

LM390

LM390 1W Battery Operated Audio Power Amplifier



Literature Number: SNOSBU0A

LM390 1W Battery Operated Audio Power Amplifier

General Description

The LM390 Power Audio Amplifier is optimized for 6V, 7.5V, 9V operation into low impedance loads. The gain is internally set at 20 to keep the external part count low, but the addition of an external resistor and capacitor between pins 2 and 6 will increase the gain to any value up to 200. The inputs are ground referenced while the output is automatically biased to one half the supply voltage.

Features

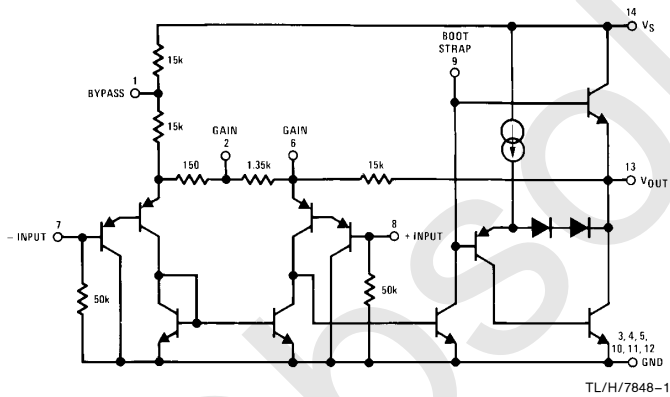
- Battery operation
- 1W output power
- Minimum external parts
- Excellent supply rejection
- Ground referenced input

- Self-centering output quiescent voltage
- Variable voltage gain
- Low distortion
- Fourteen pin dual-in-line package

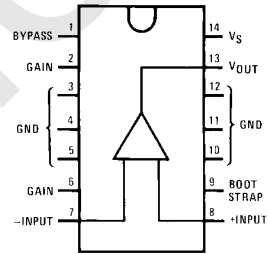
Applications

- AM-FM radio amplifiers
- Portable tape player amplifiers
- Intercoms
- TV sound systems
- Lamp drivers
- Line drivers
- Ultrasonic drivers
- Small servo drivers
- Power converters

Equivalent Schematic and Connection Diagrams



Dual-In-Line Package



Order Number **LM390N**
See NS Package Number **N14A**

Absolute Maximum Ratings

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

Supply Voltage	10V
Package Dissipation 14-Pin DIP (Note 1)	8.3W
Input Voltage	$\pm 0.4V$
Storage Temperature	$-65^{\circ}C$ to $+150^{\circ}C$

Operating Temperature	$0^{\circ}C$ to $+70^{\circ}C$
Junction Temperature	$150^{\circ}C$
Lead Temperature (Soldering, 10 sec.)	$260^{\circ}C$
Thermal Resistance	
θ_{JC}	$30^{\circ}C/W$
θ_{JA}	$79^{\circ}C/W$

Electrical Characteristics $T_A = 25^{\circ}C$, (Figure 1)

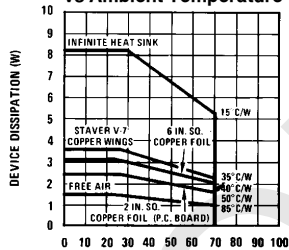
Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_S	Operating Supply Voltage		4		9	V
I_Q	Quiescent Current	$V_S = 6V, V_{IN} = 0$		10	20	mA
P_{OUT}	Output Power	$V_S = 6V, R_L = 4\Omega, THD = 10\%$	0.8	1.0		W
A_V	Voltage Gain	$V_S = 6V, f = 1\text{ kHz}$ $10\ \mu F$ from Pin 2 to 6	23	26 46	30	dB dB
BW	Bandwidth	$V_S = 6V$, Pins 2 and 6 Open		300		kHz
THD	Total Harmonic Distortion	$V_S = 6V, R_L = 4\Omega, P_{OUT} = 500\text{ mW}$ $f = 1\text{ kHz}$, Pins 2 and 6 Open		0.2	1	%
PSRR	Power Supply Rejection Ratio	$V_S = 6V, f = 1\text{ kHz}, C_{BYPASS} = 10\ \mu F$, Pins 2 and 6 Open, Referred to Output (Note 2)		50		dB
R_{IN}	Input Resistance		10	50		$k\Omega$
I_{BIAS}	Input Bias Current	$V_S = 6V$, Pins 7 and 8 Open		250		nA

Note 1: Pins 3, 4, 5, 10, 11, 12 at $25^{\circ}C$. Above $25^{\circ}C$ case, derate at $15^{\circ}C/W$ junction to case, or $85^{\circ}C/W$ junction to ambient.

Note 2: If load and bypass capacitor are returned to V_S (Figure 2), rather than ground (Figure 1), PSRR is typically 30 dB.

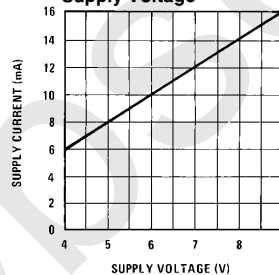
Typical Performance Characteristics

Maximum Device Dissipation vs Ambient Temperature

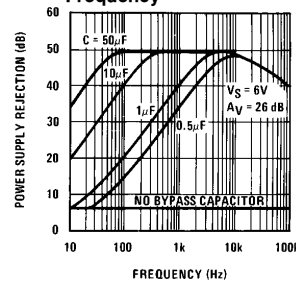


T_A - AMBIENT TEMPERATURE ($^{\circ}C$)
Note: 2 oz. copper foil, single-sided PC board.

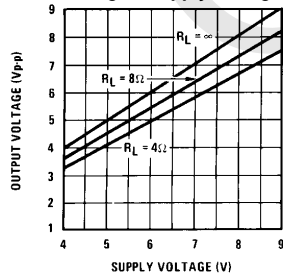
Quiescent Supply Current vs Supply Voltage



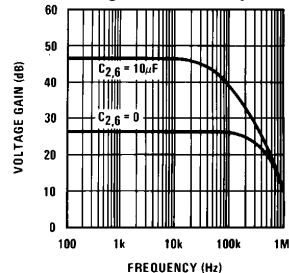
Power Supply Rejection Ratio (Referred to the Output) vs Frequency



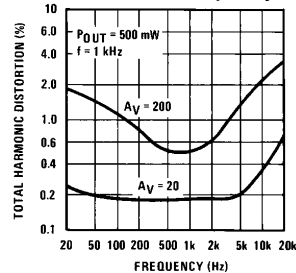
Peak-to-Peak Output Voltage Swing vs Supply Voltage



Voltage Gain vs Frequency



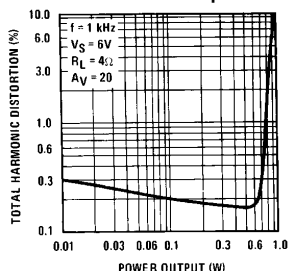
Distortion vs Frequency



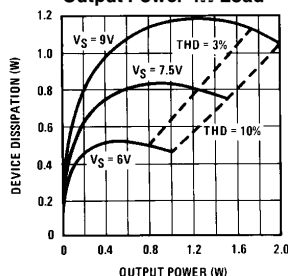
TL/H/7848-5

Typical Performance Characteristics (Continued)

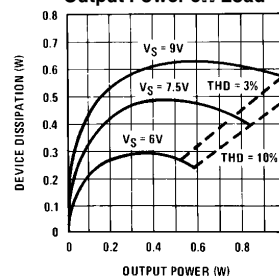
Distortion vs Output Power



Device Dissipation vs Output Power 4Ω Load



Device Dissipation vs Output Power 8Ω Load



TL/H/7848-6

Application Hints

Gain Control

To make the LM390 a more versatile amplifier, two pins (2 and 6) are provided for gain control. With pins 2 and 6 open, the 1.35 kΩ resistor sets the gain at 20 (26 dB). If a capacitor is put from pin 2 to 6, bypassing the 1.35 kΩ resistor, the gain will go up to 200 (46 dB). If a resistor is placed in series with the capacitor, the gain can be set to any value from 20 to 200. A low frequency pole in the gain response is caused by the capacitor working against the external resistor in series with the 150Ω internal resistor. If the capacitor is eliminated and a resistor connects pin 2 to 6 then the output dc level may shift due to the additional dc gain. Gain control can also be done by capacitively coupling a resistor (or FET) from pin 6 to ground, as in Figure 7.

Additional external components can be placed in parallel with the internal feedback resistors to tailor the gain and frequency response for individual applications. For example, we can compensate poor speaker bass response by frequency shaping the feedback path. This is done with a series RC from pin 6 to 13 (paralleling the internal 15 kΩ resistor). For 6 dB effective bass boost: $R \approx 15 \text{ k}\Omega$, the lowest value for good stable operation is $R = 10 \text{ k}\Omega$ if pin 2 is open. If pins 2 and 6 are bypassed then R as low as 2 kΩ can be used. This restriction is because the amplifier is only compensated for closed-loop gains greater than 9 V/V.

Input Biasing

The schematic shows that both inputs are biased to ground with a 50 kΩ resistor. The base current of the input transistors is about 250 nA, so the inputs are at about 12.5 mV when left open. If the dc source resistance driving the LM390 is higher than 250 kΩ it will contribute very little additional offset (about 2.5 mV at the input, 50 mV at the output). If the dc source resistance is less than 10 kΩ, then shorting the unused input to ground will keep the offset low (about 2.5 mV at the input 50 mV at the output). For dc source resistances between these values we can eliminate excess offset by putting a resistor from the unused input to ground, equal in value to the dc source resistance. Of course all offset problems are eliminated if the input is capacitively coupled.

When using the LM390 with higher gains (bypassing the 1.35 kΩ resistor between pins 2 and 6) it is necessary to

bypass the unused input, preventing degradation of gain and possible instabilities. This is done with a 0.1 μF capacitor or a short to ground depending on the dc source resistance on the driven input.

Bootstrapping

The base of the output transistor of the LM390 is brought out to pin 9 for Bootstrapping. The output stage of the amplifier during positive swing is shown in Figure 3 with its external circuitry.

$R1 + R2$ set the amount of base current available to the output transistor. The maximum output current divided by beta is the value required for the current in $R1$ and $R2$:

$$(R1 + R2) = \beta_O \frac{(V_S/2) - V_{BE}}{I_{O \text{ MAX}}}$$

Good design values are $V_{BE} = 0.7\text{V}$ and $\beta_O = 100$.

Example 0.8 watt into 4Ω load with $V_S = 6\text{V}$.

$$I_{O \text{ MAX}} = \sqrt{\frac{2 P_O}{R_L}} = 632 \text{ mA}$$

$$(R1 + R2) = 100 \left(\frac{(6/2) - 0.7}{0.632} \right) = 364 \Omega$$

To keep the current in $R2$ constant during positive swing capacitor C_B is added. As the output swings positive C_B lifts $R1$ and $R2$ above the supply, maintaining a constant voltage across $R2$. To minimize the value of C_B , $R1 = R2$. The pole due to C_B and $R1$ and $R2$ is usually set equal to the pole due to the output coupling capacitor and the load. This gives:

$$C_B \approx \frac{4C_C}{\beta_O} \approx \frac{C_C}{25}$$

Example: for 100 Hz pole and $R_L = 4\Omega$; $C_C = 400 \mu\text{F}$ and $C_B = 16 \mu\text{F}$, if $R1$ is made a diode and $R2$ increased to give the same current, C_B can be decreased by about a factor of 4, as in Figure 4.

For reduced component count the load can replace $R1$. The value of $(R1 + R2)$ is the same, so $R2$ is increased. Now C_B is both the coupling and the bootstrapping capacitor (see Figure 2).

Typical Applications

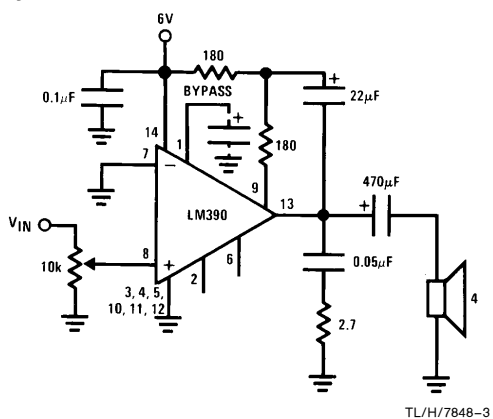


FIGURE 1. Load Returned to Ground
(Amplifier with Gain = 20)

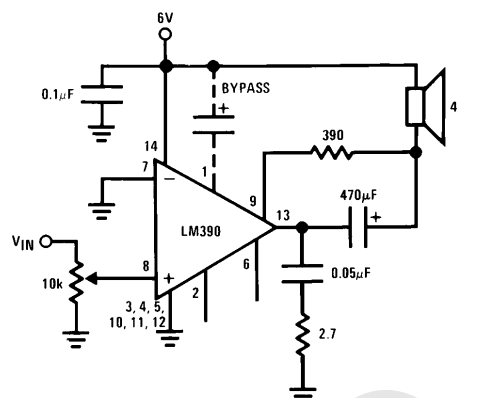


FIGURE 2. Load Returned to Supply
(Amplifier with Gain = 20)

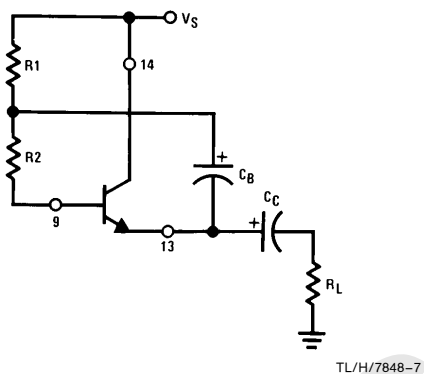


FIGURE 3

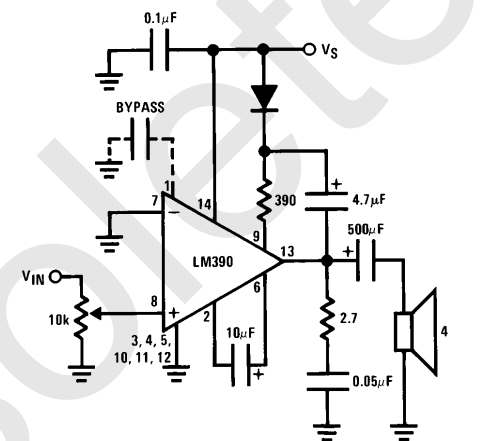


FIGURE 4. Amplifier with Gain = 200 and Minimum C_B

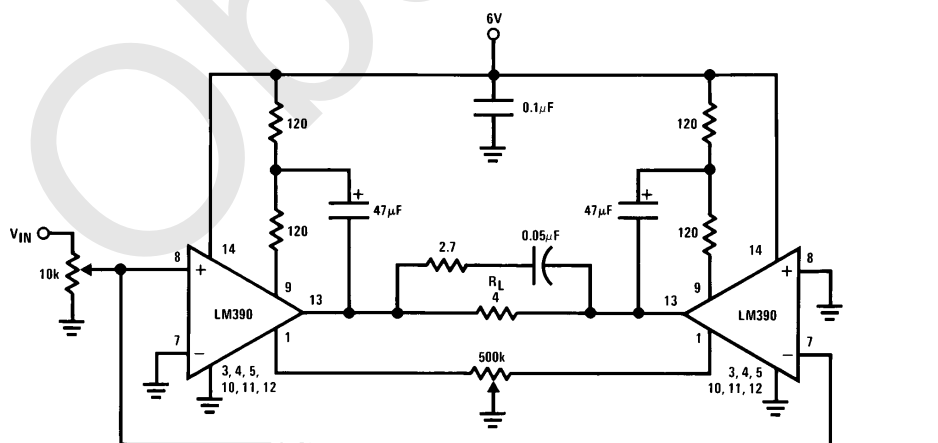


FIGURE 5. 2.5W Bridge Amplifier

Typical Applications (Continued)

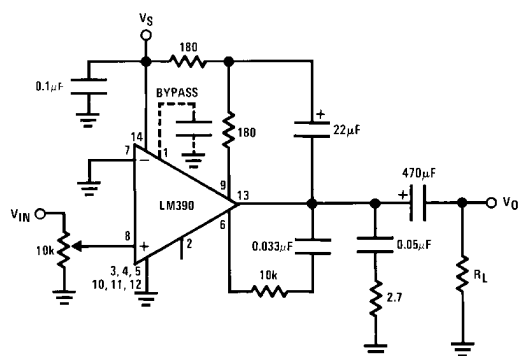
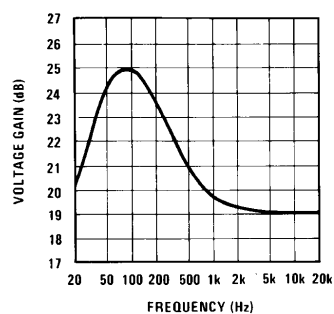


FIGURE 6(a). Amplifier with Bass Boost

TL/H/7848-10



TL/H/7848-11

FIGURE 6(b). Frequency Response with Bass Boost

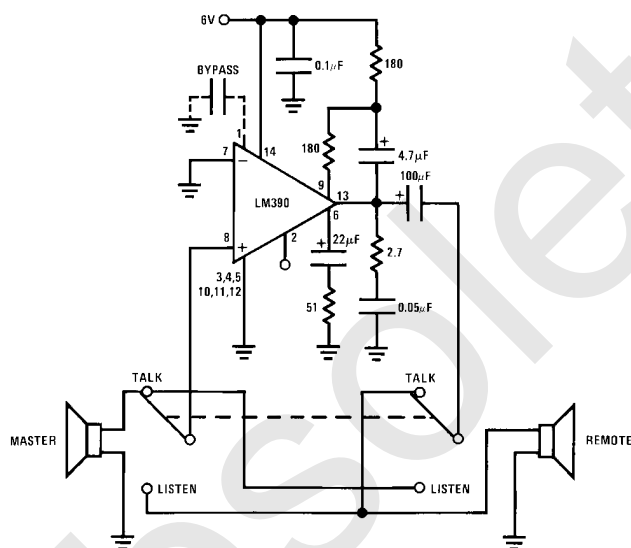


FIGURE 7. Intercom

TL/H/7848-12

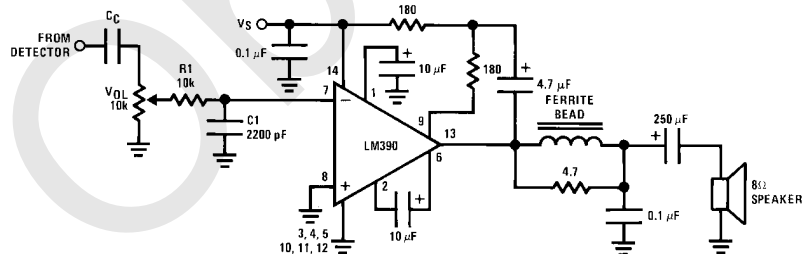


FIGURE 8. AM Radio Power Amplifier

TL/H/7848-13

Note 1: Twist supply lead and supply ground very tightly.

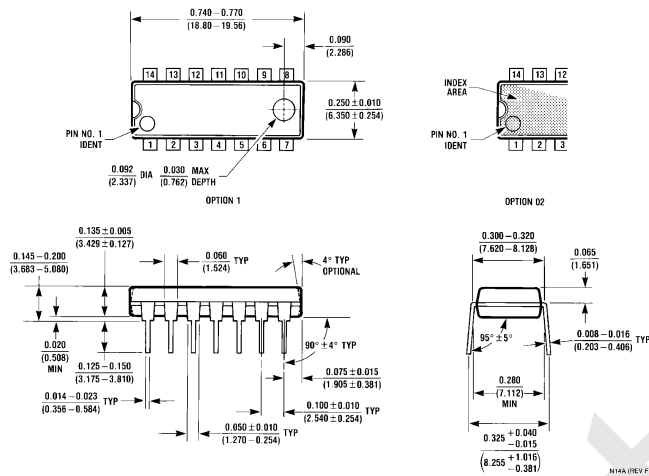
Note 2: Twist speaker lead and ground very tightly.

Note 3: Ferrite bead is Ferroxcube K5-001-001/3B with 3 turns of wire.

Note 4: R1C1 band limits input signals.

Note 5: All components must be spaced very close to IC.

Physical Dimensions inches (millimeters)



Molded Dual-In-Line Package (N)
Order Number LM390N
See NS Package Number N14A

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.
 19th 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

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

Applications

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

TI E2E Community Home Page

e2e.ti.com

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