

LF353

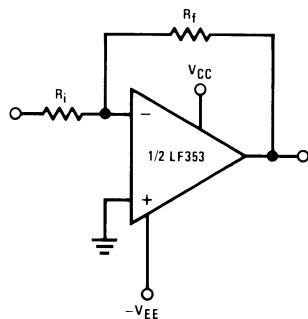
Wide Bandwidth Dual JFET Input Operational Amplifier

General Description

These devices are low cost, high speed, dual JFET input operational amplifiers with an internally trimmed input offset voltage (BI-FET II™ technology). They require low supply current yet maintain a large gain bandwidth product and fast slew rate. In addition, well matched high voltage JFET input devices provide very low input bias and offset currents. The LF353 is pin compatible with the standard LM1558 allowing designers to immediately upgrade the overall performance of existing LM1558 and LM358 designs.

These amplifiers may be used in applications such as high speed integrators, fast D/A converters, sample and hold circuits and many other circuits requiring low input offset voltage, low input bias current, high input impedance, high slew rate and wide bandwidth. The devices also exhibit low noise and offset voltage drift.

Typical Connection

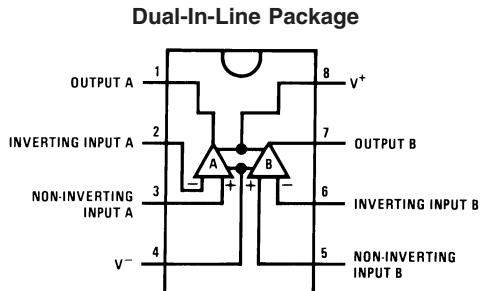


00564914

Features

- Internally trimmed offset voltage: 10 mV
- Low input bias current: 50 pA
- Low input noise voltage: 25 nV/√Hz
- Low input noise current: 0.01 pA/√Hz
- Wide gain bandwidth: 4 MHz
- High slew rate: 13 V/μs
- Low supply current: 3.6 mA
- High input impedance: $10^{12}\Omega$
- Low total harmonic distortion : $\leq 0.02\%$
- Low 1/f noise corner: 50 Hz
- Fast settling time to 0.01%: 2 μs

Connection Diagram

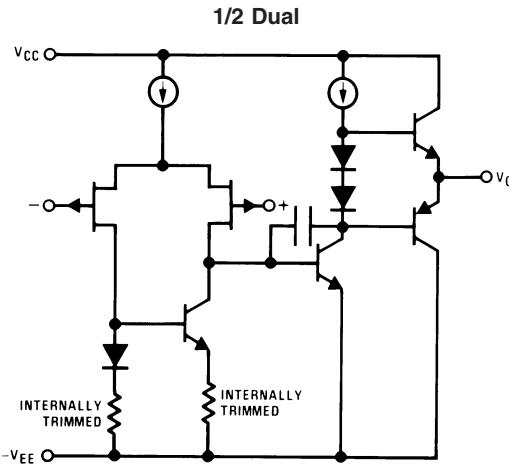


00564917

Top View

Order Number LF353M, LF353MX or LF353N
See NS Package Number M08A or N08E

Simplified Schematic



00564916

BI-FET II™ is a trademark of National Semiconductor Corporation.

Absolute Maximum Ratings (Note 1)

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

| | |
|---------------------------------|-----------------|
| Supply Voltage | $\pm 18V$ |
| Power Dissipation | (Note 2) |
| Operating Temperature Range | 0°C to +70°C |
| T _j (MAX) | 150°C |
| Differential Input Voltage | $\pm 30V$ |
| Input Voltage Range (Note 3) | $\pm 15V$ |
| Output Short Circuit Duration | Continuous |
| Storage Temperature Range | -65°C to +150°C |
| Lead Temp. (Soldering, 10 sec.) | 260°C |
| Soldering Information | |
| Dual-In-Line Package | |
| Soldering (10 sec.) | 260°C |

Small Outline Package

Vapor Phase (60 sec.)

215°C

Infrared (15 sec.)

220°C

See AN-450 "Surface Mounting Methods and Their Effect on Product Reliability" for other methods of soldering surface mount devices.

ESD Tolerance (Note 8)

1000V

θ_{JA} M Package

TBD

Note 1: Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within the Operating Ratings. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

DC Electrical Characteristics

(Note 5)

| Symbol | Parameter | Conditions | LF353 | | | Units | |
|----------------------|------------------------------------|--|-------|------------------|-----|-------|----|
| | | | Min | Typ | Max | | |
| V _{OS} | Input Offset Voltage | R _S =10kΩ, T _A =25°C Over Temperature | | 5 | 10 | mV | |
| | | | | | 13 | mV | |
| ΔV _{OS} /ΔT | Average TC of Input Offset Voltage | R _S =10 kΩ | | 10 | | µV/°C | |
| I _{OS} | Input Offset Current | T _j =25°C, (Notes 5, 6) T _j ≤70°C | | 25 | 100 | pA | |
| | | | | | 4 | nA | |
| I _B | Input Bias Current | T _j =25°C, (Notes 5, 6) T _j ≤70°C | | 50 | 200 | pA | |
| | | | | | 8 | nA | |
| R _{IN} | Input Resistance | T _j =25°C | | 10 ¹² | | Ω | |
| A _{VOL} | Large Signal Voltage Gain | V _S =±15V, T _A =25°C V _O =±10V, R _L =2 kΩ Over Temperature | 25 | 100 | | V/mV | |
| | | | 15 | | | V/mV | |
| V _O | Output Voltage Swing | V _S =±15V, R _L =10kΩ | ±12 | ±13.5 | | V | |
| V _{CM} | Input Common-Mode Voltage Range | V _S =±15V | ±11 | +15 -12 | | V | |
| CMRR | Common-Mode Rejection Ratio | R _S ≤ 10kΩ | 70 | 100 | | dB | |
| PSRR | Supply Voltage Rejection Ratio | (Note 7) | 70 | 100 | | dB | |
| I _S | Supply Current | | | | 3.6 | 6.5 | mA |

AC Electrical Characteristics

(Note 5)

| Symbol | Parameter | Conditions | LF353 | | | Units |
|----------------|---------------------------------|--|-------|------|-----|------------------------|
| | | | Min | Typ | Max | |
| | Amplifier to Amplifier Coupling | T _A =25°C, f=1 Hz–20 kHz (Input Referred) | | -120 | | dB |
| SR | Slew Rate | V _S =±15V, T _A =25°C | 8.0 | 13 | | V/µs |
| GBW | Gain Bandwidth Product | V _S =±15V, T _A =25°C | 2.7 | 4 | | MHz |
| e _n | Equivalent Input Noise Voltage | T _A =25°C, R _S =100Ω, f=1000 Hz | | 16 | | nV/ $\sqrt{\text{Hz}}$ |
| i _n | Equivalent Input Noise Current | T _j =25°C, f=1000 Hz | | 0.01 | | pA/ $\sqrt{\text{Hz}}$ |

AC Electrical Characteristics (Continued)

(Note 5)

| Symbol | Parameter | Conditions | LF353 | | | Units |
|--------|---------------------------|---|-------|-------|-----|-------|
| | | | Min | Typ | Max | |
| THD | Total Harmonic Distortion | $A_V=+10$, $R_L=10k$, $V_O=20V_{p-p}$, $BW=20$ Hz-20 kHz | | <0.02 | | % |

Note 2: For operating at elevated temperatures, the device must be derated based on a thermal resistance of $115^{\circ}\text{C}/\text{W}$ typ junction to ambient for the N package, and $158^{\circ}\text{C}/\text{W}$ typ junction to ambient for the H package.

Note 3: Unless otherwise specified the absolute maximum negative input voltage is equal to the negative power supply voltage.

Note 4: The power dissipation limit, however, cannot be exceeded.

Note 5: These specifications apply for $V_S=\pm 15\text{V}$ and $0^{\circ}\text{C} \leq T_A \leq +70^{\circ}\text{C}$. V_{OS} , I_B and I_{OS} are measured at $V_{CM}=0$.

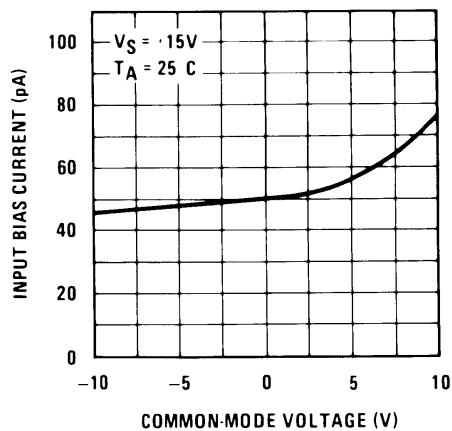
Note 6: The input bias currents are junction leakage currents which approximately double for every 10°C increase in the junction temperature, T_j . Due to the limited production test time, the input bias currents measured are correlated to junction temperature. In normal operation the junction temperature rises above the ambient temperature as a result of internal power dissipation, P_D . $T_j=T_A+\theta_{JA} P_D$ where θ_{JA} is the thermal resistance from junction to ambient. Use of a heat sink is recommended if input bias current is to be kept to a minimum.

Note 7: Supply voltage rejection ratio is measured for both supply magnitudes increasing or decreasing simultaneously in accordance with common practice. $V_S = \pm 6\text{V}$ to $\pm 15\text{V}$.

Note 8: Human body model, $1.5\text{k}\Omega$ in series with 100 pF .

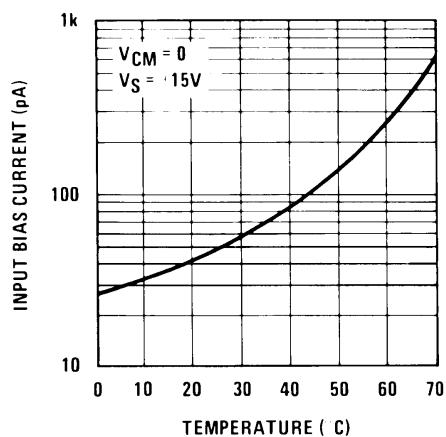
Typical Performance Characteristics

Input Bias Current



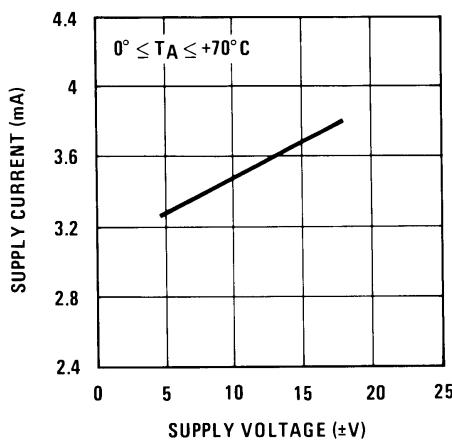
00564918

Input Bias Current



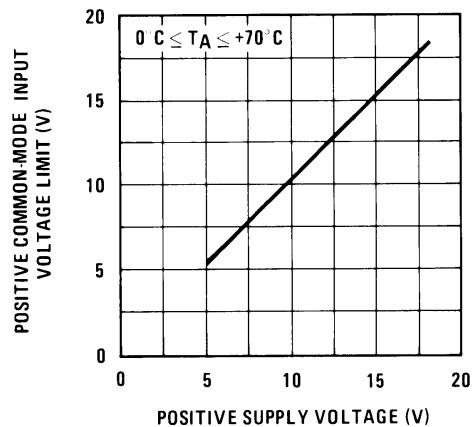
00564919

Supply Current



00564920

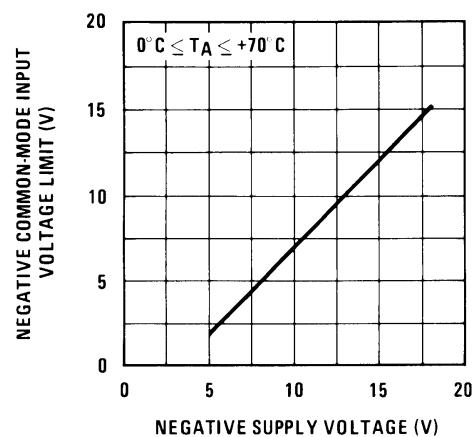
Positive Common-Mode Input Voltage Limit



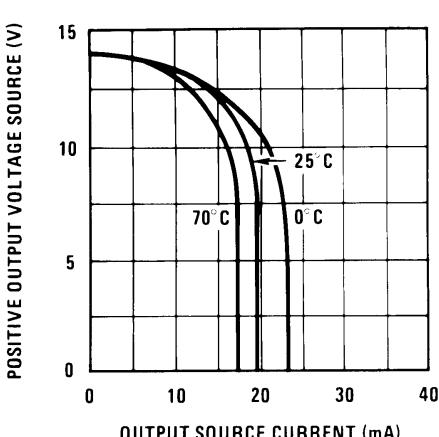
00564921

Typical Performance Characteristics (Continued)

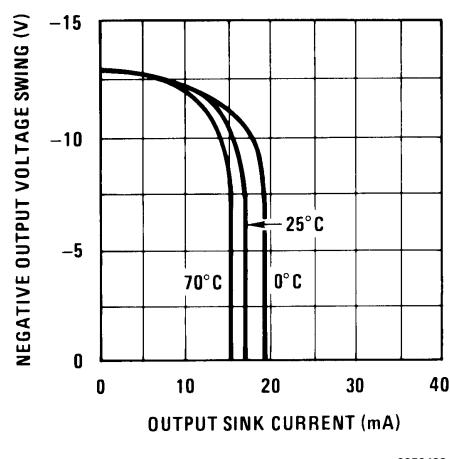
Negative Common-Mode Input Voltage Limit



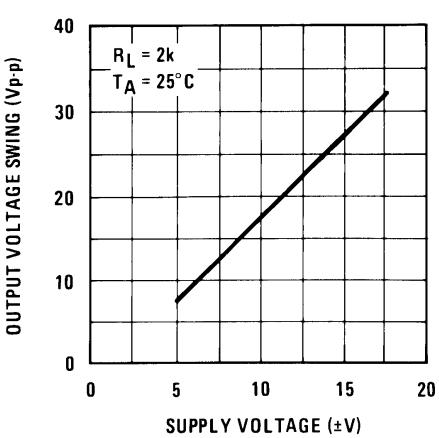
Positive Current Limit



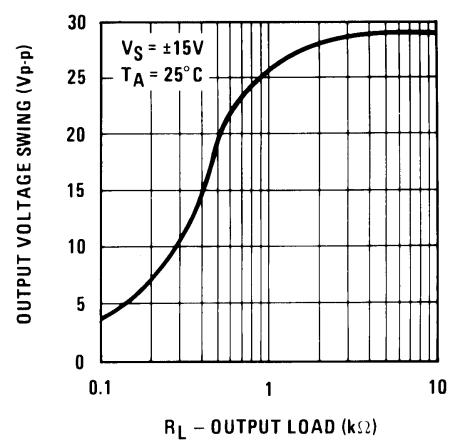
Negative Current Limit



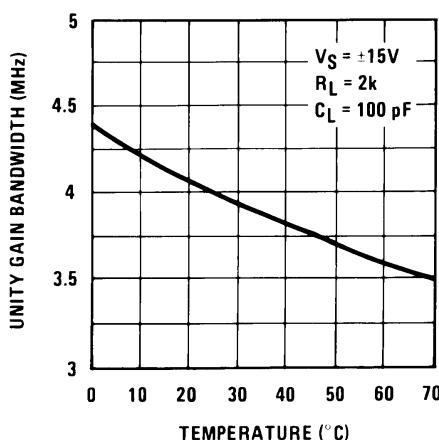
Voltage Swing



Output Voltage Swing

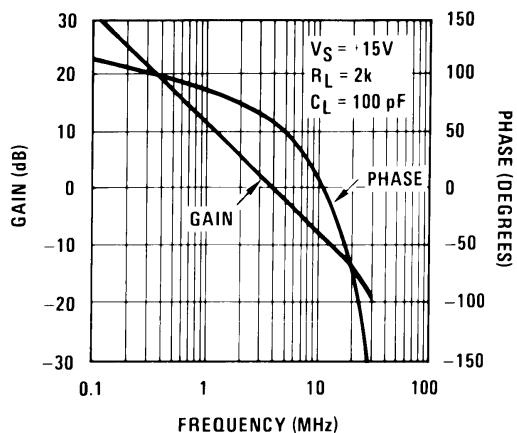


Gain Bandwidth



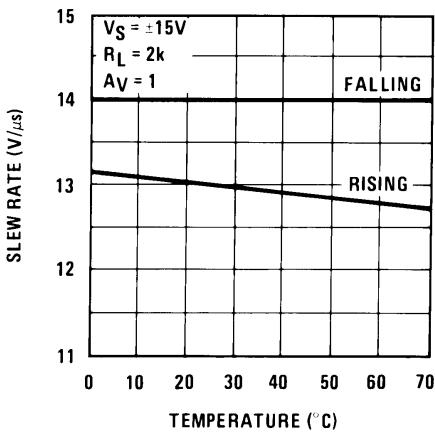
Typical Performance Characteristics (Continued)

Bode Plot



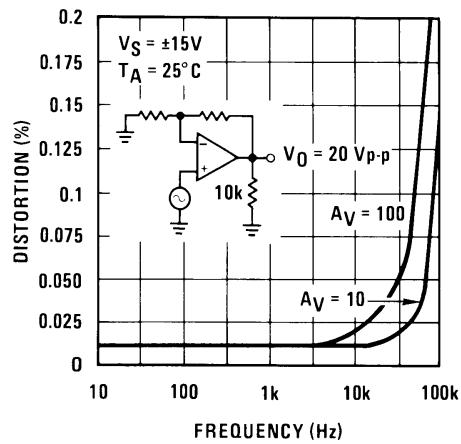
00564928

Slew Rate



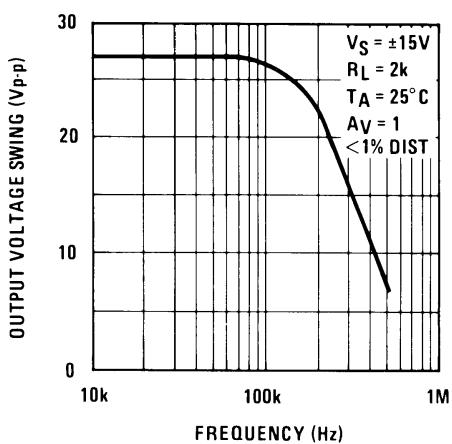
00564929

Distortion vs. Frequency



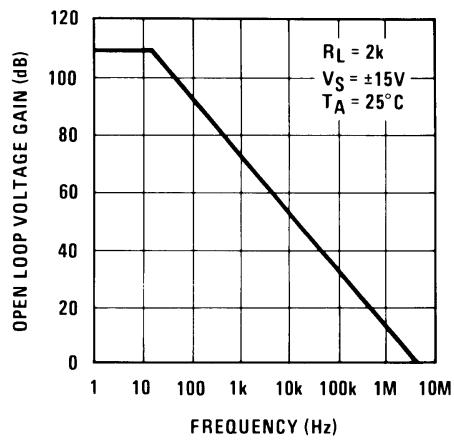
00564930

Undistorted Output Voltage Swing



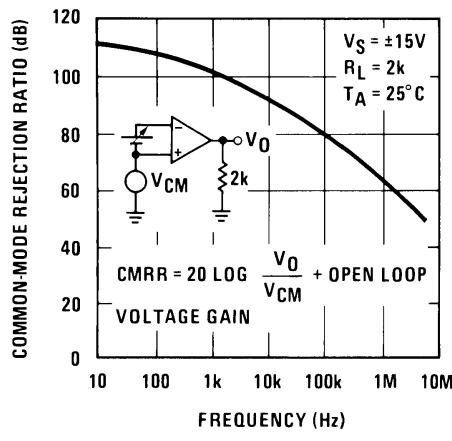
00564931

Open Loop Frequency Response



00564932

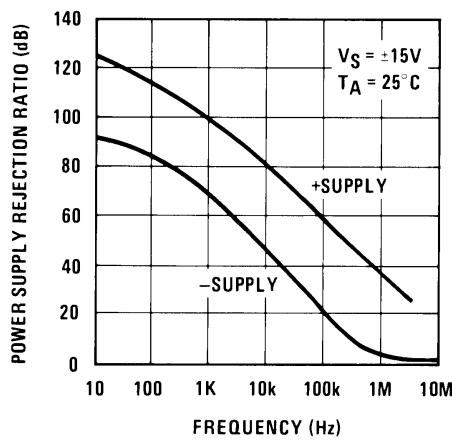
Common-Mode Rejection Ratio



00564933

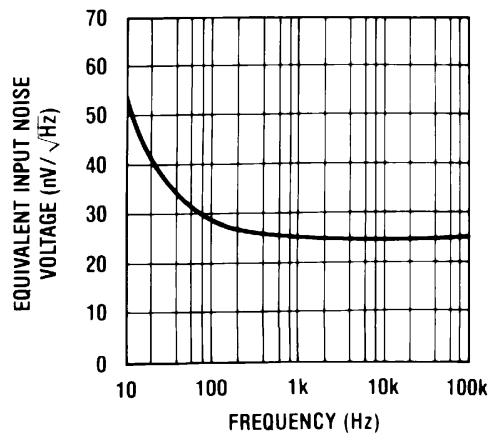
Typical Performance Characteristics (Continued)

Power Supply Rejection Ratio



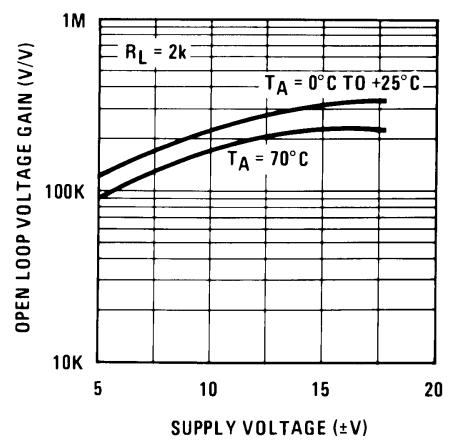
00564934

Equivalent Input Noise Voltage



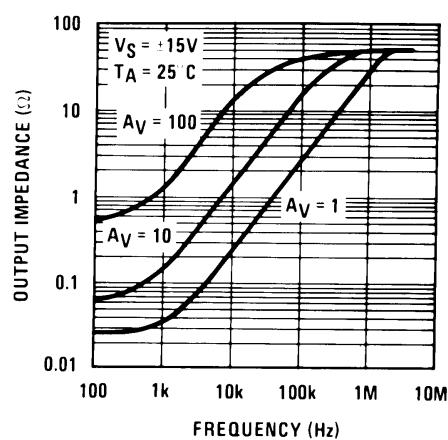
00564935

Open Loop Voltage Gain (V/V)



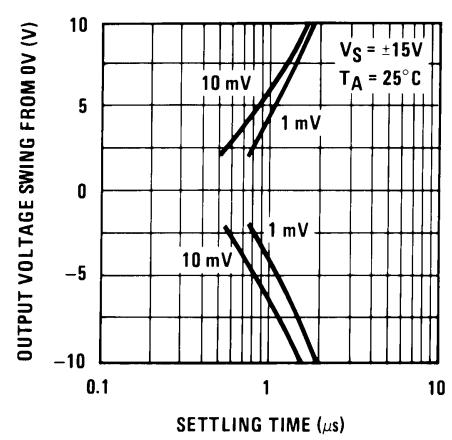
00564936

Output Impedance



00564937

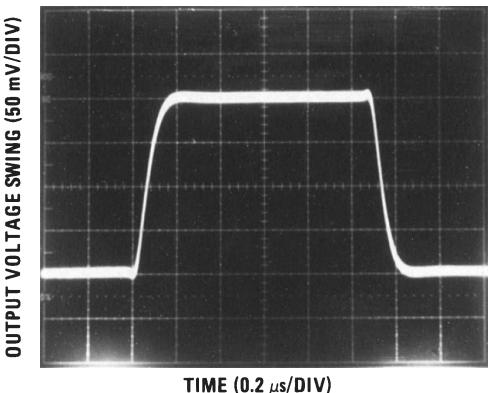
Inverter Settling Time



00564938

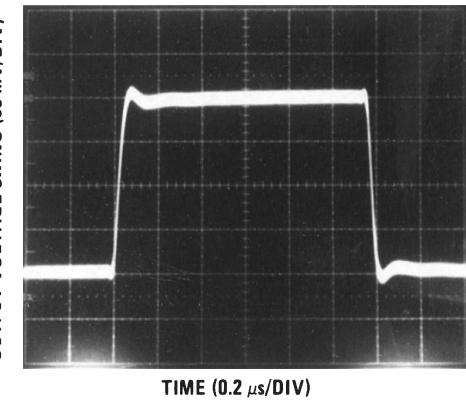
Pulse Response

Small Signaling Inverting



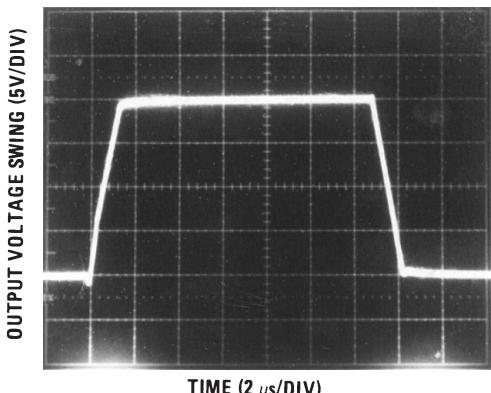
00564904

Small Signal Non-Inverting



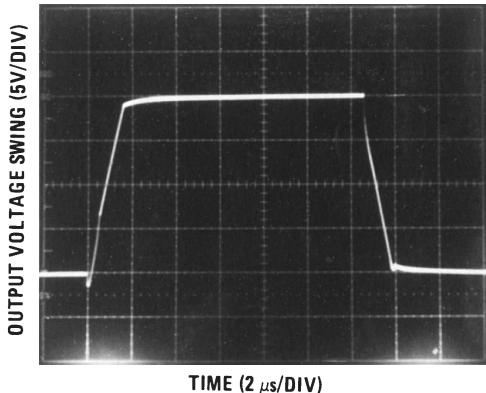
00564905

Large Signal Inverting



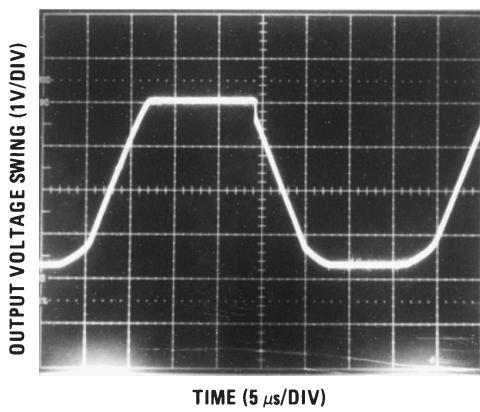
00564906

Large Signal Non-Inverting



00564907

Current Limit ($R_L = 100\Omega$)



00564908

Application Hints

These devices are op amps with an internally trimmed input offset voltage and JFET input devices (Bi-FET II). These JFETs have large reverse breakdown voltages from gate to source and drain eliminating the need for clamps across the inputs. Therefore, large differential input voltages can easily be accommodated without a large increase in input current. The maximum differential input voltage is independent of the

supply voltages. However, neither of the input voltages should be allowed to exceed the negative supply as this will cause large currents to flow which can result in a destroyed unit.

Exceeding the negative common-mode limit on either input will force the output to a high state, potentially causing a reversal of phase to the output. Exceeding the negative common-mode limit on both inputs will force the amplifier output to a high state. In neither case does a latch occur

Application Hints (Continued)

since raising the input back within the common-mode range again puts the input stage and thus the amplifier in a normal operating mode.

Exceeding the positive common-mode limit on a single input will not change the phase of the output; however, if both inputs exceed the limit, the output of the amplifier will be forced to a high state.

The amplifiers will operate with a common-mode input voltage equal to the positive supply; however, the gain bandwidth and slew rate may be decreased in this condition. When the negative common-mode voltage swings to within 3V of the negative supply, an increase in input offset voltage may occur.

Each amplifier is individually biased by a zener reference which allows normal circuit operation on $\pm 6V$ power supplies. Supply voltages less than these may result in lower gain bandwidth and slew rate.

The amplifiers will drive a $2\text{ k}\Omega$ load resistance to $\pm 10\text{V}$ over the full temperature range of 0°C to $+70^\circ\text{C}$. If the amplifier is forced to drive heavier load currents, however, an increase in input offset voltage may occur on the negative voltage swing and finally reach an active current limit on both positive and negative swings.

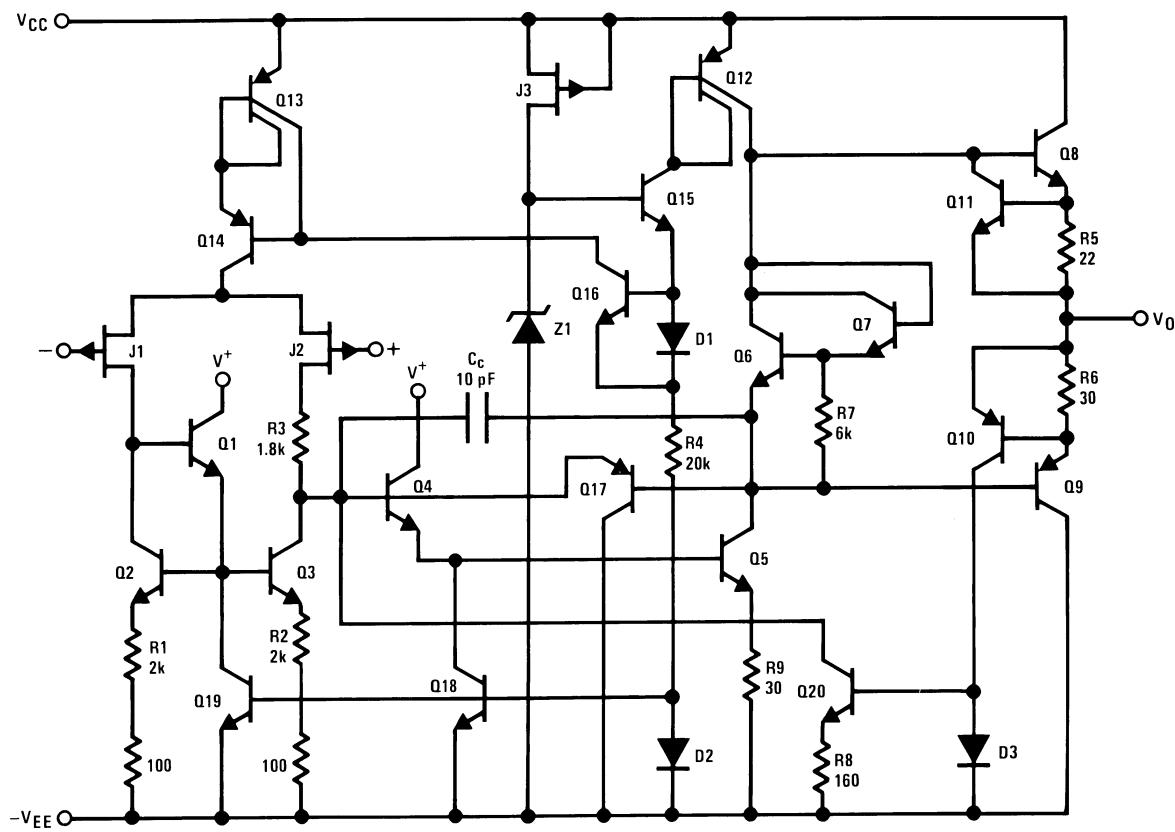
Precautions should be taken to ensure that the power supply for the integrated circuit never becomes reversed in polarity

or that the unit is not inadvertently installed backwards in a socket as an unlimited current surge through the resulting forward diode within the IC could cause fusing of the internal conductors and result in a destroyed unit.

As with most amplifiers, care should be taken with lead dress, component placement and supply decoupling in order to ensure stability. For example, resistors from the output to an input should be placed with the body close to the input to minimize "pick-up" and maximize the frequency of the feedback pole by minimizing the capacitance from the input to ground.

A feedback pole is created when the feedback around any amplifier is resistive. The parallel resistance and capacitance from the input of the device (usually the inverting input) to AC ground set the frequency of the pole. In many instances the frequency of this pole is much greater than the expected 3 dB frequency of the closed loop gain and consequently there is negligible effect on stability margin. However, if the feedback pole is less than approximately 6 times the expected 3 dB frequency a lead capacitor should be placed from the output to the input of the op amp. The value of the added capacitor should be such that the RC time constant of this capacitor and the resistance it parallels is greater than or equal to the original feedback pole time constant.

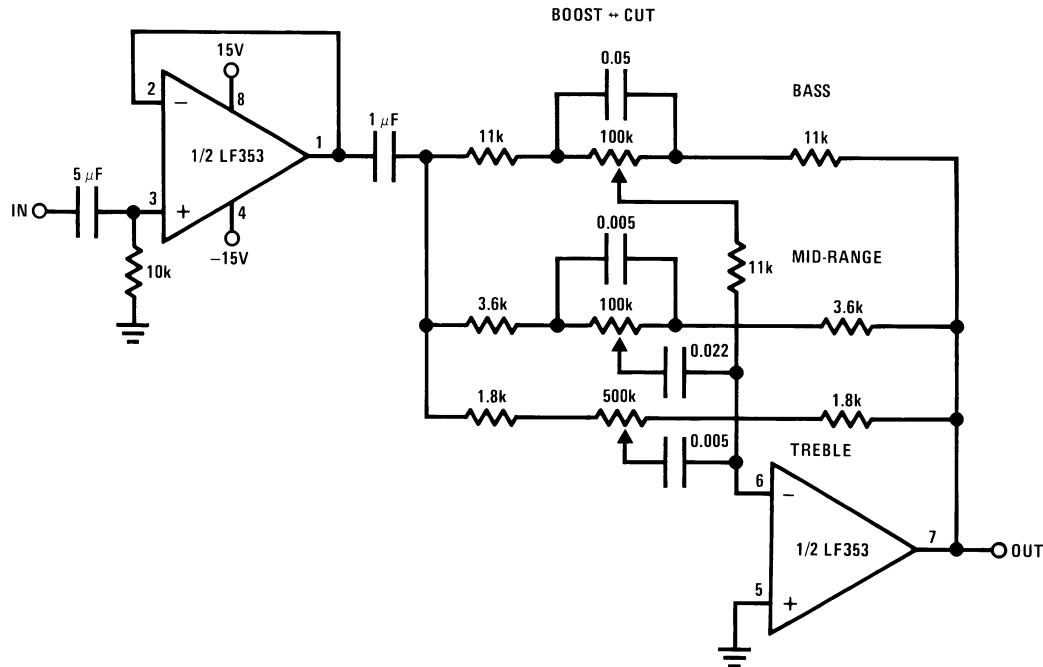
Detailed Schematic



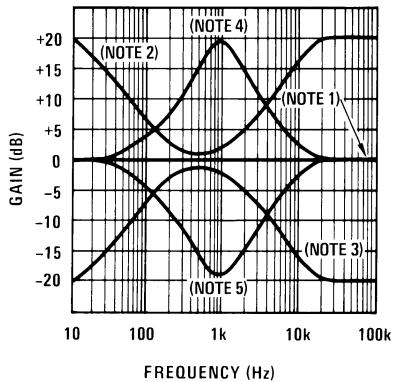
00564909

Typical Applications

Three-Band Active Tone Control



00564939



00564940

Note 1: All controls flat.

Note 2: Bass and treble boost, mid flat.

Note 3: Bass and treble cut, mid flat.

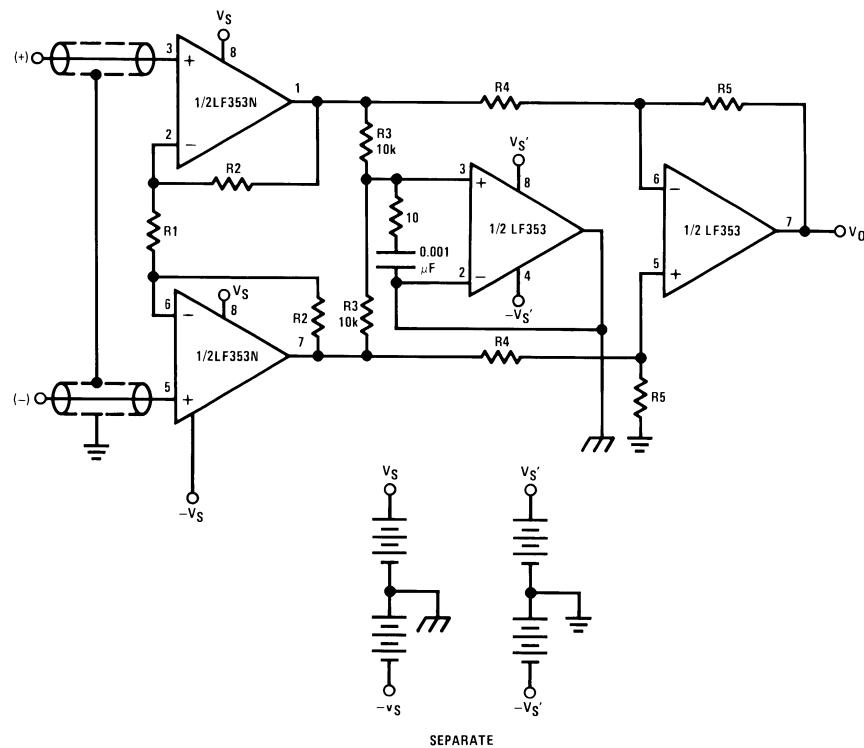
Note 4: Mid boost, bass and treble flat.

Note 5: Mid cut, bass and treble flat.

- All potentiometers are linear taper
- Use the LF347 Quad for stereo applications

Typical Applications (Continued)

Improved CMRR Instrumentation Amplifier



00564941

$$A_V = \left(\frac{2R_2}{R_1} + 1 \right) \frac{R_5}{R_4}$$

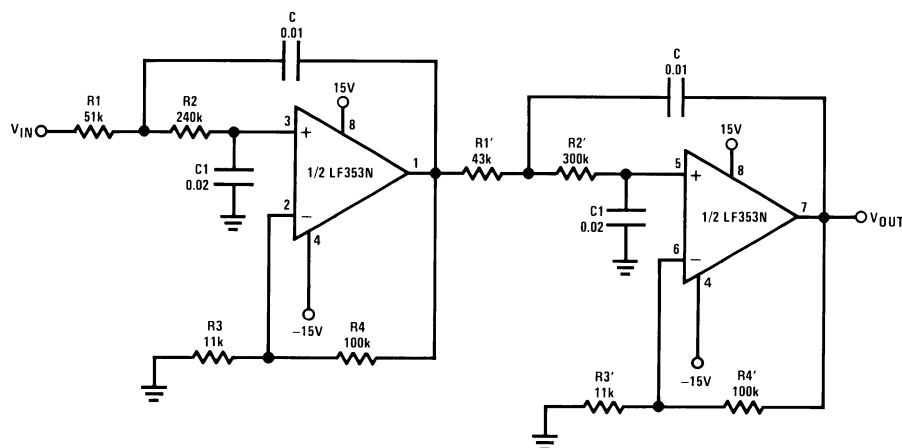
and are separate isolated grounds

Matching of R2's, R4's and R5's control CMRR

With $A_{V_T} = 1400$, resistor matching = 0.01%: CMRR = 136 dB

- Very high input impedance
- Super high CMRR

Fourth Order Low Pass Butterworth Filter

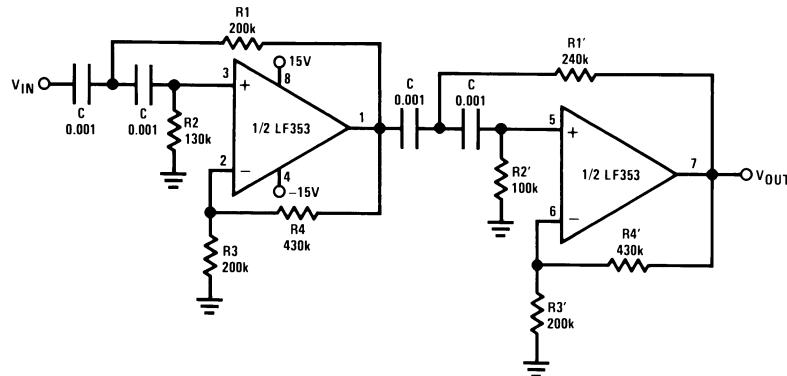


00564942

Typical Applications (Continued)

- Corner frequency (f_C) = $\sqrt{\frac{1}{R_1 R_2 C_1}} \cdot \frac{1}{2\pi} = \sqrt{\frac{1}{R'_1 R'_2 C'_1}} \cdot \frac{1}{2\pi}$
- Passband gain (H_O) = $(1 + R_4/R_3) (1 + R'_4/R'_3)$
- First stage Q = 1.31
- Second stage Q = 0.541
- Circuit shown uses nearest 5% tolerance resistor values for a filter with a corner frequency of 100 Hz and a passband gain of 100
- Offset nulling necessary for accurate DC performance

Fourth Order High Pass Butterworth Filter

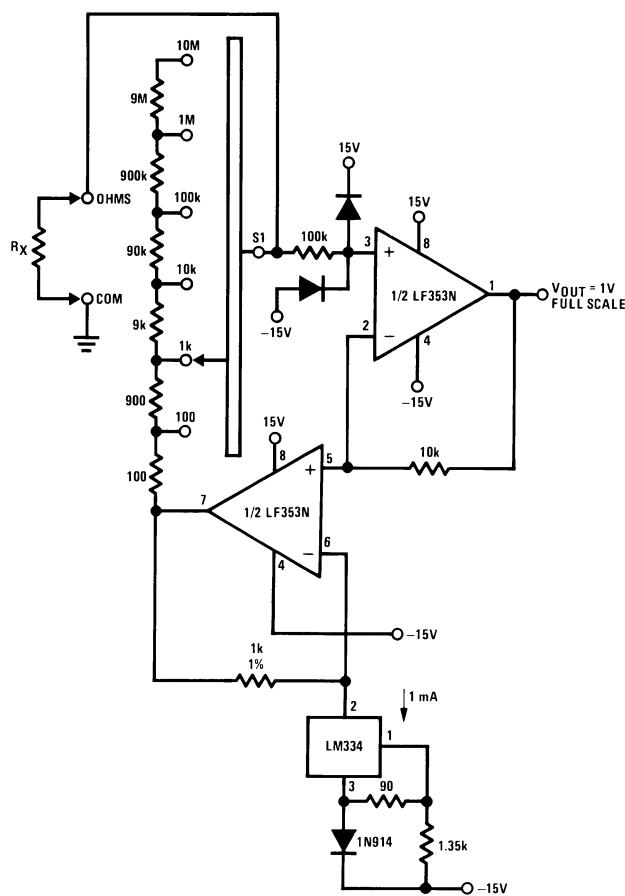


00564943

- Corner frequency (f_C) = $\sqrt{\frac{1}{R_1 R_2 C^2}} \cdot \frac{1}{2\pi} = \sqrt{\frac{1}{R'_1 R'_2 C'^2}} \cdot \frac{1}{2\pi}$
- Passband gain (H_O) = $(1 + R_4/R_3) (1 + R'_4/R'_3)$
- First stage Q = 1.31
- Second stage Q = 0.541
- Circuit shown uses closest 5% tolerance resistor values for a filter with a corner frequency of 1 kHz and a passband gain of 10.

Typical Applications (Continued)

Ohms to Volts Converter

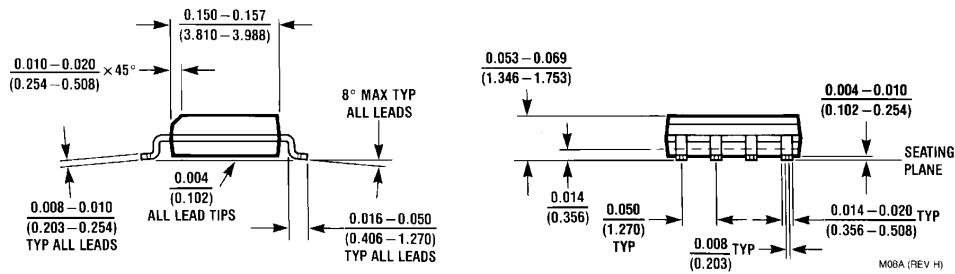
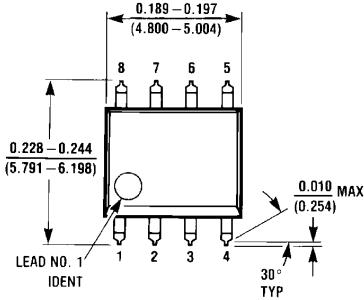


00564944

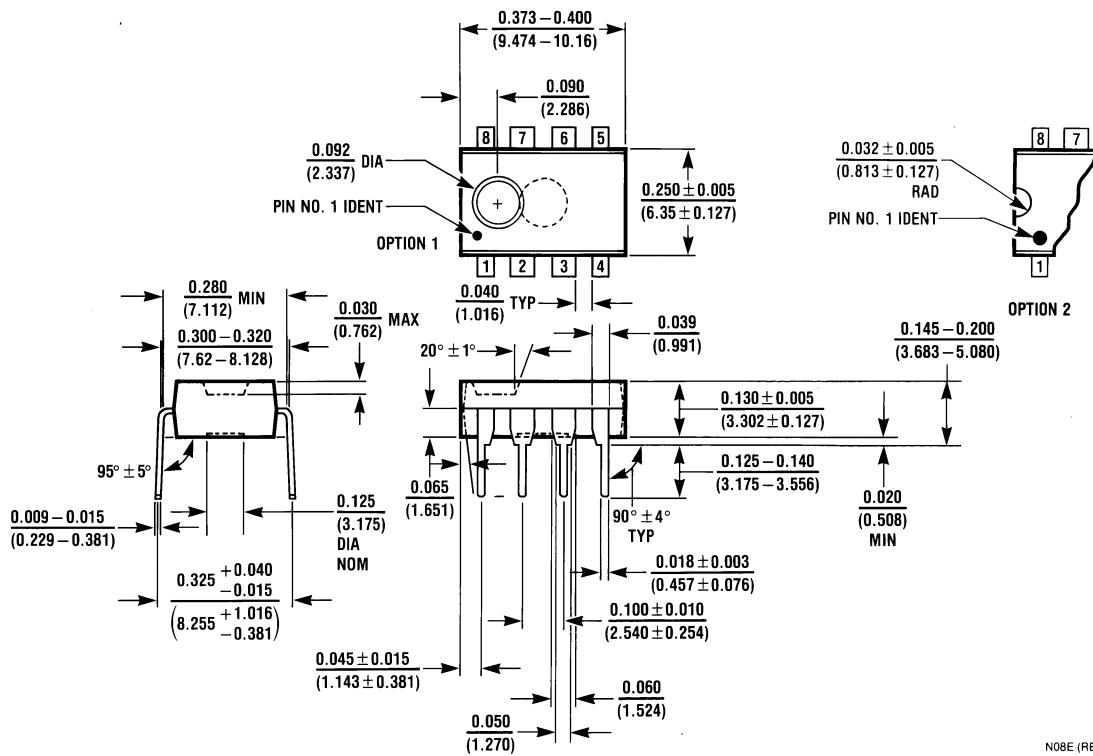
$$V_O = \frac{1V}{R_{LADDER}} \times R_X$$

Where R_{LADDER} is the resistance from switch S1 pole to pin 7 of the LF353.

Physical Dimensions inches (millimeters) unless otherwise noted



**Order Number LF353M or LF353MX
NS Package Number M08A**



**Molded Dual-In-Line Package
Order Number LF353N
NS Package N08E**

Notes

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 AND GENERAL COUNSEL 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.

BANNED SUBSTANCE COMPLIANCE

National Semiconductor certifies that the products and packing materials meet the provisions of the Customer Products Stewardship Specification (CSP-9-111C2) and the Banned Substances and Materials of Interest Specification (CSP-9-111S2) and contain no "Banned Substances" as defined in CSP-9-111S2.



National Semiconductor
Americas Customer
Support Center
Email: new.feedback@nsc.com
Tel: 1-800-272-9959
www.national.com

National Semiconductor
Europe Customer Support Center
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor
Asia Pacific Customer
Support Center
Email: ap.support@nsc.com

National Semiconductor
Japan Customer Support Center
Fax: 81-3-5639-7507
Email: jpn.feedback@nsc.com
Tel: 81-3-5639-7560

This datasheet has been download from:

www.datasheetcatalog.com

Datasheets for electronics components.