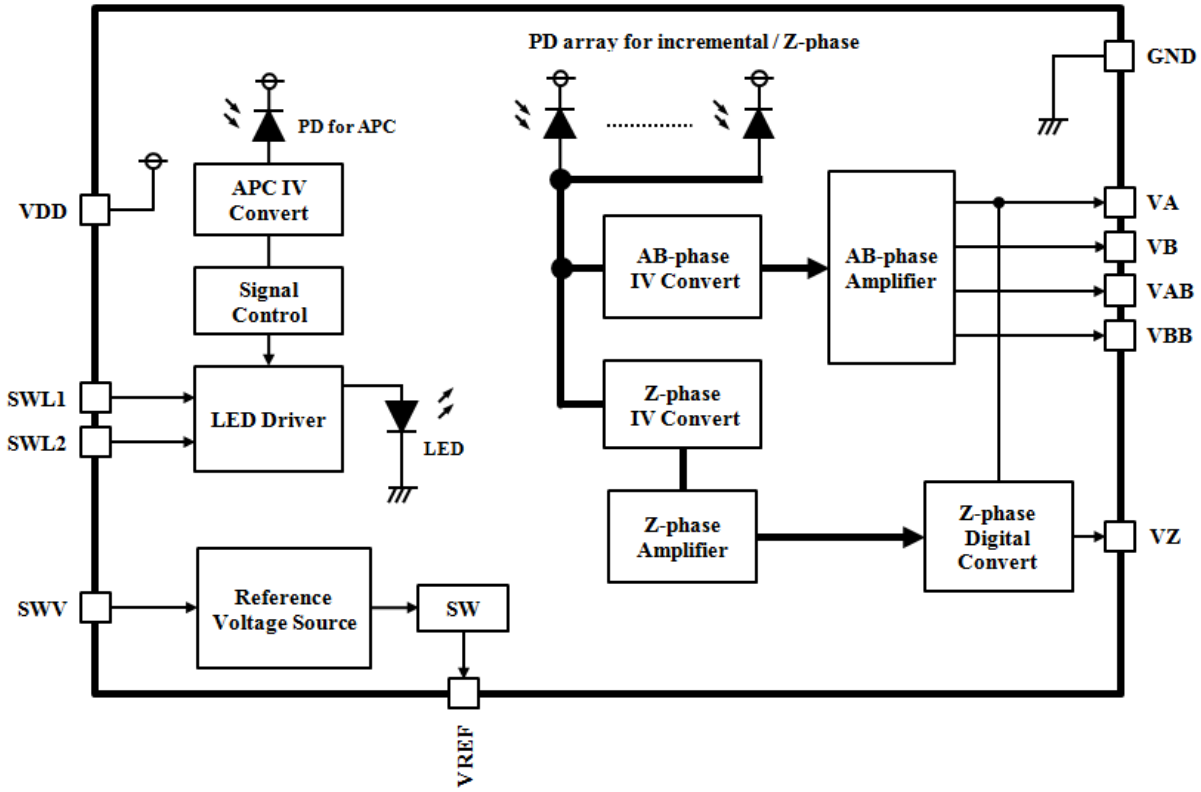
1. OVERVIEW

The SMD-04 is a high precision optical encoder that employs a diffraction image reflection method. It implements an OEIC (Opto-Electric Integrated Circuit) and LED in a single package. Light emitted from the LED is projected onto a scale, and the reflected diffraction image detected by a photodiode detector is used to determine the relative movement between the SMD-04 and the scale. A Z-phase origin signal can also be output by establishing a pattern for origin detection on the scale. It also features a photodiode detector array to reduce degradation in phase characteristics due to variations in mounting accuracy.

2. FEATURES

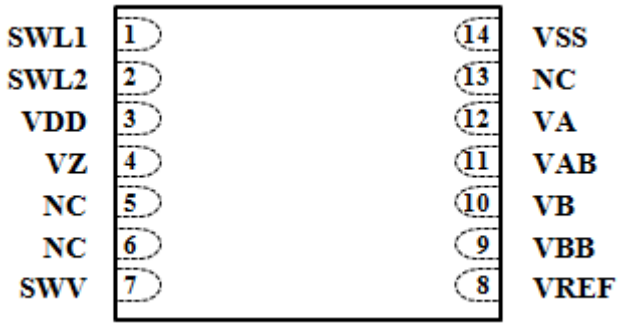
- Compact, clear molded package (5.3mm×4.3mm×1.5mm)
- 5μm resolution (generated on A and B phases using scale with 20μm pitch pattern)
- Analog output with 20μm cycle (sine wave) and Z-phase digital output
- LED and OEIC fabricated in a single package
- LED brightness setting and automatic brightness adjustment selectable using external pins
- LED brightness auto power control function to reduce variation in analog output signal amplitude
- 4.5 to 5.25V supply voltage
- 13.5mA current consumption

3. BLOCK DIAGRAM



4. PIN LAYOUT

HCOB 14 PACKAGE
(Top view)



5. PIN DESCRIPTION

No.	Name	I/O	Function
1	SWL1	I	LED brightness setting input 1 (with pull-up resistance)
2	SWL2	I	LED brightness setting input 2 (with pull-up resistance)
3	VDD	-	Supply voltage
4	VZ	O	Z-phase digital signal output
5	NC	-	No connection (leave open-circuit)
6	NC	-	No connection (leave open-circuit)
7	SWV	I	Reference voltage (V_{REF}) setting input (with pull-up resistance) (See 9.3. “Reference Voltage Switching Function”)
8	VREF	O	Reference voltage output
9	VBB	O	B-phase inverting analog signal (BB phase) output
10	VB	O	B-phase analog signal (B phase) output
11	VAB	O	A-phase inverting analog signal (AB phase) output
12	VA	O	A-phase analog signal (A phase) output
13	NC	-	No connection (leave open-circuit)
14	VSS	-	Ground

6. ABSOLUTE MAXIMUM RATINGS

V_{SS}=0V

Parameter	Symbol	Conditions	Rating	Unit	Notes
Supply voltage range	V_{DD}	VDD pin	–0.3 to +6.0	V	*1
Input voltage range	V_{IN}	SWL1, SWL2, SWV pins	–0.3 to V_{DD}+0.3	V	*1, *2
Output voltage range	V_{OUT}	VA, VAB, VB, VBB, VREF, VZ pins	–0.3 to V_{DD}+0.3	V	*1, *2
Junction temperature	T_J		+125	°C	*3
Storage temperature range	T_{STG}		–30 to +85	°C	*4

*1: Parameters must not exceed ratings, not even momentarily. If a rating is exceeded, there is a risk of IC failure, deterioration in characteristics, and decrease in reliability.
*2: V_{DD} in absolute value ratings refers to the recommended operating voltage V_{DD} value.
*3: Parameters should not exceed ratings. If a rating is exceeded, there is a risk of deterioration in characteristics and decrease in reliability.
*4: Stored separately in Nitrogen (N_2) atmosphere or vacuum.

7. RECOMMENDED OPERATING CONDITIONS

V_{SS}=0V

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Supply voltage	V_{DD}		4.5		5.25	V
Operating temperature	T_a		–30		+85	°C
Response speed	R_t		0		2	m/s

* Operation outside the recommended operating conditions may adversely affect reliability. Use only within specified ratings.

8. ELECTRICAL CHARACTERISTICS

8.1. DC Characteristics

V_{DD}=5V, V_{SS}=0V, T_a=27°C unless otherwise noted

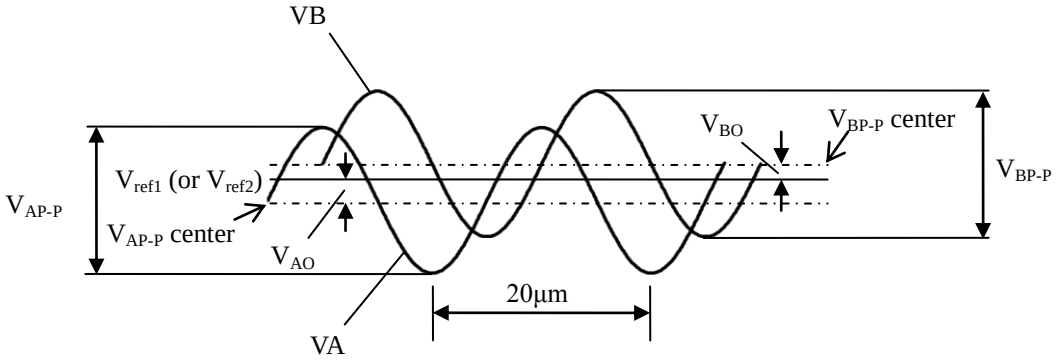
Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Current consumption 1	I_{DD1}	SWL1=H, SWL2=H		10.0	16.0	mA
Current consumption 2	I_{DD2}	SWL1=H, SWL2=L		14.2	22.0	
Current consumption 3	I_{DD3}	SWL1=L, SWL2=H		13.5	32.0	
Current consumption 4	I_{DD4}	SWL1=L, SWL2=L		5.0	9.0	
Reference voltage	V_{ref1}	SWV=H	1.1	1.45	1.8	V
	V_{ref2}	SWV=L	1.8	2.25	2.7	
A-phase signal offset voltage	V_{AO}	VA, VAB, VB, VBB pins, SWL1=L, SWL2=L Difference with VREF	-0.15	0	0.15	V
AB-phase signal offset voltage	V_{ABO}					
B-phase signal offset voltage	V_{BO}					
BB-phase signal offset voltage	V_{BBO}					
Output voltage variation 1	V_{D1}	VA, VAB, VB, VBB pins, Difference between when sink current is 50µA and 0µA	0		30	mV
Output voltage variation 2	V_{D2}	VA, VAB, VB, VBB pins, Difference between when source current is 50µA and 0µA	–30		0	
Output voltage variation 3	V_{D3}	VREF pin, Difference between when sink current is 50µA and 0µA	0		150	
Output voltage variation 4	V_{D4}	VREF pin, Difference between when source current is 50µA and 0µA	-150		0	
Input voltage	V_{IH}	SWL1, SWL2, SWV pins	$0.8V_{DD}$		V_{DD}	V
	V_{IL}	SWL1, SWL2, SWV pins	0		$0.2V_{DD}$	
Input current	I_{IH}	SWL1, SWL2, SWV pins, $V_{IN}=V_{DD}$	–1		1	µA
	I_{IL}	SWL1, SWL2, SWV pins, $V_{IN}=V_{SS}$	-20		-1	
Z-phase signal HIGH-level voltage	V_{OH}	VZ pin, I_{out}=0.5mA, SWV=L	$0.8V_{DD}$			V
Z-phase signal LOW-level voltage	V_{OL}	VZ pin, I_{out}=-0.5mA			$0.2V_{DD}$	

8.2. Analog Characteristics

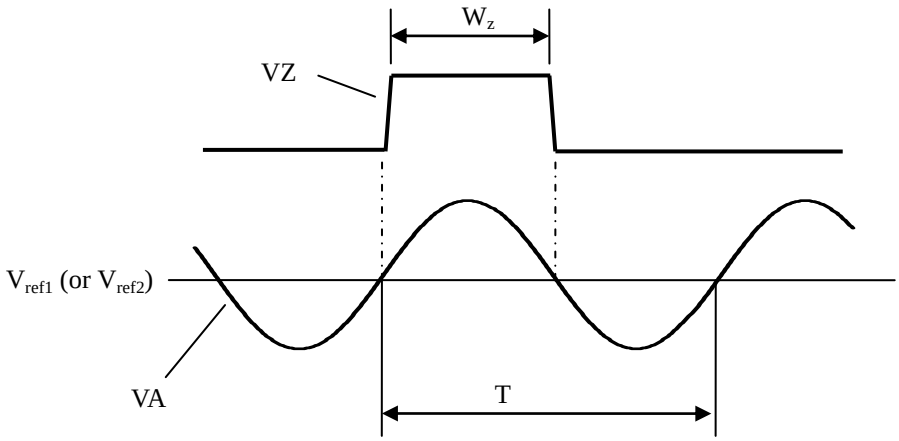
V_{DD}=5V, V_{SS}=0V, T_a=27°C unless otherwise noted

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
A-phase output signal amplitude	V_{AP-P}	VA, VAB, VB, VBB pins, Vp-p, SWL1=L, SWL2=H, Standard scale conditions	0.8	1.2	1.92	V
AB-phase output signal amplitude	V_{ABP-P}					
B-phase output signal amplitude	V_{BP-P}					
BB-phase output signal amplitude	V_{BBP-P}					
A-to-B phase difference	D_P	Standard scale conditions	80	90	100	°
Z-phase signal output width	W_Z	Standard scale conditions, T=20μm*1	0.17T	0.50T	0.70T	μm

*1: "T" indicates the width of a single VA and VB cycle.



V_{AO} and V_{BO} indicate the difference between the VA and VB center line and V_{ref1} (or V_{ref2}), respectively.



8.3. AC Characteristics

V_{DD}=5V, V_{SS}=0V, T_a=27°C unless otherwise noted

Parameter	Symbol	Conditions	MIN	TYP	MAX	Unit
Z-phase output signal rise time	t_r	SWV=L, C_L=15pF $0.1V_{DD} \rightarrow 0.9V_{DD}$			100	ns
Z-phase output signal fall time	t_f	SWV=L, C_L=15pF $0.9V_{DD} \rightarrow 0.1V_{DD}$			100	

8.4. Standard Scale Conditions

Electrical characteristics established under the following conditions.

Parameter		Conditions	Unit
Scale	Reflecting surface reflectance	50	%
	Non-reflecting surface reflectance	10	%
	Incremental pattern	20μm pitch, (10μm Cr line/10μm space)	-
	Z-phase pattern	30μm Cr line	-
Mounting	Gap (ΔGap)	0.5	mm
	Yaw angle ($\Delta\theta_y$) Roll angle ($\Delta\theta_r$) Pitch angle ($\Delta\theta_p$)	0	°

9. FUNCTIONAL DESCRIPTION

The SMD-04 projects visible LED light with a center wavelength of 632nm through a slit and onto a scale with a 20μm pitch pattern (10μm line/10μm space), and detects the relative movement between the head and the scale by receiving a diffracted image of the reflected light using a photodiode detector. It outputs analog signals (sine wave) with 20μm period comprising an A-phase (VA) and B-phase (VB) that are 90° out of phase. It can also output a Z-phase digital signal formed using a 30μm reflective pattern at one location on the 20μm pitch scale. The Z-phase signal is output when the A-phase is HIGH ($V_A > V_{ref1}$ (or V_{ref2})).

To enable the Z-phase signal, set the LED brightness switching function to APC as described in section 9.1.

9.1. LED Brightness Switching Function

The SMD-04 has a function that adjusts the variation in signal amplitude by adjusting the LED brightness. The signal amplitude can be adjusted by changing the LED current to control the LED brightness as shown in the following table.

For details about APC adjustment, see section 9.2.

SWL1	H		L	
SWL2	H	L	H	L
A,B-phase analog signal amplitude	×1.0	×1.8	APC	OFF

9.2. LED Auto Power Control (APC) Brightness Adjustment Function

The SMD-04 has a built-in APC (Auto Power Control), LED brightness automatic adjustment function. It detects the light reflected from the scale using the photodiode detector, and controls the LED current to adjust the brightness.

In addition to reducing the fluctuation in amplitude of the A-phase (VA) and B-phase (VB) signals due to fluctuations in LED brightness, it also reduces the temperature dependency of the signal amplitude by compensating for changes in LED brightness due to temperature variations.

9.3. Reference Voltage Switching Function

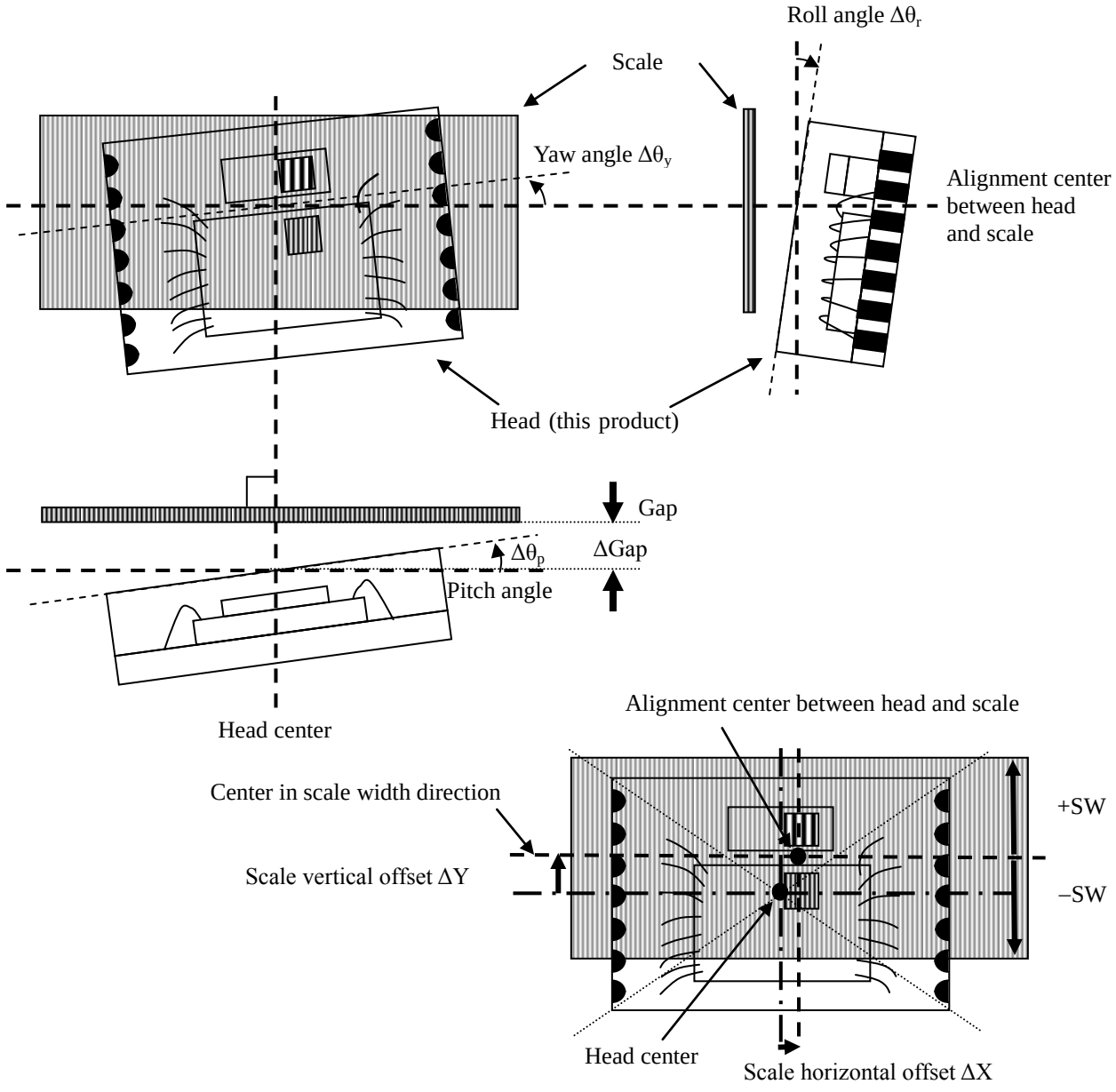
The SMD-04 has a function for switching the reference voltage (Vref) by changing the setting of the SWV pin. Set the reference voltage according to the required input conditions of the following stage circuit.

When used with SWV=H, the VZ pin becomes an open-drain output.

10. Scale Mounting Conditions

The optical center of the encoder head is offset from the physical center by (0.7 mm) in the vertical direction (ΔY in the diagram below) and 0.0mm in the horizontal direction (ΔX in the diagram below). If using a linear scale, you only need to take the offset in the scale width direction (ΔY) into account. If using a rotary scale, the offset in the horizontal direction (ΔX) must also be taken into account.

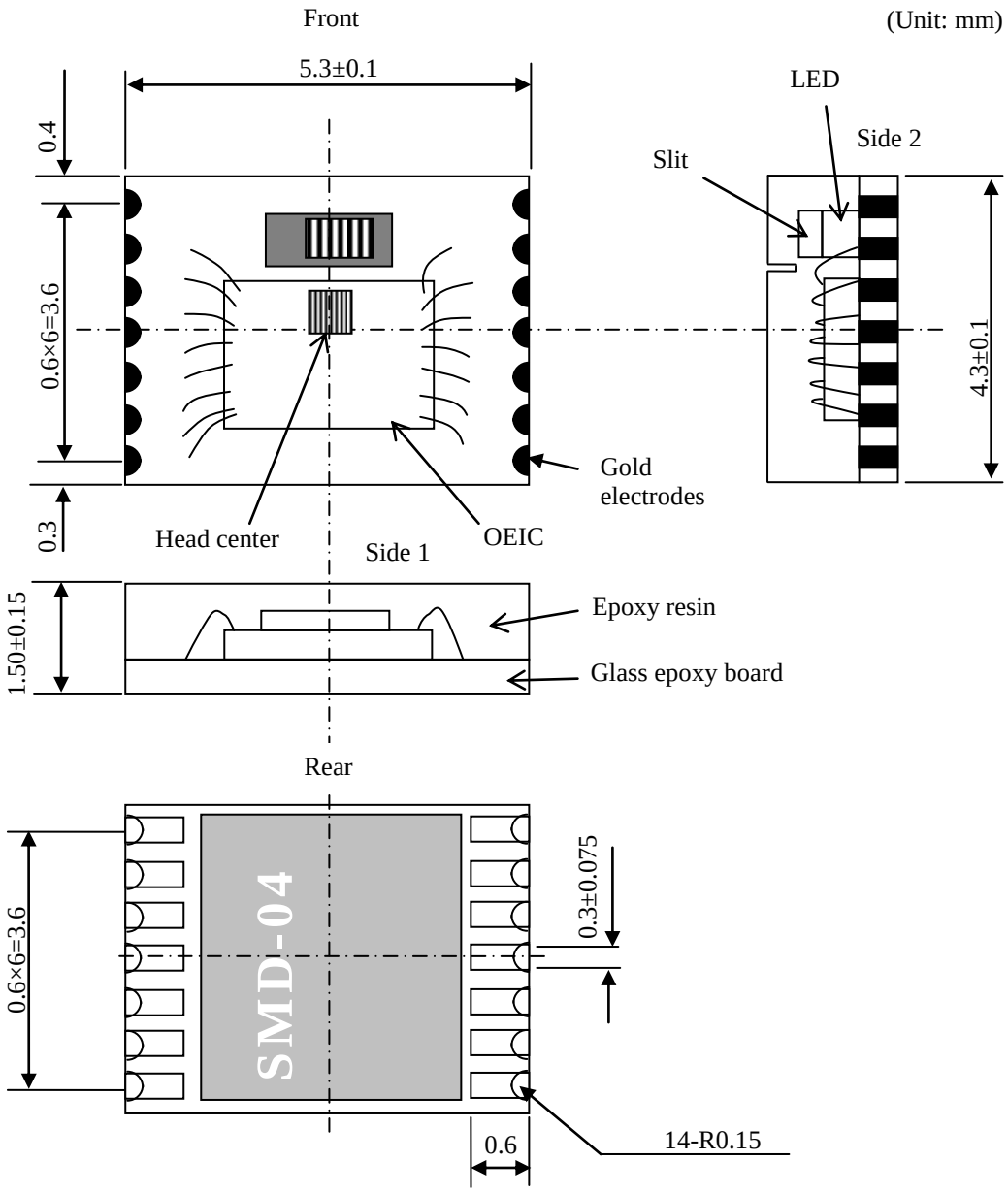
The optimum optical conditions of the product will vary depending on the mounting conditions. Conduct careful evaluation to meet requirements. In particular, the effects on amplitude and phase difference due to mounting conditions are larger if using a small diameter rotary scale than if using a linear scale. Provision of separate mounting adjustments is recommended to achieve better product performance.



[Reference data]

Parameter		Conditions	Unit
Scale	Scale width (±SW)	±1 (min.)	mm
Mounting	Scale vertical offset (ΔY)	0.7	mm
	Scale horizontal offset (ΔX)	0.0	mm

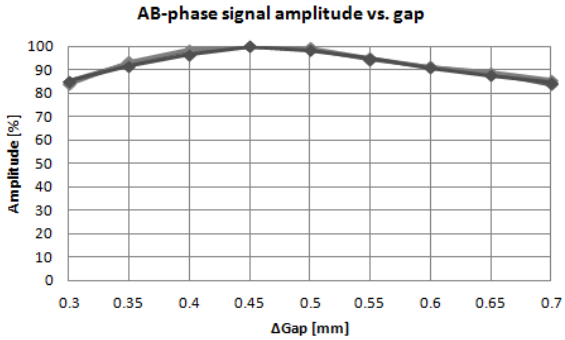
11. PACKAGE DIMENSIONS



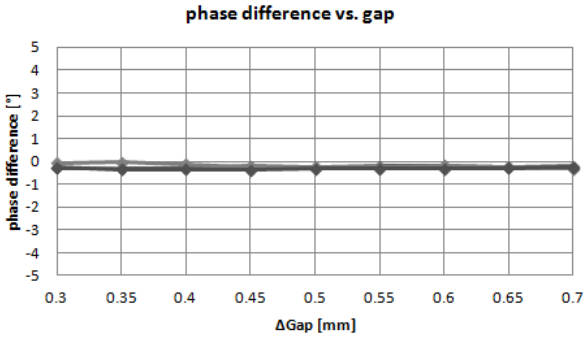
12. TYPICAL CHARACTERISTICS

* NPC standard scale and mounting conditions

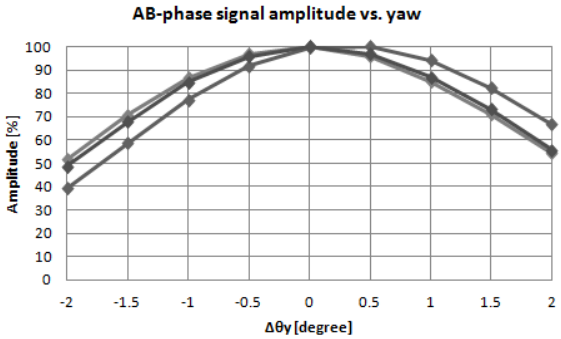
12.1. Mounting Characteristics



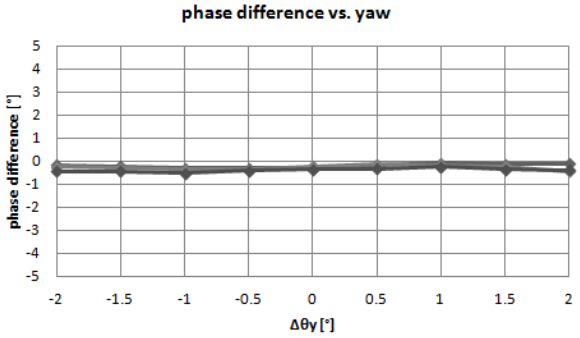
Amplitude v. Gap (ΔGap)



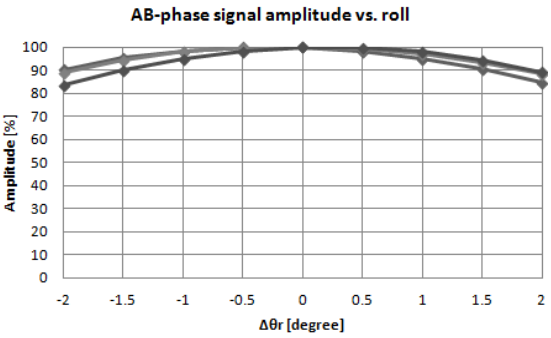
Phase difference v. Gap (ΔGap)



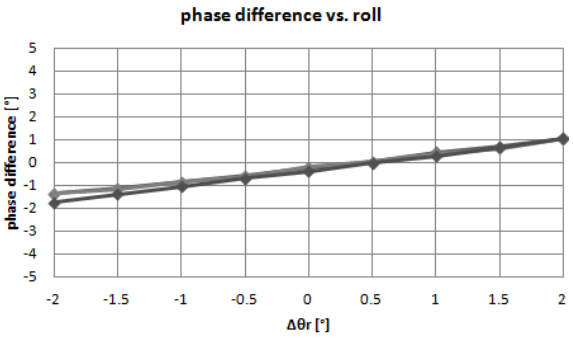
Amplitude v Yaw angle ($\Delta\theta_y$)



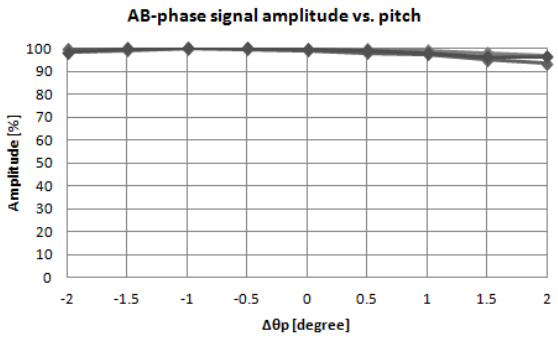
Phase difference v. Yaw angle ($\Delta\theta_y$)



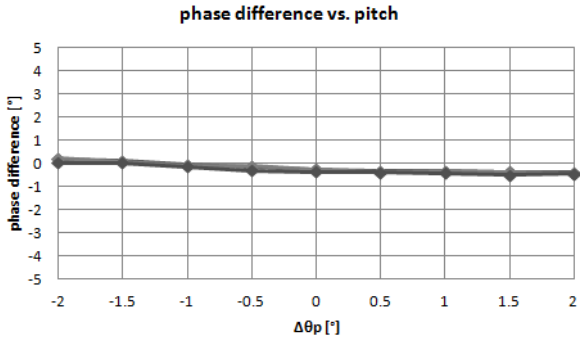
Amplitude v. Roll angle ($\Delta\theta_r$)



Phase difference v. Roll angle ($\Delta\theta_r$)

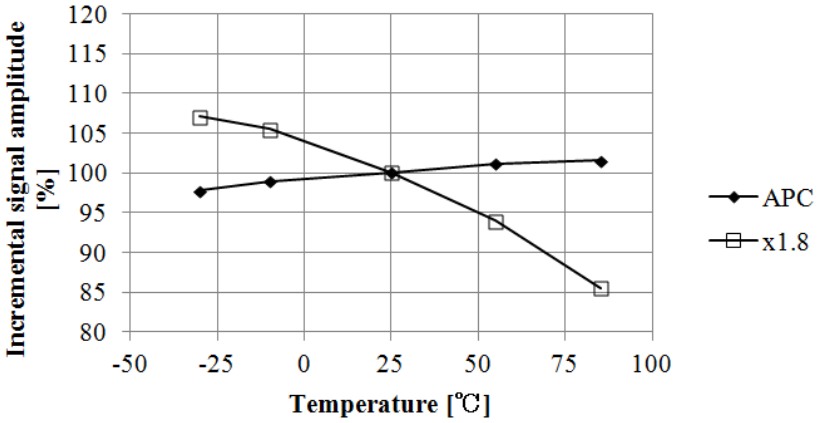


Amplitude v. Pitch angle ($\Delta\theta_p$)



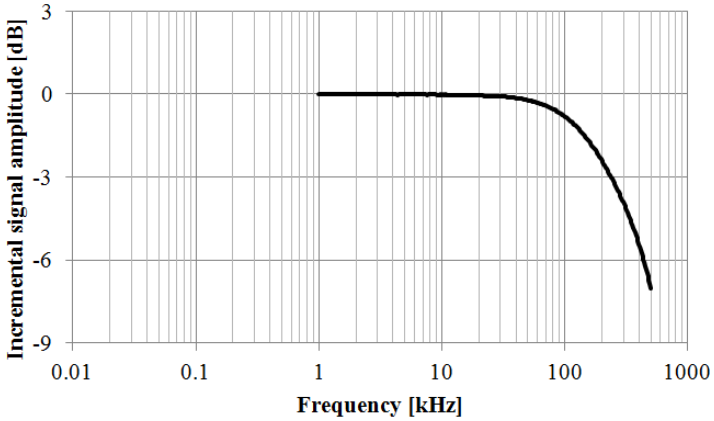
Phase difference v. Pitch angle ($\Delta\theta_p$)

12.2. Temperature Characteristic



Amplitude v. Temperature (T_a)

12.3. Frequency Response

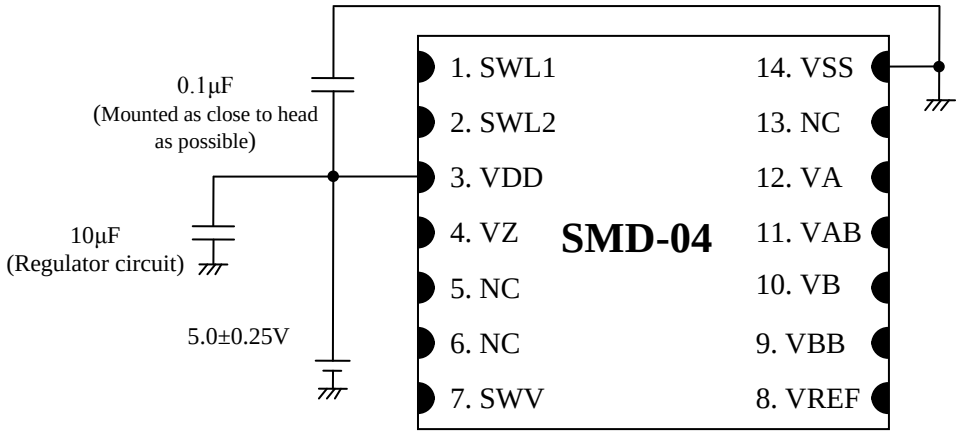


Amplitude v. Frequency

13. USAGE NOTE

Keep this product and the wiring emerging from this product (specifically the analog signal wiring) as far away as possible from the wiring for the drive actuator. The susceptibility of the encoder signal to noise will increase the closer the wiring is positioned. Chattering of the digital signal may occur with increasing noise, adversely affecting position detection accuracy.

To reduce the effects of noise, connect capacitors to the VDD and VSS lines of the product as shown below.



14. USAGE AND PRECAUTIONS

This product is designed and manufactured to the generally accepted standards of reliability as expected for use in general electronic and electrical equipment, such as personal equipment, machine tools, and measurement equipment. This product is not designed and manufactured to be used in any other special equipment requiring extremely high level of reliability and safety, such as aerospace equipment, nuclear power control equipment, medical equipment, transportation equipment, disaster prevention equipment, security equipment.

If you wish to use this product in equipment requiring extremely high level of reliability, please contact our sales department or representative in advance.

In the event that this product is used in such equipment, please take scrupulous care and apply fail-safe techniques including redundancy and malfunction prevention in order to prevent damage to life, health, property, or infrastructure etc. in case there is some malfunction in the product.

Please pay your attention to the following points at time of using the products shown in this document.

1. The products shown in this document (hereinafter "Products") are designed and manufactured to the generally accepted standards of reliability as expected for use in general electronic and electrical equipment, such as personal equipment, machine tools and measurement equipment. The Products are not designed and manufactured to be used in any other special equipment requiring extremely high level of reliability and safety, such as aerospace equipment, nuclear power control equipment, medical equipment, transportation equipment, disaster prevention equipment, security equipment. The Products are not designed and manufactured to be used for the apparatus that exerts harmful influence on the human lives due to the defects, failure or malfunction of the Products.
   If you wish to use the Products in that apparatus, please contact our sales section in advance.
   In the event that the Products are used in such apparatus without our prior approval, we assume no responsibility whatsoever for any damages resulting from the use of that apparatus.
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SEIKO NPC CORPORATION

1-9-9, Hatchobori, Chuo-ku,
Tokyo 104-0032, Japan
Telephone: +81-3-5541-6501
Facsimile: +81-3-5541-6510
http://www.npc.co.jp/
Email:sales@npc.co.jp

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