

OVERVIEW

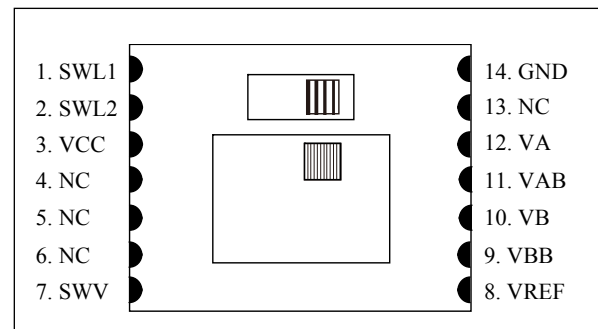
The SMD-01A is a high-precision optical encoder that employs a diffraction image projection method. It incorporates an OEIC (Opto-Electric Integrated Circuit) and LED light source in a single package. Light emitted from the LED is projected onto a scale, and the reflected diffraction image is focused on a photodiode. The reflected light contains position information that is recovered to detect the relative movement between the SMD-01A and the scale. A photodiode array is used to reduce degradation in phase characteristics due to mounting alignment. This allows the SMD-01A to be mounted without monitoring the output signal, unlike conventional high-precision optical encoders which typically need to be mounted and aligned while monitoring the output signal.

FEATURES

- Package: Miniature clear-mold package (5.3 × 4.3 × 1.68mm)
- Resolution: 5μm (using 20μm pitch pattern scale and A-phase/B-phase signal detection)
- Optimized OEIC and optics design for easy mounting alignment
- LED and OEIC fabricated in a single package
- Adjustable LED brightness using external inputs
- Analog (sine wave) output
- Supply voltage: 3.13 to 5.25V
- Current consumption: 12.2mA (typ)

PINOUT

(Top View)

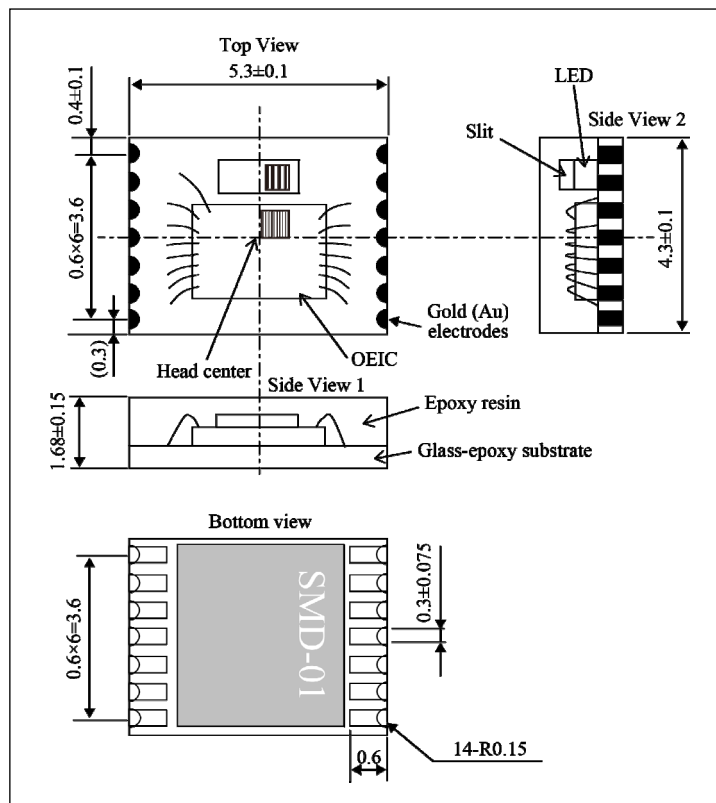


APPLICATIONS

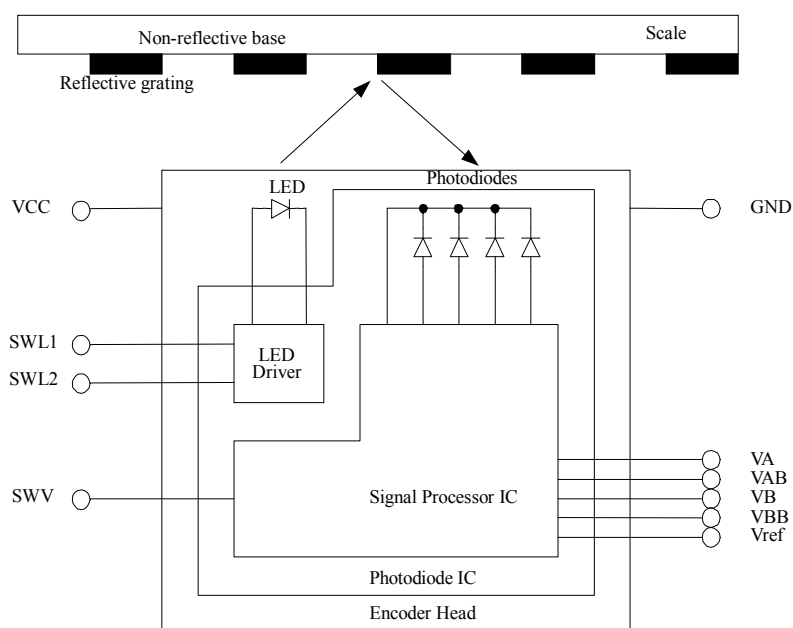
- Linear motors
- Precision stages
- Sliders
- Mounting equipment
- Robots
- Angle measurement equipment
- Various encoder devices

PACKAGE DIMENSIONS

(Unit : mm)



BLOCK DIAGRAM



PIN DESCRIPTION

Number	Name	I/O	Description
1	SWL1	IP	LED brightness adjustment 1
2	SWL2	IP	LED brightness adjustment 2
3	VCC	-	Supply voltage (+)
4	NC	-	No connection (leave open circuit)
5	NC	-	No connection (leave open circuit)
6	NC	-	No connection (leave open circuit)
7	SWV	IP	Reference voltage (VREF) select input H: VREF=1.45V (typ) L: VREF=2.25V (typ)*2
8	VREF	O	Reference voltage output
9	VBB	O	B-phase inverted analog signal (BB phase) output
10	VB	O	B-phase analog signal (B phase) output
11	VAB	O	A-phase inverted analog signal (AB phase) output
12	VA	O	A-phase analog signal (A phase) output
13	NC	-	No connection (leave open circuit)
14	GND	-	Ground

*1. IP: Input with internal pull-up

*2. It's possible to use only by $V_{CC}=5.00\pm 0.25V$.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit
Supply voltage ^{*1}	V _{CC}	-0.3 to +5.5	V
Storage temperature ^{*2}	T _{STG}	-40 to 80	°C

*1. Absolute maximum ratings are the values that must never exceed even for a moment. This product may suffer breakdown if any one of these parameter ratings is exceeded. Operation and characteristics are guaranteed only when the product is operated at recommended supply voltage range.

*2. Do not exceed the absolute maximum ratings. If they are exceeded, a characteristic and reliability will be degraded.

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Rating	Unit	Conditions
Supply voltage	V _{CC}	3.13 to 5.25	V	SWV=H
		4.75 to 5.25	V	SWV=L or H
Operating temperature	T _a	-20 to 60	°C	
Response speed	R _t	0 to 2	m/s	

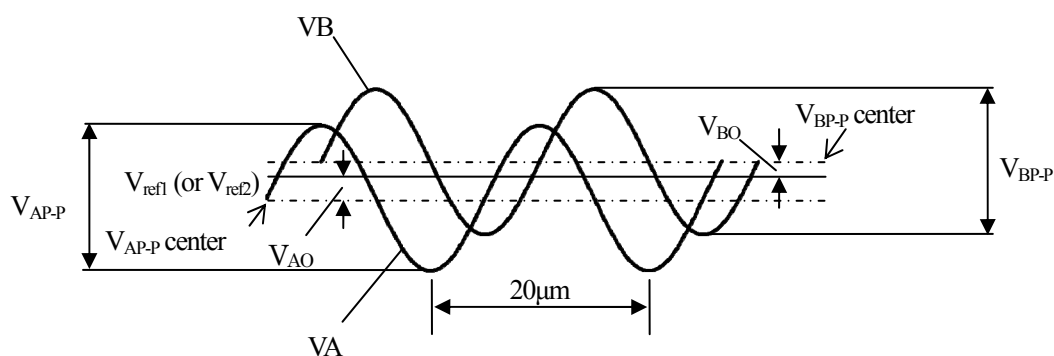
* Since it may influence the reliability if it is used out of the recommended operating conditions range, this product should be used within this range.

ELECTRICAL CHARACTERISTICS

$V_{CC}=5V$, $T_a=27^\circ C$, unless otherwise noted

Parameter	Symbol	Conditions	Min	Typ	Max	Unit	Pins
Current consumption 1	I_{CC1}	SWL1=H SWL2=H	4.0	12.2	23.0	mA	VCC
Current consumption 2	I_{CC2}	SWL1=H SWL2=L	7.0	16.9	30.0	mA	VCC
Current consumption 3	I_{CC3}	SWL1=L SWL2=H	11.0	21.0	35.5	mA	VCC
Current consumption 4	I_{CC4}	SWL1=L SWL2=L	2.0	6.0	13.5	mA	VCC
Reference voltage	V_{ref1}	SWV=H	1.00	1.45	2.00	V	VREF
	V_{ref2}^{*1}	SWV=L $V_{CC}=5.00 \pm 0.25V$	1.40	2.25	3.20		
A-phase output signal amplitude	V_{AP-P}	Vp-p SWL1=H SWL2=H *Standard scale conditions	0.13	0.85	3.00	V	VA
AB-phase output signal amplitude	V_{ABP-P}						VAB
B-phase output signal amplitude	V_{BP-P}						VB
BB-phase output signal amplitude	V_{BBP-P}						VBB
A-phase signal offset voltage	V_{AO}	SWL1=L SWL2=L Variation from VREF	-0.25	0.00	0.25	V	VA
AB-phase signal offset voltage	V_{ABO}						VAB
B-phase signal offset voltage	V_{BO}						VB
BB-phase signal offset voltage	V_{BBO}						VBB
A-phase – B-phase difference	DP	*Standard scale conditions	50	90	130	°	VA, VB
Output voltage fluctuation 1	ΔV_{O1}	Difference between $0\mu A$ and $50\mu A$ sink current	0	-	+30	mV	VREF, VA, VAB VB, VBB
Output voltage fluctuation 2	ΔV_{O2}	Difference between $0\mu A$ and $50\mu A$ source current	-30	-	0	mV	VREF, VA, VAB VB, VBB
HIGH-level input voltage	V_{IH}		$0.8 \times V_{CC}$	-	V_{CC}	V	SWL1, SWL2, SWV
LOW-level input voltage	V_{IL}		0	-	$0.2 \times V_{CC}$		
Input current	I_{o_SW}	Input voltage = 0V	1	-	20	μA	

*1. It's possible to use only by $V_{CC}=5.00 \pm 0.25V$.



V_{AO} & V_{BO} offsets represent the differences between the VA & VB cycle center lines and V_{ref1} (or V_{ref2}).

Standard Scale Conditions

Electrical characteristics ratings apply under the following conditions:

Parameter		Conditions	Unit
Scale	Reflective surface reflection factor	57	%
	Non-reflective surface reflection factor	5	%
	Pattern	20 μ m pitch (10 μ m Cr line/10 μ m spacing)	-
SMDA-01 head alignment	Gap (Δ Gap)	0.3	mm
	Yaw angle ($\Delta\theta_y$) Roll angle ($\Delta\theta_r$) Pitch angle ($\Delta\theta_p$)	0	°

FUNCTIONAL DESCRIPTION

The SMD-01A head emits 632nm center-wavelength visible light from the LED and projects the light through a slit and onto a scale having a 20 μ m pitch (10 μ m lines/10 μ m spacing) grating pattern. The reflected diffraction image is focused on a photodiode array to detect the relative movement between the head and the scale. An analog signal (sine wave) with a cycle period of 20 μ m is output. The output signal is composed by the 90° phase difference A-phase and B-phase diffraction signals.

LED Brightness Switching Function

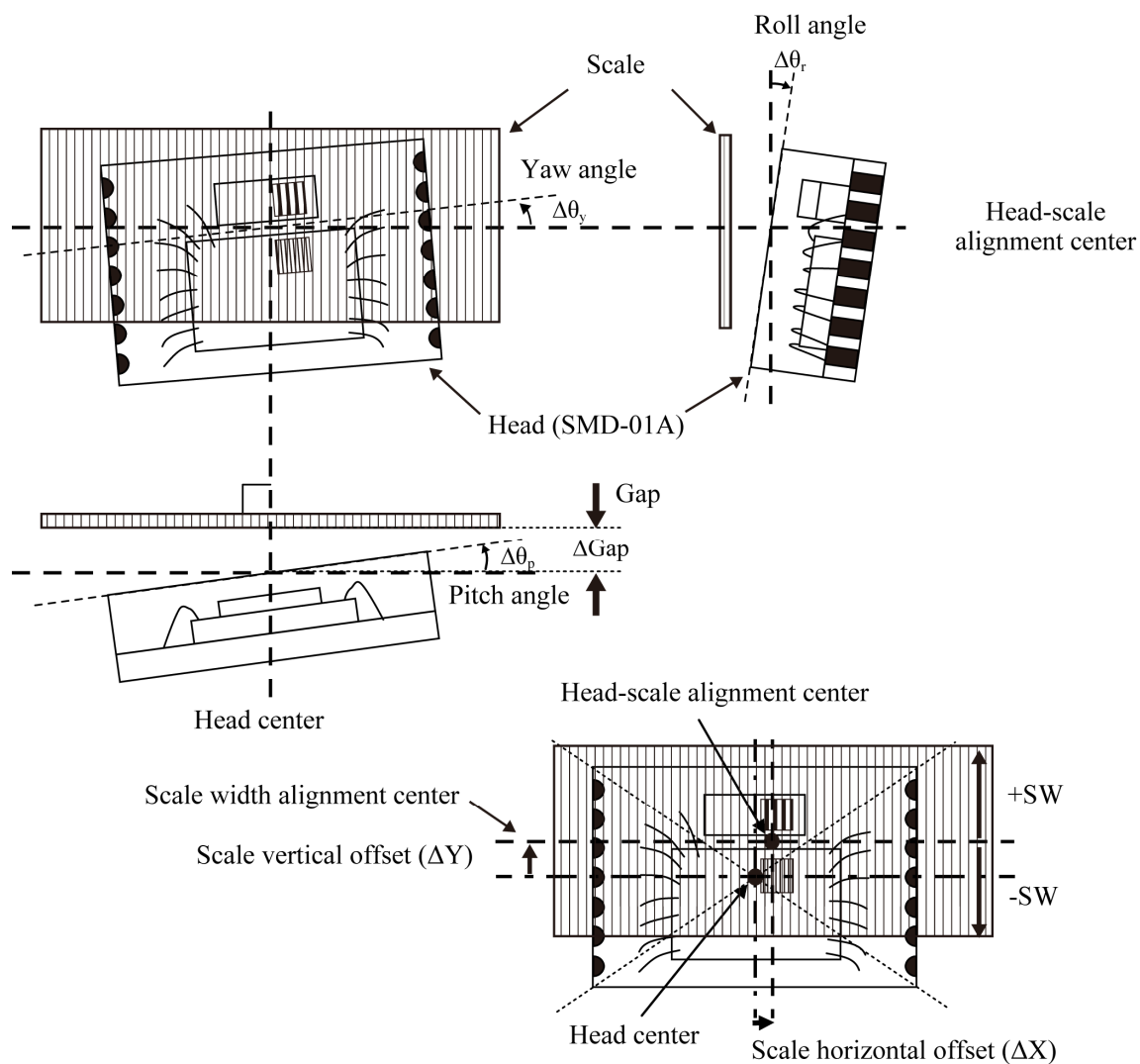
The signal amplitude can be adjusted by adjusting the LED brightness. The LED brightness is adjusted by adjusting the LED current. The amplitude adjustment options are shown in the following table.

SWL1	HIGH	HIGH	LOW	LOW
SWL2	HIGH	LOW	HIGH	LOW
A/B-phase analog signal amplitude	$\times 1.0$	$\times 1.8$	$\times 2.6$	$\times 0$

SCALE and HEAD ALIGNMENT

The encoder head optical center position is offset from the physical center of the head by 0.77mm (ΔY) in the vertical direction and 0.0mm (ΔX) in the horizontal direction. If using a linear scale, only the offset in the scale width direction (ΔY) needs to be considered. If using a rotary scale, the scale offset in the horizontal direction (ΔX) must also be taken into account.

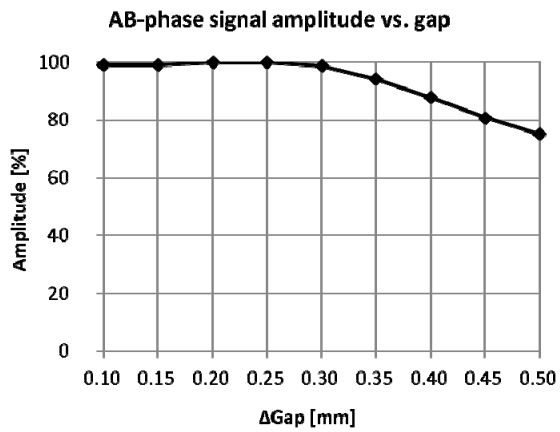
Conditions of optimum optics of this product may vary due to mounting tolerance of optical elements, so thorough evaluation is needed to set the conditions. Particularly when using small-diameter rotary scale, effect of alignment conditions on signal amplitude and phase difference is greater than when using linear scale. Individualized alignment is recommended to obtain better product characteristics.



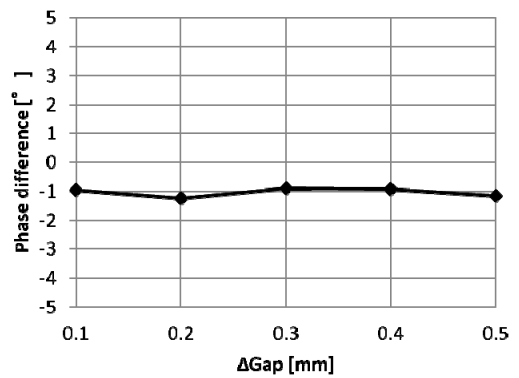
Reference data:

Parameter		Conditions	Unit
Scale	Scale width ($\pm SW$)	± 1 (min)	mm
SMDA-01 head alignment	Scale vertical offset (ΔY)	0.77	mm
	Scale horizontal offset (ΔX)	0.0	mm

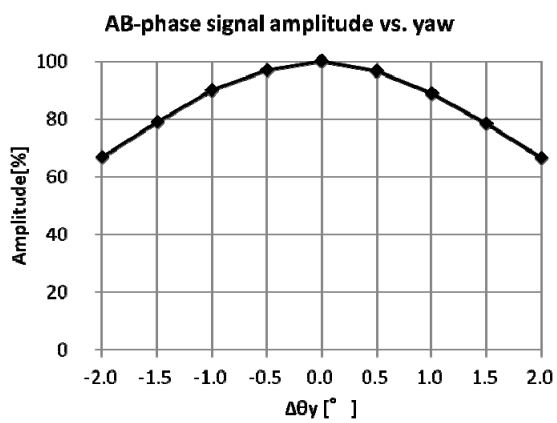
TYPICAL PERFORMANCES (*NPC Standard Conditions Scale and Head Alignment)
Alignment Characteristics



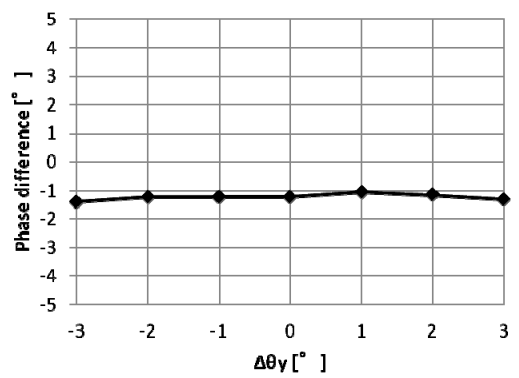
Amplitude vs. Gap (ΔGap)



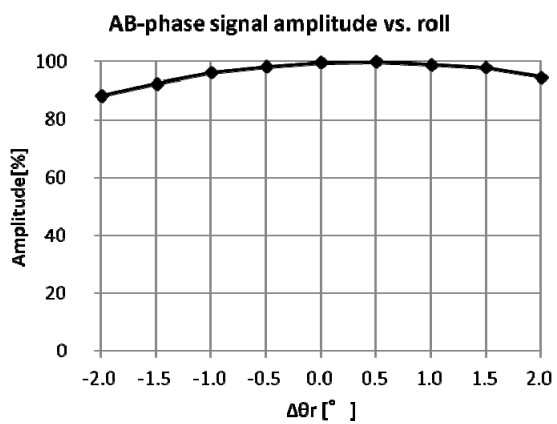
Phase difference vs. Gap (ΔGap)



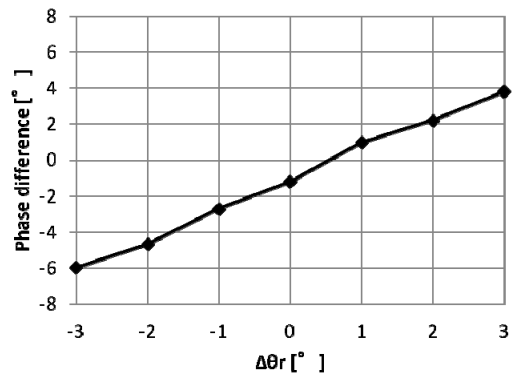
Amplitude vs. Yaw angle ($\Delta\theta_y$)



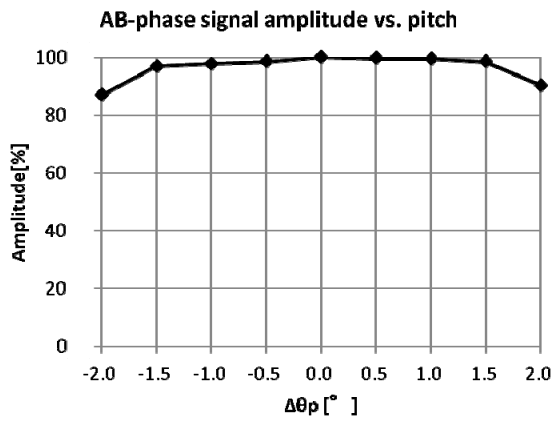
Phase difference vs. Yaw angle ($\Delta\theta_y$)



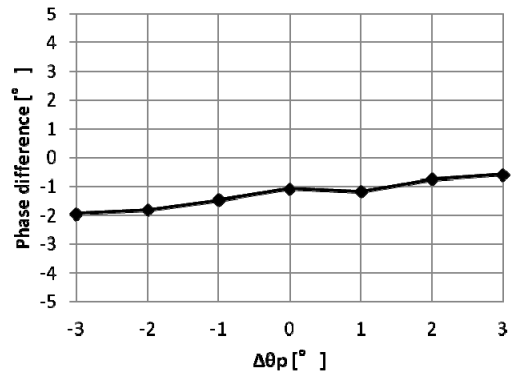
Amplitude vs. Roll angle ($\Delta\theta_r$)



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

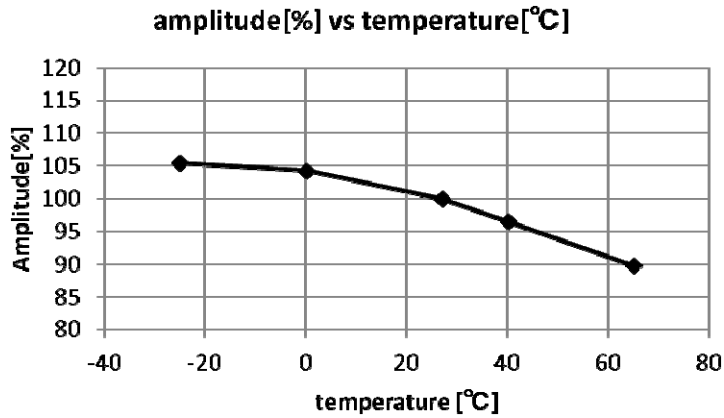


Amplitude vs. Pitch angle ($\Delta\theta_p$)



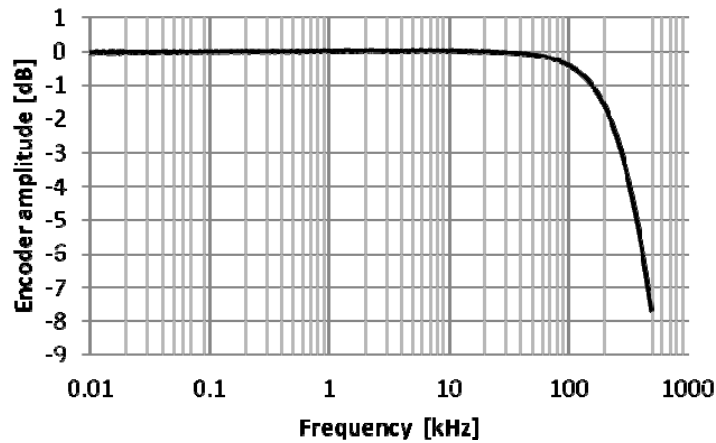
Phase difference vs. Pitch angle ($\Delta\theta_p$)

Temperature Characteristics



Amplitude vs. Temperature (T_a)

Frequency Characteristics

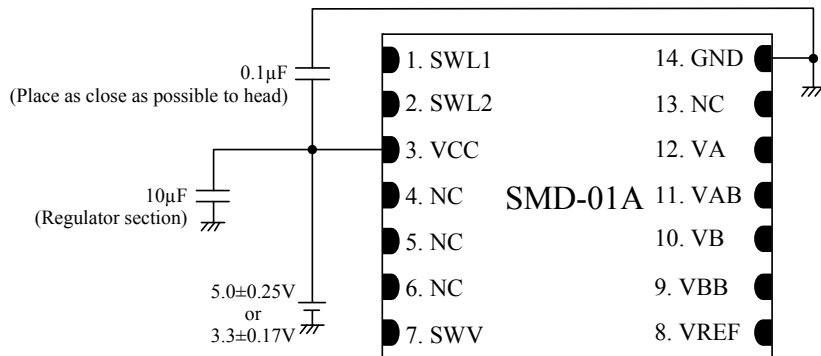


Amplitude vs. Frequency

PRECAUTION FOR USE

Wire involved in drive actuator should be placed as far away from SMD-01A and wire drawn out from SMD-01A (especially analog signal wire) as possible. The closer, the larger the noise to encoder signal. More digital signal chattering occur when the noise is larger, and position detection accuracy is deteriorated.

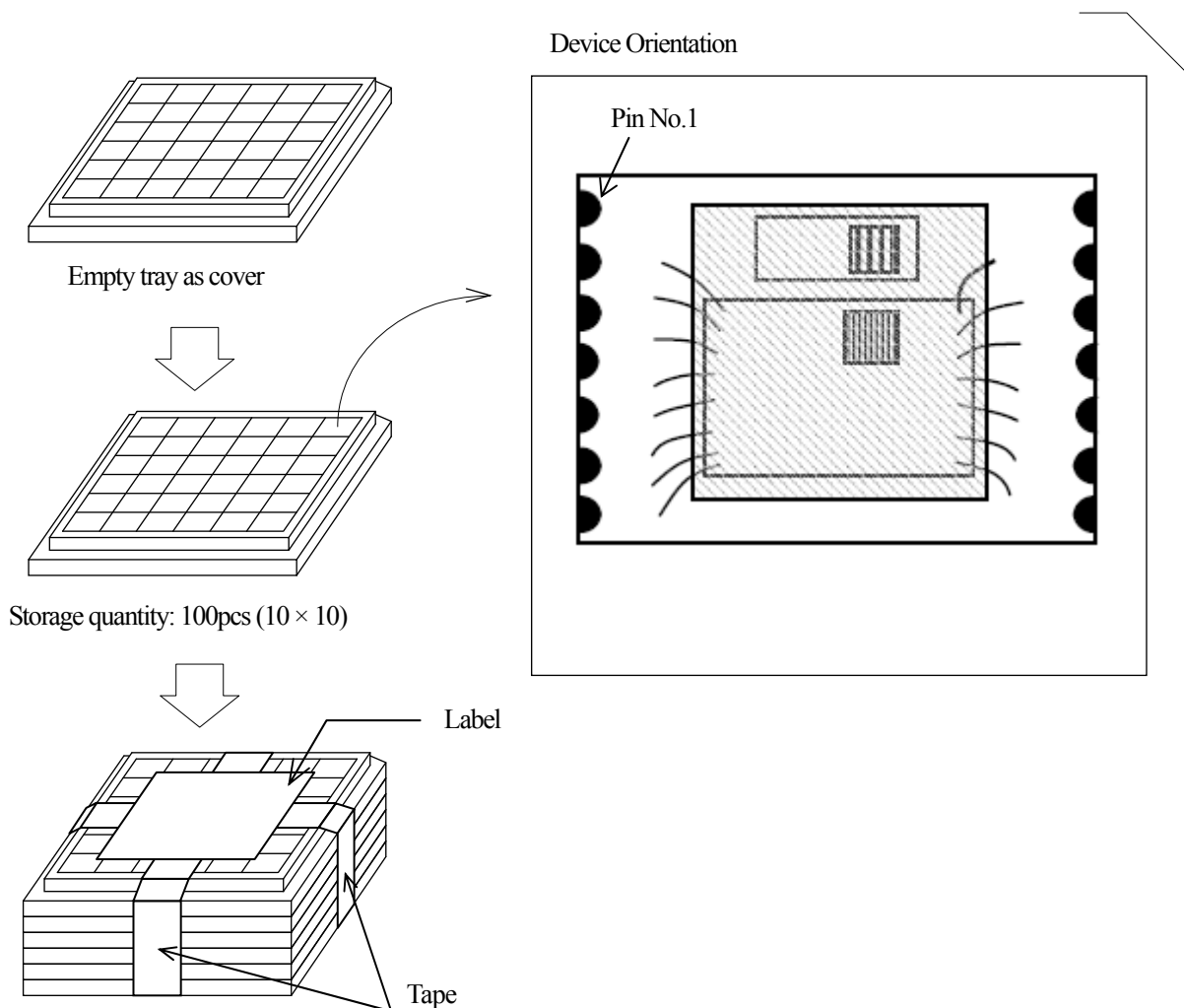
Capacitors shown below should be placed on VCC wire and GND wire of SMD-01A for protection against noise.



PACKAGING

The SMD-01A is supplied on trays. The same trays are designed to withstand the baking temperature before reflow, so the devices can be left on the trays during the baking process.

Note. The trays can be stacked without problem during baking, but tape and labels must first be removed.



MOUNTING PRECAUTIONS

Observe the following precautions when mounting the SMD-01A.

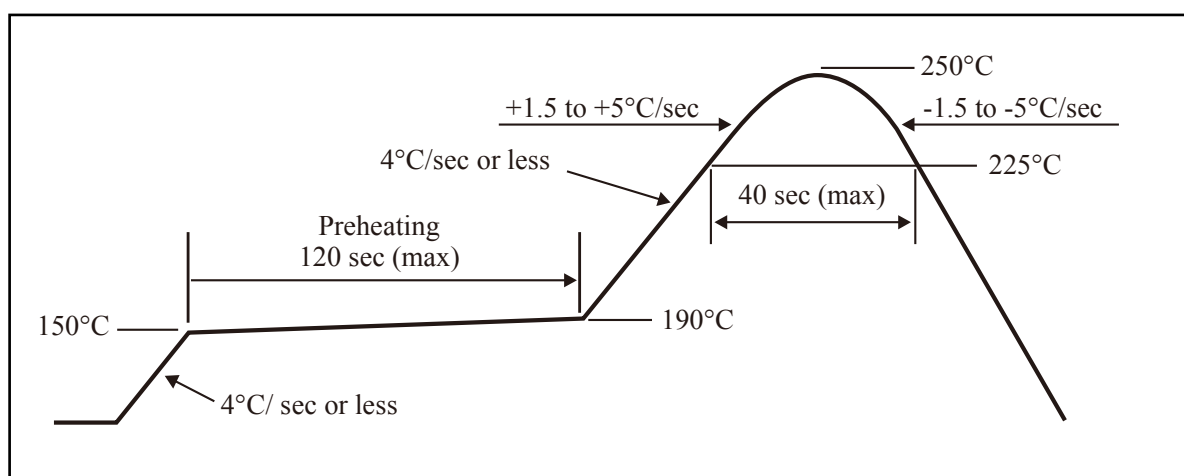
Soldering Precautions

- The SMD devices are hygroscopic (moisture absorbing). If the head is soldered after absorbing moisture, the head plastic may crack and the surfaces between the plastic and other materials may separate.
- When soldering, ensure there is no foreign matter adhering to the SMD surface.
- After soldering, ensure that no mechanical stress or strong vibration is applied until the devices reach room temperature.

Infrared Reflow Method

The following temperature profile conditions are recommended when soldering using the application of heat to the entire device.

Temperature profile conditions (Package surface temperature)



- In accordance with “Storage and Management after Opening the Package”, please reflow in time in an environment of default.
- N₂ atmosphere should be used in reflow chambers.
- Number of reflows is up to two times.
- Please make sure to reduce temperature ripple of preheat to the extent possible.
- Please do not touch the product after reflow soldering until it declines to room temperature, to prevent the resin deformation.
- Note that inadequate reflow condition could cause significant fluctuation of output signal amplitude.

Storage and Management after Opening the Package

- (1) Before opening: Stored at temperature of 30°C or less, and humidity of 60% or less, please mounting within one year.
- (2) After opening: Please mounting within 24 hours at temperature 30°C or less, and humidity of 60% or less.

If you have pass more than 24 hours, please make sure to bake the product at 125°C ± 5°C for 3 hours before the reflow, and please mounting within 24 hours at temperature 30 °C or less, and humidity of 60% or less.

Baking by 125°C should be performed only one time.

*Stored after opening, at temperature of 30°C or less, and humidity of 60% or less, please mounting within one month.

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.
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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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