

Low power JFET single operational amplifiers

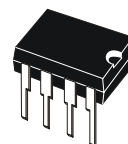
Features

- Very low power consumption: 200 μ A
- Wide common-mode (up to V_{CC}^+) and differential voltage ranges
- Low input bias and offset currents
- Output short-circuit protection
- High input impedance JFET input stage
- Internal frequency compensation
- Latch-up free operation
- High slew rate: 3.5 V/ μ s

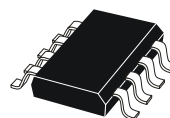
Description

The TL061 is a high-speed JFET input single operational amplifier, that incorporates well-matched, high-voltage JFET and bipolar transistors in a monolithic integrated circuit.

The device features high slew rates, low input bias and offset currents, and low offset voltage temperature coefficient.

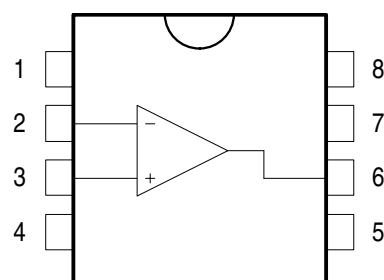


N
DIP8
(Plastic package)



D
SO-8
(Plastic micropackage)

Pin connections (top view)



- 1 - Offset null 1
- 2 - Inverting input
- 3 - Non-inverting input
- 4 - V_{CC}^-
- 5 - Offset null 2
- 6 - Output
- 7 - V_{CC}^+
- 8 - N.C.

1 Schematic diagram

Figure 1. Schematic diagram

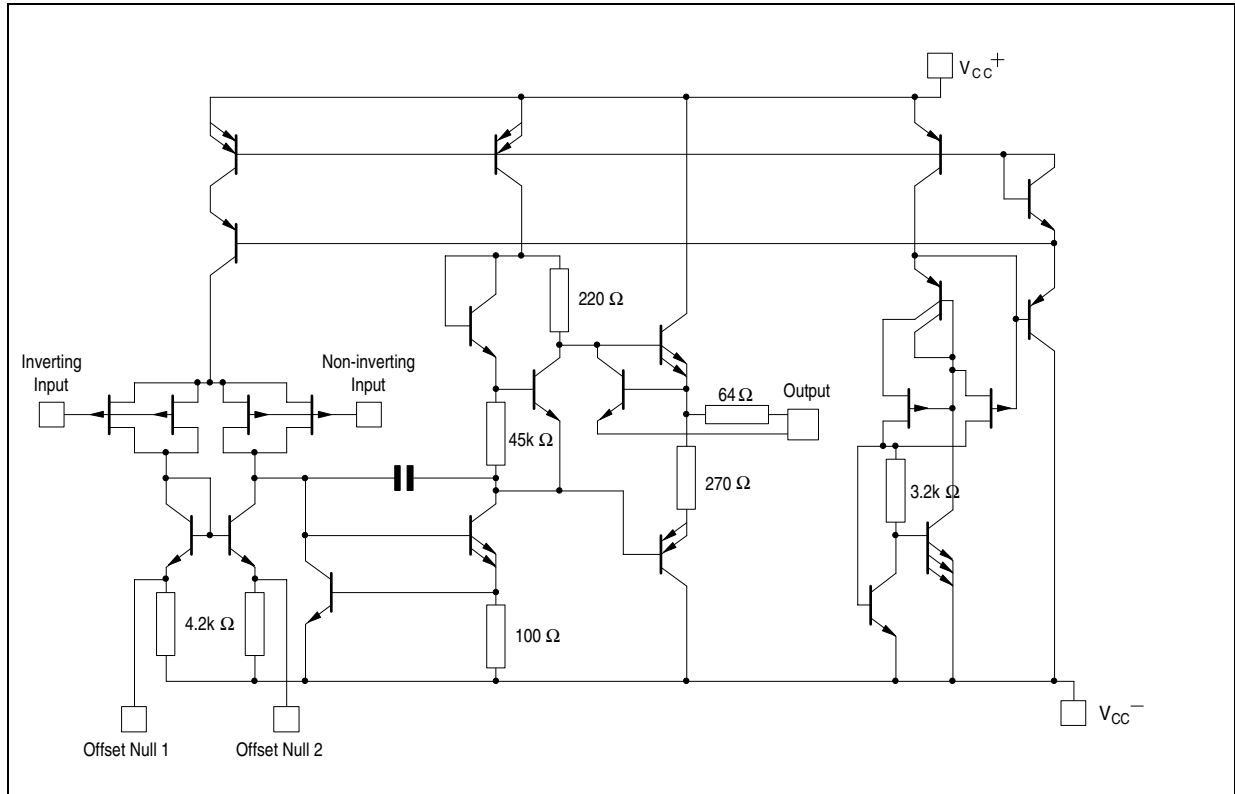
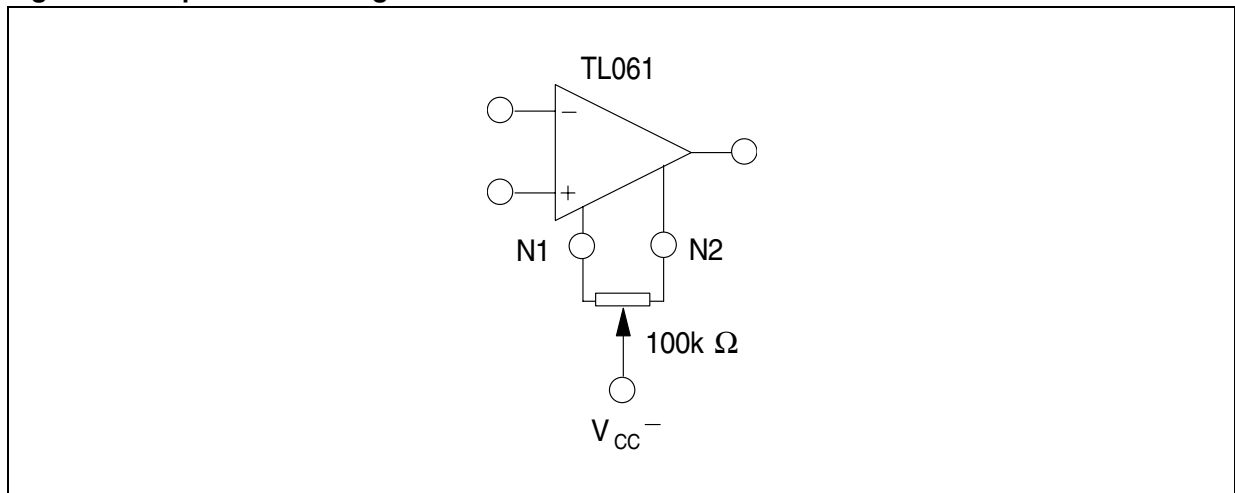


Figure 2. Input offset voltage null circuit



2 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings

| Symbol | Parameter | Value | | | Unit |
|------------|---|----------------|----------------|----------------|------|
| | | TL061M, AM, BM | TL061I, AI, BI | TL061C, AC, BC | |
| V_{CC} | Supply voltage ⁽¹⁾ | ±18 | | | V |
| V_i | Input voltage ⁽²⁾ | ±15 | | | V |
| V_{id} | Differential input voltage ⁽³⁾ | ±30 | | | V |
| P_{tot} | Power dissipation | 680 | | | mW |
| | Output short-circuit duration ⁽⁴⁾ | Infinite | | | |
| T_{stg} | Storage temperature range | -65 to +150 | -65 to +150 | -65 to +150 | °C |
| R_{thja} | Thermal resistance junction to ambient ^{(5) (6)} | | | | °C/W |
| | SO-8 DIP8 | 125 85 | | | |
| R_{thjc} | Thermal resistance junction to case ^{(5) (6)} | | | | °C/W |
| | SO-8 DIP8 | 40 41 | | | |
| ESD | HBM: human body model ⁽⁷⁾ | 800 | | | V |
| | MM: machine model ⁽⁸⁾ | 200 | | | V |
| | CDM: charged device model ⁽⁹⁾ | 1.5 | | | kV |

- All voltage values, except differential voltage, are with respect to the zero reference level (ground) of the supply voltages where the zero reference level is the midpoint between V_{CC}^+ and V_{CC}^- .
- The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 volts, whichever is less.
- Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
- The output may be shorted to ground or to either supply. Temperature and/or supply voltages must be limited to ensure that the dissipation rating is not exceeded.
- Short-circuits can cause excessive heating and destructive dissipation.
- R_{th} are typical values.
- Human body model: 100 pF discharged through a 1.5 kΩ resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
- Machine model: a 200 pF cap is charged to the specified voltage, then discharged directly between two pins of the device with no external series resistor (internal resistor < 5 Ω), done for all couples of pin combinations with other pins floating.
- Charged device model: all pins plus package are charged together to the specified voltage and then discharged directly to the ground.

Table 2. Operating conditions

| Symbol | Parameter | TL061M, AM, BM | TL061I, AI, BI | TL061C, AC, BC | Unit |
|------------|--------------------------------------|----------------|----------------|----------------|------|
| V_{CC} | Supply voltage range | 6 to 36 | | | V |
| T_{oper} | Operating free-air temperature range | -55 to +125 | -40 to +105 | 0 to +70 | °C |

3 Electrical characteristics

Table 3. $V_{CC} = \pm 15\text{ V}$, $T_{amb} = +25^\circ\text{ C}$ (unless otherwise specified)

| Symbol | Parameter | TL061M | | | TL061I | | | TL061C | | | Unit |
|-----------|--|------------|------------|-----------|------------|------------|-----------|----------|------------|-----------|------------------------------|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| V_{io} | Input offset voltage ($R_S = 50\Omega$) $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ | | 3 | 6 9 | | 3 | 6 9 | | 3 | 15 20 | mV |
| DV_{io} | Temperature coefficient of input offset voltage ($R_S = 50\Omega$) | | 10 | | | 10 | | | 10 | | $\mu\text{V}/^\circ\text{C}$ |
| I_{io} | Input offset current ⁽¹⁾ $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ | | 5 | 100 20 | | 5 | 100 10 | | 5 | 200 5 | pA nA |
| I_{ib} | Input bias current ⁽¹⁾ $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ | | 30 | 200 20 | | 30 | 200 20 | | 30 | 400 10 | pA nA |
| V_{icm} | Input common mode voltage range | ± 11.5 | +15 -12 | | ± 11.5 | +15 -12 | | ± 11 | +15 -12 | | V |
| V_{opp} | Output voltage swing ($R_L = 10\text{k}\Omega$) $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ | 20 20 | 27 | | 20 20 | 27 | | 20 20 | 27 | | V |
| A_{vd} | Large signal voltage gain $R_L = 10\text{k}\Omega$, $V_o = \pm 10\text{V}$, $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ | 4 4 | 6 | | 4 4 | 6 | | 3 3 | 6 | | V/mV |
| GBP | Gain bandwidth product $T_{amb} = +25^\circ\text{C}$, $R_L = 10\text{k}\Omega$, $C_L = 100\text{pF}$ | | 1 | | | 1 | | | 1 | | MHz |
| R_i | Input resistance | | 10^{12} | | | 10^{12} | | | 10^{12} | | Ω |
| CMR | Common mode rejection ratio $R_S = 50\Omega$ | 80 | 86 | | 80 | 86 | | 70 | 76 | | dB |
| SVR | Supply voltage rejection ratio $R_S = 50\Omega$ | 80 | 95 | | 80 | 95 | | 70 | 95 | | dB |
| I_{CC} | Supply current, no load $T_{amb} = +25^\circ\text{C}$, no load, no signal | | 200 | 250 | | 200 | 250 | | 200 | 250 | μA |
| P_D | Total power consumption $T_{amb} = +25^\circ\text{C}$, no load, no signal | | 6 | 7.5 | | 6 | 7.5 | | 6 | 7.5 | mW |
| SR | Slew rate $V_i = 10\text{V}$, $R_L = 10\text{k}\Omega$, $C_L = 100\text{pF}$, $A_v = 1$ | 1.5 | 3.5 | | 1.5 | 3.5 | | 1.5 | 3.5 | | $\text{V}/\mu\text{s}$ |
| t_r | Rise time $V_i = 20\text{mV}$, $R_L = 10\text{k}\Omega$, $C_L = 100\text{pF}$, $A_v = 1$ | | 0.2 | | | 0.2 | | | 0.2 | | μs |

Table 3. $V_{CC} = \pm 15\text{ V}$, $T_{amb} = +25^\circ\text{ C}$ (unless otherwise specified) (continued)

| Symbol | Parameter | TL061M | | | TL061I | | | TL061C | | | Unit |
|----------|---|--------|------|------|--------|------|------|--------|------|------|--------------------------------------|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| K_{ov} | Overshoot factor (see Figure 16) $V_i = 20\text{mV}$, $R_L = 10\text{k}\Omega$, $C_L = 100\text{pF}$, $A_v = 1$ | | 10 | | | 10 | | | 10 | | % |
| e_n | Equivalent input noise voltage $R_S = 100\Omega$, $f = 1\text{kHz}$ | | 42 | | | 42 | | | 42 | | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |

1. The input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible.

Table 4. $V_{CC} = \pm 15\text{ V}$, $T_{amb} = +25^\circ\text{ C}$ (unless otherwise specified)

| Symbol | Parameter | TL061AC, AI, AM | | | TL061BC, BI, BM | | | Unit |
|-----------|---|-----------------|------------|----------|-----------------|------------|----------|------------------------------|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| V_{io} | Input offset voltage ($R_S = 50\Omega$) $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ | | 3 | 6 7.5 | | 2 | 3 5 | mV |
| DV_{io} | Temperature coefficient of input offset voltage ($R_S = 50\Omega$) | | 10 | | | 10 | | $\mu\text{V}/^\circ\text{C}$ |
| I_{io} | Input offset current ⁽¹⁾ $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ | | 5 | 100 3 | | 5 | 100 3 | pA nA |
| I_{ib} | Input bias current ⁽¹⁾ $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ | | 30 | 200 7 | | 30 | 200 7 | pA nA |
| V_{icm} | Input common mode voltage range | ± 11.5 | +15 -12 | | ± 11 | +15 -12 | | V |
| V_{opp} | Output voltage swing ($R_L = 10\text{k}\Omega$) $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ | 20 20 | 27 | | 20 20 | 27 | | V |
| A_{vd} | Large signal voltage gain ($R_L = 10\text{k}\Omega$, $V_o = \pm 10\text{V}$) $T_{amb} = +25^\circ\text{C}$ $T_{min} \leq T_{amb} \leq T_{max}$ | 4 4 | 6 | | 4 4 | 6 | | V/mV |
| GBP | Gain bandwidth product $T_{amb} = +25^\circ\text{C}$, $R_L = 10\text{k}\Omega$, $C_L = 100\text{pF}$ | | 1 | | | 1 | | MHz |
| R_i | Input resistance | | 10^{12} | | | 10^{12} | | Ω |
| CMR | Common mode rejection ratio ($R_S = 50\Omega$) | 80 | 86 | | 80 | 86 | | dB |
| SVR | Supply voltage rejection ratio ($R_S = 50\Omega$) | 80 | 95 | | 80 | 95 | | dB |
| I_{CC} | Supply current, no load $T_{amb} = +25^\circ\text{C}$, no load, no signal | | 200 | 250 | | 200 | 250 | μA |
| P_D | Total power consumption $T_{amb} = +25^\circ\text{C}$, no load, no signal | | 6 | 7.5 | | 6 | 7.5 | mW |

Table 4. $V_{CC} = \pm 15\text{ V}$, $T_{amb} = +25^\circ\text{ C}$ (unless otherwise specified) (continued)

| Symbol | Parameter | TL061AC, AI, AM | | | TL061BC, BI, BM | | | Unit |
|----------|--|-----------------|------|------|-----------------|------|------|--------------------------------------|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| SR | Slew rate $V_i = 10\text{V}$, $R_L = 10\text{k}\Omega$, $C_L = 100\text{pF}$, $A_v = 1$ | 1.5 | 3.5 | | 1.5 | 3.5 | | V/ μs |
| t_r | Rise time $V_i = 20\text{mV}$, $R_L = 10\text{k}\Omega$, $C_L = 100\text{pF}$, $A_v = 1$ | | 0.2 | | | 0.2 | | μs |
| K_{ov} | Overshoot factor (see Figure 16) $V_i = 20\text{mV}$, $R_L = 10\text{k}\Omega$, $C_L = 100\text{pF}$, $A_v = 1$ | | 10 | | | 10 | | % |
| e_n | Equivalent input noise voltage $R_S = 100\Omega$, $f = 1\text{KHz}$ | | 42 | | | 42 | | $\frac{\text{nV}}{\sqrt{\text{Hz}}}$ |

- The input bias currents of a FET-input operational amplifier are normal junction reverse currents, which are temperature sensitive. Pulse techniques must be used that will maintain the junction temperature as close to the ambient temperature as possible

Figure 3. Maximum peak-to-peak output voltage versus supply voltage

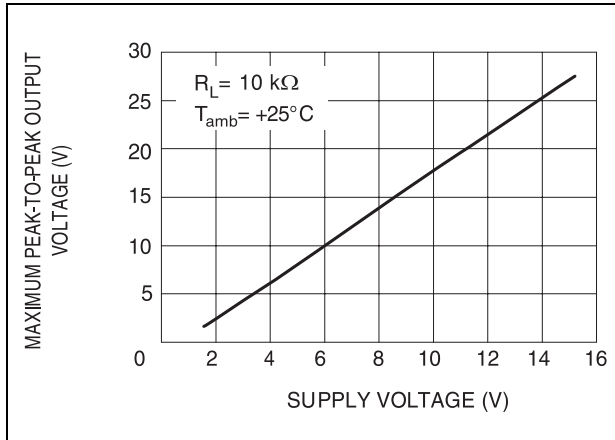


Figure 4. Maximum peak-to-peak output voltage versus free air temperature

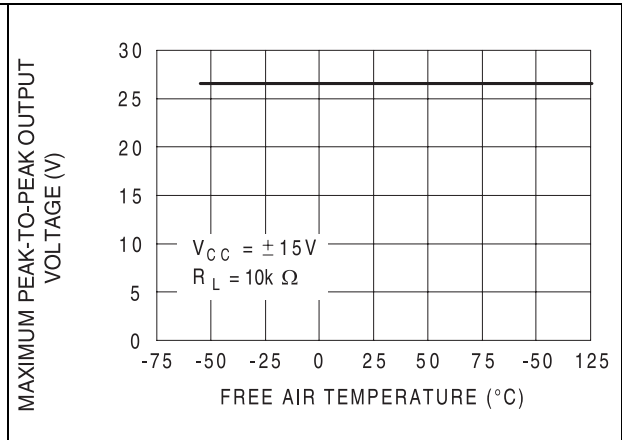


Figure 5. Maximum peak-to-peak output voltage versus load resistance

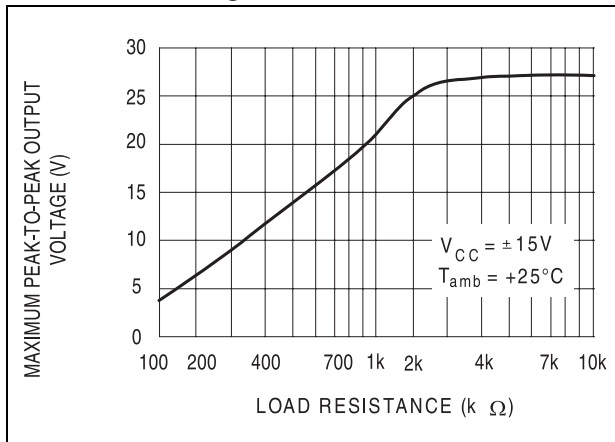


Figure 6. Maximum peak-to-peak output voltage versus frequency

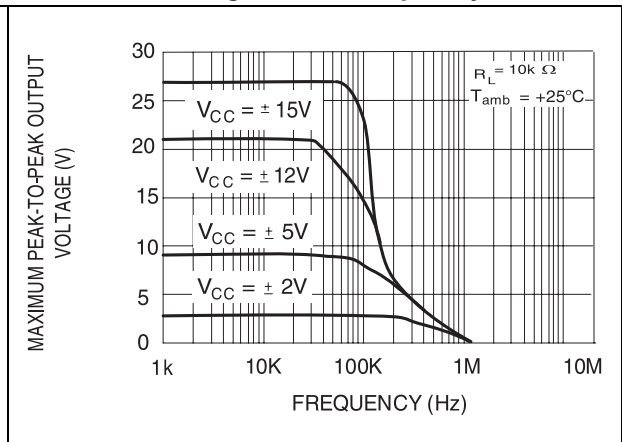


Figure 7. Differential voltage amplification versus free air temperature

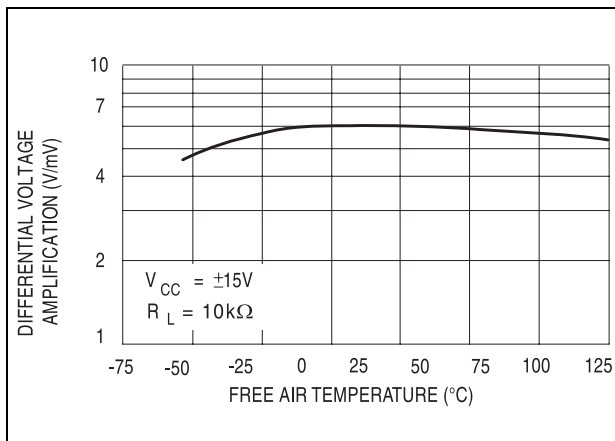


Figure 8. Large signal differential voltage amplification and phase shift versus frequency

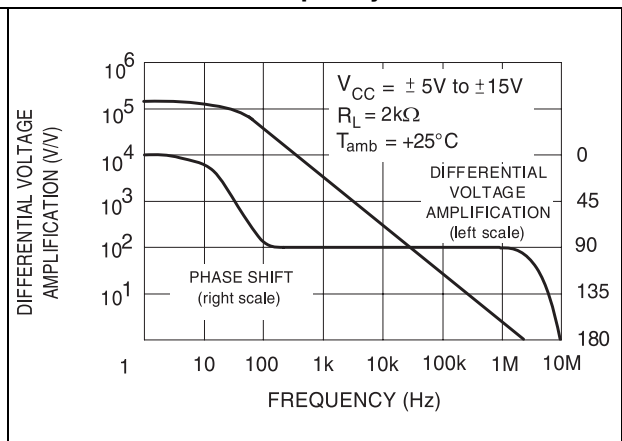


Figure 9. Supply current per amplifier versus supply voltage

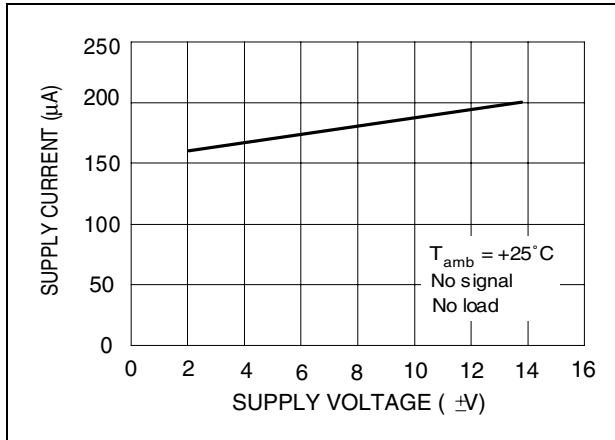


Figure 10. Supply current per amplifier versus free air temperature

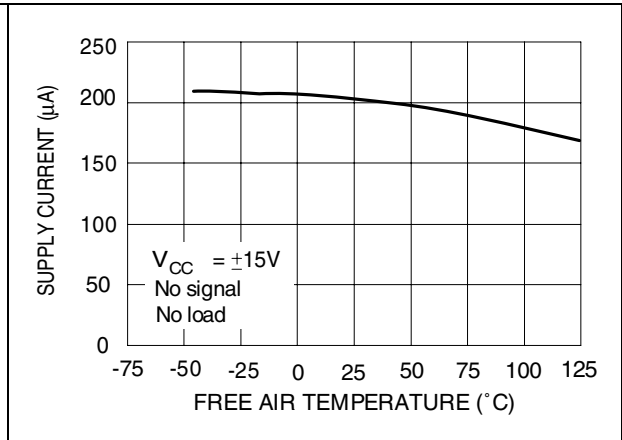


Figure 11. Total power dissipated versus free air temperature

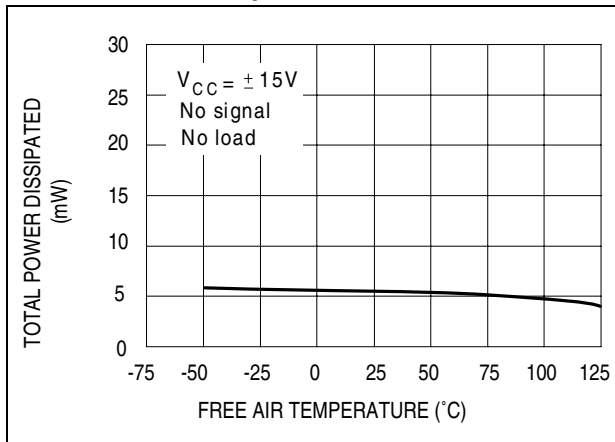


Figure 12. Common mode rejection ratio versus free air temperature

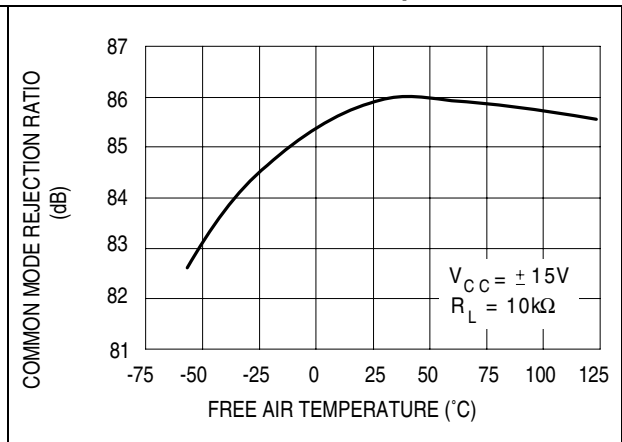


Figure 13. Normalized unity gain bandwidth, and phase shift versus temperature

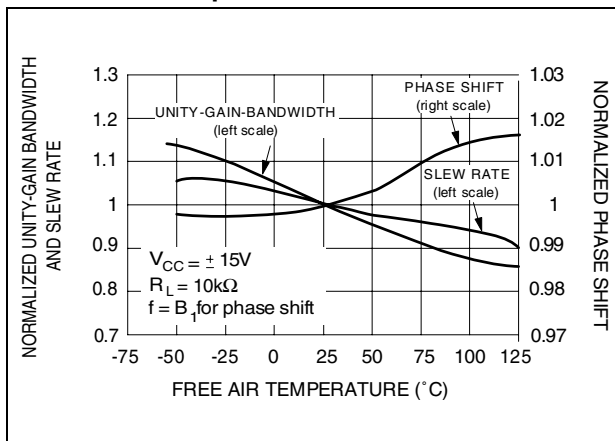


Figure 14. Input bias current versus free air temperature

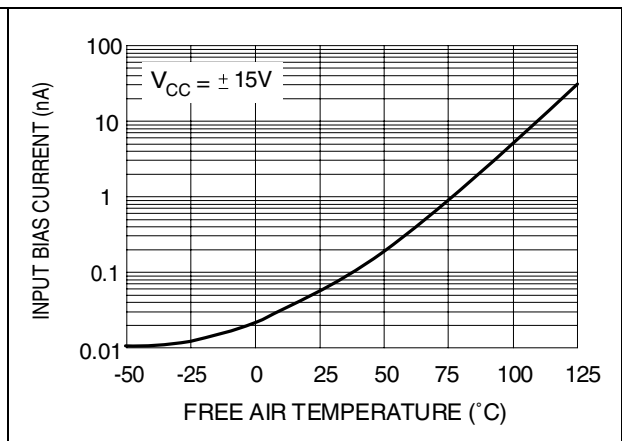


Figure 15. Voltage follower large signal pulse response

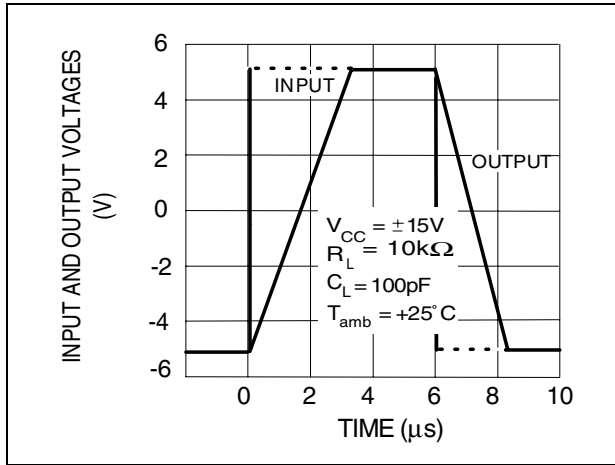


Figure 16. Output voltage versus elapsed time response

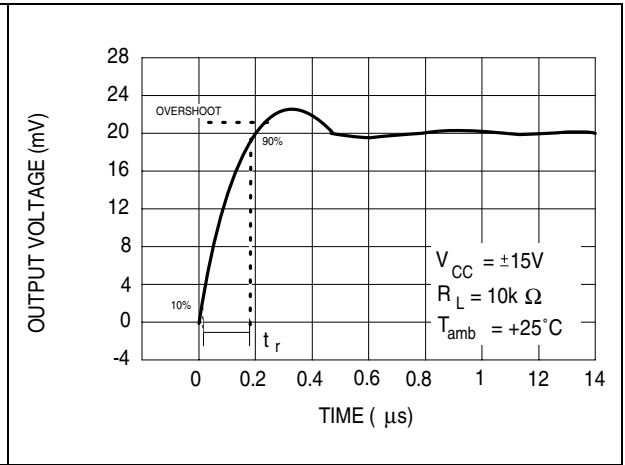
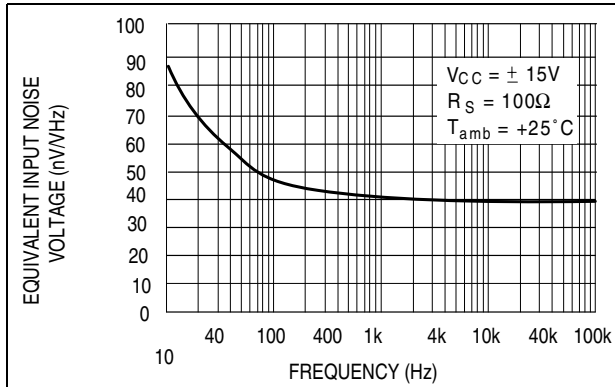


Figure 17. Equivalent input noise voltage versus frequency



4 Parameter measurement information

Figure 18. Voltage follower

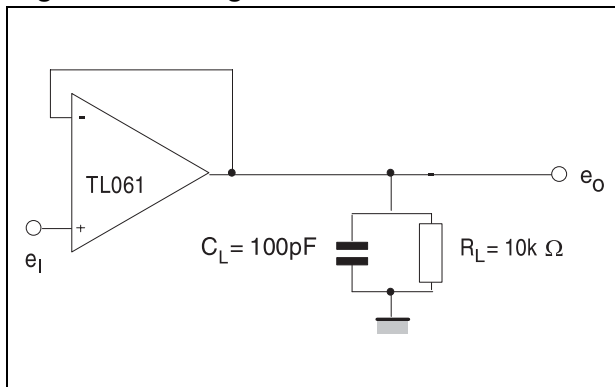
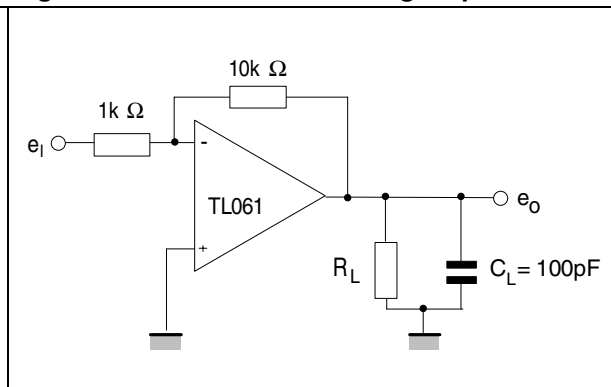


Figure 19. Gain-of-10 inverting amplifier



5 Package information

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

5.1 DIP8 package information

Figure 20. DIP8 package mechanical drawing

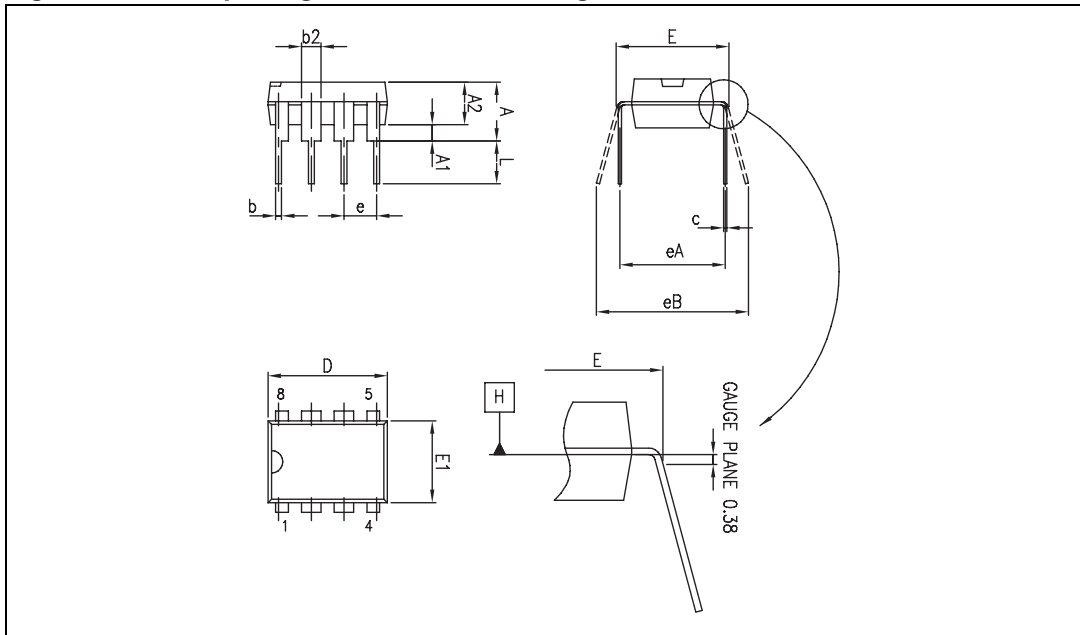


Table 5. DIP8 package mechanical data

| 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 |

5.2 SO-8 package information

Figure 21. SO-8 package mechanical drawing

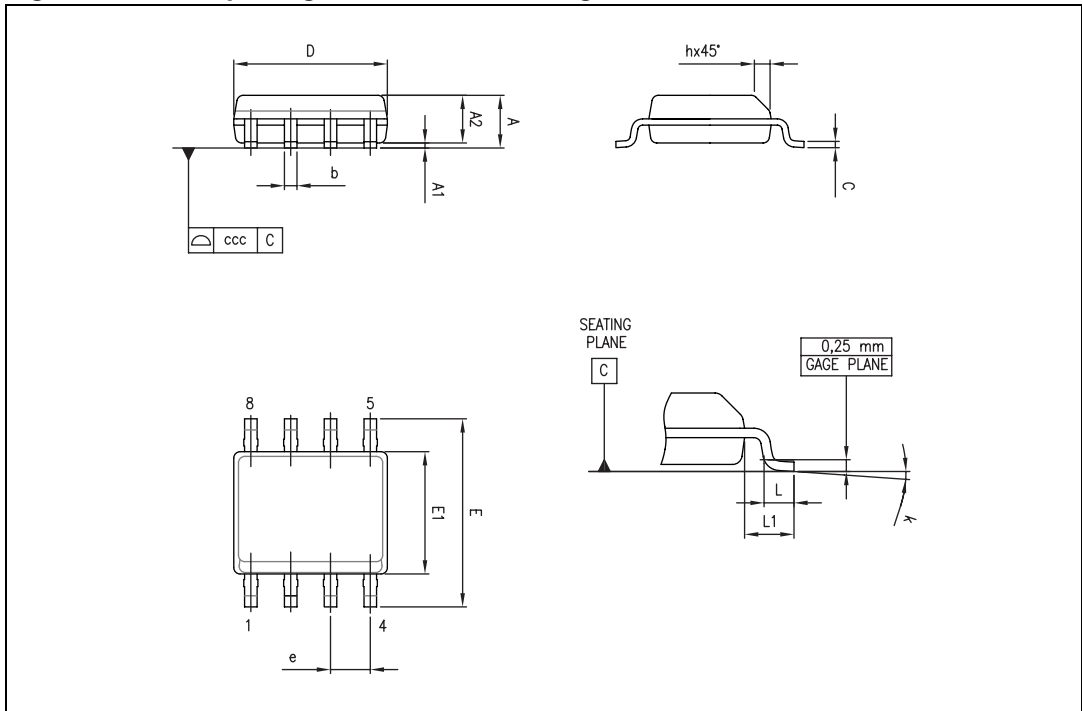


Table 6. SO-8 package mechanical data

| 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° | 1° | | 8° |
| ccc | | | 0.10 | | | 0.004 |

6 Ordering information

Table 7. Order codes

| Part number | Temperature range | Package | Packing | Marking |
|---|-------------------|---------|------------------------|---------------------------------|
| TL061MN TL061AMN TL061BMN | -55°C, +125°C | DIP8 | Tube | TL061MN TL061AMN TL061BMN |
| TL061MD/MDT TL061AMD/MDT TL061BMD/BMDT | | SO-8 | Tube or tape & reel | 061M 061AM 061BM |
| TL061IN TL061AIN TL061BIN | -40°C, +105°C | DIP8 | Tube | TL061IN TL061AIN TL061BIN |
| TL061ID/IDT TL061AID/AIDT TL061BID/BIDT | | SO-8 | Tube or tape & reel | 061I 061AI 061BI |
| TL061CN TL061ACN TL061BCN | 0°C, +70°C | DIP8 | Tube | TL061CN TL061ACN TL061BCN |
| TL061CD/CDT TL061ACD/ACDT TL061BCD/BCDT | | SO-8 | Tube or tape & reel | 061C 061AC 061BC |

7 Revision history

Table 8. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 13-Nov-2001 | 1 | Initial release. |
| 27-Jul-2007 | 2 | Added values for R_{thja} and R_{thjc} in Table 1: Absolute maximum ratings . Added Table 2: Operating conditions . Updated format. |
| 05-Mar-2009 | 3 | Updated package mechanical drawings and data in Chapter 5: Package information . |

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