

## Low-power dual operational amplifier



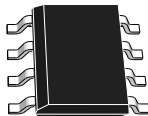
DFN8 2x2



MiniSO8



TSSOP8



SO8

### Features

- Frequency compensation implemented internally
- Large DC voltage gain: 100 dB
- Wide bandwidth (unity gain): 1.1 MHz (temperature compensated)
- Very low supply current/amplifier, 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 operational amplifiers (op amps) that have frequency compensation implemented internally. They are designed specifically for automotive and industrial control systems. The circuit 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 can now 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 easily provides the required electronic interfaces without requiring any additional power supply.

In 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.

| Maturity status link |                   |              |
|----------------------|-------------------|--------------|
|                      | Enhanced $V_{IO}$ | Enhanced ESD |
| LM2904               |                   |              |
| LM2904A              | ✓                 |              |
| LM2904W              |                   | ✓            |
| LM2904AW             | ✓                 | ✓            |

| Related products     |  |
|----------------------|--|
| TSB572               | Dual op-amps for low-power consumption<br>(380 $\mu$ A with 2.5 MHz GBP) |
| LM2902<br>LM2902W    | Quad op-amps version   |
| LM2904WH<br>LM2904AH | High temperature version (150 °C)  |

# 1 Schematic diagram

Figure 1. Schematic diagram (LM2904, LM2904A)

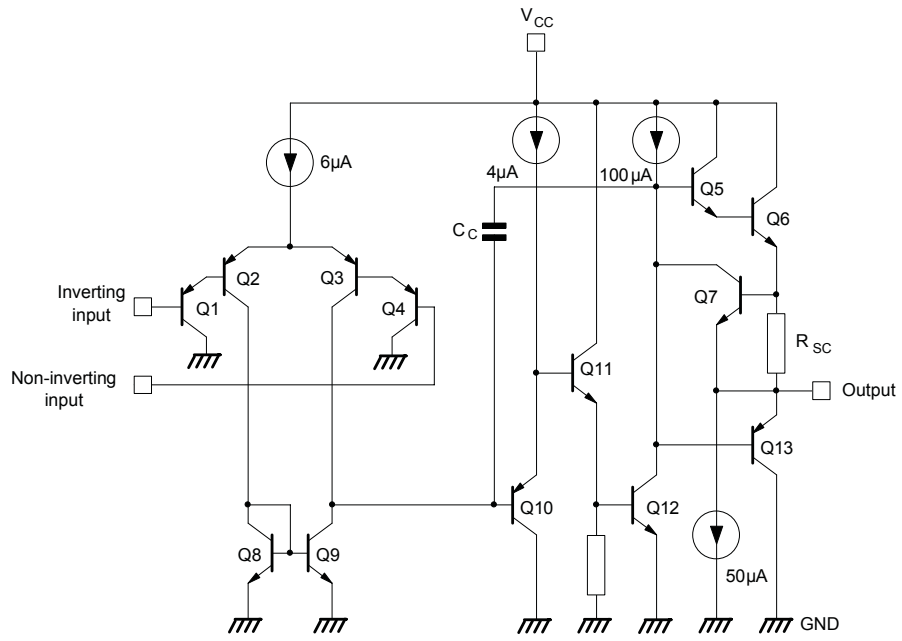
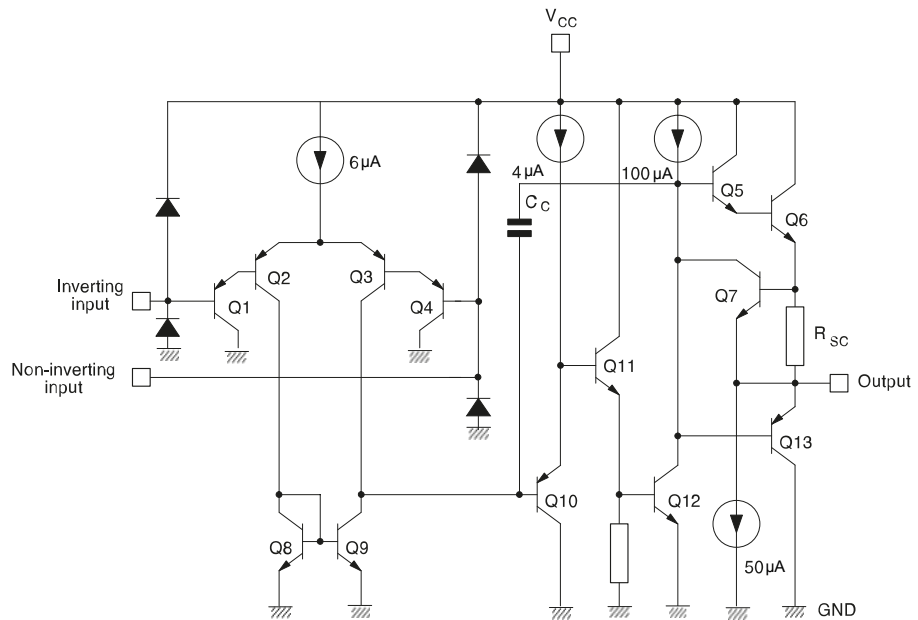


Figure 2. Schematic diagram (LM2904W, LM2904AW)



## 2 Package pin connections

Figure 3. DFN8 2x2 package pin connections (top view)



1. The exposed pad of the DFN8 2x2 can be connected to (VCC-) or left floating.

Figure 4. MiniSO8, TSSOP8, and SO8 package pin connections (top view)



### 3 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol     | Parameter   | Value   | Unit |      |
|------------|---|---|------|------|
| $V_{CC}$   | Supply voltage <sup>(1)</sup>   | $\pm 16$ or 32  | V    |      |
| $V_{id}$   | Differential input voltage (LM2904, LM2904A) <sup>(2)</sup>             | $\pm 32$  |      |      |
|            | Differential input voltage (LM2904W, LM2904AW) <sup>(2)</sup>           | -0.3 to $V_{CC} + 0.3$                                  |      |      |
| $V_{in}$   | Input voltage (LM2904, LM2904A)   | -0.3 to 32  |      |      |
|            | Input voltage (LM2904W, LM2904AW)                                       | -0.3 to $V_{CC} + 0.3$                                  |      |      |
|            | Output short-circuit duration <sup>(3)</sup>                            | Infinite  | s    |      |
| $I_{in}$   | Input current : $V_{in}$ driven negative                                | 5 mA in DC or 50 mA in AC, (duty cycle = 10 %, T = 1 s) | mA   |      |
|            | Input current : $V_{in}$ driven positive above AMR value <sup>(5)</sup> | 0.4   |      |      |
| $T_{oper}$ | Operating free-air temperature range                                    | -40 to 125  | °C   |      |
| $T_{stg}$  | Storage temperature range   | -65 to 150  |      |      |
| $T_j$      | Maximum junction temperature  | 150   |      |      |
| $R_{thja}$ | Thermal resistance junction to ambient <sup>(6)</sup>                   | DFN8 2x2  | 57   | °C/W |
|            |   | MiniSO8   | 190  |      |
|            |   | TSSOP8  | 120  |      |
|            |   | SO8   | 125  |      |
| $R_{thjc}$ | Thermal resistance junction to case <sup>(6)</sup>                      | MiniSO8   | 39   |      |
|            |   | TSSOP8  | 37   |      |
|            |   | SO8   | 40   |      |
| ESD        | HBM: human body model (LM2904, LM2904A) <sup>(7)</sup>                  | 300   | V    |      |
|            | HBM: human body model (LM2904W, LM2904AW) <sup>(7)</sup>                | 2000  |      |      |
|            | MM: machine model <sup>(8)</sup>  | 200   |      |      |
|            | CDM: charged device model <sup>(9)</sup>                                | 1.5   | kV   |      |

- All voltage values, except differential voltage are with respect to network ground terminal.
- Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
- 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.
- 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 an input diode clamp. In addition to this diode action, there is 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 during which an input is driven negative. This is not destructive and normal output is restored for input voltages above -0.3 V.
- The junction base/substrate of the input PNP transistor polarized in reverse must be protected by a resistor in series with the inputs to limit the input current to 400  $\mu$ A max ( $R = (V_{in} - 32 V)/400 \mu$ A).
- Short-circuits can cause excessive heating and destructive dissipation. Values are typical.
- Human body model: a 100 pF capacitor is charged to the specified voltage, then discharged through a 1.5 k $\Omega$  resistor between two pins of the device. This is done for all couples of connected pin combinations while the other pins are floating.
- 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  $\Omega$ ). This is done for all couples of connected pin combinations while the other pins are floating.

9. *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 $T_{amb} = 25\text{ }^{\circ}\text{C}$ | $V_{CC-}$ to $V_{CC+} - 1.5$ |                    |
|            | Common mode input voltage range $T_{min} \leq T_{amb} \leq T_{max}$    | $V_{CC-}$ to $V_{CC+} - 2$   |                    |
| $T_{oper}$ | Operating free-air temperature range                                   | -40 to 125                   | $^{\circ}\text{C}$ |

## 4 Electrical characteristics

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

| Symbol                   | Parameter   | Min. | Typ. | Max. | Unit                         |
|--------------------------|---|------|------|------|------------------------------|
| $V_{io}$                 | Input offset voltage, $T_{\text{amb}} = 25\text{ }^\circ\text{C}$ , LM2904, LM2904W <sup>(1)</sup>  |      | 2    | 7    | mV                           |
|                          | Input offset voltage, $T_{\text{amb}} = 25\text{ }^\circ\text{C}$ , LM2904A, LM2904AW <sup>(1)</sup>  |      | 1    | 2    |                              |
|                          | Input offset voltage, $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ , LM2904, LM2904W <sup>(1)</sup>   |      |      | 9    |                              |
|                          | Input offset voltage, $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ , LM2904A, LM2904AW <sup>(1)</sup>   |      |      | 4    |                              |
| $\Delta V_{io}/\Delta T$ | Input offset voltage drift  |      | 7    | 30   | $\mu\text{V}/^\circ\text{C}$ |
| $I_{io}$                 | Input offset current, $T_{\text{amb}} = 25\text{ }^\circ\text{C}$   |      | 2    | 30   | nA                           |
|                          | Input offset current, $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$  |      |      | 40   |                              |
| $\Delta I_{io}/\Delta T$ | Input offset current drift  |      | 10   | 300  | $\text{pA}/^\circ\text{C}$   |
| $I_{ib}$                 | Input bias current, $T_{\text{amb}} = 25\text{ }^\circ\text{C}$ <sup>(2)</sup>  |      | 20   | 150  | nA                           |
|                          | Input bias current, $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ <sup>(2)</sup>   |      |      | 200  |                              |
| $A_{vd}$                 | Large signal voltage gain, $V_{CC+} = 15\text{ V}$ , $R_L = 2\text{ k}\Omega$ ,<br>$V_O = 1.4\text{ V}$ to $11.4\text{ V}$ , $T_{\text{amb}} = 25\text{ }^\circ\text{C}$              | 50   | 100  |      | V/mV                         |
|                          | Large signal voltage gain, $V_{CC+} = 15\text{ V}$ , $R_L = 2\text{ k}\Omega$ ,<br>$V_O = 1.4\text{ V}$ to $11.4\text{ V}$ , $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ | 25   |      |      |                              |
| SVR                      | Supply voltage rejection ratio, $V_{CC+} = 5\text{ V}$ to $30\text{ V}$ , $V_{icm} = 0\text{ V}$ ,<br>$T_{\text{amb}} = 25\text{ }^\circ\text{C}$                                     | 65   | 100  |      | dB                           |
|                          | Supply voltage rejection ratio, $V_{CC+} = 5\text{ V}$ to $30\text{ V}$ , $V_{icm} = 0\text{ V}$ ,<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                        | 65   |      |      |                              |
| $I_{CC}$                 | Supply current, all amp, no load, $T_{\text{amb}} = 25\text{ }^\circ\text{C}$ , $V_{CC+} = 5\text{ V}$  |      | 0.7  | 1.2  | mA                           |
|                          | Supply current, all amp, no load, $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$ , $V_{CC+} = 30\text{ V}$  |      |      | 2    |                              |
| CMR                      | Common-mode rejection ratio, $V_{CC+} = 30\text{ V}$ , $V_{icm} = 0\text{ V}$ to $28.5\text{ V}$ ,<br>$T_{\text{amb}} = 25\text{ }^\circ\text{C}$                                     | 70   | 85   |      | dB                           |
|                          | Common-mode rejection ratio, $V_{CC+} = 30\text{ V}$ , $V_{icm} = 0\text{ V}$ to $28\text{ V}$ ,<br>$T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$                          | 60   |      |      |                              |
| $I_{\text{source}}$      | Output short-circuit current, $V_{CC+} = 15\text{ V}$ , $V_O = 2\text{ V}$ , $V_{id} = 1\text{ V}$  | 20   | 40   | 60   | mA                           |
| $I_{\text{sink}}$        | Output sink current, $V_O = 2\text{ V}$ , $V_{CC+} = 15\text{ V}$   | 10   | 20   |      |                              |
|                          | Output sink current, $V_O = 0.2\text{ V}$ , $V_{CC+} = 15\text{ V}$   | 12   | 50   |      | $\mu\text{A}$                |
| $V_{OH}$                 | High-level output voltage ( $V_{CC+} = 30\text{ V}$ ), $T_{\text{amb}} = 25\text{ }^\circ\text{C}$ , $R_L = 2\text{ k}\Omega$   | 26   |      |      | V                            |
|                          | High-level output voltage ( $V_{CC+} = 30\text{ V}$ ), $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   | 26   | 27   |      |                              |
|                          | High-level output voltage ( $V_{CC+} = 30\text{ V}$ ), $T_{\text{amb}} = 25\text{ }^\circ\text{C}$ , $R_L = 10\text{ k}\Omega$  | 27   |      |      |                              |
|                          | High-level output voltage ( $V_{CC+} = 30\text{ V}$ ), $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$   | 27   | 28   |      |                              |
| $V_{OL}$                 | Low-level output voltage ( $R_L = 10\text{ k}\Omega$ ), $T_{\text{amb}} = 25\text{ }^\circ\text{C}$   |      | 5    | 20   | mV                           |
|                          | Low-level output voltage ( $R_L = 10\text{ k}\Omega$ ), $T_{\text{min}} \leq T_{\text{amb}} \leq T_{\text{max}}$  |      |      | 20   |                              |

| Symbol          | Parameter   | Min. | Typ. | Max. | Unit                   |
|-----------------|---|------|------|------|------------------------|
| SR              | Slew rate, $V_{CC}^+ = 15\text{ V}$ , $V_{in} = 0.5\text{ to }3\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , unity gain, $T_{amb} = 25\text{ }^\circ\text{C}$ | 0.3  | 0.6  |      | V/ $\mu\text{s}$       |
|                 | Slew rate, $V_{CC}^+ = 15\text{ V}$ , $V_{in} = 0.5\text{ to }3\text{ V}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$ , unity gain, $T_{min} \leq T_{amb} \leq T_{max}$  | 0.2  |      |      |                        |
| GBP             | Gain bandwidth product, $f = 100\text{ kHz}$ , $V_{CC}^+ = 30\text{ V}$ , $V_{in} = 10\text{ mV}$ , $R_L = 2\text{ k}\Omega$ , $C_L = 100\text{ pF}$                            | 0.7  | 1.1  |      | MHz                    |
| THD             | Total harmonic distortion, $f = 1\text{ kHz}$ , $A_V = 20\text{ dB}$ , $R_L = 2\text{ k}\Omega$ , $V_o = 2\text{ V}_{pp}$ , $C_L = 100\text{ pF}$ , $V_{CC}^+ = 30\text{ V}$    |      | 0.02 |      | %                      |
| $e_n$           | Equivalent input noise voltage, $f = 1\text{ kHz}$ , $R_S = 100\text{ }\Omega$ , $V_{CC}^+ = 30\text{ V}$   |      | 55   |      | nV/ $\sqrt{\text{Hz}}$ |
| $V_{O1}/V_{O2}$ | Channel separation, $1\text{ kHz} \leq f \leq 20\text{ kHz}$ <sup>(3)</sup>   |      | 120  |      | dB                     |

- $V_O = 1.4\text{ V}$ ,  $5\text{ V} < V_{CC}^+ < 30\text{ V}$ ,  $0\text{ V} < V_{ic} < (V_{CC}^+) - 1.5\text{ V}$
- The direction of the input current is out of the IC. This current is essentially constant as long as the output is not saturated, so there is no change in the loading charge on the input lines.
- Due to the proximity of external components, ensure that the stray capacitance does not cause coupling between these external parts. This can typically be detected at higher frequencies because this type of capacitance increases.

## 5 Electrical characteristic curves

Figure 5. Open-loop frequency response



Figure 6. Large signal frequency response



Figure 7. Voltage follower large signal response



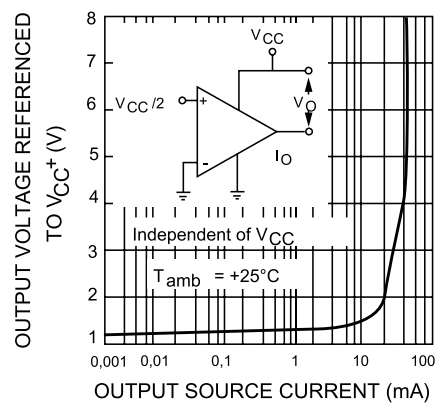
Figure 8. Current sinking output characteristics



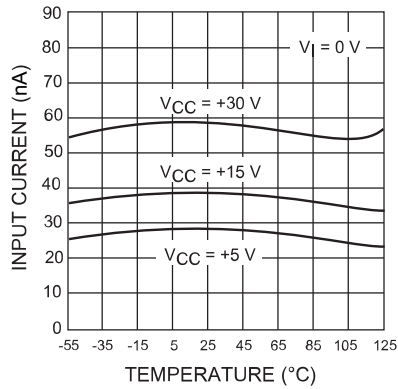
Figure 9. Voltage follower small signal response

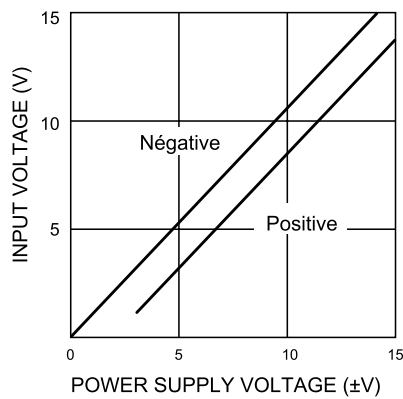


Figure 10. Current sourcing output characteristics





**Figure 11. Input current vs. temperature**

**Figure 12. Current limiting**

**Figure 13. Input voltage range**

**Figure 14. Supply current**

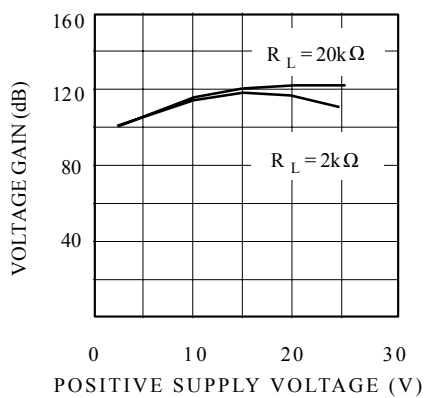
**Figure 15. Voltage gain**

**Figure 16. Input current vs. supply voltage**


Figure 17. Gain bandwidth product

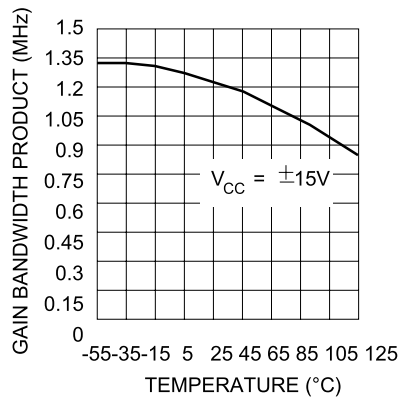


Figure 18. Power supply rejection ratio

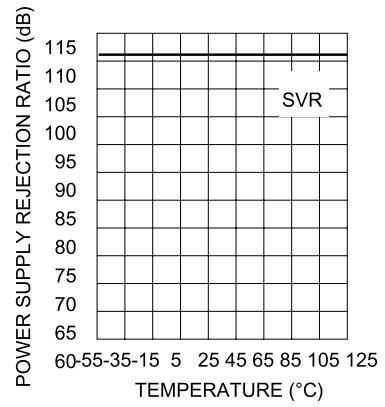


Figure 19. Common-mode rejection ratio



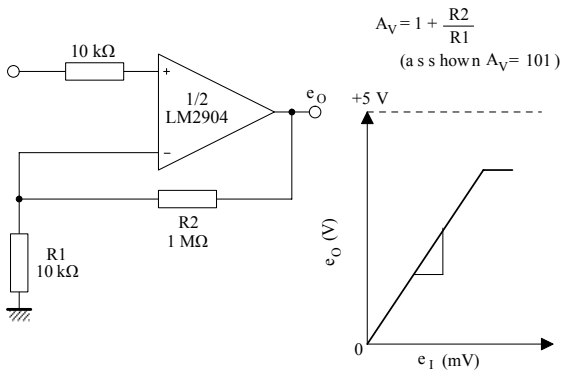
Figure 20. Phase margin vs. capacitive load



## 6 Typical single-supply applications

**Figure 21. AC coupled inverting amplifier**

**Figure 22. AC coupled non-inverting amplifier**

**Figure 23. Non-inverting DC gain**

**Figure 24. DC summing amplifier**

**Figure 25. High input Z, DC differential amplifier**

**Figure 26. Using symmetrical amplifiers to reduce input current**


Figure 27. Low drift peak detector

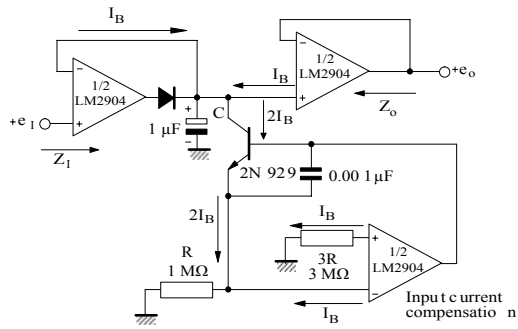
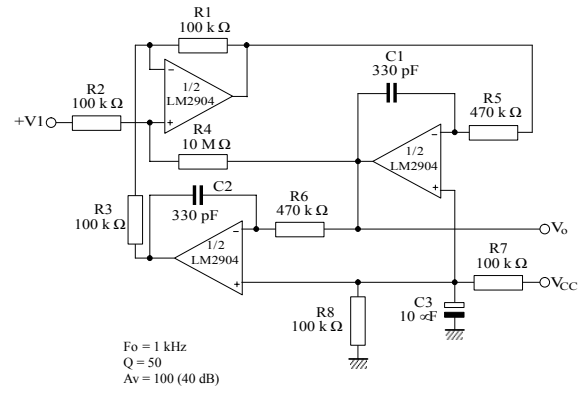


Figure 28. Active bandpass filter



## 7 Macromodel

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An accurate macromodel of the LM2904, LM2904A is available on STMicroelectronics' web site at: [www.st.com](http://www.st.com) . This model is a trade-off between accuracy and complexity (that is, time simulation) of the LM2904, LM2904A operational amplifier. It emulates the nominal performances of a typical device within the specified operating conditions mentioned in the datasheet. It also helps to validate a design approach and to select the right operational amplifier, *but it does not replace on-board measurements*.

## 8 Package information

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In order to meet environmental requirements, ST offers these devices in different grades of **ECOPACK<sup>®</sup>** packages, depending on their level of environmental compliance. ECOPACK<sup>®</sup> specifications, grade definitions and product status are available at: [www.st.com](http://www.st.com). ECOPACK<sup>®</sup> is an ST trademark.

## 8.1 DFN8 2 x 2 package information

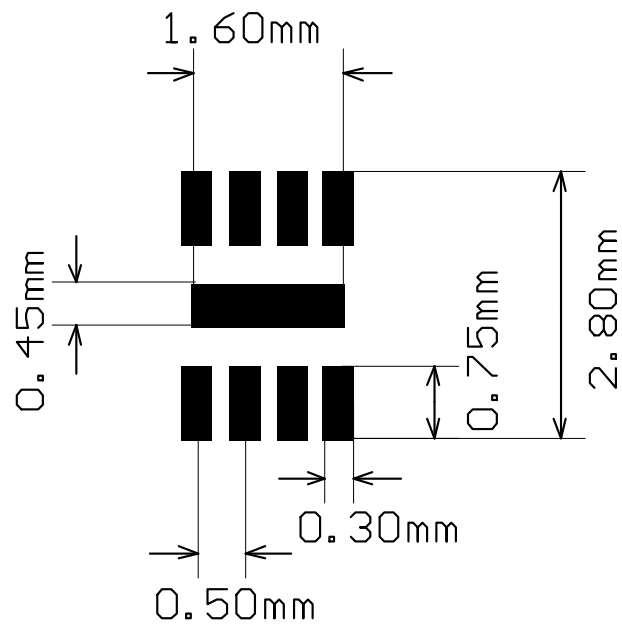
**Figure 29. DFN8 2 x 2 package outline**



**Table 4. DFN8 2 x 2 mechanical data**

| Ref. | Dimensions  |       |       |        |       |       |
|------|-------------|-------|-------|--------|-------|-------|
|      | Millimeters |       |       | Inches |       |       |
|      | Min.        | Typ.  | Max.  | Min.   | Typ.  | Max.  |
| A    | 0.51        | 0.55  | 0.60  | 0.020  | 0.022 | 0.024 |
| A1   |             |       | 0.05  |        |       | 0.002 |
| A3   |             | 0.15  |       |        | 0.006 |       |
| b    | 0.18        | 0.25  | 0.30  | 0.007  | 0.010 | 0.012 |
| D    | 1.85        | 2.00  | 2.15  | 0.073  | 0.079 | 0.085 |
| D2   | 1.45        | 1.60  | 1.70  | 0.057  | 0.063 | 0.067 |
| E    | 1.85        | 2.00  | 2.15  | 0.073  | 0.079 | 0.085 |
| E2   | 0.75        | 0.90  | 1.00  | 0.030  | 0.035 | 0.039 |
| e    |             | 0.50  |       |        | 0.020 |       |
| L    | 0.225       | 0.325 | 0.425 | 0.009  | 0.013 | 0.017 |
| ddd  |             |       | 0.08  |        |       | 0.003 |

Figure 30. DFN8 2 x 2 recommended footprint





## 8.2 MiniSO8 package information

**Figure 31. MiniSO8 package outline**

**Table 5. MiniSO8 package mechanical data**

| Ref. | Dimensions  |      |      |        |       |        |
|------|-------------|------|------|--------|-------|--------|
|      | Millimeters |      |      | Inches |       |        |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.   |
| A    |             |      | 1.1  |        |       | 0.043  |
| A1   | 0           |      | 0.15 | 0      |       | 0.0006 |
| A2   | 0.75        | 0.85 | 0.95 | 0.030  | 0.033 | 0.037  |
| b    | 0.22        |      | 0.40 | 0.009  |       | 0.016  |
| c    | 0.08        |      | 0.23 | 0.003  |       | 0.009  |
| D    | 2.80        | 3.00 | 3.20 | 0.11   | 0.118 | 0.126  |
| E    | 4.65        | 4.90 | 5.15 | 0.183  | 0.193 | 0.203  |
| E1   | 2.80        | 3.00 | 3.10 | 0.11   | 0.118 | 0.122  |
| e    |             | 0.65 |      |        | 0.026 |        |
| L    | 0.40        | 0.60 | 0.80 | 0.016  | 0.024 | 0.031  |
| L1   |             | 0.95 |      |        | 0.037 |        |
| L2   |             | 0.25 |      |        | 0.010 |        |
| k    | 0°          |      | 8°   | 0°     |       | 8°     |
| ccc  |             |      | 0.10 |        |       | 0.004  |

### 8.3 TSSOP8 package information

**Figure 32. TSSOP8 package outline**


| Ref. | Dimensions  |      |      |        |        |       |
|------|-------------|------|------|--------|--------|-------|
|      | Millimeters |      |      | Inches |        |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.   | Max.  |
| A    |             |      | 1.20 |        |        | 0.047 |
| A1   | 0.05        |      | 0.15 | 0.002  |        | 0.006 |
| A2   | 0.80        | 1.00 | 1.05 | 0.031  | 0.039  | 0.041 |
| b    | 0.19        |      | 0.30 | 0.007  |        | 0.012 |
| c    | 0.09        |      | 0.20 | 0.004  |        | 0.008 |
| D    | 2.90        | 3.00 | 3.10 | 0.114  | 0.118  | 0.122 |
| E    | 6.20        | 6.40 | 6.60 | 0.244  | 0.252  | 0.260 |
| E1   | 4.30        | 4.40 | 4.50 | 0.169  | 0.173  | 0.177 |
| e    |             | 0.65 |      |        | 0.0256 |       |
| k    | 0°          |      | 8°   | 0°     |        | 8°    |
| L    | 0.45        | 0.60 | 0.75 | 0.018  | 0.024  | 0.030 |
| L1   |             | 1    |      |        | 0.039  |       |
| aaa  |             |      | 0.10 |        |        | 0.004 |

## 8.4 SO8 package information

**Figure 33. SO8 package outline**

**Table 6. SO8 package mechanical data**

| Ref. | Dimensions  |      |      |        |       |       |
|------|-------------|------|------|--------|-------|-------|
|      | Millimeters |      |      | Inches |       |       |
|      | Min.        | Typ. | Max. | Min.   | Typ.  | Max.  |
| A    |             |      | 1.75 |        |       | 0.069 |
| A1   | 0.10        |      | 0.25 | 0.004  |       | 0.010 |
| A2   | 1.25        |      |      | 0.049  |       |       |
| b    | 0.28        |      | 0.48 | 0.011  |       | 0.019 |
| c    | 0.17        |      | 0.23 | 0.007  |       | 0.010 |
| D    | 4.80        | 4.90 | 5.00 | 0.189  | 0.193 | 0.197 |
| E    | 5.80        | 6.00 | 6.20 | 0.228  | 0.236 | 0.244 |
| E1   | 3.80        | 3.90 | 4.00 | 0.150  | 0.154 | 0.157 |
| e    |             | 1.27 |      |        | 0.050 |       |
| h    | 0.25        |      | 0.50 | 0.010  |       | 0.020 |
| L    | 0.40        |      | 1.27 | 0.016  |       | 0.050 |
| L1   |             | 1.04 |      |        | 0.040 |       |
| k    | 0°          |      | 8°   | 0°     |       | 8°    |
| ccc  |             |      | 0.10 |        |       | 0.004 |

## 9 Ordering information

**Table 7. Order codes**

| Order code                 | Temperature range | Package                          | Packing       | Marking |
|----------------------------|-------------------|----------------------------------|---------------|---------|
| LM2904D                    | -40 °C to 125 °C  | SO8                              | Tube          | 2904    |
| LM2904DT                   |                   | SO8                              | Tape and reel |         |
| LM2904PT                   |                   | TSSOP8                           |               | K403    |
| LM2904ST                   |                   | MiniSO8                          |               | K1Y     |
| LM2904Q2T                  |                   | DFN8 2x2                         |               | 2904Y   |
| LM2904YDT <sup>(1)</sup>   |                   | SO8 (automotive grade level)     |               | 2904AY  |
| LM2904AYDT <sup>(1)</sup>  |                   | TSSOP8 (automotive grade level)  |               | 2904Y   |
| LM2904YPT <sup>(1)</sup>   |                   | MiniSO8 (automotive grade level) |               | 904AY   |
| LM2904AYPT <sup>(1)</sup>  |                   | SO8                              |               | K409    |
| LM2904YST <sup>(1)</sup>   |                   | SO8 (automotive grade level)     |               | 2904W   |
| LM2904WDT                  |                   | TSSOP8 (automotive grade level)  |               | 2904WY  |
| LM2904WYDT <sup>(1)</sup>  |                   |                                  |               | K04WY   |
| LM2904WYPT <sup>(1)</sup>  |                   |                                  |               | K05WY   |
| LM2904AWYPT <sup>(1)</sup> |                   |                                  |               |         |

1. Qualified and characterized according to AEC Q100 and Q003 or equivalent, advanced screening according to AEC Q001 & Q 002 or equivalent.

## Revision history

**Table 8. Document revision history**

| Date        | Revision | Changes  |
|-------------|----------|--|
| 02-Jan-2002 | 1        | Initial release.   |
| 20-Jun-2005 | 2        | PPAP references inserted in the datasheet, see Table 9 on page 21.<br>ESD protection inserted in Table 1 on page 5.  |
| 10-Oct-2005 | 3        | PPAP part numbers added in Table 9 on page 21.   |
| 12-Dec-2005 | 4        | Pin connections identification added on cover page figure.<br>Thermal resistance junction to case information added see Table 1 on page 5.   |
| 01-Feb-2006 | 5        | Maximum junction temperature parameter added in Table 1 on page 5.   |
| 02-May-2006 | 6        | Minimum slew rate parameter in temperature Table 3 on page 7.  |
| 13-Jul-2006 | 7        | Modified ESD values and added explanation on $V_{CC}$ , $V_{id}$ in Table 1 on page 5. Added macromodel information.   |
| 28-Feb-2007 | 8        | Modified ESD/HBM values in Table 1 on page 5.<br>Updated MiniSO8 package information.<br>Added note relative to automotive grade level part numbers in Table 9 on page 21.   |
| 18-Jun-2007 | 9        | Power dissipation value corrected in Table 1: Absolute maximum ratings.<br>Table 2: Operating conditions added.<br>Equivalent input noise voltage parameter added in Table 3.<br>Electrical characteristics curves updated. Figure 19: Phase margin vs capacitive load added.<br>Section 6: Package information updated. |
| 18-Dec-2007 | 10       | Removed power dissipation parameter from Table 1: Absolute maximum ratings.<br>Removed $V_{opp}$ from electrical characteristics in Table 3.<br>Corrected MiniSO8 package mechanical data in Section 6.4: MiniSO8 package information.   |
| 08-Apr-2008 | 11       | Added table of contents.<br>Corrected the scale of Figure 7 (mA not $\mu$ A).<br>Corrected SO8 package information.  |
| 02-Jun-2009 | 12       | Added input current information in Table 1: Absolute maximum ratings.<br>Added L1 parameters in Table 6: SO8 package mechanical data.<br>Added new order codes, LM2904AYD/DT, LM2904AYPT and LM2904AYST in Table 9: Order codes.   |
| 13-Apr-2010 | 13       | Added LM2904A on cover page.<br>Corrected footnote (5) in Table 1: Absolute maximum ratings.<br>Removed order code LM2904AYST from Table 9: Order codes.   |
| 24-Jan-2012 | 14       | Removed macromodel from Chapter 5 (now available on <a href="http://www.st.com">www.st.com</a> ).<br>Added DFN8 2 x 2 mm package information in Chapter 6 and related order codes in Chapter 7.<br>Removed LM2904YD and LM2904AYD order codes from Table 9.<br>Changed note for LM2904YST order code in Table 9.         |
| 24-Jan-2014 | 15       | Updated: marking info for LM2904AYPT, package silhouette drawings in the cover page, $\Delta V_{iO}/\Delta T$ and $\Delta I_{iO}/\Delta T$ symbols in Table 3 on page 7<br>Added: ESD info in Features section and Section 2: Package pin connections<br>Removed: LM2904N from Table 9: Order codes.                     |
| 02-Oct-2015 | 16       | Figure 1: Schematic diagram (1/2 LM2904, LM2904A): updated   |

| Date        | Revision | Changes  |
|-------------|----------|--|
| 16-Feb-2016 | 17       | <p>Updated layout</p> <p>Removed "plastic micropackage" from SO8 and DFN8 2x2 package silhouettes; removed "thin shrink small outline package" from TSSOP8 package silhouette</p> <p>Table 3: unit of <math>V_{OL}</math> parameter changed from "V" to 'mV"</p> <p>DFN8 2x2 package information: updated "L"</p> <p>TSSOP8 package information: "aaa" is a typ. value not a max value</p> |
| 15-Feb-2019 | 18       | <p>Added new part numbers LM2904W, LM2904AW, <a href="#">Figure 2. Schematic diagram (LM2904W, LM2904AW)</a> and <a href="#">Table 2. Operating conditions.</a></p> <p>Updated: <a href="#">Table 1. Absolute maximum ratings, Section 4 Electrical characteristics</a> and <a href="#">Section 9 Ordering information</a></p>   |

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