s	3.0			kV
Isolation Resistance (Note 4)	R_{INS}	DC 1kV	500			MΩ
Clearance Distance (Note 4)	d_{CL}	between primary and secondary conductors	5.0	5.2		mm
Creepage Distance (Note 4)	d_{CP}	between primary and secondary conductors	5.0	5.2		mm

Note 1. These parameters can drift by long-term use or reflow process. Please see '14. Reliability Tests' for the reference of drift values.

Note 2. The primary current (I_{IN}) is swept within 0~10A. Current is applied within 35ms in each step.

Note 3. This parameter is tested on condition that current density is uniform. Sensitivity may change slightly depending on a primary conductor layout on PCB. Please see the application note provided in the AKM website.

Note 4. These parameters are guaranteed by design.

Note 5. Total accuracy E_{TO} is calculated by the equation below.

$$E_{TO} = |100 \times (V_{h\_meas} - 120) \times 20.9 / (F.S. \times 1000)| + |100 \times (V_{of\_meas} - V_{of\_meas\_35}) / F.S.| + |\rho_{meas}|$$

where V_{h_meas}[mV/A], V_{of_meas}[V], ρ_{meas}[%F.S.] represent the measured value of sensitivity, zero-current output voltage and linearity error respectively, V_h[mV/A] represent the typical value of sensitivity, and $V_{of\_meas\_35}$[V] represent the measured value of zero-current output voltage at T_a = 35°C. F.S. = V_{satH}(min) - V_{satL}(max)[V]

Note 6. This parameter is tested in mass-production line for all devices.

10. Characteristics Definitions

10.1. Sensitivity V_h [mV/A], Zero-current output 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 VOUT pin voltage (V_{OUT}) when the primary current (I_{IN}) is swept within 0~10A. Zero-current output voltage is defined as the intercept of the approximate straight line above.

10.2. Linearity Error ρ [%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 VOUT pin voltage (V_{OUT}) and the approximate straight line calculated in the sensitivity and zero-current output voltage definition. The primary current (I_{IN}) is swept within 0~10A. Definition formula is shown in below:

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

Full scale (F.S.) is defined as F.S. = V_{satH}(min) - V_{satL}(max) [V].

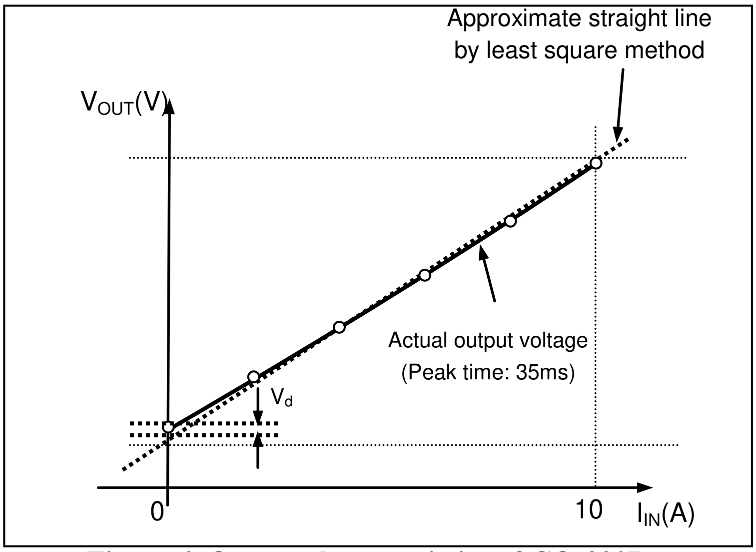


Figure 4. Output characteristics of CQ-320B.

10.3. Ratiometric Error of Sensitivity $V_{h\text{-}R}$ [%] and Ratiometric Error of Zero-Current Output Voltage $V_{of\text{-}R}$ [%F.S.]

Output of CQ-320B is ratiometric, which means the values of sensitivity (V_h) and zero-current output 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 3.3V to V_{DD1} (2.97V ≤ V_{DD1} ≤ 3.63V). Definition formula is shown in below:

$$V_{h\text{-}R} = 100 \times \{(V_h(V_{DD} = V_{DD1}) / V_h(V_{DD} = 3.3V)) - (V_{DD1} / 3.3)\} / (V_{DD1} / 3.3)$$
$$V_{of\text{-}R} = 100 \times (V_{of}(V_{DD} = V_{DD1}) - V_{of}(V_{DD} = 3.3V) \times V_{DD1} / 3.3) / F.S.$$

Full scale (F.S.) is defined as F.S. = V_{satH}(min) - V_{satL}(max) [V].

10.4. Temperature Drift of Sensitivity V_{h-d} [%] , Temperature Drift of Zero-current output Voltage V_{of-d} [mV]

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

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

Maximum temperature drift of sensitivity (V_{h-dmax}) is defined as the maximum value of $|V_{h-d}|$ through the defined temperature range.

Temperature drift of zero-current output voltage is defined as the drift value between the zero-current output voltage (V_{of}) at $T_a = T_{a1}$ ($-40°C \leq T_{a1} \leq 90°C$) and the V_{of} at $T_a = 35°C$, and calculated from the formula below:

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

Maximum temperature drift of zero-current output voltage ($V_{of-dmax}$) is defined as the maximum value of $|V_{of-d}|$ through the defined temperature range.

Reference data of the temperature drift of sensitivity and zero-current output voltage are shown in Figure 5.

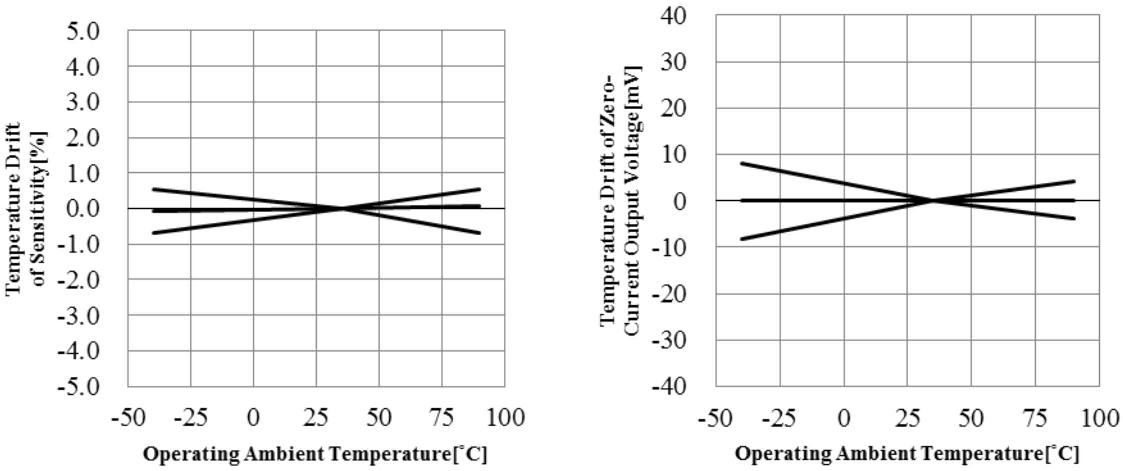


Figure 5. Temperature drift of sensitivity and zero-current output voltage.

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 VOUT pin voltage (V_{OUT}) under the pulse input of primary current (Figure 6).

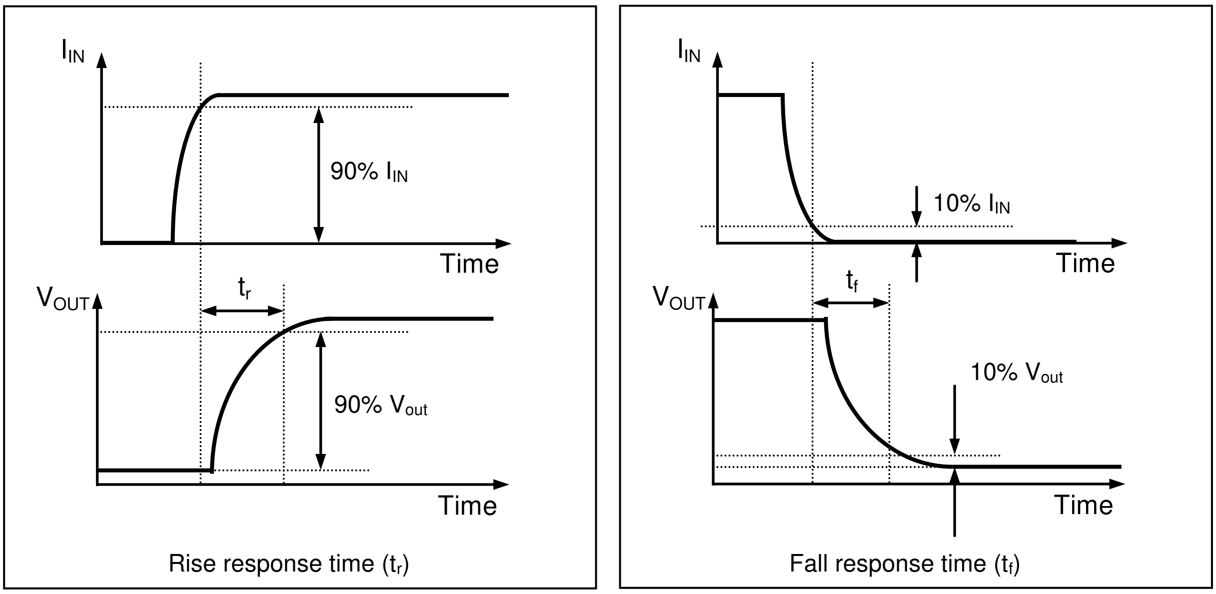


Figure 6. Definition of response time.

11. Recommended External Circuits

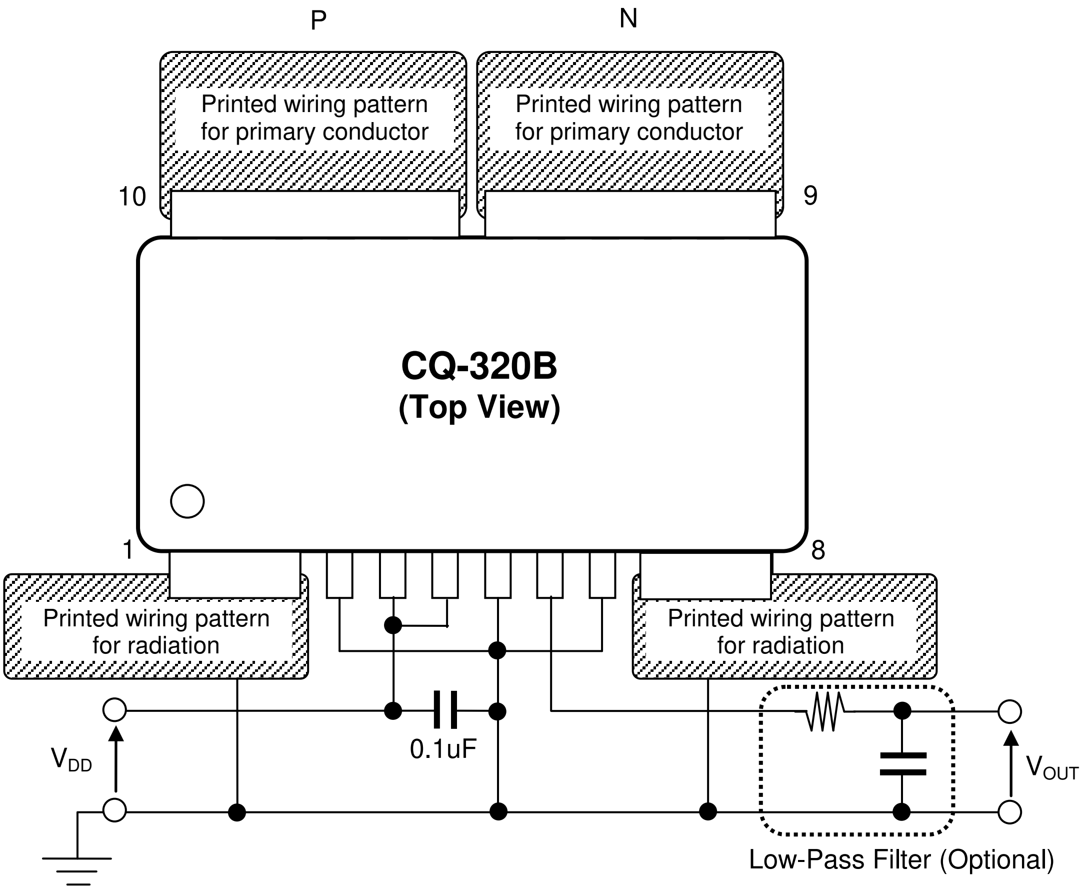


Figure 7. Recommended external circuits.

Radiation pattern should be designed as wide as possible, so that the clearance and creepage distances satisfy the requirement.

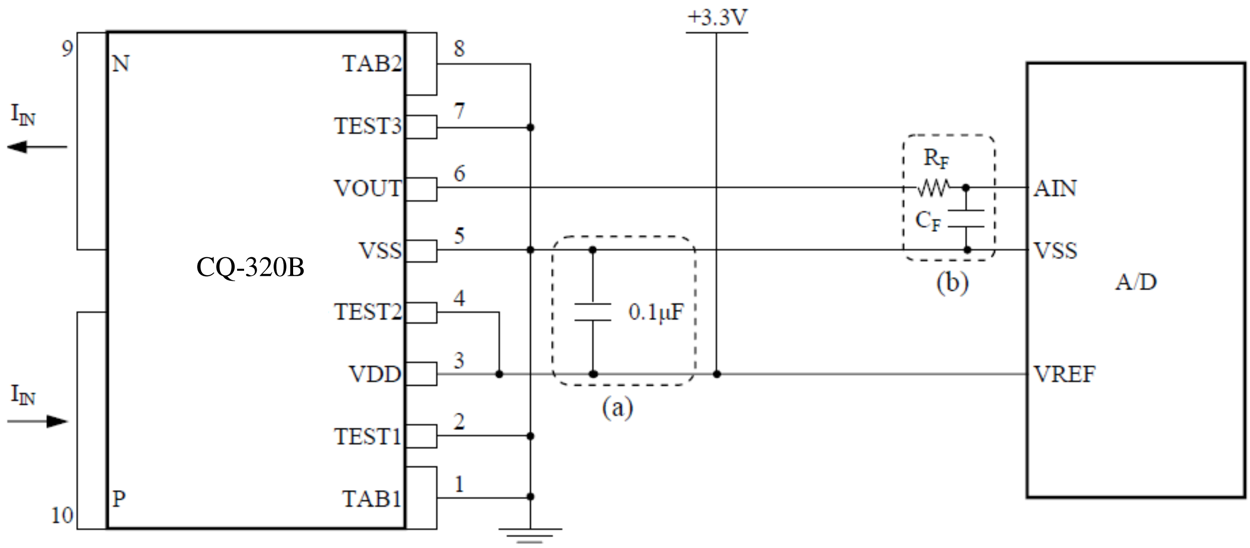
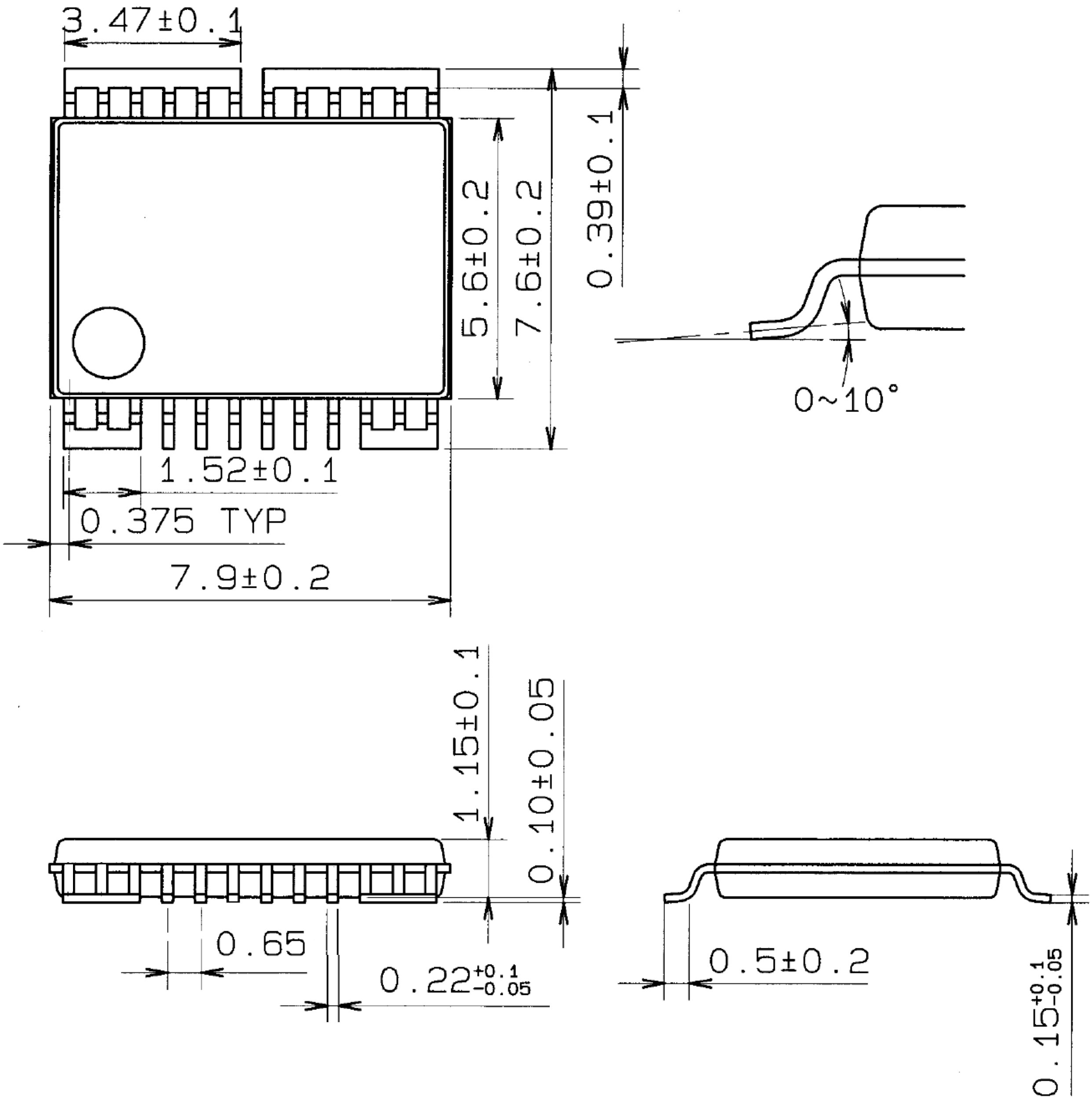


Figure 8. Recommended external circuits of CQ-320B.

(a) 0.1μF bypass capacitor should be placed near by the CQ-320B.
(b) Add a low-pass filter if it is necessary.

12. Package

12.1. Outline Dimensions



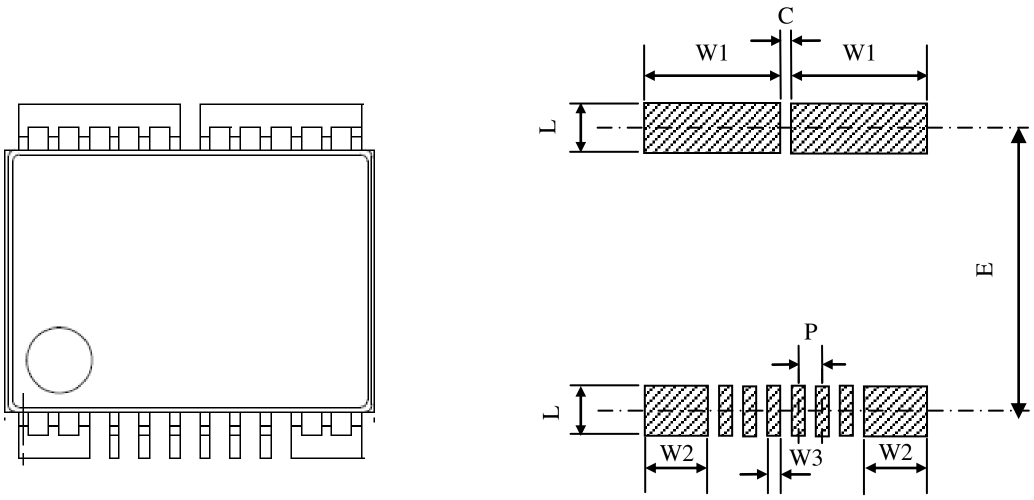
Unit: mm

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

Terminals: Cu
Plating for Terminals: Sn-100% (10µm)
RoHS compliant, halogen-free

Figure 9. Outline dimensions of CQ-320B.

12.2. Recommended Pad Dimensions



L	1.42
E	7.62
W1	3.60
W2	1.65
W3	0.35
C	0.30
P	0.65

Unit: mm

Figure 10. Pad dimensions of CQ-320B.

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.

12.3. Marking

Production information is printed on the package surface by laser marking. Markings consist of 10 characters excluding AKM logo. Except AKM logo, the markings consist of 10 characters indicating a product code and production date. The last character of product code is capitalized.

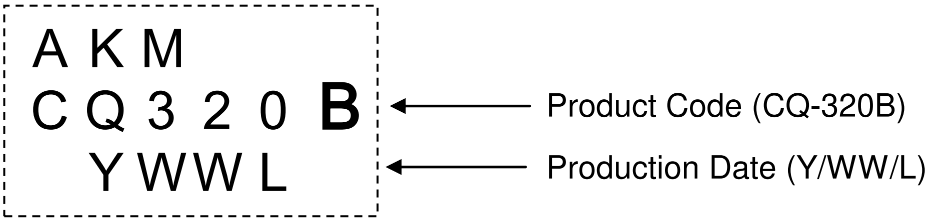
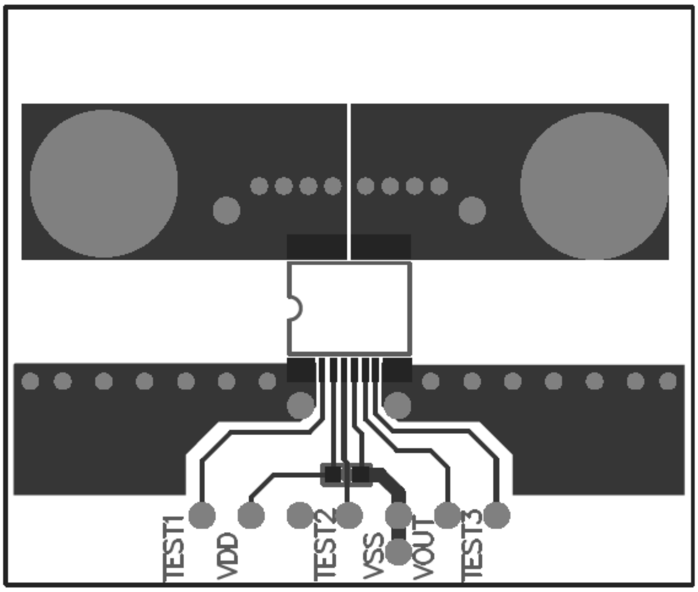


Figure 11. Markings of CQ-320B.

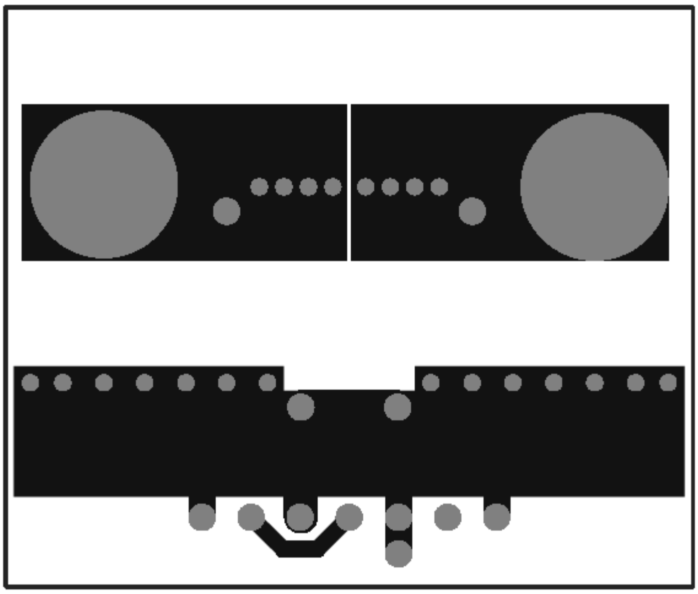
Table 6. Production date code table.

Last Number of Year		Week Date		Production Times	
Character	Number	Character	Week	Character	Times
0	0	01	1	1	1
1	1	02	2	2	2
2	2	03	3	3	3
3	3	04	4	4	4
4	4	: :	: :	5	5
5	5			6	6
6	6			7	7
7	7			8	8
8	8	51	51	9	9
9	9	52	52	0	10
		53	53	A	11
		54	54	B	12
				C	13
				D	14
				E	15
				F	16
				G	17
				H	18
				J	19
				K	20
				L	21
				M	22
				N	23
				P	24
				R	25
				S	26
				T	27
				U	28
				V	29
				W	30
				X	31
				Y	32
				Z	33

13. Board Layout Sample



(a) Top pattern



(b) Bottom pattern

Board size: 35.5mm × 42.0mm
Board thickness: 1.6mm
Copper layer thickness: 70μm

For more information about board layout, please see the application note provided in the AKM website.

Figure 12. Board layout sample of CQ-320B.

14. Reliability Tests

Table 7. Test parameters and conditions of reliability tests.

No.	Test Parameter	Test Conditions	n	Test Time
1	High Humidity Bias Test	[JEITA EIAJ ED-4701 102] T_a = 85°C, 85%RH, continuous operation	22	1000h
2	High Temperature Bias Test	[JEITA EIAJ ED-4701 101] T_a = 125°C, continuous operation	22	1000h
3	High Temperature Storage Test	[JEITA EIAJ ED-4701 201] T_a = 150°C	22	1000h
4	Low Temperature Storage Test	[JEITA EIAJ ED-4701 202] T_a = −65°C	22	1000h
5	Heat Cycle Test	[JEITA EIAJ ED-4701 105] −65°C ↔150°C 30min. ↔ 30min. Tested in vapor phase	22	100 cycles

Tested samples are pretreated as below before each reliability test:
Desiccation: 125°C/24h → Moisture Absorption: 60°C/60%RH/120h → Reflow: 3 times (JEDEC Level2a)

Criteria:

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

Sensitivity V_h (T_a=35°C) : Within ±1.5%
Zero-current output Voltage V_{of} (T_a=35°C) : Within ±120mV
Linearity ρ (T_a=35°C) : Within ±1%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(5 to 35°C). It is recommended to use the products within 4 weeks since it has opened. Keep products away from chlorine and corrosive gas.

<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 shall be check 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 100% tin. 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 characteristic can change by the influences of nearby current and magnetic 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.

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