# CMOS Single-Supply Rail-to-Rail Input/Output Operational Amplifier

## OP150/OP250/OP450



**FEATURES**

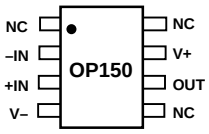
- Single-Supply Operation: 2.7 V to 6 V
- High Output Current: ±250 mA
- Low Supply Current: 600 μA/Amp
- Wide Bandwidth: 4 MHz
- Slew Rate: 6.5 V/μs
- No Phase Reversal
- Low Input Currents
- Unity Gain Stable

**APPLICATIONS**

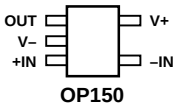
- Battery Powered Instrumentation
- Multi Media Audio
- Medical
- Remote Sensors
- ASIC Input or Output Amplifier
- Automotive
- Headphone Driver

**PIN CONFIGURATIONS**

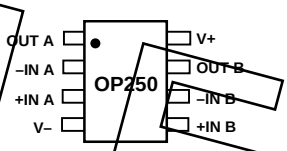
8-Lead Narrow-Body SO
(S Suffix)



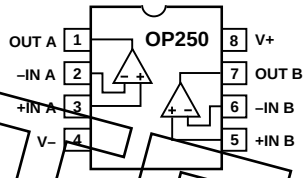

5-Lead SOT23-5
(RT Suffix)



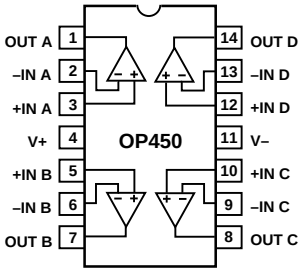

8-Lead Narrow-Body SO
(S Suffix)



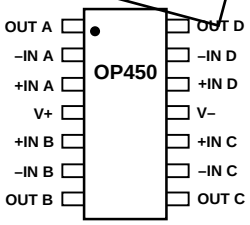

8 Lead Epoxy DIP
(P Suffix)



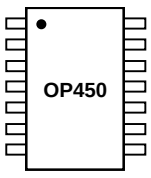

14-Lead Epoxy DIP
(P Suffix)




14-Lead SO
(S Suffix)




14-Lead
TSSOP
(RU Suffix)




**GENERAL DESCRIPTION**

The OP150, OP250 and OP450 are single, dual and quad *CMOS* single-supply, 4 MHz bandwidth amplifiers featuring *rail-to-rail inputs and outputs.* All are guaranteed to operate from a *3 volt single supply* as well as a +5 volt supply.

The OP150 family of amplifiers have very low input bias currents. The outputs are capable of driving 250 mA loads and are stable with capacitive loads as high as 500 pF.

Applications for these amplifiers include portable medical equipment, safety and security, and interface for transducers with high output impedances.

Supply current is only 600 μA per amplifier.

The ability to swing rail-to-rail at both the input and output enables designers to build multistage filters in single-supply systems and maintain high signal-to-noise ratios.

The OP150/OP250/OP450 are specified over the extended industrial (-40°C to +125°C) temperature range. The OP150 single amplifiers are available in 8-pin SO surface mount and the 5-pin SOT23-5 packages. The OP250 dual is available in 8-pin plastic DIPs and SO surface mount packages. The OP450 quad is available in 14-pin DIPs, TSSOP and narrow 14-pin SO packages. Consult factory for TSSOP availability.



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# OP150/OP250/OP450–SPECIFICATIONS

## ELECTRICAL CHARACTERISTICS (@ $V_S$ = +3.0 V, $V_{CM}$ = 0.05 V, $V_O$ = 1.4 V, $T_A$ = +25°C, unless otherwise noted)

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| INPUT CHARACTERISTICS | | | | | | |
| Offset Voltage OP150 | $V_{OS}$ | | | | 5 | mV |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | | mV |
| Offset Voltage OP250/OP450 | $V_{OS}$ | | | | 5 | mV |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | | mV |
| Input Bias Current | $I_B$ | | | 10 | 60 | pA |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | | pA |
| Input Offset Current | $I_{OS}$ | | | 25 | | pA |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | | pA |
| Input Voltage Range | | | 0 | | 3 | V |
| Common-Mode Rejection Ratio | CMRR | $V_{CM}$ = 0 V to 3 V | 60 | | | dB |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | | dB |
| Large Signal Voltage Gain | $A_{VO}$ | $R_L$ = 10 kΩ, $V_O$ = 0.3 V to 2.7 V | | 40 | | V/mV |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | | V/mV |
| Large Signal Voltage Gain | $A_{VO}$ | $R_L$ = 2 kΩ, $V_O$ = 0.3 V to 2.7 V | | 16 | | V/mV |
| Large Signal Voltage Gain | $A_{VO}$ | $R_L$ = 1 kΩ, $V_O$ = 0.3 V to 2.7 V | | 10 | | V/mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | | | | | µV/°C |
| Bias Current Drift | $\Delta I_B/\Delta T$ | | | | | pA/°C |
| Offset Current Drift | $\Delta I_{OS}/\Delta T$ | | | | | pA/°C |
| OUTPUT CHARACTERISTICS | | | | | | |
| Output Voltage High | $V_{OH}$ | $I_L$ = 100 µA | 2.95 | 2.99 | | V |
| | | –40°C to +125°C | | | | V |
| | | $I_L$ = 10 mA | | 2.95 | | V |
| | | –40°C to +125°C | | | | V |
| Output Voltage Low | $V_{OL}$ | $I_L$ = 100 µA | | 2 | 10 | mV |
| | | –40°C to +125°C | | | | mV |
| | | $I_L$ = 10 mA | | 30 | 55 | mV |
| | | –40°C to +125°C | | | | mV |
| Output Current | $I_{OUT}$ | | | ±250 | | mA |
| | | –40°C to +125°C | | | | mA |
| Open Loop Impedance | $Z_{OUT}$ | f = 1 MHz, $A_V$ = 1 | | | | Ω |
| POWER SUPPLY | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S$ = 2.7 V to 6 V | 70 | | | dB |
| | | –40°C ≤ $T_A$ ≤ +125°C | 68 | | | dB |
| Supply Current/Amplifier | $I_{SY}$ | $V_O$ = 0 V | | 500 | 600 | µA |
| | | –40°C ≤ $T_A$ ≤ +125°C | | 650 | | µA |
| DYNAMIC PERFORMANCE | | | | | | |
| Slew Rate | SR | $R_L$ =10 kΩ | | 2.7 | | V/µs |
| Settling Time | $t_S$ | To 0.01% | | | | µs |
| Gain Bandwidth Product | GBP | | | 2 | | MHz |
| Phase Margin | Øo | | | 75 | | Degrees |
| Channel Separation | CS | f = 1 kHz, $R_L$ =10 kΩ | | | | dB |
| NOISE PERFORMANCE | | | | | | |
| Voltage Noise | $e_n$ p-p | 0.1 Hz to 10 Hz | | | | µV p-p |
| Voltage Noise Density | $e_n$ | f = 1 kHz | | 55 | | nV/√Hz |
| Current Noise Density | $i_n$ | | | | | pA/√Hz |

Specifications subject to change without notice.

## ELECTRICAL CHARACTERISTICS (@ $V_S$ = +5.0 V, $V_{CM}$ = 0.05 V, $V_O$ = 1.4 V, $T_A$ = +25°C, unless otherwise noted)

| Parameter | Symbol | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| INPUT CHARACTERISTICS | | | | | | |
| Offset Voltage OP150 | $V_{OS}$ | | | | 5 | mV |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | | mV |
| Offset Voltage OP250/OP450 | $V_{OS}$ | | | | 5 | mV |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | | mV |
| Input Bias Current | $I_B$ | | | 30 | 50 | pA |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | 60 | pA |
| Input Offset Current | $I_{OS}$ | | | 0.1 | 8 | pA |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | 16 | pA |
| Input Voltage Range | | | 0 | | 5 | V |
| Common-Mode Rejection Ratio | CMRR | $V_{CM}$ = 0 V to 5 V | 60 | | | dB |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | | dB |
| Large Signal Voltage Gain | $A_{VO}$ | $R_L$ = 10 kΩ, $V_O$ = 0.3 V to 4.7 V | | 40 | | V/mV |
| | | –40°C ≤ $T_A$ ≤ +125°C | | | | V/mV |
| Large Signal Voltage Gain | $A_{VO}$ | $R_L$ = 2 kΩ, $V_O$ = 0.3 V to 2.7 V | | 16 | | V/mV |
| Large Signal Voltage Gain | $A_{VO}$ | $R_L$ = 1 kΩ, $V_O$ = 0.3 V to 2.7 V | | 10 | | V/mV |
| Offset Voltage Drift | $\Delta V_{OS}/\Delta T$ | –40°C ≤ $T_A$ ≤ +125°C | | 1.5 | | µV/°C |
| Bias Current Drift | $\Delta I_B/\Delta T$ | | | 100 | | pA/°C |
| Offset Current Drift | $\Delta I_{OS}/\Delta T$ | | | 20 | | pA/°C |
| OUTPUT CHARACTERISTICS | | | | | | |
| Output Voltage High | $V_{OH}$ | $I_L$ = 100 µA | | 4.99 | | V |
| | | –40°C to +125°C | | | | V |
| | | $I_L$ = 10 mA | | 4.95 | | V |
| | | –40°C to +125°C | | | | V |
| Output Voltage Low | $V_{OL}$ | $I_L$ = 100 µA | | 2 | | mV |
| | | –40°C to +125°C | | | | mV |
| | | $I_L$ = 10 mA | | 30 | | mV |
| | | –40°C to +125°C | | | | mV |
| Output Current | $I_{OUT}$ | | | ±250 | | mA |
| | | –40°C to +125°C | | | | mA |
| Open Loop Impedance | $Z_{OUT}$ | f = 1 MHz, $A_V$ = 1 | | | | Ω |
| POWER SUPPLY | | | | | | |
| Power Supply Rejection Ratio | PSRR | $V_S$ = 2.7 V to 6 V | 75 | | | dB |
| | | –40°C ≤ $T_A$ ≤ +125°C | 70 | | | dB |
| Supply Current/Amplifier | $I_{SY}$ | $V_O$ = 0 V | | | | µA |
| | | –40°C ≤ $T_A$ ≤ +125°C | | 550 | 650 | µA |
| DYNAMIC PERFORMANCE | | | | | | |
| Slew Rate | SR | $R_L$ =10 kΩ | | 6.5 | | V/µs |
| Full Power Bandwidth | $BW_p$ | 1% Distortion | | | | kHz |
| Settling Time | $t_S$ | To 0.01% | | | | µs |
| Gain Bandwidth Product | GBP | | | 4 | | MHz |
| Phase Margin | Øo | | | 75 | | Degrees |
| Channel Separation | CS | f = 1 kHz, $R_L$ =10 kΩ | | | | dB |
| NOISE PERFORMANCE | | | | | | |
| Voltage Noise | $e_n$ p-p | 0.1 Hz to 10 Hz | | | | µV p-p |
| Voltage Noise Density | $e_n$ | f = 1 kHz | | 55 | | nV/√Hz |
| Voltage Noise Density | $e_n$ | f = 10 kHz | | 35 | | nV/√Hz |
| Current Noise Density | $i_n$ | | | | | pA/√Hz |

Specifications subject to change without notice.

## WAFER TEST LIMITS (@ $V_S$ = +5.0 V, $V_{CM}$ = 0 V, $T_A$ = +25°C unless otherwise noted.)

| Parameter | Symbol | Conditions | Limit | Units |
|---|---|---|---|---|
| Offset Voltage | $V_{OS}$ | | ±10 | mV max |
| Input Bias Current | $I_B$ | | 50 | pA max |
| Input Offset Current | $I_{OS}$ | | 10 | pA max |
| Input Voltage Range | $V_{CM}$ | | V– to V+ | V min |
| Common-Mode Rejection Ratio | CMRR | $V_{CM}$ = 0 V to 10 V | 60 | dB min |
| Power Supply Rejection Ratio | PSRR | V = +2.7 V to +7 V | 70 | dB min |
| Large Signal Voltage Gain | $A_{VO}$ | $R_L$ = 10 kΩ | | V/mV min |
| Output Voltage High | $V_{OH}$ | $R_L$ = 2 kΩ to GND | 2.9 | V min |
| Output Voltage Low | $V_{OL}$ | $R_L$ = 2 kΩ to V+ | 55 | mV max |
| Supply Current/Amplifier | $I_{SY}$ | $V_O$ = 0 V, $R_L$ = ∞ | 650 | µA max |

NOTE
Electrical tests and wafer probe to the limits shown. Due to variations in assembly methods and normal yield loss, yield after packaging is not guaranteed for standard product dice. Consult factory to negotiate specifications based on dice lot qualifications through sample lot assembly and testing.



**ABSOLUTE MAXIMUM RATINGS**[1]

Supply Voltage . . . . . +7 V
Input Voltage . . . . . GND to $V_S$
Differential Input Voltage . . . . . 7 V
Output Short-Circuit Duration to GND[2] . . . . . Indefinite
Storage Temperature Range
P, S, RT, RU Package . . . . . –65°C to +150°C
Operating Temperature Range
OP150/OP250/OP450G . . . . . –40°C to +125°C
Junction Temperature Range
P, S, RT, RU Package . . . . . –65°C to +150°C
Lead Temperature Range (Soldering, 60 sec) . . . . . +300°C

| Package Type | $\theta_{JA}$[3] | $\theta_{JC}$ | Units |
|---|---|---|---|
| 5-Pin SOT (RT) | 325 | | °C/W |
| 8-Pin Plastic DIP (P) | 103 | 43 | °C/W |
| 8-Pin SOIC (S) | 158 | 43 | °C/W |
| 8-Pin TSSOP (RU) | 240 | 43 | °C/W |
| 14-Pin Plastic DIP (P) | 76 | 33 | °C/W |
| 14-Pin SOIC (S) | 120 | 36 | °C/W |
| 14-Pin TSSOP( RU) | 180 | 35 | °C/W |

NOTES
[1]Absolute maximum ratings apply to both DICE and packaged parts, unless otherwise noted.
[2]$\theta_{JA}$ is specified for the worst case conditions, i.e., $\theta_{JA}$ is specified for device in socket for P-DIP packages; $\theta_{JA}$ is specified for device soldered in circuit board for SOIC package.

**ORDERING GUIDE**

| Model | Temperature Range | Package Option |
|---|---|---|
| OP150GS | –40°C to +125°C | 8-Pin SOIC |
| OP150GRT | –40°C to +125°C | 5-Pin SOT |
| OP150GBC | +25°C | DICE |
| OP250GP | –40°C to +125°C | 8-Pin Plastic DIP |
| OP250GS | –40°C to +125°C | 8-Pin SOIC |
| OP250GRU | –40°C to +125°C | 8-Pin TSSOP |
| OP250GBC | +25°C | DICE |
| OP450GP | –40°C to +125°C | 14-Pin Plastic DIP |
| OP450GS | –40°C to +125°C | 14-Pin SOIC |
| OP450GRU | –40°C to +125°C | 14-Pin TSSOP |
| OP450GBC | +25°C | DICE |

**CAUTION**

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the OP150/OP250/OP450 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.

**DICE CHARACTERISTICS**

*OP150 Die Size 0.00 × 0.00 Inch, 00 Sq. Mils*
*Substrate (Die Backside) Is Connected to V–*
*Transistor Count, 00.*
*OP250 Die Size 0.044 × 0.045 Inch, 1,980 Sq. Mils*
*Substrate (Die Backside) Is Connected to V–*
*Transistor Count, 0.*
*OP450 Die Size 0.052 × 0.058 Inch, 3,016 Sq. Mils*
*Substrate (Die Backside) Is Connected to V–*
*Transistor Count, 127.*

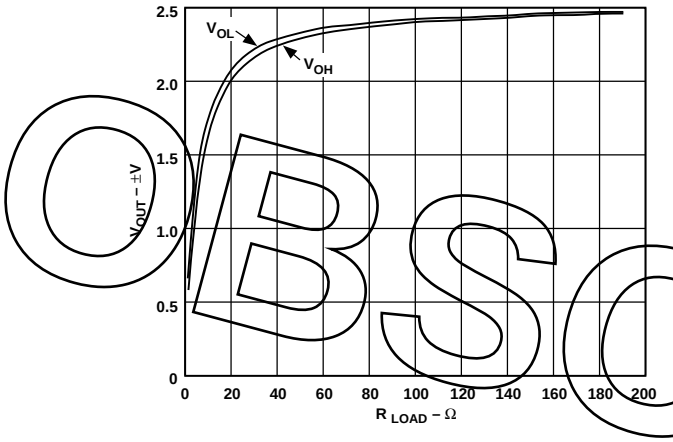


*Figure 1. $\pm V_{OUT}$ vs. $R_{LOAD}$*