National Semiconductor

February 1995

LM3303/LM3403 Quad Operational Amplifiers

General Description

The LM3303 and LM3403 are monolithic quad operational amplifiers consisting of four independent high gain, internally frequency compensated, operational amplifiers designed to operate from a single power supply or dual power supplies over a wide range of voltages. The common mode input range includes the negative supply, thereby eliminating the necessity for external biasing components in many applications.

Features

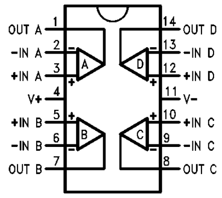
- Input common mode voltage range includes ground or negative supply
- Output voltage can swing to ground or negative supply
- Four internally compensated operational amplifiers in a single package
- Wide power supply range single supply of 3.0V to 36V dual supply of ±1.5V to ±18V
- Class AB output stage for minimal crossover distortion
- Short circuit protected outputs
- High open loop gain 200k
- LM741 operational amplifier type performance

Applications

- Filters
- Voltage controlled oscillators

Connection Diagram

14-Lead DIP and SO-14 Package



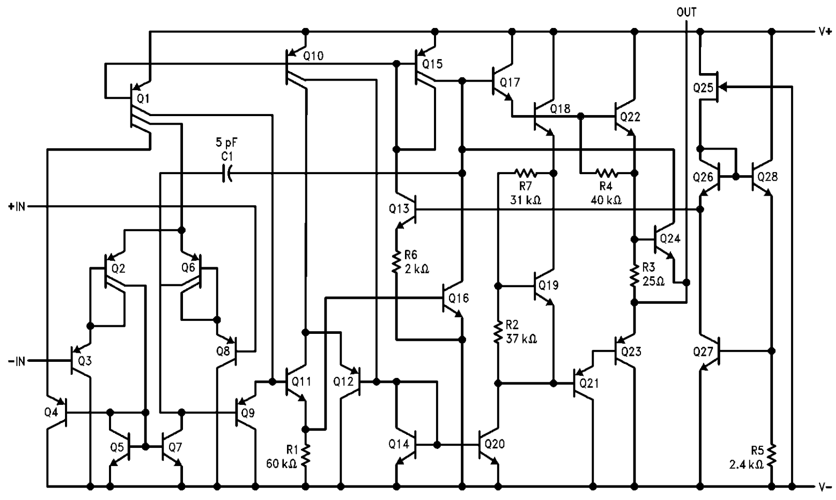
TL/H/10064–1

Top View

Order Information

Device Code	Package Code	Package Description
LM3303J	J14A	Ceramic DIP
LM3303N	N14A	Molded DIP
LM3303M	M14A	Molded Surface Mount
LM3403J	J14A	Ceramic DIP
LM3403N	N14A	Molded DIP
LM3403M	M14A	Molded Surface Mount

Equivalent Circuit (¼ of Circuit)



TL/H/10064–2

 TL/H/10064

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	
Ceramic DIP	−65°C to +175°C
Molded DIP and SO-14	−65°C to +150°C
Operating Temperature Range	
Industrial (LM3303)	−40°C to +85°C
Commercial (LM3403)	0°C to +70°C
Lead Temperature	
Ceramic DIP (Soldering, 60 sec.)	300°C
Molded DIP and SO-14 (Soldering, 10 sec.)	265°C
Internal Power Dissipation (Notes 1, 2)	
14L-Ceramic DIP	1.36W
14L-Molded DIP	1.04W
SO-14	0.93W
Supply Voltage between V+ and V−	36V
Differential Input Voltage (Note 3)	±30V
Input Voltage	(V−) − 0.3V to V+
ESD Tolerance	(To Be Determined)

LM3303 and LM3403 Electrical Characteristics

T_A = 25°C, V_{CC} = ±15V, unless otherwise specified

Symbol	Parameter		Conditions	LM3303			LM3403			Units
				Min	Typ	Max	Min	Typ	Max	
V_{IO}	Input Offset Voltage				2.0	8.0		2.0	8.0	mV
I_{IO}	Input Offset Current				30	75		30	50	nA
I_{IB}	Input Bias Current				200	500		200	500	nA
Z_I	Input Impedance			0.3	1.0		0.3	1.0		MΩ
I_{CC}	Supply Current		V_O = 0V, R_L = ∞		2.8	7.0		2.8	7.0	mA
CMR	Common Mode Rejection		R_S ≤ 10 kΩ	70	90		70	90		dB
V_{IR}	Input Voltage Range			+12V to V−	+12.5V to V−		+13V to V−	+13.5V to V−		V
PSRR	Power Supply Rejection Ratio				30	150		30	150	μV/V
I_{OS}	Output Short Circuit Current (Per Amplifier) (Note 4)			±10	±30	±45	±10	±30	±45	mA
A_{VS}	Large Signal Voltage Gain		V_O = ±10V, R_L ≥ 2.0 kΩ	20	200		20	200		V/mV
V_{OP}	Output Voltage Swing		R_L = 10 kΩ	±12	12.5		±12	+13.5		V
			R_L = 2.0 kΩ	±10	12		±10	±13		V
TR	Transient Response	Rise Time/ Fall Time	V_O = 50 mV, A_V = 1.0, R_L = 10 kΩ		0.3			0.3		μs
		Overshoot	V_O = 50 mV, A_V = 1.0, R_L = 10 kΩ		5.0			5.0		%
BW	Bandwidth		V_O = 50 mV, A_V = 1.0, R_L = 10 kΩ		1.0			1.0		MHz
SR	Slew Rate		V_I = −10V to +10V, A_V = 1.0		0.6			0.6		V/μs

LM3303 and LM3403 (Continued)

Electrical Characteristics $T_A = 25°C$, $V_{CC} = \pm 15V$, unless otherwise specified

The following specifications apply for $-40°C \leq T_A \leq +85°C$ for the LM3303, and $0°C \leq T_A \leq +70°C$ for the LM3403

Symbol	Parameter	Conditions	LM3303			LM3403			Units
			Min	Typ	Max	Min	Typ	Max	
V_{IO}	Input Offset Voltage				10			10	mV
$\Delta V_{IO}/\Delta T$	Input Offset Voltage Temperature Sensitivity			10			10		μV/°C
I_{IO}	Input Offset Current				250			200	nA
$\Delta I_{IO}/\Delta T$	Input Offset Current Temperature Sensitivity			50			50		pA/°C
I_{IB}	Input Bias Current				1000			800	nA
A_{VS}	Large Signal Voltage Gain	$V_O = \pm 10V$, $R_L \geq 2.0\ k\Omega$	15			15			V/mV
V_{OP}	Output Voltage Swing	$R_L = 2.0\ k\Omega$	±10			±10			V

LM3303 and LM3403
Electrical Characteristics $T_A = 25°C$, $V+ = 5.0V$, $V- = GND$, unless otherwise specified

Symbol	Parameter	Conditions	LM3303			LM3403			Units
			Min	Typ	Max	Min	Typ	Max	
V_{IO}	Input Offset Voltage				8.0		2.0	8.0	mV
I_{IO}	Input Offset Current				75		30	50	nA
I_{IB}	Input Bias Current				500		200	500	nA
I_{CC}	Supply Current			2.5	7.0		2.5	7.0	mA
PSRR	Power Supply Rejection Ratio				150			150	μV/V
A_{VS}	Large Signal Voltage Gain	$R_L \geq 2.0\ k\Omega$	20	200		20	200		V/mV
V_{OP}	Output Voltage Swing (Note 5)	$R_L = 10\ k\Omega$	3.3			3.3			V
		$5.0V \leq V+ \leq 30V$, $R_L = 10\ k\Omega$	(V+) −2.0			(V+) −2.0			
CS	Channel Separation	$1.0\ Hz \leq f \leq 20\ kHz$ (Input Referenced)		−120			−120		dB

Note 1: $T_{J\ Max} = 150°C$ for the Molded DIP and SO-14, and 175°C for the Ceramic DIP.

Note 2: Ratings apply to ambient temperature at 25°C. Above this temperature, derate the 14L-Ceramic DIP at 9.1 mW/°C, the 14L-Molded DIP at 8.3 mW/°C, and the SO-14 at 7.5 mW/°C.

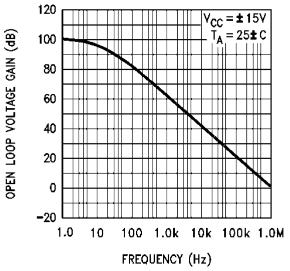
Note 3: For supply voltage less than 30V between V+ and V−, the absolute maximum input voltage is equal to the supply voltage.

Note 4: Not to exceed maximum package power dissipation.

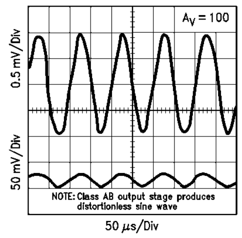
Note 5: Output will swing to ground.

Typical Performance Characteristics

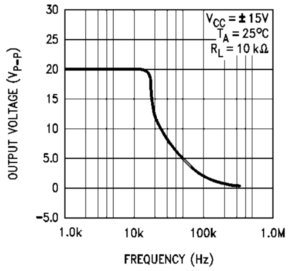
Open Loop Frequency Response



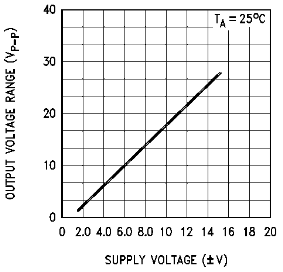
Sine Wave Response



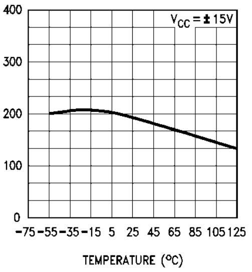
Output Voltage vs Frequency



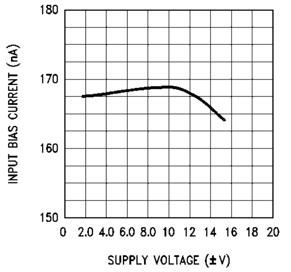
Output Swing vs Supply Voltage



Input Bias Current vs Temperature



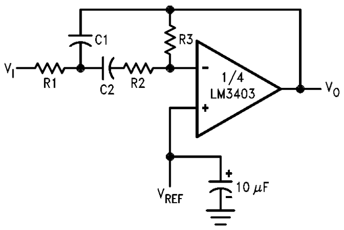
Input Bias Current vs Supply Voltage



TL/H/10064–3

Typical Applications

Multiple Feedback Bandpass Filter



TL/H/10064–4

f_o = center frequency
BW = Bandwidth
R in kΩ
C in µF

$$Q = \frac{f_o}{BW} < 10$$

$$C1 = C2 = \frac{Q}{3}$$

R1 = R2 = 1 R3 = $9Q^2 - 1$ } Using scaling factors in these expressions.

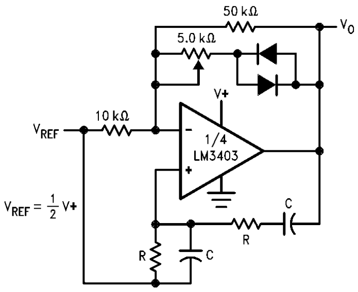
If source impedance is high or varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

Design example:

given: Q = 5, f_o = 1 kHz
Let R1 = R2 = 10 kΩ
then R3 = $9(5)^2 - 10$
R3 = 215 kΩ

$$C = \frac{5}{3} = 1.6\ \text{nF}$$

Wein Bridge Oscillator

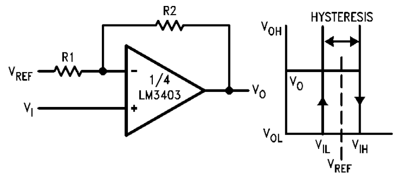


TL/H/10064–5

$$f_o = \frac{1}{2\pi RC} \text{ for } f_o = 1\ \text{kHz}$$

R = 16 kΩ
C = 0.01 µF

Comparator with Hysteresis



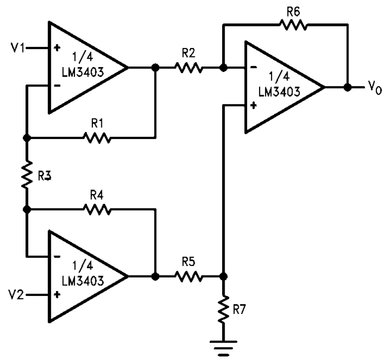
TL/H/10064–6

$$V_{IL} = \frac{R1}{R1 + R2}(V_{OL} - V_{REF}) + V_{REF}$$

$$V_{IH} = \frac{R1}{R1 + R2}(V_{OH} - V_{REF}) + V_{REF}$$

$$H = \frac{R1}{R1 + R2}(V_{OH} - V_{OL})$$

High Impedance Differential Amplifier



TL/H/10064–7

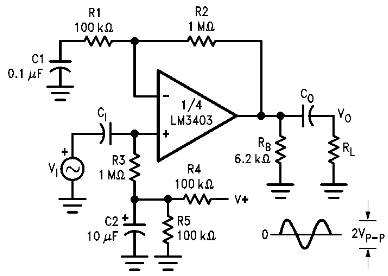
V_{OUT} = C(1 + a + b)(V2 − V1)

$$\frac{R2}{R5} \equiv \frac{R6}{R7} \text{ for best CMRR}$$

R1 = R4
R2 = R5

$$\text{Gain} = \frac{R6}{R5}\left(1 + \frac{2R1}{R3}\right) = C\,(1 + a + b)$$

AC Coupled Non-Inverting Amplifier



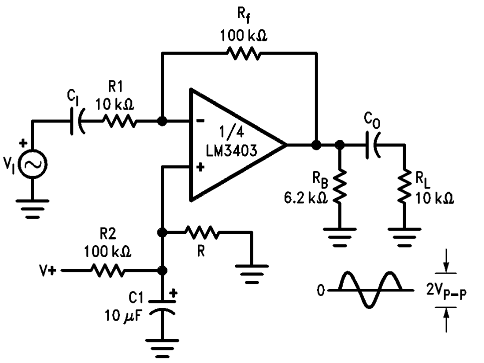
TL/H/10064–9

$$A_V = 1 + \frac{R2}{R1}$$

A_V = 11 (as shown)

Typical Applications (Continued)

AC Coupled Inverting Amplifier

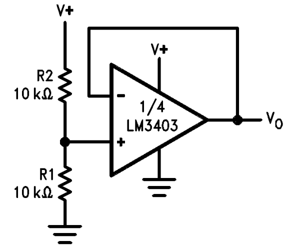


TL/H/10064–8

$A_V = \frac{Rf}{R1}$

$A_V = 10$ (as shown)

Voltage Reference

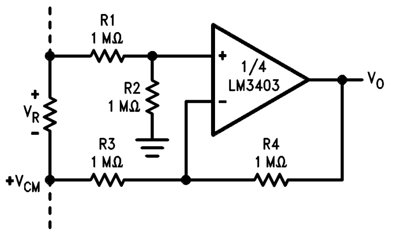


TL/H/10064–10

$V_O = \frac{R1}{R1 + R2}\left(= \frac{V+}{2} \text{ as shown}\right)$

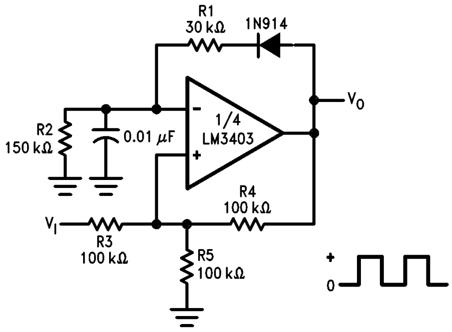
$V_O = \frac{1}{2} V+$

Ground Referencing a Differential Input Signal



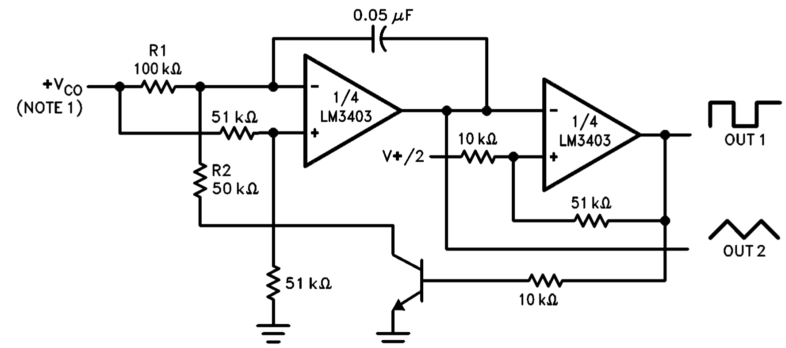
TL/H/10064–11

Pulse Generator



TL/H/10064–14

Voltage Controlled Oscillator



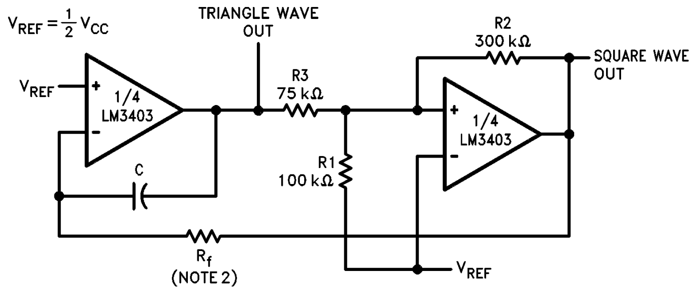
TL/H/10064–12

Note 1: Wide Control Voltage Range:

$0V \leq V_{CO} \leq 2\ (V \pm 1.5V)$

Typical Applications (Continued)

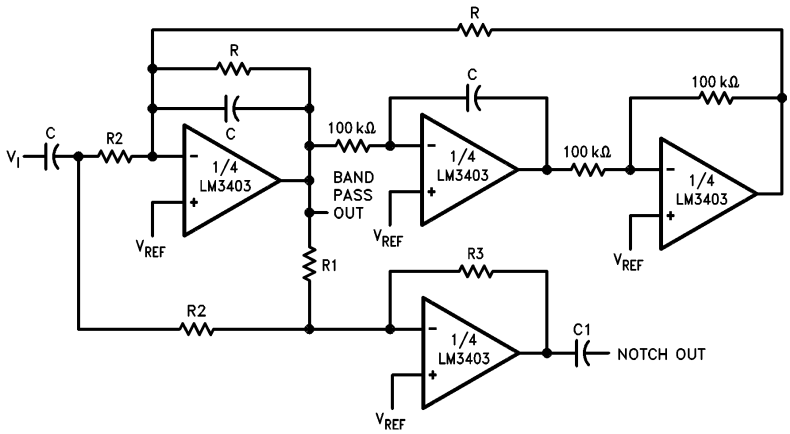
Function Generator



TL/H/10064–13

Note 2: $f = \frac{R1 + R2}{4CR_fR1}$ if $R3 = \frac{R2R1}{R2 + R1}$

Bi-Quad Filter



TL/H/10064–15

$Q = \frac{BW}{f_o}$

where:

T_{BP} = Center Frequency Gain
T_N = Bandpass Notch Gain

$f_o = \frac{1}{2\pi RC}$, $V_{REF} = \frac{1}{2} V_{CC}$

R1 = QR

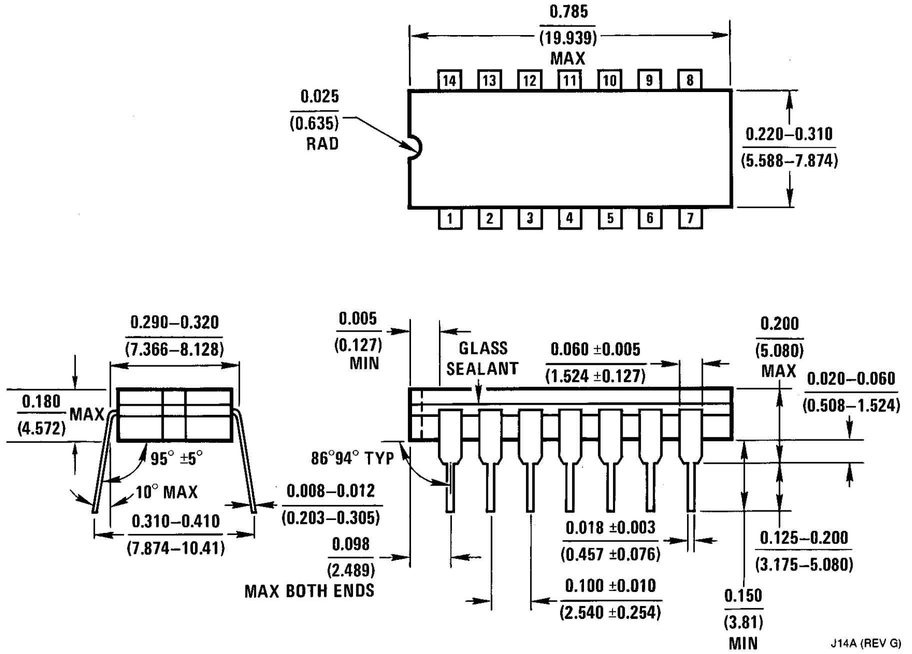
$R2 = \frac{R1}{T_{BP}}$

$R3 = T_NR2$
C1 = 10 C

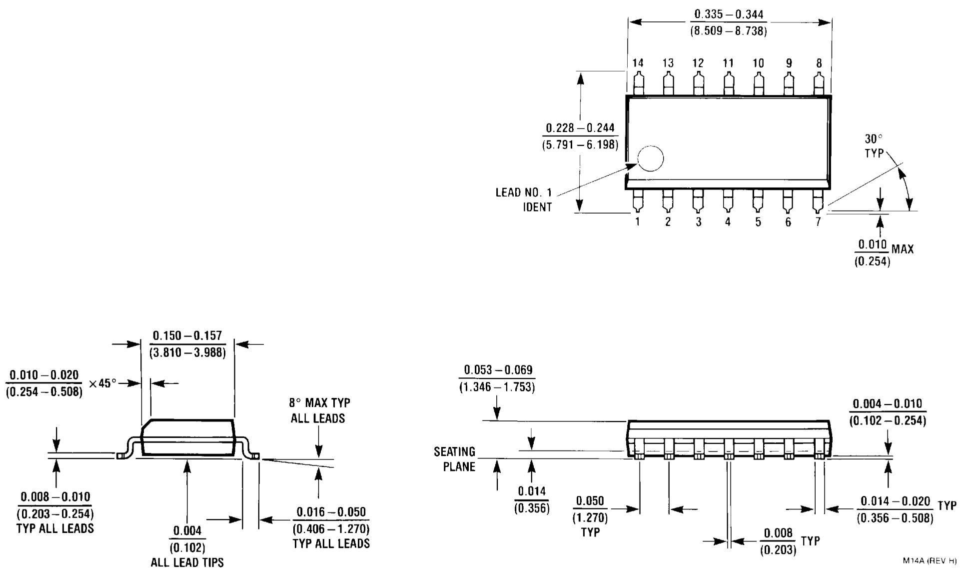
Example:

f_o = 1000 Hz
BW = 100 Hz
T_{BP} = 1
T_N = 1
R = 160 kΩ
R1 = 1.6 MΩ
R2 = 1.6 MΩ
R3 = 1.6 MΩ
C = 0.001 μF

Physical Dimensions inches (millimeters)

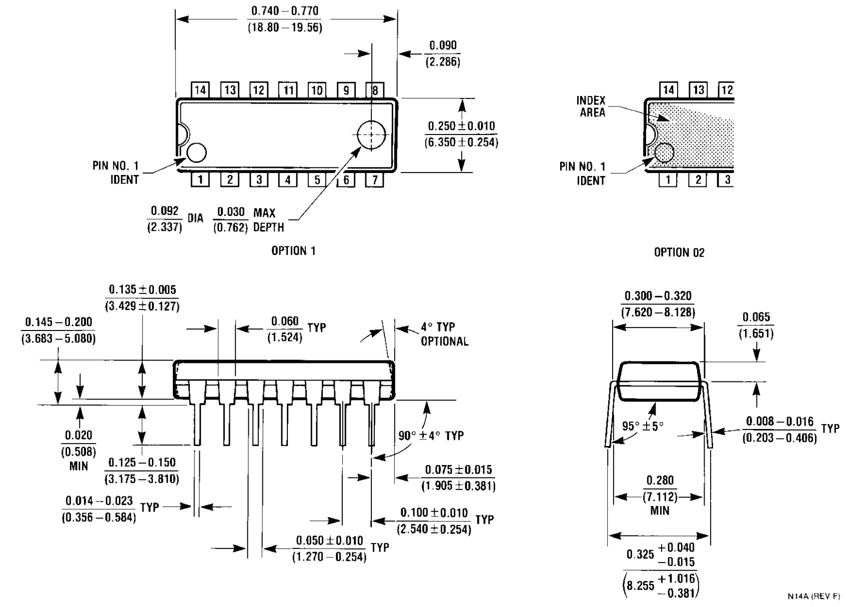


14-Lead Ceramic Dual-In-Line Package (J)
Order Number LM3303J or LM3403J
NS Package Number J14A



14-Lead Molded Surface Mount (M)
Order Number LM3403M
NS Package Number M14A

Physical Dimensions inches (millimeters) (Continued)



14-Lead Molded Dual-In-Line Package (N)
Order Number LM3303N or LM3403N
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