# μA709

# HIGH PERFORMANCE OPERATIONAL AMPLIFIER

## FAIRCHILD LINEAR INTEGRATED CIRCUITS

**GENERAL DESCRIPTION** – The μA709 is a high gain operational amplifier constructed on a single silicon chip using the Fairchild Planar* epitaxial process. It features low offset, high input impedance, large input common mode range, high output swing under load and low power consumption. The device displays exceptional temperature stability and will operate over a wide range of supply voltages with little degradation of performance. The amplifier is intended for use in DC servo systems, high impedance analog computers, low-level instrumentation applications and for the generation of special linear and nonlinear transfer functions.

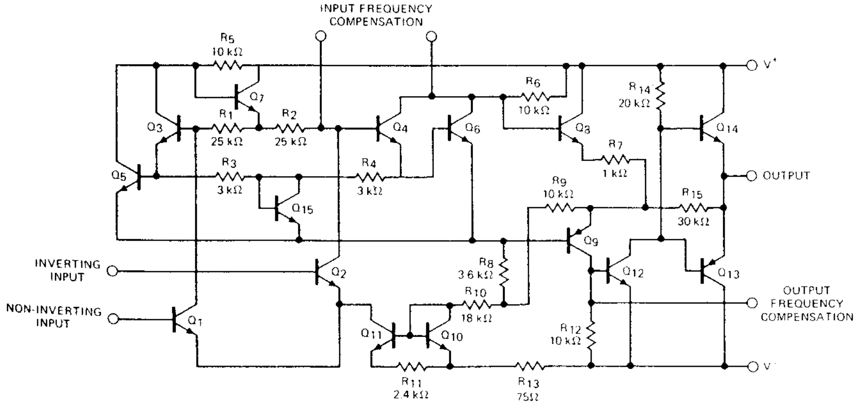
**ABSOLUTE MAXIMUM RATINGS**

| | |
|---|---|
| Supply Voltage | ±18 V |
| Internal Power Dissipation (Note) | |
| Metal Can | 500 mW |
| Ceramic DIP | 670 mW |
| Flatpak | 570 mW |
| Differential Input Voltage | ±5.0 V |
| Input Voltage | ±10 V |
| Storage Temperature Range | |
| Metal Can, Ceramic DIP, and Flatpak | –65°C to +150°C |
| Operating Temperature Range | |
| Military (311 and 312 Grades) | –55°C to +125°C |
| Commerical (393 Grade) | 0°C to +70°C |
| Lead Temperature | |
| Metal Can, Ceramic DIP and Flatpak (Soldering 60 seconds) | 300°C |
| Output Short Circuit Duration | 5 seconds |

NOTE

Rating applies to ambient temperatures up to 70°C. Above 70°C ambient derate linearly at 6.3 mW/°C for Metal Can, 6.3 mW/°C for Silicone DIP, 8.3 mW/°C for Ceramic DIP and 7.1 mW/°C for the Flatpak package.

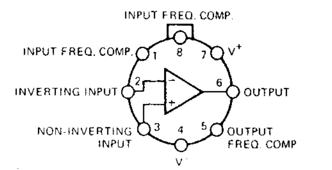
**EQUIVALENT CIRCUIT**




**CONNECTION DIAGRAMS**

(TOP VIEWS)

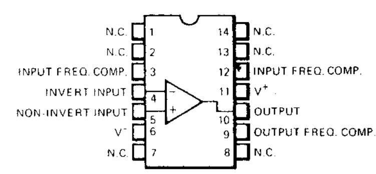
**8 LEAD METAL CAN**




NOTE: Pin 4 connected to case

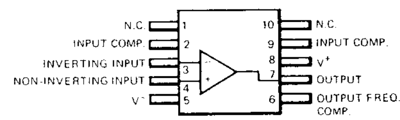
**ORDER PART NOS.:**
**U5B7709311**
**U5B7709312**
**U5B7709393**

**14 LEAD DIP**




**ORDER PART NOS.:**
**U6A7709311**
**U6A7709312**
**U6A7709393**

**FLATPAK**




**ORDER PART NOS.:**
**U3F7709311**
**U3F7709312**

*Planar is a patented Fairchild process.

## (311 GRADE)

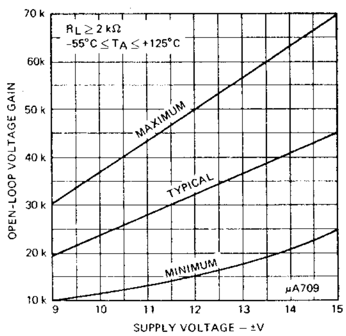
**ELECTRICAL CHARACTERISTICS** ($T_A$ = +25°C, ±9 V ≤ $V_S$ ≤ ±15 V unless otherwise specified)

| PARAMETER (see definitions) | CONDITIONS | MIN. | TYP. | MAX. | UNITS |
|---|---|---|---|---|---|
| Input Offset Voltage | $R_S \leq 10$ kΩ | | 0.6 | 2.0 | mV |
| Input Offset Current | | | 10 | 50 | nA |
| Input Bias Current | | | 100 | 200 | nA |
| Input Resistance | | 350 | 700 | | kΩ |
| Output Resistance | | | 150 | | Ω |
| Supply Current | $V_S$ = ±15 V | | 2.5 | 3.6 | mA |
| Power Consumption | $V_S$ = ±15 V | | 75 | 108 | mW |
| Transient Response | $V_S$ = ±15 V, $V_{IN}$ = 20 mV, $R_L$ = 2 kΩ, $C_1$ = 5 nF, $R_1$ = 1.5 kΩ, $C_2$ = 200 pF, $R_2$ = 50Ω | | | | |
| Risetime | | | | 1.5 | μs |
| Overshoot | $C_L \leq 100$ pF | | | 30 | % |
| The following specifications apply for −55°C ≤ $T_A$ ≤ +125°C: | | | | | |
| Input Offset Voltage | $R_S \leq 10$ kΩ | | | 3.0 | mV |
| Average Temperature Coefficient of Input Offset Voltage | $R_S$ = 50Ω, $T_A$ = +25°C to +125°C | | 1.8 | 10 | μV/°C |
| | $R_S$ = 50Ω, $T_A$ = +25°C to −55°C | | 1.8 | 10 | μV/°C |
| | $R_S$ = 10 kΩ, $T_A$ = +25°C to +125°C | | 2.0 | 15 | μV/°C |
| | $R_S$ = 10 kΩ, $T_A$ = +25°C to −55°C | | 4.8 | 25 | μV/°C |
| Input Offset Current | $T_A$ = +125°C | | 3.5 | 50 | nA |
| | $T_A$ = −55°C | | 40 | 250 | nA |
| Average Temperature Coefficient of Input Offset Current | $T_A$ = +25°C to $T_A$ = +125°C | | 0.08 | 0.5 | nA/°C |
| | $T_A$ = +25°C to $T_A$ = −55°C | | 0.45 | 2.8 | nA/°C |
| Input Bias Current | $T_A$ = −55°C | | 300 | 600 | nA |
| Input Resistance | $T_A$ = −55°C | 85 | 170 | | kΩ |
| Input Voltage Range | $V_S$ = ±15 V | ±8.0 | | | V |
| Common Mode Rejection Ratio | $R_S \leq 10$ kΩ | 80 | 110 | | dB |
| Supply Voltage Rejection Ratio | $R_S \leq 10$ kΩ | | 40 | 100 | μV/V |
| Large-Signal Voltage Gain | $V_S$ = ±15 V, $R_L \geq 2$ kΩ, $V_{OUT}$ = ±15 V | 25,000 | | 70,000 | |
| Output Voltage Swing | $V_S$ = ±15 V, $R_L \geq 10$ kΩ | ±12 | ±14 | | V |
| | $V_S$ = ±15 V, $R_L \geq 2$ kΩ | ±10 | ±13 | | V |
| Supply Current | $T_A$ = +125°C, $V_S$ = ±15 V | | 2.1 | 3.0 | mA |
| | $T_A$ = −55°C, $V_S$ = ±15 V | | 2.7 | 4.5 | mA |
| Power Consumption | $T_A$ = +125°C, $V_S$ = ±15 V | | 63 | 90 | mW |
| | $T_A$ = −55°C, $V_S$ = ±15 V | | 81 | 135 | mW |

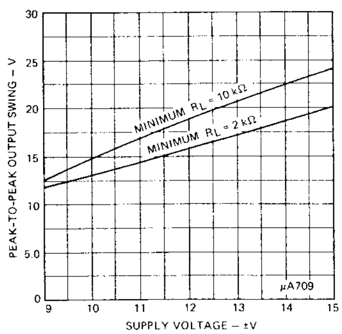
## GUARANTEED ELECTRICAL CHARACTERISTICS

## (311 GRADE)

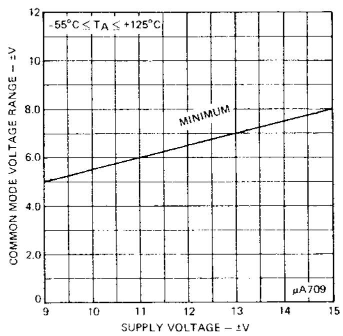
### VOLTAGE GAIN



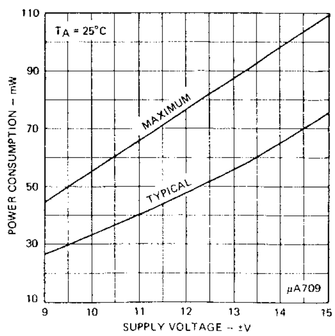

### OUTPUT VOLTAGE SWING




### INPUT COMMON MODE VOLTAGE RANGE




### POWER CONSUMPTION



(312 GRADE)

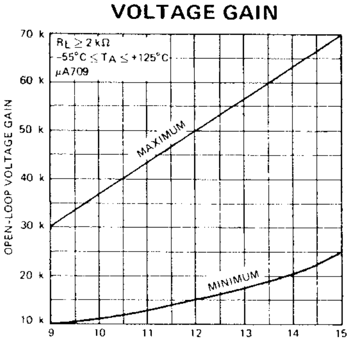
**ELECTRICAL CHARACTERISTICS** ($T_A$ = +25°C, ±9 V ≤ $V_S$ ≤ ±15 V unless otherwise specified)

| PARAMETER (see definitions) | CONDITIONS | MIN. | TYP. | MAX. | UNITS |
|---|---|---|---|---|---|
| Input Offset Voltage | $R_S$ ≤ 10 kΩ | | 1.0 | 5.0 | mV |
| Input Offset Current | | | 50 | 200 | nA |
| Input Bias Current | | | 200 | 500 | nA |
| Input Resistance | | 150 | 400 | | kΩ |
| Output Resistance | | | 150 | | Ω |
| Power Consumption | $V_S$ = ±15 V | | 80 | 165 | mW |
| Transient Response | $V_{IN}$ = 20 mV, $R_L$ = 2 kΩ, | | | | |
| Risetime | $C_1$ = 5000 pF, $R_1$ = 1.5 kΩ, $C_2$ = 200 pF, $R_2$ = 50Ω | | 0.3 | 1.0 | μs |
| Overshoot | $C_L$ ≤ 100 pF | | 10 | 30 | % |
| The following specifications apply for −55°C ≤ $T_A$ ≤ +125°C: | | | | | |
| Input Offset Voltage | $R_S$ ≤ 10 kΩ | | | 6.0 | mV |
| Average Temperature Coefficient of Input Offset Voltage | $R_S$ = 50Ω | | 3.0 | | μV/°C |
| | $R_S$ ≤ 10 kΩ | | 6.0 | | μV/°C |
| Large-Signal Voltage Gain | $V_S$ = ±15 V, $R_L$ ≥ 2 kΩ, $V_{OUT}$ = ±10 V | 25,000 | 45,000 | 70,000 | |
| Output Voltage Swing | $V_S$ = ±15 V, $R_L$ ≥ 10 kΩ | ±12 | ±14 | | V |
| | $V_S$ = ±15 V, $R_L$ ≥ 2 kΩ | ±10 | ±13 | | V |
| Input Voltage Range | $V_S$ = ±15 V | ±8.0 | ±10 | | V |
| Common Mode Rejection Ratio | $R_S$ ≤ 10 kΩ | 70 | 90 | | dB |
| Supply Voltage Rejection Ratio | $R_S$ ≤ 10 kΩ | | 25 | 150 | μV/V |
| Input Offset Current | $T_A$ = +125°C | | 20 | 200 | nA |
| | $T_A$ = −55°C | | 100 | 500 | nA |
| Input Bias Current | $T_A$ = −55°C | | 0.5 | 1.5 | μA |
| Input Resistance | | 40 | 100 | | kΩ |

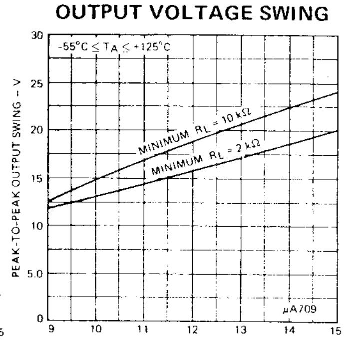
## GUARANTEED ELECTRICAL CHARACTERISTCS

(312 GRADE)

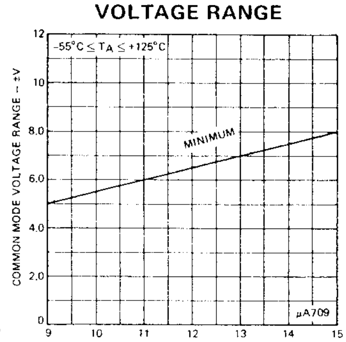
### VOLTAGE GAIN



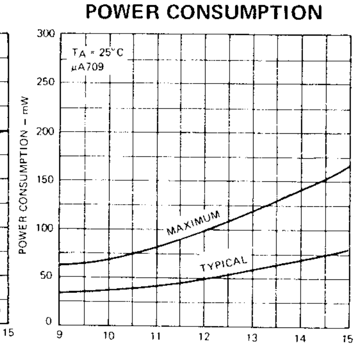

### OUTPUT VOLTAGE SWING




### INPUT COMMON MODE VOLTAGE RANGE




### POWER CONSUMPTION



## (393 GRADE)

**ELECTRICAL CHARACTERISTICS** ($V_S$ = ±15 V, $T_A$ = 25°C unless otherwise specified)

| PARAMETER (see definitions) | CONDITIONS | MIN. | TYP. | MAX. | UNITS |
|---|---|---|---|---|---|
| Input Offset Voltage | $R_S \leq 10\ k\Omega$, $\pm 9\ V \leq V_S \leq \pm 15\ V$ | | 2.0 | 7.5 | mV |
| Input Offset Current | | | 100 | 500 | nA |
| Input Bias Current | | | 0.3 | 1.5 | μA |
| Input Resistance | | 50 | 250 | | kΩ |
| Output Resistance | | | 150 | | Ω |
| Large-Signal Voltage Gain | $R_L \geq 2\ k\Omega$, $V_{OUT} = \pm 10\ V$ | 15,000 | 45,000 | | |
| Output Voltage Swing | $R_L \geq 10\ k\Omega$ | ±12 | ±14 | | V |
| | $R_L \geq 2\ k\Omega$ | ±10 | ±13 | | V |
| Input Voltage Range | | ±8.0 | ±10 | | V |
| Common Mode Rejection Ratio | $R_S \leq 10\ k\Omega$ | 65 | 90 | | dB |
| Supply Voltage Rejection Ratio | $R_S \leq 10\ k\Omega$ | | 25 | 200 | μV/V |
| Power Consumption | | | 80 | 200 | mW |
| Transient Response | $V_{IN}$ = 20 mV, $R_L$ = 2 kΩ, | | | | |
| Risetime | $C_1$ = 5000 pF, $R_1$ = 1.5 kΩ, $C_2$ = 200 pF, $R_2$ = 50Ω | | 0.3 | | μs |
| Overshoot | $C_L \leq 100$ pF | | 10 | | % |

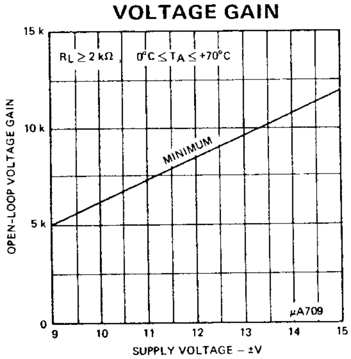
The following specifications apply for $0°C \leq T_A \leq +70°C$:

| PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNITS |
|---|---|---|---|---|---|
| Input Offset Voltage | $R_S \leq 10\ k\Omega$, $\pm 9\ V \leq V_S \leq \pm 15\ V$ | | | 10 | mV |
| Input Offset Current | | | | 750 | nA |
| Input Bias Current | | | | 2.0 | μA |
| Large-Signal Voltage Gain | $R_L \geq 2\ k\Omega$, $V_{OUT} = \pm 10\ V$ | 12,000 | | | |
| Input Resistance | | 35 | | | kΩ |

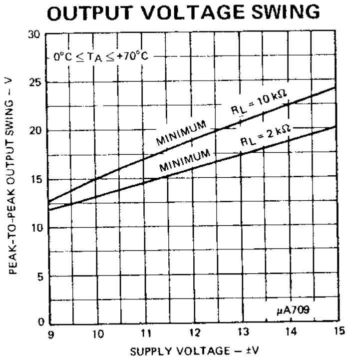
## GUARANTEED ELECTRICAL CHARACTERISTICS

## (393 GRADE)

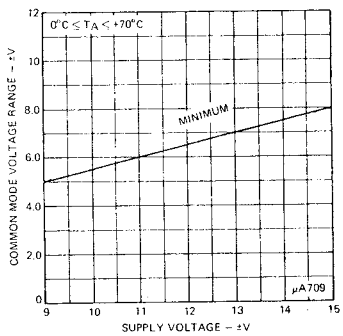
### VOLTAGE GAIN




### OUTPUT VOLTAGE SWING

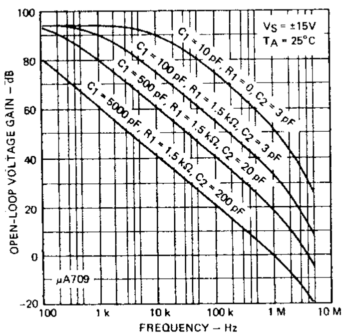



### INPUT COMMON MODE VOLTAGE RANGE

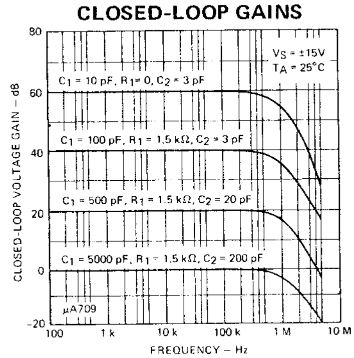



## FREQUENCY COMPENSATION CURVES(FOR ALL GRADES)

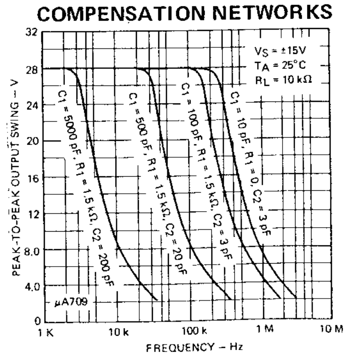
### OPEN-LOOP FREQUENCY RESPONSE FOR VARIOUS VALUES OF COMPENSATION




### FREQUENCY RESPONSE FOR VARIOUS CLOSED-LOOP GAINS

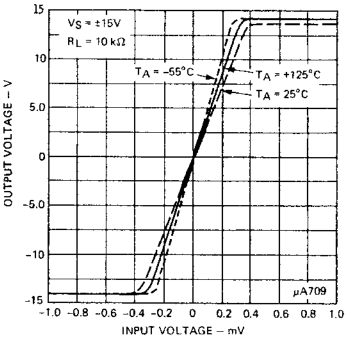



### OUTPUT VOLTAGE SWING AS A FUNCTION OF FREQUENCY FOR VARIOUS COMPENSATION NETWORKS

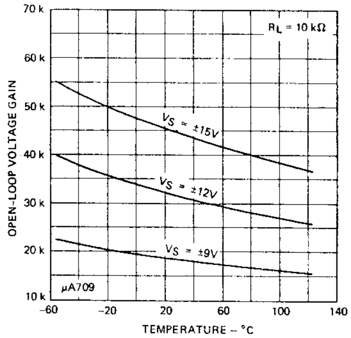


## TYPICAL PERFORMANCE CURVES (FOR 311 GRADE)

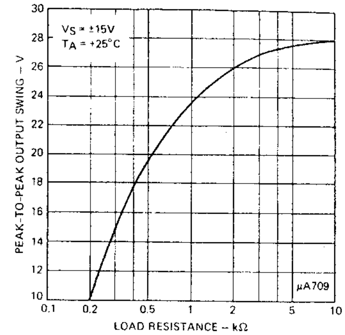
### VOLTAGE TRANSFER CHARACTERISTIC



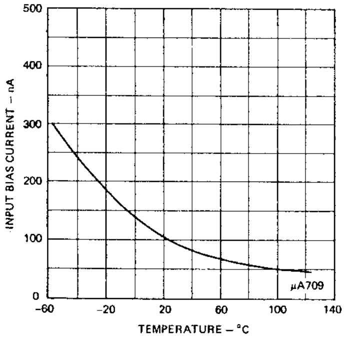

### VOLTAGE GAIN AS A FUNCTION OF AMBIENT TEMPERATURE



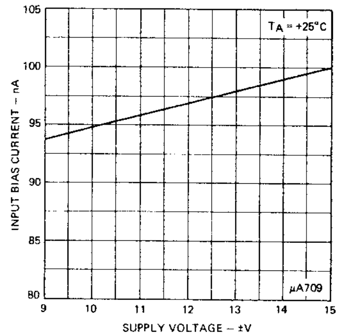

### OUTPUT VOLTAGE SWING AS A FUNCTION OF LOAD RESISTANCE



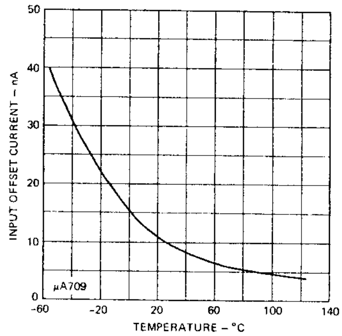

### INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



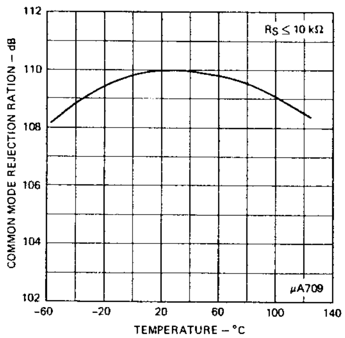

### INPUT BIAS CURRENT AS A FUNCTION OF SUPPLY VOLTAGE



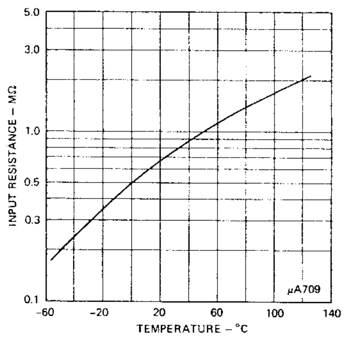

### INPUT OFFSET CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



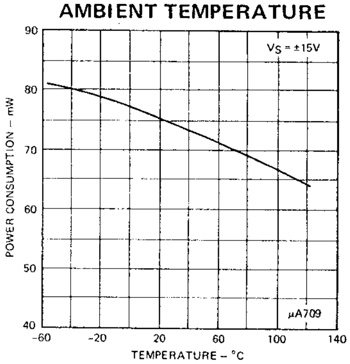

### COMMON MODE REJECTION RATIO AS A FUNCTION OF AMBIENT TEMPERATURE



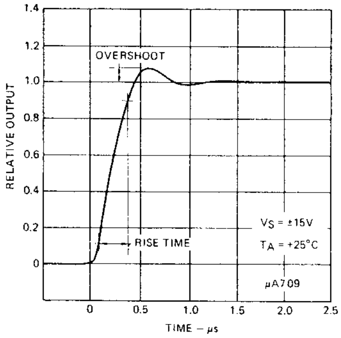

### INPUT RESISTANCE AS A FUNCTION OF AMBIENT TEMPERATURE



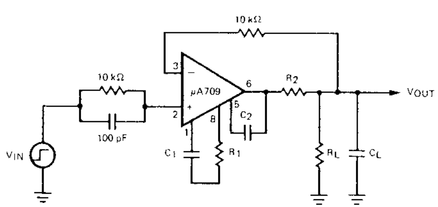

### POWER CONSUMPTION AS A FUNCTION OF AMBIENT TEMPERATURE




### TRANSIENT RESPONSE

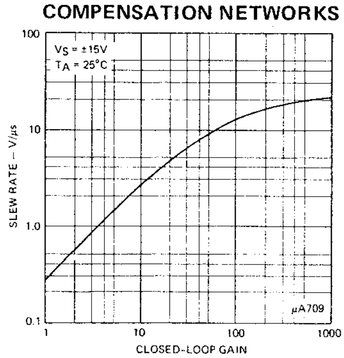



### TRANSIENT RESPONSE TEST CIRCUIT



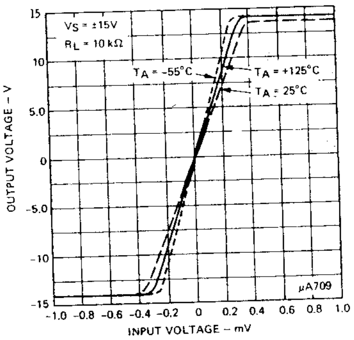

Pin numbers only apply to metal can package.

### SLEW RATE AS A FUNCTION OF CLOSED-LOOP GAIN USING RECOMMENDED COMPENSATION NETWORKS

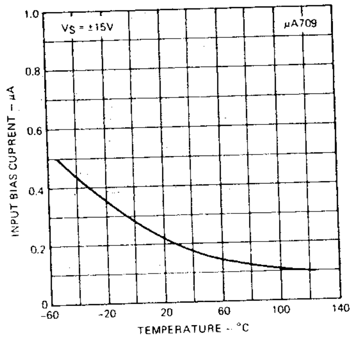


## TYPICAL PERFORMANCE CURVES
(FOR 312 AND 393 GRADES)

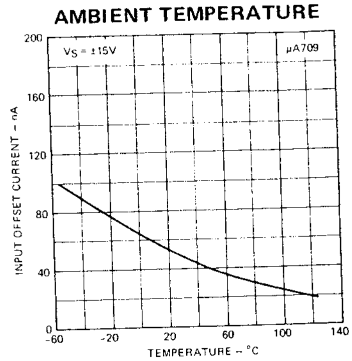
### VOLTAGE TRANSFER CHARACTERISTIC



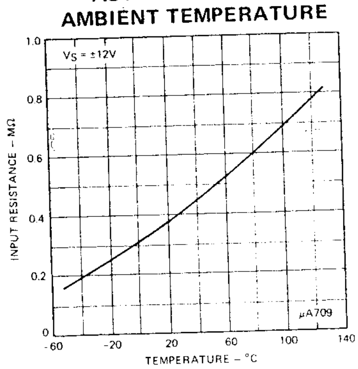

### INPUT BIAS CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



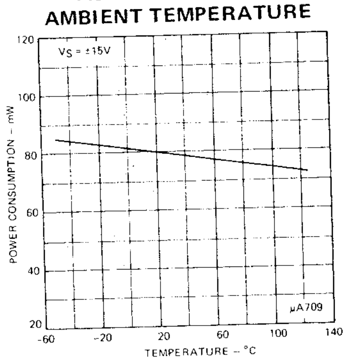

### INPUT OFFSET CURRENT AS A FUNCTION OF AMBIENT TEMPERATURE



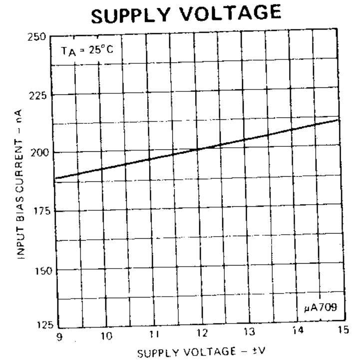

### INPUT RESISTANCE AS A FUNCTION OF AMBIENT TEMPERATURE



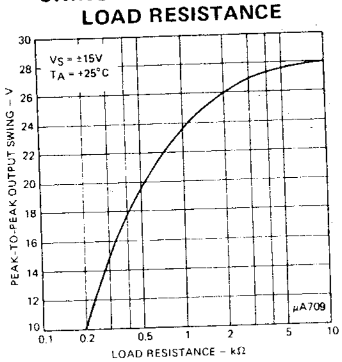

### POWER CONSUMPTION AS A FUNCTION OF AMBIENT TEMPERATURE



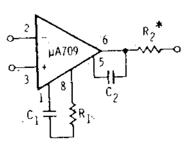

### INPUT BIAS CURRENT AS A FUNCTION OF SUPPLY VOLTAGE




### OUTPUT VOLTAGE SWING AS A FUNCTION OF LOAD RESISTANCE

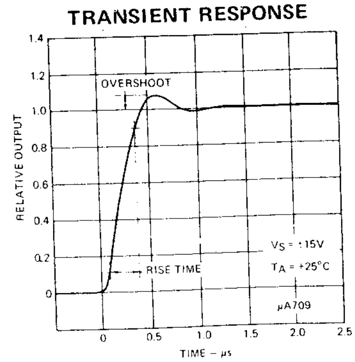



### FREQUENCY COMPENSATION CIRCUIT



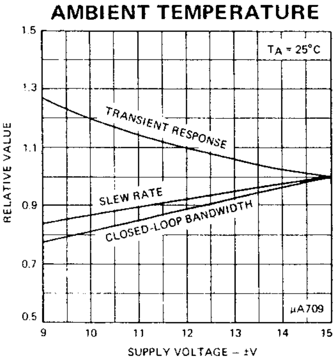

* Use $R_2$ = 50 Ω when the amplifier is operated with capacitive loading.

### TRANSIENT RESPONSE

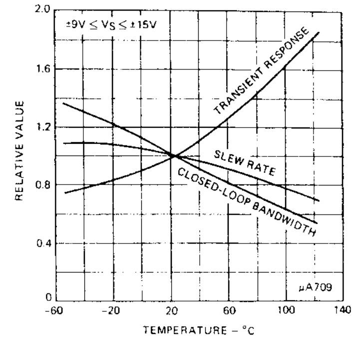


## TYPICAL PERFORMANCE CURVES
(FOR 312 AND 393 GRADES)

### FREQUENCY CHARACTERISTICS AS A FUNCTION OF AMBIENT TEMPERATURE

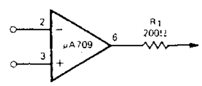



### FREQUENCY CHARACTERISTICS AS A FUNCTION OF SUPPLY VOLTAGE

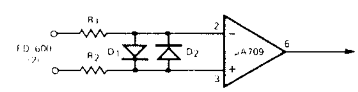



## PROTECTION CIRCUITS

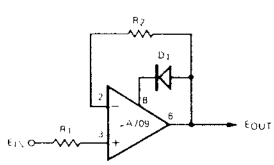
### OUTPUT SHORT-CIRCUIT PROTECTION



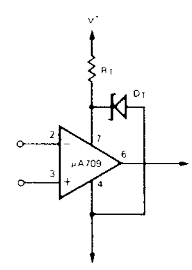

### INPUT BREAKDOWN PROTECTION




### LATCH-UP PROTECTION




### SUPPLY OVERVOLTAGE PROTECTION




Pin numbers only apply to metal can package.