

# $\mu$ A709C, $\mu$ A709M, $\mu$ A709AM GENERAL-PURPOSE OPERATIONAL AMPLIFIERS

SLOS096 – D942, FEBRUARY 1971 – REVISED MAY 1988

- **Common-Mode Input Range . . .  $\pm 10$  V Typical**
- **Designed to Be Interchangeable With Fairchild  $\mu$ A709A,  $\mu$ A709, and  $\mu$ A709C**
- **Maximum Peak-to-Peak Output Voltage Swing . . . 28-V Typical With 15-V Supplies**

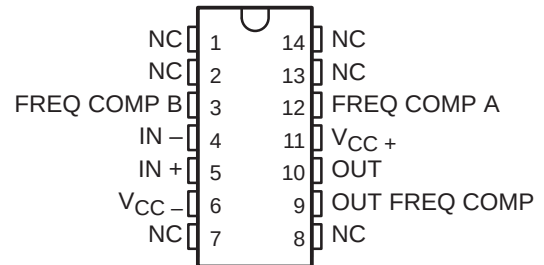
## description

These circuits are general-purpose operational amplifiers, each having high-impedance differential inputs and a low-impedance output. Component matching, inherent with silicon monolithic circuit-fabrication techniques, produces an amplifier with low-drift and low-offset characteristics. Provisions are incorporated within the circuit whereby external components may be used to compensate the amplifier for stable operation under various feedback or load conditions. These amplifiers are particularly useful for applications requiring transfer or generation of linear or nonlinear functions.

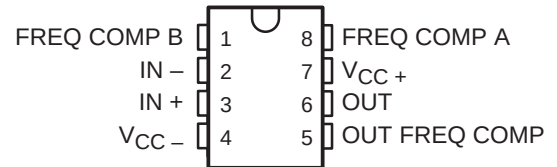
The  $\mu$ A709A circuit features improved offset characteristics, reduced input-current requirements, and lower power dissipation when compared to the  $\mu$ A709 circuit. In addition, maximum values of the average temperature coefficients of offset voltage and current are specified for the  $\mu$ A709A.

The  $\mu$ A709C is characterized for operation from 0°C to 70°C. The  $\mu$ A709AM and  $\mu$ A709M are characterized for operation over the full military temperature range of –55°C to 125°C.

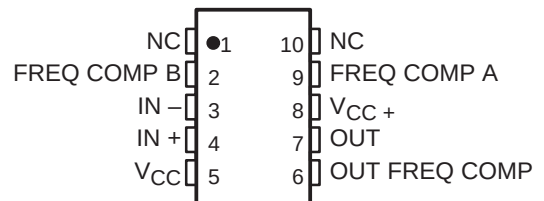
$\mu$ A709AM,  $\mu$ A709M . . . J OR W PACKAGE  
(TOP VIEW)



$\mu$ A709AM,  $\mu$ A709M . . . JG PACKAGE  
 $\mu$ A709C . . . D, JG, OR P PACKAGE  
(TOP VIEW)

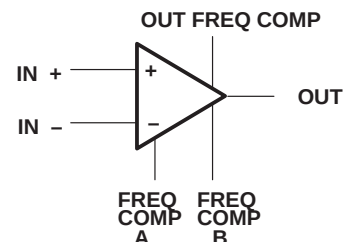


$\mu$ A709AM,  $\mu$ A709M . . . U FLAT PACKAGE  
(TOP VIEW)



NC – No internal connection

## symbol



## AVAILABLE OPTIONS

| T <sub>A</sub>       | V <sub>IO</sub> max<br>AT 25°C | PACKAGE              |                                   |                                     |                    |                                   |                                   |
|----------------------|--------------------------------|----------------------|-----------------------------------|-------------------------------------|--------------------|-----------------------------------|-----------------------------------|
|                      |                                | SMALL OUTLINE<br>(D) | CERAMIC<br>(J)                    | CERAMIC DIP<br>(JG)                 | PLASTIC DIP<br>(P) | FLAT PACK<br>(U)                  | FLAT PACK<br>(W)                  |
| 0°C<br>to<br>70°C    | 7.5 mV                         | $\mu$ A709CD         | —                                 | $\mu$ A709CJG                       | $\mu$ A709CP       | —                                 | —                                 |
| –55°C<br>to<br>125°C | 5 mV<br><br>2 mV               | —                    | $\mu$ A709MJ<br><br>$\mu$ A709AMJ | $\mu$ A709MJG<br><br>$\mu$ A709AMJG | —                  | $\mu$ A709MU<br><br>$\mu$ A709AMU | $\mu$ A709MW<br><br>$\mu$ A709AMW |

The D package is available taped and reeled. Add the suffix R to the device type when ordering, (e.g.,  $\mu$ A709CDR).

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

**TEXAS**  
**INSTRUMENTS**

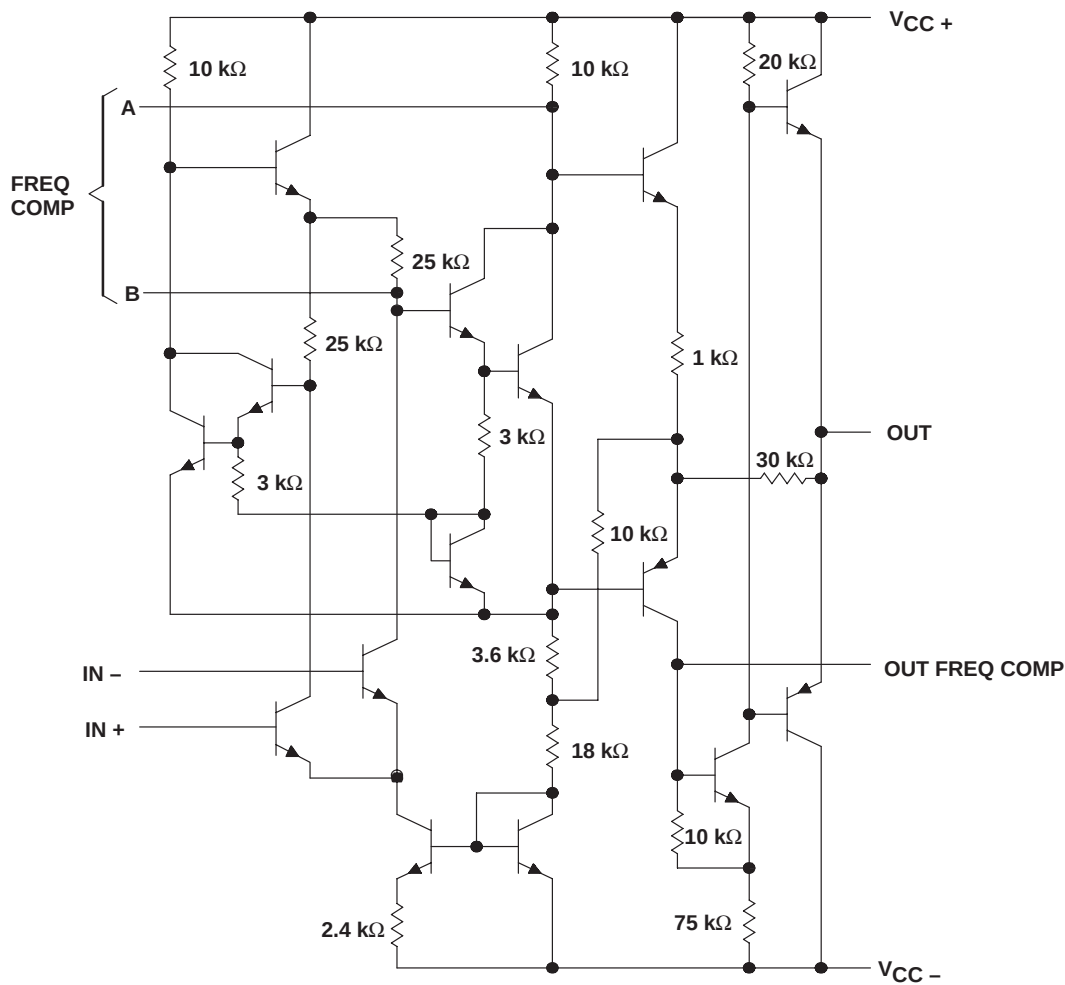
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uA709C, uA709M, uA709AM  
GENERAL-PURPOSE OPERATIONAL AMPLIFIERS

SLOS096 – D942, FEBRUARY 1971 – REVISED MAY 1988

schematic



Component values shown are nominal.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

|                                                              | uA709C                       | uA709M<br>uA709AM | UNIT               |
|--------------------------------------------------------------|------------------------------|-------------------|--------------------|
| Supply voltage, $V_{CC+}$ (see Note 1)                       | 18                           | 18                | V                  |
| Supply voltage, $V_{CC-}$ (see Note 1)                       | -18                          | -18               | V                  |
| Differential input voltage (see Note 2)                      | $\pm 5$                      | $\pm 5$           | V                  |
| Input voltage (either input, see Notes 1 and 3)              | $\pm 10$                     | $\pm 10$          | V                  |
| Duration of output short circuit (see Note 4)                | 5                            | 5                 | s                  |
| Continuous total power dissipation                           | See Dissipation Rating Table |                   |                    |
| Operating free-air temperature range                         | 0 to 70                      | -55 to 125        | $^{\circ}\text{C}$ |
| Storage temperature range                                    | -65 to 150                   | -65 to 150        | $^{\circ}\text{C}$ |
| Lead temperature 1,6 mm (1/16 inch) from case for 60 seconds | J, JG, U, or W package       | 300               | $^{\circ}\text{C}$ |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds | D or P package               | 260               | $^{\circ}\text{C}$ |

NOTES: 1. All voltage values, unless otherwise noted, are with respect to the midpoint between  $V_{CC+}$  and  $V_{CC-}$ .  
2. Differential voltages are at the noninverting input terminal with respect to the inverting input terminal.  
3. The magnitude of the input voltage must never exceed the magnitude of the supply voltage or 10 V, whichever is less.  
4. The output may be shorted to ground or either power supply.



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DISSIPATION RATING TABLE

| PACKAGE      | $T_A \leq 25^\circ\text{C}$<br>POWER RATING | DERATING<br>FACTOR        | DERATE<br>ABOVE $T_A$ | $T_A = 70^\circ\text{C}$<br>POWER RATING | $T_A = 125^\circ\text{C}$<br>POWER RATING |
|--------------|---------------------------------------------|---------------------------|-----------------------|------------------------------------------|-------------------------------------------|
| D            | 300 mW                                      | N/A                       | N/A                   | 300 mW                                   | N/A                                       |
| J (uA709_M)  | 300 mW                                      | 11.0 mW/ $^\circ\text{C}$ | 123 $^\circ\text{C}$  | 300 mW                                   | 275 mW                                    |
| JG (uA709_M) | 300 mW                                      | 8.4 mW/ $^\circ\text{C}$  | 114 $^\circ\text{C}$  | 300 mW                                   | 210 mW                                    |
| JG (uA709C)  | 300 mW                                      | N/A                       | N/A                   | 300 mW                                   | N/A                                       |
| P            | 300 mW                                      | N/A                       | N/A                   | 300 mW                                   | N/A                                       |
| U            | 300 mW                                      | 5.4 mW/ $^\circ\text{C}$  | 94 $^\circ\text{C}$   | 300 mW                                   | 135 mW                                    |
| W            | 300 mW                                      | 8.0 mW/ $^\circ\text{C}$  | 113 $^\circ\text{C}$  | 300 mW                                   | 200 mW                                    |

# uA709M, uA709AM

## GENERAL-PURPOSE OPERATIONAL AMPLIFIERS

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electrical characteristics at specified free-air temperature,  $V_{CC} \pm = \pm 9 \text{ V to } \pm 15 \text{ V}$  (unless otherwise noted)

| PARAMETER          | TEST CONDITIONS†                                                | T <sub>A</sub> ‡                                                         | uA709AMC      |      |     | uA709M |      |     | UNIT  |
|--------------------|-----------------------------------------------------------------|--------------------------------------------------------------------------|---------------|------|-----|--------|------|-----|-------|
|                    |                                                                 |                                                                          | MIN           | TYP§ | MAX | MIN    | TYP§ | MAX |       |
| V <sub>IO</sub>    | Input offset voltage                                            | V <sub>O</sub> = 0, R <sub>S</sub> ≤ 10 kΩ                               | 25°C          | 0.6  | 2   | 1      | 5    |     | mV    |
|                    |                                                                 |                                                                          | Full range    |      | 3   |        | 6    |     |       |
| α <sub>VIO</sub>   | Average temperature coefficient of input offset voltage         | V <sub>O</sub> = 0, R <sub>S</sub> = 50 Ω                                | Full range    | 1.8  | 10  | 3      |      |     | μV/°C |
|                    |                                                                 | V <sub>O</sub> = 0, R <sub>S</sub> = 10 kΩ                               | Full range    | 4.8  | 25  | 6      |      |     |       |
| I <sub>IO</sub>    | Input offset current                                            | V <sub>O</sub> = 0                                                       | 25°C          | 10   | 50  | 50     | 200  |     | nA    |
|                    |                                                                 |                                                                          | –55°C         | 40   | 250 | 100    | 500  |     |       |
|                    |                                                                 |                                                                          | 125°C         | 3.5  | 50  | 20     | 200  |     |       |
| α <sub>VIO</sub>   | Average temperature coefficient of input offset voltage         | V <sub>O</sub> = 0                                                       | –55°C to 25°C | 0.45 | 2.8 |        |      |     | nA/°C |
|                    |                                                                 |                                                                          | 25°C to 125°C | 0.08 | 0.5 |        |      |     |       |
| I <sub>IB</sub>    | Input bias current                                              | V <sub>O</sub> = 0                                                       | 25°C          | 0.1  | 0.2 | 0.2    | 0.5  |     | μA    |
|                    |                                                                 |                                                                          | –55°C         | 0.3  | 0.6 | 0.5    | 1.5  |     |       |
| V <sub>ICR</sub>   | Common-mode input voltage range                                 | V <sub>CC</sub> ± = ±15 V                                                | 25°C          | ±8   | ±10 | ±8     | ±10  |     | V     |
|                    |                                                                 |                                                                          | Full range    | ±8   |     | ±8     |      |     |       |
| V <sub>O(PP)</sub> | Maximum peak-to-peak output voltage swing                       | V <sub>CC</sub> ± = ±15 V, R <sub>L</sub> ≥ 10 kΩ                        | 25°C          | 24   | 28  | 24     | 28   |     | V     |
|                    |                                                                 |                                                                          | Full range    | 24   |     | 24     |      |     |       |
|                    |                                                                 | V <sub>CC</sub> ± = ±15 V, R <sub>L</sub> = 2 kΩ                         | 25°C          | 20   | 26  | 20     | 26   |     |       |
|                    |                                                                 |                                                                          | Full range    | 20   |     | 20     |      |     |       |
| A <sub>VD</sub>    | Large-signal differential voltage amplification                 | V <sub>CC</sub> ± = ±15 V, R <sub>L</sub> ≥ 2 kΩ, V <sub>O</sub> = ±10 V | 25°C          | 45   |     | 45     |      |     | V/mV  |
|                    |                                                                 |                                                                          | Full range    | 25   | 70  | 25     | 70   |     |       |
| r <sub>i</sub>     | Input resistance                                                |                                                                          | 25°C          | 350  | 750 | 150    | 400  |     | kΩ    |
|                    |                                                                 |                                                                          | –55°C         | 85   | 185 | 40     | 100  |     |       |
| r <sub>o</sub>     | Output resistance                                               | V <sub>O</sub> = 0, See Note 5                                           | 25°C          | 150  |     | 150    |      |     | Ω     |
| CMRR               | Common-mode rejection ratio                                     | V <sub>IC</sub> = V <sub>ICRmin</sub>                                    | 25°C          | 80   | 110 | 70     | 90   |     | dB    |
|                    |                                                                 |                                                                          | Full range    | 80   |     | 70     |      |     |       |
| k <sub>SVS</sub>   | Power supply sensitivity (ΔV <sub>IO</sub> / ΔV <sub>CC</sub> ) | V <sub>CC</sub> = ±9 V to ±15 V                                          | 25°C          | 40   | 100 | 25     | 150  |     | μV/V  |
|                    |                                                                 |                                                                          | Full range    |      | 100 |        | 150  |     |       |
| I <sub>CC</sub>    | Supply current                                                  | V <sub>CC</sub> ± = ±15 V, No load, V <sub>O</sub> = 0                   | 25°C          | 2.5  | 3.6 | 2.6    | 5.5  |     | mA    |
|                    |                                                                 |                                                                          | –55°C         | 2.7  | 4.5 |        |      |     |       |
|                    |                                                                 |                                                                          | 125°C         | 2.1  | 3   |        |      |     |       |
| P <sub>D</sub>     | Total power dissipation                                         | V <sub>CC</sub> ± = ±15 V, No load, V <sub>O</sub> = 0                   | 25°C          | 75   | 108 | 78     | 165  |     | mW    |
|                    |                                                                 |                                                                          | –55°C         | 81   | 135 |        |      |     |       |
|                    |                                                                 |                                                                          | 125°C         | 63   | 90  |        |      |     |       |

† All characteristics are specified under open-loop with zero common-mode input voltage unless otherwise specified.

‡ Full range for uA709C is 0°C to 70°C. Full range for uA709AM and uA709M is –55°C to 125°C.

§ All typical values are at V<sub>CC</sub> ± = ±15 V.

NOTE 5: This typical value applies only at frequencies above a few hundred hertz because of the effects of drift and thermal feedback.



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**electrical characteristics at specified free-air temperature (unless otherwise noted  $V_{CC} \pm \pm 15\text{ V}$ )**

| PARAMETER                                                | TEST CONDITIONS <sup>†</sup>                                   | $T_A$ <sup>‡</sup> | uA709C |     |     | UNIT |
|----------------------------------------------------------|----------------------------------------------------------------|--------------------|--------|-----|-----|------|
|                                                          |                                                                |                    | MIN    | TYP | MAX |      |
| $V_{IO}$ Input offset voltage                            | $V_{CC} \pm = \pm 9\text{ V}$ to $\pm 15\text{ V}$ , $V_O = 0$ | 25°C               |        | 2   | 7.5 | mV   |
|                                                          |                                                                | Full range         |        |     | 10  |      |
| $I_{IO}$ Input offset current                            | $V_{CC} \pm = \pm 9\text{ V}$ to $\pm 15\text{ V}$ , $V_O = 0$ | 25°C               |        | 100 | 500 | nA   |
|                                                          |                                                                | Full range         |        |     | 750 |      |
| $I_{IB}$ Input bias current                              | $V_{CC} \pm = \pm 9\text{ V}$ to $\pm 15\text{ V}$ , $V_O = 0$ | 25°C               |        | 0.3 | 1.5 | μA   |
|                                                          |                                                                | Full range         |        |     | 2   |      |
| $V_{ICR}$ Common-mode input voltage range                |                                                                | 25°C               | ±8     | ±10 |     | V    |
| $V_{O(PP)}$ Maximum peak-to-peak output voltage swing    | $R_L \geq 10\text{ k}\Omega$                                   | 25°C               |        | 24  | 28  | V    |
|                                                          |                                                                | Full range         |        | 24  |     |      |
|                                                          | $R_L = 2\text{ k}\Omega$                                       | 25°C               |        | 20  | 26  |      |
|                                                          | $R_L \geq 2\text{ k}\Omega$                                    | Full range         |        | 20  |     |      |
| $A_{VD}$ Large-signal differential voltage amplification | $R_L \leq 2\text{ k}\Omega$ , $V_O = \pm 10\text{ V}$          | 25°C               |        | 15  | 45  | V/mV |
|                                                          |                                                                | Full range         |        | 12  |     |      |
| $r_i$ Input resistance                                   |                                                                | 25°C               |        | 50  | 250 | kΩ   |
|                                                          |                                                                | Full range         |        | 35  |     |      |
| $r_o$ Output resistance                                  | $V_O = 0$ , See Note 5                                         | 25°C               |        | 150 |     | Ω    |
| CMRR Common-mode rejection ratio                         | $V_{IC} = V_{ICR} \text{ min}$                                 | 25°C               | 65     | 90  |     | dB   |
| $k_{SVS}$ Supply voltage sensitivity                     | $V_{CC} = \pm 9\text{ V}$ to $\pm 15\text{ V}$                 | 25°C               |        | 25  | 200 | μV/V |
| $P_D$ Total power dissipation                            | $V_O = 0$ , No load                                            | 25°C               |        | 80  | 200 | mW   |

<sup>†</sup> All characteristics are specified under open-loop operation with zero volts common-mode voltage unless otherwise specified.

<sup>‡</sup> Full range for uA709C is 0°C to 70°C. Full range for uA709AM and uA709M is –55°C to 125°C.

NOTE 5: This typical value applies only at frequencies above a few hundred hertz because of the effects of drift and thermal feedback.

**operating characteristics,  $V_{CC} \pm = \pm 9\text{ V}$  to  $\pm 15\text{ V}$ ,  $T_A = 25^\circ\text{C}$**

| PARAMETER        | TEST CONDITIONS <sup>†</sup>                                   | uA709C<br>uA709M<br>uA709AM |     |     | UNIT |
|------------------|----------------------------------------------------------------|-----------------------------|-----|-----|------|
|                  |                                                                | MIN                         | TYP | MAX |      |
| $t_r$ Rise time  | $V_I = 20\text{ mV}$ , $R_L = 2\text{ k}\Omega$ , See Figure 1 |                             | 0.3 | 1   | μs   |
| Overshoot factor |                                                                |                             | 6%  | 30% |      |

### PARAMETER MEASUREMENT INFORMATION

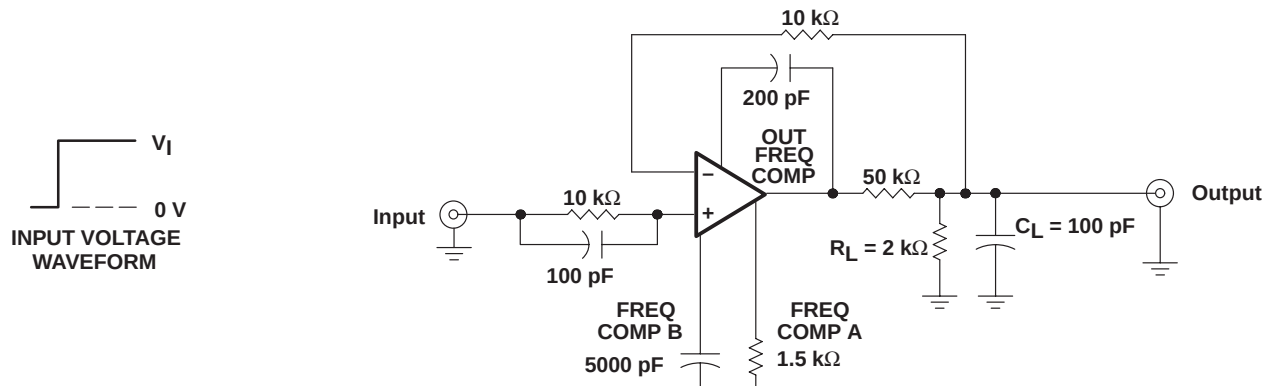


Figure 1. Rise Time and Slew Rate Test Circuit

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