S-89713 Series

LOW INPUT OFFSET VOLTAGE CMOS OPERATIONAL AMPLIFIER

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Rev.3.5_00

This IC incorporates a general purpose analog circuit in a small package.
The S-89713 Series is an auto-zero operation, zero-drift operational amplifier that has input and output of low input offset voltage and Rail-to-Rail. The S-89713 Series is suitable for applications requiring less offset voltage.
The S-89713 Series is a dual operational amplifier (with 2 circuits).

■ Features

- Low input offset voltage: V_{IO} = 10 µV max. (Ta = +25°C)
- Operation power supply voltage range: V_{DD} = 2.65 V to 5.50 V
- Low current consumption: I_{DD} = 165 µA typ. (Per circuit, Ta = +25°C)
  I_{DD} = 330 µA typ. (2 circuits, Ta = +25°C)
- Internal phase compensation: No external parts required
- Rail-to-Rail input and output
- Operation temperature range: Ta = –40°C to +85°C
- Lead-free (Sn 100%), halogen-free

■ Applications

- Various sensor interfaces
- High-accuracy current detection
- Strain gauge amplifier
- Game
- Various electric devices

■ Packages

- TMSOP-8
- SNT-8A

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■ Block Diagram

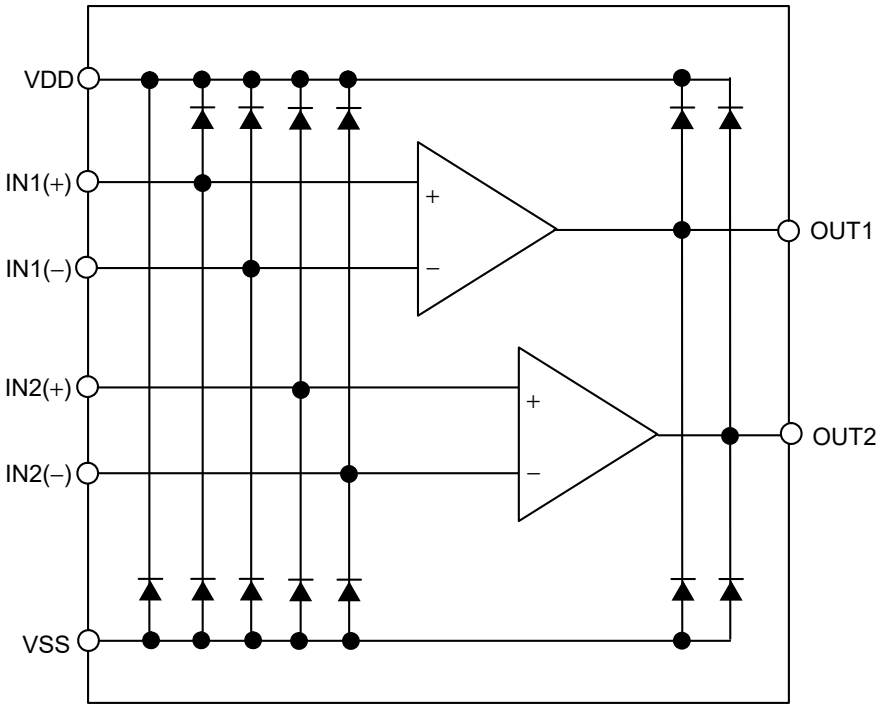


Figure 1

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■ Product Name Structure

Users can select the package type for the S-89713 Series. Refer to "**1. Product name**" regarding the contents of product name, "**2. Packages**" regarding the package drawings and "**3. Product name list**" regarding the product type.

1. Product name

S-89713B - xxxx U

Environmental code
U: Lead-free (Sn 100%), halogen-free

Product name abbreviation and IC packing specifications*1
K8T2: TMSOP-8, Tape
I8T1: SNT-8A, Tape

***1.** Refer to the tape drawing.

2. Packages

Table 1 Package Drawing Codes

Package Name	Dimension	Tape	Reel	Land
TMSOP-8	FM008-A-P-SD	FM008-A-C-SD	FM008-A-R-SD	–
SNT-8A	PH008-A-P-SD	PH008-A-C-SD	PH008-A-R-SD	PH008-A-L-SD

3. Product name list

Table 2

Product Name	Package
S-89713B-K8T2U	TMSOP-8
S-89713B-I8T1U	SNT-8A

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■ Pin Configurations

1. TMSOP-8

Top view

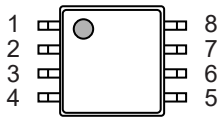


Figure 2

Table 3

Pin No.	Symbol	Description
1	OUT1	Output pin 1
2	IN1(–)	Inverted input pin 1
3	IN1(+)	Non-inverted input pin 1
4	VSS	GND pin
5	IN2(+)	Non-inverted input pin 2
6	IN2(–)	Inverted input pin 2
7	OUT2	Output pin 2
8	VDD	Positive power supply pin

2. SNT-8A

Top view

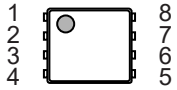


Figure 3

Table 4

Pin No.	Symbol	Description
1	OUT1	Output pin 1
2	IN1(–)	Inverted input pin 1
3	IN1(+)	Non-inverted input pin 1
4	VSS	GND pin
5	IN2(+)	Non-inverted input pin 2
6	IN2(–)	Inverted input pin 2
7	OUT2	Output pin 2
8	VDD	Positive power supply pin

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■ Absolute Maximum Ratings

Table 5

(Ta = +25°C unless otherwise specified)

Item		Symbol	Absolute Maximum Rating	Unit
Power supply voltage		V_{DD}	V_{SS} – 0.3 to V_{SS} + 7.0	V
Input voltage		$V_{IN(+)}$, $V_{IN(-)}$	V_{SS} – 0.3 to V_{DD} + 0.3	V
Output voltage		V_{OUT}	V_{SS} – 0.3 to V_{DD} + 0.3	V
Differential input voltage		V_{IND}	±5.5	V
Output pin current		I_{SOURCE}	10.0	mA
		I_{SINK}	10.0	mA
Power dissipation	TMSOP-8	P_D	650*1	mW
	SNT-8A		450*1	mW
Operation ambient temperature		T_{opr}	–40 to +85	°C
Storage temperature		T_{stg}	–55 to +125	°C

***1.** When mounted on board
[Mounted board]
(1) Board size: 114.3 mm × 76.2 mm × t1.6 mm
(2) Board name: JEDEC STANDARD51-7

Caution The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

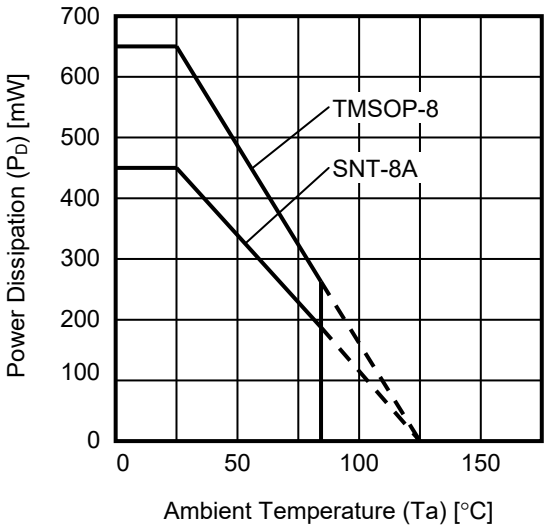


Figure 4 Power Dissipation of Package (When Mounted on Board)

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■ Electrical Characteristics

Table 6

DC Electrical Characteristics (V_{DD} = 3.0 V, Ta = +25°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit	Test Circuit
Operation power supply voltage range	V_{DD}	–	2.65	3.00	5.50	V	–
Current consumption (for 2 circuits)	I_{DD}	$V_{CMR} = V_{OUT} = V_{DD} / 2$	–	330	380	µA	5
Input offset voltage	V_{IO}	$V_{CMR} = V_{DD} / 2$	−10	±1	+10	µV	1
Input offset voltage drift	$\frac{\Delta V_{IO}}{\Delta Ta}$	$V_{CMR} = V_{DD} / 2$	–	±0.1	–	µV/°C	1
Input offset current	I_{IO}	–	–	±140	–	pA	–
Input bias current	I_{BIAS}	–	–	±70	–	pA	–
Common-mode input voltage range	V_{CMR}	–	V_{SS} – 0.1	–	V_{DD} + 0.1	V	2
Voltage gain (open loop)	A_{VOL}	V_{SS} + 0.1 V ≤ V_{OUT} ≤ V_{DD} – 0.1 V, $V_{CMR} = V_{DD} / 2$, R_L = 10 kΩ	110	130	–	dB	8
Maximum output swing voltage	V_{OH}	R_L = 10 kΩ	2.9	–	–	V	3
	V_{OL}	R_L = 10 kΩ	–	–	0.1	V	4
Common-mode input signal rejection ratio	CMRR	V_{SS} – 0.1 V ≤ V_{CMR} ≤ V_{DD} + 0.1 V	106	130	–	dB	2
Power supply voltage rejection ratio	PSRR	V_{DD} = 2.65 V to 5.50 V	106	120	–	dB	1
Source current	I_{SOURCE}	$V_{OUT} = V_{DD}$ – 0.1 V	1.3	1.6	–	mA	6
Sink current	I_{SINK}	V_{OUT} = 0.1 V	1.6	2.0	–	mA	7

Table 7

AC Electrical Characteristics (V_{DD} = 3.0 V, Ta = +25°C unless otherwise specified)

Item	Symbol	Condition	Min.	Typ.	Max.	Unit
Slew rate	SR	R_L = 1.0 MΩ, C_L = 15 pF (Refer to **Figure 13**)	–	0.16	–	V/µs
Gain-bandwidth product	GBP	C_L = 0 pF	–	240	–	kHz

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■ Test Circuits (Per circuit)

1. Power supply voltage rejection ratio, input offset voltage

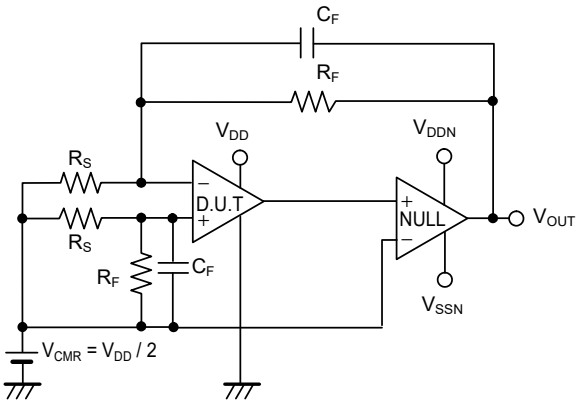


Figure 5 Test Circuit 1

- **Power supply voltage rejection ratio (PSRR)**

The power supply voltage rejection ratio (PSRR) can be calculated by the following expression, with V_{OUT} measured at each V_{DD}.

Test conditions:
V_{DD} = 2.65 V: $V_{DD} = V_{DD1}$, $V_{OUT} = V_{OUT1}$
V_{DD} = 5.5 V: $V_{DD} = V_{DD2}$, $V_{OUT} = V_{OUT2}$

$$PSRR = 20 \log \left(\left| \frac{V_{DD1} - V_{DD2}}{\left(V_{OUT1} - \frac{V_{DD1}}{2}\right) - \left(V_{OUT2} - \frac{V_{DD2}}{2}\right)} \right| \times \frac{R_F + R_S}{R_S} \right)$$

- **Input offset voltage (V_{IO})**

$$V_{IO} = \left(V_{OUT} - \frac{V_{DD}}{2}\right) \times \frac{R_S}{R_F + R_S}$$

2. Common-mode input signal rejection ratio, common-mode input voltage range

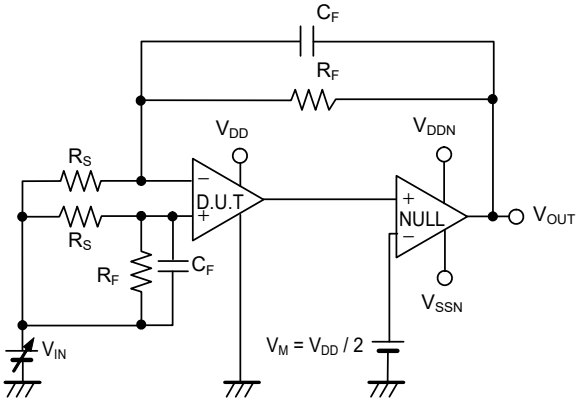


Figure 6 Test Circuit 2

- **Common-mode input signal rejection ratio (CMRR)**

The common-mode input signal rejection ratio (CMRR) can be calculated by the following expression, with V_{OUT} measured at each V_{IN}.

Test conditions:
$V_{IN} = V_{CMR\ Max.}$: $V_{IN} = V_{IN1}$, $V_{OUT} = V_{OUT1}$
$V_{IN} = V_{CMR\ Min.}$: $V_{IN} = V_{IN2}$, $V_{OUT} = V_{OUT2}$

$$CMRR = 20 \log \left(\left| \frac{V_{IN1} - V_{IN2}}{(V_{OUT1} - V_{IN1}) - (V_{OUT2} - V_{IN2})} \right| \times \frac{R_F + R_S}{R_S} \right)$$

- **Common-mode input voltage range (V_{CMR})**

The common-mode input voltage range is the range of V_{IN} in which V_{OUT} satisfies the common-mode input signal rejection ratio specifications.

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3. Maximum output swing voltage

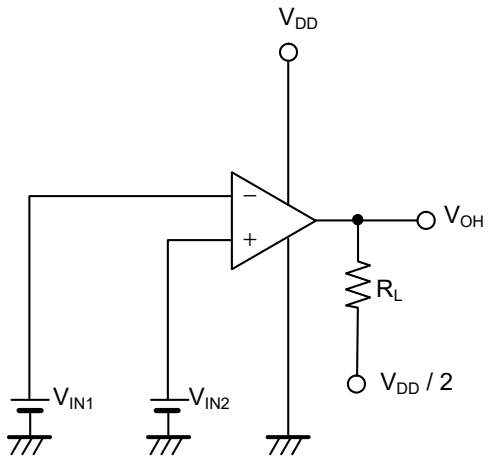


Figure 7 Test Circuit 3

- **Maximum output swing voltage (V_{OH})**

  Test conditions:

  $V_{IN1} = \frac{V_{DD}}{2} - 0.1$ V

  $V_{IN2} = \frac{V_{DD}}{2} + 0.1$ V

  R_L = 10 kΩ

4. Maximum output swing voltage

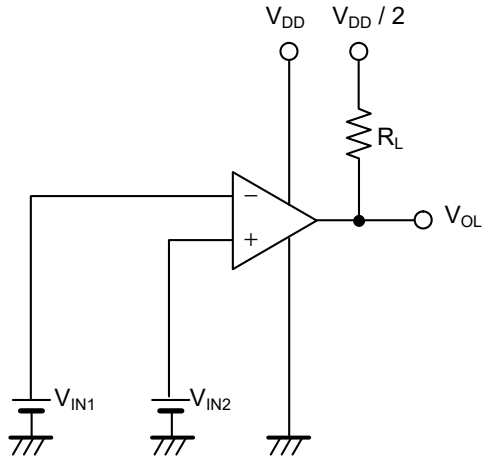


Figure 8 Test Circuit 4

- **Maximum output swing voltage (V_{OL})**

  Test conditions:

  $V_{IN1} = \frac{V_{DD}}{2} + 0.1$ V

  $V_{IN2} = \frac{V_{DD}}{2} - 0.1$ V

  R_L = 10 kΩ

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5. Current consumption

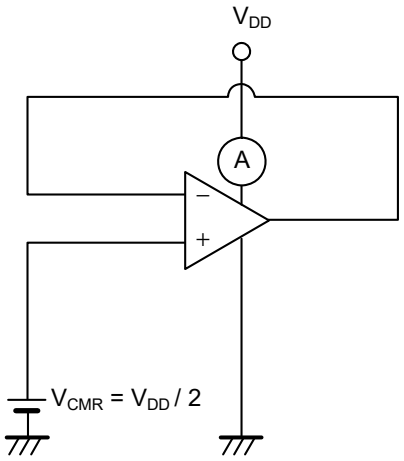


Figure 9 Test Circuit 5

- **Current consumption (I_{DD})**

6. Source current

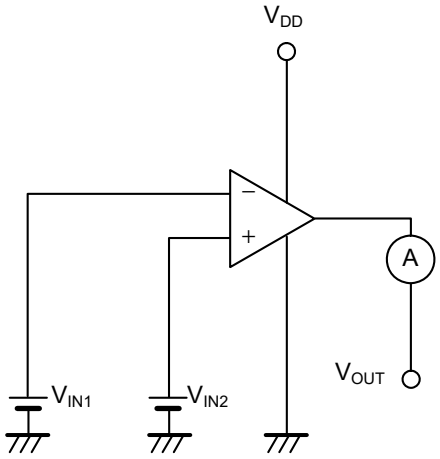


Figure 10 Test Circuit 6

- **Source current (I_{SOURCE})**

Test conditions:
$V_{OUT} = V_{DD} - 0.1$ V
$V_{IN1} = \frac{V_{DD}}{2} - 0.1$ V
$V_{IN2} = \frac{V_{DD}}{2} + 0.1$ V

7. Sink current

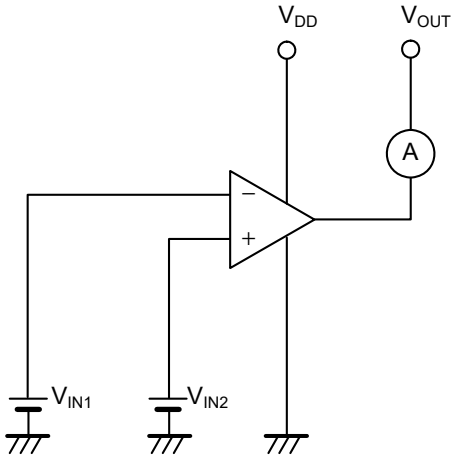


Figure 11 Test Circuit 7

- **Sink current (I_{SINK})**

Test conditions:
$V_{OUT} = 0.1$ V
$V_{IN1} = \frac{V_{DD}}{2} + 0.1$ V
$V_{IN2} = \frac{V_{DD}}{2} - 0.1$ V

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8. Voltage gain

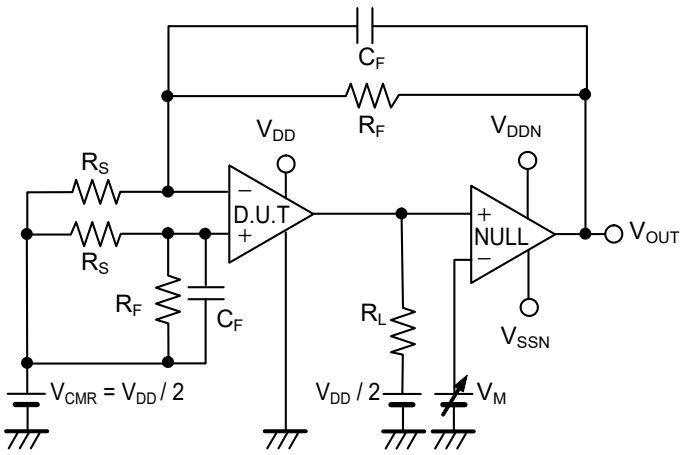


Figure 12 Test Circuit 8

- **Voltage gain (open loop) (A_{VOL})**

The voltage gain (A_{VOL}) can be calculated by the following expression, with V_{OUT} measured at each V_M.

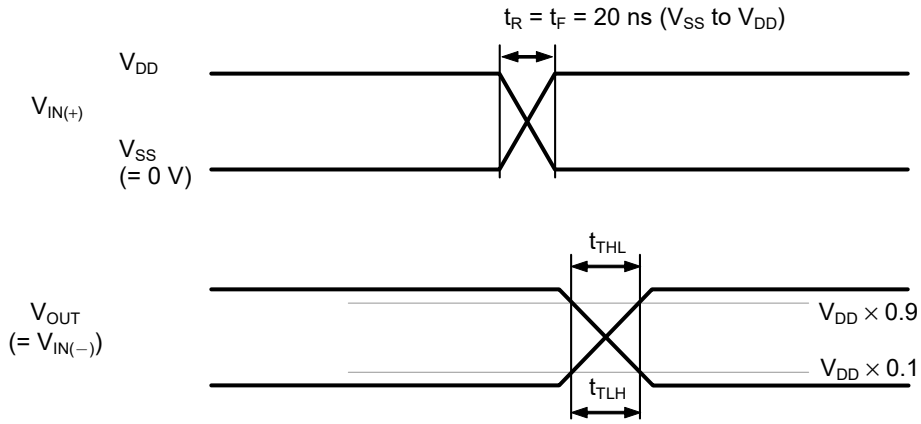
Test conditions:
$V_M = V_{DD} - 0.1$ V: $V_M = V_{M1}$, $V_{OUT} = V_{OUT1}$
$V_M = 0.1$ V: $V_M = V_{M2}$, $V_{OUT} = V_{OUT2}$

$$A_{VOL} = 20 \log \left(\left| \frac{V_{M1} - V_{M2}}{V_{OUT1} - V_{OUT2}} \right| \times \frac{R_F + R_S}{R_S} \right)$$

$R_L = 10\ k\Omega$

9. Slew rate

Measured by the voltage follower circuit.



- **Slew rate (SR)**

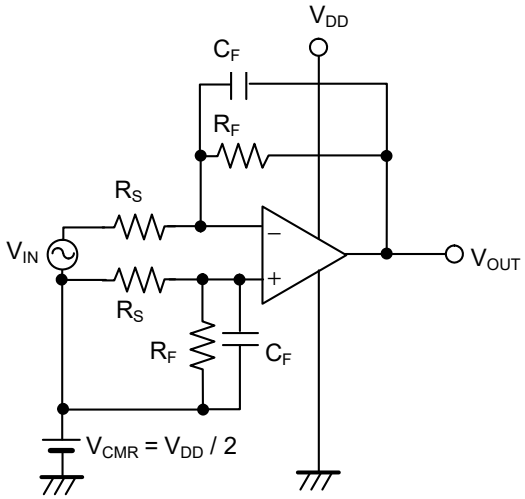
When falling
$$SR = \frac{V_{DD} \times 0.8}{t_{THL}}$$

When rising
$$SR = \frac{V_{DD} \times 0.8}{t_{TLH}}$$

Figure 13

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■ Usage Example



[Example of Gain = 1000 times]
R_S = 1 kΩ
R_F = 1 MΩ
C_F = 1000 pF

[Example of Gain = 100 times]
R_S = 1 kΩ
R_F = 100 kΩ
C_F = 1000 pF

Figure 14 Differential Amplifier Circuit

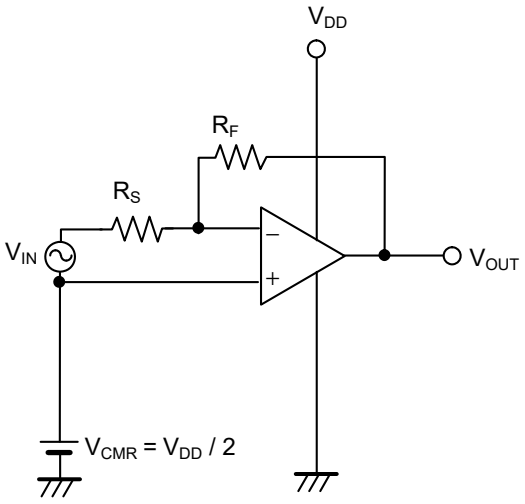


Figure 15 Inverting Amplifier Circuit

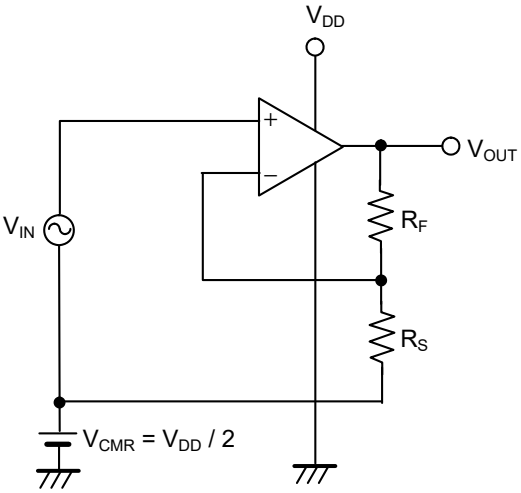


Figure 16 Non-inverting Amplifier Circuit

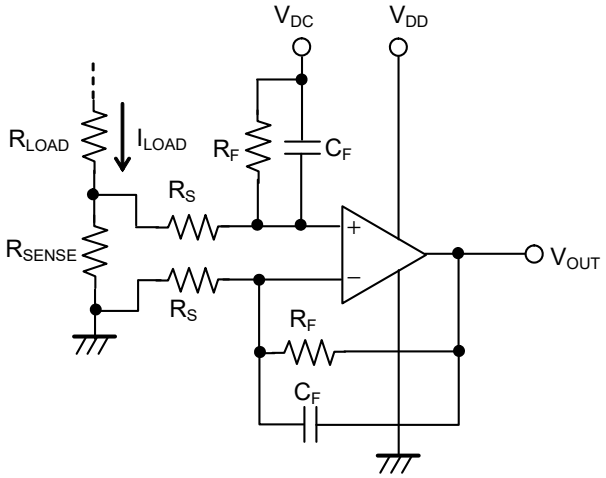


Figure 17 Low-side Current Detection Circuit

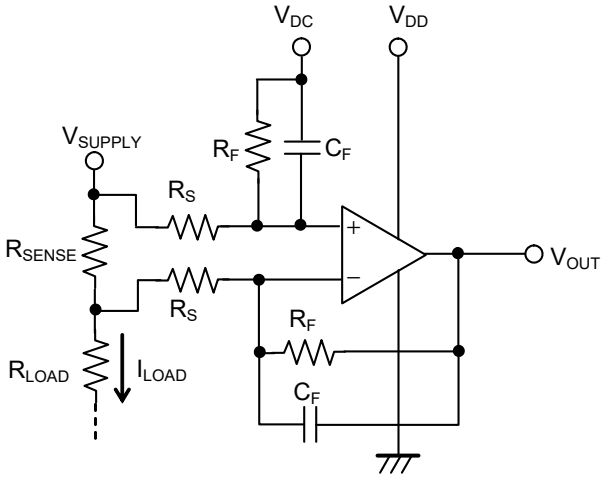


Figure 18 High-side Current Detection Circuit

Caution The above connection diagram and constant will not guarantee successful operation. Perform through evaluation using the actual application to set the constant.

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■ Precautions

- During the operation of an operational amplifier circuit, when $V_{OUT} \leq V_{SS}$ + 100 mV or $V_{OUT} \geq V_{DD}$ – 100 mV, the signal becomes difficult to be output, and the output voltage (V_{OUT}) may become V_{SS} or V_{DD}. If this happens, supply an appropriate input signal to the operational amplifier so that V_{OUT} is within the range of V_{SS} + 100 mV to V_{DD} – 100 mV. Contact our sales representatives if you have any questions for use in the above operation conditions.
- Generally an operational amplifier may cause oscillation depending on the selection of external parts. Perform thorough evaluation using the actual application to set the constant.
- Do not apply an electrostatic discharge to this IC that exceeds performance ratings of the built-in electrostatic protection circuit.
- ABLIC Inc. claims no responsibility for any disputes arising out of or in connection with any infringement by products including this IC of patents owned by a third party.
- Use this IC with the output current of 10 mA or less.
- When using the voltage follower circuit (Gain = 1 time), connect a resistor of 470 Ω or more for the stable operation, as shown in **Figure 19**. The operation may be unstable depending on the value of the load capacitance connected to the output pin, even when the voltage follower circuit is not used. Use the product under thorough evaluation.

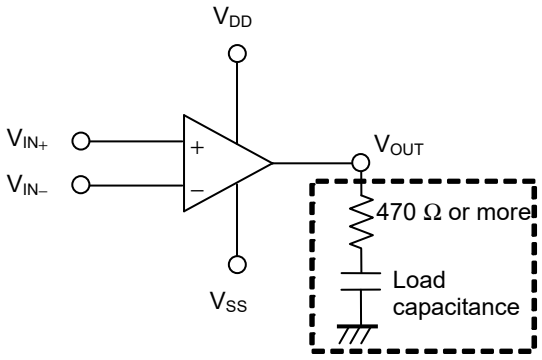


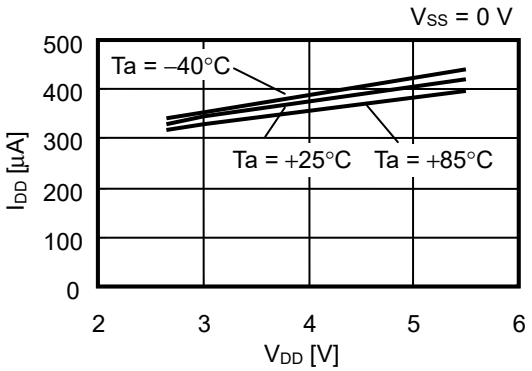
Figure 19

Caution The above connection diagram and constant will not guarantee successful operation. Perform through evaluation using the actual application to set the constant.

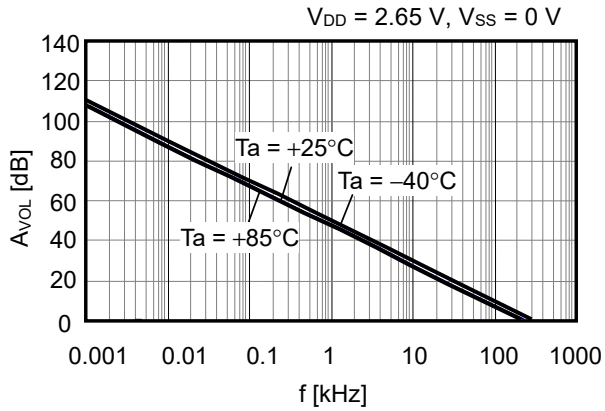
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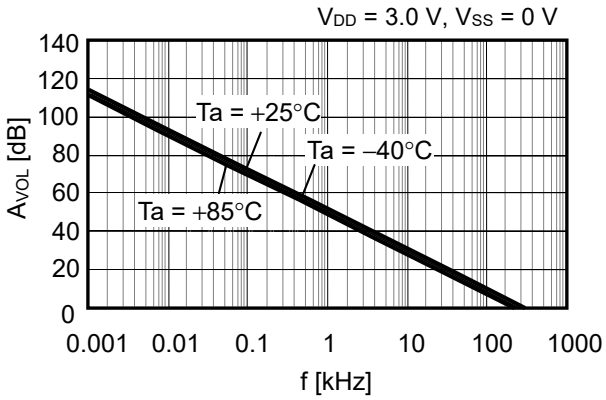
■ Characteristics (Typical Data)

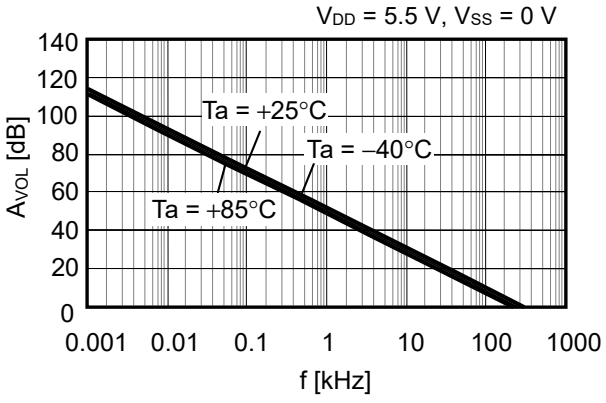
1. Current consumption (I_{DD}) (2 circuits) vs. Power supply voltage (V_{DD})



2. Voltage gain (A_{VOL}) vs. Frequency (f)



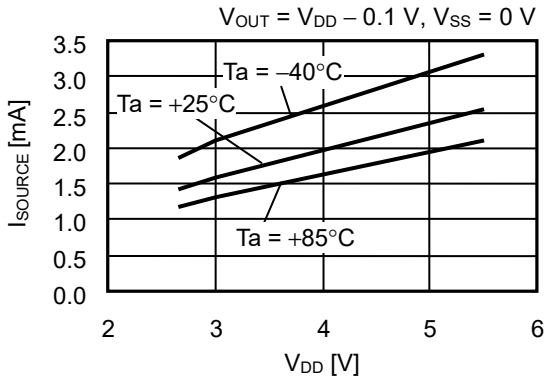




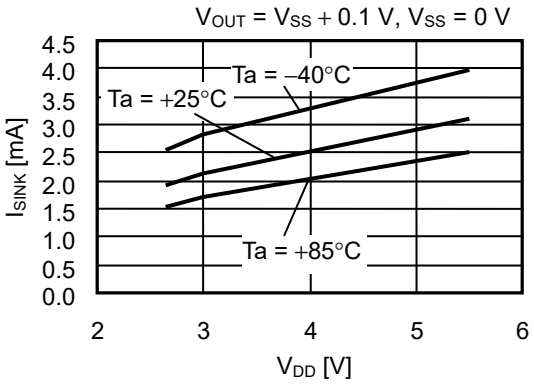
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3. Output current

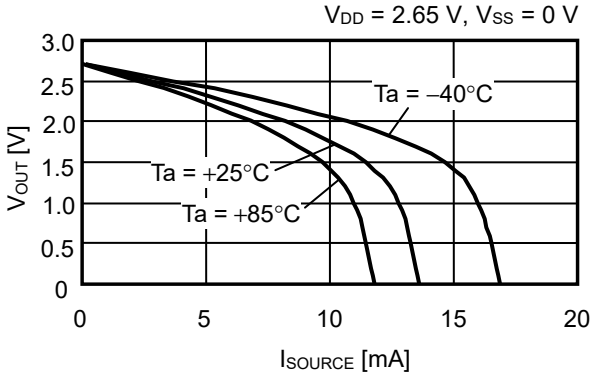
3. 1 Source current (I_{SOURCE}) vs. Power supply voltage (V_{DD})

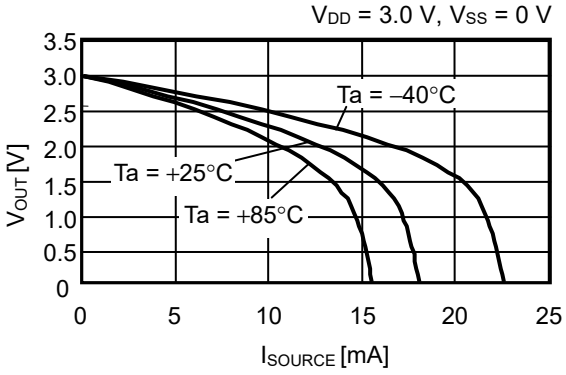


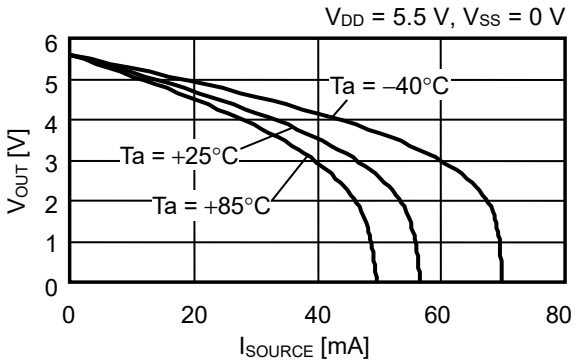
3. 2 Sink current (I_{SINK}) vs. Power supply voltage(V_{DD})



3. 3 Output voltage (V_{OUT}) vs. Source current (I_{SOURCE})

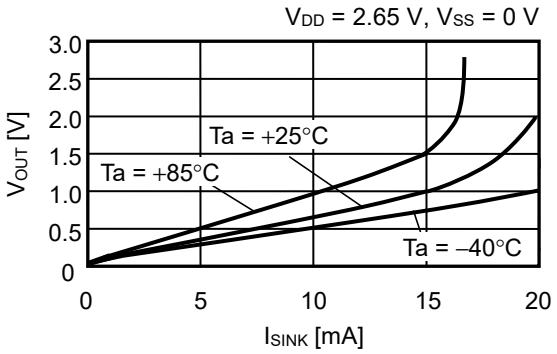


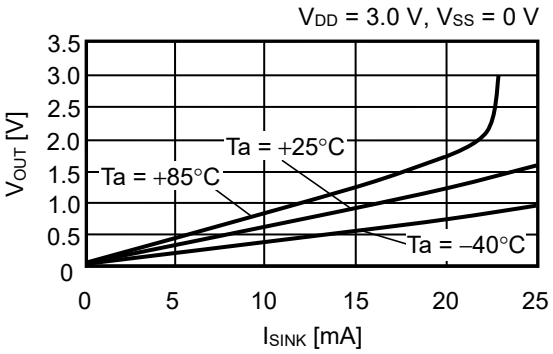


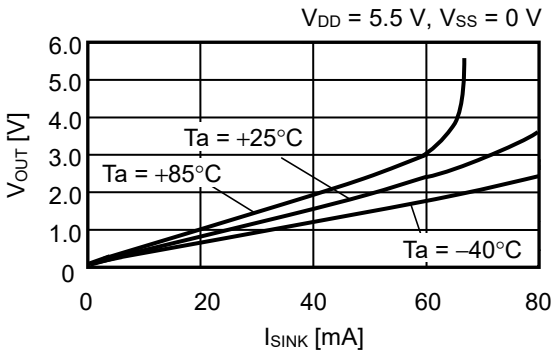


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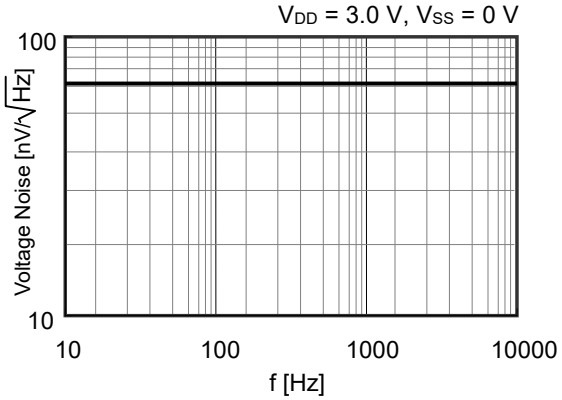
3. 4 Output voltage (V_{OUT}) vs. Sink current (I_{SINK})







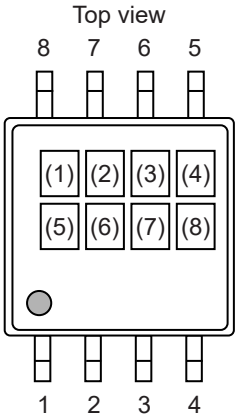
4. Input-referred noise voltage vs. Frequency (f)



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■ Marking Specifications

1. TMSOP-8

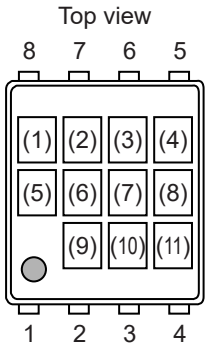


(1): Blank
(2) to (4): Product code (Refer to **Product name vs. Product code**)
(5): Blank
(6) to (8): Lot number

Product name vs. Product code

Product Name	Product Code		
	(2)	(3)	(4)
S-89713B-K8T2U	Z	Y	C

2. SNT-8A

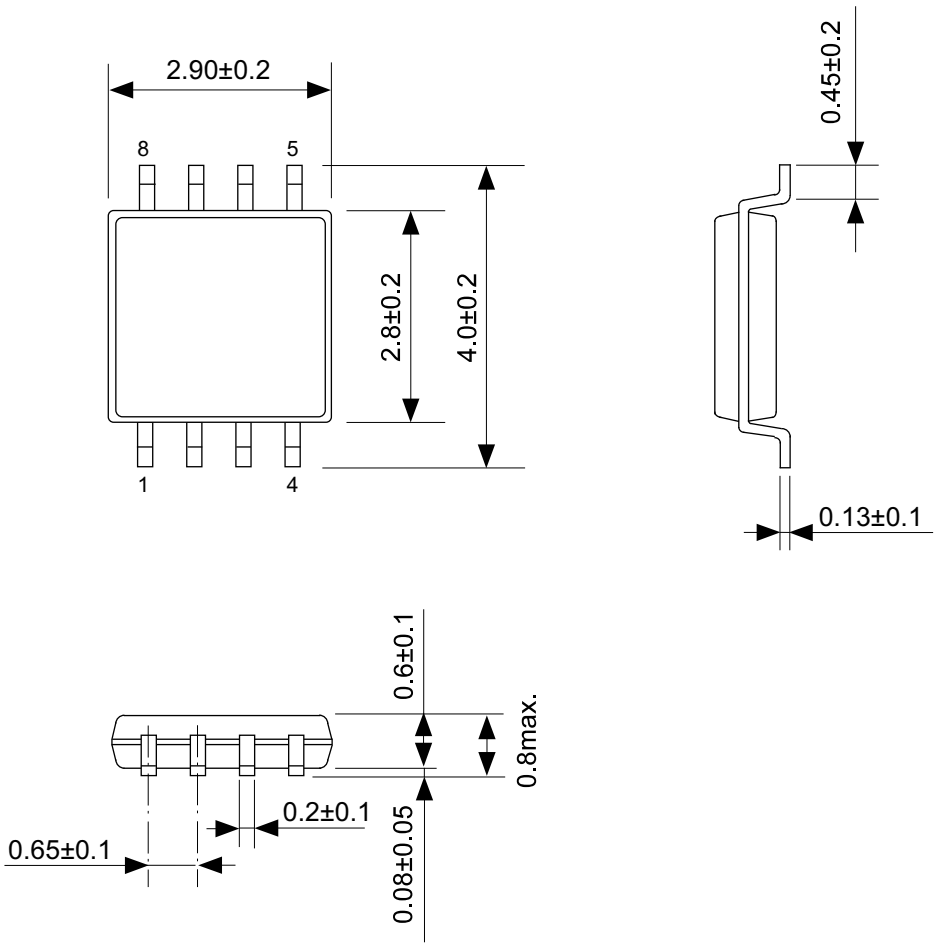


(1): Blank
(2) to (4): Product code (Refer to **Product name vs. Product code**)
(5), (6): Blank
(7) to (11): Lot number

Product name vs. Product code

Product Name	Product Code		
	(2)	(3)	(4)
S-89713B-I8T1U	Z	Y	C

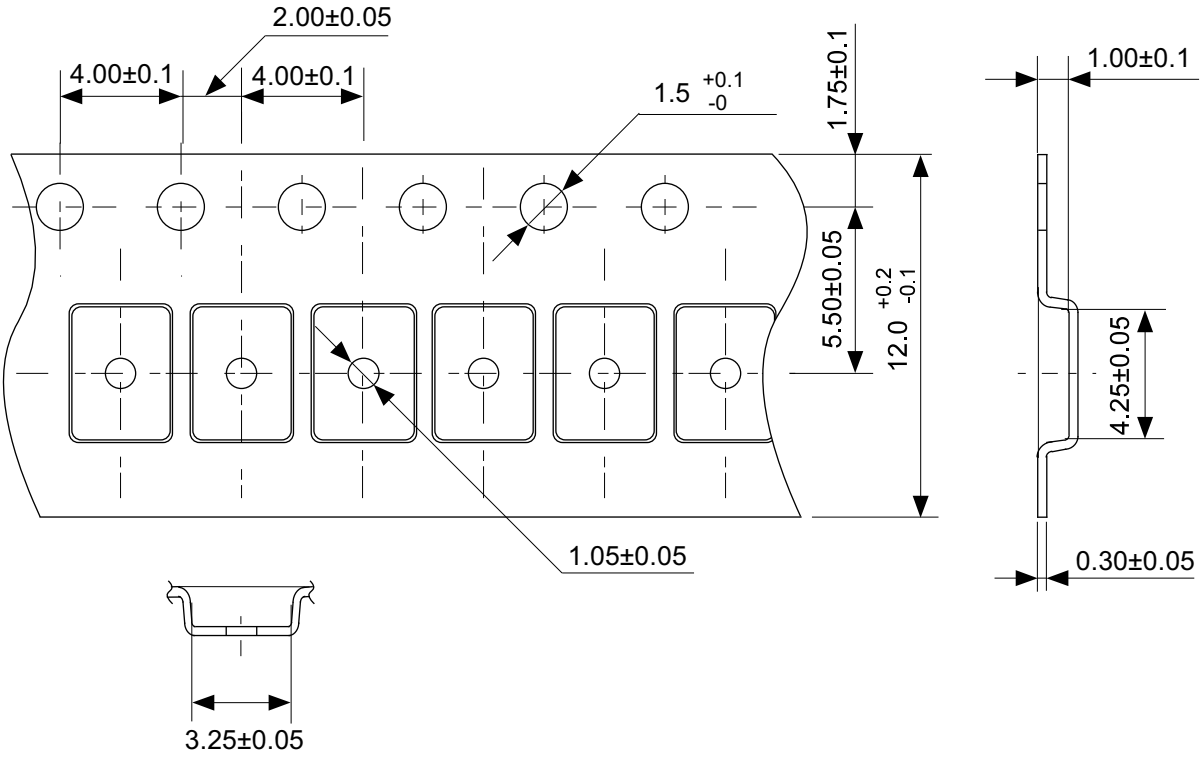
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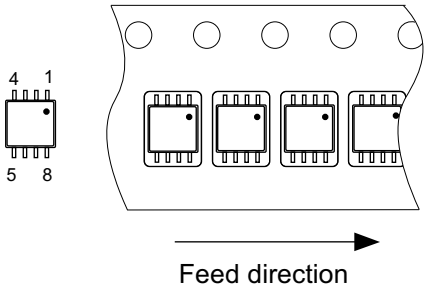


No. FM008-A-P-SD-1.2

TITLE	TMSOP8-A-PKG Dimensions
No.	FM008-A-P-SD-1.2
ANGLE	
UNIT	mm
ABLIC Inc.	

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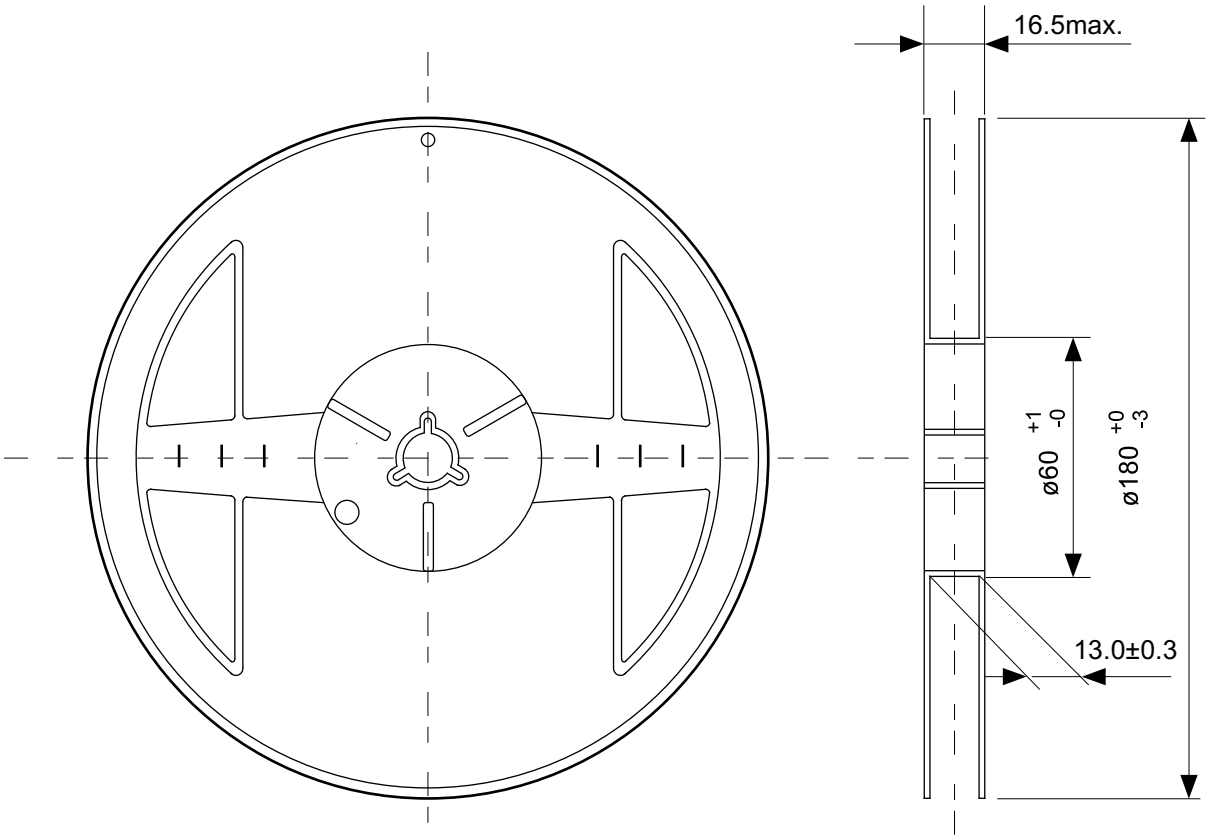




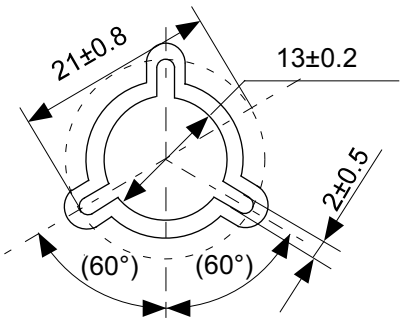
No. FM008-A-C-SD-2.0

TITLE	TMSOP8-A-Carrier Tape
No.	FM008-A-C-SD-2.0
ANGLE	
UNIT	mm
ABLIC Inc.	

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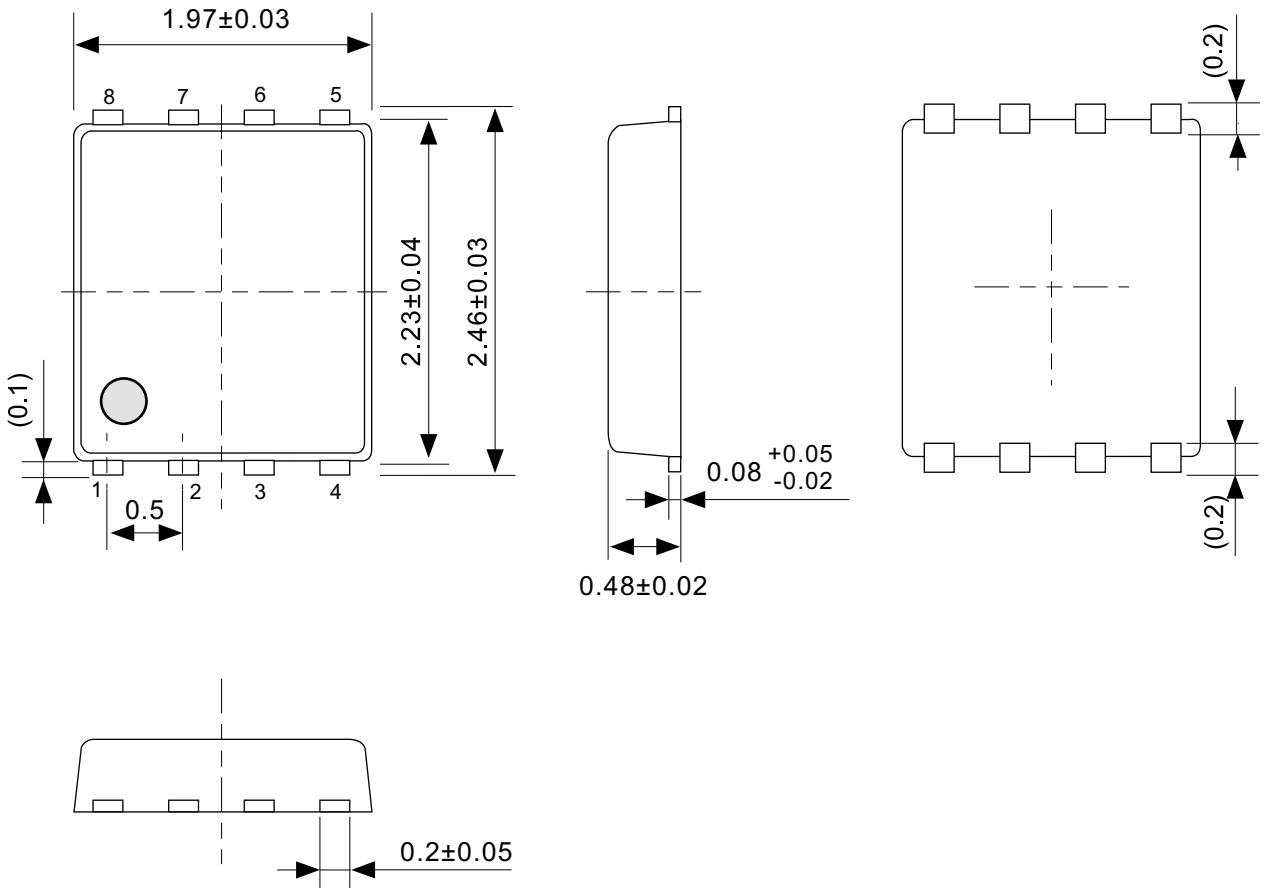
Enlarged drawing in the central part



No. FM008-A-R-SD-1.0

TITLE	TMSOP8-A-Reel		
No.	FM008-A-R-SD-1.0		
ANGLE		QTY.	4,000
UNIT	mm		
ABLIC Inc.			

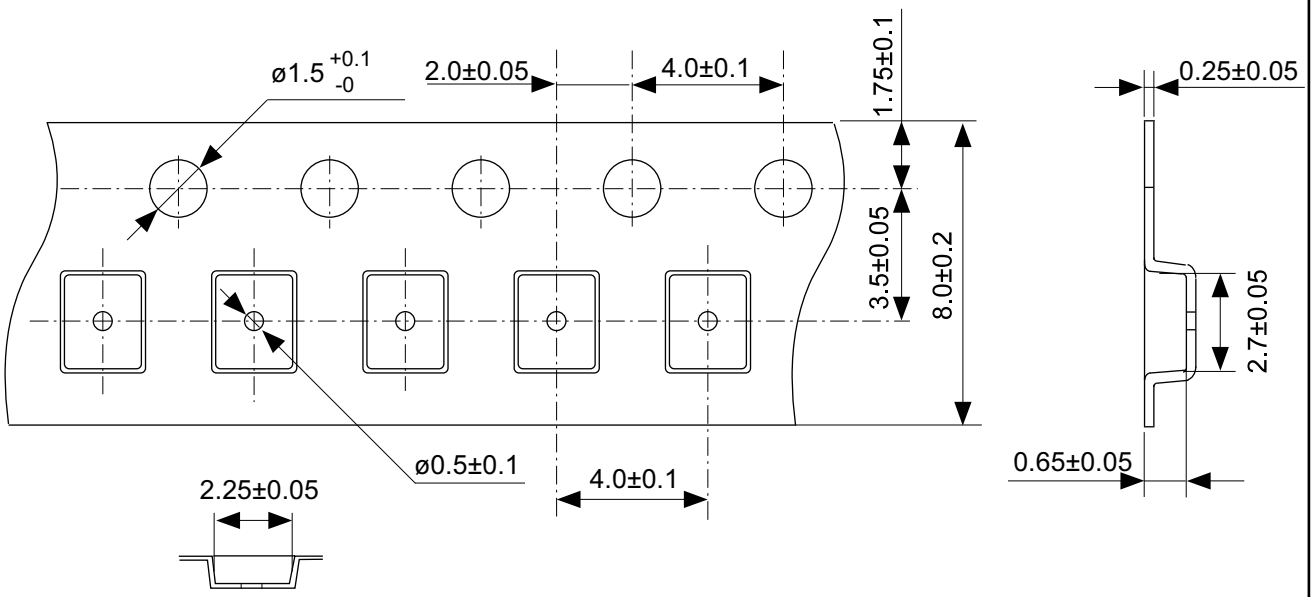
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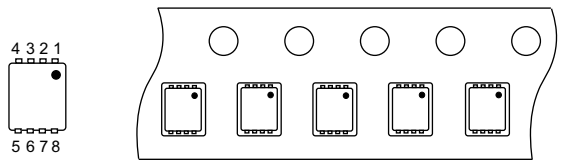


No. PH008-A-P-SD-2.1

TITLE	SNT-8A-A-PKG Dimensions
No.	PH008-A-P-SD-2.1
ANGLE	
UNIT	mm
ABLIC Inc.	

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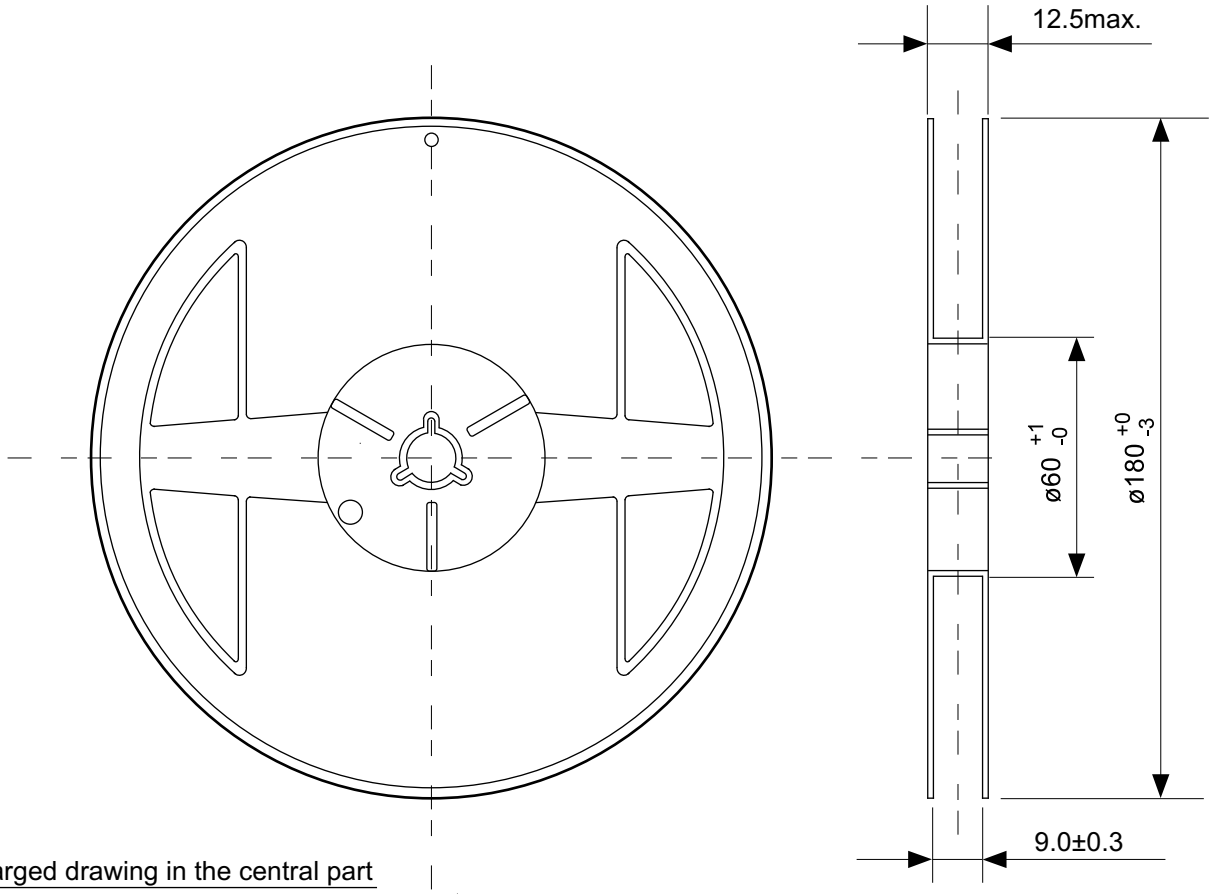


Feed direction

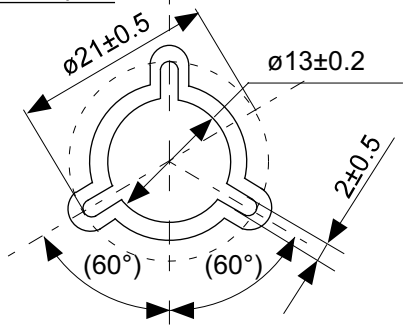
No. PH008-A-C-SD-2.0

TITLE	SNT-8A-A-Carrier Tape
No.	PH008-A-C-SD-2.0
ANGLE	
UNIT	mm
ABLIC Inc.	

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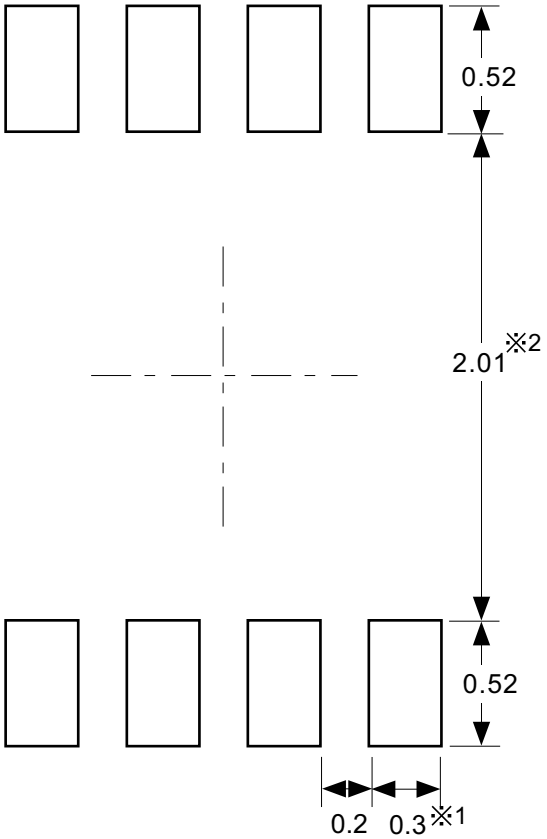
Enlarged drawing in the central part



No. PH008-A-R-SD-1.0

TITLE	SNT-8A-A-Reel		
No.	PH008-A-R-SD-1.0		
ANGLE		QTY.	5,000
UNIT	mm		
ABLIC Inc.			

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※1. ランドパターンの幅に注意してください (0.25 mm min. / 0.30 mm typ.)。
※2. パッケージ中央にランドパターンを広げないでください (1.96 mm ~ 2.06 mm)。

注意 1. パッケージのモールド樹脂下にシルク印刷やハンダ印刷などしないでください。
2. パッケージ下の配線上のソルダーレジストなどの厚みをランドパターン表面から0.03 mm 以下にしてください。
3. マスク開口サイズと開口位置はランドパターンと合わせてください。
4. 詳細は〝SNTパッケージ活用の手引き〟を参照してください。

※1. Pay attention to the land pattern width (0.25 mm min. / 0.30 mm typ.).
※2. Do not widen the land pattern to the center of the package (1.96 mm to 2.06mm).

Caution 1. Do not do silkscreen printing and solder printing under the mold resin of the package.
2. The thickness of the solder resist on the wire pattern under the package should be 0.03 mm or less from the land pattern surface.
3. Match the mask aperture size and aperture position with the land pattern.
4. Refer to "SNT Package User's Guide" for details.

※1. 请注意焊盘模式的宽度 (0.25 mm min. / 0.30 mm typ.)。
※2. 请勿向封装中间扩展焊盘模式 (1.96 mm ~ 2.06 mm)。

注意 1. 请勿在树脂型封装的下面印刷丝网、焊锡。
2. 在封装下、布线上的阻焊膜厚度 (从焊盘模式表面起) 请控制在 0.03 mm 以下。
3. 钢网的开口尺寸和开口位置请与焊盘模式对齐。
4. 详细内容请参阅 "SNT 封装的应用指南"。

No. PH008-A-L-SD-4.1

TITLE	SNT-8A-A -Land Recommendation
No.	PH008-A-L-SD-4.1
ANGLE	
UNIT	mm
ABLIC Inc.	

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