National Semiconductor

November 1994

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.

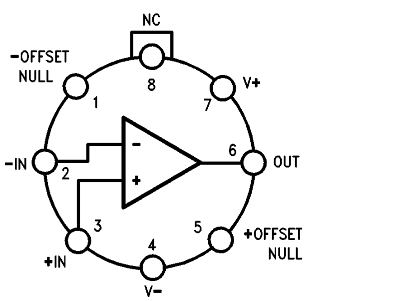
Features

- 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

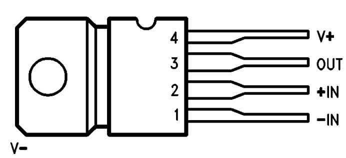


TL/H/10075–1

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

LM759/LM77000 Power Operational Amplifiers

 RRD-B30M115/Printed in U. S. A.

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		$\|V_{CC}-V_O\| = 30V$		±200		mA
$I_{O\ PEAK}$	Peak Output Current		$3.0V \leq \|V_{CC}-V_O\| \leq 10V$	±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		$\|V_{CC}-V_O\| = 30V$		± 200		mA
$I_{O\ PEAK}$	Peak Output Current		$3.0V \leq \|V_{CC}-V_O\| \leq 10V$	± 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 $0° \leq T_J \leq +125°C$

Symbol	Parameter	Conditions	Min	Typ	Max	Units
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 $T_J = 25°C$, $V_{CC} = \pm15V$, 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		$\|V_{CC}-V_O\| = 30V$		±200		mA
$I_{O\ PEAK}$	Peak Output Current		$3.0V \leq \|V_{CC}-V_O\| \leq 10V$	±250	±400		mA
A_{VS}	Large Signal Voltage Gain		$R_L \geq 50\Omega$, $V_O = \pm10V$	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 $0° \leq T_J \leq +125°C$

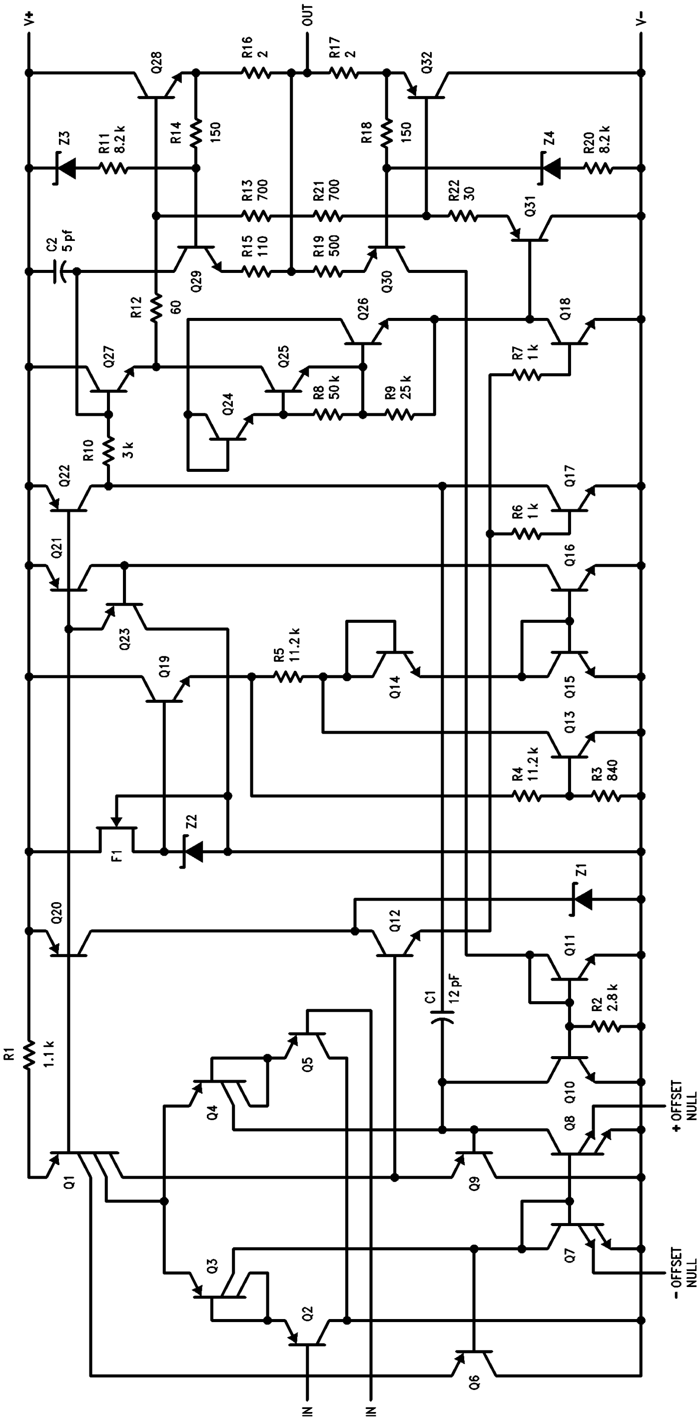
Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{IO}	Input Offset Voltage	$R_S \leq 10\ k\Omega$			10	mV
I_{IO}	Input Offset Current				100	nA
I_{IB}	Input Bias Current				400	nA
CMR	Common Mode Rejection	$R_S \leq 10\ k\Omega$	70	100		dB
PSRR	Power Supply Rejection Ratio	$R_S \leq 10\ k\Omega$	80	100		dB
A_{VS}	Large Signal Voltage Gain	$R_L \geq 50\Omega$, $V_O = \pm10V$	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 θ_{JC} °C/W	Max θ_{JC} °C/W	Typ θ_{JA} °C/W	Max θ_{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
θ_{JA} = Junction to ambient thermal resistance
θ_{JC} = Junction to case thermal resistance
θ_{CA} = Case to ambient thermal resistance
θ_{CS} = Case to heat sink thermal resistance
θ_{SA} = Heat sink to ambient thermal resistance

Mounting Hints

Metal Can Package (LM759CH/LM759MH)

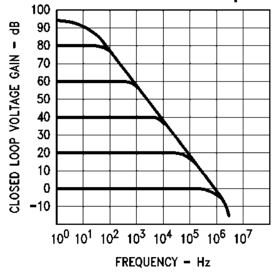
The LM759 in the 8-Lead TO-99 metal can package must be used with a heat sink. With ±15V power supplies, the LM759 can dissipate up to 540 mW in its quiescent (no load) state. This would result in a 100°C rise in chip temperature to 125°C (assuming a 25°C ambient temperature). In order to avoid this 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)

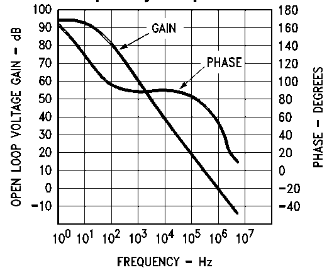
The LM759CP and LM77000CP are designed to be attached by the tab to a heat sink. This heat sink can be either one of the many heat sinks which are commercially available, a piece of metal such as the equipment chassis, or a suitable amount of copper foil as on a double sided PC board. The important thing 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

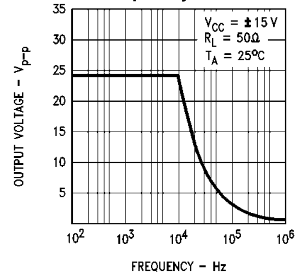
Frequency Response for Various Closed Loop Gains



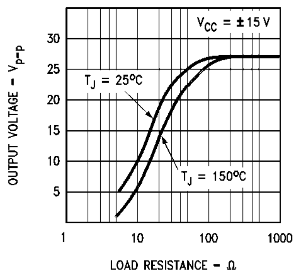
Open Loop vs Frequency Response



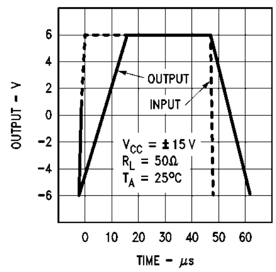
Output Voltage vs Frequency



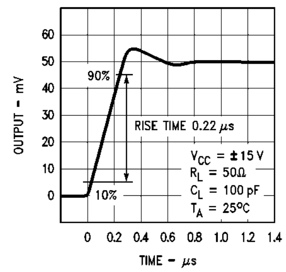
Output Voltage vs Load Resistance



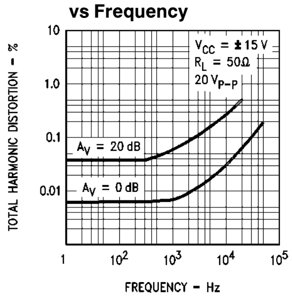
Voltage Follower Large Signal Pulse Response



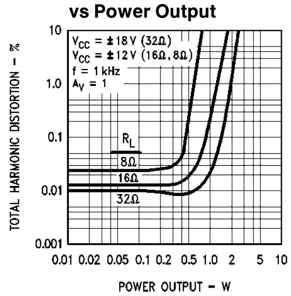
Voltage Follower Transient Response



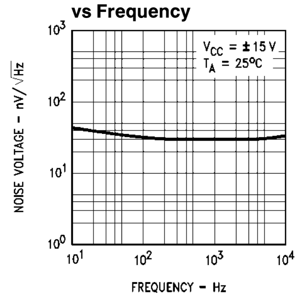
Total Harmonic Distortion vs Frequency



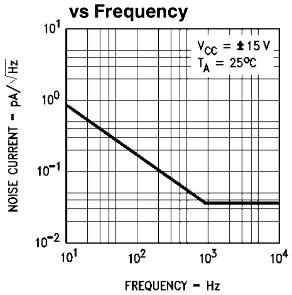
Total Harmonic Distortion vs Power Output



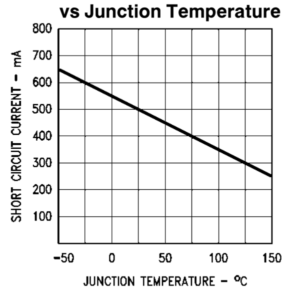
Input Noise Voltage vs Frequency



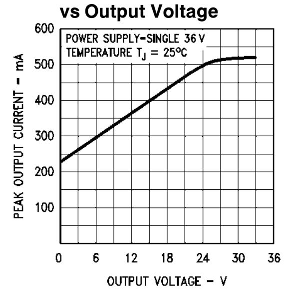
Noise Current vs Frequency



Short Circuit Current vs Junction Temperature



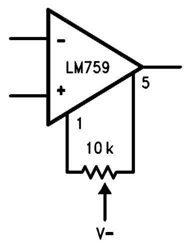
Peak Output Current vs Output Voltage



TL/H/10075–4

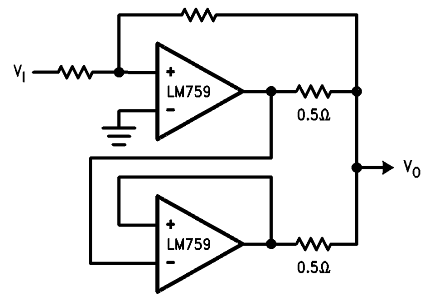
Applications

Offset Null Circuit



TL/H/10075–5

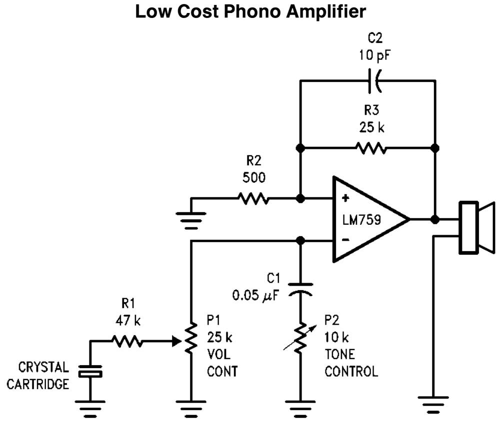
Paralleling LM759 Power Op Amps



TL/H/10075–6

Audio Applications

Low Cost Phono Amplifier

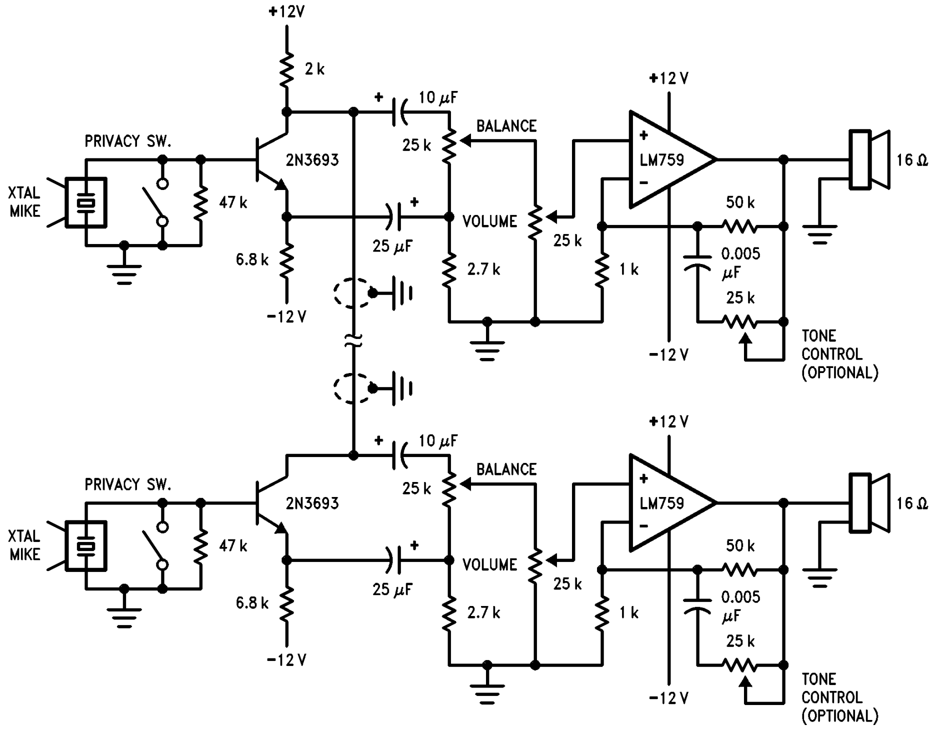


TL/H/10075–7

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

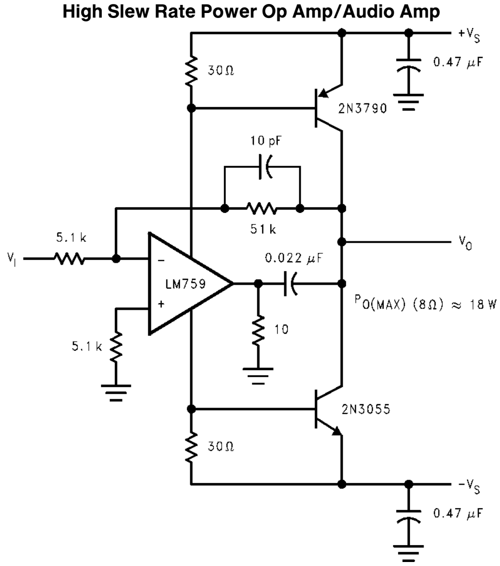
1 Watt of Audio Output

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

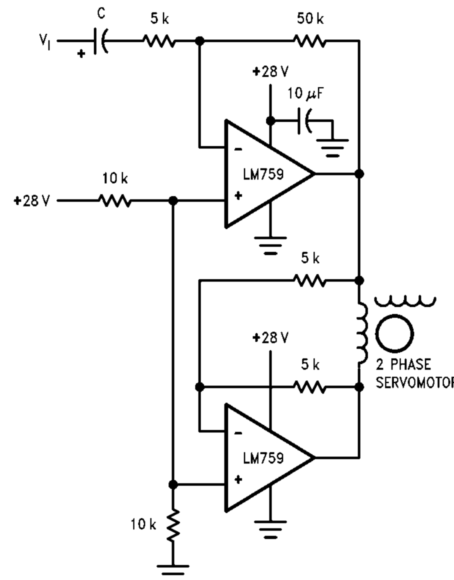
Features:

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

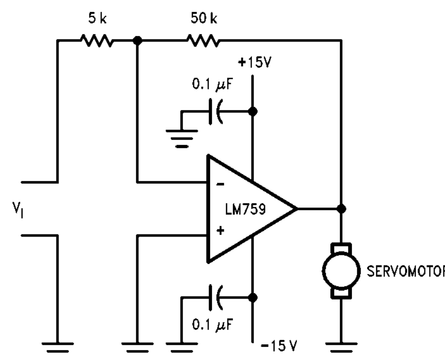


TL/H/10075–11

Features:
Gain of 10
Use of LM759 Means Simple Inexpensive Circuit

Design Considerations:
325 mA Max Output Current

DC Servo Amplifier



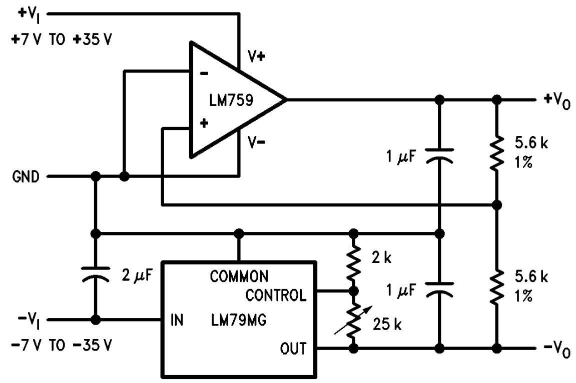
TL/H/10075–12

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:

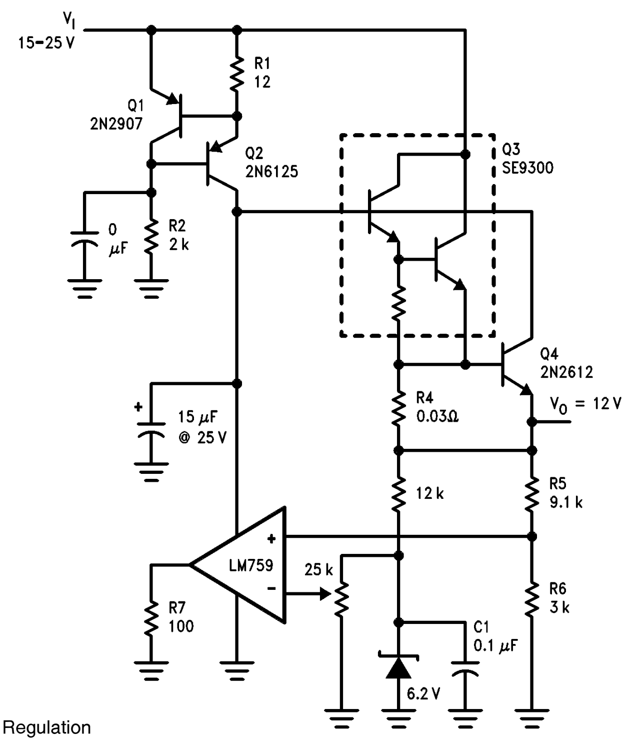
Wide Output Voltage Range (±2.2V to ±30V)

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 $\Delta V_I = 10V$

Note 1: All resistor values in ohms.

10 Amp — 12 Volt Regulator



TL/H/10075–14

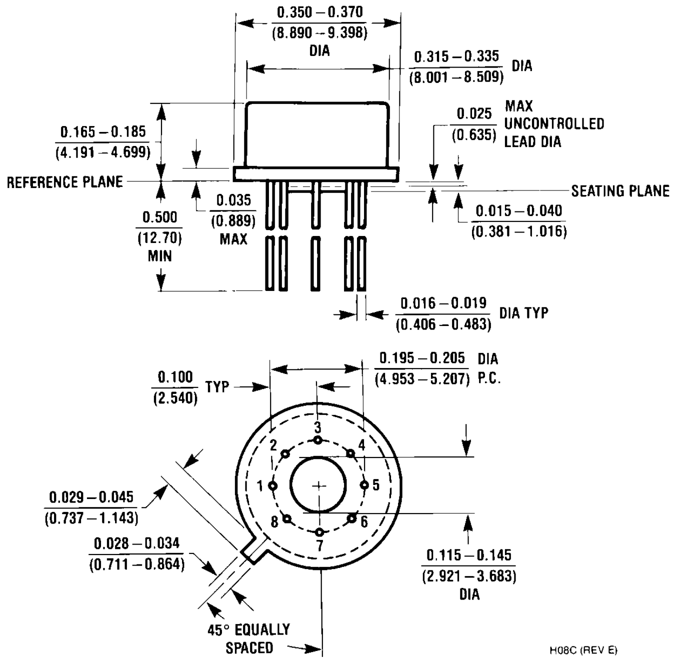
Features:

Excellent Load and Line Regulation

Excellent Temperature Coefficient-Depends Largely on Tempco of the Reference Zener

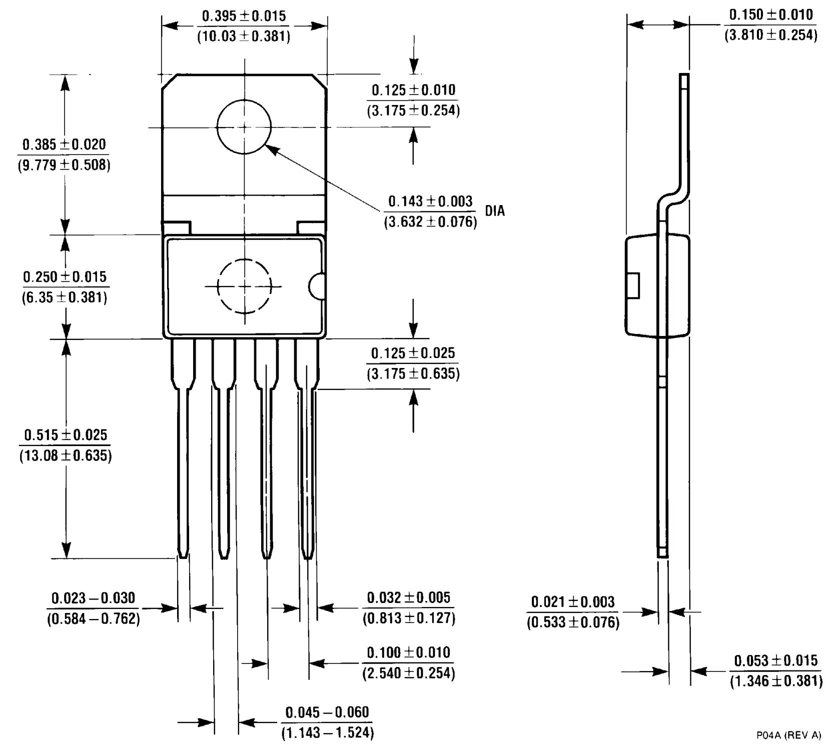
Note 1: All resistor values in ohms.

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.

National Semiconductor Corporation
1111 West Bardin Road
Arlington, TX 76017
Tel: 1(800) 272-9959
Fax: 1(800) 737-7018

National Semiconductor Europe
Fax: (+49) 0-180-530 85 86
Email: cnjwge@tevm2.nsc.com
Deutsch Tel: (+49) 0-180-530 85 85
English Tel: (+49) 0-180-532 78 32
Français Tel: (+49) 0-180-532 93 58
Italiano Tel: (+49) 0-180-534 16 80

National Semiconductor Hong Kong Ltd.
13th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
Fax: (852) 2736-9960

National Semiconductor Japan Ltd.
Tel: 81-043-299-2309
Fax: 81-043-299-2408