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:
  - HT9291: SOT23-5
  - HT9292: 8-pin SOP
  - HT9294: 14-pin SOP

Applications

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

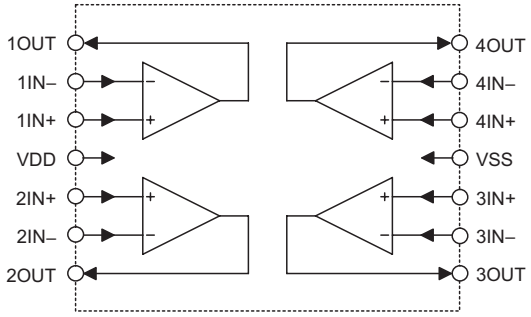
General Description

The Holtek HT9291/HT9292/HT9294 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.

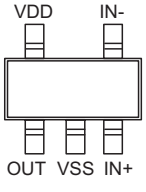
Selection Table

Part No.	Amplifiers	Package
HT9291	1	SOT23-5
HT9292	2	8SOP
HT9294	4	14SOP

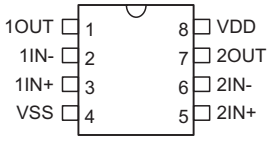
Block Diagram



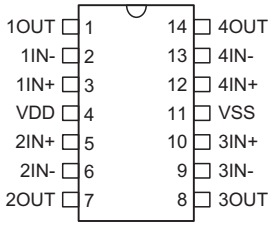
Pin Assignment



HT9291
SOT23-5



HT9292
8 SOP-A



HT9294
14 SOP-A

Pin Descriptions

HT9291

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

HT9292

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

HT9294

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

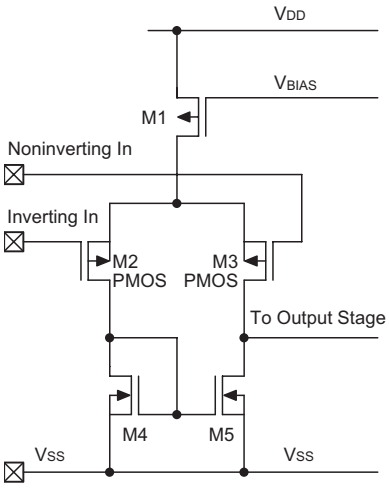
Unless otherwise indicated, V_{SS}=GND, Ta=25°C, V_{CM}=V_{DD}/2, V_L=V_{DD}/2, and R_L=1MΩ to V_L, C_L=60pF

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}	Maximum Output Voltage Swing	5V	0.5V input overdrive R_L=1MΩ to V_L	V_{SS}+10	—	V_{DD}−10	mV
V_{OL}	Maximum Output Voltage Swing	5V	0.5V input overdrive R_L=50kΩ to V_L	V_{SS}+20	—	V_{DD}−50	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=1MΩ, C_L=60pF, V_{IN}=V_{CM}/2	—	11	—	kHz
Φm	Phase Margin	5V	R_L=1MΩ, C_L=60pF 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	V_{CM} = 0.2V	65	95	—	dB
I_{CC}	Supply Current Per Single Amplifier	5V	Io=0A for HT9291	0.50	0.80	1.20	μA
			Io=0A for HT9292/HT9294	0.30	0.60	1.00	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 HT9291/HT9292/HT9294 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.



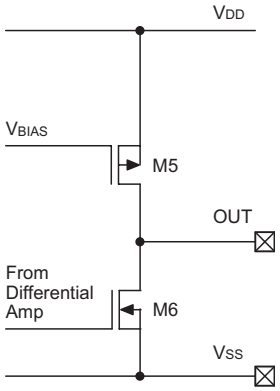
Since the input impedance of PMOS is inherently very high, it can directly couple to high impedance elements without loading effect. For example, coupling to ceramic transducers, integrating capacitor and resistor networks.

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 HT9291/HT9292/HT9294 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)×R_L.

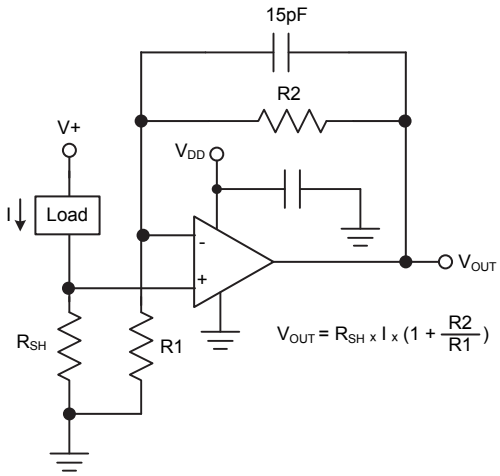


Because of the consideration for minimized power consumption, the output short circuit current is limited to about -1.2mA for source drive and 4mA for sink drive. This is believed to be enough for most low power systems, however it is recommended to use the load resistor of >1MΩ for normal applications.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

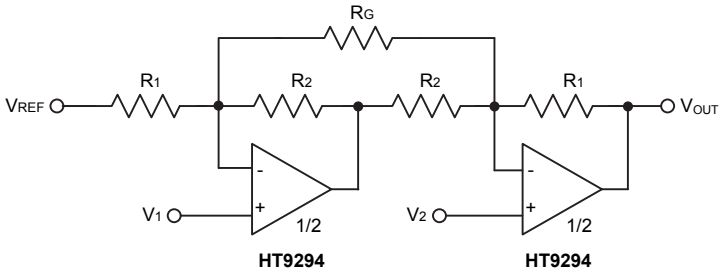
The HT9291/HT9292/HT9294 is internally compensated for AC stability and capable to withstand up to a 60pF capacitive load.

Application Circuits

Low Side Battery Current Sensor



Two Op Amp Instrumentation Amplifier



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

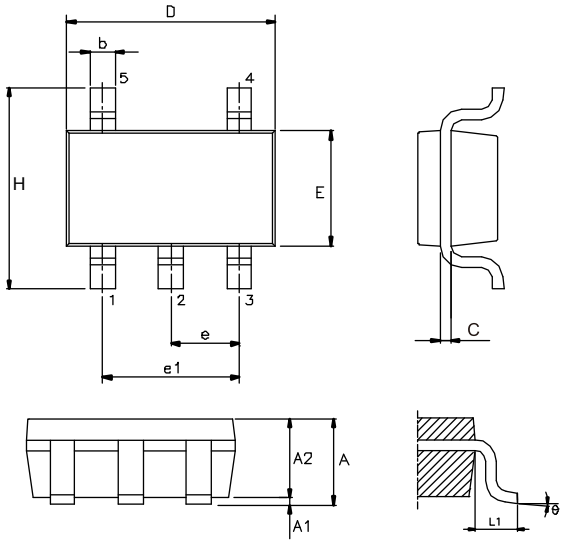
Package Information

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 Meterials Information
- Carton information

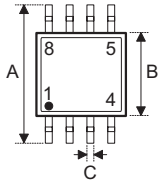
5-pin SOT23-5 Outline Dimensions

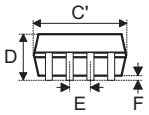


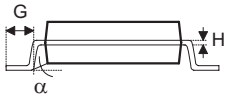
Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	—	—	0.057
A1	—	—	0.006
A2	0.035	0.045	0.051
b	0.012	—	0.020
C	0.003	—	0.009
D	—	0.114 BSC	—
E	—	0.063 BSC	—
e	—	0.037 BSC	—
e1	—	0.075 BSC	—
H	—	0.110 BSC	—
L1	—	0.024 BSC	—
θ	0°	—	8°

Symbol	Dimensions in mm		
	Min.	Nom.	Max.
A	—	—	1.45
A1	—	—	0.15
A2	0.90	1.15	1.30
b	0.30	—	0.50
C	0.08	—	0.22
D	—	2.90 BSC	—
E	—	1.60 BSC	—
e	—	0.95 BSC	—
e1	—	1.90 BSC	—
H	—	2.80 BSC	—
L1	—	0.60 BSC	—
θ	0°	—	8°

8-pin SOP (150mil) Outline Dimensions



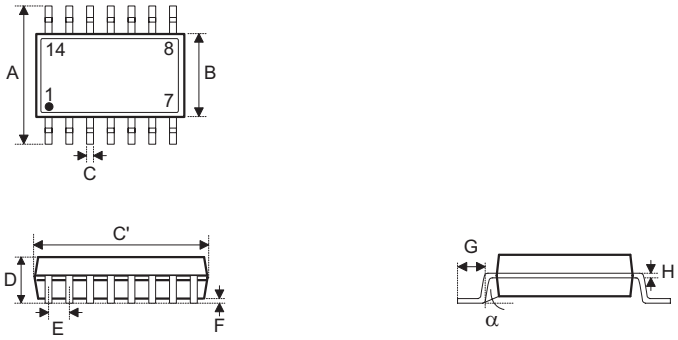




Symbol	Dimensions in inch		
	Min.	Nom.	Max.
A	—	0.236 BSC	—
B	—	0.154 BSC	—
C	0.012	—	0.020
C′	—	0.193 BSC	—
D	—	—	0.069
E	—	0.050 BSC	—
F	0.004	—	0.010
G	0.016	—	0.050
H	0.004	—	0.010
α	0°	—	8°

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°