# LF351

## Wide bandwidth single JFET operational amplifiers

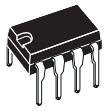
## Features

- Internally adjustable input offset voltage
- Low power consumption
- Wide common-mode (up to $V_{CC}^+$) and differential voltage range
- Low input bias and offset current
- Output short-circuit protection
- High input impedance JFET input stage
- Internal frequency compensation
- Latch up free operation
- High slew rate 16 V/µs (typical)

## Description

These circuits are high speed JFET input single operational amplifiers incorporating well matched, high voltage JFET and bipolar transistors in a monolithic integrated circuit.

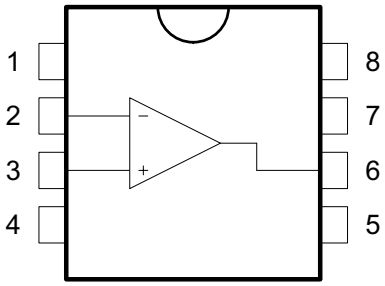
The devices feature high slew rates, low input bias and offset currents, and low offset voltage temperature coefficient.



**N**
**DIP8**
(Plastic package)

**D**
**SO-8**
(Plastic micro package)

**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 Schematics

**Figure 1. Schematic diagram**

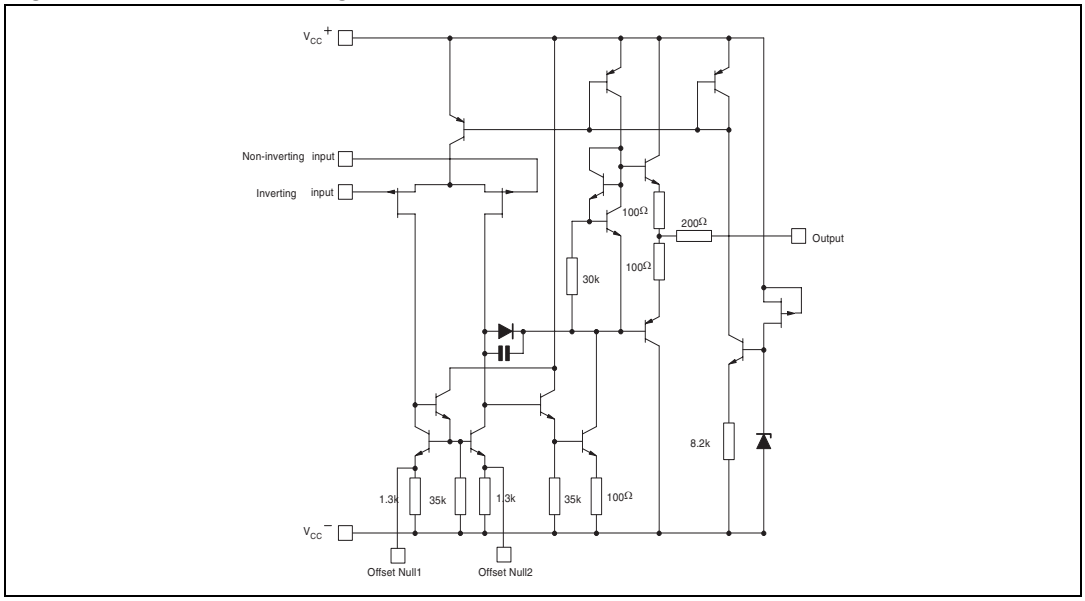
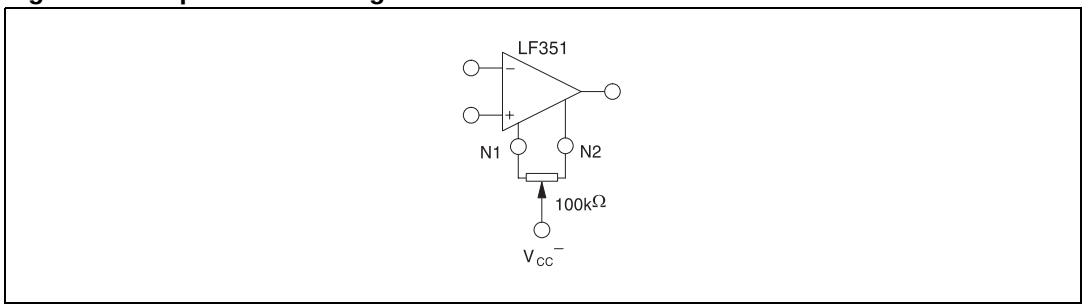



**Figure 2. Input offset voltage null circuit**



# 2 Absolute maximum ratings and operating conditions

**Table 1. Absolute maximum ratings**

| Symbol | Parameter | Value | Unit |
|---|---|---|---|
| $V_{CC}$ | 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)<br>SO-8<br>DIP8 | <br>125<br>85 | °C/W |
| $R_{thjc}$ | Thermal resistance junction to case(4)<br>SO-8<br>DIP8 | <br>40<br>41 | °C/W |
| | Output short-circuit duration(5) | Infinite | |
| $T_{stg}$ | Storage temperature range | -65 to +150 | °C |
| ESD | HBM: human body model(6) | 500 | 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 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 and destructive dissipation. Values are typical.
5. 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
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 | LF151 | LF251 | LF351 | Unit |
|---|---|---|---|---|---|
| $V_{CC}$ | Supply voltage | 6 to 32 | | | V |
| $T_{oper}$ | Operating free-air temperature range | -55 to +125 | -40 to +105 | 0 to +70 | °C |

# 3 Electrical characteristics

**Table 3. Electrical characteristics at $V_{CC}$ = ±15 V, $T_{amb}$ = +25°C (unless otherwise specified)**

| Symbol | Parameter | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $V_{io}$ | Input offset voltage ($R_S$ = 10kΩ)<br>$T_{min} \le T_{amb} \le T_{max}$ | | 3 | 10<br>13 | mV |
| $DV_{io}$ | Input offset voltage drift | | 10 | | µV/°C |
| $I_{io}$ | Input offset current (1)<br>$T_{min} \le T_{amb} \le T_{max}$ | | 5 | 100<br>4 | pA<br>nA |
| $I_{ib}$ | Input bias current (1)<br>$T_{min} \le T_{amb} \le T_{max}$ | | 20 | 200<br>20 | pA<br>nA |
| $A_{vd}$ | Large signal voltage gain ($R_L$ = 2kΩ, $V_o$ = ±10V)<br>$T_{min} \le T_{amb} \le T_{max}$ | 50<br>25 | 200 | | V/mV |
| SVR | Supply voltage rejection ratio ($R_S$ = 10kΩ)<br>$T_{min} \le T_{amb} \le T_{max}$ | 80<br>80 | 86 | | dB |
| $I_{CC}$ | Supply current, no load<br>$T_{min} \le T_{amb} \le T_{max}$ | | 1.4 | 3.4<br>3.4 | mA |
| $V_{icm}$ | Input common mode voltage range | ±11 | +15<br>-12 | | V |
| CMR | Common mode rejection ratio ($R_S$ = 10kΩ)<br>$T_{min} \le T_{amb} \le T_{max}$ | 70<br>70 | 86 | | dB |
| $I_{OS}$ | Output short-circuit current<br>$T_{min} \le T_{amb} \le T_{max}$ | 10<br>10 | 40 | 60<br>60 | mA |
| $\pm V_{opp}$ | Output voltage swing<br>$R_L$ = 2kΩ<br>$R_L$ = 10kΩ<br>$T_{min} \le T_{amb} \le T_{max}$<br>$R_L$ = 2kΩ<br>$R_L$ = 10kΩ | 10<br>12<br><br>10<br>12 | 12<br>13.5 | | V |
| SR | Slew rate, $V_i$ = 10V, $R_L$ = 2kΩ, $C_L$ = 100pF, unity gain | 12 | 16 | | V/µs |
| $t_r$ | Rise time, $V_i$ = 20mV, $R_L$ = 2kΩ, $C_L$ = 100pF, unity gain | | 0.1 | | µs |
| $K_{ov}$ | Overshoot, $V_i$ = 20mV, $R_L$ = 2kΩ, $C_L$ = 100pF, unity gain | | 10 | | % |
| GBP | Gain bandwidth product, f = 100kHz, $V_{in}$ = 10mV, $R_L$ = 2kΩ, $C_L$ = 100pF | 2.5 | 4 | | MHz |
| $R_i$ | Input resistance | | $10^{12}$ | | Ω |
| THD | Total harmonic distortion<br>f= 1kHz, $A_v$= 20dB, $R_L$= 2kΩ, $C_L$=100pF, $V_o$= $2V_{pp}$ | | 0.01 | | % |
| $e_n$ | Equivalent input noise voltage<br>$R_S$ = 100Ω, f = 1KHz | | 15 | | $\frac{nV}{\sqrt{Hz}}$ |
| ∅m | Phase margin | | 45 | | Degrees |

1. The input bias currents are junction leakage currents which approximately double for every 10°C increase in the junction temperature.

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

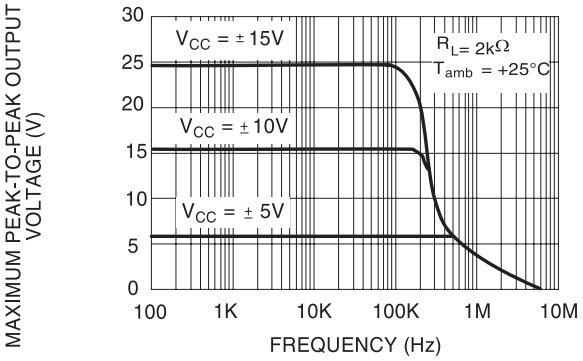



**Figure 4. Maximum peak-to-peak output voltage versus frequency**

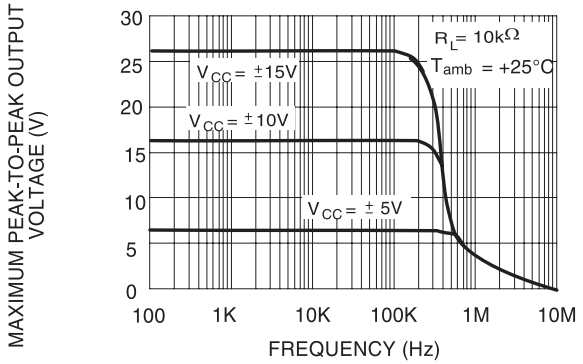



**Figure 5. Maximum peak-to-peak output voltage versus frequency**

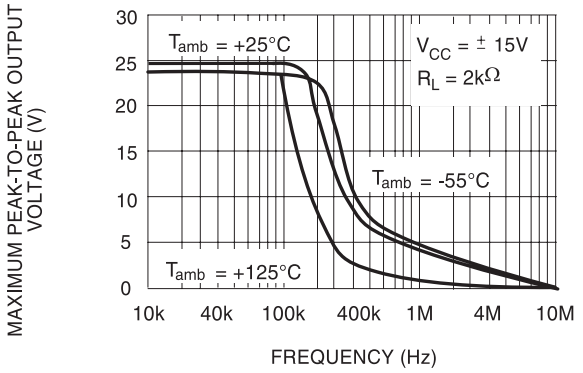



**Figure 6. Maximum peak-to-peak output voltage versus free air temp.**

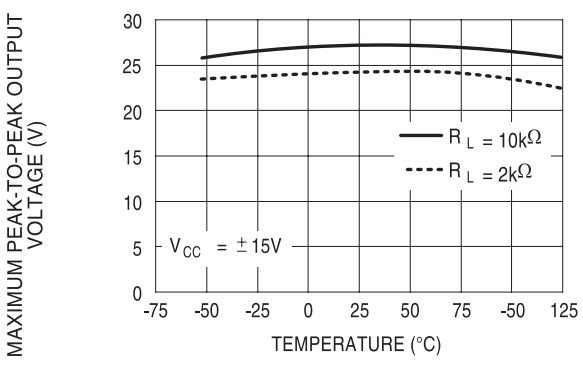



**Figure 7. Maximum peak-to-peak output voltage versus load resistance**

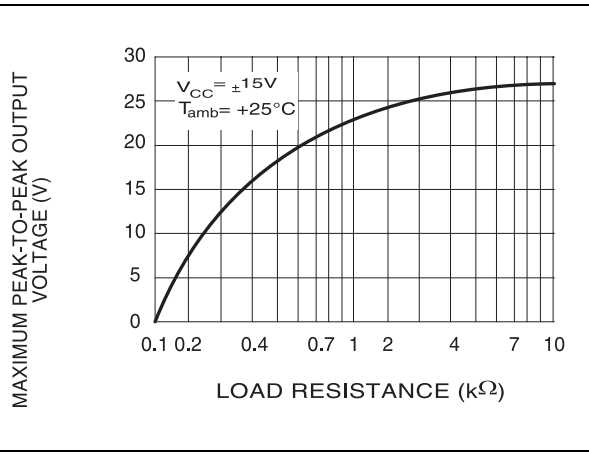



**Figure 8. Maximum peak-to-peak output voltage versus supply voltage**

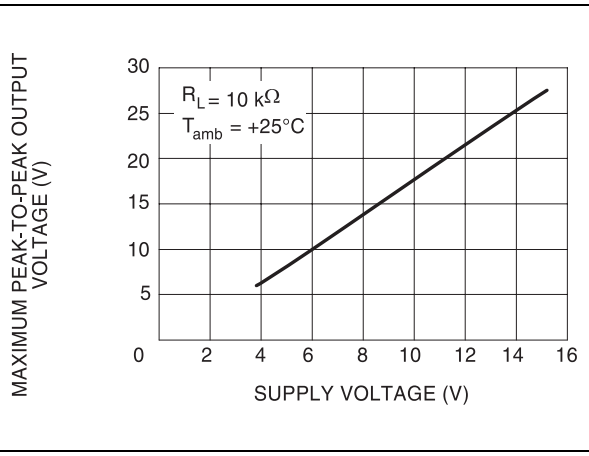


**Figure 9. Input bias current versus free air temperature**

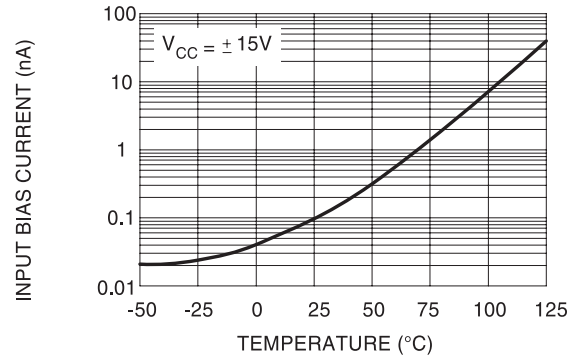



**Figure 10. Large signal differential voltage amplification versus free air temp.**

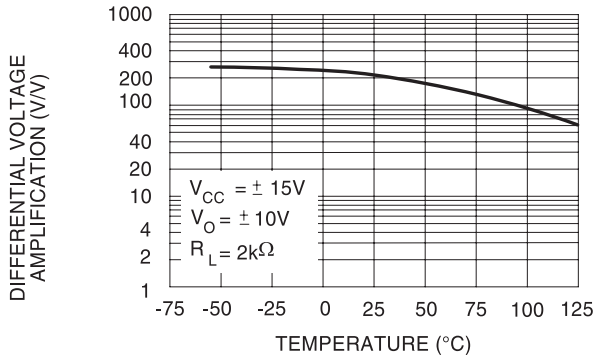



**Figure 11. Large signal differential voltage amplification and phase shift versus frequency**

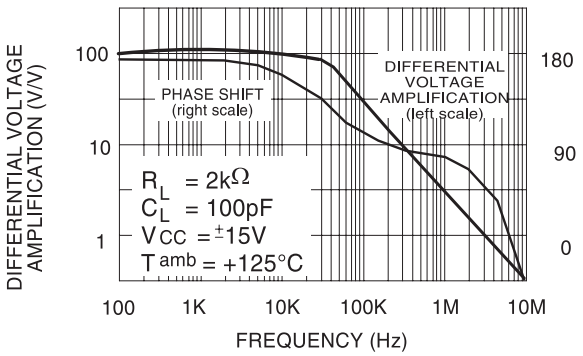



**Figure 12. Total power dissipation versus free air temperature**

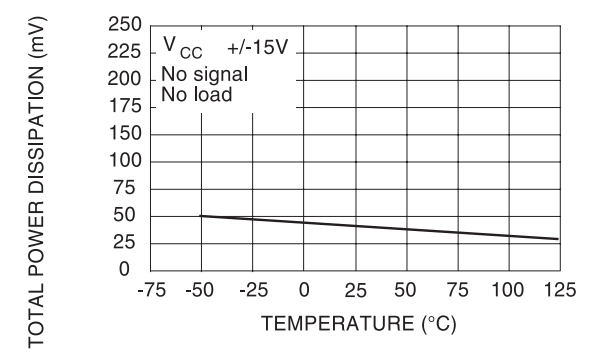



**Figure 13. Supply current per amplifier versus free air temperature**

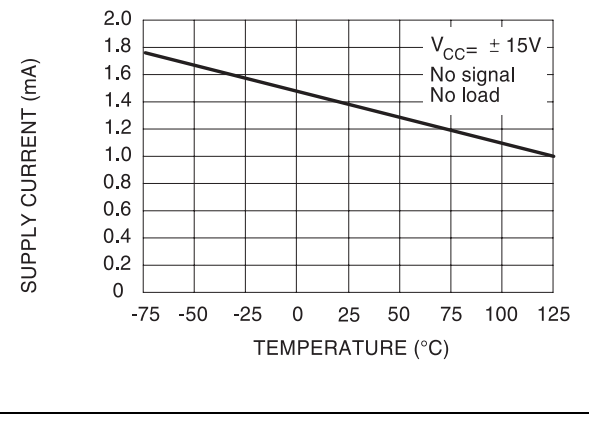



**Figure 14. Supply current per amplifier versus supply voltage**

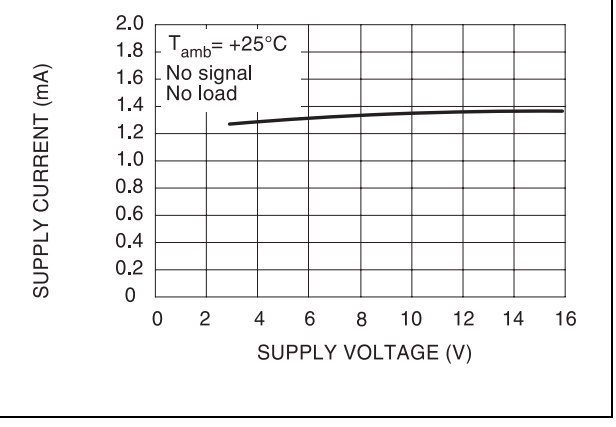


**Figure 15. Common mode rejection ratio versus free air temperature**

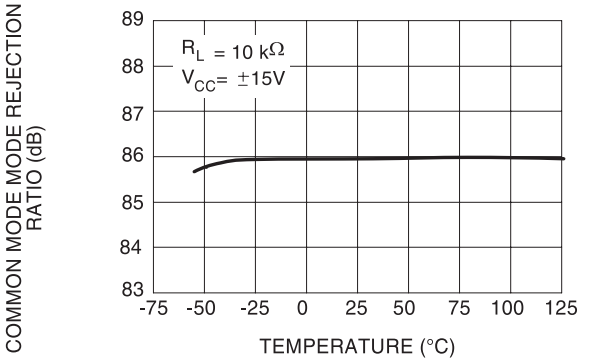



**Figure 16. Voltage follower large signal pulse response**

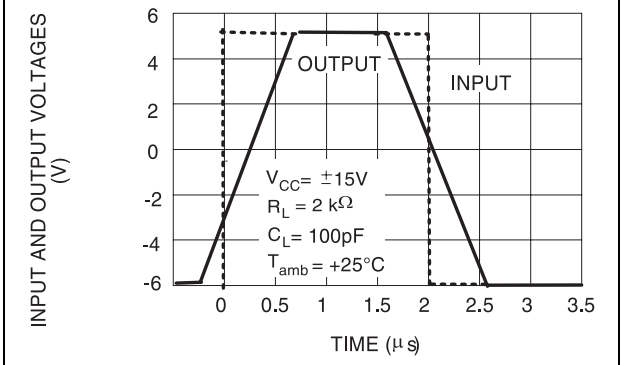



**Figure 17. Output voltage versus elapsed time**

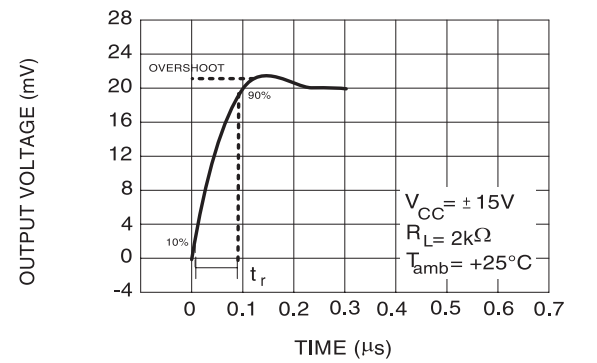



**Figure 18. Equivalent input noise voltage versus frequency**

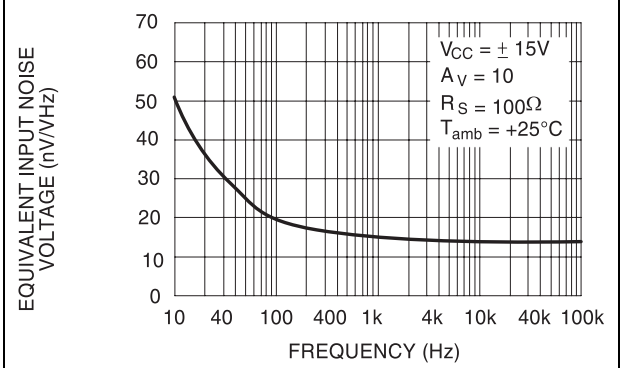
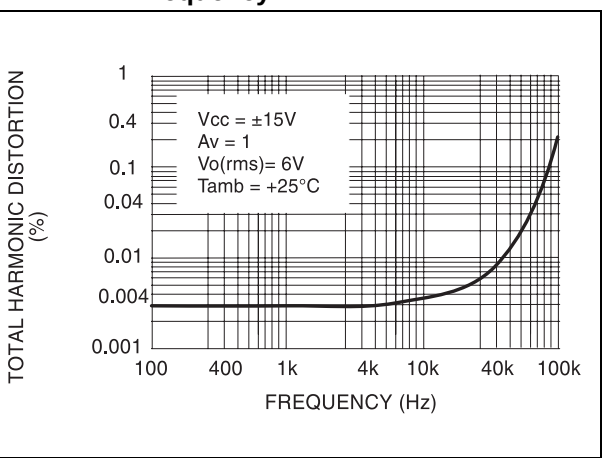



**Figure 19. Total harmonic distortion versus frequency**



# 4 Parameter measurement information

**Figure 20. Voltage follower**

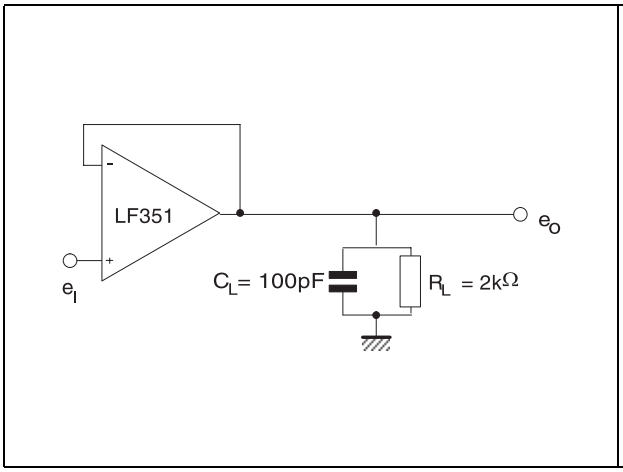
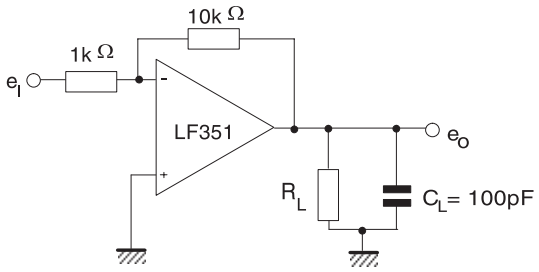



**Figure 21. Gain-of-10 inverting amplifier**



# 5 Typical application

**Figure 22. Square wave oscillator (0.5 Hz)**

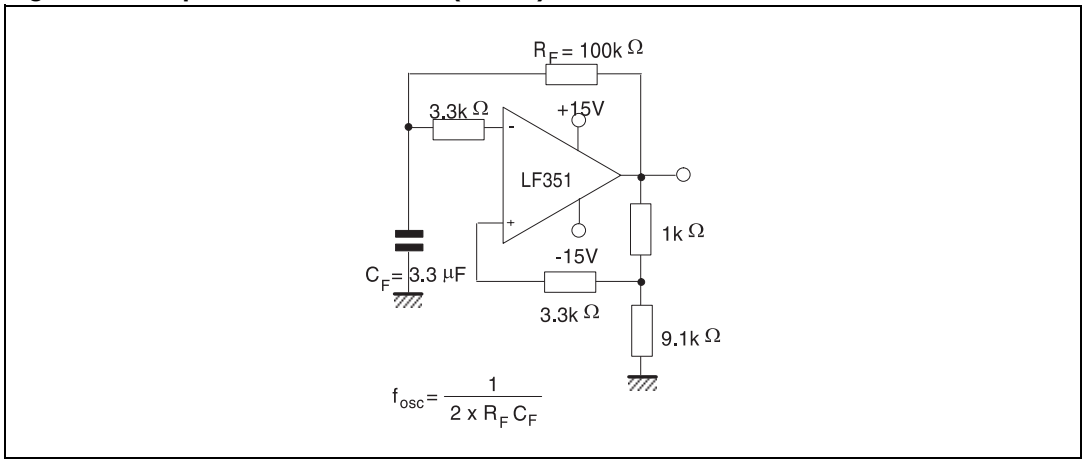
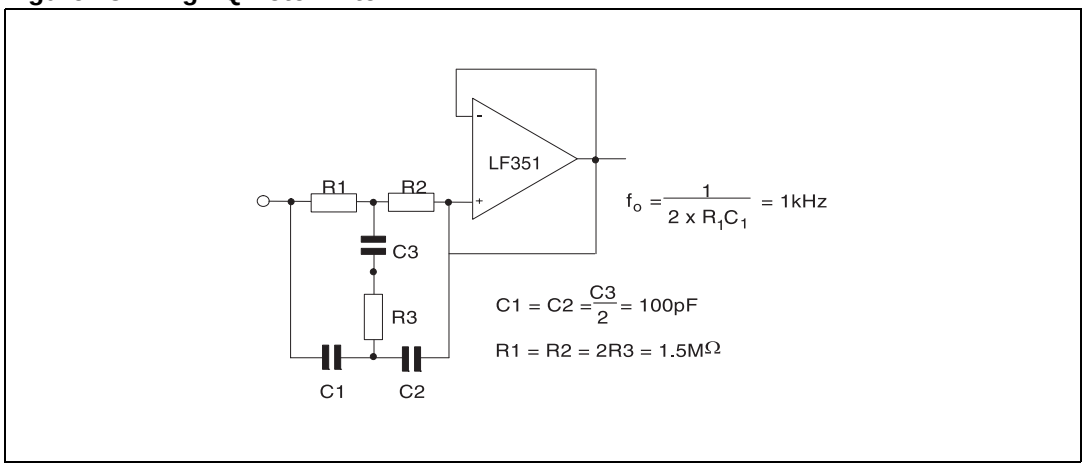



**Figure 23. High Q notch filter**



# 6 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.

## 6.1 DIP8 package information

**Figure 24. DIP8 package mechanical drawing**

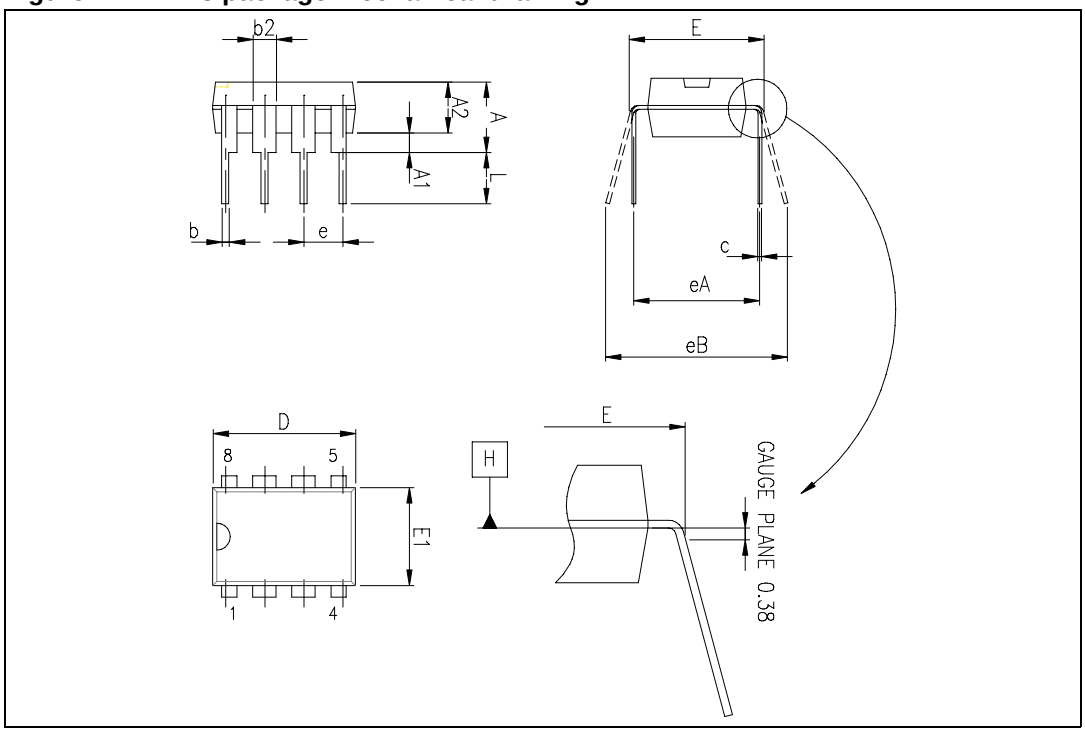



**Table 4. DIP8 package mechanical data**

| 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 |

## 6.2 SO-8 package information

**Figure 25. SO-8 package mechanical drawing**

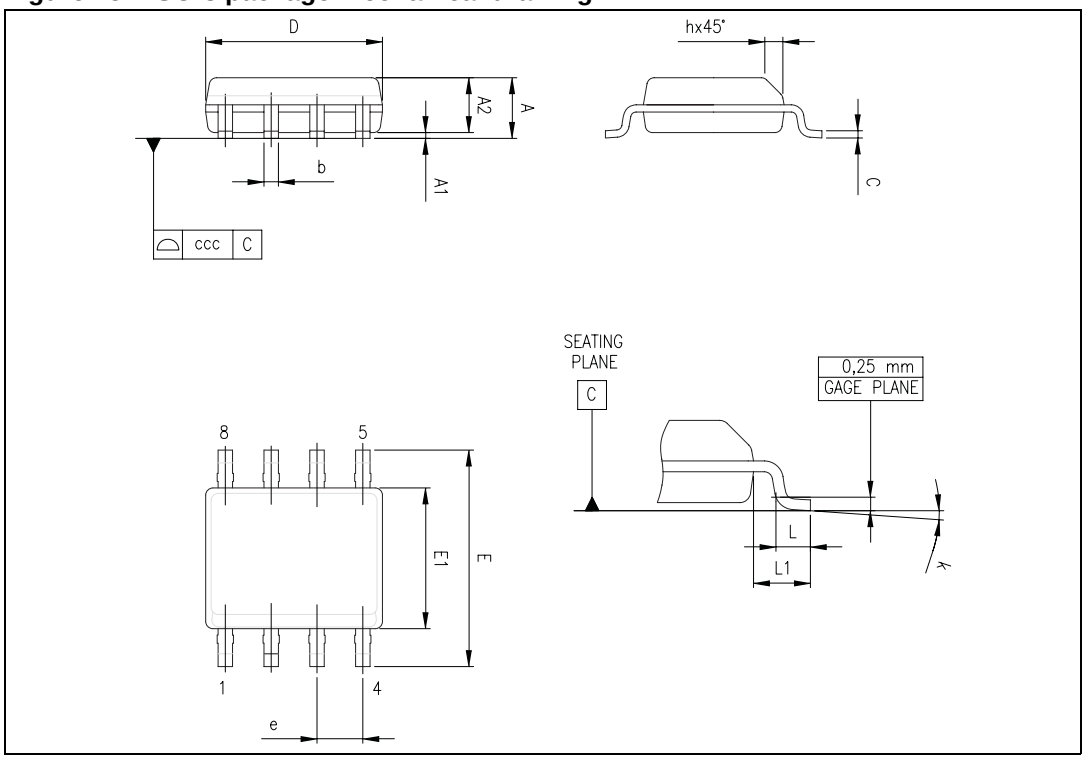



**Table 5. SO-8 package mechanical data**

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

# 7 Ordering information

**Table 6. Order codes**

| Order code | Temperature range | Package | Packing | Marking |
|---|---|---|---|---|
| LF151N | -55°C, +125°C | DIP8 | Tape | LF151N |
| LF151D<br>LF151DT | | SO-8 | Tape or<br>Tape & reel | 151 |
| LF251N | -40°C, +105°C | DIP8 | Tape | LF251N |
| LF251D<br>LF251DT | | SO-8 | Tape or<br>Tape & reel | 251 |
| LF351N | 0°C, +70°C | DIP8 | Tape | LF351N |
| LF351D<br>LF351DT | | SO-8 | Tape or<br>Tape & reel | 351 |

# 8 Revision history

**Table 7. Document revision history**

| Date | Revision | Changes |
|---|---|---|
| 17-May-2001 | 1 | Initial release. |
| 28-April-2008 | 2 | Updated document format. |

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