

Low power dual operational amplifier

Features

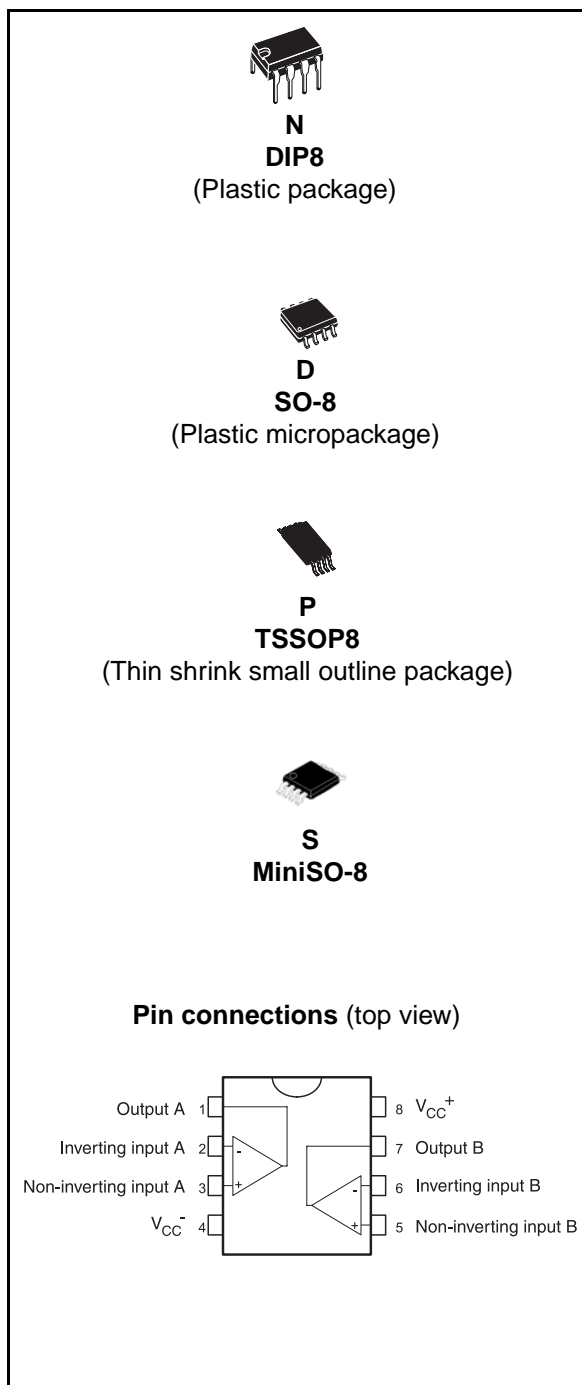
- Internally frequency compensated
- Large DC voltage gain: 100 dB
- Wide bandwidth (unity gain): 1.1 MHz (temperature compensated)
- Very low supply current/op (500 μ A) essentially independent of supply voltage
- Low input bias current: 20 nA (temperature compensated)
- Low input offset current: 2 nA
- Input common-mode voltage range includes negative rail
- Differential input voltage range equal to the power supply voltage
- Large output voltage swing 0 V to ($V_{CC}^+ - 1.5$ V)

Description

This circuit consists of two independent, high gain, internally frequency compensated operational amplifiers which were designed specifically for automotive and industrial control system. It operates from a single power supply over a wide range of voltages. The low power supply drain is independent of the magnitude of the power supply voltage.

Application areas include transducer amplifiers, DC gain blocks and all the conventional op-amp circuits which now can be more easily implemented in single power supply systems. For example, these circuits can be directly supplied from the standard +5 V which is used in logic systems and will easily provide the required interface electronics without requiring any additional power supply.

In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to ground, even though operated from a single power supply.



2 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings (AMR)

| Symbol | Parameter | Value | Unit |
|------------|---|-------------|------|
| V_{CC} | Supply voltage ⁽¹⁾ | ±16 or 32 | V |
| V_{id} | Differential input voltage ⁽²⁾ | ±32 | V |
| V_{in} | Input voltage | -0.3 to 32 | V |
| | Output short-circuit duration ⁽³⁾ | Infinite | s |
| I_{in} | Input current ⁽⁴⁾ | 50 | mA |
| T_{oper} | Operating free-air temperature range | -40 to +125 | °C |
| T_{stg} | Storage temperature range | -65 to +150 | °C |
| T_j | Maximum junction temperature | 150 | °C |
| R_{thja} | Thermal resistance junction to ambient ⁽⁵⁾ | | °C/W |
| | SO-8 | 125 | |
| | TSSOP8 | 120 | |
| | DIP8 | 85 | |
| R_{thjc} | Thermal resistance junction to case ⁽⁵⁾ | | °C/W |
| | SO-8 | 40 | |
| | TSSOP8 | 37 | |
| | DIP8 | 41 | |
| ESD | HBM: human body model ⁽⁶⁾ | 300 | V |
| | MM: machine model ⁽⁷⁾ | 200 | V |
| | CDM: charged device model ⁽⁸⁾ | 1.5 | kV |

1. All voltage values, except differential voltage are with respect to network ground terminal.
2. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
3. Short-circuits from the output to V_{CC} can cause excessive heating if $V_{cc}^+ > 15 V$. The maximum output current is approximately 40 mA, independent of the magnitude of V_{CC} . Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
4. This input current only exists when the voltage at any of the input leads is driven negative. It is due to the collector-base junction of the input PNP transistor becoming forward biased and thereby acting as input diodes clamps. In addition to this diode action, there is also NPN parasitic action on the IC chip. This transistor action can cause the output voltages of the op-amps to go to the V_{CC} voltage level (or to ground for a large overdrive) for the time duration than an input is driven negative. This is not destructive and normal output will set up again for input voltage higher than -0.3 V.
5. Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
6. Human body model: A 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 kΩ resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
7. Machine model: A 200 pF capacitor is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω). This is done for all couples of connected pin combinations while the other pins are floating.
8. Charged device model: all pins and the package are charged together to the specified voltage and then discharged directly to the ground through only one pin. This is done for all pins.

Table 2. Operating conditions

| Symbol | Parameter | Value | Unit |
|------------|--------------------------------------|------------------|------|
| V_{CC} | Supply voltage | 3 to 30 | V |
| V_{icm} | Common mode input voltage range | $V_{CC}^+ - 1.5$ | V |
| T_{oper} | Operating free-air temperature range | -40 to +125 | °C |

3 Electrical characteristics

Table 3. $V_{CC}^+ = 5V$, $V_{CC}^- = \text{Ground}$, $V_O = 1.4V$, $T_{\text{amb}} = 25^\circ\text{C}$ (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---------------------|--|----------------------|----------|------------------------------------|------------------------------|
| V_{io} | Input offset voltage ⁽¹⁾ $T_{\text{amb}} = 25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | | 2 | 7 9 | mV |
| DV_{io} | Input offset voltage drift | | 7 | 30 | $\mu\text{V}/^\circ\text{C}$ |
| I_{io} | Input offset current $T_{\text{amb}} = 25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | | 2 | 30 40 | nA |
| DI_{io} | Input offset current drift | | 10 | 300 | $\text{pA}/^\circ\text{C}$ |
| I_{ib} | Input bias current ⁽²⁾ $T_{\text{amb}} = 25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | | 20 | 150 200 | nA |
| A_{vd} | Large signal voltage gain $V_{CC}^+ = +15V, R_L = 2\text{k}\Omega, V_O = 1.4V \text{ to } 11.4V$ $T_{\text{amb}} = 25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 50 25 | 100 | | V/mV |
| SVR | Supply voltage rejection ratio ($R_S \leq 10\text{k}\Omega$) $T_{\text{amb}} = 25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 65 65 | 100 | | dB |
| I_{CC} | Supply current, all amp, no load $T_{\text{amb}} = 25^\circ\text{C}, V_{CC}^+ = +5V$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}, V_{CC}^+ = +30V$ | | 0.7 | 1.2 2 | mA |
| V_{icm} | Input common mode voltage range ($V_{CC}^+ = +30V$) ⁽³⁾ $T_{\text{amb}} = 25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 0 0 | | $V_{CC}^+ - 1.5$ $V_{CC}^+ - 2$ | V |
| CMR | Common-mode rejection ratio ($R_S = 10\text{k}\Omega$) $T_{\text{amb}} = 25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 70 60 | 85 | | dB |
| I_{source} | Output short-circuit current $V_{CC}^+ = +15V, V_O = +2V, V_{id} = +1V$ | 20 | 40 | 60 | mA |
| I_{sink} | Output sink current $V_O = 2V, V_{CC}^+ = +5V$ $V_O = +0.2V, V_{CC}^+ = +15V$ | 10 12 | 20 50 | | mA μA |
| V_{OH} | High level output voltage ($V_{CC}^+ = +30V$) $T_{\text{amb}} = +25^\circ\text{C}, R_L = 2\text{k}\Omega$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ $T_{\text{amb}} = +25^\circ\text{C}, R_L = 10\text{k}\Omega$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 26 26 27 27 | 27 28 | | V |
| V_{OL} | Low level output voltage ($R_L = 10\text{k}\Omega$) $T_{\text{amb}} = +25^\circ\text{C}$ $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | | 5 | 20 20 | mV |

Table 3. $V_{CC}^+ = 5V$, $V_{CC}^- = \text{Ground}$, $V_O = 1.4V$, $T_{\text{amb}} = 25^\circ\text{C}$ (unless otherwise specified)

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|-----------------|---|------------|------|------|------------------------|
| SR | Slew rate $V_{CC}^+ = 15V$, $V_{\text{in}} = 0.5$ to $3V$, $R_L = 2k\Omega$, $C_L = 100\text{pF}$, unity gain $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 0.3 0.2 | 0.6 | | V/ μs |
| GBP | Gain bandwidth product $f = 100\text{kHz}$ $V_{CC}^+ = 30V$, $V_{\text{in}} = 10\text{mV}$, $R_L = 2k\Omega$, $C_L = 100\text{pF}$ | 0.7 | 1.1 | | MHz |
| THD | Total harmonic distortion $f = 1\text{kHz}$, $A_V = 20\text{dB}$, $R_L = 2k\Omega$, $V_O = 2V_{\text{pp}}$, $C_L = 100\text{pF}$, $V_{CC}^+ = 30V$ | | 0.02 | | % |
| e_n | Equivalent input noise voltage $f = 1\text{kHz}$, $R_S = 100\Omega$, $V_{CC}^+ = 30V$ | | 55 | | nV/ $\sqrt{\text{Hz}}$ |
| V_{O1}/V_{O2} | Channel separation ⁽⁴⁾ $1\text{kHz} \leq f \leq 20\text{kHz}$ | | 120 | | dB |

- $V_O = 1.4V$, $R_S = 0\Omega$, $5V < V_{CC}^+ < 30V$, $0V < V_{\text{ic}} < V_{CC}^+ - 1.5V$.
- The direction of the input current is out of the IC. This current is essentially constant, independent of the state of the output, so there is no change in the loading charge on the input lines.
- The input common-mode voltage of either input signal voltage should not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is $V_{CC}^+ - 1.5V$, but either or both inputs can go to +32 V without damage.
- Due to the proximity of external components ensure that stray capacitance does not cause coupling between these external parts. This typically can be detected at higher frequencies because this type of capacitance increases.

5.1 DIP8 package information

Figure 26. DIP8 package mechanical drawing

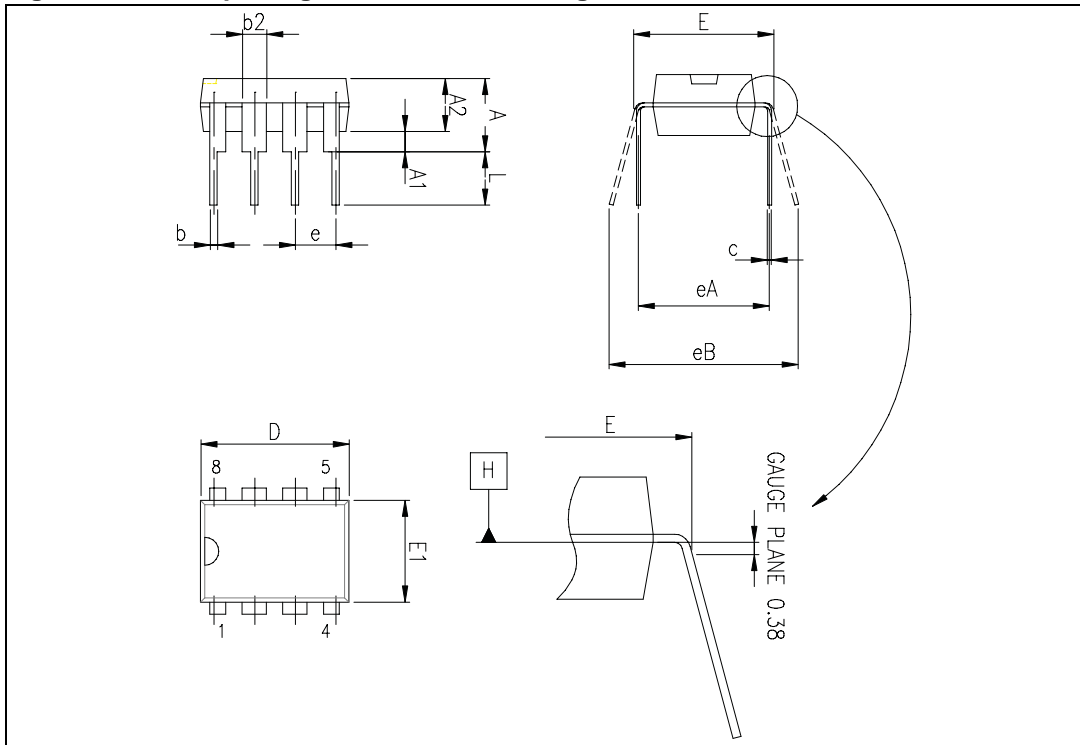


Table 4. DIP8 package mechanical data

| Ref. | Dimensions | | | | | |
|------|-------------|------|-------|--------|-------|-------|
| | Millimeters | | | Inches | | |
| | Min. | Typ. | Max. | Min. | Typ. | Max. |
| A | | | 5.33 | | | 0.210 |
| A1 | 0.38 | | | 0.015 | | |
| A2 | 2.92 | 3.30 | 4.95 | 0.115 | 0.130 | 0.195 |
| b | 0.36 | 0.46 | 0.56 | 0.014 | 0.018 | 0.022 |
| b2 | 1.14 | 1.52 | 1.78 | 0.045 | 0.060 | 0.070 |
| c | 0.20 | 0.25 | 0.36 | 0.008 | 0.010 | 0.014 |
| D | 9.02 | 9.27 | 10.16 | 0.355 | 0.365 | 0.400 |
| E | 7.62 | 7.87 | 8.26 | 0.300 | 0.310 | 0.325 |
| E1 | 6.10 | 6.35 | 7.11 | 0.240 | 0.250 | 0.280 |
| e | | 2.54 | | | 0.100 | |
| eA | | 7.62 | | | 0.300 | |
| eB | | | 10.92 | | | 0.430 |
| L | 2.92 | 3.30 | 3.81 | 0.115 | 0.130 | 0.150 |

6 Ordering information

Table 8. Order codes

| Order code | Temperature range | Package | Packing | Marking |
|---|-------------------|---|------------------------|---------|
| LM2904N | -40°C to +125°C | DIP8 | Tube | LM2904N |
| LM2904D/DT | | SO-8 | Tube or tape & reel | 2904 |
| LM2904PT | | TSSOP8 (Thin shrink outline package) | Tape & reel | |
| LM2904ST | | MiniSO-8 | Tape & reel | K403 |
| LM2904YD ⁽¹⁾ LM2904YDT ⁽¹⁾ | | SO-8 (Automotive grade level) | Tube or tape & reel | 2904Y |
| LM2904YPT ⁽²⁾ | | TSSOP8 (Automotive grade level) | Tape & reel | |
| LM2904YST ⁽²⁾ | | MiniSO-8 (Automotive grade level) | Tape & reel | K409 |

1. Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent.
2. Qualification and characterization according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent are on-going.