HT9231/HT9232/HT9234
Operation Amplifier

Features

- Operating Voltage: 2.0V to 5.5V
- Supply Current: 220μA/amplifier typical
- Rail-to-Rail Output
- Gain Bandwidth: 2.3MHz typical
- Unity Gain Stable
- Available in Single, Dual and Quad Op′s package types
- Package type:
  HT9231: TSOT23-5
  HT9232: 8-pin DIP/SOP
  HT9234: 14-pin DIP/SOP

Applications

- Automotive
- Portable Equipment
- Photo diode Amplifier
- Analog Filters
- Notebooks and PDAs
- Battery Powered Systems

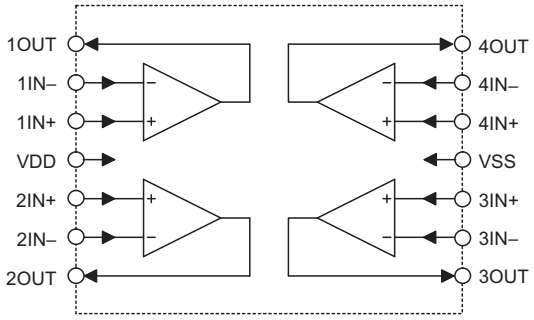
General Description

The Holtek HT9231/HT9232/HT9234 range of Operational Amplifiers operate with a single supply voltage as low as 2.0V and offer a low supply current of only 220μA/amplifier. In offering rail-to-rail output voltage the devices can operate with a maximum voltage range. The devices also provide a gain bandwidth product of 2.3MHz and are also unity gain stable. These products are suitable for a wide range of analog signal processing applications but especially suitable for the portable device and battery powered equipment application areas.

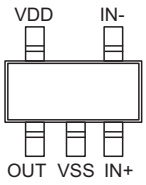
Selection Table

Part No.	Amplifiers	Package
HT9231	1	TSOT23-5
HT9232	2	8DIP/SOP
HT9234	4	14DIP/SOP

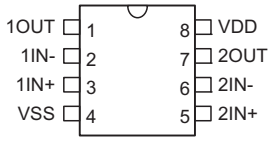
Block Diagram



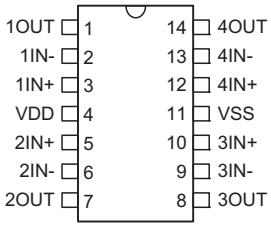
Pin Assignment



HT9231
TSOT23-5



HT9232
8 DIP-A/SOP-A



HT9234
14 DIP-A/SOP-A

Pin Descriptions

HT9231

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

HT9232

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

HT9234

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

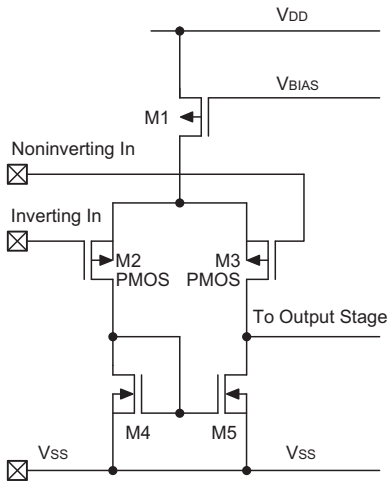
Unless otherwise indicated, V_{SS}=GND, Ta=25°C, V_{CM}=V_{DD}/2, V_L=V_{DD}/2, and R_L=10kΩ to V_L, C_L=60pF

Symbol	Parameter	Test Conditions		Min.	Typ.	Max.	Unit
		V_{DD}	Conditions				
V_{DD}	Supply Voltage	—	—	2.0	—	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}–1.4	V
V_{OH} V_{OL}	Maximum Output Voltage Swing	5V	0.5V input overdrive R_L=10kΩ to V_L	V_{SS}+50	—	V_{DD}–100	mV
			0.5V input overdrive R_L=2kΩ to V_L	V_{SS}+150	—	V_{DD}–250	mV
A_{OL}	DC Open-Loop Gain (large signal)	5V	V_{OUT}=0.2V to V_{DD}-0.2V, V_{IN}=V_{CM}/2	70	100	—	dB
GBW	Gain BandWidth Product	5V	R_L=10kΩ, C_L=60pF V_{IN}=V_{CM}/2	—	2.3	—	MHz
Φm	Phase Margin	5V	R_L=10kΩ, C_L=60pF G=+1V/V, V_{IN+}= V_{DD}/2	—	63	—	°
CMRR	Common Mode Rejection Ratio	5V	V_{CM}=0V to V_{DD}-1.4V	60	90	—	dB
PSRR	Power Supply Rejection Ratio	5V	V_{CM}=0.2V	65	95	—	dB
I_{CC}	Supply Current Per Single Amplifier	5V	Io=0A	100	220	340	μA
SR	Slew Rate at Unity Gain	5V	R_L=10kΩ, C_L=60pF	—	2	—	V/ms
I_{O_SOURCE}	Output Short Circuit Source Current	5V	V_{IN+} – V_{IN-} ≥ 10mV	–5.0	–9.0	—	mA
I_{O_SINK}	Output Short Circuit Sink Current	5V	V_{IN-} – V_{IN+} ≥ 10mV	5.5	9.5	—	mA

Functional Description

Input stage

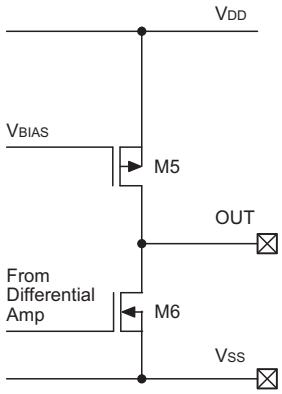
As the input stage of these op-amps is a PMOS differential amplifiers, the amplifiers can offer an extended common mode low input voltage down to V_{SS}-0.6V. At the other end of the voltage spectrum, the common mode input voltage has to be maintained at a level below V_{DD}–1.4 to keep the input devices, M2 and M3, in their active region. This implies that when using HT9231/HT9232/HT9234 in voltage follower applications, the inputs as well as the output active range will be limited between V_{SS}~V_{DD}-1V (approx.). It is necessary to 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 a PMOS transistor is inherently very high, they can be directly coupled to high impedance elements without loading effects. Examples could be coupling to ceramic transducers, integrating capacitors and resistor networks. It is this high input impedance characteristic that is its major advantage over its bipolar counterpart in certain application fields such as integrators where op-amp input currents can cause significant errors.

Output stage

The devices use a push-pull CMOS configuration for the op-amp output stage to minimise power consumption and to provide adequate output drive currents. 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 is expressed as (gm5+ gm6)×R_L.

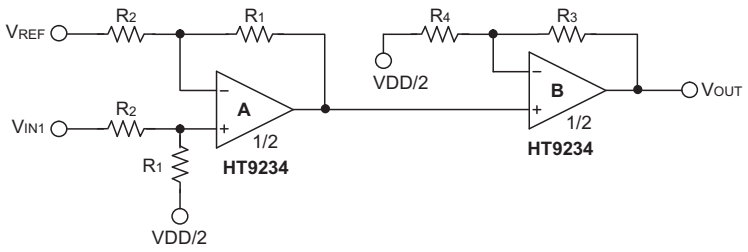


To keep power consumption to a minimum, the output short circuit current is limited to about -9mA for the source drive and 9.5mA for the sink drive. This is considered to be enough for most low power systems, however it is recommended only to used load resistors of >10kΩ for most applications. For heavy load driving applications, an external buffer stage using bipolar transistors is recommended.

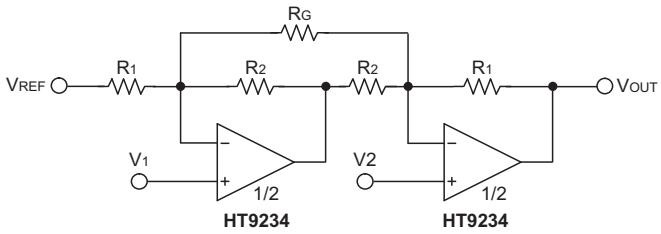
The HT9231/HT9232/HT9234 is internally compensated for AC stability and can drive capacitive loads of up to 60pF.

Application Circuits

Difference Amplifier Circuit



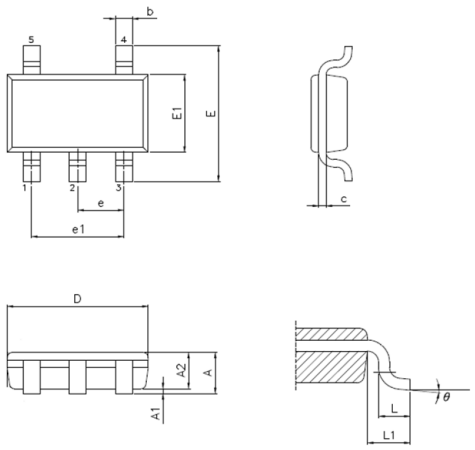
Two Op Amp Instrumentation Amplifier



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

Package Information

5-pin TSOT23-5 Outline Dimensions

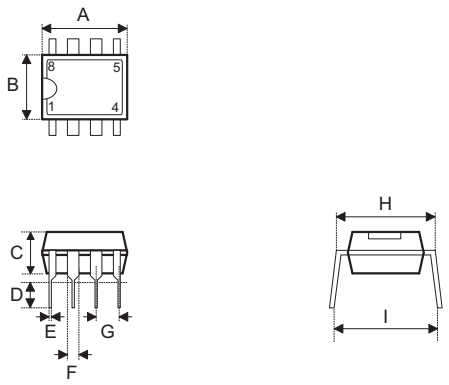


- MO-193C

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°

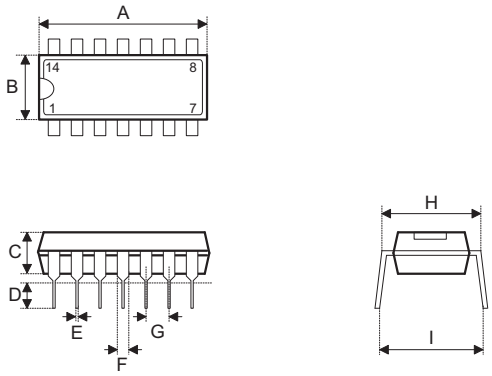
8-pin DIP (300mil) Outline Dimensions



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	—

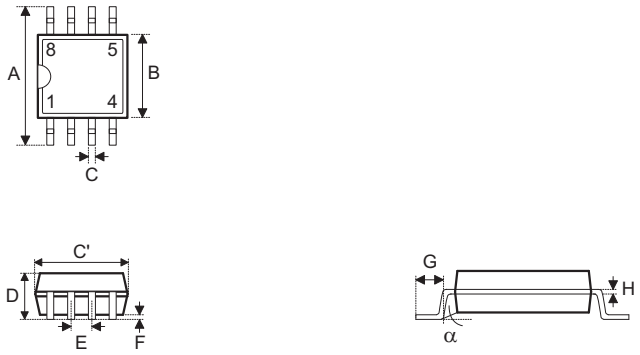
14-pin DIP (300mil) Outline Dimensions



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

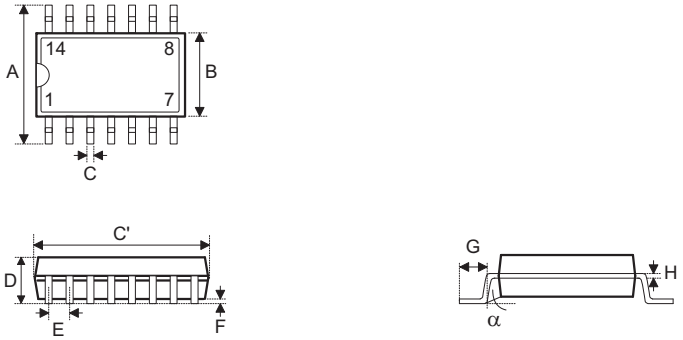


• MS-012

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

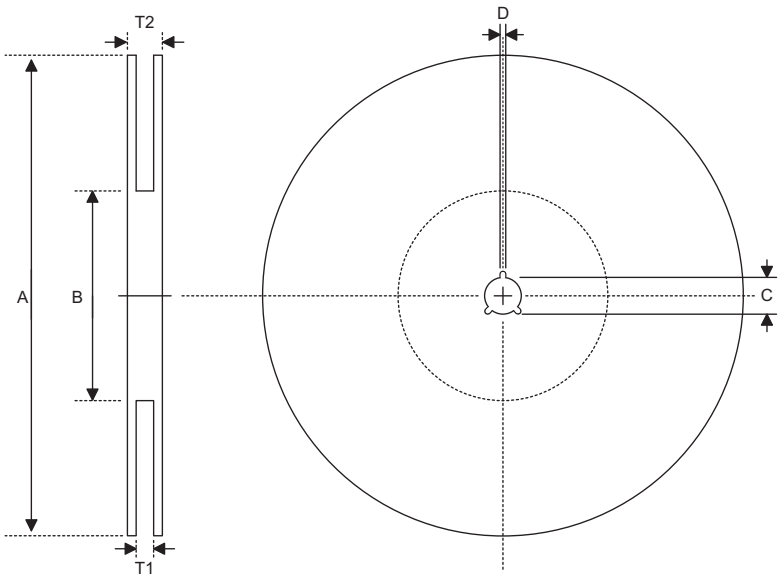


- MS-012

Symbol	Dimensions in inch		
	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

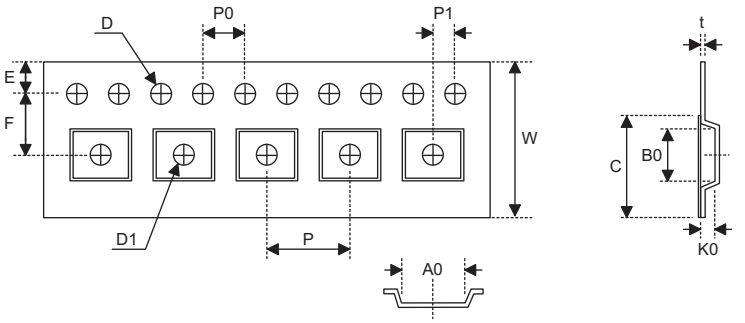
SOP 14N

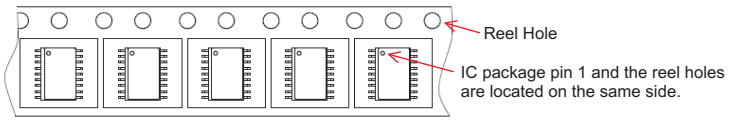
Symbol	Description	Dimensions in mm
A	Reel Outer Diameter	330.0±1.0
B	Reel Inner Diameter	100.0±1.5
C	Spindle Hole Diameter	13.0 $^{+0.5/-0.2}$
D	Key Slit Width	2.0±0.5
T1	Space Between Flange	16.8 $^{+0.3/-0.2}$
T2	Reel Thickness	22.2±0.2

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





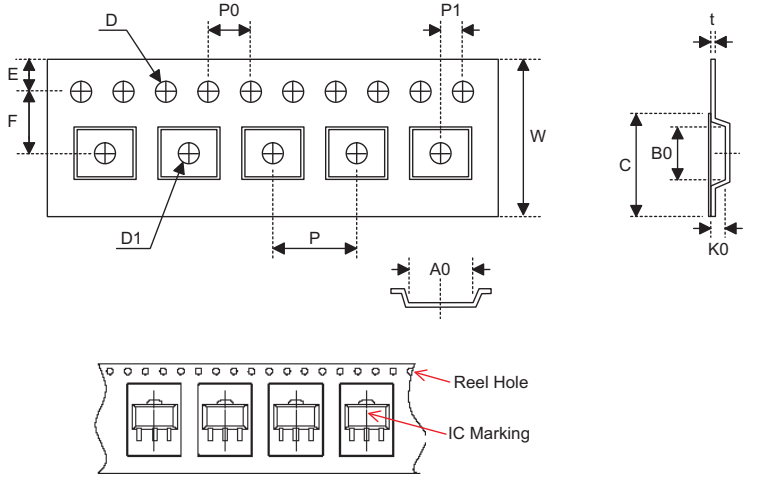
SOP 8N

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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