

Features

- Operating Voltage: 2.0V to 5.5V
- Supply Current: 220 μ A/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: SOT23-5
 - ◆ 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

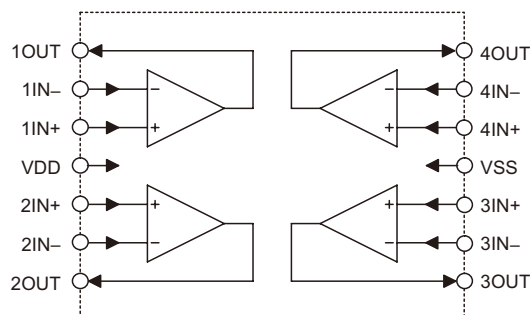
General Description

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 220 μ A/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.

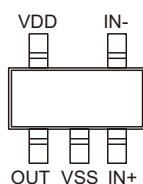
Selection Table

Part No.	Amplifiers	Package
HT9231	1	SOT23-5
HT9232	2	8DIP/SOP
HT9234	4	14DIP/SOP

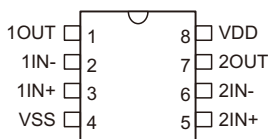
Block Diagram



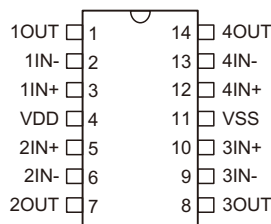
Pin Assignment



HT9231
SOT23-5



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	Input Voltage	$V_{SS}-0.3V \sim V_{DD}+0.3V$
Difference Input Voltage	$\pm(V_{DD}-V_{SS})$	ESD protection on all pins (HBM;MM) ...	$\geq 4kV$; 400V
Storage Temperature	$-65^{\circ}C$ to $+150^{\circ}C$	Operating Temperature	$-40^{\circ}C$ to $85^{\circ}C$
Junction Temperature.....	150°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

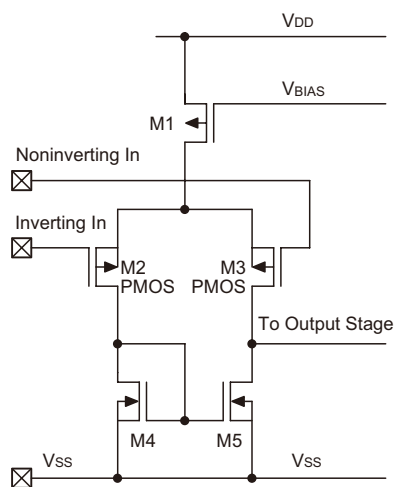
Unless otherwise indicated, $V_{SS}=GND$, $T_a=25^{\circ}C$, $V_{CM}=V_{DD}/2$, $V_L=V_{DD}/2$, and $R_L=10k\Omega$ to V_L , $C_L=60pF$

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	—	$\mu V/^{\circ}C$
I_{OS}	Input Offset Current	5V	$T_a=25^{\circ}C$	—	± 5	—	pA
I_B	Input Bias Current	5V	$T_a=25^{\circ}C$	—	± 50	—	pA
V_{CM}	Input Common Mode Range	5V	—	0	—	$V_{DD}-1.4$	V
V_{OH}	Maximum Output Voltage Swing	5V	0.5V input overdrive $R_L=10k\Omega$ to V_L	$V_{SS}+50$	—	$V_{DD}-100$	mV
V_{OL}	Maximum Output Voltage Swing	5V	0.5V input overdrive $R_L=2k\Omega$ 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	$R_L=10k\Omega$, $C_L=60pF$, $V_{IN}=V_{CM}/2$	—	2.3	—	MHz
Φ_m	Phase Margin	5V	$R_L=10k\Omega$, $C_L=60pF$ $G=+1V/V$, $V_{IN+}=V_{DD}/2$	—	63	—	$^{\circ}$
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	$I_O=0A$	100	220	340	μA
SR	Slew Rate at Unity Gain	5V	$R_L=10k\Omega$, $C_L=60pF$	—	2	—	$V/\mu s$
I_{O_SOURCE}	Output Short Circuit Source Current	5V	$V_{IN+}-V_{IN-} \geq 10mV$	-5.0	-9.0	—	mA
I_{O_SINK}	Output Short Circuit Sink Current	5V	$V_{IN-}-V_{IN+} \geq 10mV$	5.5	9.5	—	mA

Functional Description

Input Stage

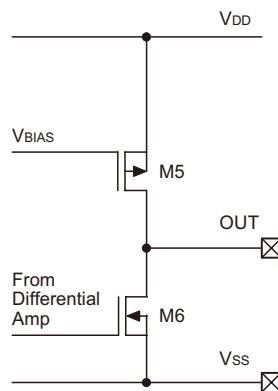
As the input stage of these op-amps is a PMOS differential amplifiers, the amplifiers can offer an extended common mode low input voltage down to $V_{SS}-0.6V$. At the other end of the voltage spectrum, the common mode input voltage has to be maintained at a level below $V_{DD}-1.4$ to keep the input 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 $V_{SS}\sim V_{DD}-1V$ (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 $(gm5+ gm6)\times R_L$.

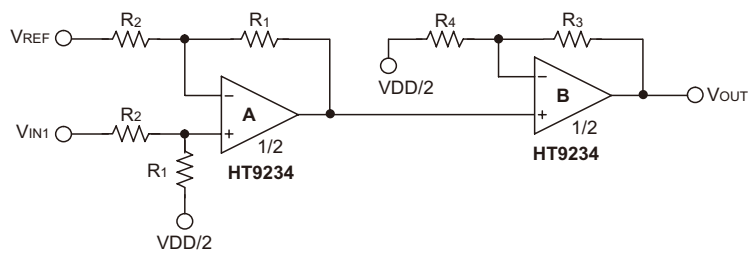


To keep power consumption to a minimum, the output short circuit current is limited to about -9mA for the source drive and 9.5mA for the sink drive. This is considered to be enough for most low power systems, however it is recommended only to used load resistors of $>10k\Omega$ for most applications.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

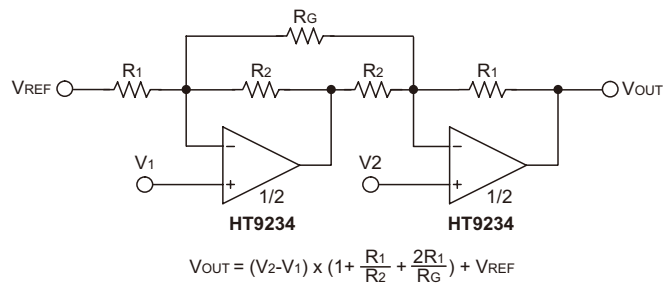
The HT9231/HT9232/HT9234 is internally compensated for AC stability and can drive capacitive loads of up to 60pF.

Application Circuits

Difference Amplifier Circuit



Two Op Amp Instrumentation Amplifier

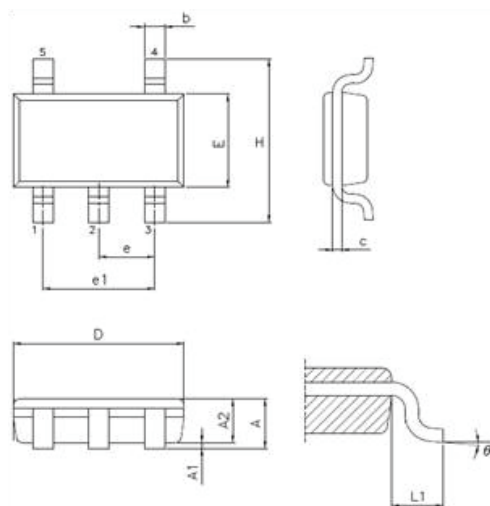


Package Information

Note that the package information provided here is for consultation purposes only. As this information may be updated at regular intervals users are reminded to consult the [Holtek website](#) for the latest version of the package information.

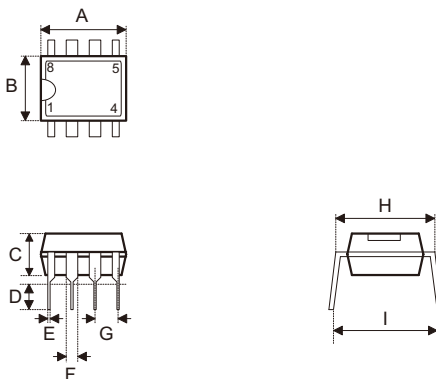
Additional supplementary information with regard to packaging is listed below. Click on the relevant section to be transferred to the relevant website page.

- [Further Package Information](#) (include Outline Dimensions, Product Tape and Reel Specifications)
- [Packing Materials Information](#)
- [Carton information](#)
- [PB FREE Products](#)
- [Green Packages Products](#)

5-pin SOT23-5 Outline Dimensions


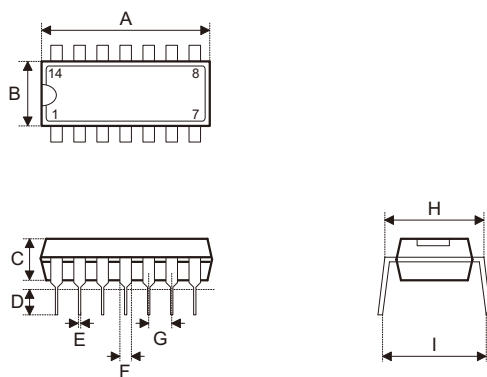
Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	0.030	—	0.031
A1	0.000	—	0.002
A2	0.028	0.030	0.031
b	0.014	—	0.020
C	0.004	—	0.008
D	—	0.114 BSC	—
E	—	0.110 BSC	—
E1	—	0.063 BSC	—
e	—	0.037 BSC	—
e1	—	0.075 BSC	—
L	0.015	0.018	0.024
L1	—	0.024 BSC	—
θ	0°	—	8°

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	0.75	—	0.80
A1	0.00	—	0.05
A2	0.70	0.75	0.78
b	0.35	—	0.50
C	0.10	—	0.20
D	—	2.90 BSC	—
E	—	2.80 BSC	—
E1	—	1.60 BSC	—
e	—	0.95 BSC	—
e1	—	1.90 BSC	—
L	0.37	0.45	0.60
L1	—	0.60 BSC	—
θ	0°	—	8°

8-pin DIP (300mil) Outline Dimensions


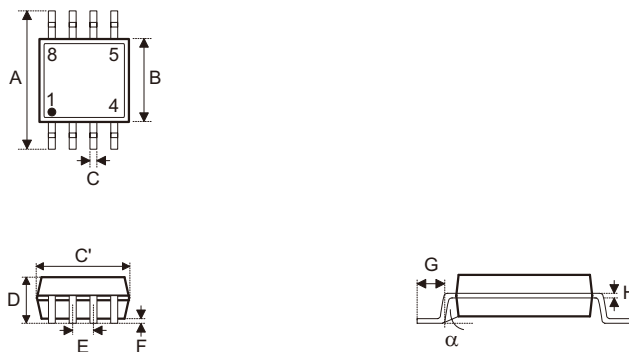
Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	0.355	0.365	0.400
B	0.240	0.250	0.280
C	0.115	0.130	0.195
D	0.115	0.130	0.150
E	0.014	0.018	0.022
F	0.045	0.060	0.070
G	—	0.100 BSC	—
H	0.300	0.310	0.325
I	—	—	0.430

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	9.02	9.27	10.16
B	6.10	6.35	7.11
C	2.92	3.30	4.95
D	2.92	3.30	3.81
E	0.36	0.46	0.56
F	1.14	1.52	1.78
G	—	2.54 BSC	—
H	7.26	7.87	8.26
I	—	—	10.92

14-pin DIP (300mil) Outline Dimensions


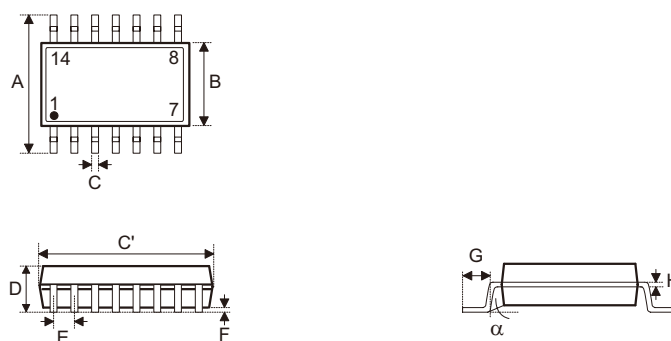
Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	0.735	0.750	0.775
B	0.240	0.250	0.280
C	0.115	0.130	0.195
D	0.115	0.130	0.150
E	0.014	0.018	0.022
F	0.045	0.060	0.070
G	—	0.10 BSC	—
H	0.300	0.310	0.325
I	—	—	0.430

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	18.67	19.05	19.69
B	6.10	6.35	7.11
C	2.92	3.30	4.95
D	2.92	3.30	3.81
E	0.36	0.46	0.56
F	1.14	1.52	1.78
G	—	2.54 BSC	—
H	7.62	7.87	8.26
I	—	—	10.92

8-pin SOP (150mil) Outline Dimensions


Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	—	0.236 BSC	—
B	—	0.154 BSC	—
C	0.012	—	0.020
C'	—	0.193 BSC	—
D	—	—	0.069
E	—	0.050 BSC	—
F	0.004	—	0.010
G	0.016	—	0.050
H	0.004	—	0.010
α	0°	—	8°

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	—F	6.00 BSC	—
B	—	3.90 BSC	—
C	0.31	—	0.51
C'	—	4.90 BSC	—
D	—	—	1.75
E	—	1.27 BSC	—
F	0.10	—	0.25
G	0.40	—	1.27
H	0.10	—	0.25
α	0°	—	8°

14-pin SOP (150mil) Outline Dimensions


Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	—	0.236 BSC	—
B	—	0.154 BSC	—
C	0.012	—	0.020
C'	—	0.341 BSC	—
D	—	—	0.069
E	—	0.050 BSC	—
F	0.004	—	0.010
G	0.016	—	0.050
H	0.004	—	0.010
α	0°	—	8°

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	—	6.00 BSC	—
B	—	3.90 BSC	—
C	0.31	—	0.51
C'	—	8.65 BSC	—
D	—	—	1.75
E	—	1.27 BSC	—
F	0.10	—	0.25
G	0.40	—	1.27
H	0.10	—	0.25
α	0°	—	8°

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