

# LM143,LM343

*LM143/LM343 High Voltage Operational Amplifier*



Literature Number: SNVS759

## LM143/LM343 High Voltage Operational Amplifier

### General Description

The LM143 is a general purpose high voltage operational amplifier featuring operation to  $\pm 40V$ , complete input over-voltage protection up to  $\pm 40V$  and input currents comparable to those of other super- $\beta$  op amps. Increased slew rate, together with higher common-mode and supply rejection, insure improved performance at high supply voltages. Operating characteristics, in particular supply current, slew rate and gain, are virtually independent of supply voltage and temperature. Furthermore, gain is unaffected by output loading at high supply voltages due to thermal symmetry on the die. The LM143 is pin compatible with general purpose op amps and has offset null capability.

Application areas include those of general purpose op amps, but can be extended to higher voltages and higher output power when externally boosted. For example, when used in audio power applications, the LM143 provides a power bandwidth that covers the entire audio spectrum. In addition, the LM143 can be reliably operated in environments with large overvoltage spikes on the power supplies, where other internally-compensated op amps would suffer catastrophic failure.

The LM343 is similar to the LM143 for applications in less severe supply voltage and temperature environments.

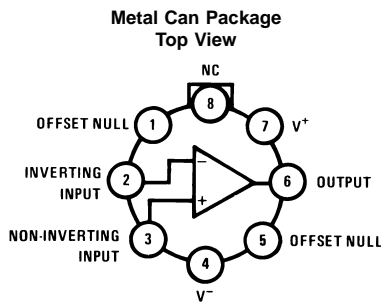
### Features

- Wide supply voltage range:  $\pm 4.0V$  to  $\pm 40V$
- Large output voltage swing:  $\pm 37V$
- Wide input common-mode range:  $\pm 38V$
- Input overvoltage protection: Full  $\pm 40V$
- Supply current is virtually independent of supply voltage and temperature

### Unique Characteristics

- Low input bias current: 8.0 nA
- Low input offset current: 1.0 nA
- High slew rate—essentially independent of temperature and supply voltage:  $2.5V/\mu s$
- High voltage gain—virtually independent of resistive loading, temperature, and supply voltage: 100k min
- Internally compensated for unity gain
- Output short circuit protection
- Pin compatible with general purpose op amps

### Connection Diagram



DS007783-1

\* Available per SMD# 7800303

**Order Number LM143H, LM143H/883\* or LM343H  
See NS Package Number H08C**

## Absolute Maximum Ratings (Notes 1, 4)

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

	LM143	LM343
Supply Voltage	±40V	±34V
Power Dissipation (Note 1)	680 mW	680 mW
Differential Input Voltage (Note 2)	80V	68V
Input Voltage (Note 2)	±40V	±34V
Operating Temperature Range	-55°C to +125°C	0°C to +70°C
Storage Temperature Range	-65°C to +150°C	-65°C to +150°C
Output Short Circuit Duration	5 seconds	5 seconds
Lead Temperature (Soldering, 10 sec.)	300°C	300°C
ESD rating to be determined.		

## Electrical Characteristics (Note 3)

Parameter	Conditions	LM143			LM343			Units
		Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$T_A = 25^\circ\text{C}$		2.0	5.0		2.0	8.0	mV
Input Offset Current	$T_A = 25^\circ\text{C}$		1.0	3.0		1.0	10	nA
Input Bias Current	$T_A = 25^\circ\text{C}$		8.0	20		8.0	40	nA
Supply Voltage Rejection Ratio	$T_A = 25^\circ\text{C}$		10	100		10	200	$\mu\text{V/V}$
Output Voltage Swing	$T_A = 25^\circ\text{C}$ , $R_L \geq 5\text{ k}\Omega$	22	25		20	25		V
Large Signal Voltage Gain	$T_A = 25^\circ\text{C}$ , $V_{\text{OUT}} = \pm 10\text{V}$ , $R_L \geq 100\text{ k}\Omega$	100k	180k		70k	180k		V/V
Common-Mode Rejection Ratio	$T_A = 25^\circ\text{C}$	80	90		70	90		dB
Input Voltage Range	$T_A = 25^\circ\text{C}$	±24	±26		±22	±26		V
Supply Current (Note 5)	$T_A = 25^\circ\text{C}$		2.0	4.0		2.0	5.0	mA
Short Circuit Current	$T_A = 25^\circ\text{C}$		20			20		mA
Slew Rate	$T_A = 25^\circ\text{C}$ , $A_V = 1$		2.5			2.5		V/ $\mu\text{s}$
Power Bandwidth	$T_A = 25^\circ\text{C}$ , $V_{\text{OUT}} = 40\text{ V}_{\text{p-p}}$ , $R_L \geq 5\text{ k}\Omega$ , $\text{THD} \leq 1\%$		20k			20k		Hz
Unity Gain Frequency	$T_A = 25^\circ\text{C}$		1.0M			1.0M		Hz
Input Offset Voltage	$T_A = \text{Max}$ $T_A = \text{Min}$			6.0 6.0			10 10	mV
Input Offset Current	$T_A = \text{Max}$ $T_A = \text{Min}$		0.8 1.8	4.5 7.0		0.8 1.8	14 14	nA
Input Bias Current	$T_A = \text{Max}$ $T_A = \text{Min}$		5.0 16	35 35		5.0 16	55 55	nA
Large Signal Voltage Gain	$R_L \geq 100\text{ k}\Omega$ , $T_A = \text{Max}$ $R_L \geq 100\text{ k}\Omega$ , $T_A = \text{Min}$	50k 50k	150k 220k		50k 50k	150k 220k		V/V
Output Voltage Swing	$R_L \geq 5.0\text{ k}\Omega$ , $T_A = \text{Max}$ $R_L \geq 5.0\text{ k}\Omega$ , $T_A = \text{Min}$	22 22	26 25		20 20	26 25		V

**Note 1:** Absolute maximum ratings are not necessarily concurrent, and care must be taken not to exceed the maximum junction temperature of the LM143 (150°C) or the LM343 (100°C). For operating at elevated temperatures, devices in the H08 package must be derated based on a thermal resistance of 155°C/W, junction to ambient, or 20°C/W, junction to case.

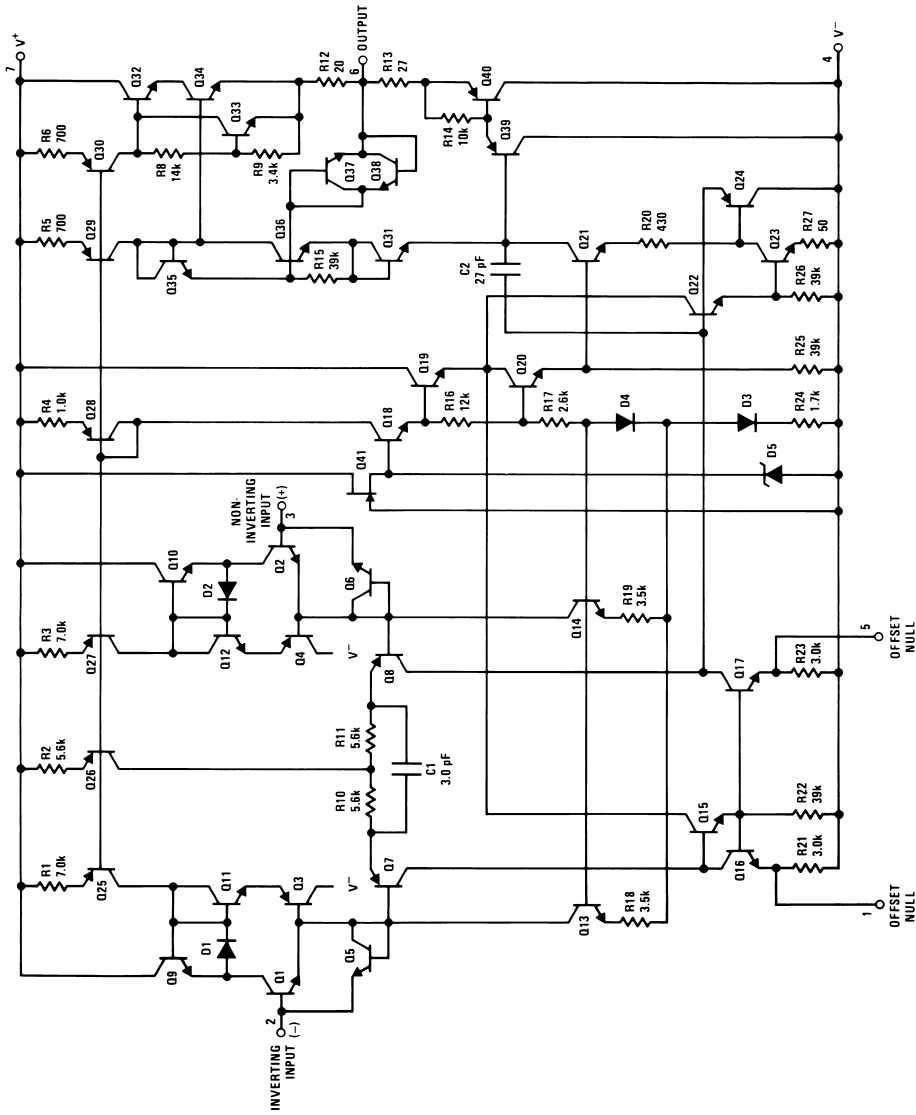
**Note 2:** For supply voltage less than ±40V for the LM143 and less than ±34V for the LM343, the absolute maximum input voltage is equal to the supply voltage.

**Note 3:** These specifications apply for  $V_S = \pm 28\text{V}$ . For LM143,  $T_A = \text{max} = 125^\circ\text{C}$  and  $T_A = \text{min} = -55^\circ\text{C}$ . For LM343,  $T_A = \text{max} = 70^\circ\text{C}$  and  $T_A = \text{min} = 0^\circ\text{C}$ .

**Note 4:** Refer to RETS143X for LM143H and LM1536H military specifications.

**Note 5:** The maximum supply currents are guaranteed at  $V_S = \pm 40\text{V}$  for the LM143 and  $V_S = \pm 34\text{V}$  for the LM343.

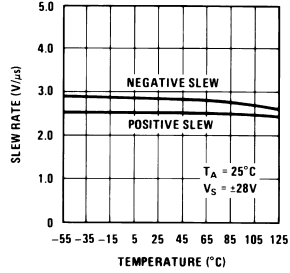
# Schematic Diagram



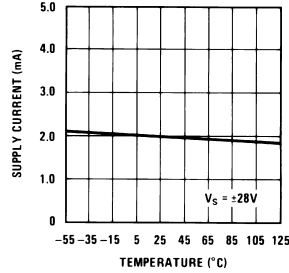
DS007783-2

## Typical Performance Characteristics

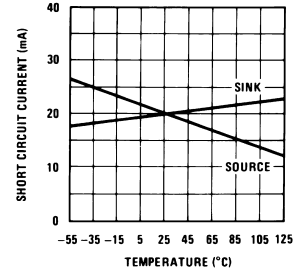
Voltage Follower Slew Rate



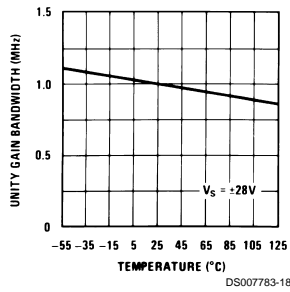
Supply Current



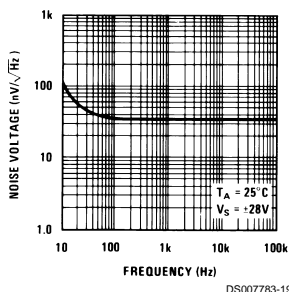
Short Circuit Current



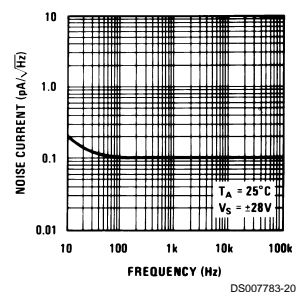
Unity Gain Bandwidth



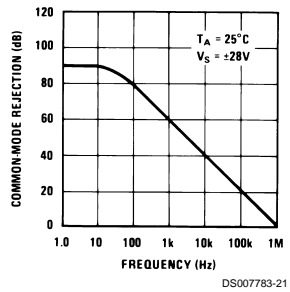
Input Noise Voltage



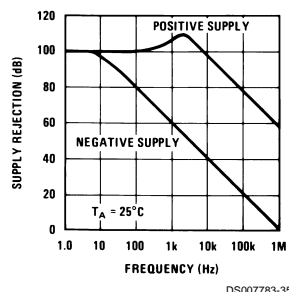
Input Noise Current



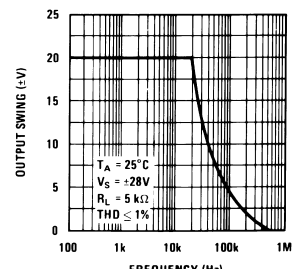
Common-Mode Rejection



Power Supply Rejection

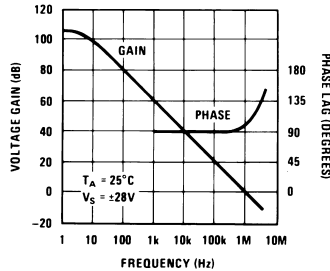


Large Signal Frequency Response



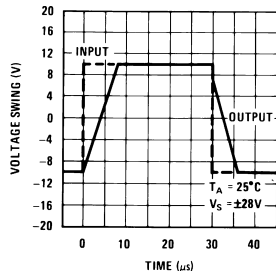
## Typical Performance Characteristics (Continued)

**Open Loop Frequency Response**



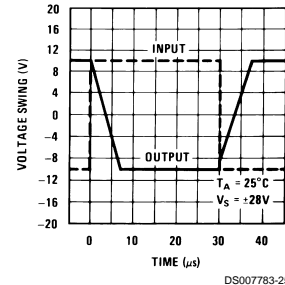
DS007783-23

**Voltage Follower Pulse Response**



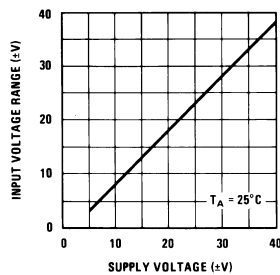
DS007783-24

**Inverter Pulse Response**



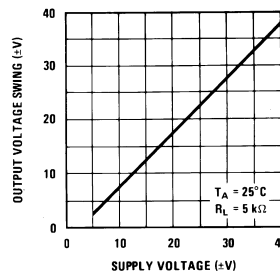
DS007783-25

**Input Voltage Range**



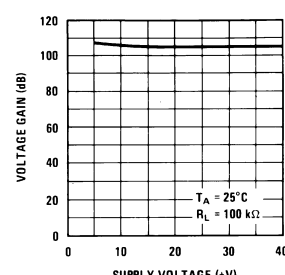
DS007783-26

**Output Voltage Swing**



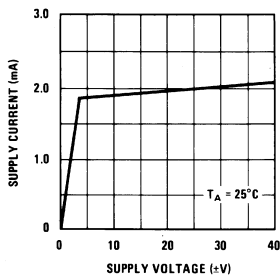
DS007783-27

**Voltage Gain**



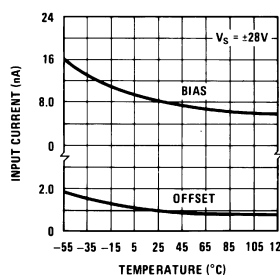
DS007783-28

**Supply Current**



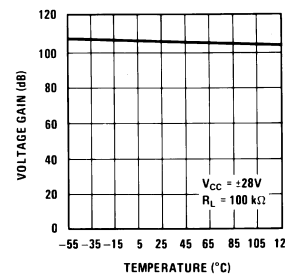
DS007783-29

**Input Current**



DS007783-30

**Voltage Gain**



DS007783-31

## Application Hints (See AN-127)

The LM143 is designed for trouble free operation at any supply voltage up to and including the guaranteed maximum of  $\pm 40\text{V}$ . Input overvoltage protection, both common-mode and differential, is 100% tested and guaranteed at the maximum supply voltage. Furthermore, all possible high voltage destructive modes during supply voltage turn-on have been eliminated by design. As with most IC op amps, however, certain precautions should be observed to insure that the LM143 remains virtually blow-out proof.

Although output short circuits to ground or either supply can be sustained indefinitely at lower supply voltages, these short circuits should be of limited duration when operating at higher supply voltages. Units can be destroyed by any com-

bination of high ambient temperature, high supply voltages, and high power dissipation which results in excessive die temperature. This is also true when driving low impedance or reactive loads or loads that can revert to low impedance; for example, the LM143 can drive most general purpose op amps outside of the maximum input voltage range, causing heavy current to flow and possibly destroying both devices.

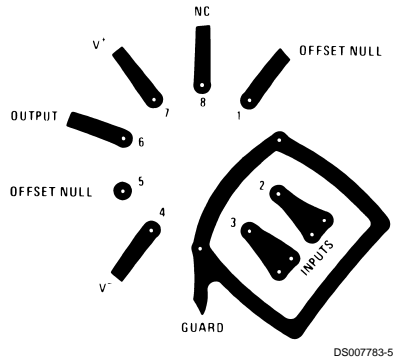
Precautions should be taken to insure that the power supplies never become reversed in polarity — even under transient conditions. With reverse voltage, the IC will conduct excessive current, fusing the internal aluminum interconnects. Voltage reversal between the power supplies will almost always result in a destroyed unit.

## Application Hints (See AN-127) (Continued)

In high voltage applications which are sensitive to very low input currents, special precautions should be exercised. For example, with high source resistances, care should be taken to prevent the magnitude of the PC board leakage currents, although quite small, from approaching those of the op amp input currents. These leakage currents become larger at 125°C and are made worse by high supply voltages. To prevent this, PC boards should be properly cleaned and coated to prevent contamination and to provide protection from condensed water vapor when operating below 0°C. A guard ring is also recommended to significantly reduce leakage currents from the op amp input pins to the adjacent high voltage pins in the standard op amp pin connection as shown in Figure 1. Figures 2, 3, 4 show how the guard ring is connected for the three most common op amp configurations.

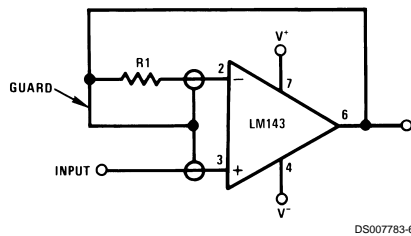
Finally, caution should be exercised in high voltage applications as electrical shock hazards are present. Since the negative supply is connected to the case, users may inadvertently contact voltages equal to those across the power supplies.

The LM143 can be used as a plug-in replacement in most general purpose op amp applications. The circuits presented in the following section emphasize those applications which take advantage of the unique high voltage abilities of the LM143.



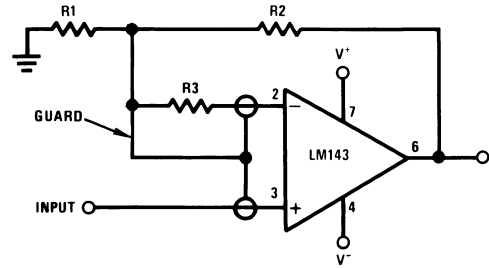
Bottom View

FIGURE 1. Printed Circuit Layout for Input Guarding with TO-5 Package



$$R1 = R_{SOURCE}$$

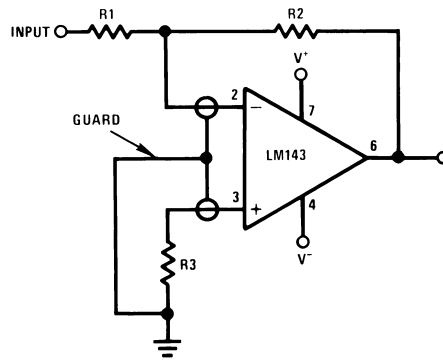
FIGURE 2. Guarded Voltage Follower



DS007783-7

$$R3 + \frac{R1 \times R2}{R1 + R2} = R_{SOURCE}$$

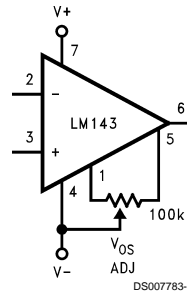
FIGURE 3. Guarded Non-Inverting Amplifier



DS007783-8

$$R3 = \frac{R1 \times R2}{R1 + R2}$$

FIGURE 4. Guarded Inverting Amplifier

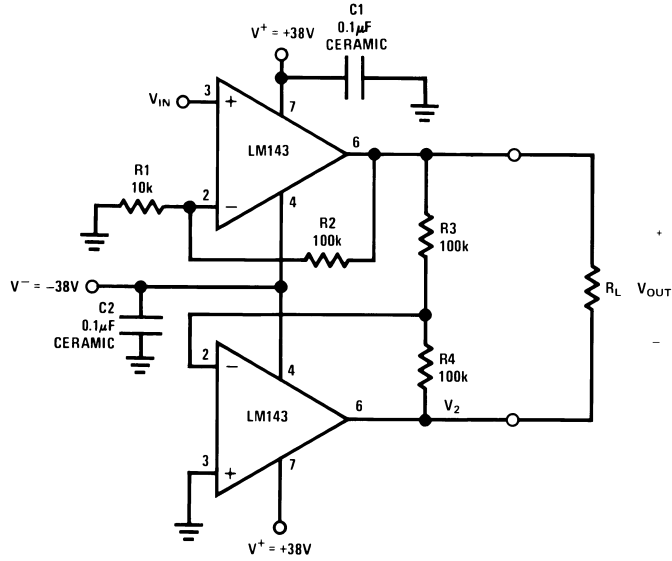


DS007783-14

FIGURE 5. Offset Voltage Adjustment

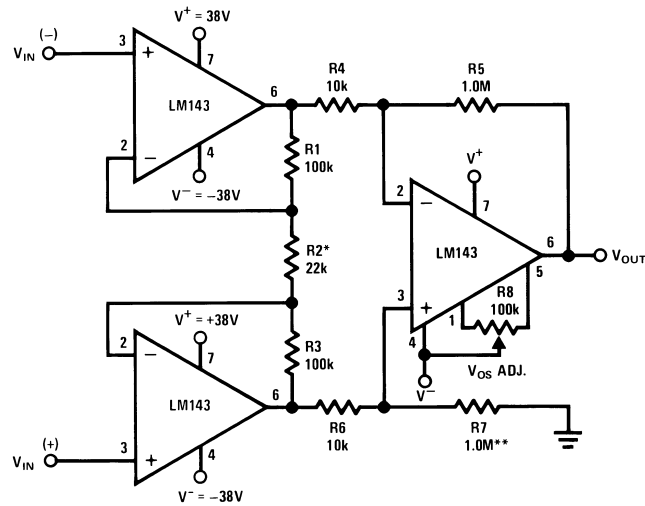
## Typical Applications (Note 6) (For more detail see AN-127)

### 130 V<sub>p-p</sub> Drive Across a Floating Load



DS007783-9

### ±34V Common-Mode Instrumentation Amplifier



DS007783-10

$$A_V = \left( 1 + \frac{2R_1}{R_2} \right) \frac{R_5}{R_4} \quad \text{WHERE: } R_4 = R_6 \\ R_5 = R_7$$

\* R2 may be adjustable to trim the gain.

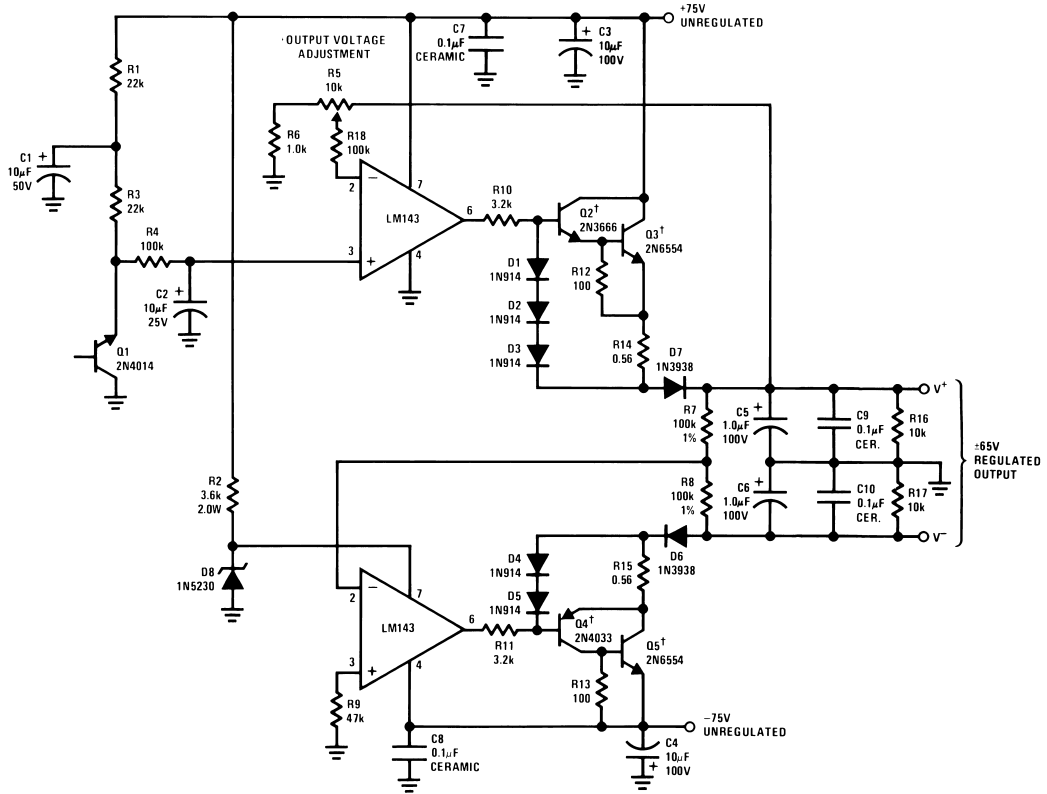
\*\* R7 may be adjusted to compensate for the resistance tolerance of R4–R7 for best CMR.

**Note 6:** The 38V supplies allow for a 5% voltage tolerance. All resistors are ½ watt, except as noted.



**Typical Applications** (Note 6) (For more detail see AN-127) (Continued)

**Tracking  $\pm 65V$ , 1 Amp Power Supply with Short Circuit Protection**

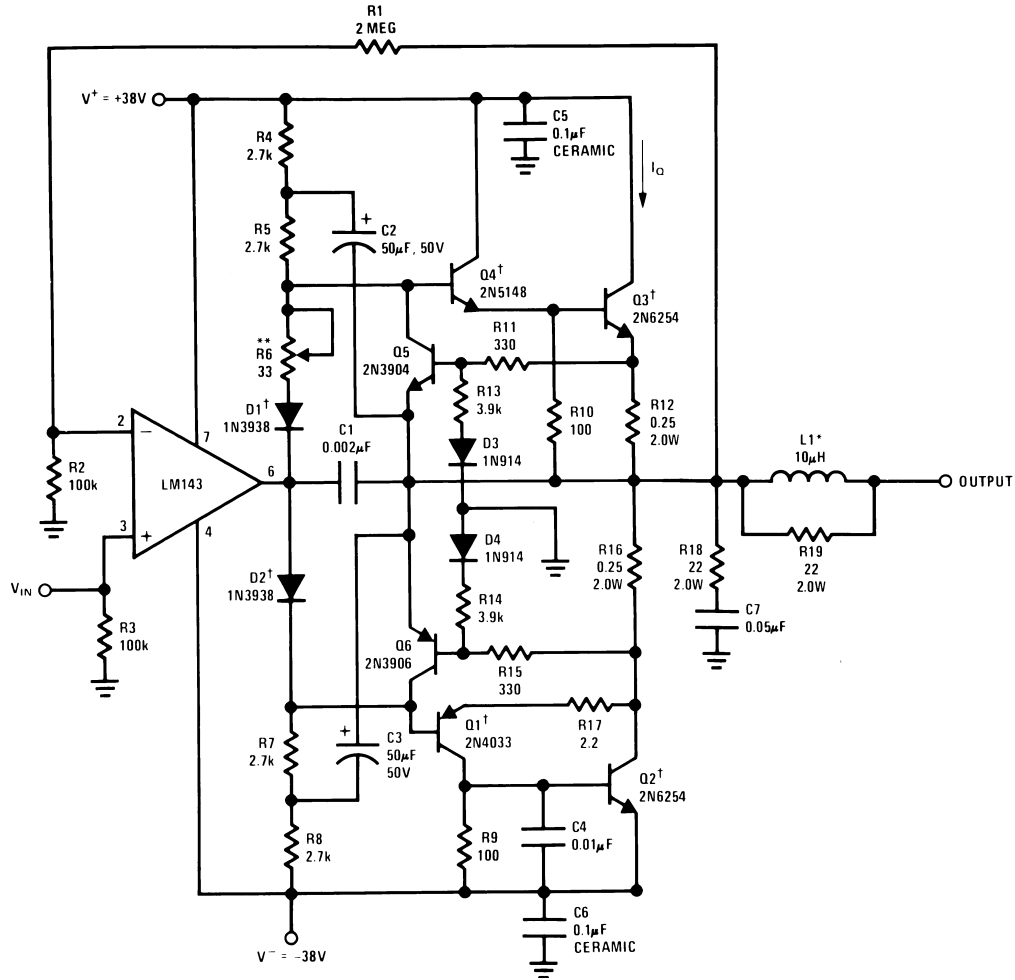


† Put on common heat sink.  
All resistors are 1/2 watt, 5%, except as noted.

DS007783-11

**Typical Applications** (Note 6) (For more detail see AN-127) (Continued)

**90W Audio Power Amplifier with Safe Area Protection**



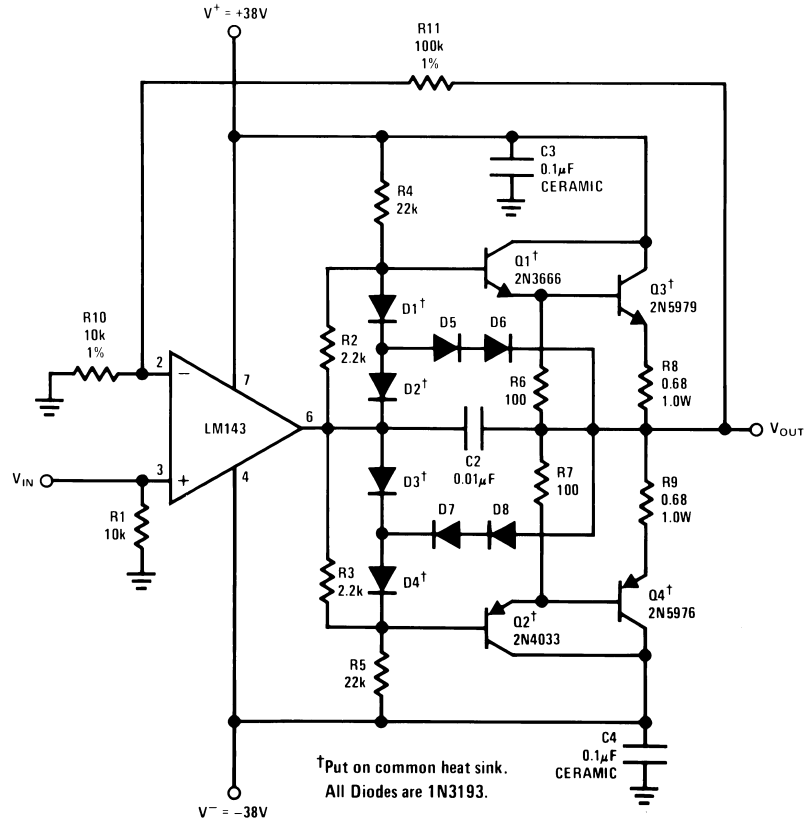
DS007783-12

† Put on common heat sink  
 \* 34 turns of no. 20 wire on a 3/8" form  
 \*\* Adjust R6 to set  $I_O = 100$  mA

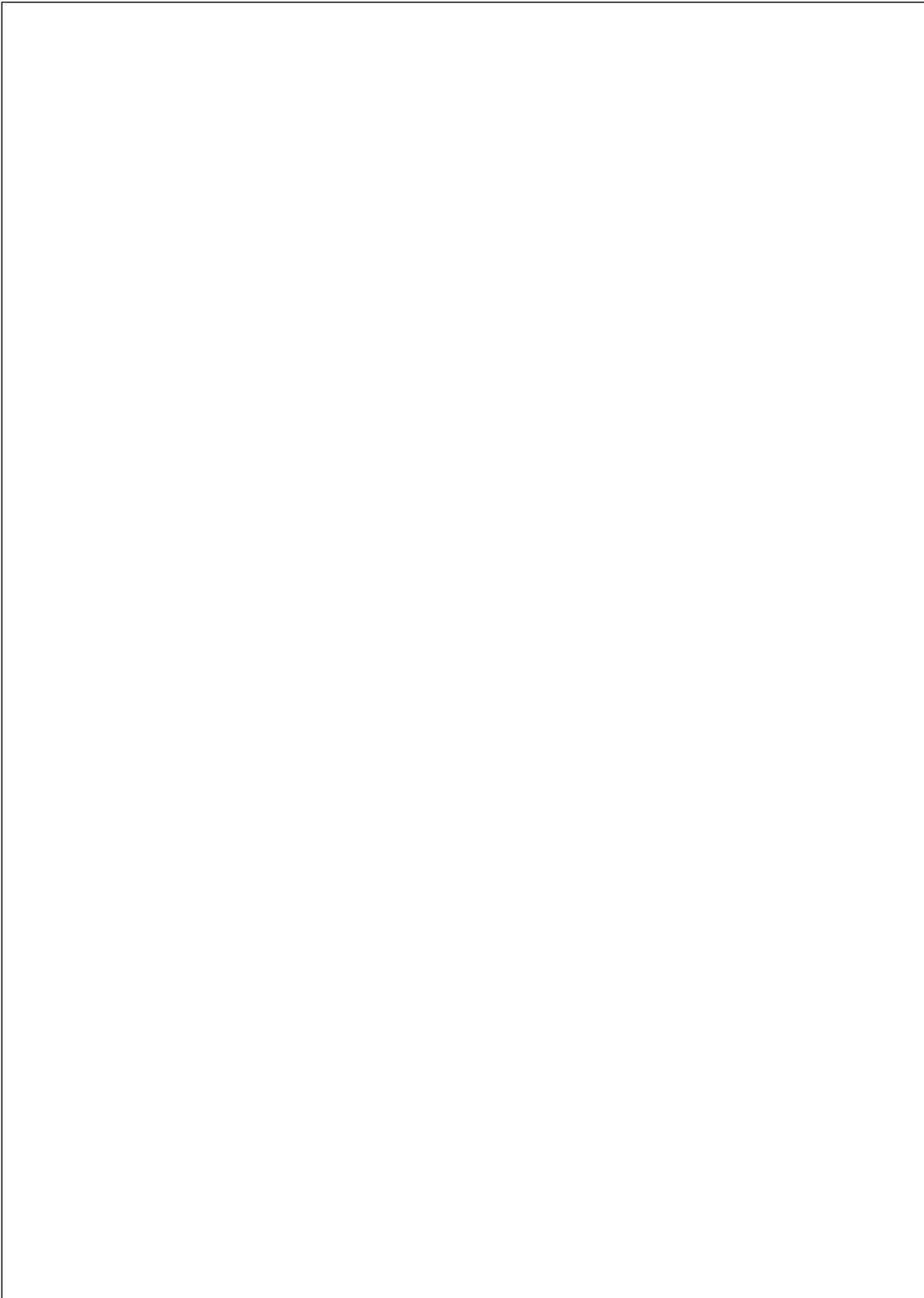
Book  
 Extract  
 End

**Typical Applications** (Note 6) (For more detail see AN-127) (Continued)

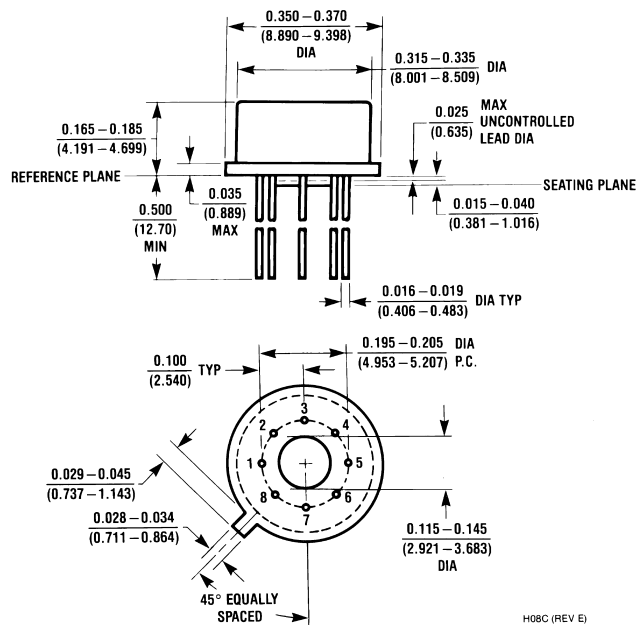
**1 Amp Power Amplifier with Short Circuit Protection**



DS007783-13



**Physical Dimensions** inches (millimeters) unless otherwise noted



**Metal Can Package (H)**  
**Order Number LM143H, LM143H/883 or LM343H**  
**NS Package Number H08C**

H08C (REV E)

**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 in 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**  
 Americas  
 Tel: 1-800-272-9959  
 Fax: 1-800-737-7018  
 Email: support@nsc.com

**National Semiconductor Europe**  
 Fax: +49 (0) 1 80-530 85 86  
 Email: europe.support@nsc.com  
 Deutsch Tel: +49 (0) 1 80-530 85 85  
 English Tel: +49 (0) 1 80-532 78 32  
 Français Tel: +49 (0) 1 80-532 93 58  
 Italiano Tel: +49 (0) 1 80-534 16 80

**National Semiconductor Asia Pacific Customer Response Group**  
 Tel: 65-2544466  
 Fax: 65-2504466  
 Email: sea.support@nsc.com

**National Semiconductor Japan Ltd.**  
 Tel: 81-3-5620-6175  
 Fax: 81-3-5620-6179

www.national.com

National does not assume any responsibility for use of any circuitry described, no circuit patent licenses are implied and National reserves the right at any time without notice to change said circuitry and specifications.

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Mobile Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Transportation and Automotive	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

TI E2E Community Home Page

[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2011, Texas Instruments Incorporated