

# Low Noise, JFET Input Operational Amplifiers

These low noise JFET input operational amplifiers combine two state-of-the-art analog technologies on a single monolithic integrated circuit. Each internally compensated operational amplifier has well matched high voltage JFET input device for low input offset voltage. The BIFET technology provides wide bandwidths and fast slew rates with low input bias currents, input offset currents, and supply currents. Moreover, the devices exhibit low noise and low harmonic distortion, making them ideal for use in high fidelity audio amplifier applications.

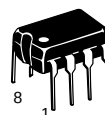
These devices are available in single, dual and quad operational amplifiers which are pin-compatible with the industry standard MC1741, MC1458, and the MC3403/LM324 bipolar products.

- Low Input Noise Voltage: 18 nV/ $\sqrt{\text{Hz}}$  Typ
- Low Harmonic Distortion: 0.01% Typ
- Low Input Bias and Offset Currents
- High Input Impedance:  $10^{12} \Omega$  Typ
- High Slew Rate: 13 V/ $\mu\text{s}$  Typ
- Wide Gain Bandwidth: 4.0 MHz Typ
- Low Supply Current: 1.4 mA per Amp

## TL071C,AC TL072C,AC TL074C,AC

### LOW NOISE, JFET INPUT OPERATIONAL AMPLIFIERS

#### SEMICONDUCTOR TECHNICAL DATA

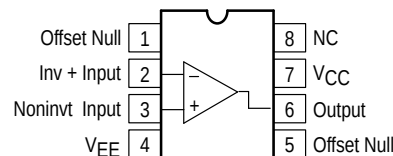


**P SUFFIX**  
PLASTIC PACKAGE  
CASE 626

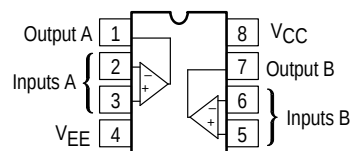


**D SUFFIX**  
PLASTIC PACKAGE  
CASE 751  
(SO-8)

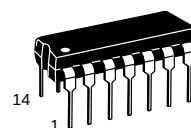
#### PIN CONNECTIONS



TL071 (Top View)

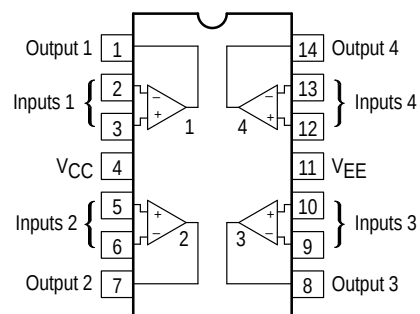


TL072 (Top View)



**N SUFFIX**  
PLASTIC PACKAGE  
CASE 646  
(TL074 Only)

#### PIN CONNECTIONS



TL074 (Top View)

#### ORDERING INFORMATION

| Op Amp Function | Device       | Operating Temperature Range                   | Package     |
|-----------------|--------------|-----------------------------------------------|-------------|
| Single          | TL071CD      | $T_A = 0^\circ \text{ to } +70^\circ\text{C}$ | SO-8        |
|                 | TL071ACP     |                                               | Plastic DIP |
| Dual            | TL072CD      | $T_A = 0^\circ \text{ to } +70^\circ\text{C}$ | SO-8        |
|                 | TL072ACP     |                                               | Plastic DIP |
| Quad            | TL074CN, ACN | $T_A = 0^\circ \text{ to } +70^\circ\text{C}$ | Plastic DIP |

# TL071C,AC TL072C,AC TL074C,AC

## MAXIMUM RATINGS

| Rating                                                                               | Symbol                     | Value         | Unit                       |
|--------------------------------------------------------------------------------------|----------------------------|---------------|----------------------------|
| Supply Voltage                                                                       | $V_{CC}$<br>$V_{EE}$       | 18<br>-18     | V                          |
| Differential Input Voltage                                                           | $V_{ID}$                   | $\pm 30$      | V                          |
| Input Voltage Range (Note 1)                                                         | $V_{IDR}$                  | $\pm 15$      | V                          |
| Output Short Circuit Duration (Note 2)                                               | $t_{SC}$                   | Continuous    |                            |
| Power Dissipation<br>Plastic Package (N, P)<br>Derate above $T_A = 47^\circ\text{C}$ | $P_D$<br>$1.0/\theta_{JA}$ | 680<br>10     | mW<br>mW/ $^\circ\text{C}$ |
| Operating Ambient Temperature Range                                                  | $T_A$                      | 0 to $+70$    | $^\circ\text{C}$           |
| Storage Temperature Range                                                            | $T_{stg}$                  | -65 to $+150$ | $^\circ\text{C}$           |

- NOTES:** 1. The magnitude of the input voltage must not exceed the magnitude of the supply voltage or 15 V, whichever is less.  
2. The output may be shorted to ground or either supply. Temperature and/or supply voltages must be limited to ensure that power dissipation ratings are not exceeded.  
3. ESD data available upon request.

## ELECTRICAL CHARACTERISTICS ( $V_{CC} = 15\text{ V}$ , $V_{EE} = -15\text{ V}$ , $T_A = T_{\text{high}}$ to $T_{\text{low}}$ [Note 1])

| Characteristics                                                                                       | Symbol    | Min         | Typ         | Max             | Unit |
|-------------------------------------------------------------------------------------------------------|-----------|-------------|-------------|-----------------|------|
| Input Offset Voltage ( $R_S \leq 10\text{ k}$ , $V_{CM} = 0$ )<br>TL071C, TL072C<br>TL074C<br>TL07_AC | $V_{IO}$  | -<br>-<br>- | -<br>-<br>- | 13<br>13<br>7.5 | mV   |
| Input Offset Current ( $V_{CM} = 0$ ) (Note 2)<br>TL07_C<br>TL07_AC                                   | $I_{IO}$  | -<br>-      | -<br>-      | 2.0<br>2.0      | nA   |
| Input Bias Current ( $V_{CM} = 0$ ) (Note 2)<br>TL07_C<br>TL07_AC                                     | $I_{IB}$  | -<br>-      | -<br>-      | 7.0<br>7.0      | nA   |
| Large-Signal Voltage Gain ( $V_O = \pm 10\text{ V}$ , $R_L \geq 2.0\text{ k}$ )<br>TL07_C<br>TL07_AC  | $A_{VOL}$ | 15<br>25    | -<br>-      | -<br>-          | V/mV |
| Output Voltage Swing (Peak-to-Peak)<br>( $R_L \geq 10\text{ k}$ )<br>( $R_L \geq 2.0\text{ k}$ )      | $V_O$     | 24<br>20    | -<br>-      | -<br>-          | V    |

- NOTES:** 1.  $T_{\text{low}} = 0^\circ\text{C}$  for TL071C,AC TL072C,AC TL074C,AC  $T_{\text{high}} = 70^\circ\text{C}$  for TL071C,AC TL072C,AC TL074C,AC  
2. Input Bias currents of JFET input op amps approximately double for every  $10^\circ\text{C}$  rise in junction temperature as shown in Figure 3. To maintain junction temperature as close to ambient temperature as possible, pulse techniques must be used during testing.

Figure 1. Unity Gain Voltage Follower

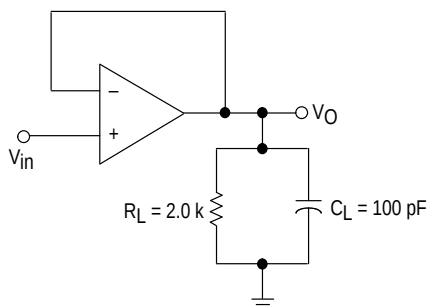
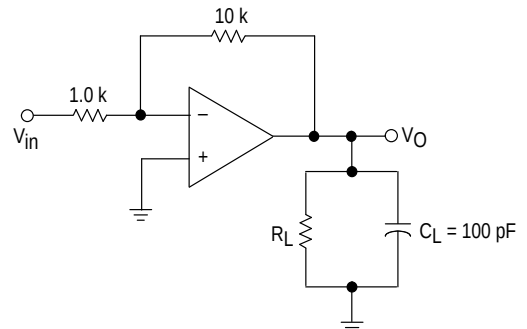


Figure 2. Inverting Gain of 10 Amplifier



# TL071C,AC TL072C,AC TL074C,AC

## ELECTRICAL CHARACTERISTICS ( $V_{CC} = 15\text{ V}$ , $V_{EE} = -15\text{ V}$ , $T_A = 25^\circ\text{C}$ , unless otherwise noted.)

| Characteristics                                                                                                           | Symbol                   | Min                  | Typ                | Max             | Unit                         |
|---------------------------------------------------------------------------------------------------------------------------|--------------------------|----------------------|--------------------|-----------------|------------------------------|
| Input Offset Voltage ( $R_S \leq 10\text{ k}$ , $V_{CM} = 0$ )<br>TL071C, TL072C<br>TL074C<br>TL07_AC                     | $V_{IO}$                 | –<br>–<br>–          | 3.0<br>3.0<br>3.0  | 10<br>10<br>6.0 | mV                           |
| Average Temperature Coefficient of Input Offset Voltage<br>$R_S = 50\ \Omega$ , $T_A = T_{low}$ to $T_{high}$ (Note 1)    | $\Delta V_{IO}/\Delta T$ | –                    | 10                 | –               | $\mu\text{V}/^\circ\text{C}$ |
| Input Offset Current ( $V_{CM} = 0$ ) (Note 2)<br>TL07_C<br>TL07_AC                                                       | $I_{IO}$                 | –<br>–               | 5.0<br>5.0         | 50<br>50        | pA                           |
| Input Bias Current ( $V_{CM} = 0$ ) (Note 2)<br>TL07_C<br>TL07_AC                                                         | $I_{IB}$                 | –<br>–               | 30<br>30           | 200<br>200      | pA                           |
| Input Resistance                                                                                                          | $r_i$                    | –                    | $10^{12}$          | –               | $\Omega$                     |
| Common Mode Input Voltage Range<br>TL07_C<br>TL07_AC                                                                      | $V_{ICR}$                | $\pm 10$<br>$\pm 11$ | 15, –12<br>15, –12 | –<br>–          | V                            |
| Large-Signal Voltage Gain ( $V_O = \pm 10\text{ V}$ , $R_L \geq 2.0\text{ k}$ )<br>TL07_C<br>TL07_AC                      | $A_{VOL}$                | 25<br>50             | 150<br>150         | –<br>–          | V/mV                         |
| Output Voltage Swing (Peak-to-Peak)<br>( $R_L = 10\text{ k}$ )                                                            | $V_O$                    | 24                   | 28                 | –               | V                            |
| Common Mode Rejection Ratio ( $R_S \leq 10\text{ k}$ )<br>TL07_C<br>TL07_AC                                               | CMRR                     | 70<br>80             | 100<br>100         | –<br>–          | dB                           |
| Supply Voltage Rejection Ratio ( $R_S \leq 10\text{ k}$ )<br>TL07_C<br>TL07_AC                                            | PSRR                     | 70<br>80             | 100<br>100         | –<br>–          | dB                           |
| Supply Current (Each Amplifier)                                                                                           | $I_D$                    | –                    | 1.4                | 2.5             | mA                           |
| Unity Gain Bandwidth                                                                                                      | BW                       | –                    | 4.0                | –               | MHz                          |
| Slew Rate (See Figure 1)<br>$V_{in} = 10\text{ V}$ , $R_L = 2.0\text{ k}$ , $C_L = 100\text{ pF}$                         | SR                       | –                    | 13                 | –               | $\text{V}/\mu\text{s}$       |
| Rise Time (See Figure 1)                                                                                                  | $t_r$                    | –                    | 0.1                | –               | $\mu\text{s}$                |
| Overshoot ( $V_{in} = 20\text{ mV}$ , $R_L = 2.0\text{ k}$ , $C_L = 100\text{ pF}$ )                                      | OS                       | –                    | 10                 | –               | %                            |
| Equivalent Input Noise Voltage<br>$R_S = 100\ \Omega$ , $f = 1000\text{ Hz}$                                              | $e_n$                    | –                    | 18                 | –               | $\text{nV}/\sqrt{\text{Hz}}$ |
| Equivalent Input Noise Current<br>$R_S = 100\ \Omega$ , $f = 1000\text{ Hz}$                                              | $i_n$                    | –                    | 0.01               | –               | $\text{pA}/\sqrt{\text{Hz}}$ |
| Total Harmonic Distortion<br>$V_O$ (RMS) = 10 V, $R_S \leq 1.0\text{ k}$ , $R_L \geq 2.0\text{ k}$ , $f = 1000\text{ Hz}$ | THD                      | –                    | 0.01               | –               | %                            |
| Channel Separation<br>$A_V = 100$                                                                                         | CS                       | –                    | 120                | –               | dB                           |

**NOTES:** 1.  $T_{low} = 0^\circ\text{C}$  for TL071C,AC TL072C,AC TL074C,AC  
 $T_{high} = 70^\circ\text{C}$  for TL071C,AC TL072C,AC TL074C,AC

2. Input Bias currents of JFET input op amps approximately double for every  $10^\circ\text{C}$  rise in junction temperature as shown in Figure 3. To maintain junction temperature as close to ambient temperature as possible, pulse techniques must be used during testing.

Figure 3. Input Bias Current versus Temperature

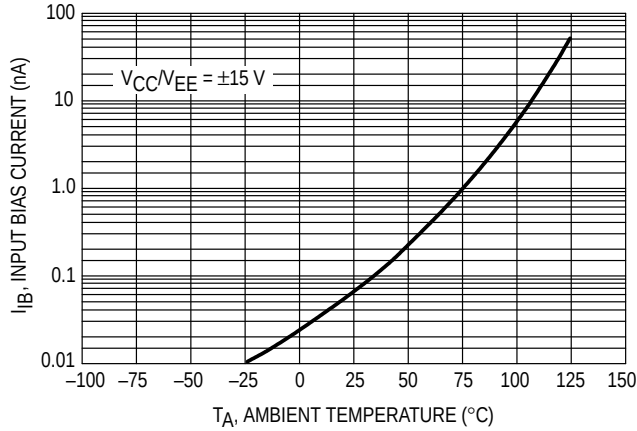


Figure 4. Output Voltage Swing versus Frequency

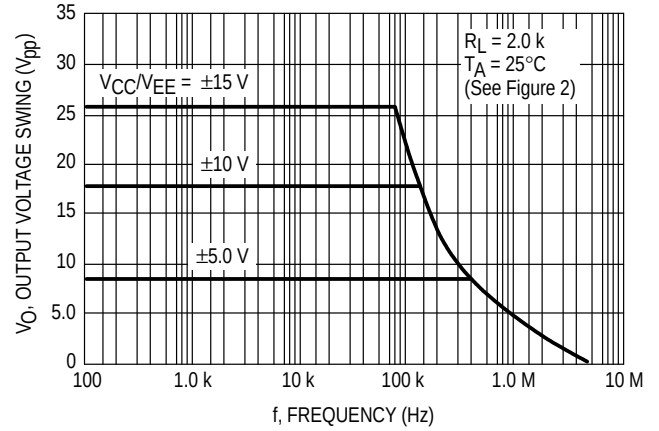


Figure 5. Output Voltage Swing versus Load Resistance

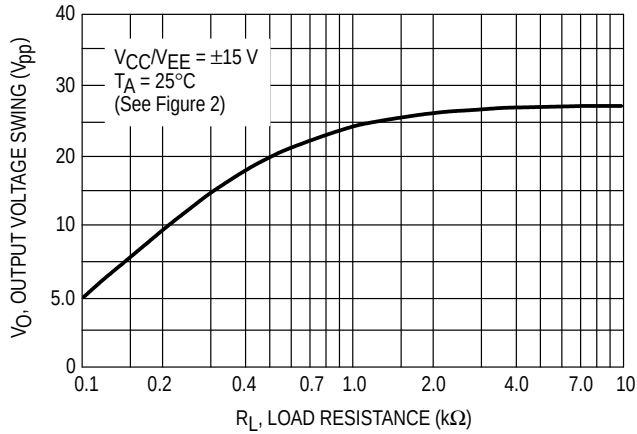


Figure 6. Output Voltage Swing versus Supply Voltage

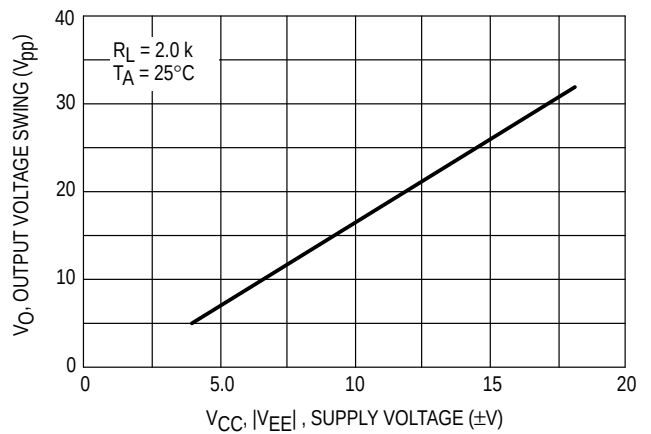


Figure 7. Output Voltage Swing versus Temperature

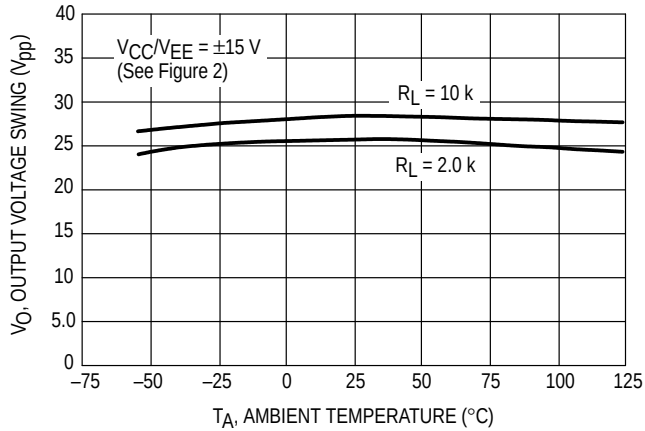
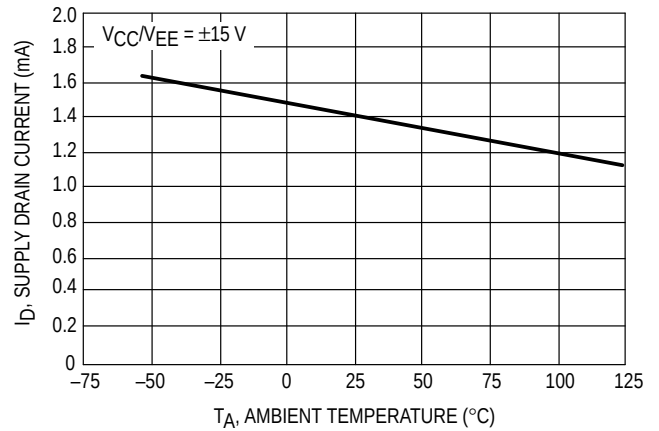
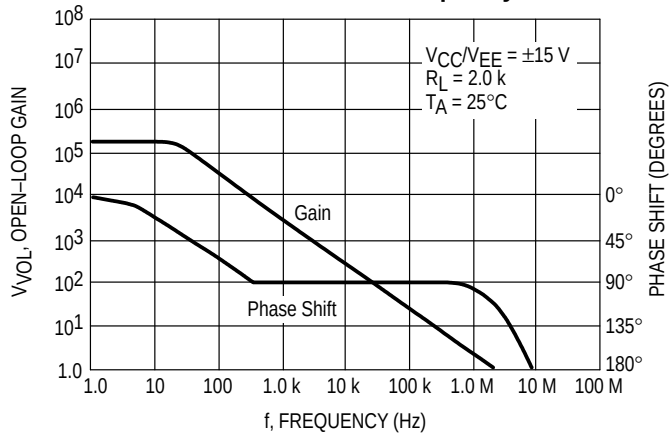


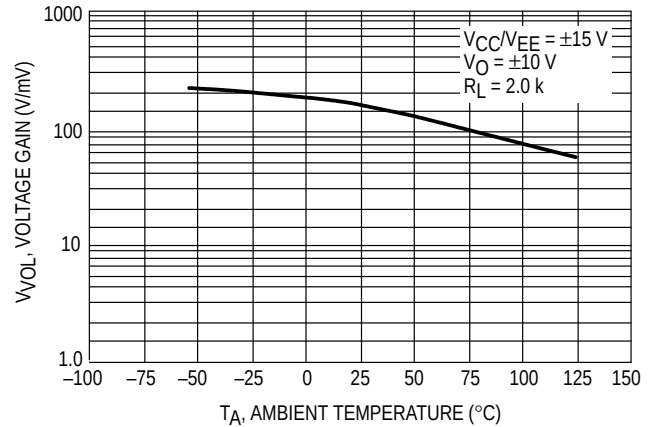
Figure 8. Supply Current per Amplifier versus Temperature



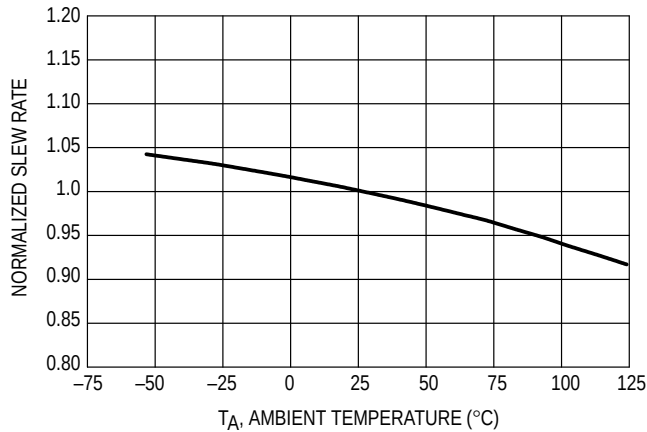
**Figure 9. Large Signal Voltage Gain and Phase Shift versus Frequency**



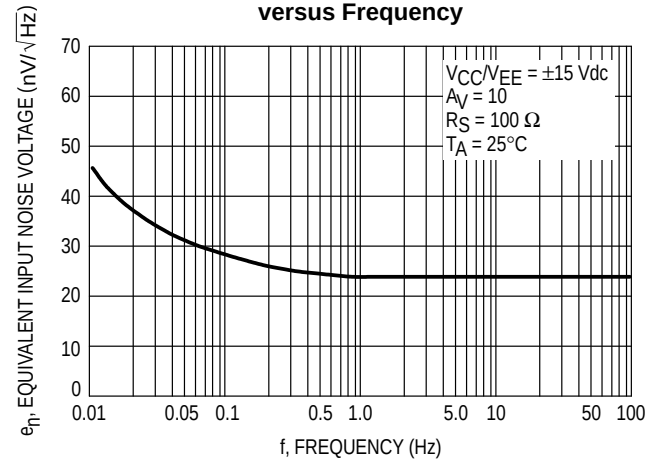
**Figure 10. Large Signal Voltage Gain versus Temperature**



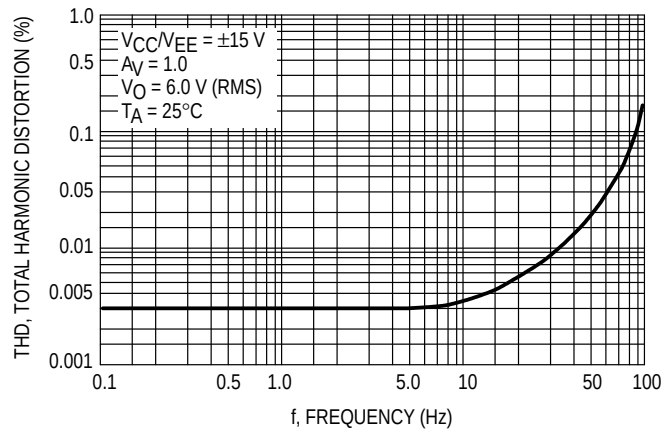
**Figure 11. Normalized Slew Rate versus Temperature**



**Figure 12. Equivalent Input Noise Voltage versus Frequency**

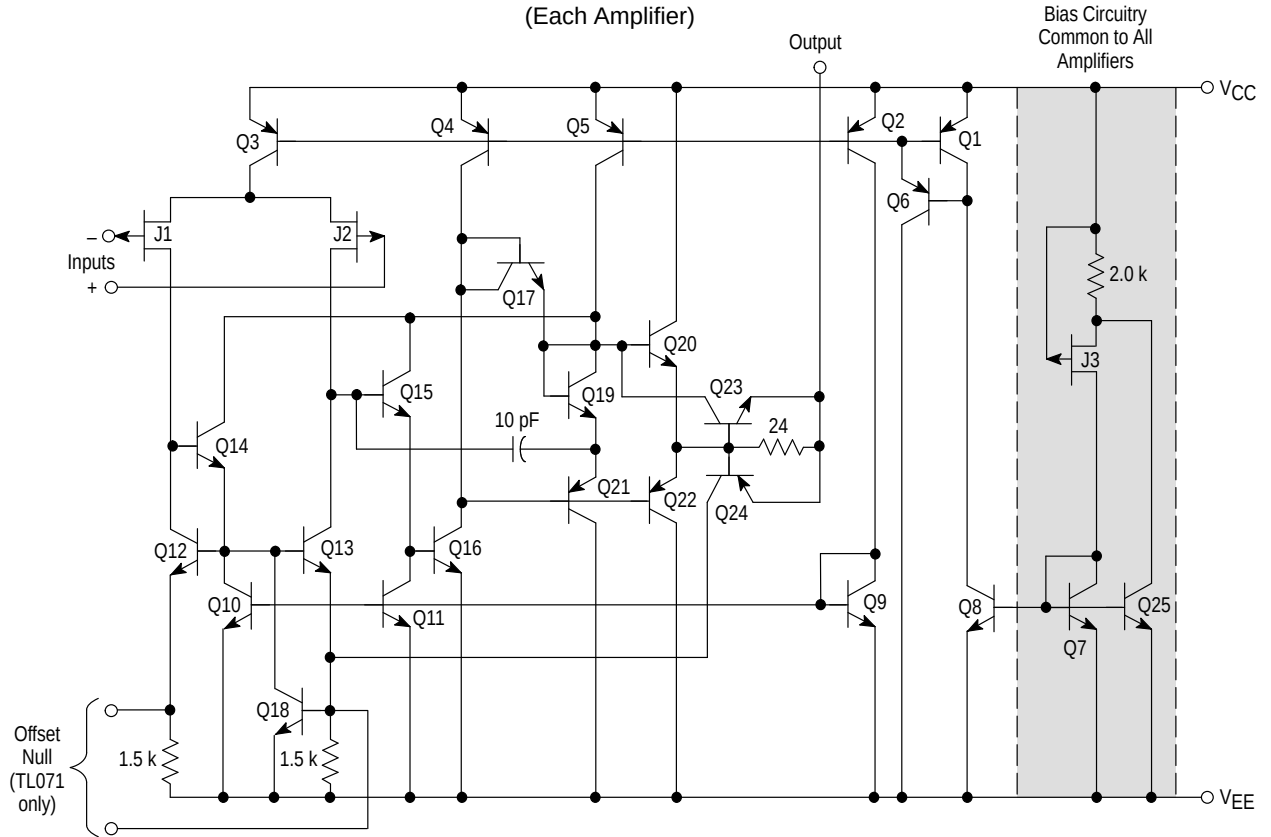


**Figure 13. Total Harmonic Distortion versus Frequency**

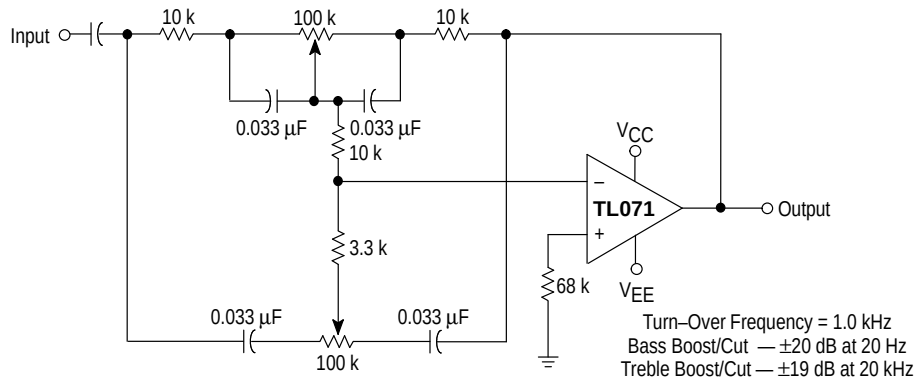


# TL071C,AC TL072C,AC TL074C,AC

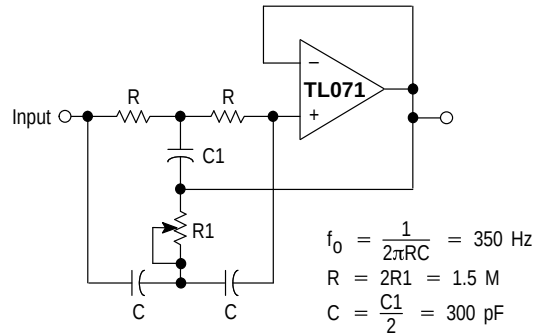
**Representative Schematic Diagram**  
(Each Amplifier)



**Figure 14. Audio Tone Control Amplifier**



**Figure 15. High Q Notch Filter**

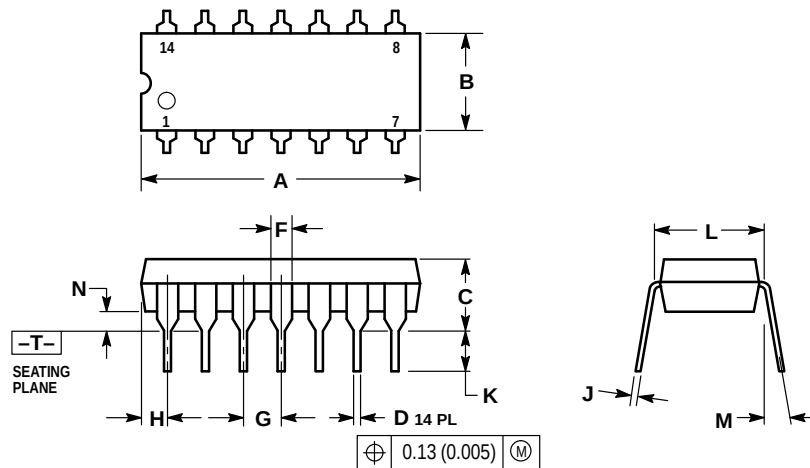




# TL071C,AC TL072C,AC TL074C,AC

## OUTLINE DIMENSIONS

N SUFFIX  
PLASTIC PACKAGE  
CASE 646-06  
ISSUE M



| DIM | INCHES    |       | MILLIMETERS |       |
|-----|-----------|-------|-------------|-------|
|     | MIN       | MAX   | MIN         | MAX   |
| A   | 0.715     | 0.770 | 18.16       | 18.80 |
| B   | 0.240     | 0.260 | 6.10        | 6.60  |
| C   | 0.145     | 0.185 | 3.69        | 4.69  |
| D   | 0.015     | 0.021 | 0.38        | 0.53  |
| F   | 0.040     | 0.070 | 1.02        | 1.78  |
| G   | 0.100 BSC |       | 2.54 BSC    |       |
| H   | 0.052     | 0.095 | 1.32        | 2.41  |
| J   | 0.008     | 0.015 | 0.20        | 0.38  |
| K   | 0.115     | 0.135 | 2.92        | 3.43  |
| L   | 0.290     | 0.310 | 7.37        | 7.87  |
| M   | 10°       |       | 10°         |       |
| N   | 0.015     | 0.039 | 0.38        | 1.01  |

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TL071C/D