



# AK2973

## Zero Drift operational amplifiers

### 1. Device Outline

AK2973 is the dual channel CMOS operational amplifiers which is available to output with very low input offset voltage ( $\pm 10\mu\text{V}$ ) and near zero input offset drift.

It's operated with very small current consumptions,  $17\mu\text{A}/\text{ch}$ . Typ.(VDD:5.0V), which is available to operate full swing signals in input and output.

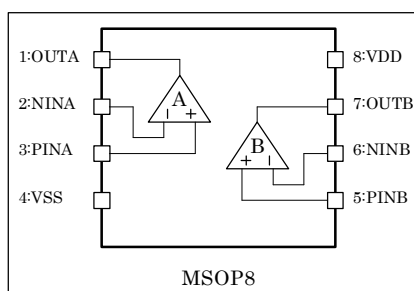
AK2973 is appropriate to portable Sensor Pre Amp. applications.

### 2. Feature

- Wide Supply Operation Range: 1.6V ~ 5.5V ( $\pm 0.8\text{V} \sim \pm 2.75\text{V}$ )
- Very Low Input Offset Voltage :  $\pm 1\mu\text{V}$  typ.
- Near Zero Drift over time and temperature :  $\pm 10\text{nV}/^\circ\text{C}$  typ.
- Input Range : VSS to VDD
- Full Swing Outputs to  $50\text{k}\Omega$  Load @[VDD/2]
- Power Supply Current :  $34\mu\text{A}$  typ.(VDD: 5.0V, No Load)
- Gain Bandwidth : 80kHz typ.
- Slew Rate :  $30\text{mV}/\mu\text{sec}$  typ.
- Operating Temperature Range :  $-40 \sim 125^\circ\text{C}$
- Package : MSOP8

Part Name	Channel Number	Package
AK2973H	2	MSOP8

### 3. Pin Location



(AK2973H)

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#### 5. Pin Function Descriptions

Pin number	Name	I/O (* 1)	Function
1	OUTA	AO	Amplifier A Output
2	NINA	AI	Amplifier A Inverted Input
3	PINA	AI	Amplifier A No Inverted Input
4	VSS	PWR	Power Supply Ground
5	PINB	AI	Amplifier B No Inverted Input
6	NINB	AI	Amplifier B Inverted Input
7	OUTB	AO	Amplifier B Output
8	VDD	PWR	Positive Power Supply

Note

- \* 1. PWR : Power Supply  
 AI : Analog Input  
 AO : Analog Output

#### 6. Absolute Maximum Ratings

( VSS = 0V, \* 2 )

Parameter	Symbol	Min	Max	Units
Supply Voltage	VDD	-0.3	6.5	V
Input Voltage	V <sub>TD</sub>	-0.3	VDD + 0.3	V
Input Current	I <sub>IN</sub>	-10	+10	mA
Storage Temperature Range	T <sub>stg</sub>	-65	150	°C

Note

- \* 2. All voltage with respect to VSS(ground).

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

## 7. Recommended Operating Conditions

(VSS = 0V, \* 2)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Operating Temperature Range	T <sub>a</sub>	-40		125	°C	
Ground level (* 2)	VSS	0	0	0	V	
Supply Voltage	VDD	1.6		5.5	V	

[ WARNING ] We assume no responsibility for the usage beyond the conditions in this datasheet.

## 8. Electrical Characteristics

□ DC Characteristics (typ. : VDD=5V, V<sub>CM</sub>=VDD/2 (\* 3), T<sub>a</sub>=25°C)VDD=1.6V~5.5V, V<sub>cm</sub>=VDD/2, T<sub>a</sub>=-40~125°C, unless otherwise noted

Item	Symbol	Condition	min	typ	max	Unit
Input Voltage Offset	V <sub>IO</sub>	V <sub>CM</sub> = VDD/2 (* 3)		±1	±10	μV
Input Voltage Offset Drift	V <sub>IOD</sub>	(* 4)		±10	±50	nV/°C
Input Bias Current	I <sub>s</sub>			±10	±200	pA
Input Common Mode Range	V <sub>ICM</sub>		VSS		VDD	V
Output Voltage Swing	V <sub>OM</sub>	R <sub>L</sub> ≥ 50kΩ (@VDD/2)	0.05		VDD-0.05	V
Common Mode Rejection Ratio (* 5)	CMR	VSS ≤ V <sub>cm</sub> ≤ VDD	100	130		dB
Power Supply Rejection Ratio (* 6)	SVR	VDD = 1.6V to 5.5V	110	130		dB
Large Signal Voltage Gain (* 7)	A <sub>v</sub>	0.1 V < V <sub>out</sub> < VDD-0.1V R <sub>L</sub> ≥ 50kΩ (to VDD/2)	100	130		dB
Output short current	I <sub>OS</sub>	I <sub>source</sub> : V <sub>out</sub> node forced V <sub>DD</sub> I <sub>sink</sub> : V <sub>out</sub> node forced V <sub>SS</sub>		7		mA
Output current	I <sub>O</sub>	I <sub>source</sub> : V <sub>cm</sub> =V <sub>DD</sub> V <sub>out</sub> node forced V <sub>DD</sub> -1 I <sub>sink</sub> : V <sub>cm</sub> =V <sub>SS</sub> V <sub>out</sub> node forced V <sub>SS</sub> +1		3		mA
Power Supply Current	I <sub>DD</sub>	V <sub>cm</sub> =V <sub>out</sub> =VDD/2 (* 8)		34	60	μA

**Notes**\* 3. V<sub>CM</sub> means the common voltage of an input pin (PIN/NIN).\* 4. V<sub>IOD</sub> = [(high temperature side WST(\*\*)) - (low temperature side WST(\*\*))] / [125°C - (-40°C)]\*\* WST is MIN. or MAX. value of V<sub>IO</sub>.ex.) If high temperature side is MAX. and low temperature side is MIN. the V<sub>IOD</sub> polarity is positive.  
And if high temperature side is MIN. and low temperature side is MAX. the V<sub>IOD</sub> polarity is negative.

\* 5. CMRR = 20 x Log[ (VDD-VSS) / (α) ]

(α) is a Max. value among [(Offset at input = VDD)-(Offset at Input = VSS)] and  
[(Offset at input = VDD)-(Offset at input = VDD/2)] and  
[(Offset at input = VDD/2)-(Offset at input = VSS)].

\* 6. PSRR = 20 x Log[(Max. supply voltage - Min. supply voltage) / (Offset at Max. supply voltage - Offset at Min. supply voltage)]

\* 7. A<sub>v</sub> = 20×LOG [ ((VDD-0.1) - (VSS+0.1)) / ((Offset at output= VDD-0.1) - (Offset at output = VSS+0.1)) ]

\* 8. It contains consumption of two OPamp circuits. It doesn't include an output drive current.

□ AC Characteristics (Typ. VDD= 5V, VCM= VDD/2, Ta= 25°C)

VDD:1.6~5.5V, VCM= VDD/2, VSS=0V, Ta= -40~125°C, unless otherwise noted

Item	Symbol	Condition	min	typ	max	Unit
Gain Bandwidth	GB			80		kHz
Slew Rate	SR	AV=1 Vin=4Vpp CL=100pF 10%-90%		30		mV/μs
Input Voltage Noise	VNI1	@1kHz		200		nVrms /√Hz
	VNI2	0.1~10Hz (* 9)		4.2		μVpp
	VNI3	0.1~1Hz (* 10)		1.3		μVpp
Overload Recovery Time (* 11)	TOR	Av=-10, Load: 20pF Vin: 2.0V (±2.5V)@90%		80		μsec
Input capacitance	Diff.	CIND		18		pF
	common	CINC		30		pF
Maximum Capacitance Loads	CL				100	pF

Notes.

\* 9. VNI2 is calculated by the following numerical expression from VNI1.

$$V_{NI2} = 200\text{nVrms}/\sqrt{\text{Hz}} \times \sqrt{(10\text{Hz} - 0.1\text{Hz})} \times 6.6 = 4.16\mu\text{Vpp}$$

\* 10. VNI3 is calculated by the following numerical expression from VNI1.

$$V_{NI3} = 200\text{nVrms}/\sqrt{\text{Hz}} \times \sqrt{(1\text{Hz} - 0.1\text{Hz})} \times 6.6 = 1.26\mu\text{Vpp}$$

\* 11. The definition of “Overload Recovery Time”

- Positive side overload recovery time (Time until it returns to VDD/2 from VDD saturation)

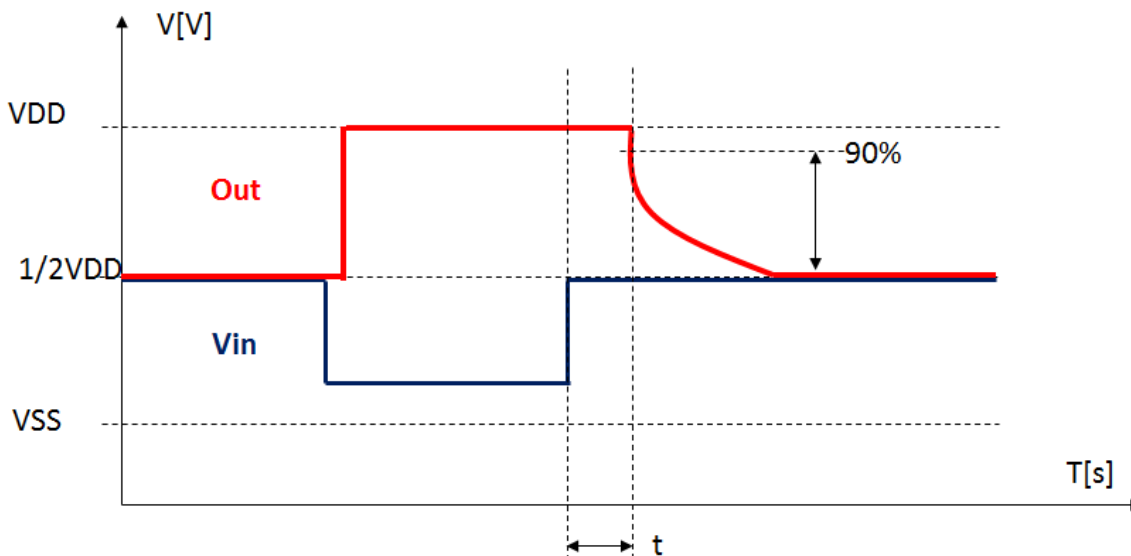


Figure 8.1 Positive side overload recovery time

- Negative side overload recovery time (Time until it returns to VDD/2 from VSS saturation)

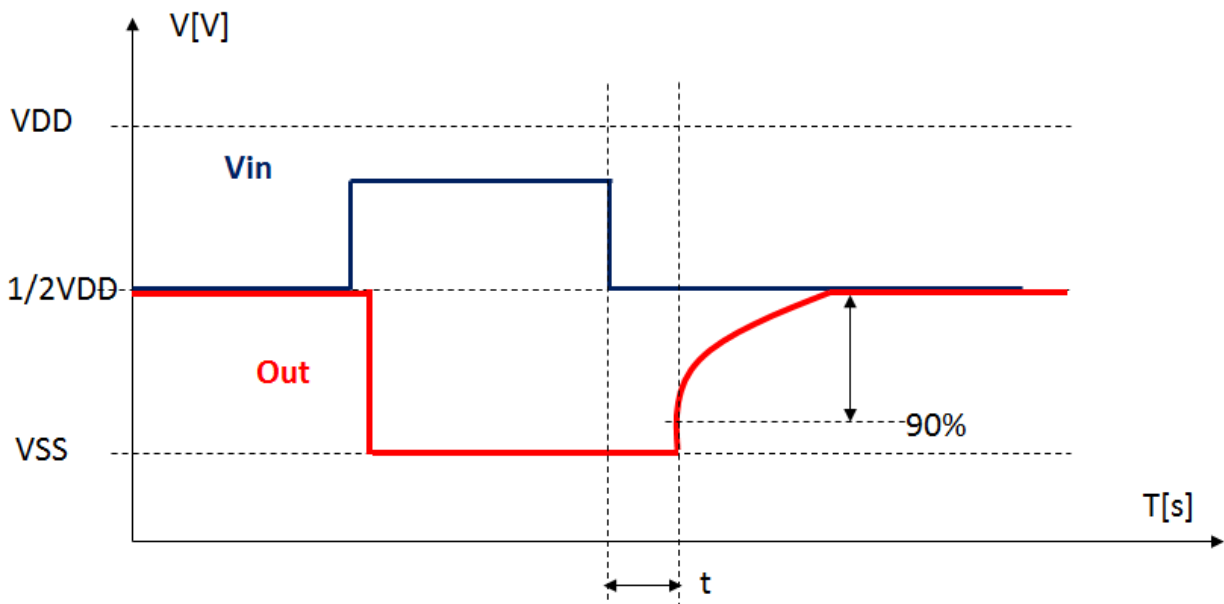


Figure 8.2 Negative side overload recovery time

**9. Typical Operating Characteristics (for reference)**

■ Current consumption - Operating temperature characteristic (Vin, Vout: VDD/2)

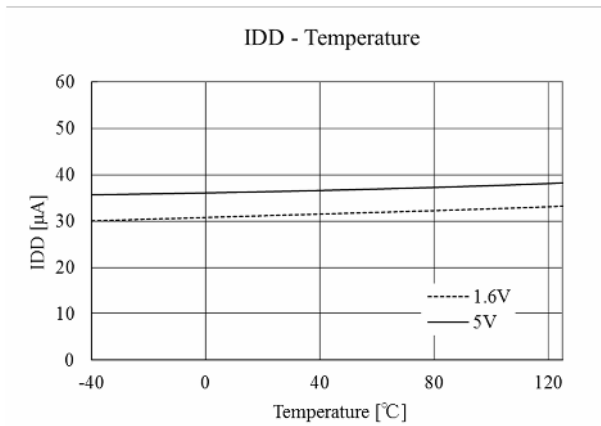


Figure 9.1 Current consumption vs. Operating temperature

■ Current consumption – Power supply Voltage characteristic (Vin, Vout: VDD/2)

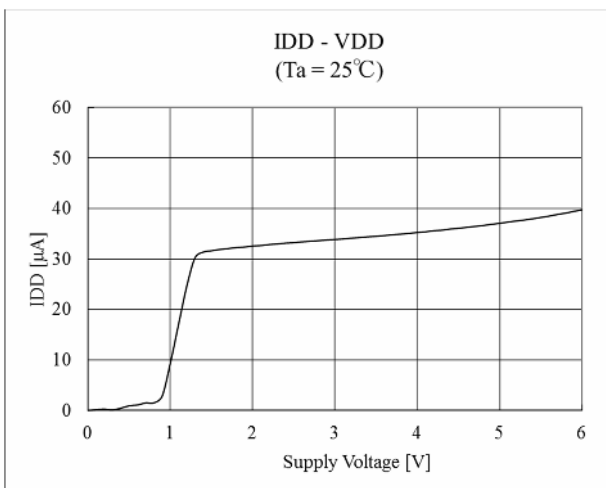


Figure 9.2 Current consumption vs. Power supply Voltage

[ 9. Typical Operating Characteristics (for reference) continuation]

■ Output voltage – Output current characteristic (VDD=1.6V, Ta=25°C)

■ Output voltage – Output current characteristic (VDD=5V, Ta=25°C)

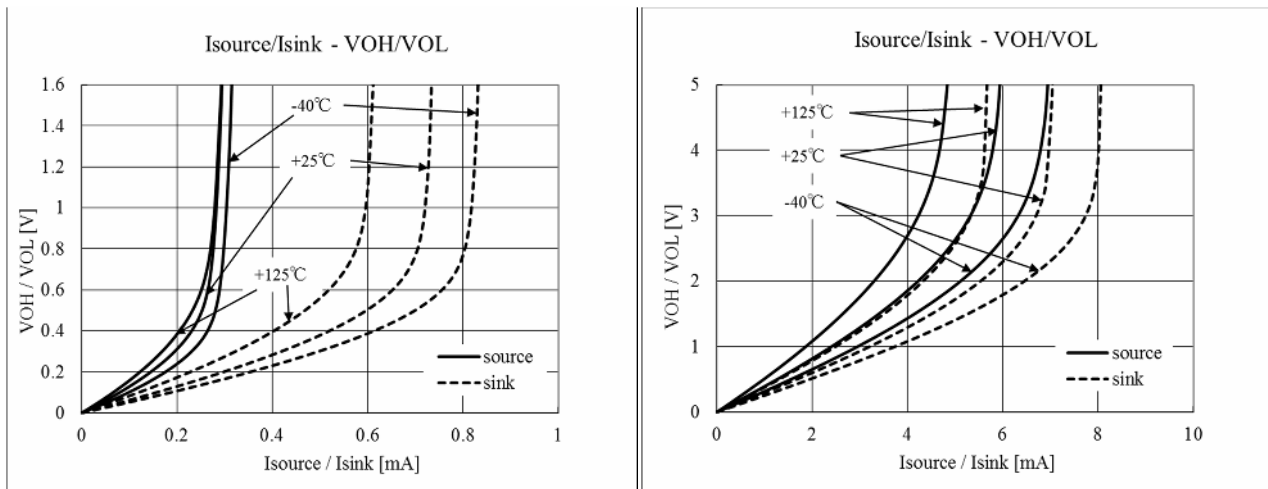


Figure 9.3 Output voltage vs. Output current

■ Closed loop gain – frequency characteristic (VDD=1.6V, Ta=25°C)

■ Closed loop gain – frequency characteristic (VDD=1.6V, Ta=25°C)

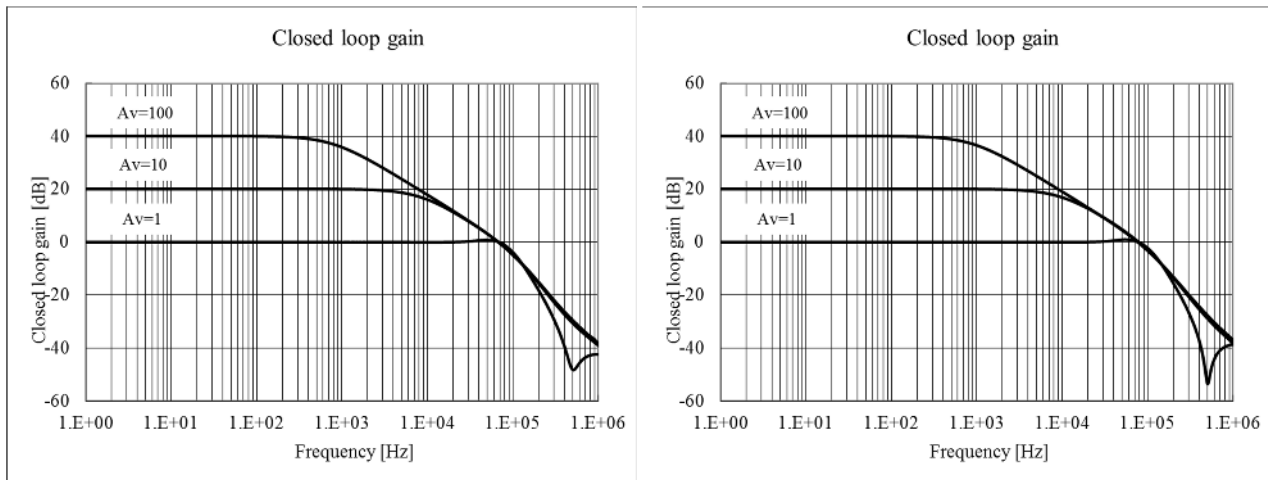


Figure 9.4 Closed loop gain vs. Frequency

[ 9. Typical Operating Characteristics (for reference) continuation]

■ Open loop gain/phase – frequency characteristic (VDD=1.6V, Ta=25°C)

■ Open loop gain/phase – frequency characteristic (VDD=5V, Ta=25°C)

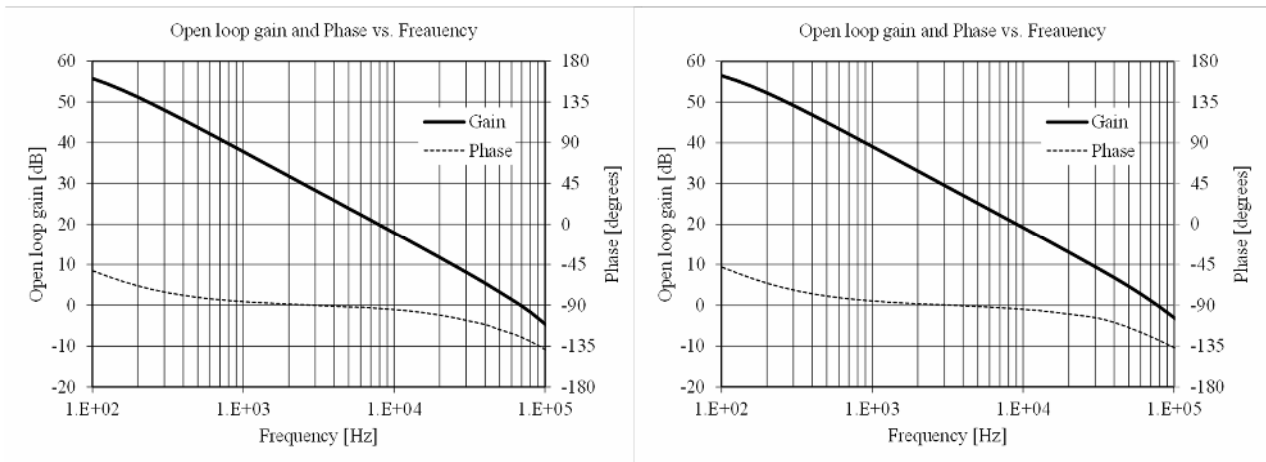


Figure 9.5 Open loop gain/phase vs. Frequency

■ Output impedance – frequency characteristic (VDD=1.6V, Ta=25°C)

■ Output impedance – frequency characteristic (VDD=5.0V, Ta=25°C)

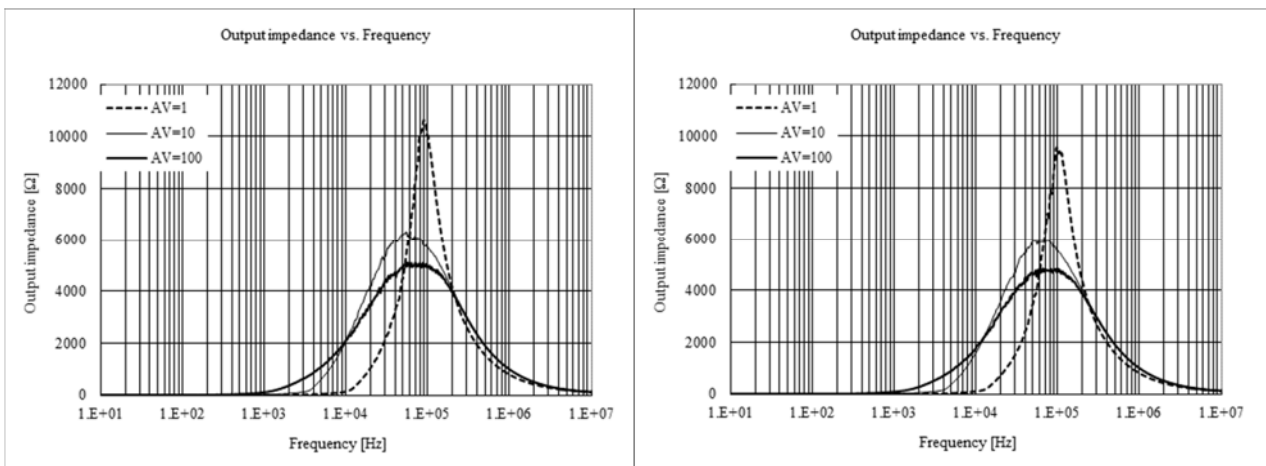


Figure 9.6 Output impedance vs. Frequency



[ 9. Typical Operating Characteristics (for reference) continuation]

■ Large signal pulse response  
 (VDD/VSS=+0.8V / -0.8V, Ta=25°C, CL=100pF)

■ Large signal pulse response  
 (VDD/VSS=+2.5V / -2.5V, Ta=25°C, CL=100pF)

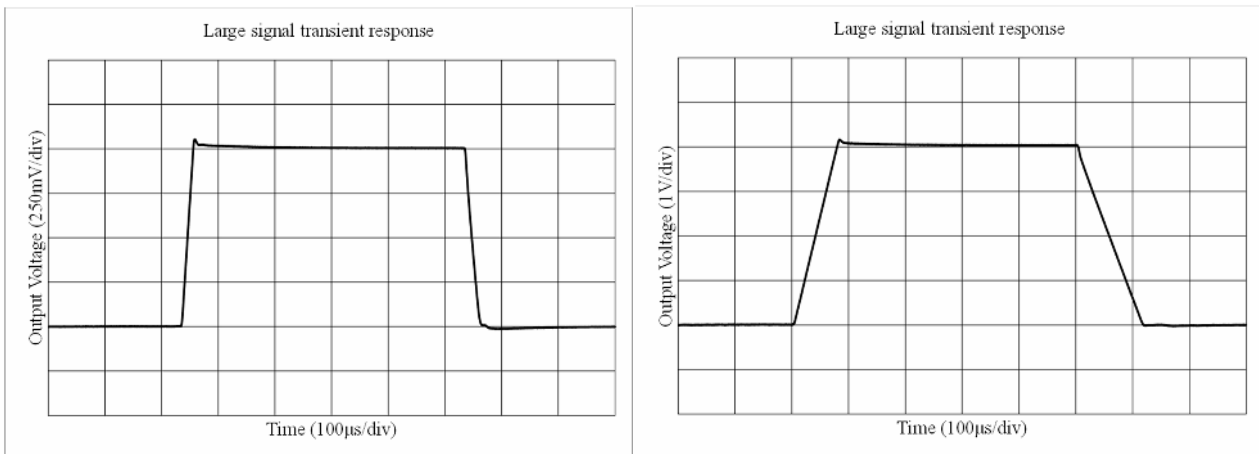


Figure 9.7 Large signal pulse response

■ Small signal pulse response  
 (VDD/VSS=+0.8V / -0.8V, Ta=25°C, CL=100pF)

■ Small signal pulse response  
 (VDD/VSS=+2.5V / -2.5V, Ta=25°C, CL=100pF)

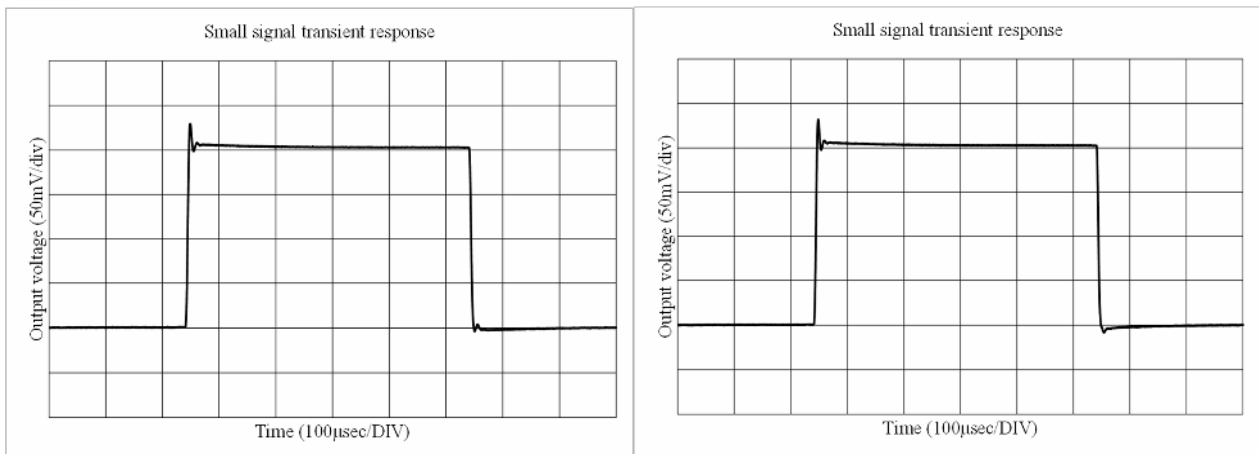


Figure 9.8 Small signal pulse response

[ 9. Typical Operating Characteristics (for reference) continuation]

■ Negative side overload recovery time  
(VDD/VSS=+2.5V/-2.5V , Ta=25°C)

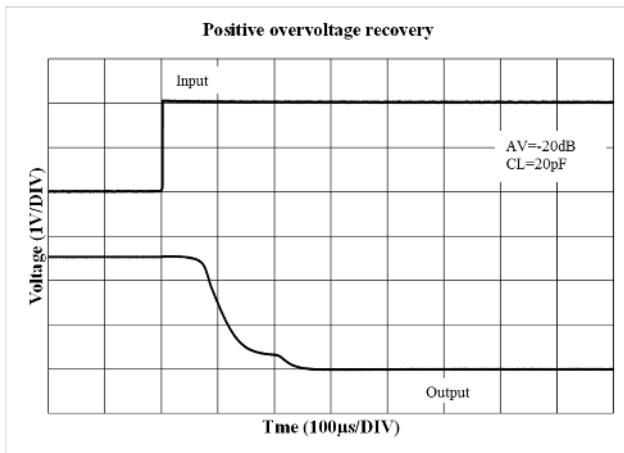


Figure 9.9 Positive side overload recovery time

■ Negative side overload recovery time  
(VDD/VSS=+2.5V/-2.5V , Ta=25°C)

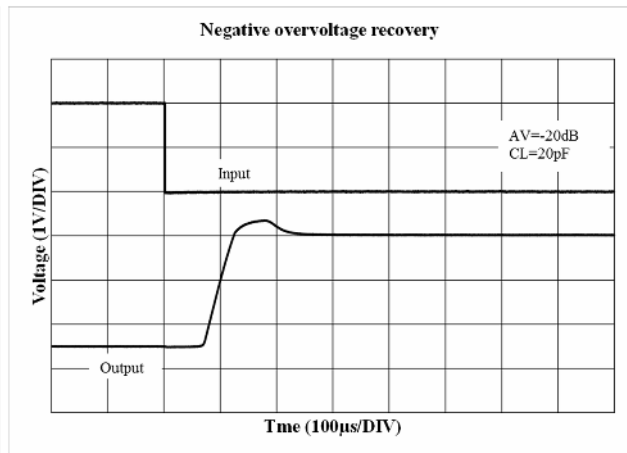


Figure 9.10 Negative side overload recovery

■ CMRR characteristic

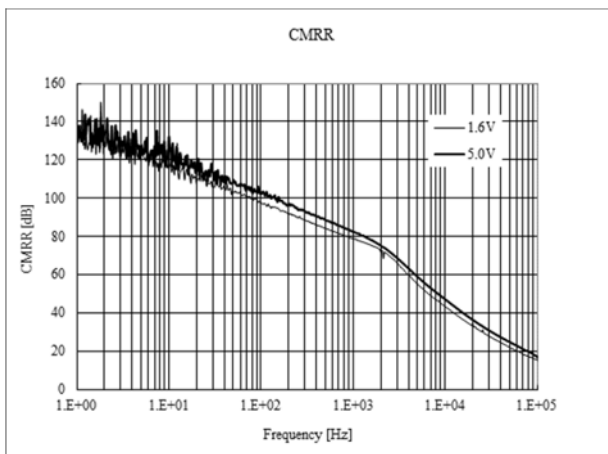


Figure 9.11 CMRR vs. Frequency

[ 9. Typical Operating Characteristics (for reference) continuation]

■PSRR (VDD=1.6V , Ta=25°C)

■PSRR (VDD=5.0V , Ta=25°C)

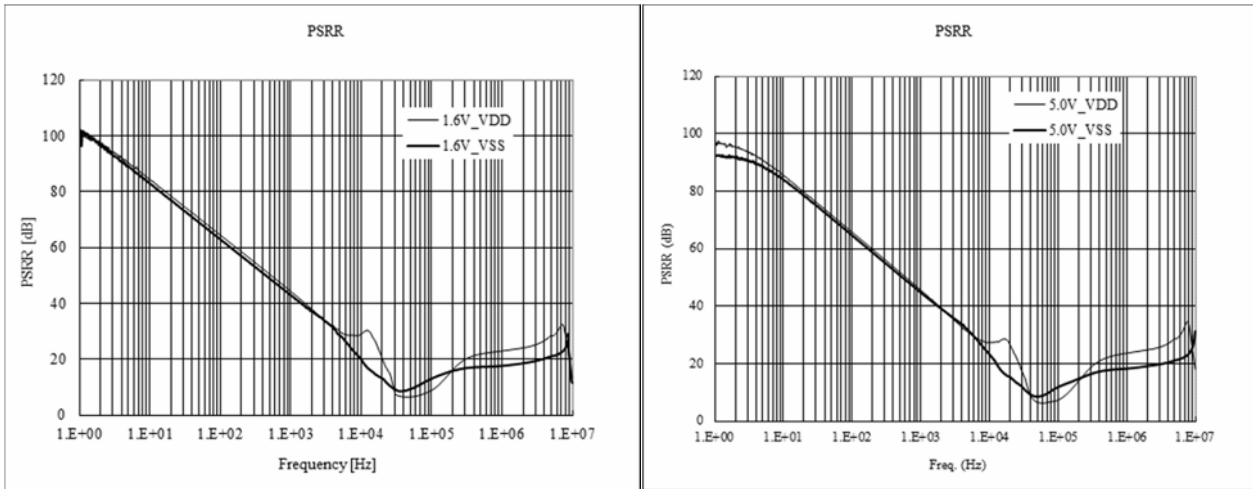


Figure 9.12 PSRR vs. Frequency

■Max. output voltage – frequency characteristic (VDD =1.6V, Ta=25°C,Av=1 , RL=47kΩ)

■Max. output voltage – frequency characteristic (VDD =5V, Ta=25°C,Av=1 , RL=47kΩ)

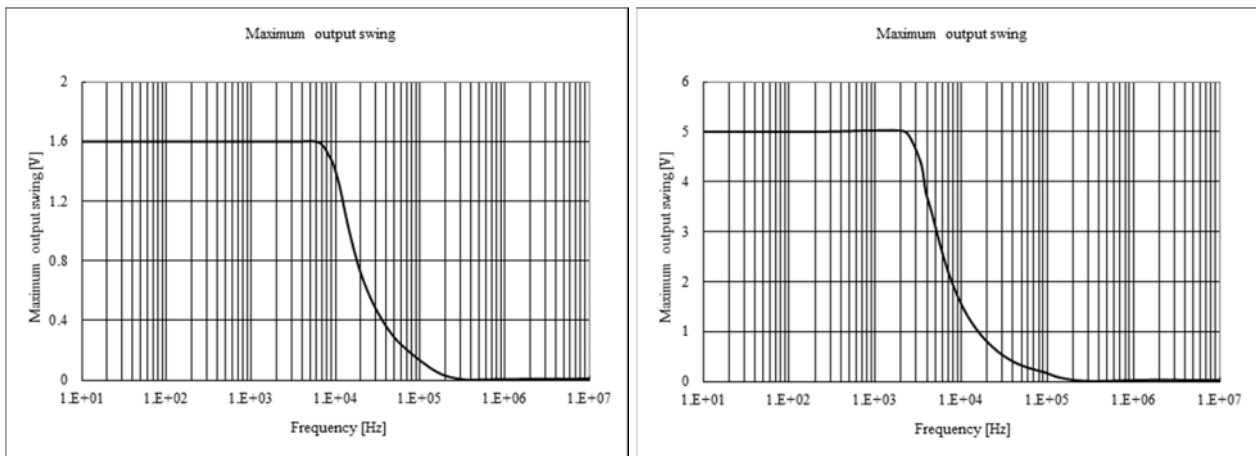
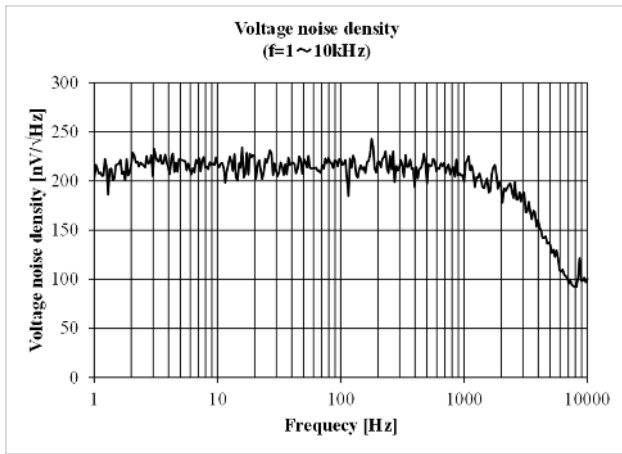


Figure 9.13 Max. output voltage vs. Frequency

[ 9. Typical Operating Characteristics (for reference) continuation]

■ Input voltage noise – frequency characteristic  
(VDD=1.6V , Ta=25°C , f=1~10kHz)



■ Input voltage noise – frequency characteristic  
(VDD=5.0V , Ta=25°C , f=1~10kHz)

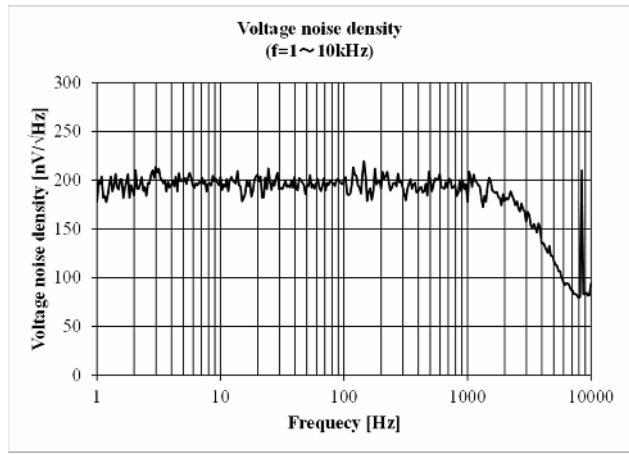
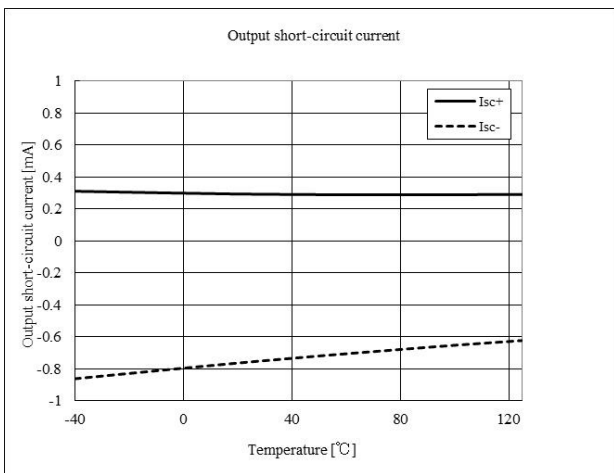


Figure 9.14 Input voltage noise vs. Frequency

■ Output short current – temperature characteristic  
(VDD =1.6V , Ta=-40 to 125°C)



■ Output short current – temperature characteristic  
(VDD =5.0V , Ta=-40 to 125°C)

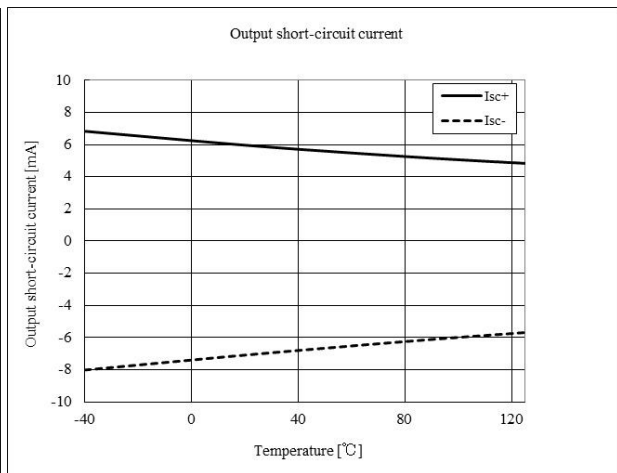


Figure 9.15 Output short current vs. Temperature

[ 9. Typical Operating Characteristics (for reference) continuation]

■ Output short current – power supply characteristic

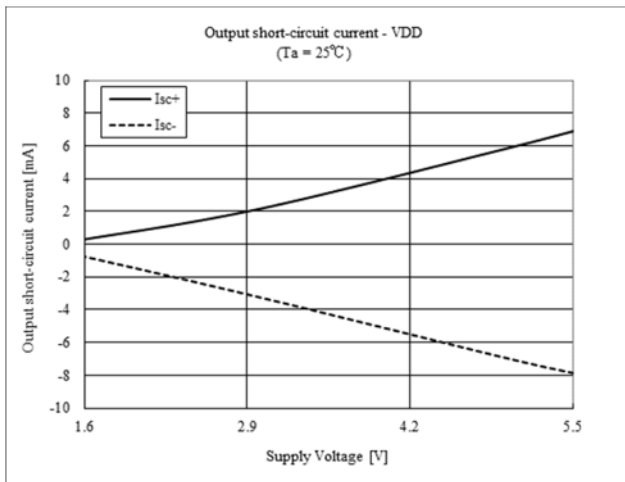


Figure 9.16 Output short current vs. Supply voltage

■ Input Bias current - temperature

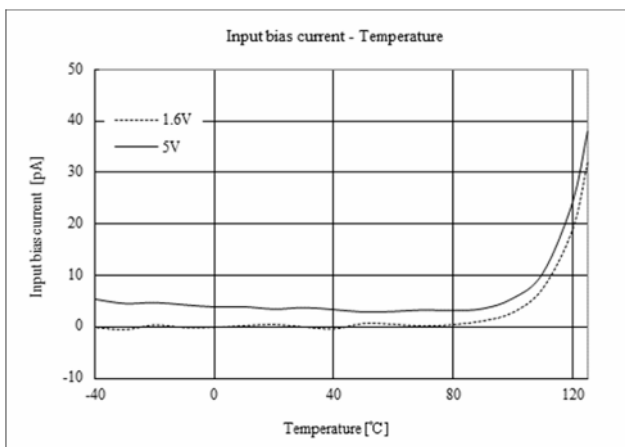


Figure 9.17 Input Bias current vs. Temperature

[ 9. Typical Operating Characteristics (for reference) continuation]

■ Input offset voltage – temperature characteristic

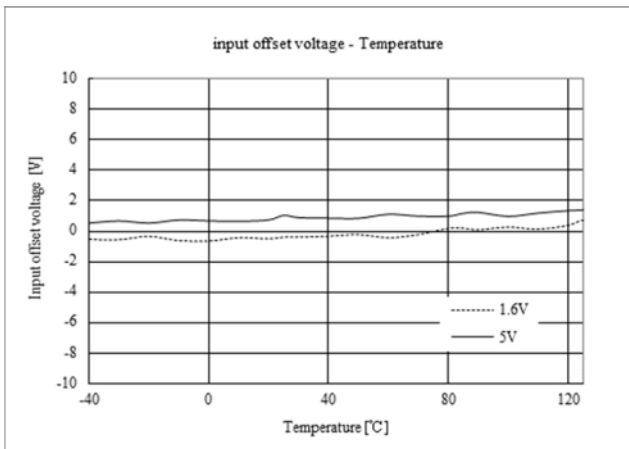


Figure 9.18 Input offset voltage vs. Temperature

■ Distribution of Input offset drift (VDD=5V , Ta=-40 to 125°C)

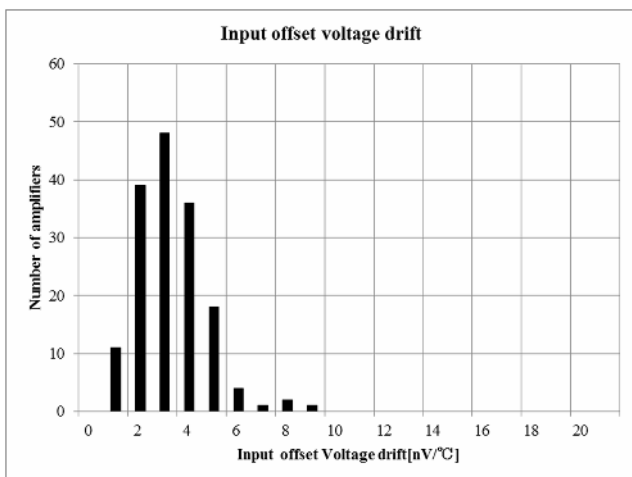


Figure 9.19 Distribution of Input offset drift

## 10. Restriction of Comparator Operation

Although an operational amplifier may be used as a comparator, in case of AK8473 this is not recommended.

In order that AK2973 may realize low power consumption, the output stage is designed optimally. The output stage is adjusting consumption current by closing a loop. But, since the loop does not close when AK2973 is used by an open-loop, adjustment of consumption current may become impossible. Therefore, as shown in this Figure 10.1, consumption current may become very large if this is used as a comparator.

In addition, even when designed as a voltage follower(BUFFER), In the outside of the range of large amplitude voltage gain conditions[  $0.1V < V_{out} < V_{DD} - 0.1V$  ], since the element of an output stage separates from a saturated area and a loop does not close, consumption current may become large.

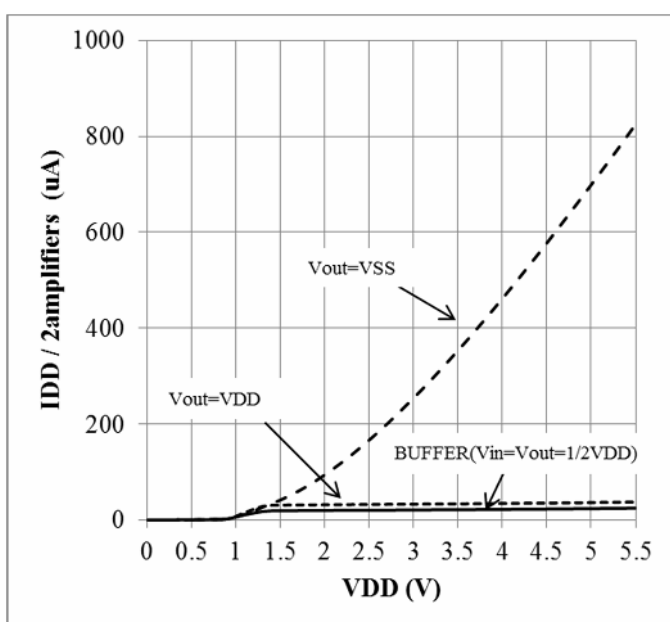


Figure 10.1 Current consumption vs. Supply voltage

## 11. Notes for a board design

The features of AK2973 are a maximum of  $\pm 10\mu V$ , super-low offset, and a zero drift. Therefore, also in a board design, especially cautions are required. In an unsuitable board layout, it has big influence on the characteristic.

### 11.1. About connection of a decoupling capacitor

If AK2973 is influenced to the impedance and inductance of a power supply, the characteristic may deteriorate. If possible, please connect the decoupling capacitor between power supplies near the power supply pin.

### 11.2. About the Seebeck effect

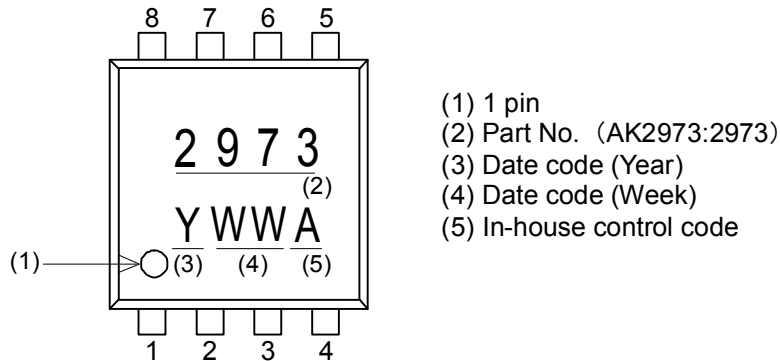
The thermoelectric voltage which occurs in the connection of a different metal is known as the Seebeck effect. On a board, it generates in the bonded surface of solder, substrate wiring, a pin, etc. Therefore, please take care that a difference in temperature does not occur over the whole substrate. If the Seebeck effect occurs, AK2973 will amplify this voltage. In order to prevent this, keep a thermal equilibrium state and be careful also about the leak path on a board.

- A) Lay out dummy parts. (Make environment of a difference input terminal the same.)
- B) Lay out a guard ring for differential input pin.
- C) Lay out a ground plane etc. and extend heat on the whole board.

**12. Package**

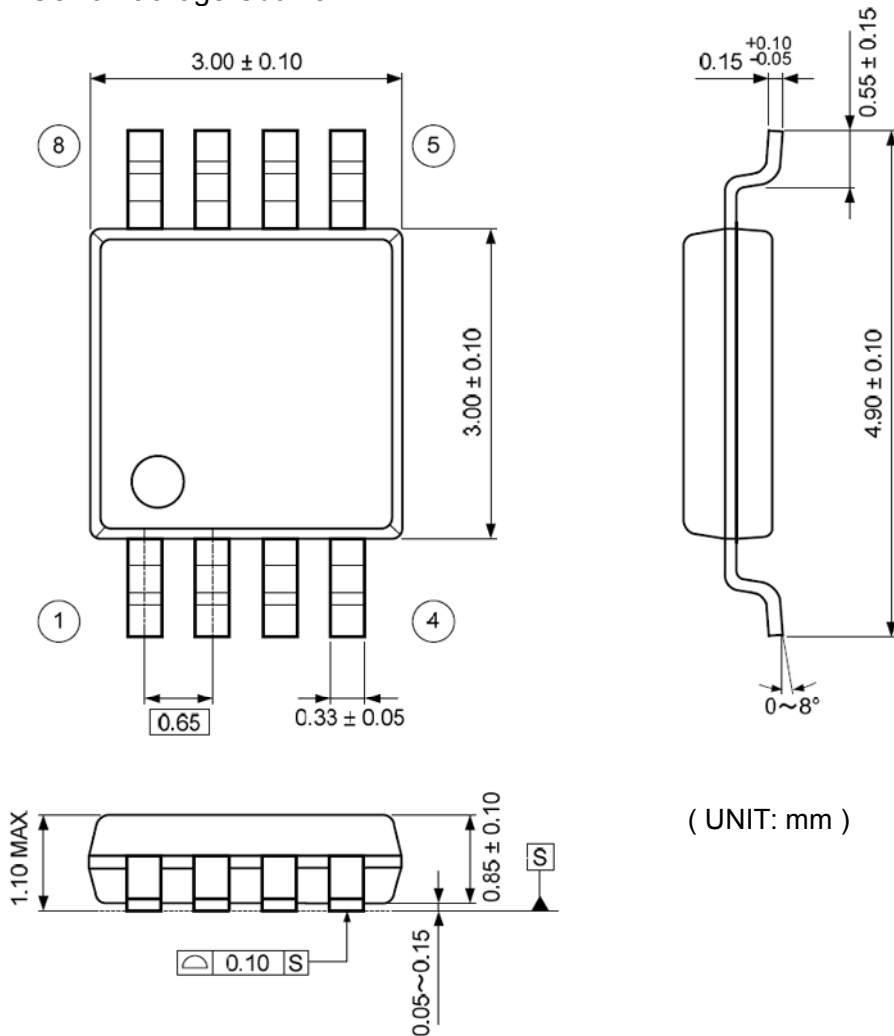
12.1 Marking

- MSOP8



12.2 Outline Dimensions

- MSOP8 Package Outline





**13. Ordering Guide**

AK2973H

-40 ~ 125°C

8-pin MSOP

## IMPORTANT NOTICE

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