

Low noise JFET single operational amplifier

Features

- Wide common-mode (up to V_{CC}^+) and differential voltage range
- Low input bias and offset current
- Low noise $e_n = 15 \text{ nV}/\sqrt{\text{Hz}}$ (typ)
- Output short-circuit protection
- High input impedance JFET input stage
- Low harmonic distortion: 0.01 % (typ)
- Internal frequency compensation
- Latch-up free operation
- High slew rate: $16 \text{ V}/\mu\text{s}$ (typ)

Description

The TL071 is a high-speed JFET input single operational amplifier. This JFET input operational amplifier 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.

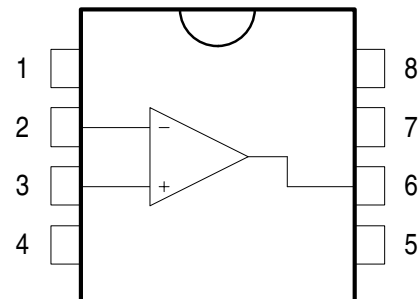


**N
DIP8**
(Plastic package)



**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. Circuit schematics

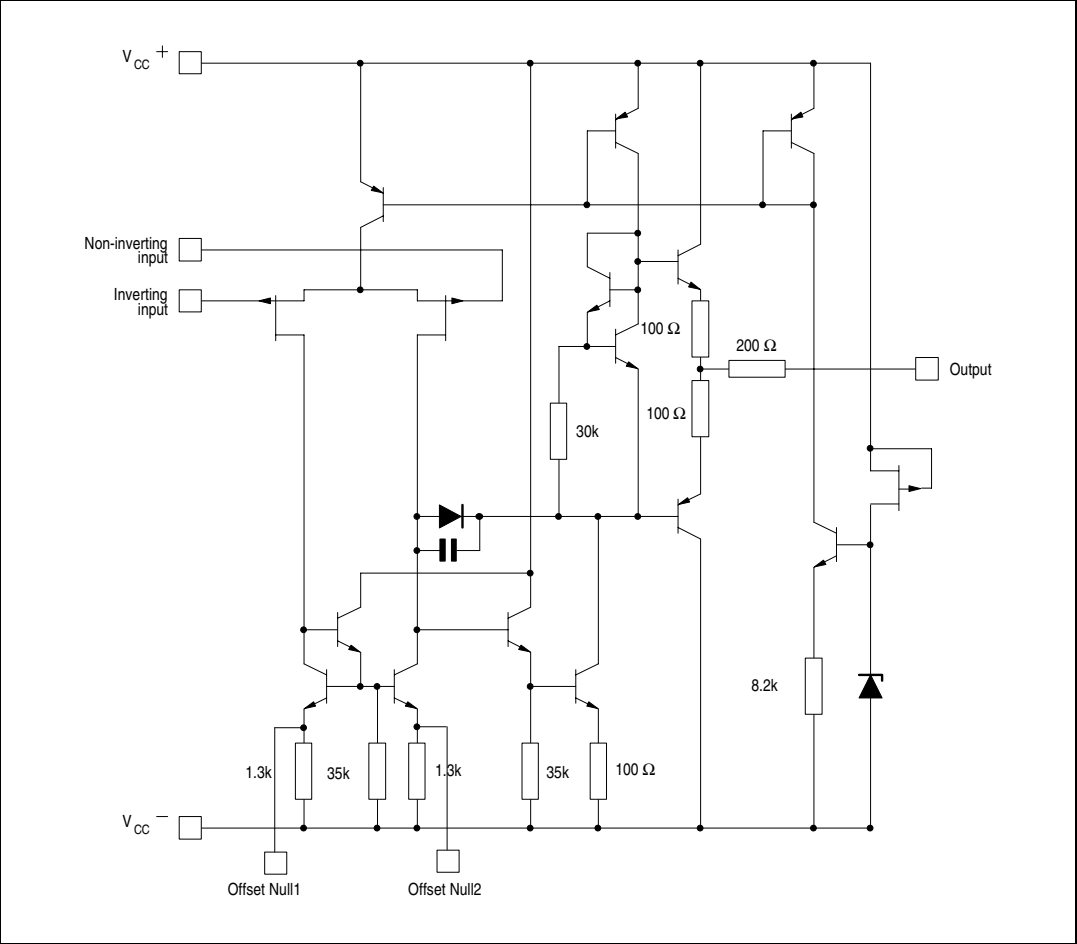
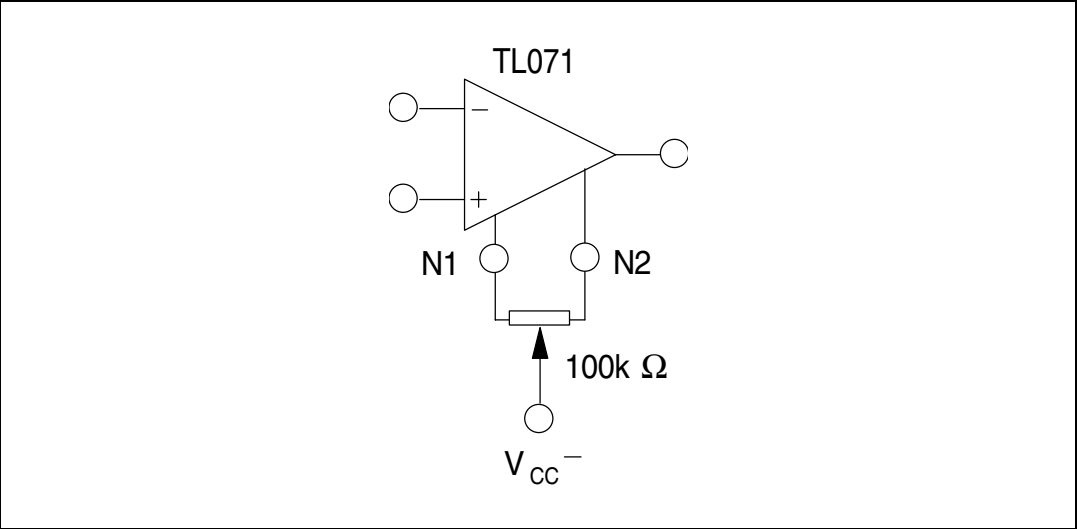


Figure 2. Input offset voltage null circuit



2 Absolute maximum ratings and operating conditions

Table 1. Absolute maximum ratings

| Symbol | Parameter | Value | | | Unit |
|-------------------|---|----------------|----------------|----------------|------|
| | | TL071M, AM, BM | TL071I, AI, BI | TL071C, AC, BC | |
| V _{CC} | Supply voltage ⁽¹⁾ | ±18 | | | V |
| V _i | Input voltage ⁽²⁾ | ±15 | | | V |
| V _{id} | Differential input voltage ⁽³⁾ | ±30 | | | V |
| R _{thja} | Thermal resistance junction to ambient ^{(4) (5)} | | | | °C/W |
| | SO-8 | 125 | | | |
| | DIP8 | 85 | | | |
| R _{thjc} | Thermal resistance junction to case ^{(4) (5)} | | | | °C/W |
| | SO-8 | 40 | | | |
| | DIP8 | 41 | | | |
| | Output short-circuit duration ⁽⁶⁾ | Infinite | | | |
| T _{oper} | Operating free-air temperature range | -55 to +125 | -40 to +105 | 0 to +70 | °C |
| T _{stg} | Storage temperature range | -65 to +150 | | | °C |
| ESD | HBM: human body model ⁽⁷⁾ | 500 | | | V |
| | MM: machine model ⁽⁸⁾ | 200 | | | V |
| | CDM: charged device model ⁽⁹⁾ | 1500 | | | V |

1. 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}^- .
2. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 15 volts, whichever is less.
3. Differential voltages are the non-inverting input terminal with respect to the inverting input terminal.
4. Short-circuits can cause excessive heating. Destructive dissipation can result from simultaneous short-circuits on all amplifiers.
5. R_{th} are typical values.
6. 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.
7. Human body model: 100 pF discharged through a 1.5 k Ω resistor between two pins of the device, done for all couples of pin combinations with other pins floating.
8. 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.
9. 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 | TL071I, AI, BI | TL071C, AC, BC | Unit |
|------------|--------------------------------------|----------------|----------------|------|
| V_{CC} | Supply voltage | 6 to 36 | | V |
| T_{oper} | Operating free-air temperature range | -40 to +105 | 0 to +70 | °C |

3 Electrical characteristics

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

| Symbol | Parameter | TL071I,M,AC,AI,AM, BC,BI,BM | | | TL071C | | | Unit |
|---------------|---|--------------------------------|-------------|------------------------------|----------------------|------------|--------------|-------------------|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| V_{io} | Input offset voltage ($R_S = 50\Omega$) $T_{amb} = +25^{\circ}C$ TL071 TL071A TL071B $T_{min} \leq T_{amb} \leq T_{max}$ TL071 TL071A TL071B | | 3 3 1 | 10 6 3 13 7 5 | | 3 | 10 13 | mV |
| DV_{io} | Input offset voltage drift | | 10 | | | 10 | | $\mu V/^{\circ}C$ |
| I_{io} | Input offset current $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$ | | 5 | 100 4 | | 5 | 100 10 | pA nA |
| I_{ib} | Input bias current ⁽¹⁾ $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$ | | 20 | 200 20 | | 20 | 200 20 | pA nA |
| A_{vd} | Large signal voltage gain ($R_L = 2k\Omega$, $V_o = \pm 10V$) $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$ | 50 25 | 200 | | 25 15 | 200 | | V/mV |
| SVR | Supply voltage rejection ratio ($R_S = 50\Omega$) $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$ | 80 80 | 86 | | 70 70 | 86 | | dB |
| I_{CC} | Supply current, no load $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$ | | 1.4 | 2.5 2.5 | | 1.4 | 2.5 2.5 | mA |
| V_{icm} | Input common mode voltage range | ± 11 | +15 -12 | | ± 11 | +15 -12 | | V |
| CMR | Common mode rejection ratio ($R_S = 50\Omega$) $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$ | 80 80 | 86 | | 70 70 | 86 | | dB |
| I_{os} | Output short-circuit current $T_{amb} = +25^{\circ}C$ $T_{min} \leq T_{amb} \leq T_{max}$ | 10 10 | 40 | 60 60 | 10 10 | 40 | 60 60 | mA |
| $\pm V_{opp}$ | Output voltage swing $T_{amb} = +25^{\circ}C$ $R_L = 2k\Omega$ $R_L = 10k\Omega$ $T_{min} \leq T_{amb} \leq T_{max}$ $R_L = 2k\Omega$ $R_L = 10k\Omega$ | 10 12 10 12 | 12 13.5 | | 10 12 10 12 | 12 13.5 | | V |
| SR | Slew rate $V_{in} = 10V$, $R_L = 2k\Omega$, $C_L = 100pF$, unity gain | 8 | 16 | | 8 | 16 | | V/ μs |

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

| Symbol | Parameter | TL071I,M,AC,AI,AM, BC,BI,BM | | | TL071C | | | Unit |
|----------|---|--------------------------------|-----------|------|--------|-----------|------|------------------------|
| | | Min. | Typ. | Max. | Min. | Typ. | Max. | |
| t_r | Rise time $V_{in} = 20mV$, $R_L = 2k\Omega$, $C_L = 100pF$, unity gain | | 0.1 | | | 0.1 | | μs |
| K_{ov} | Overshoot $V_{in} = 20mV$, $R_L = 2k\Omega$, $C_L = 100pF$, unity gain | | 10 | | | 10 | | % |
| GBP | Gain bandwidth product $V_{in} = 10mV$, $R_L = 2k\Omega$, $C_L = 100pF$, $f = 100kHz$ | 2.5 | 4 | | 2.5 | 4 | | MHz |
| R_i | Input resistance | | 10^{12} | | | 10^{12} | | W |
| THD | Total harmonic distortion, $f = 1kHz$, $R_L = 2k\Omega$, $C_L = 100pF$, $A_v = 20dB$, $V_o = 2V_{pp}$ | | 0.01 | | | 0.01 | | % |
| e_n | Equivalent input noise voltage $R_S = 100\Omega$, $f = 1KHz$ | | 15 | | | 15 | | $\frac{nV}{\sqrt{Hz}}$ |
| ϕ_m | Phase margin | | 45 | | | 45 | | degrees |

1. The input bias currents are junction leakage currents which approximately double for every $10^{\circ}C$ increase in the junction temperature.

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

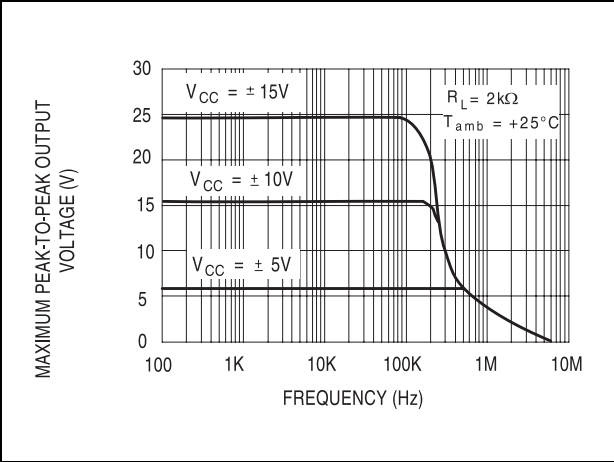


Figure 4. Maximum peak-to-peak output voltage versus frequency

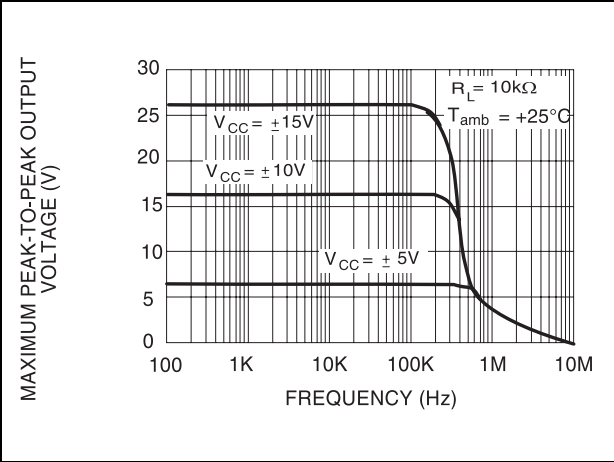


Figure 5. Maximum peak-to-peak output voltage versus frequency

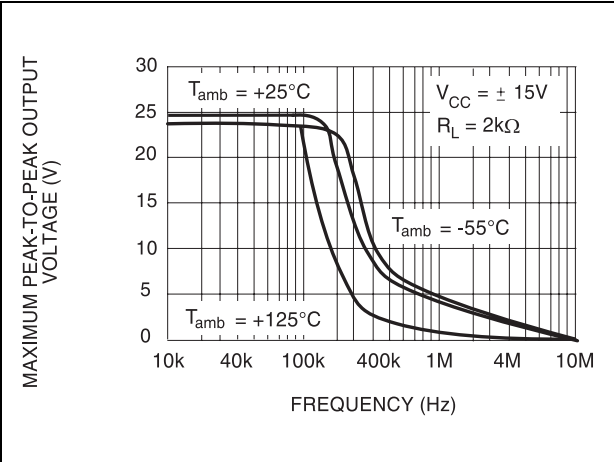


Figure 6. Maximum peak-to-peak output voltage versus free air temp.

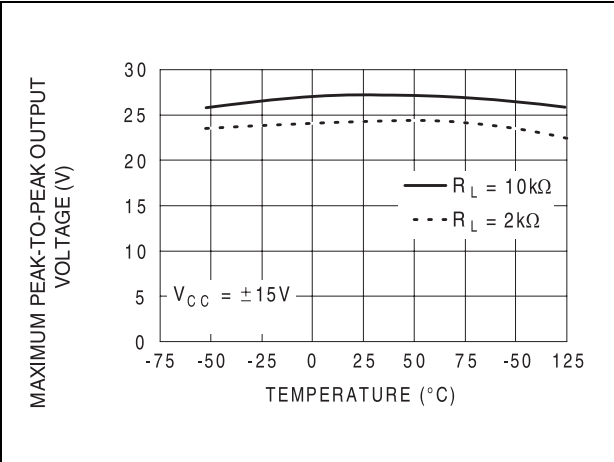


Figure 7. Maximum peak-to-peak output voltage versus load resistance

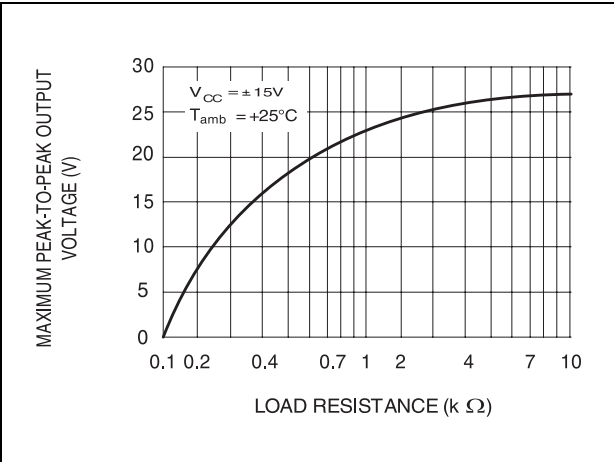


Figure 8. Maximum peak-to-peak output voltage versus supply voltage

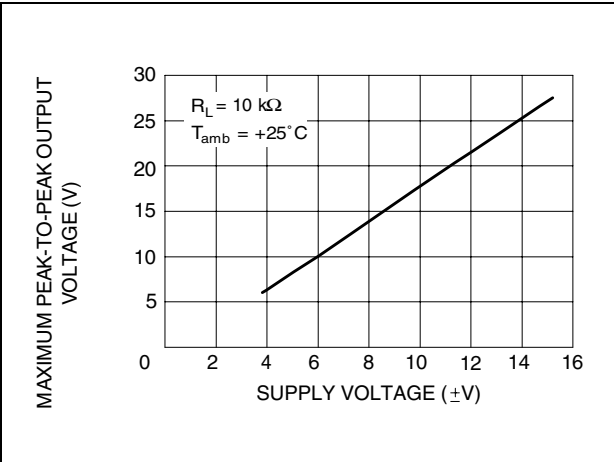


Figure 9. Input bias current versus free air temperature

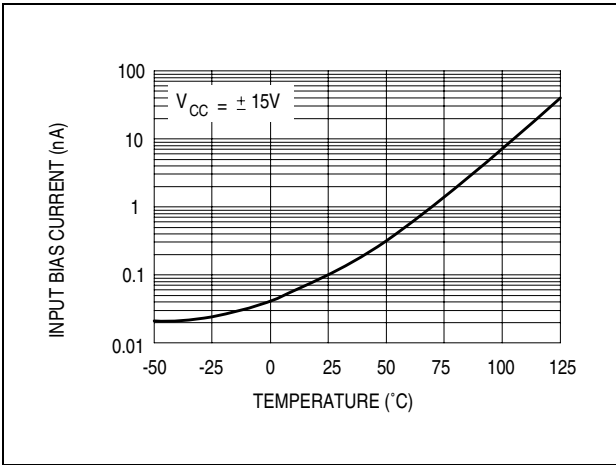


Figure 10. Large signal differential voltage amplification versus free air temp.

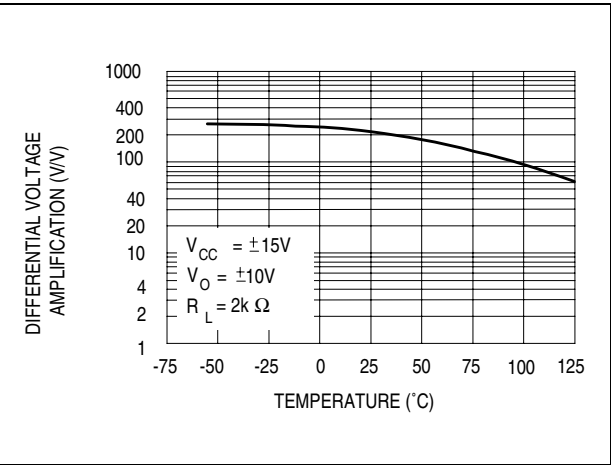


Figure 11. Large signal differential voltage amplification and phase shift versus frequency

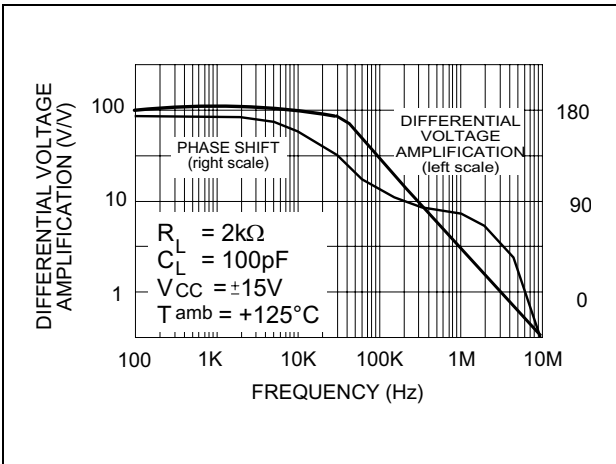


Figure 12. Total power dissipation versus free air temperature

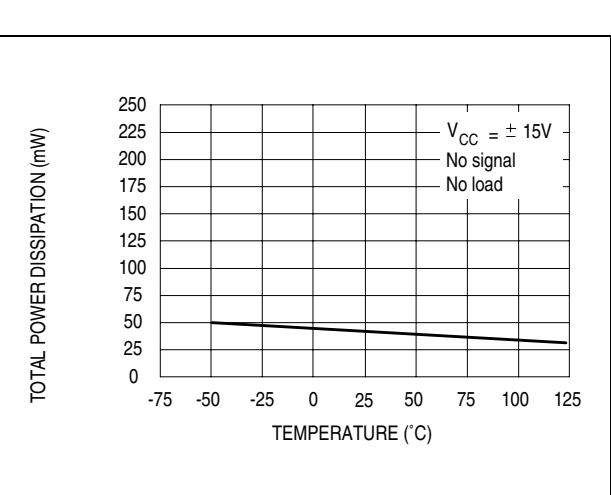


Figure 13. Supply current per amplifier versus free air temperature

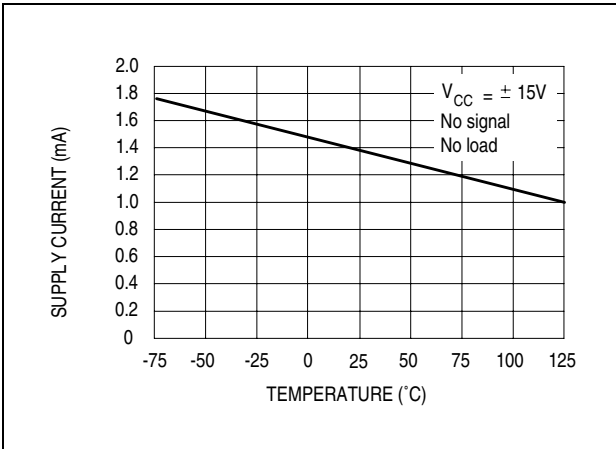


Figure 14. Common mode rejection ratio versus free air temperature

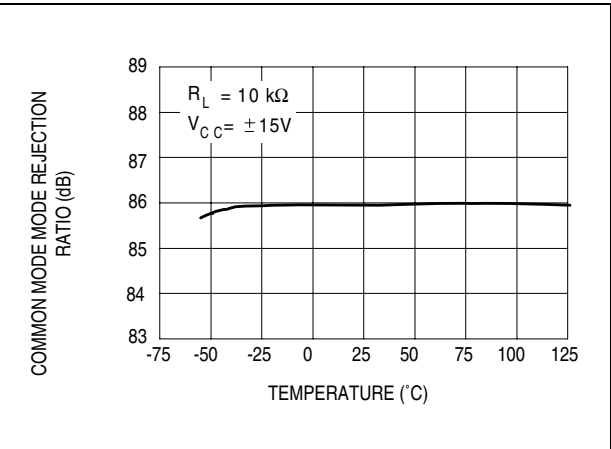


Figure 15. Voltage follower large signal pulse response

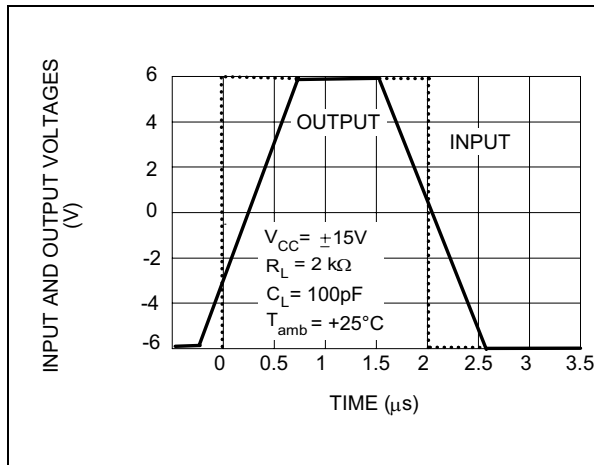


Figure 16. Output voltage versus elapsed time response

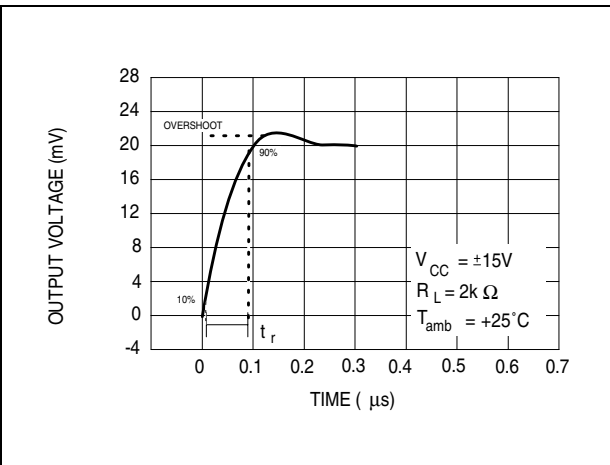


Figure 17. Equivalent input noise voltage versus frequency

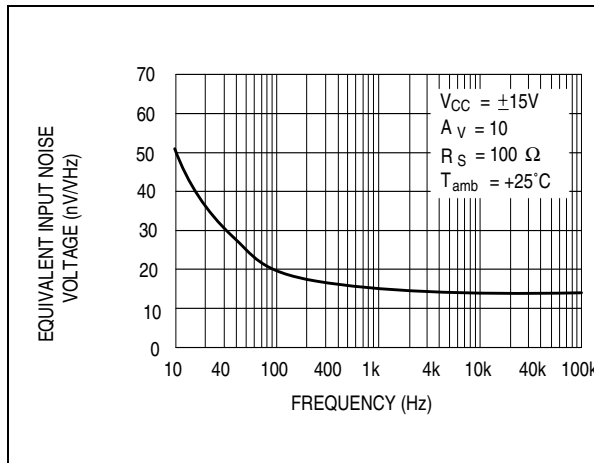
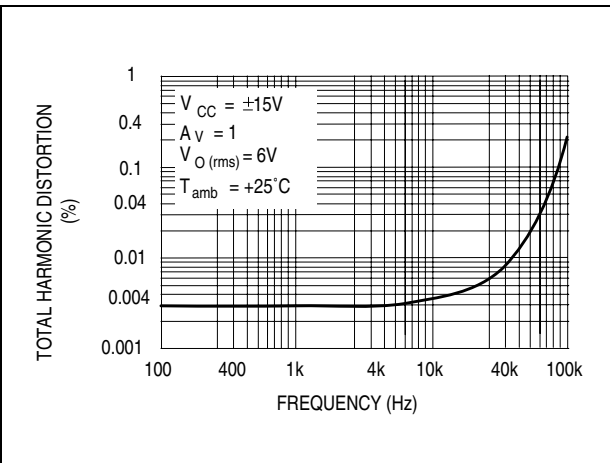


Figure 18. Total harmonic distortion versus frequency



Parameter measurement information

Figure 19. Voltage follower

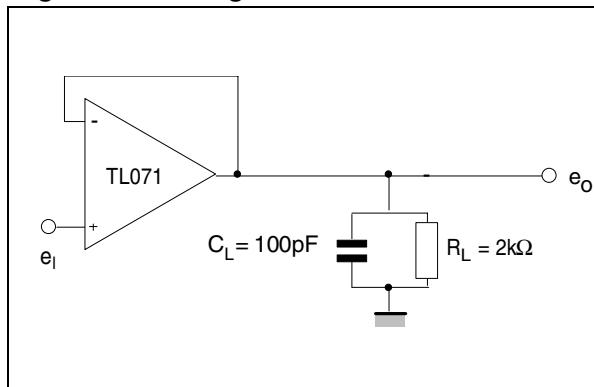
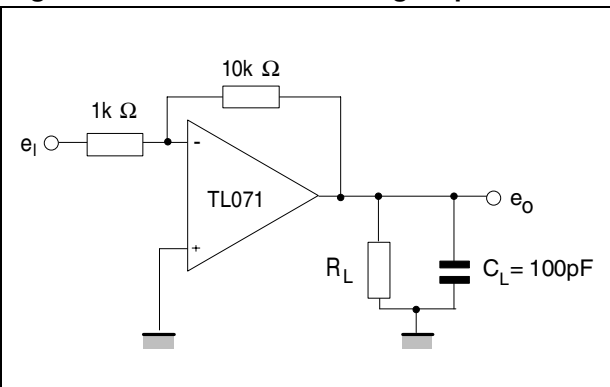


Figure 20. Gain-of-10 inverting amplifier



4 Typical applications

Figure 21. (0.5 Hz) Square wave oscillator

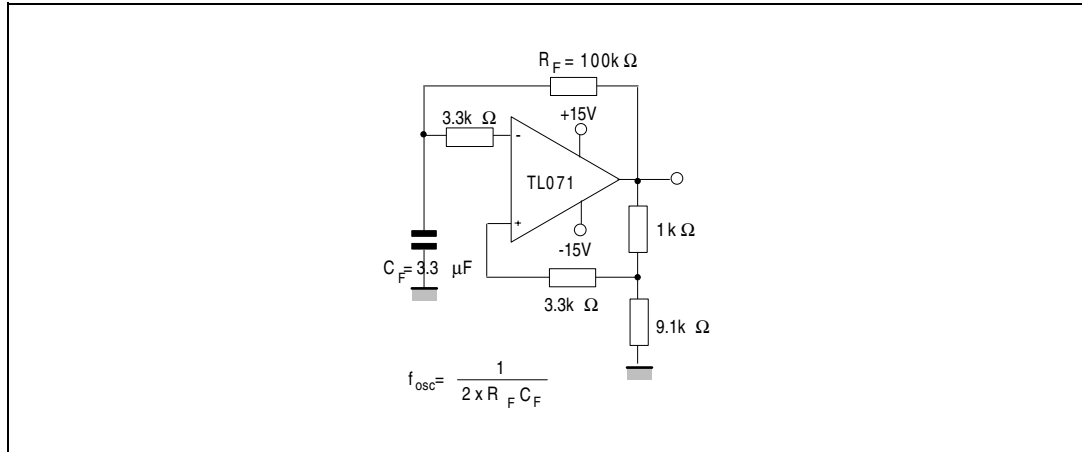
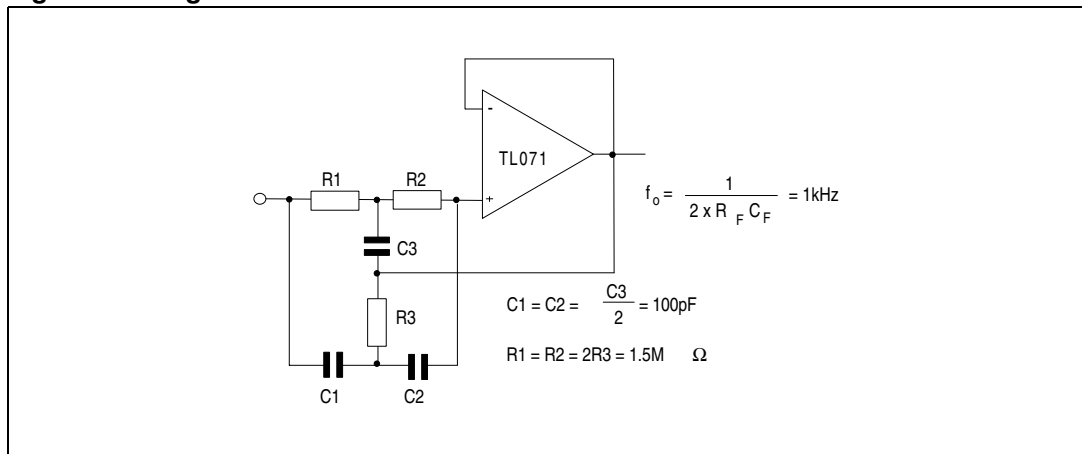


Figure 22. High Q notch filter



5 Package information

In order to meet environmental requirements, STMicroelectronics offers these devices in ECOPACK® packages. These packages have a lead-free second level interconnect. The category of second level interconnect is marked on the package and on the inner box label, in compliance with JEDEC Standard JESD97. The maximum ratings related to soldering conditions are also marked on the inner box label. ECOPACK is an STMicroelectronics trademark. ECOPACK specifications are available at: www.st.com.

5.1 DIP8 package information

Figure 23. DIP8 package mechanical drawing

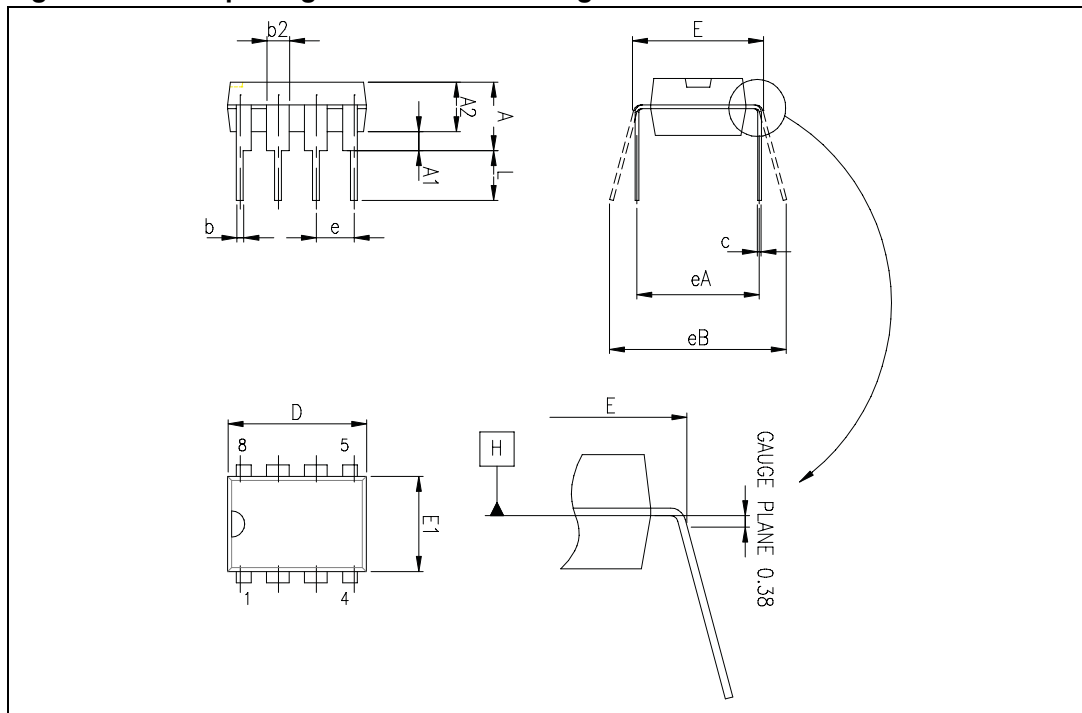


Table 4. DIP8 package mechanical data

| 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 |

5.2 SO-8 package information

Figure 24. SO-8 package mechanical drawing

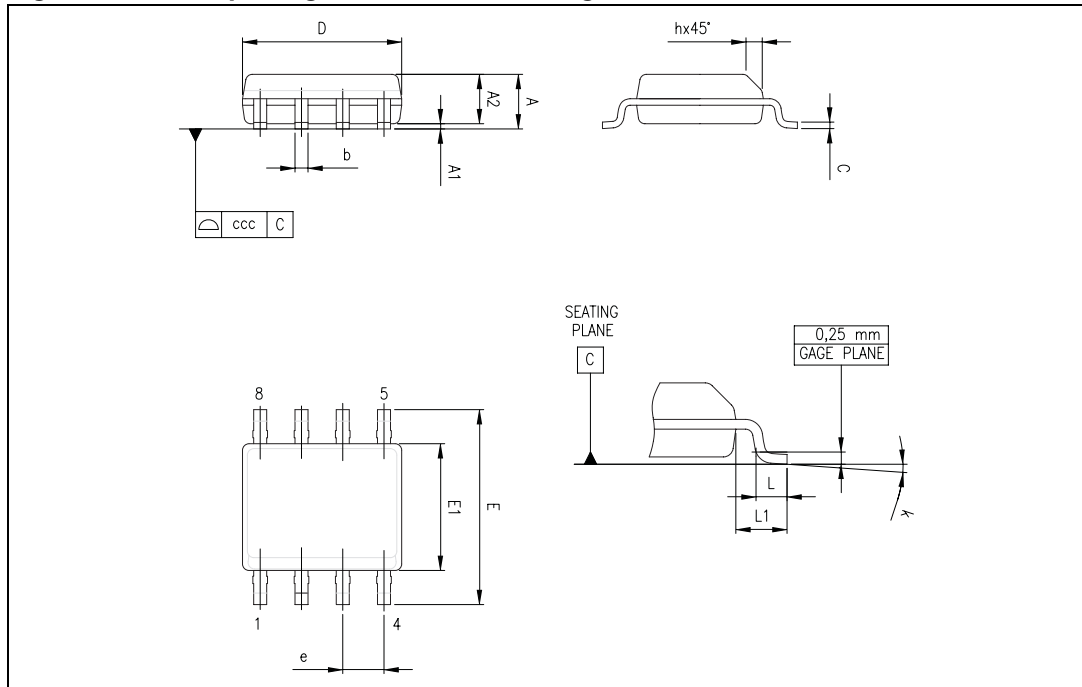


Table 5. SO-8 package mechanical data

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

6 Ordering information

Table 6. Order codes

| Part number | Temperature range | Package | Packing | Marking |
|--|-------------------|-------------------------------|------------------------|---------------------------------|
| TL071IN TL071AIN TL071BIN | -40°C, +105°C | DIP8 | Tube | TL071IN TL071AIN TL071BIN |
| TL071ID/IDT TL071AID/AIDT TL071BID/BIDT | | SO-8 | Tube or tape & reel | 071I 071AI 071BI |
| TL071CN TL071ACN TL071BCN | 0°C, +70°C | DIP8 | Tube | TL071CN TL071ACN TL071BCN |
| TL071CD/CDT TL071ACD/ACDT TL071BCD/BCDT | | SO-8 | Tube or tape & reel | 071C 071AC 071BC |
| TL071IYD/DT ⁽¹⁾ TL071AIYD/DT ⁽¹⁾ TL071BIYD/DT ⁽¹⁾ | -40°C, +105°C | SO-8 (Automotive grade) | Tube or tape & reel | 071IY 071AIY 071BIY |

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

7 Revision history

Table 7. Document revision history

| Date | Revision | Changes |
|-------------|----------|---|
| 29-Mar-2001 | 1 | Initial release. |
| 30-Jul-2007 | 2 | Added values for R_{thja} , R_{thjc} and ESD in Table 1: Absolute maximum ratings . Added Table 2: Operating conditions . Expanded Table 6: Order codes . Format update. |
| 19-Sep-2008 | 3 | Corrected ESD HBM value in Table 1: Absolute maximum ratings . Added L1 parameter in Table 5: SO-8 package mechanical data . Added missing order codes for automotive grade products in Table 6: Order codes . Removed information concerning military temperature ranges (TL071Mx, TL071AMx, TL071BMx) in Table 6 . |

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