

DATA SHEET

NE/SA/SE532

LM258/358/A/2904

Low power dual operational amplifiers

Product data
Supersedes data of 2002 Jan 22

2002 Jul 12

Low power dual operational amplifiers

**NE/SA/SE532/
LM258/358/A/2904**

DESCRIPTION

The 532/358/LM2904 consists of two independent, high gain, internally frequency-compensated operational amplifiers internally frequency-compensated operational amplifiers designed specifically to operate from a single power supply over a wide range of voltages. Operation from dual power supplies is also possible, and the low power supply current drain is independent of the magnitude of the power supply voltage.

UNIQUE FEATURES

In the linear mode the input common-mode voltage range includes ground and the output voltage can also swing to includes ground and the output voltage can also swing to ground, even though operated from only a single power supply voltage. The unity gain cross frequency is temperature-compensated. The input bias current is also temperature-compensated.

FEATURES

- Internally frequency-compensated for unity gain
- Large DC voltage gain: 100 dB
- Wide bandwidth (unity gain): 1 MHz (temperature-compensated)
- Wide power supply range single supply: $3 V_{DC}$ to $30 V_{DC}$, or dual supplies: $\pm 1.5 V_{DC}$ to $\pm 15 V_{DC}$
- Very low supply current drain ($400 \mu A$)—essentially independent of supply voltage ($1 mW/op\ amp$ at $+5 V_{DC}$)
- Low input biasing current: $45 nA_{DC}$ temperature-compensated
- Low input offset voltage: $2 mV_{DC}$, and offset current: $5 nA_{DC}$
- Differential input voltage range equal to the power supply voltage
- Large output voltage: $0 V_{DC}$ to $V+ 1.5 V_{DC}$ swing

PIN CONFIGURATION

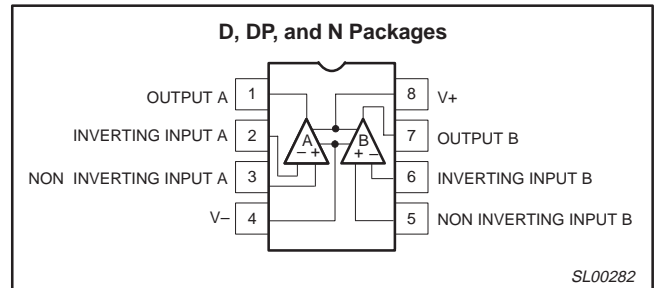


Figure 1. Pin configuration.

EQUIVALENT CIRCUIT

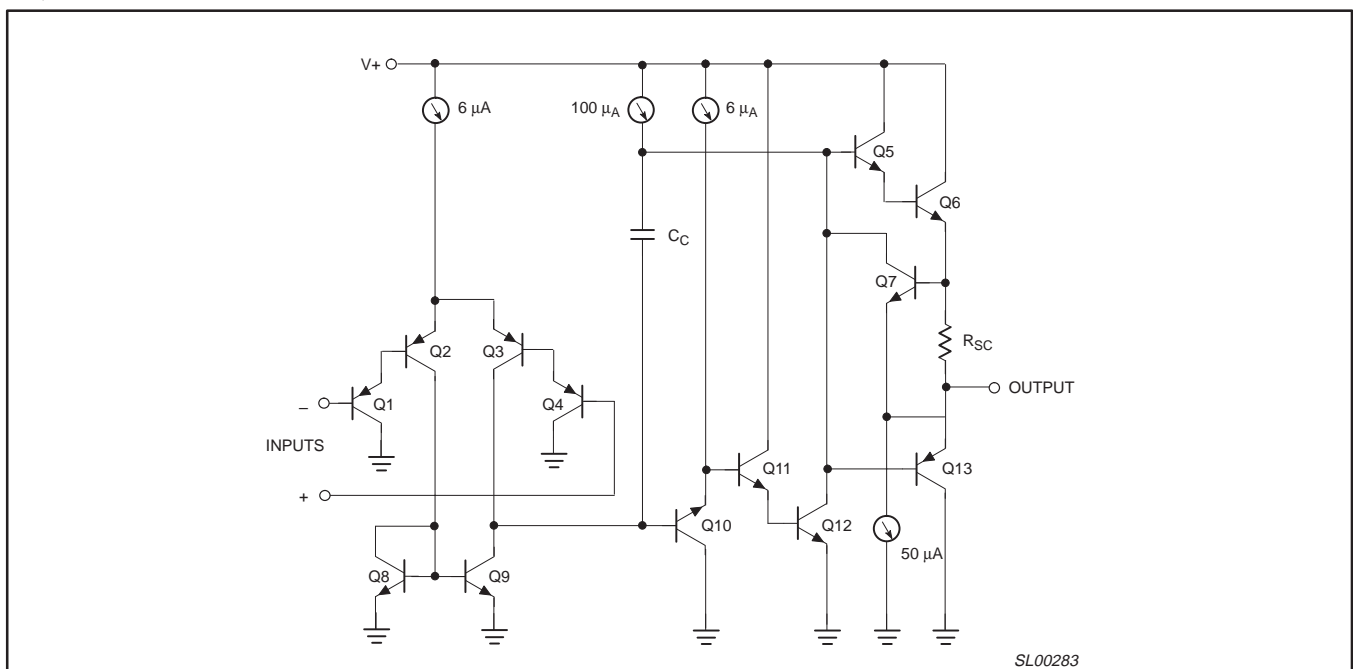


Figure 2. Equivalent circuit.

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ORDERING INFORMATION

| DESCRIPTION | TEMPERATURE RANGE | ORDER CODE | DWG # |
|---|-------------------|------------|----------|
| 8-Pin Plastic Small Outline (SO) Package | 0 °C to +70 °C | NE532D | SOT96-1 |
| 8-Pin Plastic Dual In-Line Package (DIP) | 0 °C to +70 °C | NE532N | SOT97-1 |
| 8-Pin Plastic Small Outline (SO) Package | -40 °C to +85 °C | SA532D | SOT96-1 |
| 8-Pin Plastic Small Outline (SO) Package | -40 °C to +125 °C | LM2904D | SOT96-1 |
| 8-Pin Plastic Thin Shrink Small Outline Package (TSSOP) | -40 °C to +125 °C | LM2904DP | SOT505-1 |
| 8-Pin Plastic Dual In-Line Package (DIP) | -40 °C to +125 °C | LM2904N | SOT97-1 |
| 8-Pin Plastic Small Outline (SO) Package | -25 °C to +125 °C | LM258D | SOT96-1 |
| 8-Pin Plastic Dual In-Line Package (DIP) | -25 °C to +125 °C | LM258N | SOT97-1 |
| 8-Pin Plastic Small Outline (SO) Package | 0 °C to +70 °C | LM358D | SOT96-1 |
| 8-Pin Plastic Thin Shrink Small Outline Package (TSSOP) | 0 °C to +70 °C | LM358DP | SOT505-1 |
| 8-Pin Plastic Dual In-Line Package (DIP) | 0 °C to +70 °C | LM358N | SOT97-1 |
| 8-Pin Plastic Small Outline (SO) Package | 0 °C to +70 °C | LM358AD | SOT96-1 |
| 8-Pin Plastic Dual In-Line Package (DIP) | 0 °C to +70 °C | LM358AN | SOT97-1 |
| 8-Pin Plastic Dual In-Line Package (DIP) | -55 °C to +125 °C | SE532N | SOT97-1 |

ABSOLUTE MAXIMUM RATINGS

| SYMBOL | PARAMETER | RATING | UNIT |
|-----------|--|--|----------------------------|
| V_S | Supply voltage, V+ | 32 or ± 16 | V_{DC} |
| | Differential input voltage | 32 | V_{DC} |
| V_{IN} | Input voltage | -0.3 to +32 | V_{DC} |
| P_D | Maximum power dissipation $T_{amb} = 25\text{ °C}$ (Still air) ¹ N package D package DP package | 1160 780 714 | mW mW mW |
| | Output short-circuit to GND ² $V_+ < 15 V_{DC}$ and $T_{amb} = 25\text{ °C}$ | Continuous | |
| T_{amb} | Operating ambient temperature range NE532/LM358/LM358A LM258 LM2904 SA532 SE532 | 0 to +70 -25 to +85 -40 to +125 -40 to +85 -55 to +125 | °C °C °C °C °C |
| T_{stg} | Storage temperature range | -65 to +150 | °C |
| T_{sld} | Lead soldering temperature (10 sec max) | 230 | °C |

NOTE:

- Derate above 25 °C, at the following rates:
N package at 9.3 mW/°C
D package at 6.2 mW/°C
DP package at 5.72 mW/°C
- Short-circuits from the output to V+ can cause excessive heating and eventual destruction. The maximum output current is approximately 40 mA independent of the magnitude of V+. At values of supply voltage in excess of +15 V_{DC} , continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction.

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DC ELECTRICAL CHARACTERISTICS

 $T_{amb} = 25\text{ }^{\circ}\text{C}$; $V_{+} = +5\text{ V}$, unless otherwise specified.

| SYMBOL | PARAMETER | TEST CONDITIONS | SE532, LM258 | | | NE/SA532/ LM358/LM2904 | | | UNIT |
|-------------|--|--|--------------|---------|---------------|---------------------------|---------|---------------|--------------------------------|
| | | | Min | Typ | Max | Min | Typ | Max | |
| V_{OS} | Offset voltage ¹ | $R_S = 0\ \Omega$ | | ± 2 | ± 5 | | ± 2 | ± 7 | mV |
| | | $R_S = 0\ \Omega$; over temp. | | | ± 7 | | | ± 9 | mV |
| V_{OS} | Drift | $R_S = 0\ \Omega$; over temp. | | 7 | | | 7 | | $\mu\text{V}/^{\circ}\text{C}$ |
| I_{OS} | Offset current | $I_{IN(+)} - I_{IN(-)}$ | | ± 3 | ± 30 | | ± 5 | ± 50 | nA |
| | | Over temp. | | | ± 100 | | | ± 150 | nA |
| I_{OS} | Drift | Over temp. | | 10 | | | 10 | | $\text{pA}/^{\circ}\text{C}$ |
| I_{BIAS} | Input current ² | $I_{IN(+)}$ or $I_{IN(-)}$ | | 45 | 150 | | 45 | 250 | nA |
| | | $I_{IN(+)}$ or $I_{IN(-)}$; Over temp. | | 40 | 300 | | 40 | 500 | nA |
| I_B | Drift | Over temp. | | 50 | | | 50 | | $\text{pA}/^{\circ}\text{C}$ |
| V_{CM} | Common-mode voltage range ³ | $V_{+} = 30\text{ V}$ | 0 | | $V_{+} - 1.5$ | 0 | | $V_{+} - 1.5$ | V |
| | | $V_{+} = 30\text{ V}$; Over temp. | 0 | | $V_{+} - 2.0$ | 0 | | $V_{+} - 2.0$ | V |
| CMRR | Common-mode rejection ratio | $V_{+} = 30\text{ V}$ | 70 | 85 | | 65 | 70 | | dB |
| V_{OH} | Output voltage swing | $R_L \geq 2\text{ k}\Omega$; $V_{+} = 30\text{ V}$; over temp. | 26 | | | 26 | | | V |
| | | $R_L \geq 10\text{ k}\Omega$; $V_{+} = 30\text{ V}$; over temp. | 27 | 28 | | 27 | 28 | | V |
| V_{OL} | Output voltage swing | $R_L \geq 10\text{ k}\Omega$; over temp. | | 5 | 20 | | 5 | 20 | mV |
| I_{CC} | Supply current | $R_L = \infty$; $V_{+} = 30\text{ V}$ | | 0.5 | 1.0 | | 0.5 | 1.0 | mA |
| | | $R_L = \infty$ on all amplifiers; $V_{+} = 30\text{ V}$; over temp. | | 0.6 | 1.2 | | 0.6 | 1.2 | mA |
| A_{VOL} | Large-signal voltage gain | $R_L \geq 2\text{ k}\Omega$; $V_{OUT} \pm 10\text{ V}$ | 50 | 100 | | 25 | 100 | | V/mV |
| | | $V_{+} = 15\text{ V}$ (for large V_O swing); over temp. | 25 | | | 15 | | | V/mV |
| PSRR | Supply voltage rejection ratio | $R_S = 0\ \Omega$ | 65 | 100 | | 65 | 100 | | dB |
| | Amplifier-to-amplifier coupling ⁴ | $f = 1\text{ kHz to } 20\text{ kHz}$ (input referred) | | -120 | | | -120 | | dB |
| I_{OUT} | Output current (Source) | $V_{IN+} = +1\text{ V}_{DC}$; $V_{IN-} = 0\text{ V}_{DC}$; $V_{+} = 15\text{ V}_{DC}$ | 20 | 40 | | 20 | 40 | | mA |
| | | $V_{IN+} = +1\text{ V}_{DC}$; $V_{IN-} = 0\text{ V}_{DC}$; $V_{+} = 15\text{ V}_{DC}$; over temp. | 10 | 20 | | 10 | 20 | | mA |
| | Output current (Sink) | $V_{IN-} = +1\text{ V}_{DC}$; $V_{IN+} = 0\text{ V}_{DC}$; $V_{+} = 15\text{ V}_{DC}$ | 10 | 20 | | 10 | 20 | | mA |
| | | $V_{IN-} = +1\text{ V}_{DC}$; $V_{IN+} = 0\text{ V}_{DC}$; $V_{+} = 15\text{ V}_{DC}$; over temp. | 5 | 8 | | 5 | 8 | | mA |
| | | $V_{IN+} = 0\text{ V}$; $V_{IN-} = +1\text{ V}_{DC}$; $V_O = 200\text{ mV}$ | 12 | 50 | | 12 | 50 | | μA |
| I_{SC} | Short circuit current ⁵ | | 40 | 60 | | 40 | 60 | mA | |
| | Differential input voltage ⁶ | | | V_{+} | | | V_{+} | V | |
| GBW | Unity gain bandwidth | $T_{amb} = 25\text{ }^{\circ}\text{C}$ | | 1 | | | 1 | | MHz |
| SR | Slew rate | $T_{amb} = 25\text{ }^{\circ}\text{C}$ | | 0.3 | | | 0.3 | | $\text{V}/\mu\text{s}$ |
| V_{NOISE} | Input noise voltage | $T_{amb} = 25\text{ }^{\circ}\text{C}$; $f = 1\text{ kHz}$ | | 40 | | | 40 | | $\text{nV}/\sqrt{\text{Hz}}$ |

(Notes on next page).

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NE/SA/SE532/
LM258/358/A/2904**DC ELECTRICAL CHARACTERISTICS** (continued) $T_{amb} = 25\text{ }^{\circ}\text{C}$; $V_+ = +5\text{ V}$; unless otherwise specified.

| SYMBOL | PARAMETER | TEST CONDITIONS | LM358A | | | UNIT |
|-------------|--|--|--------|---------|-------------|--------------------------------|
| | | | Min | Typ | Max | |
| V_{OS} | Offset voltage ¹ | $R_S = 0\ \Omega$ | | ± 2 | ± 3 | mV |
| | | $R_S = 0\ \Omega$; over temp. | | | ± 5 | mV |
| V_{OS} | Drift | $R_S = 0\ \Omega$; over temp. | | 7 | 20 | $\mu\text{V}/^{\circ}\text{C}$ |
| I_{OS} | Offset current | $I_{IN(+)} - I_{IN(-)}$ | | 5 | ± 30 | nA |
| | | Over temp. | | | ± 75 | nA |
| I_{OS} | Drift | Over temp. | | 10 | 300 | $\text{pA}/^{\circ}\text{C}$ |
| I_{BIAS} | Input current ² | $I_{IN(+)} \text{ or } I_{IN(-)}$ | | 45 | 100 | nA |
| | | $I_{IN(+)} \text{ or } I_{IN(-)}$; Over temp. | | 40 | 200 | nA |
| I_B | Drift | Over temp. | | 50 | | $\text{pA}/^{\circ}\text{C}$ |
| V_{CM} | Common-mode voltage range ³ | $V_+ = 30\text{ V}$ | 0 | | $V_+ - 1.5$ | V |
| | | $V_+ = 30\text{ V}$; Over temp. | 0 | | $V_+ - 2.0$ | V |
| CMRR | Common-mode rejection ratio | $V_+ = 30\text{ V}$ | 65 | 85 | | dB |
| V_{OH} | Output voltage swing | $R_L \geq 2\text{ k}\Omega$; $V_+ = 30\text{ V}$; over temp. | 26 | | | V |
| | | $R_L \geq 10\text{ k}\Omega$; $V_+ = 30\text{ V}$; over temp. | 27 | 28 | | V |
| V_{OL} | Output voltage swing | $R_L \geq 10\text{ k}\Omega$; over temp. | | 5 | 20 | mV |
| I_{CC} | Supply current | $R_L = \infty$, $V_+ = 30\text{ V}$ | | 0.5 | 1.0 | mA |
| | | $R_L = \infty$ on all amplifiers; $V_+ = 30\text{ V}$; over temp. | | 0.6 | 1.2 | mA |
| A_{VOL} | Large-signal voltage gain | $R_L \geq 2\text{ k}\Omega$; $V_{OUT} \pm 10\text{ V}$ | 25 | 100 | | V/mV |
| | | $V_+ = 15\text{ V}$ (for large V_O swing); over temp. | 15 | | | V/mV |
| PSRR | Supply voltage rejection ratio | $R_S = 0\ \Omega$ | 65 | 100 | | dB |
| | Amplifier-to-amplifier coupling ⁴ | $f = 1\text{ kHz to } 20\text{ kHz}$ (input referred) | | -120 | | dB |
| I_{OUT} | Output current (Source) | $V_{IN+} = +1\text{ V}_{DC}$; $V_{IN-} = 0\text{ V}_{DC}$; $V_+ = 15\text{ V}_{DC}$ | 20 | 40 | | mA |
| | | $V_{IN+} = +1\text{ V}_{DC}$; $V_{IN-} = 0\text{ V}_{DC}$; $V_+ = 15\text{ V}_{DC}$; over temp. | 10 | 20 | | mA |
| | Output current (Sink) | $V_{IN-} = +1\text{ V}_{DC}$; $V_{IN+} = 0\text{ V}_{DC}$; $V_+ = 15\text{ V}_{DC}$ | 10 | 20 | | mA |
| | | $V_{IN-} = +1\text{ V}_{DC}$; $V_{IN+} = 0\text{ V}_{DC}$; $V_+ = 15\text{ V}_{DC}$; over temp. | 5 | 8 | | mA |
| | | $V_{IN+} = 0\text{ V}$; $V_{IN-} = +1\text{ V}_{DC}$; $V_O = 200\text{ mV}$ | 12 | 50 | | μA |
| I_{SC} | Short circuit current ⁵ | | 40 | 60 | | mA |
| | Differential input voltage ⁶ | | | V_+ | | V |
| GBW | Unity gain bandwidth | $T_{amb} = 25\text{ }^{\circ}\text{C}$ | | 1 | | MHz |
| SR | Slew rate | $T_{amb} = 25\text{ }^{\circ}\text{C}$ | | 0.3 | | V/ μs |
| V_{NOISE} | Input noise voltage | $T_{amb} = 25\text{ }^{\circ}\text{C}$; $f = 1\text{ kHz}$ | | 40 | | nV/ $\sqrt{\text{Hz}}$ |

NOTES:

- $V_O \approx 1.4\text{ V}$, $R_S = 0\ \Omega$ with V_+ from 5 V to 30 V ; and over the full input common-mode range (0 V to $V_+ - 1.5\text{ V}$).
- The direction of the input current is out of the IC due to the PNP input stage. This current is essentially constant, independent of the state of the output so no loading change exists on the input lines.
- The input common-mode voltage or 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 $V_+ - 1.5\text{ V}$, but either or both inputs can go to $+32\text{ V}$ without damage.
- Due to proximity of external components, insure that coupling is not originating via stray capacitance between these external parts. This typically can be detected as this type of capacitance coupling increases at higher frequencies.
- Short-circuits from the output to V_+ can cause excessive heating and eventual destruction. The maximum output current is approximately 40 mA independent of the magnitude of V_+ . At values of supply voltage in excess of $+15\text{ V}_{DC}$, continuous short-circuits can exceed the power dissipation ratings and cause eventual destruction.
- The input common-mode voltage or 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 $V_+ - 1.5\text{ V}$, but either or both inputs can go to $+32\text{ V}_{DC}$ without damage.

Low power dual operational amplifiers

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LM258/358/A/2904

TYPICAL PERFORMANCE CHARACTERISTICS

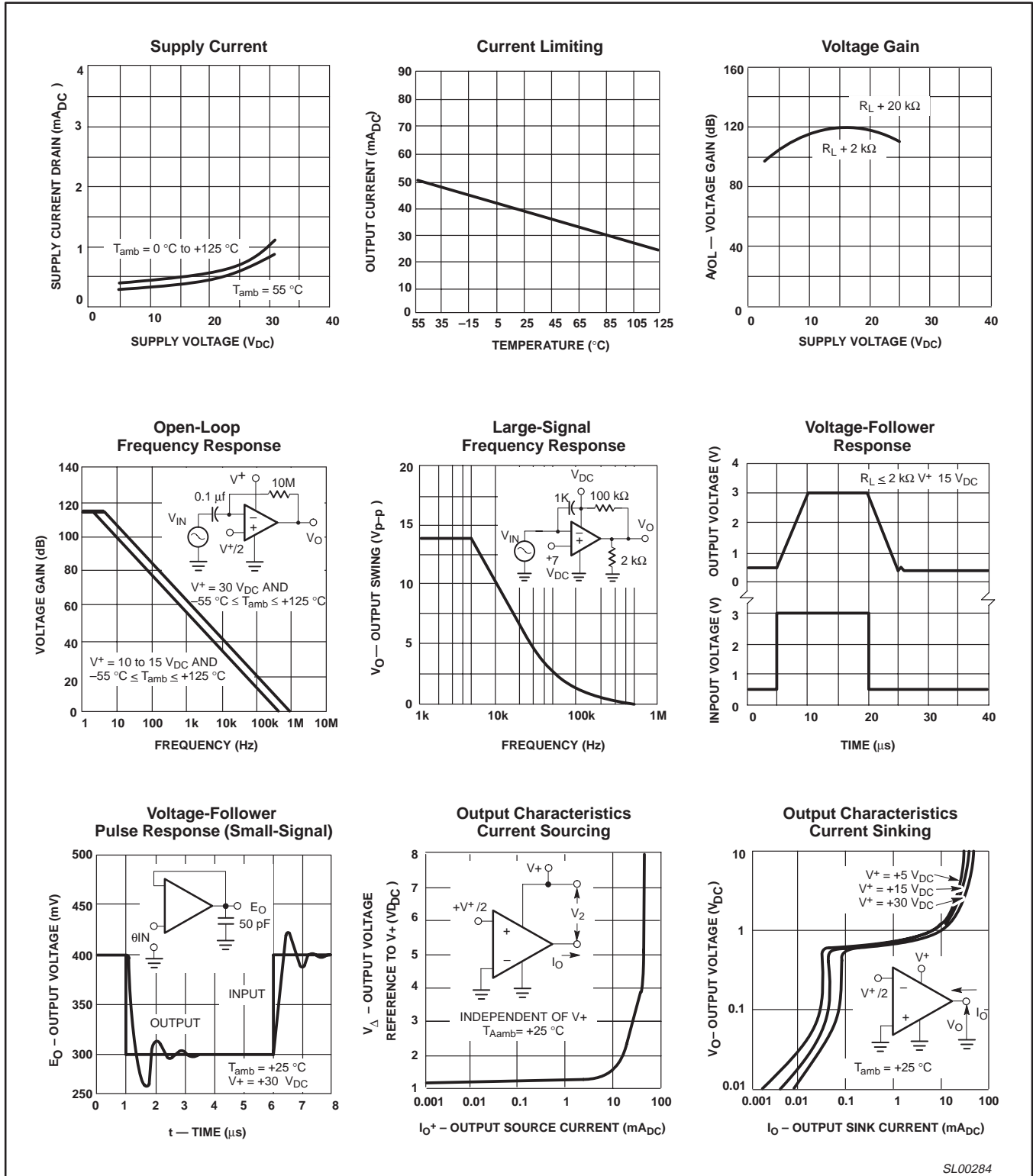


Figure 3. Typical performance characteristics.

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TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

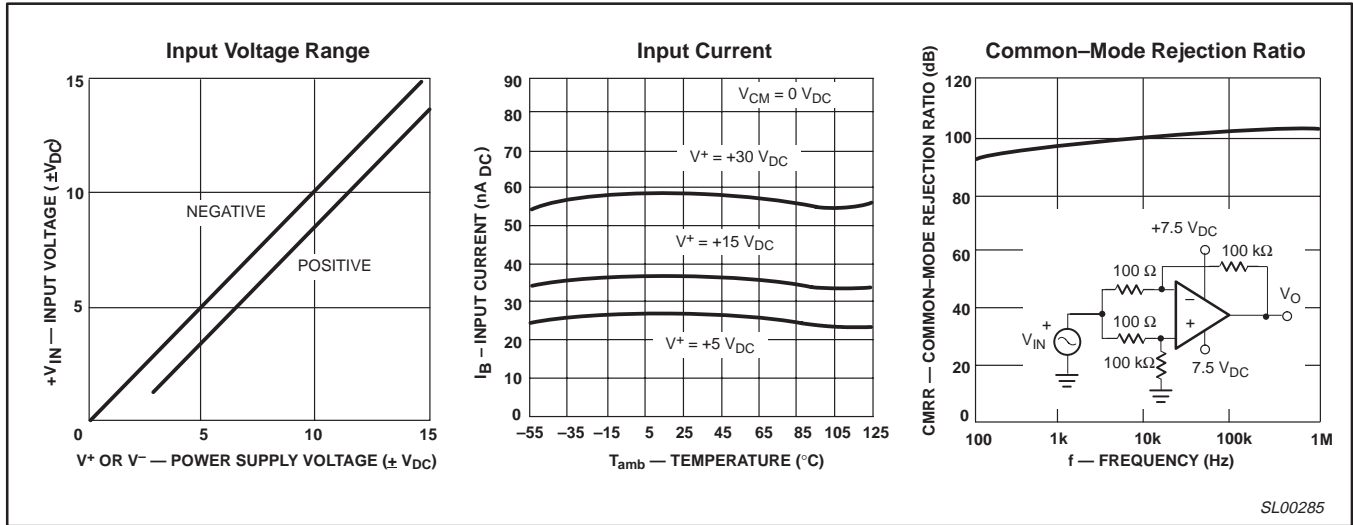


Figure 4. Typical performance characteristics (continued).

TYPICAL APPLICATIONS

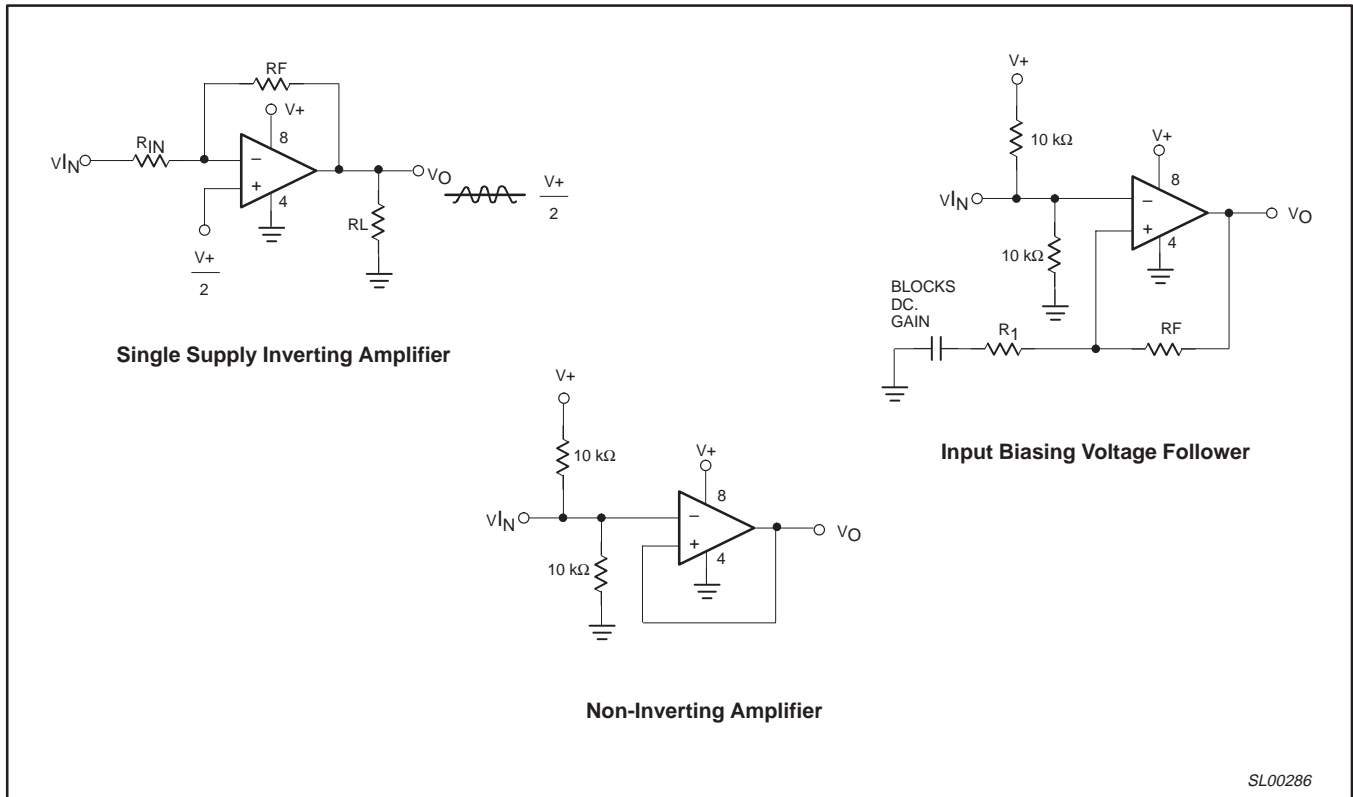


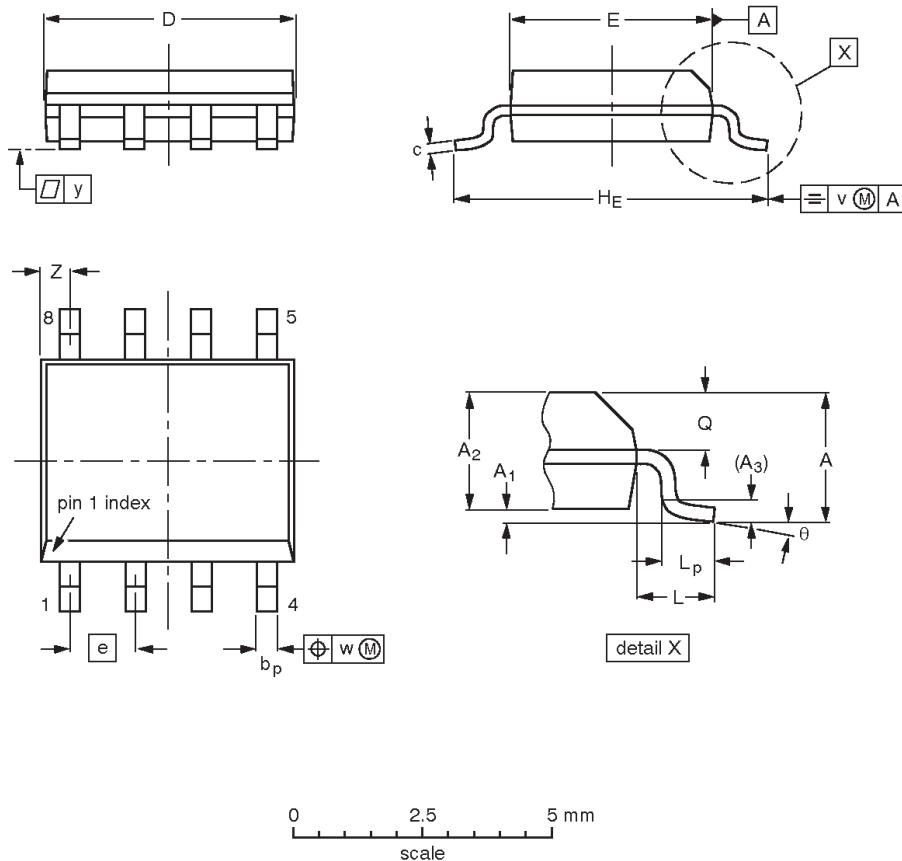
Figure 5. Typical applications.

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S08: plastic small outline package; 8 leads; body width 3.9 mm

SOT96-1



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

| UNIT | A max. | A ₁ | A ₂ | A ₃ | b _p | c | D ⁽¹⁾ | E ⁽²⁾ | e | H _E | L | L _p | Q | v | w | y | Z ⁽¹⁾ | θ |
|--------|--------|----------------|----------------|----------------|----------------|------------------|------------------|------------------|-------|----------------|-------|----------------|----------------|------|------|-------|------------------|----------|
| mm | 1.75 | 0.25 0.10 | 1.45 1.25 | 0.25 | 0.49 0.36 | 0.25 0.19 | 5.0 4.8 | 4.0 3.8 | 1.27 | 6.2 5.8 | 1.05 | 1.0 0.4 | 0.7 0.6 | 0.25 | 0.25 | 0.1 | 0.7 0.3 | 8° 0° |
| inches | 0.069 | 0.010 0.004 | 0.057 0.049 | 0.01 | 0.019 0.014 | 0.0100 0.0075 | 0.20 0.19 | 0.16 0.15 | 0.050 | 0.244 0.228 | 0.041 | 0.039 0.016 | 0.028 0.024 | 0.01 | 0.01 | 0.004 | 0.028 0.012 | |

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

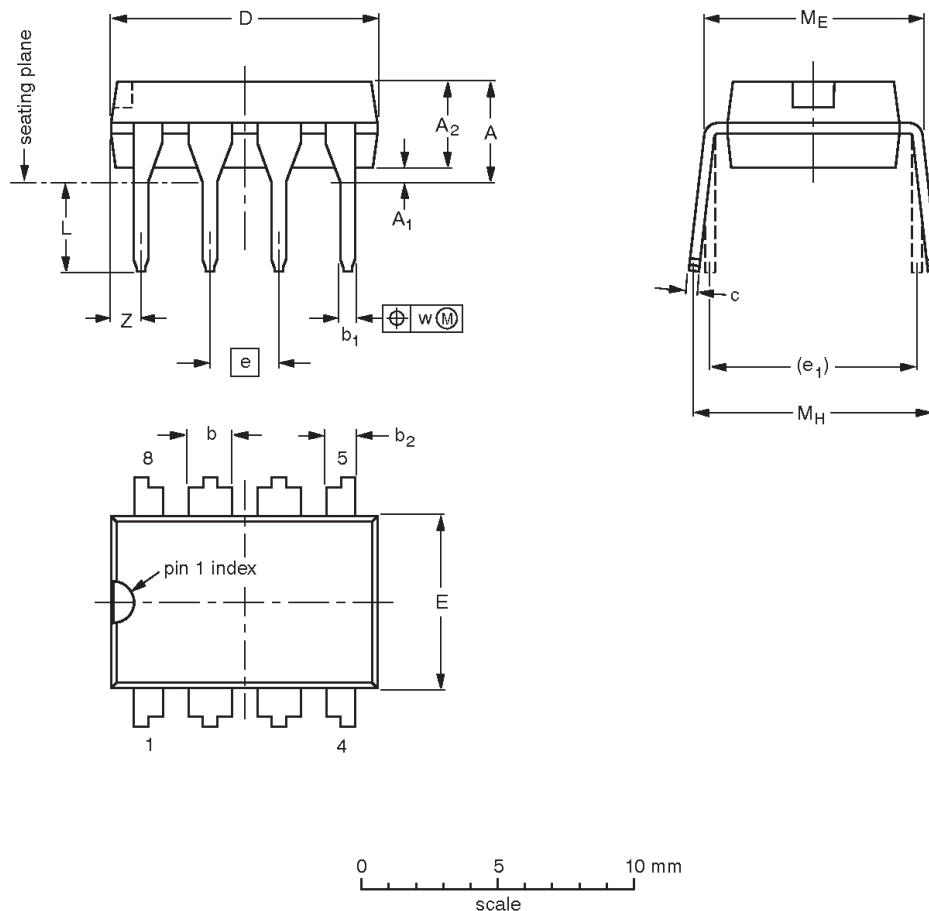
| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|--------|------|--|---------------------|-----------------------|
| | IEC | JEDEC | EIAJ | | | |
| SOT96-1 | 076E03 | MS-012 | | | | 97-05-22- 99-12-27 |

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DIP8: plastic dual in-line package; 8 leads (300 mil)

SOT97-1



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

| UNIT | A max. | A ₁ min. | A ₂ max. | b | b ₁ | b ₂ | c | D ⁽¹⁾ | E ⁽¹⁾ | e | e ₁ | L | M _E | M _H | w | Z ⁽¹⁾ max. |
|--------|--------|---------------------|---------------------|----------------|----------------|----------------|----------------|------------------|------------------|------|----------------|--------------|----------------|----------------|-------|-----------------------|
| mm | 4.2 | 0.51 | 3.2 | 1.73 1.14 | 0.53 0.38 | 1.07 0.89 | 0.36 0.23 | 9.8 9.2 | 6.48 6.20 | 2.54 | 7.62 | 3.60 3.05 | 8.25 7.80 | 10.0 8.3 | 0.254 | 1.15 |
| inches | 0.17 | 0.020 | 0.13 | 0.068 0.045 | 0.021 0.015 | 0.042 0.035 | 0.014 0.009 | 0.39 0.36 | 0.26 0.24 | 0.10 | 0.30 | 0.14 0.12 | 0.32 0.31 | 0.39 0.33 | 0.01 | 0.045 |

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

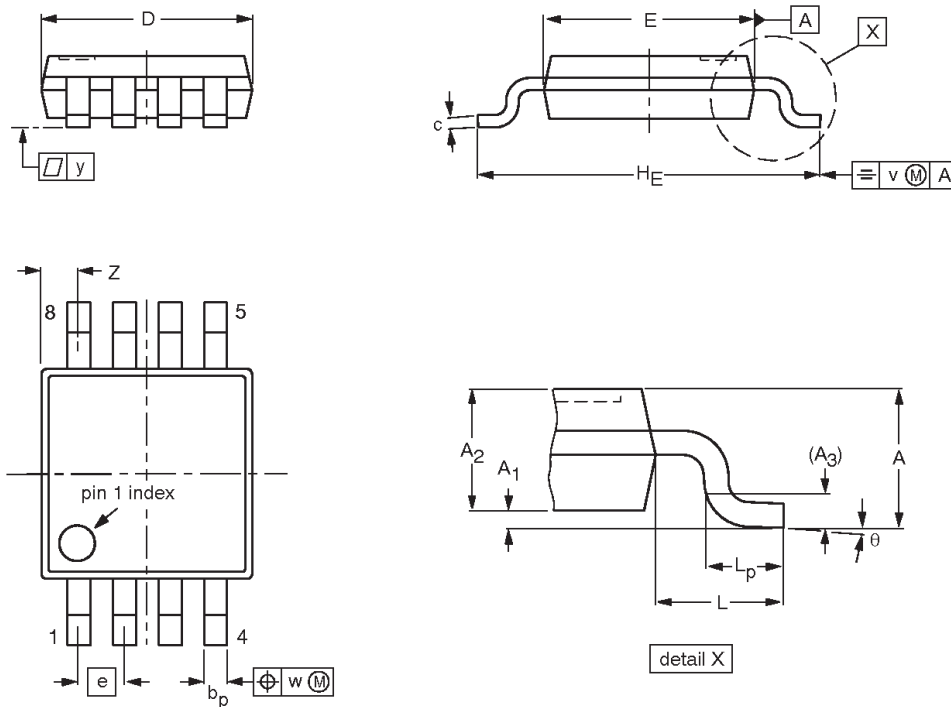
| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|--------|----------|--|---------------------|----------------------|
| | IEC | JEDEC | EIAJ | | | |
| SOT97-1 | 050G01 | MO-001 | SC-504-8 | | | 95-02-04 99-12-27 |

Low power dual operational amplifiers

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TSSOP8: plastic thin shrink small outline package; 8 leads; body width 3 mm

SOT505-1



DIMENSIONS (mm are the original dimensions)

| UNIT | A max. | A ₁ | A ₂ | A ₃ | b _p | c | D ⁽¹⁾ | E ⁽²⁾ | e | H _E | L | L _p | v | w | y | Z ⁽¹⁾ | θ |
|------|--------|----------------|----------------|----------------|----------------|--------------|------------------|------------------|------|----------------|------|----------------|-----|-----|-----|------------------|----------|
| mm | 1.10 | 0.15 0.05 | 0.95 0.80 | 0.25 | 0.45 0.25 | 0.28 0.15 | 3.10 2.90 | 3.10 2.90 | 0.65 | 5.10 4.70 | 0.94 | 0.70 0.40 | 0.1 | 0.1 | 0.1 | 0.70 0.35 | 6° 0° |

Notes

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|-------|------|--|---------------------|------------|
| | IEC | JEDEC | EIAJ | | | |
| SOT505-1 | | | | | | 99-04-09 |

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NOTES

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Data sheet status

| Data sheet status ^[1] | Product status ^[2] | Definitions |
|----------------------------------|-------------------------------|--|
| Objective data | Development | This data sheet contains data from the objective specification for product development. Philips Semiconductors reserves the right to change the specification in any manner without notice. |
| Preliminary data | Qualification | This data sheet contains data from the preliminary specification. Supplementary data will be published at a later date. Philips Semiconductors reserves the right to change the specification without notice, in order to improve the design and supply the best possible product. |
| Product data | Production | This data sheet contains data from the product specification. Philips Semiconductors reserves the right to make changes at any time in order to improve the design, manufacturing and supply. Changes will be communicated according to the Customer Product/Process Change Notification (CPCN) procedure SNW-SQ-650A. |

[1] Please consult the most recently issued data sheet before initiating or completing a design.

[2] The product status of the device(s) described in this data sheet may have changed since this data sheet was published. The latest information is available on the Internet at URL <http://www.semiconductors.philips.com>.

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