LM709

LM709 Operational Amplifier

Literature Number: SNOS659A

National Semiconductor

February 1995

LM709
Operational Amplifier

General Description

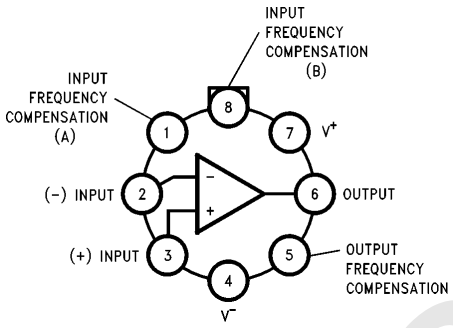
The LM709 series is a monolithic operational amplifier intended for general-purpose applications. Operation is completely specified over the range of voltages commonly used for these devices. The design, in addition to providing high gain, minimizes both offset voltage and bias currents. Further, the class-B output stage gives a large output capability with minimum power drain.

External components are used to frequency compensate the amplifier. Although the unity-gain compensation network specified will make the amplifier unconditionally stable in all feedback configurations, compensation can be tailored to optimize high-frequency performance for any gain setting.

The LM709C is the commercial-industrial version of the LM709. It is identical to the LM709 except that it is specified for operation from 0°C to +70°C.

Connection Diagrams

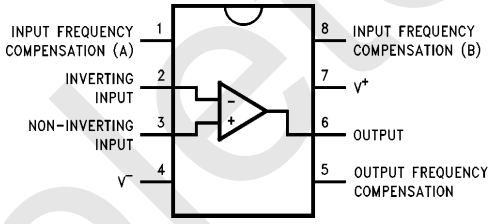
Metal Can Package



TL/H/11477–4

Order Number LM709AH, LM709H or LM709CH
See NS Package Number H08C

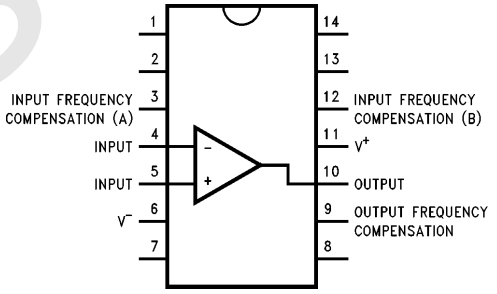
Dual-In-Line Package



TL/H/11477–6

Order Number LM709CN-8
See NS Package Number N08E

Dual-In-Line Package



TL/H/11477–5

Order Number LM709CN
See NS Package Number N14A

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

Absolute Maximum Ratings (Note 3)

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

Supply Voltage
LM709/LM709A/LM709C ±18V

Power Dissipation (Note 1)
LM709/LM709A 300 mW
LM709C 250 mW

Differential Input Voltage
LM709/LM709A/LM709C ±5V

Input Voltage
LM709/LM709A/LM709C ±10V

Output Short-Circuit Duration ($T_A = +25°C$)
LM709/LM709A/LM709C 5 seconds

Storage Temperature Range
LM709/LM709A/LM709C −65°C to +150°C

Lead Temperature (Soldering, 10 sec.)
LM709/LM709A/LM709C 300°C

Operating Ratings (Note 3)

Junction Temperature Range (Note 1)
LM709/LM709A −55°C to +150°C
LM709C 0°C to +100°C

Thermal Resistance (θ_{JA})
H Package 150°C/W, (θ_{JC}) 45°C/W
8-Pin N Package 134°C/W
14-Pin N Package 109°C/W

Electrical Characteristics (Note 2)

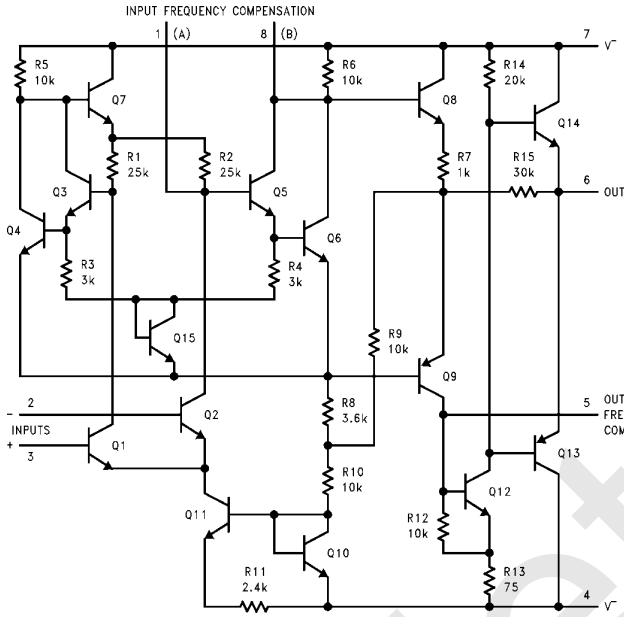
Parameter	Conditions	LM709A			LM709			LM709C			Units
		Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	
Input Offset Voltage	$T_A = 25°C$, $R_S \le 10\ k\Omega$		0.6	2.0		1.0	5.0		2.0	7.5	mV
Input Bias Current	$T_A = 25°C$		100	200		200	500		300	1500	nA
Input Offset Current	$T_A = 25°C$		10	50		50	200		100	500	nA
Input Resistance	$T_A = 25°C$	350	700		150	400		50	250		kΩ
Output Resistance	$T_A = 25°C$		150			150			150		Ω
Supply Current	$T_A = 25°C$, $V_S = \pm 15V$		2.5	3.6		2.6	5.5		2.6	6.6	mA
Transient Response Risetime Overshoot	$V_{IN} = 20$ mV, $C_L \le 100$ pF $T_A = 25°C$			 1.5 30		 0.3 10	 1.0 30		 0.3 10	 1.0 30	 μs %
Slew Rate	$T_A = 25°C$		0.25			0.25			0.25		V/μs
Input Offset Voltage	$R_S \le 10\ k\Omega$			3.0			6.0			10	mV
Average Temperature Coefficient of Input Offset Voltage	$R_S = 50\Omega$ $T_A = 25°C$ to T_{MAX}		1.8	10		3.0			6.0		μV/°C
	$T_A = 25°C$ to T_{MIN}		1.8	10		6.0			12		
	$R_S = 10\ k\Omega$ $T_A = 25°C$ to T_{MAX}		2.0	15							
	$T_A = 25°C$ to T_{MIN}		4.8	25							
Large Signal Voltage Gain	$V_S = \pm 15V$, $R_L \ge 2\ k\Omega$ $V_{OUT} = \pm 10V$	25		70	25	45	70	15	45		V/mV
Output Voltage Swing	$V_S = \pm 15V$, $R_L = 10\ k\Omega$	±12	±14		±12	±14		±12	±14		V
	$V_S = \pm 15V$, $R_L = 2\ k\Omega$	±10	±13		±10	±13		±10	±13		
Input Voltage Range	$V_S = \pm 15V$	±8			±8	±10		±8	±10		V
Common-Mode Rejection Ratio	$R_S \le 10\ k\Omega$	80	110		70	90		65	90		dB
Supply Voltage Rejection Ratio	$R_S \le 10\ k\Omega$		40	100		25	150		25	200	μV/V
Input Offset Current	$T_A = T_{MAX}$		3.5	50		20	200		75	400	nA
	$T_A = T_{MIN}$		40	250		100	500		125	750	
Input Bias Current	$T_A = T_{MIN}$		0.3	0.6		0.5	1.5		0.36	2.0	μA
Input Resistance	$T_A = T_{MIN}$	85	170		40	100		50	250		kΩ

Note 1: For operating at elevated temperatures, the device must be derated based on a 150°C maximum junction temperature for LM709/LM709A and 100°C maximum for L709C. For operating at elevated temperatures, the device must be derated based on thermal resistance θ_{JA}, $T_{J(MAX)}$ and T_A.

Note 2: These specifications apply for $-55°C \le T_A \le +125°C$ for the LM709/LM709A and $0°C \le T_A \le +70°C$ for the LM709C with the following conditions: $\pm 9V \le V_S \le \pm 15V$, C1 = 5000 pF, R1 = 1.5 kΩ, C2 = 200 pF and R2 = 51Ω.

Note 3: Absolute Maximum Ratings indicate limits which if exceeded may result in damage. Operating Ratings are conditions where the device is expected to be functional but not necessarily within the guaranteed performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics.

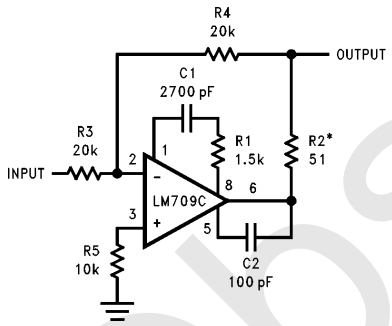
Schematic Diagram**



TL/H/11477–1

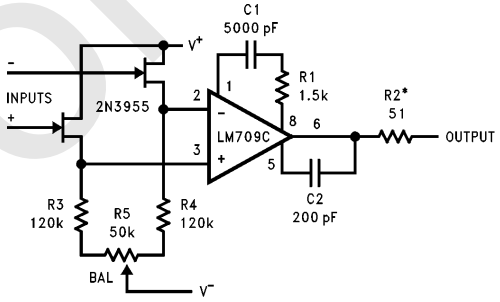
Typical Applications**

Unity Gain Inverting Amplifier



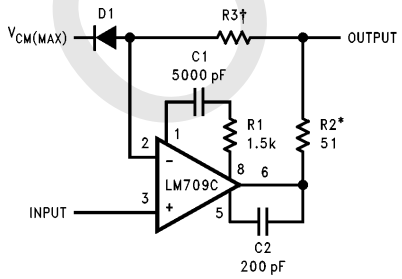
TL/H/11477–2

FET Operational Amplifier



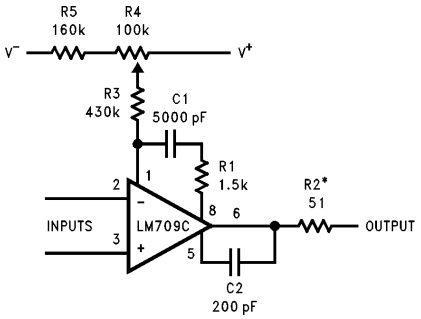
TL/H/11477–3

Voltage Follower



TL/H/11477–7

Offset Balancing Circuit



TL/H/11477–8

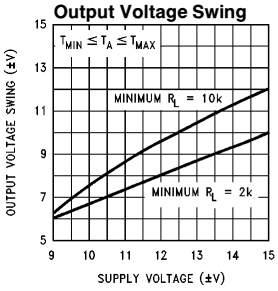
*To be used with any capacitive loading on output.

**Pin connections shown are for metal can package.

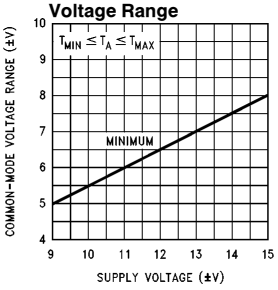
†Should be equal to DC source resistance on input.

Guaranteed Performance Characteristics

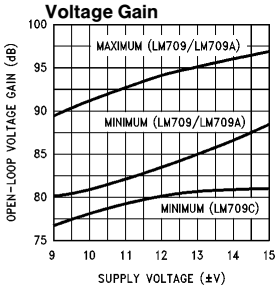
Output Voltage Swing



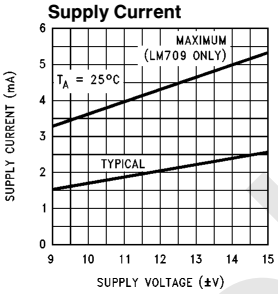
Input Common-Mode Voltage Range



Voltage Gain



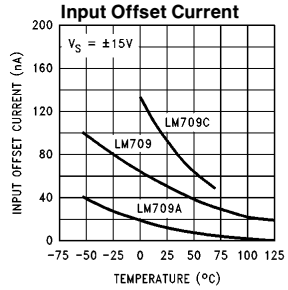
Supply Current



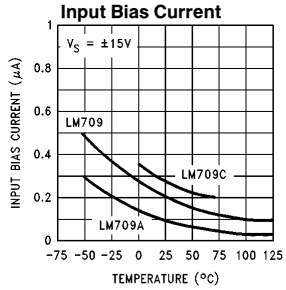
TL/H/11477–9

Typical Performance Characteristics

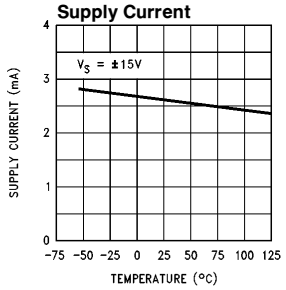
Input Offset Current



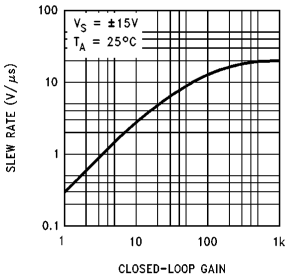
Input Bias Current



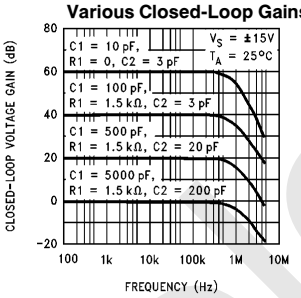
Supply Current



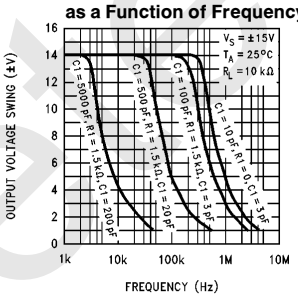
Slew Rate as a Function of Closed-Loop Gain Using Recommended Compensation Networks



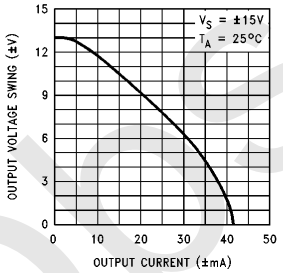
Frequency Response for Various Closed-Loop Gains



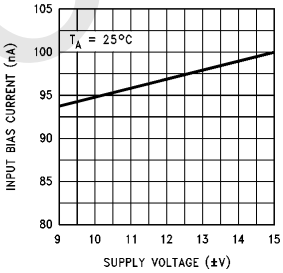
Output Voltage Swing as a Function of Frequency



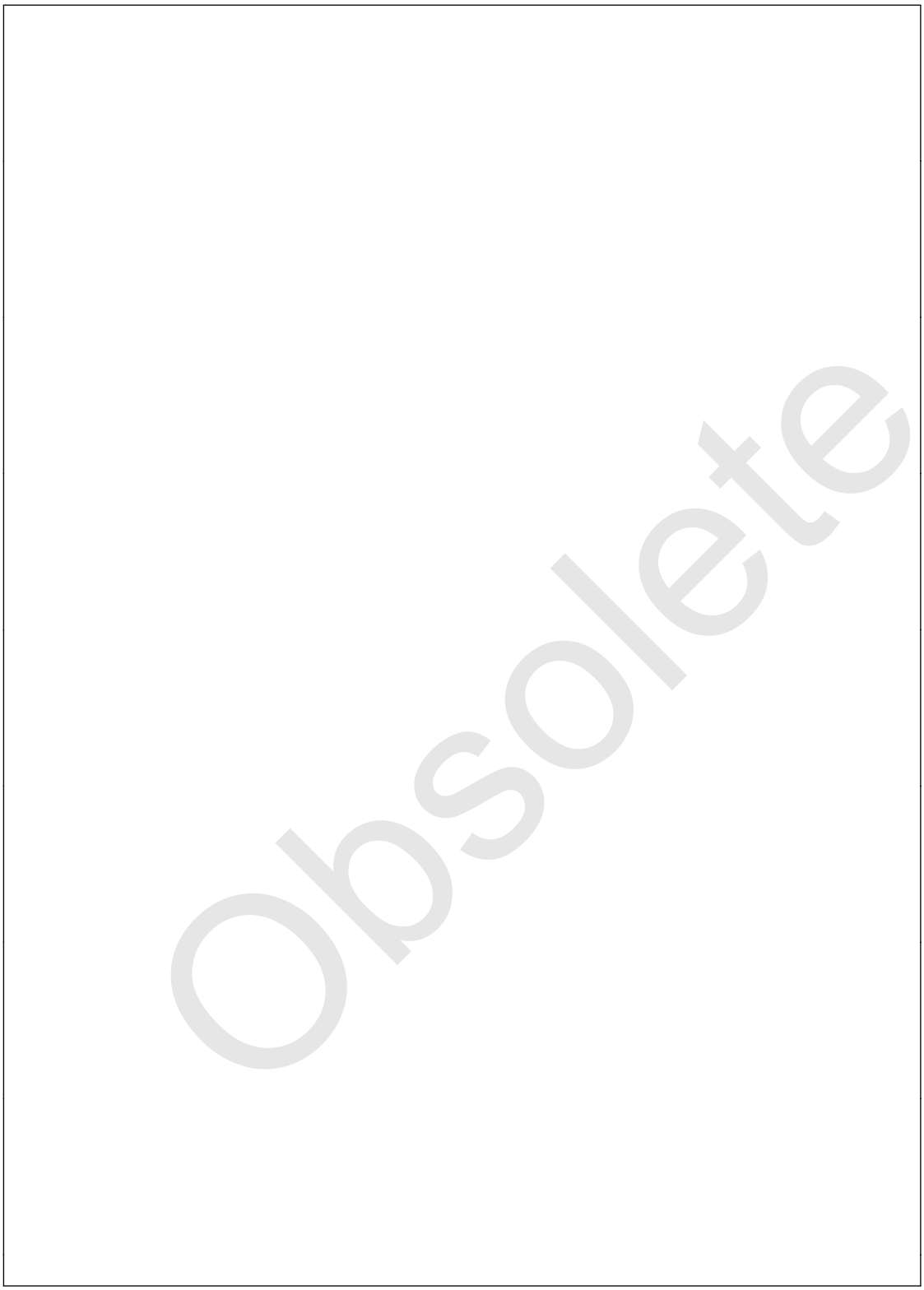
Output Voltage Swing



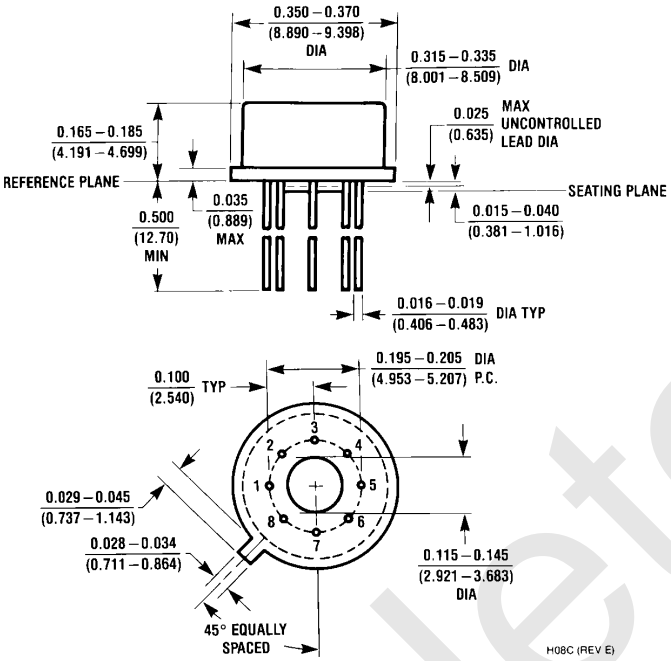
Input Bias Current as a Function of Supply Voltage



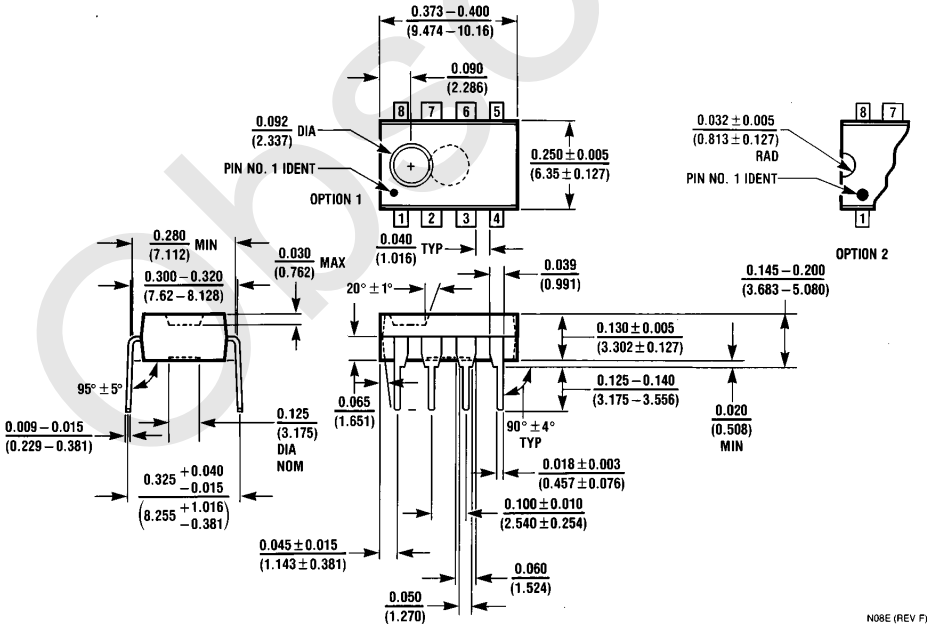
TL/H/11477–10


Obsolete

Physical Dimensions inches (millimeters)

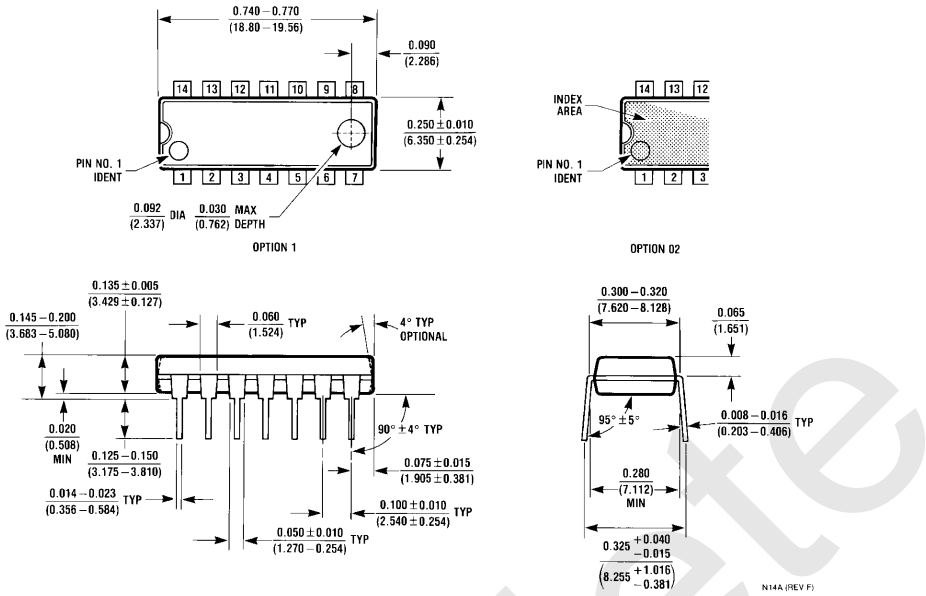


Metal Can Package (H)
Order Number LM709AH, LM709H or LM709CH
NS Package Number H08C



8-Lead Molded Dual-In-Line Package (N)
Order Number LM709CN-8
NS Package Number N08E

Physical Dimensions inches (millimeters) (Continued)



14-Lead Molded Dual-In-Line Package (N)
Order Number LM709CN
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.
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

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		**Applications**	
Audio	www.ti.com/audio	Communications and Telecom	www.ti.com/communications
Amplifiers	amplifier.ti.com	Computers and Peripherals	www.ti.com/computers
Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Mobile Processors	www.ti.com/omap		
Wireless Connectivity	www.ti.com/wirelessconnectivity		
	TI E2E Community Home Page		e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265