# HT9261/HT9262/HT9264
# TinyPower™ Operation Amplifier

## Features

- Wide operating voltage: 1.4V to 5.5V
- Low quiescent current: typical 0.6μA/amplifier
- Rail-to-Rail output
- Gain bandwidth: 11kHz typical
- Unity gain stable
- Available in Single, Dual and Quad OP's package types
- Package type:
  HT9261: TSOT23-5
  HT9262: 8-pin DIP/SOP
  HT9264: 14-pin DIP/SOP

## Applications

- Wearable products
- Temperature measurement
- Battery powered products
- Portable equipment
- Low power sensors

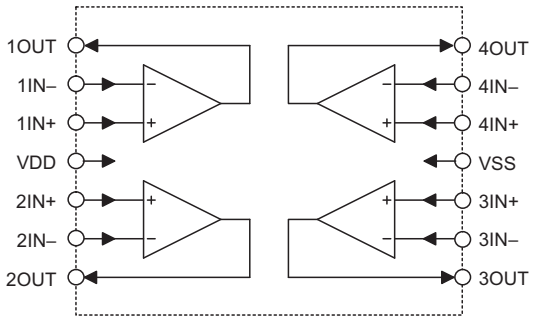
## General Description

The Holtek HT9261/HT9262/HT9264 range of Low Power Operation Amplifiers offer the advantage of a single supply voltage down to as low as 1.4V as well as the advantages of an extremely low quiescent current of only 0.6μA/amplifier. One other major advantage of these devices lie in their rail-to-rail voltage operation for maximum range. The devices also provide a typical gain bandwidth product of 11kHz and are also unity gain stable. The devices are available in a range of packages according the number of internal amplifiers. The special characteristics of these devices will ensure their excellent use in applications with stringent low power demands such as portable products, battery powered equipment, low power sensor signal processing etc.

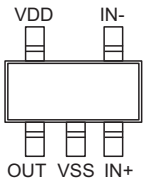
## Selection Table

| Part No. | Amplifiers | Package |
|---|---|---|
| HT9261 | 1 | TSOT23-5 |
| HT9262 | 2 | 8DIP/SOP |
| HT9264 | 4 | 14DIP/SOP |

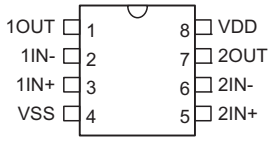
## Block Diagram



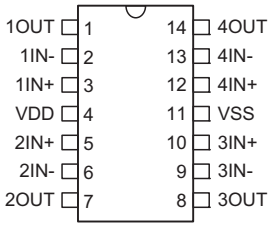
## Pin Assignment




HT9261
TSOT23-5




HT9262
8 DIP-A/SOP-A




HT9264
14 DIP-A/SOP-A

## Pin Descriptions

**HT9261**

| Pin No. | Pin Name | Description |
|---|---|---|
| 1 | OUT | Analog output |
| 2 | VSS | Negative power supply |
| 3 | IN+ | Non-inverting input |
| 4 | IN- | Inverting input |
| 5 | VDD | Positive power supply |

**HT9262**

| Pin No. | Pin Name | Description |
|---|---|---|
| 1 | 1OUT | Analog output (operation amplifier 1) |
| 2 | 1IN- | Inverting input (operation amplifier 1) |
| 3 | 1IN+ | Non-inverting input (operation amplifier 1) |
| 4 | VSS | Negative power supply |
| 5 | 2IN+ | Non-inverting input (operation amplifier 2) |
| 6 | 2IN- | Inverting input (operation amplifier 2) |
| 7 | 2OUT | Analog output (operation amplifier 2) |
| 8 | VDD | Positive power supply |

**HT9264**

| Pin No. | Pin Name | Description |
|---|---|---|
| 1 | 1OUT | Analog output (operation amplifier 1) |
| 2 | 1IN- | Inverting input (operation amplifier 1) |
| 3 | 1IN+ | Non-inverting input (operation amplifier 1) |
| 4 | VDD | Positive power supply |
| 5 | 2IN+ | Non-inverting input (operation amplifier 2) |
| 6 | 2IN- | Inverting input (operation amplifier 2) |
| 7 | 2OUT | Analog output (operation amplifier 2) |
| 8 | 3OUT | Analog output (operation amplifier 3) |
| 9 | 3IN- | Inverting input (operation amplifier 3) |
| 10 | 3IN+ | Non-inverting input (operation amplifier 3) |
| 11 | VSS | Negative power supply |
| 12 | 4IN+ | Non-inverting input (operation amplifier 4) |
| 13 | 4IN- | Inverting input (operation amplifier 4) |
| 14 | 4OUT | Analog output (operation amplifier 4) |

## Absolute Maximum Ratings

Supply Voltage .....6.0V

Difference Input Voltage .....±($V_{DD}$–$V_{SS}$)

Storage Temperature .....–65°C to +150°C

Junction Temperature .....150°C

Input Voltage.....$V_{SS}$–0.3V ~ $V_{DD}$+0.3V

ESD protection on all pins (HBM;MM) .....≥4kV; 400V

Operating Temperature .....–40°C to +85°C

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

## Electrical Characteristics

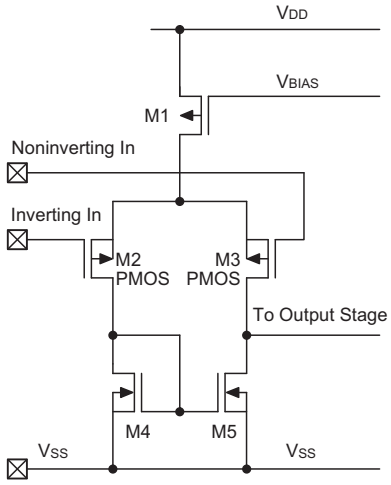
Unless otherwise indicated, $V_{SS}$=GND, Ta=25°C, $V_{CM}$=$V_{DD}$/2, $V_L$=$V_{DD}$/2, and $R_L$=1MΩ to $V_L$, $C_L$=60pF

| Symbol | Parameter | Test Conditions | | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|---|
| | | $V_{DD}$ | Conditions | | | | |
| $V_{DD}$ | Supply Voltage | — | — | 1.4 | — | 5.5 | V |
| $V_{OS}$ | Input Offset Voltage | 5V | $V_{IN}$=$V_{CM}$/2 | –5.0 | — | 5.0 | mV |
| $\Delta V_{OS}/\Delta T$ | Drift with Temperature | 5V | $V_{IN}$=$V_{CM}$/2 | — | ±2 | — | μV/°C |
| $I_{OS}$ | Input Offset Current | 5V | Ta=25°C | — | ±5 | — | pA |
| $I_B$ | Input Bias Current | 5V | Ta=25°C | — | ±50 | — | pA |
| $V_{CM}$ | Input Common Mode Range | 5V | — | 0 | — | $V_{DD}$–1.2 | V |
| $V_{OH}$<br>$V_{OL}$ | Maximum Output Voltage Swing | 5V | 0.5V input overdrive<br>$R_L$=1MΩ to $V_L$ | $V_{SS}$+10 | — | $V_{DD}$–10 | mV |
| | | | 0.5V input overdrive<br>$R_L$=50kΩ to $V_L$ | $V_{SS}$+20 | — | $V_{DD}$–50 | mV |
| $A_{OL}$ | DC Open-Loop Gain<br>(large signal) | 5V | $V_{OUT}$=0.2V to $V_{DD}$-0.2V,<br>$V_{IN}$=$V_{CM}$/2 | 70 | 100 | — | dB |
| GBW | Gain BandWidth Product | 5V | $R_L$=1MΩ, $C_L$=60pF<br>$V_{IN}$=$V_{CM}$/2 | — | 11 | — | kHz |
| Φm | Phase Margin | 5V | $R_L$=1MΩ, $C_L$=60pF<br>G=+1V/V, $V_{IN+}$= $V_{DD}$/2 | — | 50 | — | ° |
| CMRR | Common Mode Rejection Ratio | 5V | $V_{CM}$=0V to $V_{DD}$-1.4V | 60 | 90 | — | dB |
| PSRR | Power Supply Rejection Ratio | 5V | VCM = 0.2V | 65 | 95 | — | dB |
| $I_{CC}$ | Supply Current Per Single Amplifier | 5V | Io=0A | 0.3 | 0.6 | 1.0 | μA |
| SR | Slew Rate at Unity Gain | 5V | $R_L$=1MΩ, $C_L$=60pF | — | 5 | — | V/ms |
| $I_{O\_SOURCE}$ | Output Short Circuit Source Current | 5V | $V_{IN+}$ – $V_{IN-}$ ≥ 10mV | –0.3 | –1.2 | — | mA |
| $I_{O\_SINK}$ | Output Short Circuit Sink Current | 5V | $V_{IN-}$ – $V_{IN+}$ ≥ 10mV | 1 | 4 | — | mA |

## Functional Description

### Input Stage

The input stage of op amps are nominal PMOS differential amplifiers (see the following diagram), therefore the common mode input voltage can extend to $V_{SS}$-0.6V. On the other hand the common mode input voltage has to be maintained below ($V_{DD}$–1.2V) to keep the input device (M2 and M3) active. This implies that when using HT9261/HT9262/HT9264 as a voltage follower, the input as well as output active range will be limited between $V_{SS}$~$V_{DD}$-1V (approx.). Avoid applying any voltage greater than $V_{DD}$+0.6V or less than $V_{SS}$-0.6V to the input pins, otherwise the internal input protection devices may be damaged.



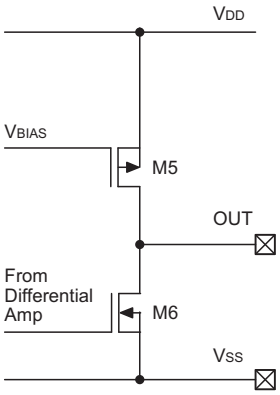

Since the input impedance of PMOS is inherently very high, it can directly couple to high impedance elements without loading effect. For example, coupling to ceramic transducers, integrating capacitor and resistor networks.

Actually the extremly high input impedance is its major advantage over the bipolar counterpart, in some application fields such as integrators where the input current of op amp can cause significant error.

### Output Stage

The HT9261/HT9262/HT9264 uses push-pull CMOS configuration as the output stage of op amps to minimize low power consumption and to provide adequate output driving current.

Note that the output is an unbuffered structure, therefore the open loop gain will be affected by the load resistor since the voltage gain of this stage can be expressed as $(gm5+ gm6)\times R_L$.

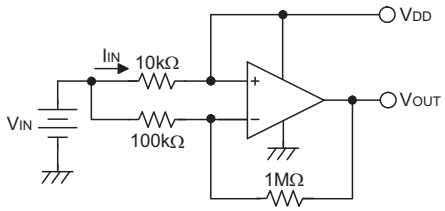



Because of the consideration for minimized power consumption, the output short circuit current is limited to about -1.2mA for source drive and 4mA for sink drive. This is believed to be enough for most low power systems, however it is recommended to use the load resistor of >1MΩ for normal applications. In case of heavy load driving, an external buffer stage using bipolar transistors is recommended.

The HT9261/HT9262/HT9264 is internally compensated for AC stability and capable to withstand up to a 60pF capacitive load.

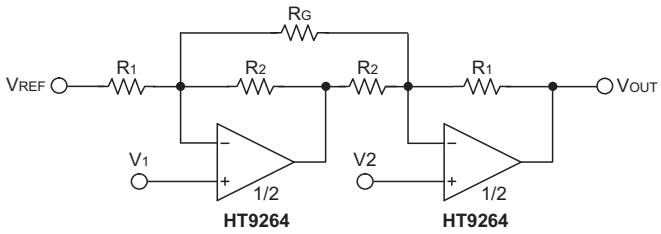
## Application Circuits

### High Side Battery Current Sensor




$$I_{IN} = \frac{V_{DD}-V_{OUT}}{(11V/V) \times (10k\Omega)}$$

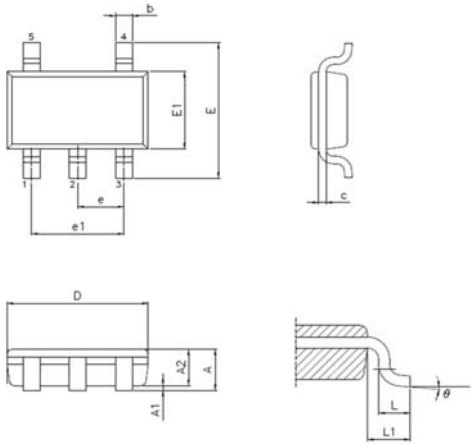
### Two Op Amp Instrumentation Amplifier




$$V_{OUT} = (V_2-V_1) \times (1+ \frac{R_1}{R_2} + \frac{2R_1}{R_G}) + V_{REF}$$

## Package Information

**5-pin TSOT23-5 Outline Dimensions**

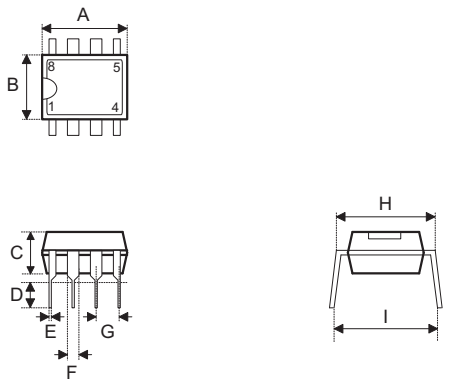



- MO-193C

| Symbol | Dimensions in inch | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | — | — | 0.043 |
| A1 | 0.000 | — | 0.004 |
| A2 | 0.028 | — | 0.039 |
| b | 0.012 | — | 0.020 |
| C | 0.003 | — | 0.008 |
| D | — | 0.114 | — |
| E | — | 0.110 | — |
| E1 | | 0.063 | |
| e | — | 0.037 | — |
| e1 | | 0.075 | |
| L | 0.012 | — | 0.024 |
| L1 | — | 0.024 | — |
| θ | 0° | — | 8° |

| Symbol | Dimensions in mm | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | — | — | 1.10 |
| A1 | 0.00 | — | 0.10 |
| A2 | 0.70 | — | 1.00 |
| b | 0.30 | — | 0.50 |
| C | 0.08 | — | 0.20 |
| D | — | 2.90 | — |
| E | — | 2.80 | — |
| E1 | | 1.60 | |
| e | — | 0.95 | — |
| e1 | — | 1.90 | |
| L | 0.30 | — | 0.60 |
| L1 | — | 0.60 | — |
| θ | 0° | — | 8° |

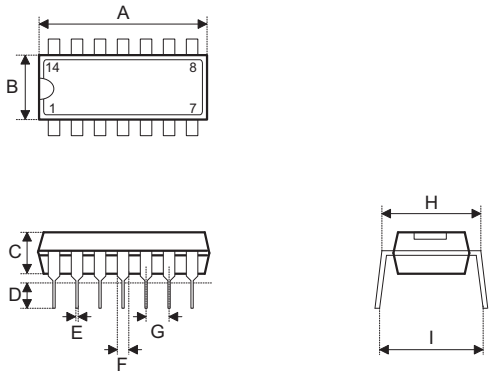
**8-pin DIP (300mil) Outline Dimensions**




| Symbol | Dimensions in inch | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | 0.355 | — | 0.375 |
| B | 0.240 | — | 0.260 |
| C | 0.125 | — | 0.135 |
| D | 0.125 | — | 0.145 |
| E | 0.016 | — | 0.020 |
| F | 0.050 | — | 0.070 |
| G | — | 0.100 | — |
| H | 0.295 | — | 0.315 |
| I | — | 0.375 | — |

| Symbol | Dimensions in mm | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | 9.02 | — | 9.53 |
| B | 6.10 | — | 6.60 |
| C | 3.18 | — | 3.43 |
| D | 3.18 | — | 3.68 |
| E | 0.41 | — | 0.51 |
| F | 1.27 | — | 1.78 |
| G | — | 2.54 | — |
| H | 7.49 | — | 8.00 |
| I | — | 9.53 | — |

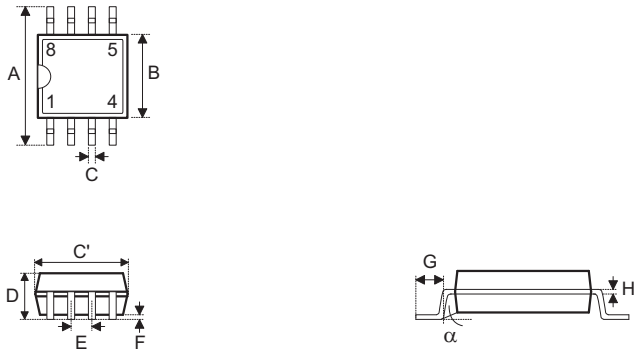
**14-pin DIP (300mil) Outline Dimensions**




| Symbol | Dimensions in inch | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | 0.745 | — | 0.775 |
| B | 0.240 | — | 0.260 |
| C | 0.125 | — | 0.135 |
| D | 0.125 | — | 0.145 |
| E | 0.016 | — | 0.020 |
| F | 0.050 | — | 0.070 |
| G | — | 0.1100 | — |
| H | 0.295 | — | 0.315 |
| I | — | 0.375 | — |

| Symbol | Dimensions in mm | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | 18.92 | — | 19.69 |
| B | 6.10 | — | 6.60 |
| C | 3.18 | — | 3.43 |
| D | 3.18 | — | 3.68 |
| E | 0.41 | — | 0.51 |
| F | 1.27 | — | 1.78 |
| G | — | 2.54 | — |
| H | 7.49 | — | 8.00 |
| I | — | 9.53 | — |

**8-pin SOP (150mil) Outline Dimensions**

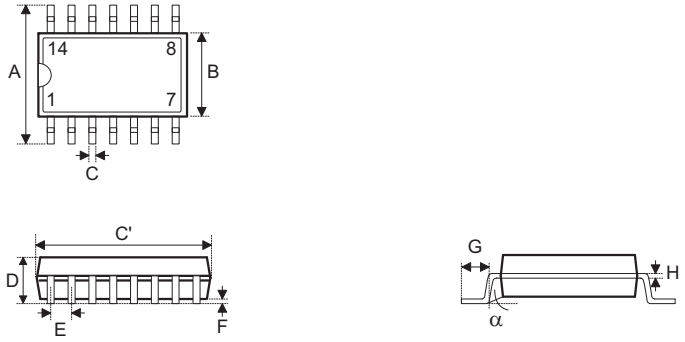



• MS-012

| Symbol | Dimensions in inch | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | 0.228 | — | 0.244 |
| B | 0.150 | — | 0.157 |
| C | 0.012 | — | 0.020 |
| C′ | 0.188 | — | 0.197 |
| D | — | — | 0.069 |
| E | — | 0.050 | — |
| F | 0.004 | — | 0.010 |
| G | 0.016 | — | 0.050 |
| H | 0.007 | — | 0.010 |
| α | 0° | — | 8° |

| Symbol | Dimensions in mm | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | 5.79 | — | 6.20 |
| B | 3.81 | — | 3.99 |
| C | 0.30 | — | 0.51 |
| C′ | 4.78 | — | 5.00 |
| D | — | — | 1.75 |
| E | — | 1.27 | — |
| F | 0.10 | — | 0.25 |
| G | 0.41 | — | 1.27 |
| H | 0.18 | — | 0.25 |
| α | 0° | — | 8° |

**14-pin SOP (150mil) Outline Dimensions**

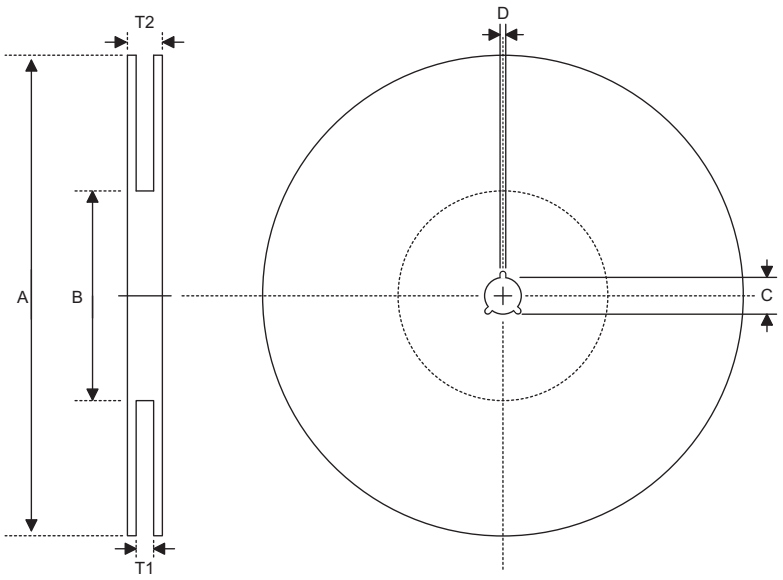



• MS-012

| Symbol | Dimensions in mil | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | 0.228 | — | 0.244 |
| B | 0.150 | — | 0.157 |
| C | 0.012 | — | 0.020 |
| C′ | 0.337 | — | 0.344 |
| D | — | — | 0.069 |
| E | — | 0.050 | — |
| F | 0.004 | — | 0.010 |
| G | 0.016 | — | 0.050 |
| H | 0.007 | — | 0.010 |
| α | 0° | — | 8° |

| Symbol | Dimensions in mm | | |
|---|---|---|---|
| | Min. | Nom. | Max. |
| A | 5.79 | — | 6.20 |
| B | 3.81 | — | 3.99 |
| C | 0.30 | — | 0.51 |
| C′ | 8.56 | — | 8.74 |
| D | — | — | 1.75 |
| E | — | 1.27 | — |
| F | 0.10 | — | 0.25 |
| G | 0.41 | — | 1.27 |
| H | 0.18 | — | 0.25 |
| α | 0° | — | 8° |

## Product Tape and Reel Specifications




**Reel Dimensions**

SOP 8N

| Symbol | Description | Dimensions in mm |
|---|---|---|
| A | Reel Outer Diameter | 330.0±1.0 |
| B | Reel Inner Diameter | 100.0±1.5 |
| C | Spindle Hole Diameter | 13.0 $^{+0.5/-0.2}$ |
| D | Key Slit Width | 2.0±0.5 |
| T1 | Space Between Flange | 12.8 $^{+0.3/-0.2}$ |
| T2 | Reel Thickness | 18.2±0.2 |

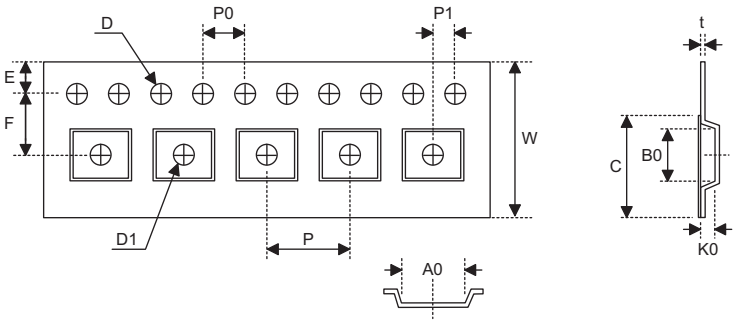
SOP 14N

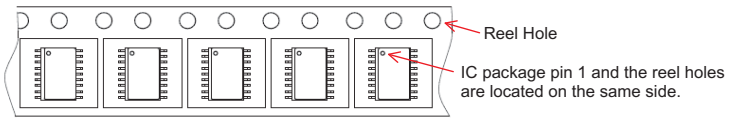
| Symbol | Description | Dimensions in mm |
|---|---|---|
| A | Reel Outer Diameter | 330.0±1.0 |
| B | Reel Inner Diameter | 100.0±1.5 |
| C | Spindle Hole Diameter | 13.0 $^{+0.5/-0.2}$ |
| D | Key Slit Width | 2.0±0.5 |
| T1 | Space Between Flange | 16.8 $^{+0.3/-0.2}$ |
| T2 | Reel Thickness | 22.2±0.2 |

TSOT23-5

| Symbol | Description | Dimensions in mm |
|---|---|---|
| A | Reel Outer Diameter | 178.0±1.0 |
| B | Reel Inner Diameter | 60.0±1.0 |
| C | Spindle Hole Diameter | 13.0 $^{+0.5/-0.2}$ |
| D | Key Slit Width | 2.4±0.1 |
| T1 | Space Between Flange | 9.0±0.5 |
| T2 | Reel Thickness | 11.8±0.5 |

## Carrier Tape Dimensions



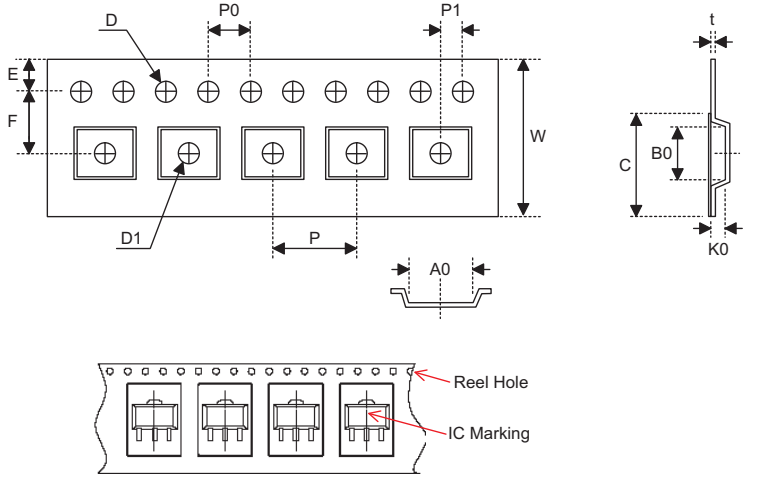

SOP 8N

| Symbol | Description | Dimensions in mm |
|---|---|---|
| W | Carrier Tape Width | 12.0 +0.3/-0.1 |
| P | Cavity Pitch | 8.0±0.1 |
| E | Perforation Position | 1.75±0.1 |
| F | Cavity to Perforation (Width Direction) | 5.5±0.1 |
| D | Perforation Diameter | 1.55±0.1 |
| D1 | Cavity Hole Diameter | 1.50 +0.25/-0.00 |
| P0 | Perforation Pitch | 4.0±0.1 |
| P1 | Cavity to Perforation (Length Direction) | 2.0±0.1 |
| A0 | Cavity Length | 6.4±0.1 |
| B0 | Cavity Width | 5.2±0.1 |
| K0 | Cavity Depth | 2.1±0.1 |
| t | Carrier Tape Thickness | 0.30±0.05 |
| C | Cover Tape Width | 9.3±0.1 |

SOP 14N

| Symbol | Description | Dimensions in mm |
|---|---|---|
| W | Carrier Tape Width | 16.0 +0.3/-0.1 |
| P | Cavity Pitch | 8.0±0.1 |
| E | Perforation Position | 1.75±0.1 |
| F | Cavity to Perforation (Width Direction) | 7.5±0.1 |
| D | Perforation Diameter | 1.5 +0.1/-0.0 |
| D1 | Cavity Hole Diameter | 1.50 +0.25/-0.00 |
| P0 | Perforation Pitch | 4.0±0.1 |
| P1 | Cavity to Perforation (Length Direction) | 2.0±0.1 |
| A0 | Cavity Length | 6.5±0.1 |
| B0 | Cavity Width | 9.5±0.1 |
| K0 | Cavity Depth | 2.1±0.1 |
| t | Carrier Tape Thickness | 0.30±0.05 |
| C | Cover Tape Width | 13.3±0.1 |

**Carrier Tape Dimensions**




TSOT23-5

| Symbol | Description | Dimensions in mm |
|---|---|---|
| W | Carrier Tape Width | 8.0±0.2 |
| P | Cavity Pitch | 4.0±0.1 |
| E | Perforation Position | 1.75±0.10 |
| F | Cavity to Perforation (Width Direction) | 3.50±0.05 |
| D | Perforation Diameter | $1.5^{+0.1/-0.0}$ |
| D1 | Cavity Hole Diameter | $1.1^{+0.1/-0.0}$ |
| P0 | Perforation Pitch | 4.0±0.1 |
| P1 | Cavity to Perforation (Length Direction) | 2.00±0.05 |
| A0 | Cavity Length | 3.2±0.1 |
| B0 | Cavity Width | 3.2±0.1 |
| K0 | Cavity Depth | 1.1±0.1 |
| t | Carrier Tape Thickness | 0.25±0.05 |
| C | Cover Tape Width | 5.3±0.1 |

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