# LM759, LM77000

## *Power Operational Amplifiers*

The LM759 and LM77000 are high performance operational amplifiers that feature high output current capability. The LM759 is capable of providing 325 mA and the LM77000 providing 250 mA. Both amplifiers feature small signal characteristics that are better than the LM741. The amplifiers are designed to operate from a single or dual power supply with an input common mode range that includes the negative supply. The high gain and high output power provide superior performance. Internal current limiting, thermal shutdown, and safe area compensation are employed making the LM759 and LM77000 essentially indestructible.

### Rochester Electronics Manufactured Components

Rochester branded components are manufactured using either die/wafers purchased from the original suppliers or Rochester wafers recreated from the original IP. All recreations are done with the approval of the OCM.

Parts are tested using original factory test programs or Rochester developed test solutions to guarantee product meets or exceeds the OCM data sheet.

### Quality Overview

- ISO-9001
- AS9120 certification
- Qualified Manufacturers List (QML) MIL-PRF-38535
    - Class Q Military
    - Class V Space Level
- Qualified Suppliers List of Distributors (QSLD)
    - Rochester is a critical supplier to DLA and meets all industry and DLA standards.

Rochester Electronics, LLC is committed to supplying products that satisfy customer expectations for quality and are equal to those originally supplied by industry manufacturers.

*The original manufacturer's datasheet accompanying this document reflects the performance and specifications of the Rochester manufactured version of this device. Rochester Electronics guarantees the performance of its semiconductor products to the original OEM specifications. 'Typical' values are for reference purposes only. Certain minimum or maximum ratings may be based on product characterization, design, simulation, or sample testing.*

National Semiconductor

# LM759/LM77000
# Power Operational Amplifiers

## General Description

The LM759 and LM77000 are high performance operational amplifiers that feature high output current capability. The LM759 is capable of providing 325 mA and the LM77000 providing 250 mA. Both amplifiers feature small signal characteristics that are better than the LM741. The amplifiers are designed to operate from a single or dual power supply with an input common mode range that includes the negative supply. The high gain and high output power provide superior performance. Internal current limiting, thermal shutdown, and safe area compensation are employed making the LM759 and LM77000 essentially indestructible.

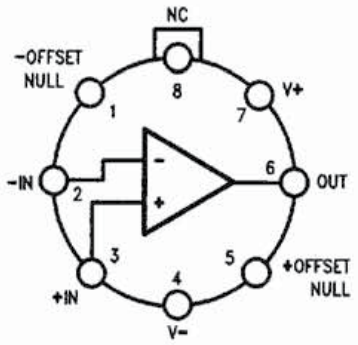
## Features

- Output current
  - LM759—325 mA minimum
  - LM77000—250 mA minimum
- Internal short circuit current limiting
- Internal thermal overload protection
- Internal output transistors safe-area protection
- Input common mode voltage range includes ground or negative supply

## Applications

- Voltage regulators
- Audio amplifiers
- Servo amplifiers
- Power drivers

## Connection Diagrams and Ordering Information

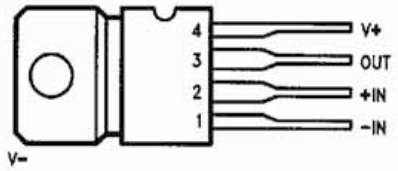



TL/H/10075–1

Lead 4 connected to case.

**Top View**

**Order Number LM759MH, LM759CH or LM759H/883**
**See NS Package Number H08C**




TL/H/10075–2

**Top View**

**Order Number LM759CP or LM77000CP**
**See NS Package Number P04A**

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## Absolute Maximum Ratings

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

Storage Temperature Range
- Metal Can: −65°C to +175°C
- Plastic Package: −65°C to +150°C

Operating Junction Temperature Range
- Military (LM759M): −55°C to +150°C
- Commercial (LM759C, LM77000C): 0°C to +125°C

Lead Temperature
- Metal Can (soldering, 60 sec): 300°C
- Plastic Package (soldering, 10 sec): 265°C

Internal Power Dissipation (Note 1): Internally Limited
Supply Voltage: ±18V
Differential Input Voltage: 30V
Input Voltage (note 2): ±15V

## LM759
## Electrical Characteristics $T_J = 25°C$, $V_{CC} = \pm 15V$, unless otherwise specified

| Symbol | Parameter | | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input Offset Voltage | | $R_S \leq 10\ k\Omega$ | | 1.0 | 3.0 | mV |
| $I_{IO}$ | Input Offset Current | | | | 5.0 | 30 | nA |
| $I_{IB}$ | Input Bias Current | | | | 50 | 150 | nA |
| $Z_I$ | Input Impedance | | | 0.25 | 1.5 | | MΩ |
| $I_{CC}$ | Supply Current | | | | 12 | 18 | mA |
| $V_{IR}$ | Input Voltage Range | | | $V^+ - 2V$ to $V^-$ | $V^+ - 2V$ to $V^-$ | | V |
| $I_{OS}$ | Output Short Circuit Current | | $\lvert V_{CC} - V_O \rvert = 30V$ | | ±200 | | mA |
| $I_{O\ PEAK}$ | Peak Output Current | | $3.0V \leq \lvert V_{CC} - V_O \rvert \leq 10V$ | ±325 | ±500 | | mA |
| $A_{VS}$ | Large Signal Voltage Gain | | $R_L \geq 50\Omega$, $V_O = \pm 10V$ | 50 | 200 | | V/mV |
| TR | Transient Response | Rise Time | $R_L = 50\Omega$, $A_V = 1.0$ | | 300 | | ns |
| | | Overshoot | | | 5.0 | | % |
| SR | Slew Rate | | $R_L = 50\Omega$, $A_V = 1.0$ | | 0.6 | | V/μs |
| BW | Bandwidth | | $A_V = 1.0$ | | 1.0 | | MHz |
| The following specifications apply for $-55°C \leq T_J \leq +150°C$ | | | | | | | |
| $V_{IO}$ | Input Offset Voltage | | $R_S \leq 10\ k\Omega$ | | | 4.5 | mV |
| $I_{IO}$ | Input Offset Current | | | | | 60 | nA |
| $I_{IB}$ | Input Bias Current | | | | | 300 | nA |
| CMRR | Common Mode Rejection Ratio | | $R_S \leq 10\ k\Omega$ | 80 | 100 | | dB |
| PSRR | Power Supply Rejection Ratio | | $R_S \leq 10\ k\Omega$ | 80 | 100 | | dB |
| $A_{VS}$ | Large Signal Voltage Gain | | $R_L \geq 50\Omega$, $V_O = \pm 10V$ | 25 | 200 | | V/mV |
| $V_{OP}$ | Output Voltage Swing | | $R_L = 50\Omega$ | ±10 | ±12.5 | | V |

## LM759C
## Electrical Characteristics $T_J = 25°C$, $V_{CC} = \pm 15V$, unless otherwise specified

| Symbol | Parameter | | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input Offset Voltage | | $R_S \leq 10\ k\Omega$ | | 1.0 | 6.0 | mV |
| $I_{IO}$ | Input Offset Current | | | | 5.0 | 50 | nA |
| $I_{IB}$ | Input Bias Current | | | | 50 | 250 | nA |
| $Z_I$ | Input Impedance | | | 0.25 | 1.5 | | MΩ |
| $I_{CC}$ | Supply Current | | | | 12 | 18 | mA |
| $V_{IR}$ | Input Voltage Range | | | $V^+ - 2V$ to $V^-$ | $V^+ - 2V$ to $V^-$ | | V |
| $I_{OS}$ | Output Short Circuit Current | | $\lvert V_{CC} - V_O \rvert = 30V$ | | ±200 | | mA |
| $I_{O\ PEAK}$ | Peak Output Current | | $3.0V \leq \lvert V_{CC} - V_O \rvert \leq 10V$ | ±325 | ±500 | | mA |
| $A_{VS}$ | Large Signal Voltage Gain | | $R_L \geq 50\Omega$, $V_O = \pm 10V$ | 25 | 200 | | V/mV |
| TR | Transient Response | Rise Time | $R_L = 50\Omega$, $A_V = 1.0$ | | 300 | | ns |
| | | Overshoot | | | 10 | | % |
| SR | Slew Rate | | $R_L = 50\Omega$, $A_V = 1.0$ | | 0.5 | | V/μs |
| BW | Bandwidth | | $A_V = 1.0$ | | 1.0 | | MHz |
| The following specifications apply for $0° \leq T_J \leq +125°C$ | | | | | | | |
| $V_{IO}$ | Input Offset Voltage | | $R_S \leq 10\ k\Omega$ | | | 7.5 | mV |
| $I_{IO}$ | Input Offset Current | | | | | 100 | nA |
| $I_{IB}$ | Input Bias Current | | | | | 400 | nA |
| CMRR | Common Mode Rejection Ratio | | $R_S \leq 10\ k\Omega$ | 70 | 100 | | dB |
| PSRR | Power Supply Rejection Ratio | | $R_S \leq 10\ k\Omega$ | 80 | 100 | | dB |
| $A_{VS}$ | Large Signal Voltage Gain | | $R_L \geq 50\Omega$, $V_O = \pm 10V$ | 25 | 200 | | V/mV |
| $V_{OP}$ | Output Voltage Swing | | $R_L = 50\Omega$ | ±10 | ±12.5 | | V |

## LM77000
## Electrical Characteristics $T_J = 25°C$, $V_{CC} = \pm 15V$, unless otherwise specified

| Symbol | Parameter | | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|---|
| $V_{IO}$ | Input Offset Voltage | | $R_S \leq 10\ k\Omega$ | | 1.0 | 8.0 | mV |
| $I_{IO}$ | Input Offset Current | | | | 5.0 | 50 | nA |
| $I_{IB}$ | Input Bias Current | | | | 50 | 250 | nA |
| $Z_I$ | Input Impedance | | | 0.25 | 1.5 | | MΩ |
| $I_{CC}$ | Supply Current | | | | 12 | 18 | mA |
| $V_{IR}$ | Input Voltage Range | | | +13 to $V^-$ | +13 to $V^-$ | | V |
| $I_{OS}$ | Output Short Circuit Current | | $\lvert V_{CC}-V_O \rvert = 30V$ | | ±200 | | mA |
| $I_{O\ PEAK}$ | Peak Output Current | | $3.0V \leq \lvert V_{CC}-V_O \rvert \leq 10V$ | ±250 | ±400 | | mA |
| $A_{VS}$ | Large Signal Voltage Gain | | $R_L \geq 50\Omega$, $V_O = \pm 10V$ | 25 | 200 | | V/mV |
| TR | Transient Response | Rise Time | $R_L = 50\Omega$, $A_V = 1.0$ | | 300 | | ns |
| | | Overshoot | | | 10 | | % |
| SR | Slew Rate | | $R_L = 50\Omega$, $A_V = 1.0$ | | 0.5 | | V/μs |
| BW | Bandwidth | | $A_V = 1.0$ | | 1.0 | | MHz |

The following specifications apply for $0° \leq T_J \leq +125°C$

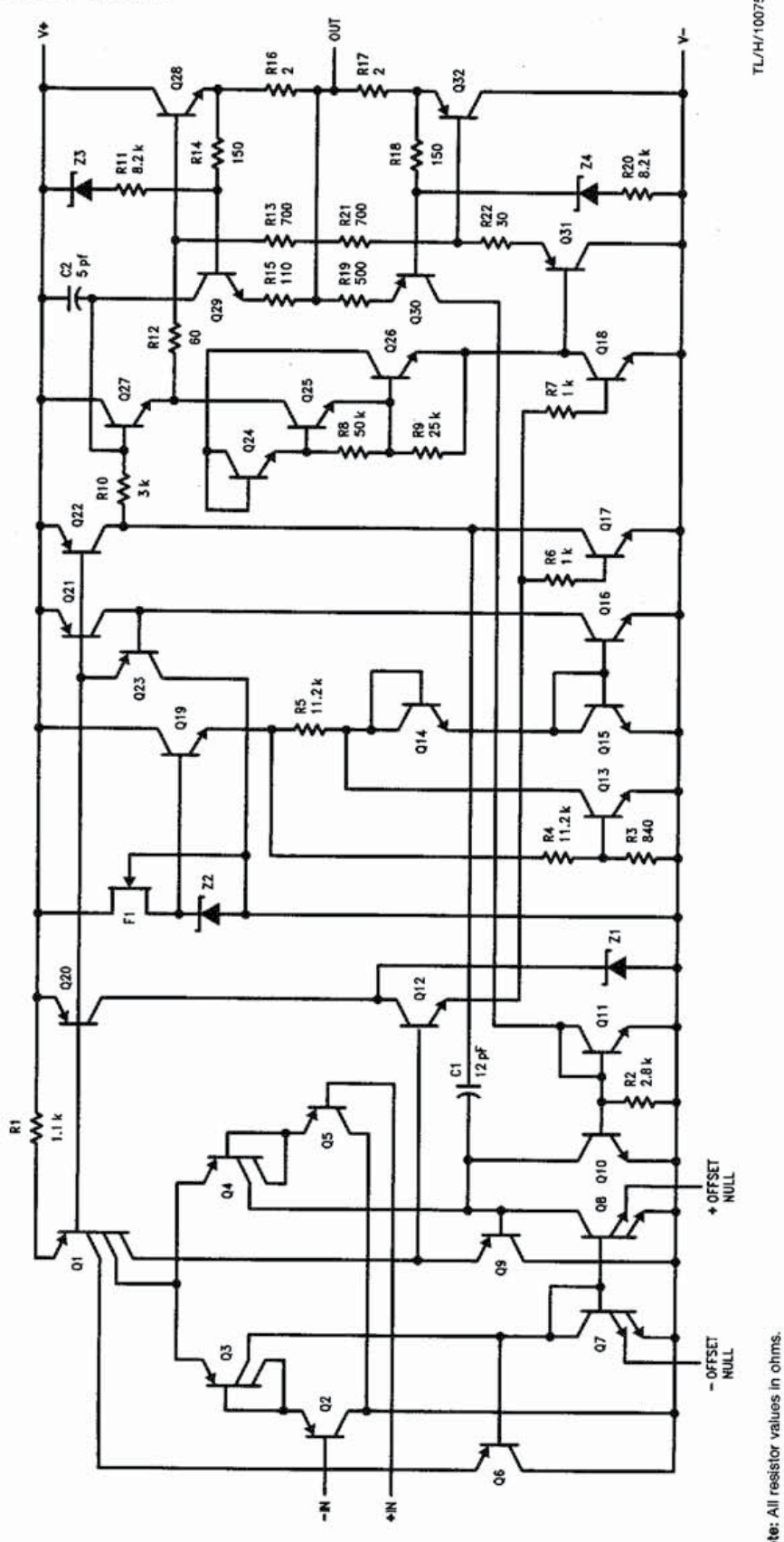
| | | | | | | |
|---|---|---|---|---|---|---|
| $V_{IO}$ | Input Offset Voltage | $R_S \leq 10\ k\Omega$ | | | 10 | mV |
| $I_{IO}$ | Input Offset Current | | | | 100 | nA |
| $I_{IB}$ | Input Bias Current | | | | 400 | nA |
| CMR | Common Mode Rejection | $R_S \leq 10\ k\Omega$ | 70 | 100 | | dB |
| PSRR | Power Supply Rejection Ratio | $R_S \leq 10\ k\Omega$ | 80 | 100 | | dB |
| $A_{VS}$ | Large Signal Voltage Gain | $R_L \geq 50\Omega$, $V_O = \pm 10V$ | 25 | 200 | | V/mV |
| $V_{OP}$ | Output Voltage Swing | $R_L = 50\Omega$ | ±10 | ±12.5 | | V |

**Note 1:** Although the internal power dissipation is limited, the junction temperature must be kept below the maximum specified temperature in order to meet data sheet specifications. To calculate the maximum junction temperature or heat sink required, use the thermal resistance values which follow the Equivalent Circuit Schematic.

**Note 2:** For a supply voltage less than 30V between $V^+$ and $V^-$, the absolute maximum input voltage is equal to the supply voltage.

**Note 3:** For military electrical specifications RETS759X are available for LM759H.

## Equivalent Circuit




TL/H/10075–3

**Note:** All resistor values in ohms.

| Package | Typ $\theta_{JC}$ °C/W | Max $\theta_{JC}$ °C/W | Typ $\theta_{JA}$ °C/W | Max $\theta_{JA}$ °C/W |
|---|---|---|---|---|
| Plastic Package (P) | 8.0 | 12 | 75 | 80 |
| Metal Can (H) | 30 | 40 | 120 | 150 |

$$P_{D\,Max} = \frac{T_{J\,Max} - T_A}{\theta_{JC} + \theta_{CA}} \text{ or}$$

$$= \frac{T_{J\,Max} - T_A}{\theta_{JA}} \text{ (without a heat sink)}$$

$$\theta_{CA} = \theta_{CS} + \theta_{SA}$$

Solving $T_J$:

$$T_J = T_A + P_D(\theta_{JC} + \theta_{CA}) \text{ or}$$

$$= T_A + P_D\theta_{JA} \text{ (without a heat sink)}$$

Where:

$T_J$ = Junction Temperature
$T_A$ = Ambient Temperature
$P_D$ = Power Dissipation
$\theta_{JA}$ = Junction to ambient thermal resistance
$\theta_{JC}$ = Junction to case thermal resistance
$\theta_{CA}$ = Case to ambient thermal resistance
$\theta_{CS}$ = Case to heat sink thermal resistance
$\theta_{SA}$ = Heat sink to ambient thermal resistance

## Mounting Hints

**Metal Can Package (LM759CH/LM759MH)**

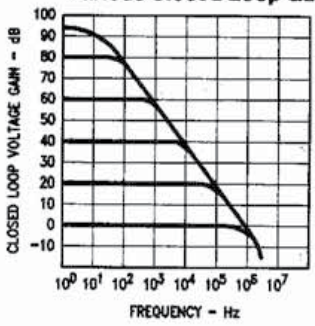
The LM759 in the 8-Lead TO-99 metal can package must be used with a heat sink. With ±15V power supplies, the LM759 can dissipate up to 540 mW in its quiescent (no load) state. This would result in a 100°C rise in chip temperature to 125°C (assuming a 25°C ambient temperature). In order to avoid this problem, it is advisable to use either a slip on or stud mount heat sink with this package. If a stud mount heat sink is used, it may be necessary to use insulating washers between the stud and the chassis because the case of the LM759 is internally connected to the negative power supply terminal.

**Plastic Package (LM759CP/LM77000CP)**

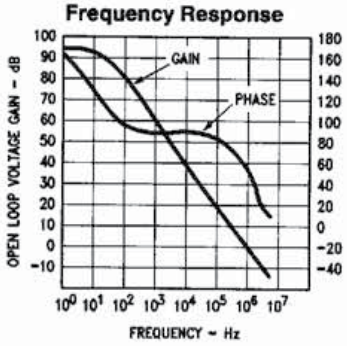
The LM759CP and LM77000CP are designed to be attached by the tab to a heat sink. This heat sink can be either one of the many heat sinks which are commercially available, a piece of metal such as the equipment chassis, or a suitable amount of copper foil as on a double sided PC board. The important thing to remember is that the negative power supply connection to the op amp must be made through the tab. Furthermore, adequate heat sinking must be provided to keep the chip temperature below 125°C under worst case load and ambient temperature conditions.

# Typical Performance Characteristics

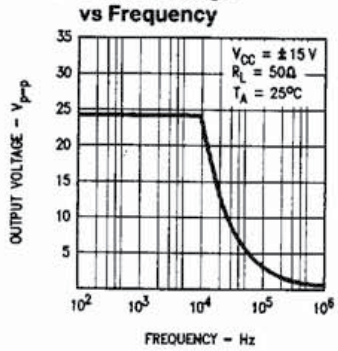
**Frequency Response for Various Closed Loop Gains**



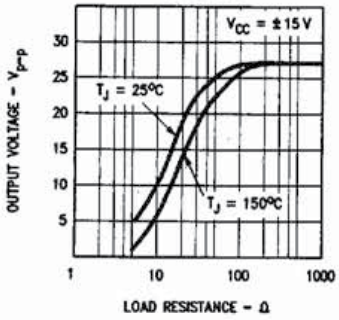

**Open Loop vs Frequency Response**



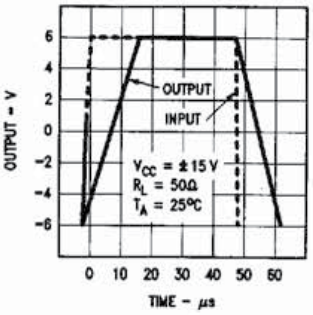

**Output Voltage vs Frequency**



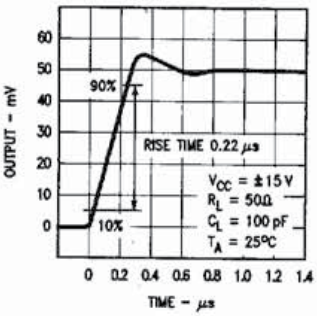

**Output Voltage vs Load Resistance**



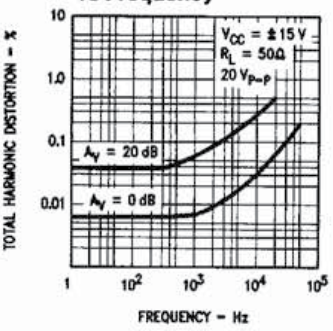

**Voltage Follower Large Signal Pulse Response**



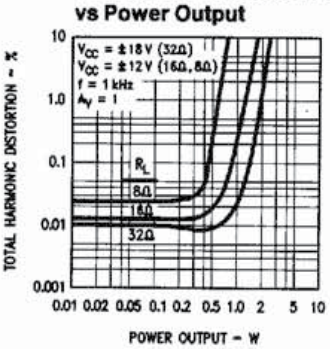

**Voltage Follower Transient Response**



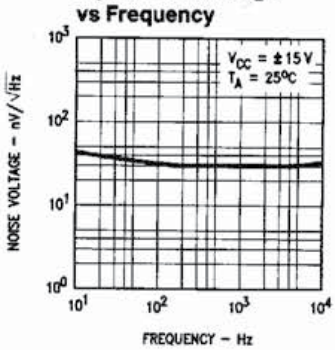

**Total Harmonic Distortion vs Frequency**



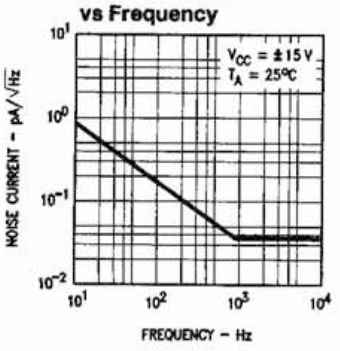

**Total Harmonic Distortion vs Power Output**



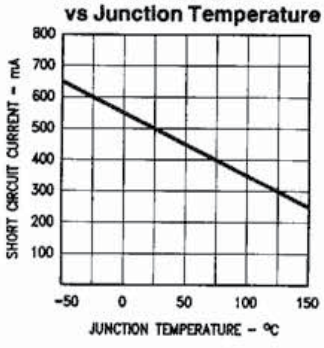

**Input Noise Voltage vs Frequency**



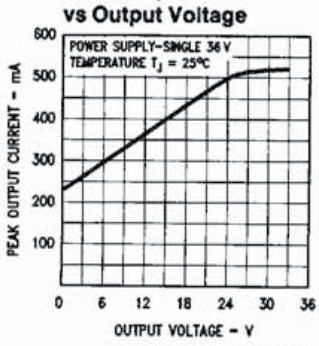

**Noise Current vs Frequency**




**Short Circuit Current vs Junction Temperature**



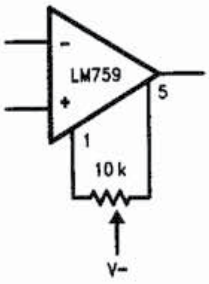

**Peak Output Current vs Output Voltage**




TL/H/10075–4

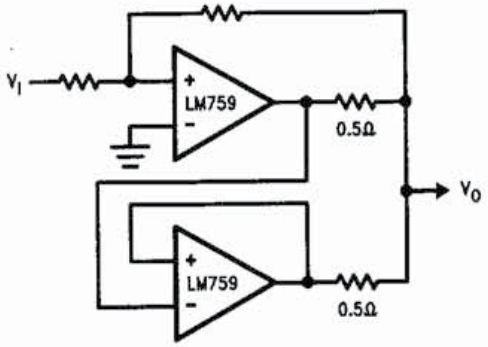
## Applications

**Offset Null Circuit**




TL/H/10075–5

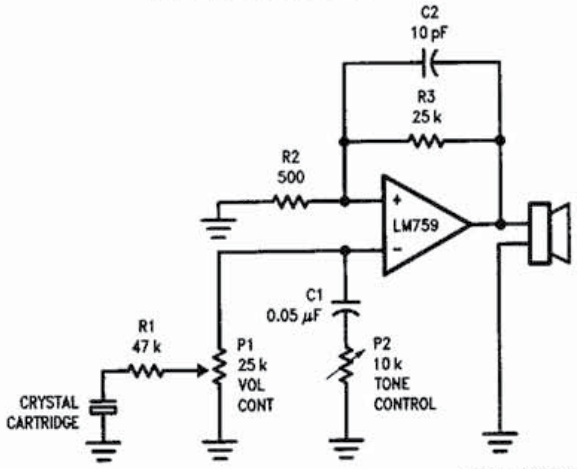
**Paralleling LM759 Power Op Amps**




TL/H/10075–6

## Audio Applications

**Low Cost Phono Amplifier**

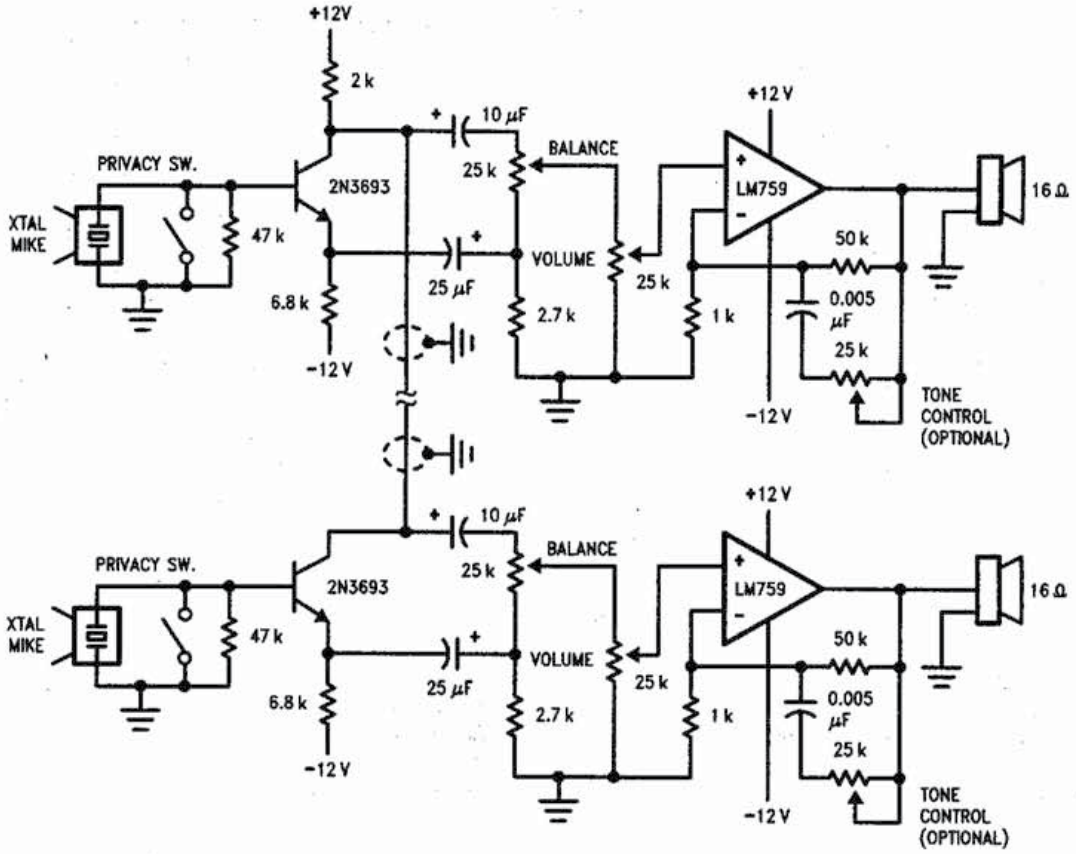



TL/H/10075–7

| Speaker Impedance (Ohms) | Output Power (Watts) | Min Supply (Volts) | $V_{OP-P}$ (Volts) |
|---|---|---|---|
| 4 | 0.18 | 9 | 2.4 |
| 8 | 0.36 | 12 | 4.8 |
| 16 | 0.72 | 15 | 9.6 |
| 32 | 1.44 | 25 | 19.2 |

## Applications (Continued)

**Bi-Directional Intercom System Using the LM759 Power Op Amp**




TL/H/10075–9

**Features:**

Circuit Simplicity

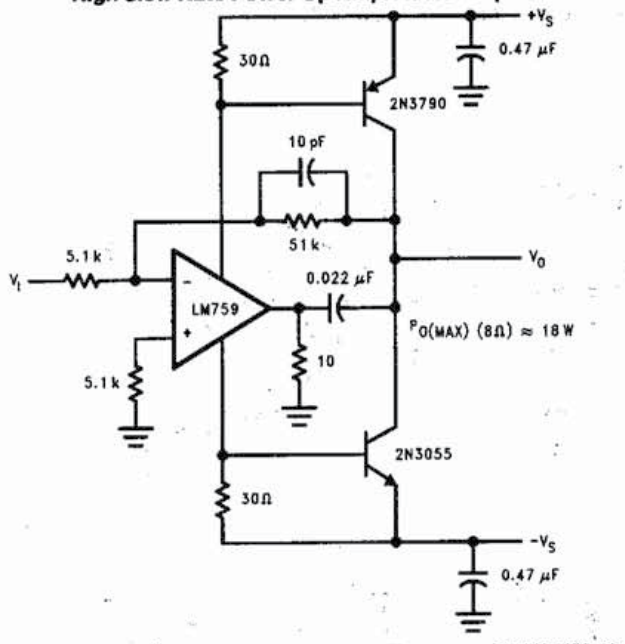
1 Watt of Audio Output

Duplex operation with only one two-wire cable as interconnect.

**Note 1:** All resistor values in ohms.

## Applications (Continued)

### High Slew Rate Power Op Amp/Audio Amp



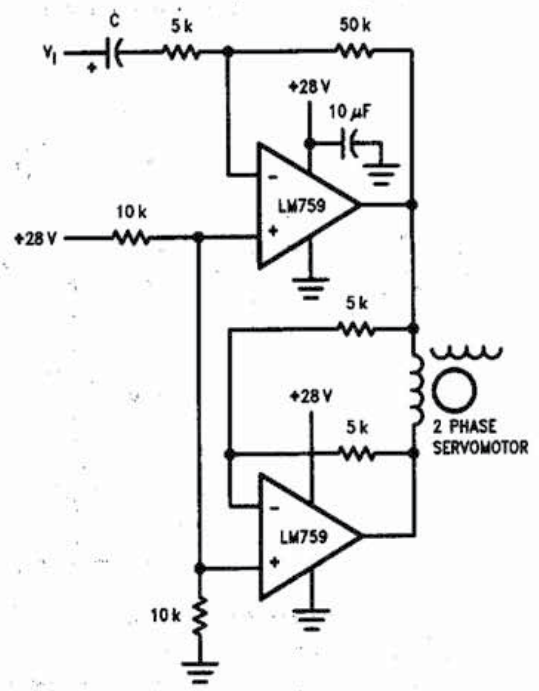

TL/H/10075–10

**Features:**

High Slew Rate 9 V/µs
High 3 dB Power Bandwidth 85 kHz
18 Watts Output Power into an 8Ω load.
Low Distortion—0.2%, 10 Vrms, 1 kHz into 8Ω
Design Consideration
$A_V \geq 10$

## Servo Applications

### AG Servo Amplifier—Bridge Type




TL/H/10075–11

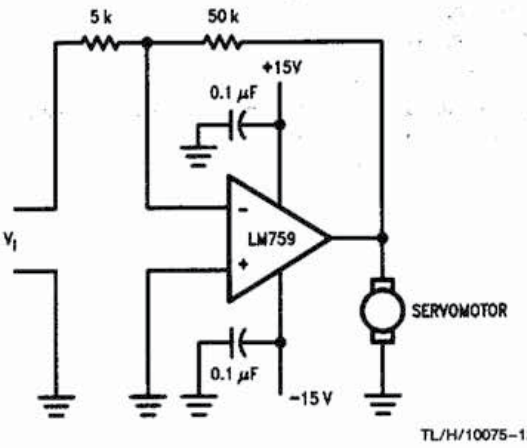
**Features:**

Gain of 10
Use of LM759 Means Simple Inexpensive Circuit

**Design Considerations:**

325 mA Max Output Current

### DC Servo Amplifier




TL/H/10075–12

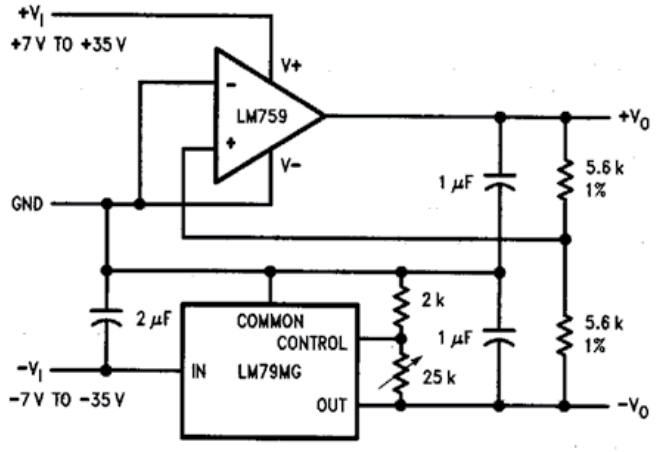
**Features:**

Circuit Simplicity
One Chip Means Excellent Reliability
Design Considerations
$I_O \leq 325$ mA

**Note 1:** All resistor values in ohms.

## Regulator Applications

**Adjustable Dual Tracking Regulator**

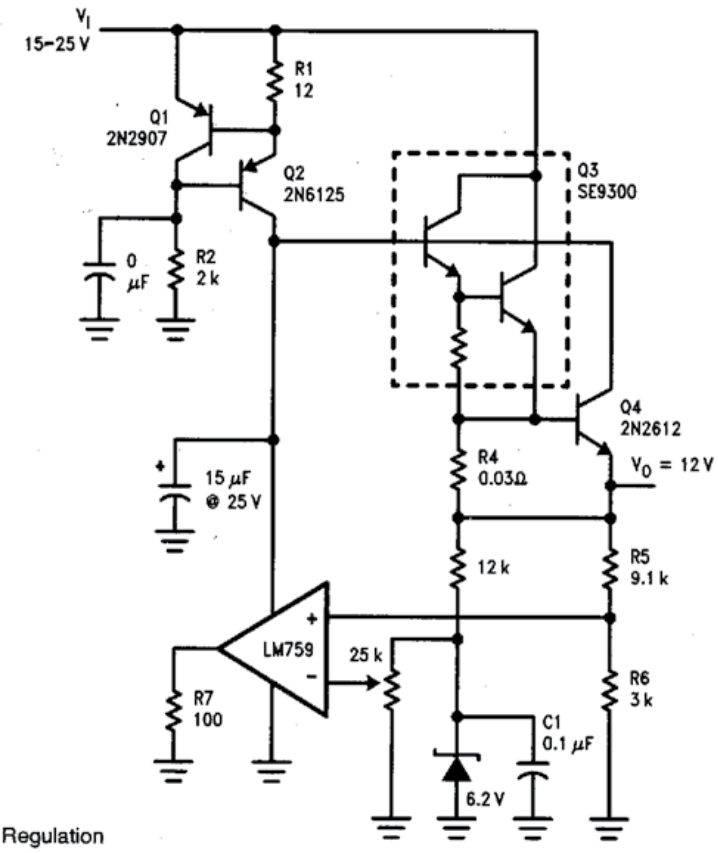



TL/H/10075–13

**Features:**
Wide Output Voltage Range (±2.2V to ±30V)
Excellent Load Regulation $\Delta V_O < \pm 5$ mV for $\Delta I_O = \pm 0.2$ A
Excellent Line Regulation $\Delta V_O < \pm 2$ mV for $\Delta V_I = 10$V

**Note 1:** All resistor values in ohms.

**10 Amp — 12 Volt Regulator**

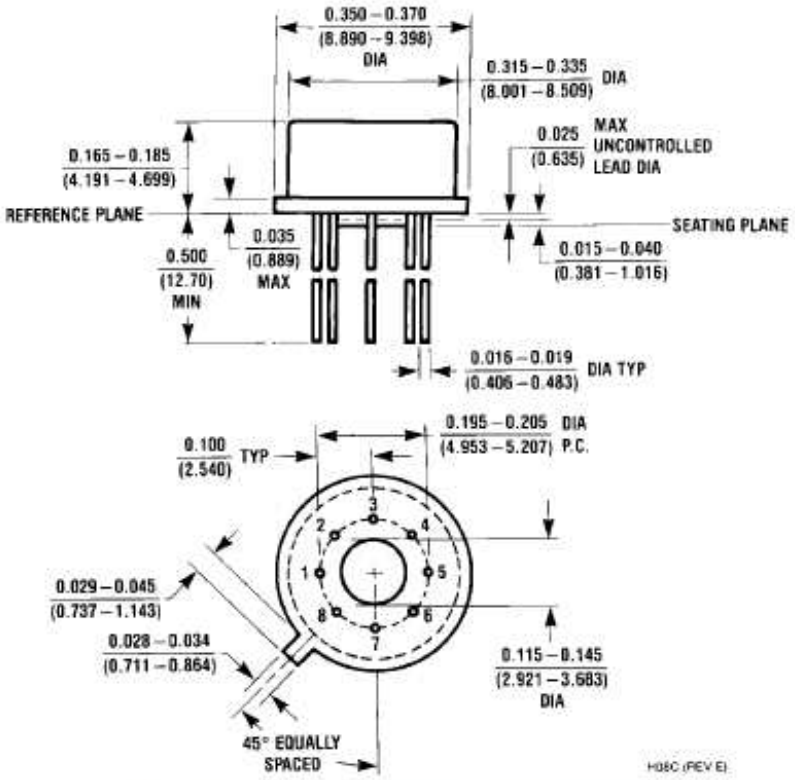



TL/H/10075–14

**Features:**
Excellent Load and Line Regulation
Excellent Temperature Coefficient-Depends Largely on Tempco of the Reference Zener

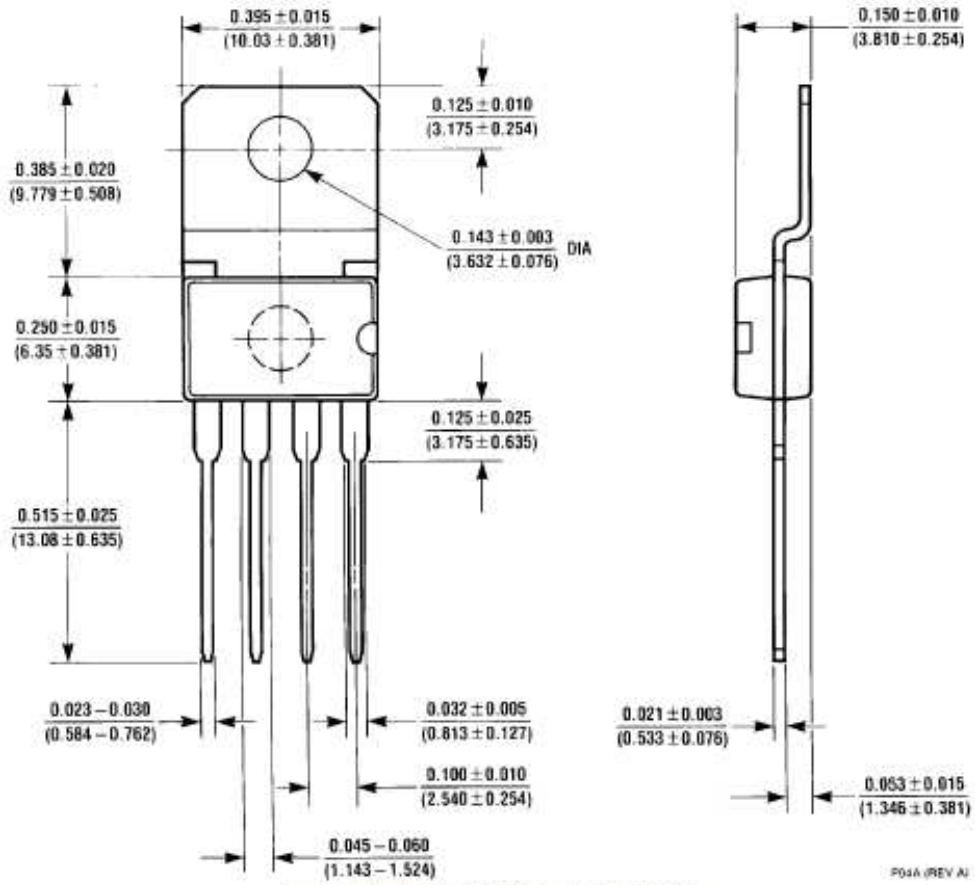
**Note 1:** All resistor values in ohms.

## Physical Dimensions inches (millimeters)




**8-Lead Metal Package**
**Order Number LM759MH, LM759CH or LM759H/883**
**NS Package Number H08C**

## Physical Dimensions inches (millimeters) (Continued)




**Order Number LM759CP or LM77000CP**
**NS Package Number P04A**

### LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform, when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.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