

## LM709 Operational Amplifier

### General Description

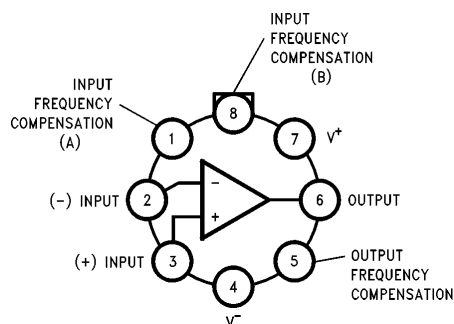
The LM709 series is a monolithic operational amplifier intended for general-purpose applications. Operation is completely specified over the range of voltages commonly used for these devices. The design, in addition to providing high gain, minimizes both offset voltage and bias currents. Further, the class-B output stage gives a large output capability with minimum power drain.

External components are used to frequency compensate the amplifier. Although the unity-gain compensation network specified will make the amplifier unconditionally stable in all feedback configurations, compensation can be tailored to optimize high-frequency performance for any gain setting.

The LM709C is the commercial-industrial version of the LM709. It is identical to the LM709 except that it is specified for operation from 0°C to +70°C.

### Connection Diagrams

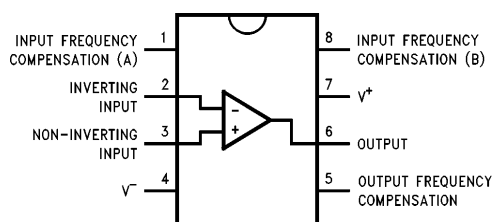
**Metal Can Package**



TL/H/11477-4

**Order Number LM709AH, LM709H or LM709CH**  
**See NS Package Number H08C**

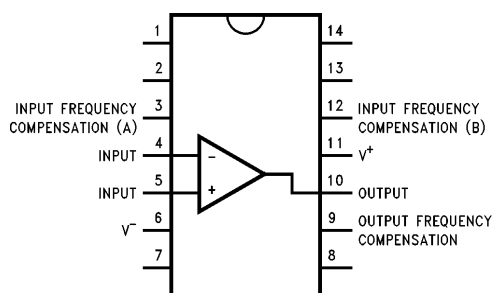
**Dual-In-Line Package**



TL/H/11477-6

**Order Number LM709CN-8**  
**See NS Package Number N08E**

**Dual-In-Line Package**



TL/H/11477-5

**Order Number LM709CN**  
**See NS Package Number N14A**

## Absolute Maximum Ratings (Note 3)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

|                                                             |                     |           |
|-------------------------------------------------------------|---------------------|-----------|
| Supply Voltage                                              | LM709/LM709A/LM709C | ±18V      |
| Power Dissipation (Note 1)                                  | LM709/LM709A        | 300 mW    |
|                                                             | LM709C              | 250 mW    |
| Differential Input Voltage                                  | LM709/LM709A/LM709C | ±5V       |
| Input Voltage                                               | LM709/LM709A/LM709C | ±10V      |
| Output Short-Circuit Duration ( $T_A = +25^\circ\text{C}$ ) | LM709/LM709A/LM709C | 5 seconds |

|                                       |                     |                 |
|---------------------------------------|---------------------|-----------------|
| Storage Temperature Range             | LM709/LM709A/LM709C | −65°C to +150°C |
| Lead Temperature (Soldering, 10 sec.) | LM709/LM709A/LM709C | 300°C           |

## Operating Ratings (Note 3)

|                                      |                  |                                   |
|--------------------------------------|------------------|-----------------------------------|
| Junction Temperature Range (Note 1)  | LM709/LM709A     | −55°C to +150°C                   |
|                                      | LM709C           | 0°C to +100°C                     |
| Thermal Resistance ( $\theta_{JA}$ ) | H Package        | 150°C/W, ( $\theta_{JC}$ ) 45°C/W |
|                                      | 8-Pin N Package  | 134°C/W                           |
|                                      | 14-Pin N Package | 109°C/W                           |

## Electrical Characteristics (Note 2)

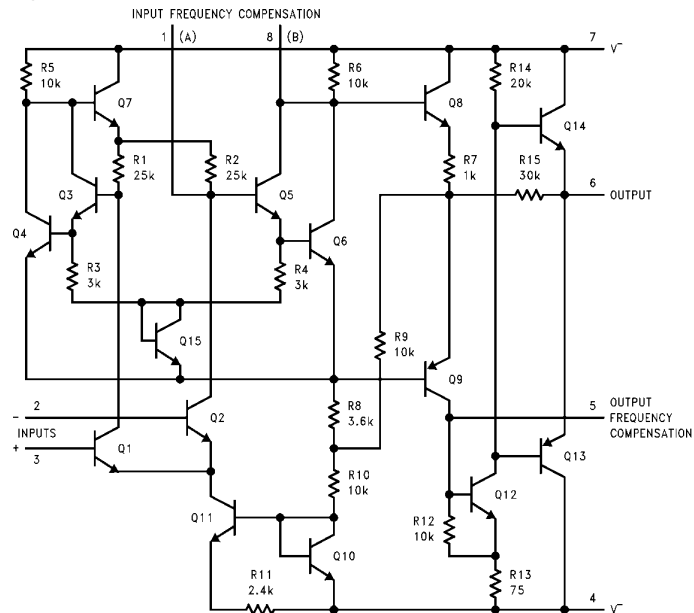
| Parameter                      | Conditions                                                                                              | LM709A |     |     | LM709 |     |     | LM709C |      |     | Units                        |
|--------------------------------|---------------------------------------------------------------------------------------------------------|--------|-----|-----|-------|-----|-----|--------|------|-----|------------------------------|
|                                |                                                                                                         | Min    | Typ | Max | Min   | Typ | Max | Min    | Typ  | Max |                              |
| Input Offset Voltage           | $T_A = 25^\circ\text{C}$ , $R_S \leq 10\text{ k}\Omega$                                                 | 0.6    | 2.0 |     | 1.0   | 5.0 |     | 2.0    | 7.5  |     | mV                           |
| Input Bias Current             | $T_A = 25^\circ\text{C}$                                                                                | 100    | 200 |     | 200   | 500 |     | 300    | 1500 |     | nA                           |
| Input Offset Current           | $T_A = 25^\circ\text{C}$                                                                                | 10     | 50  |     | 50    | 200 |     | 100    | 500  |     | nA                           |
| Input Resistance               | $T_A = 25^\circ\text{C}$                                                                                | 350    | 700 |     | 150   | 400 |     | 50     | 250  |     | k $\Omega$                   |
| Output Resistance              | $T_A = 25^\circ\text{C}$                                                                                | 150    |     |     | 150   |     |     | 150    |      |     | $\Omega$                     |
| Supply Current                 | $T_A = 25^\circ\text{C}$ , $V_S = \pm 15\text{V}$                                                       | 2.5    | 3.6 |     | 2.6   | 5.5 |     | 2.6    | 6.6  |     | mA                           |
| Transient Response             | $V_{IN} = 20\text{ mV}$ , $C_L \leq 100\text{ pF}$                                                      |        |     |     |       |     |     |        |      |     |                              |
| Risetime                       | $T_A = 25^\circ\text{C}$                                                                                |        |     | 1.5 | 0.3   | 1.0 |     | 0.3    | 1.0  |     | $\mu\text{s}$                |
| Overshoot                      |                                                                                                         |        |     | 30  | 10    | 30  |     | 10     | 30   |     | %                            |
| Slew Rate                      | $T_A = 25^\circ\text{C}$                                                                                | 0.25   |     |     | 0.25  |     |     | 0.25   |      |     | V/ $\mu\text{s}$             |
| Input Offset Voltage           | $R_S \leq 10\text{ k}\Omega$                                                                            |        | 3.0 |     |       | 6.0 |     |        | 10   |     | mV                           |
| Average Temperature            | $R_S = 50\Omega$ , $T_A = 25^\circ\text{C}$ to $T_{MAX}$                                                | 1.8    | 10  |     | 3.0   |     |     | 6.0    |      |     | $\mu\text{V}/^\circ\text{C}$ |
| Coefficient of                 | $T_A = 25^\circ\text{C}$ to $T_{MIN}$                                                                   | 1.8    | 10  |     | 6.0   |     |     | 12     |      |     |                              |
| Input Offset Voltage           | $R_S = 10\text{ k}\Omega$ , $T_A = 25^\circ\text{C}$ to $T_{MAX}$                                       | 2.0    | 15  |     |       |     |     |        |      |     |                              |
|                                | $T_A = 25^\circ\text{C}$ to $T_{MIN}$                                                                   | 4.8    | 25  |     |       |     |     |        |      |     |                              |
| Large Signal Voltage Gain      | $V_S = \pm 15\text{V}$ , $R_L \geq 2\text{ k}\Omega$<br>$V_{OUT} = \pm 10\text{V}$                      | 25     |     | 70  | 25    | 45  | 70  | 15     | 45   |     | V/mV                         |
| Output Voltage Swing           | $V_S = \pm 15\text{V}$ , $R_L = 10\text{ k}\Omega$<br>$V_S = \pm 15\text{V}$ , $R_L = 2\text{ k}\Omega$ | ±12    | ±14 |     | ±12   | ±14 |     | ±12    | ±14  |     | V                            |
|                                |                                                                                                         | ±10    | ±13 |     | ±10   | ±13 |     | ±10    | ±13  |     |                              |
| Input Voltage Range            | $V_S = \pm 15\text{V}$                                                                                  | ±8     |     |     | ±8    | ±10 |     | ±8     | ±10  |     | V                            |
| Common-Mode Rejection Ratio    | $R_S \leq 10\text{ k}\Omega$                                                                            | 80     | 110 |     | 70    | 90  |     | 65     | 90   |     | dB                           |
| Supply Voltage Rejection Ratio | $R_S \leq 10\text{ k}\Omega$                                                                            | 40     | 100 |     | 25    | 150 |     | 25     | 200  |     | $\mu\text{V}/\text{V}$       |
| Input Offset Current           | $T_A = T_{MAX}$                                                                                         | 3.5    | 50  |     | 20    | 200 |     | 75     | 400  |     | nA                           |
|                                | $T_A = T_{MIN}$                                                                                         | 40     | 250 |     | 100   | 500 |     | 125    | 750  |     |                              |
| Input Bias Current             | $T_A = T_{MIN}$                                                                                         | 0.3    | 0.6 |     | 0.5   | 1.5 |     | 0.36   | 2.0  |     | $\mu\text{A}$                |
| Input Resistance               | $T_A = T_{MIN}$                                                                                         | 85     | 170 |     | 40    | 100 |     | 50     | 250  |     | k $\Omega$                   |

**Note 1:** For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature for LM709/LM709A and 100°C maximum for LM709C. For operating at elevated temperatures, the device must be derated based on thermal resistance  $\theta_{JA}$ ,  $T_{J(MAX)}$  and  $T_A$ .

**Note 2:** These specifications apply for  $-55^\circ\text{C} \leq T_A \leq +125^\circ\text{C}$  for the LM709/LM709A and  $0^\circ\text{C} \leq T_A \leq +70^\circ\text{C}$  for the LM709C with the following conditions:  $\pm 9\text{V} \leq V_S \leq \pm 15\text{V}$ ,  $C_1 = 5000\text{ pF}$ ,  $R_1 = 1.5\text{ k}\Omega$ ,  $C_2 = 200\text{ pF}$  and  $R_2 = 51\Omega$ .

**Note 3:** Absolute Maximum Ratings indicate limits which if exceeded may result in damage. Operating Ratings are conditions where the device is expected to be functional but not necessarily within the guaranteed performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

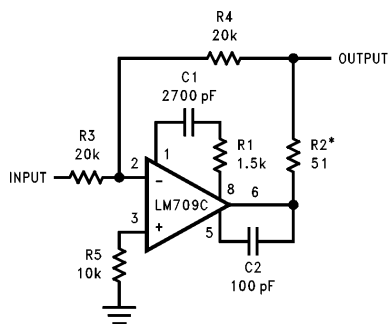
## Schematic Diagram \*\*



TL/H/11477-1

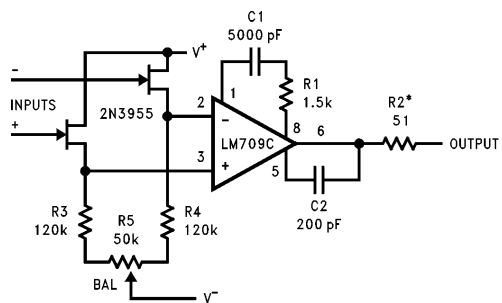
## Typical Applications \*\*

### Unity Gain Inverting Amplifier



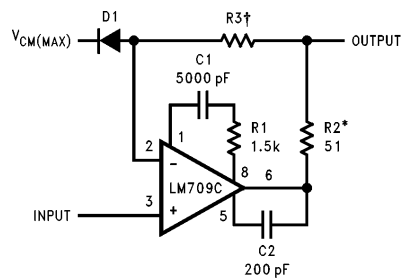
TL/H/11477-2

### FET Operational Amplifier



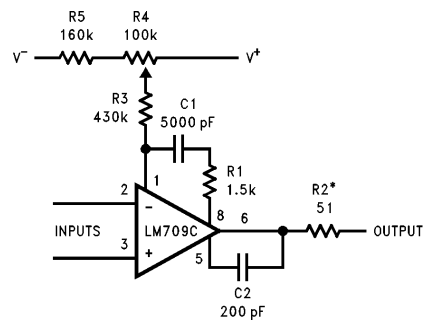
TL/H/11477-3

### Voltage Follower



TL/H/11477-7

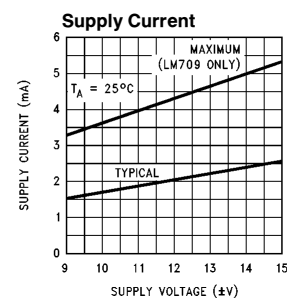
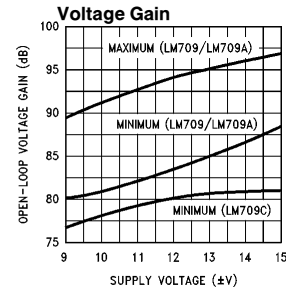
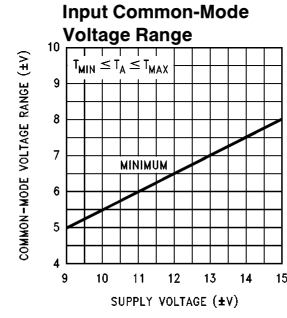
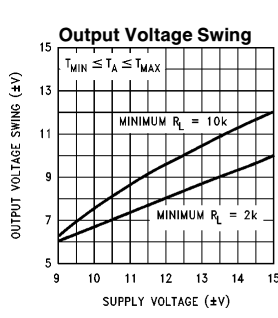
### Offset Balancing Circuit



TL/H/11477-8

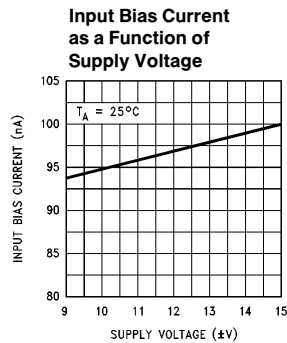
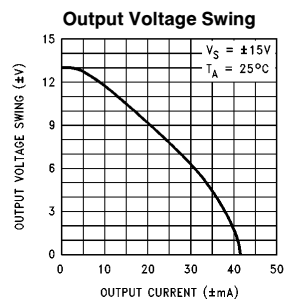
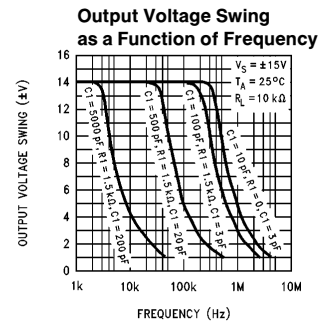
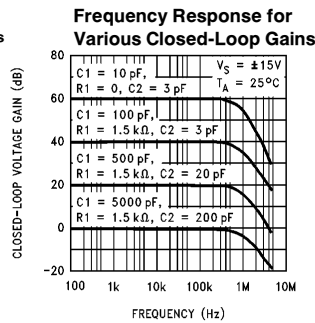
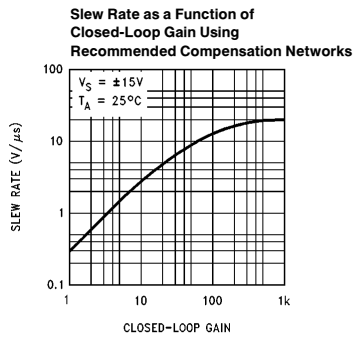
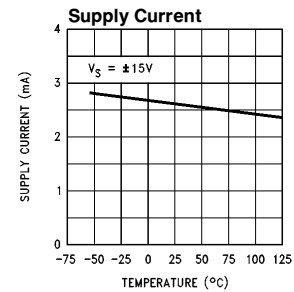
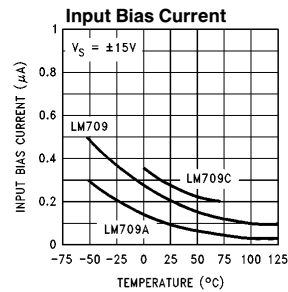
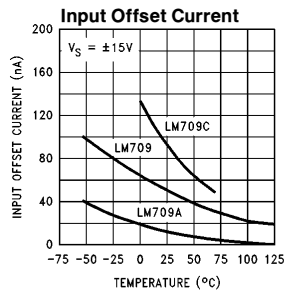
\*To be used with any capacitive loading on output.  
 \*\*Pin connections shown are for metal can package.  
 †Should be equal to DC source resistance on input.

# Guaranteed Performance Characteristics



TL/H/11477-9

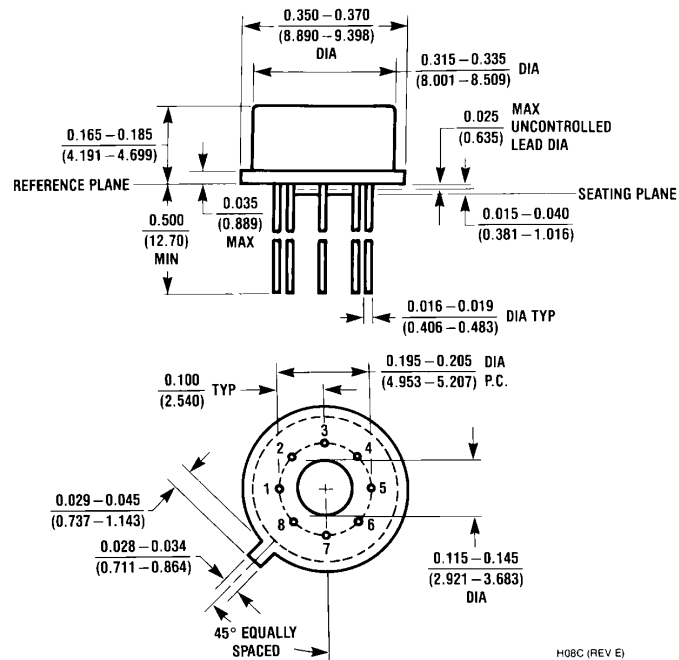
## Typical Performance Characteristics



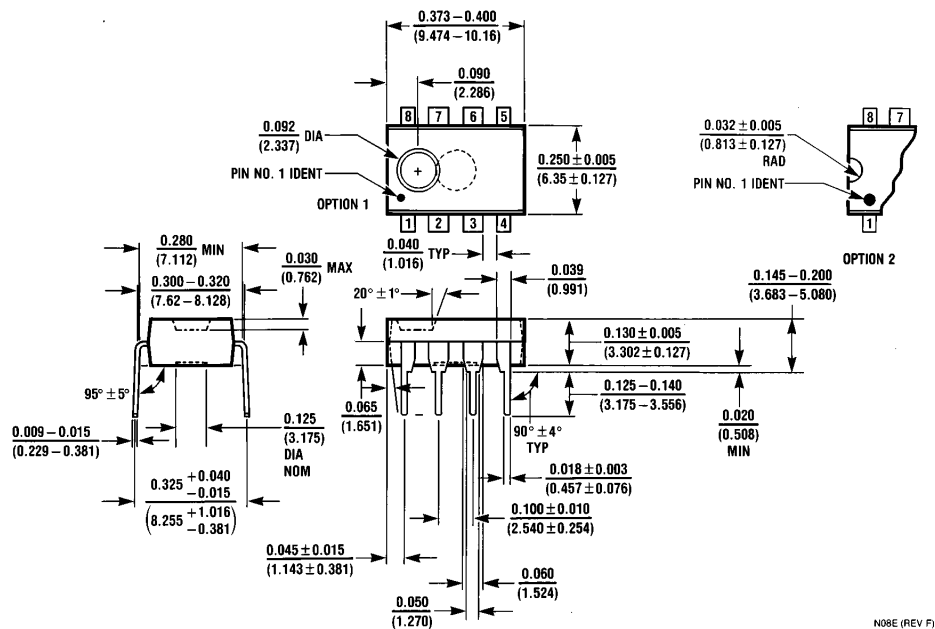
TL/H/11477-10



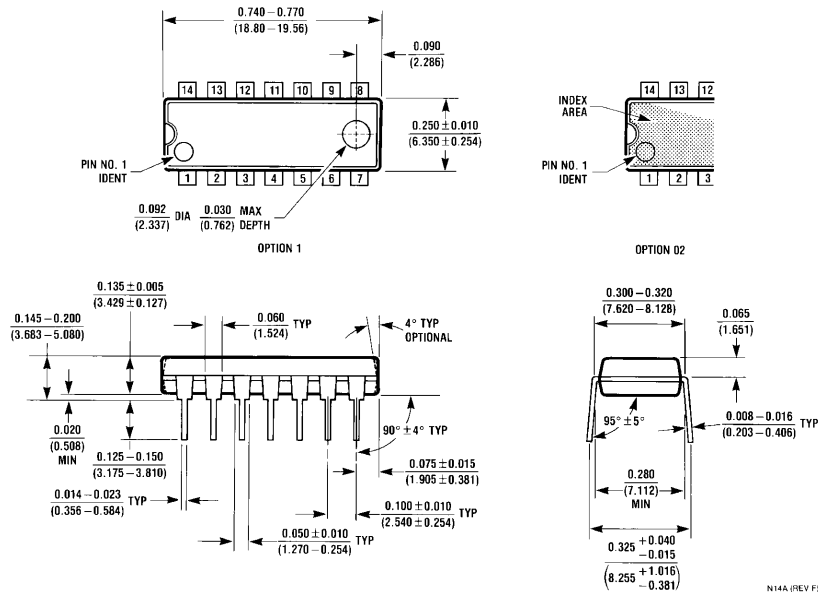
## Physical Dimensions inches (millimeters)



**Metal Can Package (H)**  
**Order Number LM709AH, LM709H or LM709CH**  
**NS Package Number H08C**



**8-Lead Molded Dual-In-Line Package (N)**  
**Order Number LM709CN-8**  
**NS Package Number N08E**

**Physical Dimensions** inches (millimeters) (Continued)

**14-Lead Molded Dual-In-Line Package (N)**  
**Order Number LM709CN**  
**NS Package Number N14A**

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