Low Voltage, Rail-to-Rail Operational Amplifiers

MC33201, MC33202, MC33204, NCV33201, NCV33202, NCV33204

The MC33201/2/4 family of operational amplifiers provide rail−to−rail operation on both the input and output. The inputs can be driven as high as 200 mV beyond the supply rails without phase reversal on the outputs, and the output can swing within 50 mV of each rail. This rail−to−rail operation enables the user to make full use of the supply voltage range available. It is designed to work at very low supply voltages ($\pm$ 0.9 V) yet can operate with a supply of up to +12 V and ground. Output current boosting techniques provide a high output current capability while keeping the drain current of the amplifier to a minimum. Also, the combination of low noise and distortion with a high slew rate and drive capability make this an ideal amplifier for audio applications.

Features
- Low Voltage, Single Supply Operation
  (+1.8 V and Ground to +12 V and Ground)
- Input Voltage Range Includes both Supply Rails
- Output Voltage Swings within 50 mV of both Rails
- No Phase Reversal on the Output for Over−driven Input Signals
- High Output Current (I_{SC} = 80 mA, Typ)
- Low Supply Current (I_D = 0.9 mA, Typ)
- 600 Ω Output Drive Capability
- Extended Operating Temperature Ranges
  (−40° to +105°C and −55° to +125°C)
- Typical Gain Bandwidth Product = 2.2 MHz
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable
- These Devices are Pb−Free and are RoHS Compliant

CASE 751

Micro8
DM SUFFIX
CASE 846A
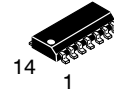
SOIC−14
D, VD SUFFIX
CASE 751A

TSSOP−14
DTB SUFFIX
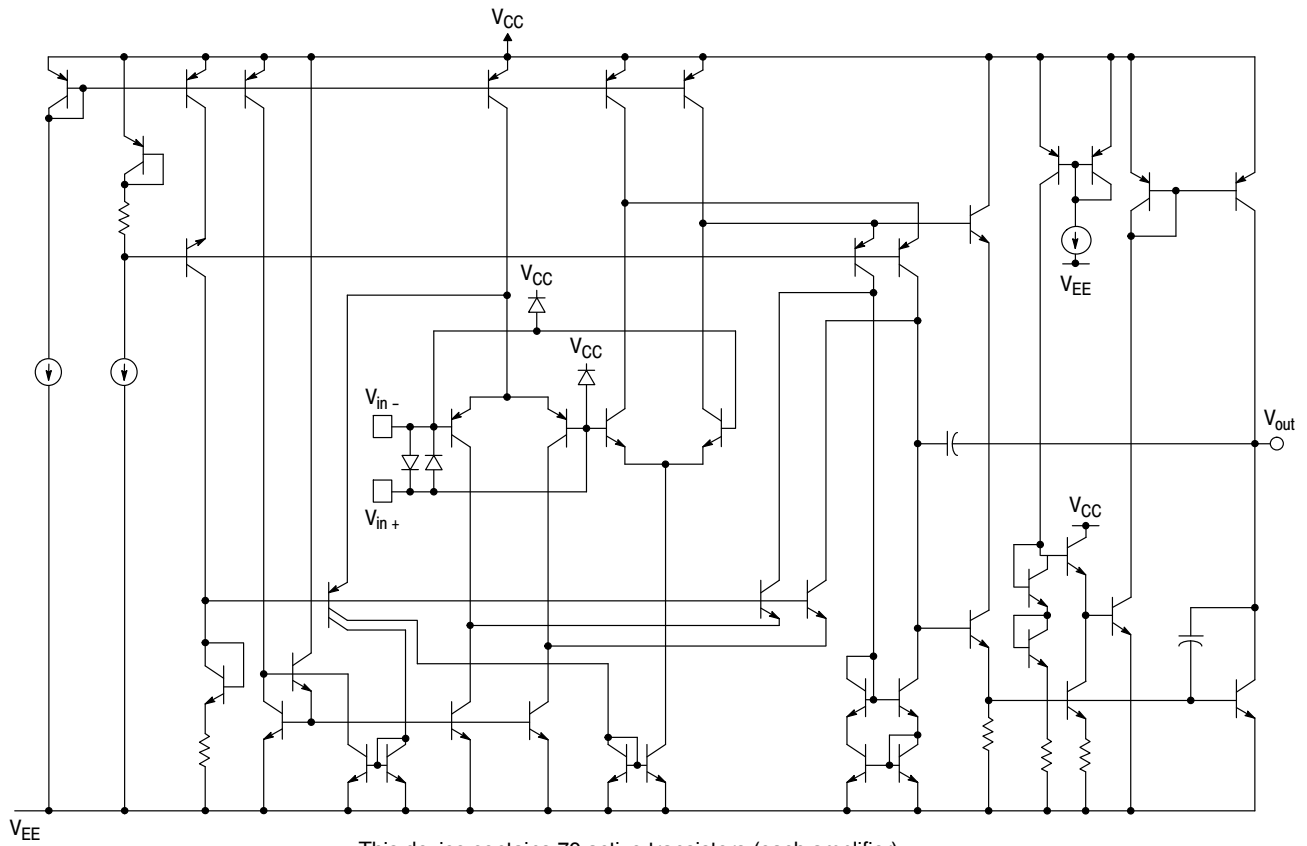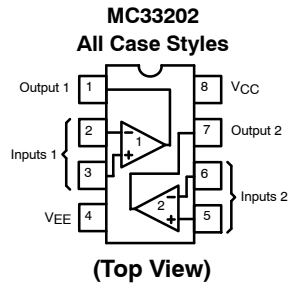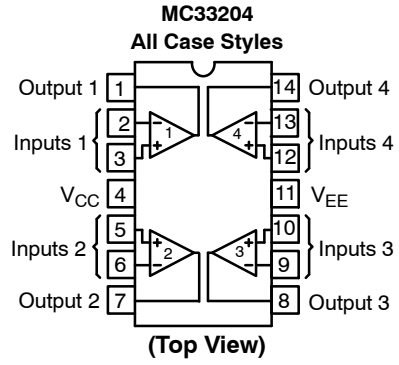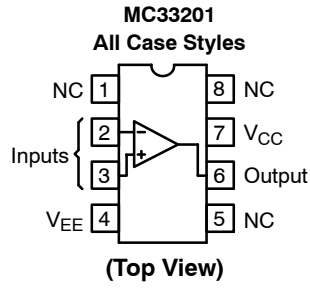**CASE 948G**

ORDERING INFORMATION
See detailed ordering and shipping information in the package dimensions section on page 10 of this data sheet.

DEVICE MARKING INFORMATION
See general marking information in the device marking section on page 10 of this data sheet.

MC33201, MC33202, MC33204, NCV33201, NCV33202, NCV33204

PIN CONNECTIONS

MC33201
All Case Styles

NC [1]   [8] NC
Inputs { [2] [7] V_{CC}
[3] [6] Output
V_{EE} [4] [5] NC

(Top View)

MC33204
All Case Styles

Output 1 [1]   [14] Output 4
Inputs 1 { [2] 1   [13] } Inputs 4
[3]   [12]
V_{CC} [4]   [11] V_{EE}
Inputs 2 { [5] 2   [10] } Inputs 3
[6]   [9]
Output 2 [7]   [8] Output 3

(Top View)

MC33202
All Case Styles

Output 1 [1]   [8] V_{CC}
Inputs 1 { [2] 1   [7] Output 2
[3]   [6]
V_{EE} [4]   [5] } Inputs 2

(Top View)

This device contains 70 active transistors (each amplifier).

Figure 1. Circuit Schematic
(Each Amplifier)

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage (V_{CC} to V_{EE})	V_S	+13	V
Input Differential Voltage Range	V_{IDR}	Note 1	V
Common Mode Input Voltage Range (Note 2)	V_{CM}	V_{CC} + 0.5 V to V_{EE} − 0.5 V	V
Output Short Circuit Duration	t_s	Note 3	sec
Maximum Junction Temperature	T_J	+150	°C
Storage Temperature	T_{stg}	− 65 to +150	°C
Maximum Power Dissipation	P_D	Note 3	mW

DC ELECTRICAL CHARACTERISTICS (T_A = 25°C)

Characteristic	V_{CC} = 2.0 V	V_{CC} = 3.3 V	V_{CC} = 5.0 V	Unit
Input Offset Voltage $V_{IO\ (max)}$ MC33201, NCV33201V MC33202, NCV33202, V MC33204, NCV33204, V	 ± 8.0 ±10 ±12	 ± 8.0 ±10 ±12	 ± 6.0 ± 8.0 ±10	mV
Output Voltage Swing V_{OH} (R_L = 10 kΩ) V_{OL} (R_L = 10 kΩ)	 1.9 0.10	 3.15 0.15	 4.85 0.15	 V_{min} V_{max}
Power Supply Current per Amplifier (I_D)	 1.125	 1.125	 1.125	mA

Specifications at V_{CC} = 3.3 V are guaranteed by the 2.0 V and 5.0 V tests. V_{EE} = GND.

DC ELECTRICAL CHARACTERISTICS (V_{CC} = + 5.0 V, V_{EE} = Ground, T_A = 25°C, unless otherwise noted.)

Characteristic	Figure	Symbol	Min	Typ	Max	Unit
Input Offset Voltage (V_{CM} 0 V to 0.5 V, V_{CM} 1.0 V to 5.0 V)	3	$\lvert V_{IO} \rvert$				mV
MC33201/NCV33201V: T_A = + 25°C			−	−	6.0	
MC33201: T_A = − 40° to +105°C			−	−	9.0	
MC33201V/NCV33201V: T_A = − 55° to +125°C			−	−	13	
MC33202/NCV33202, V: T_A = + 25°C			−	−	8.0	
MC33202/NCV33202: T_A = − 40° to +105°C			−	−	11	
MC33202V/NCV33202V: T_A = − 55° to +125°C (Note 4)			−	−	14	
MC33204/NCV33204V: T_A = + 25°C			−	−	10	
MC33204: T_A = − 40° to +105°C			−	−	13	
MC33204V/NCV33204V: T_A = − 55° to +125°C (Note 4)			−	−	17	
Input Offset Voltage Temperature Coefficient (R_S = 50 Ω)	4	$\Delta V_{IO}/\Delta T$				µV/°C
T_A = − 40° to +105°C			−	2.0	−	
T_A = − 55° to +125°C			−	2.0	−	
Input Bias Current (V_{CM} = 0 V to 0.5 V, V_{CM} = 1.0 V to 5.0 V)	5, 6	$\lvert I_{IB} \rvert$				nA
T_A = + 25°C			−	80	200	
T_A = − 40° to +105°C			−	100	250	
T_A = − 55° to +125°C			−	−	500	

Stresses exceeding those listed in the Maximum Ratings table may damage the device. If any of these limits are exceeded, device functionality should not be assumed, damage may occur and reliability may be affected.

1. The differential input voltage of each amplifier is limited by two internal parallel back−to−back diodes. For additional differential input voltage range, use current limiting resistors in series with the input pins.
2. The input common mode voltage range is limited by internal diodes connected from the inputs to both supply rails. Therefore, the voltage on either input must not exceed either supply rail by more than 500 mV.
3. Power dissipation must be considered to ensure maximum junction temperature (T_J) is not exceeded. (See Figure 2)
4. *All NCV devices are qualified for Automotive use.*

DC ELECTRICAL CHARACTERISTICS (cont.) (V_{CC} = + 5.0 V, V_{EE} = Ground, T_A = 25°C, unless otherwise noted.)

Characteristic	Figure	Symbol	Min	Typ	Max	Unit
Input Offset Current (V_{CM} = 0 V to 0.5 V, V_{CM} = 1.0 V to 5.0 V) T_A = + 25°C T_A = − 40° to +105°C T_A = − 55° to +125°C	–	$\lvert I_{IO} \rvert$	 – – –	 5.0 10 –	 50 100 200	nA
Common Mode Input Voltage Range	–	V_{ICR}	V_{EE}	–	V_{CC}	V
Large Signal Voltage Gain (V_{CC} = + 5.0 V, V_{EE} = − 5.0 V) R_L = 10 kΩ R_L = 600 Ω	7	A_{VOL}	 50 25	 300 250	 – –	kV/V
Output Voltage Swing (V_{ID} = ± 0.2 V) R_L = 10 kΩ R_L = 10 kΩ R_L = 600 Ω R_L = 600 Ω	8, 9, 10	 V_{OH} V_{OL} V_{OH} V_{OL}	 4.85 – 4.75 –	 4.95 0.05 4.85 0.15	 – 0.15 – 0.25	V
Common Mode Rejection (V_{in} = 0 V to 5.0 V)	11	CMR	60	90	–	dB
Power Supply Rejection Ratio V_{CC}/V_{EE} = 5.0 V/GND to 3.0 V/GND	12	PSRR	 500	 25	 –	μV/V
Output Short Circuit Current (Source and Sink)	13, 14	I_{SC}	50	80	–	mA
Power Supply Current per Amplifier (V_O = 0 V) T_A = − 40° to +105°C T_A = − 55° to +125°C	15	I_D	 – –	 0.9 0.9	 1.125 1.125	mA

AC ELECTRICAL CHARACTERISTICS (V_{CC} = + 5.0 V, V_{EE} = Ground, T_A = 25°C, unless otherwise noted.)

Characteristic	Figure	Symbol	Min	Typ	Max	Unit
Slew Rate (V_S = ± 2.5 V, V_O = − 2.0 V to + 2.0 V, R_L = 2.0 kΩ, A_V = +1.0)	16, 26	SR	 0.5	 1.0	 –	V/μs
Gain Bandwidth Product (f = 100 kHz)	17	GBW	–	2.2	–	MHz
Gain Margin (R_L = 600 Ω, C_L = 0 pF)	20, 21, 22	A_M	–	12	–	dB
Phase Margin (R_L = 600 Ω, C_L = 0 pF)	20, 21, 22	$\emptyset_M$	–	65	–	Deg
Channel Separation (f = 1.0 Hz to 20 kHz, A_V = 100)	23	CS	–	90	–	dB
Power Bandwidth (V_O = 4.0 V_{pp}, R_L = 600 Ω, THD ≤ 1 %)		BW_P	–	28	–	kHz
Total Harmonic Distortion (R_L = 600 Ω, V_O = 1.0 V_{pp}, A_V = 1.0) f = 1.0 kHz f = 10 kHz	24	THD	 – –	 0.002 0.008	 – –	%
Open Loop Output Impedance (V_O = 0 V, f = 2.0 MHz, A_V = 10)		$\lvert Z_O \rvert$	 –	 100	 –	Ω
Differential Input Resistance (V_{CM} = 0 V)		R_{in}	–	200	–	kΩ
Differential Input Capacitance (V_{CM} = 0 V)		C_{in}	–	8.0	–	pF
Equivalent Input Noise Voltage (R_S = 100 Ω) f = 10 Hz f = 1.0 kHz	25	e_n	 – –	 25 20	 – –	nV/$\sqrt{\text{Hz}}$
Equivalent Input Noise Current f = 10 Hz f = 1.0 kHz	25	i_n	 – –	 0.8 0.2	 – –	pA/$\sqrt{\text{Hz}}$

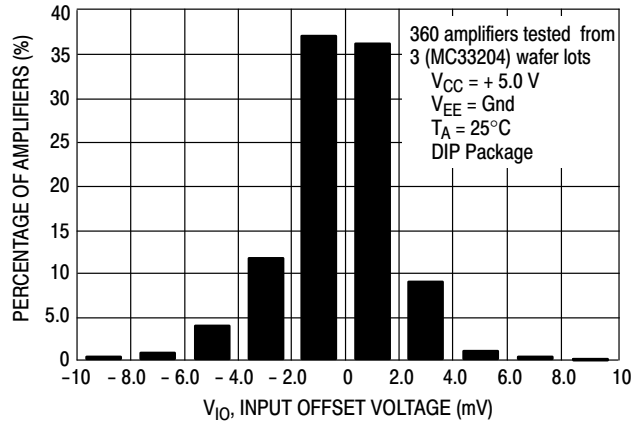**Figure 2. Maximum Power Dissipation versus Temperature**

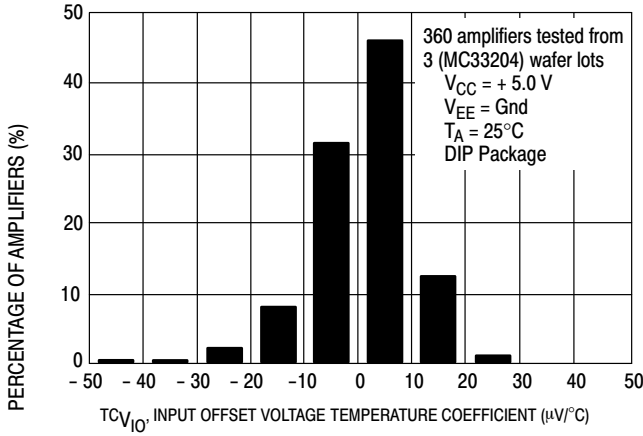**Figure 3. Input Offset Voltage Distribution**

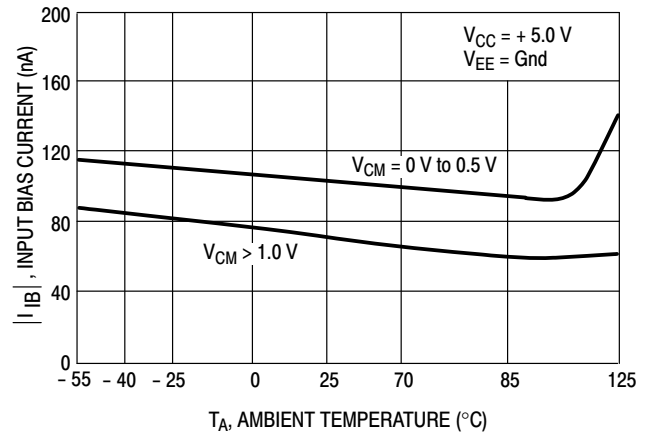**Figure 4. Input Offset Voltage Temperature Coefficient Distribution**
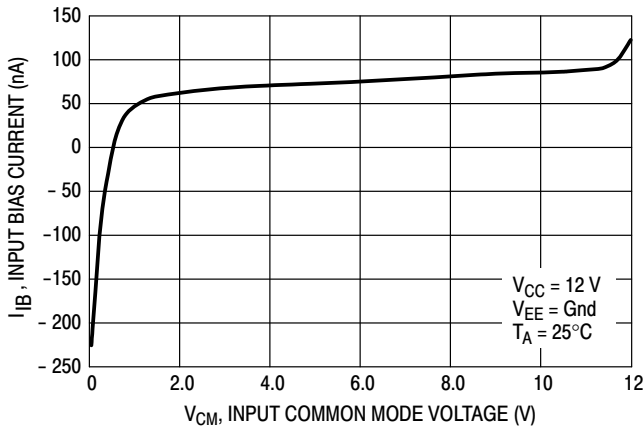

Figure 5. Input Bias Current versus Temperature

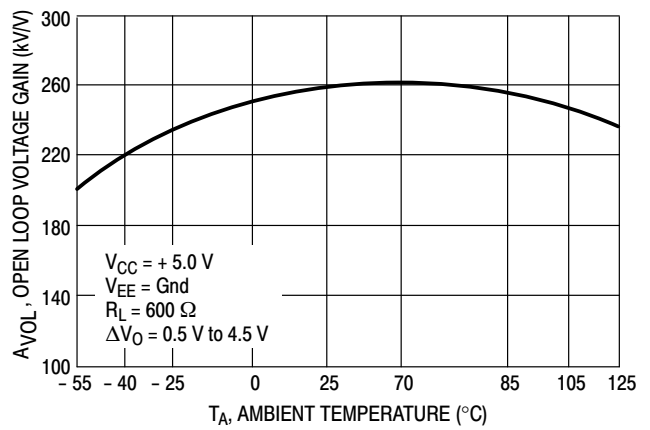**Figure 6. Input Bias Current versus Common Mode Voltage**

Figure 7. Open Loop Voltage Gain versus Temperature
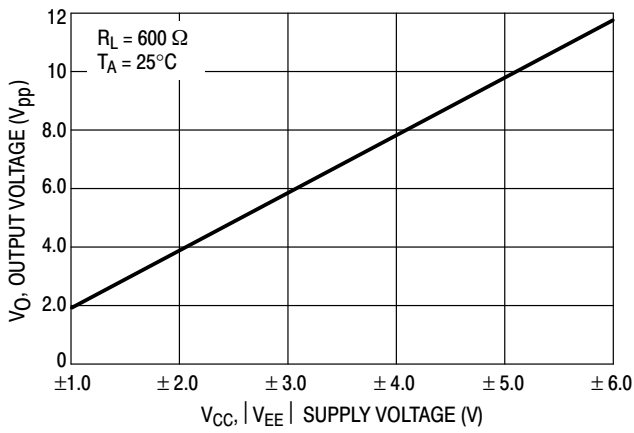
**Figure 8. Output Voltage Swing
versus Supply Voltage**
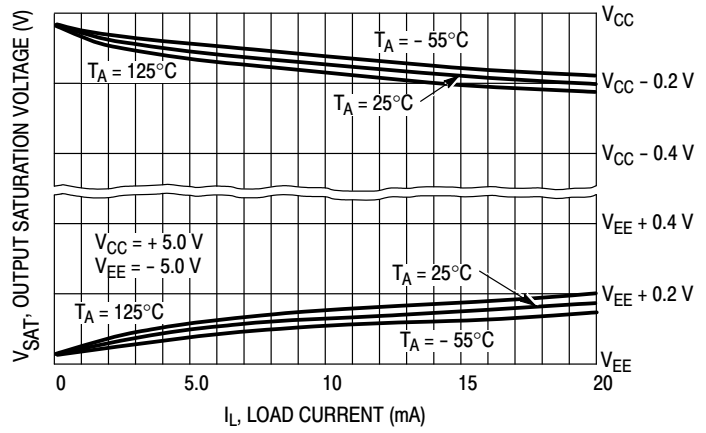
**Figure 9. Output Saturation Voltage
versus Load Current**
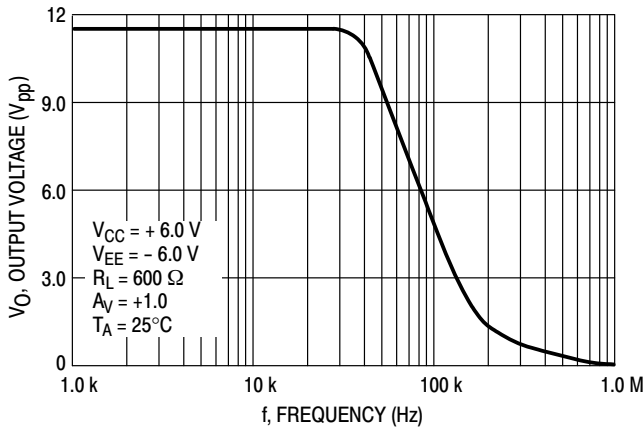
**Figure 10. Output Voltage
versus Frequency**
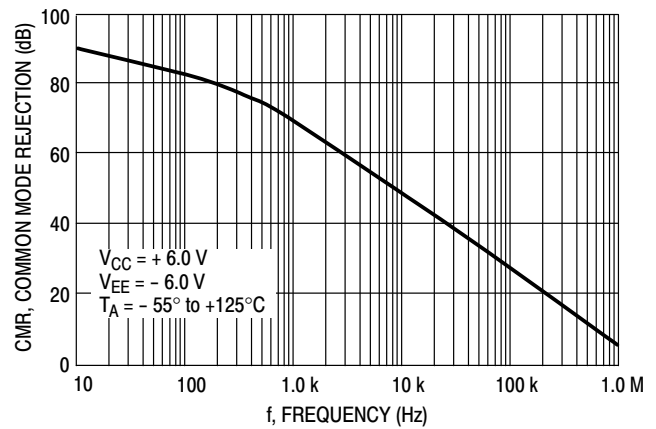
**Figure 11. Common Mode Rejection
versus Frequency**
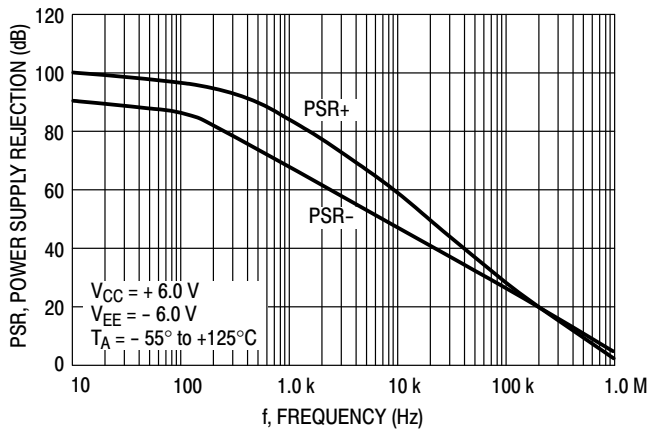
**Figure 12. Power Supply Rejection
versus Frequency**
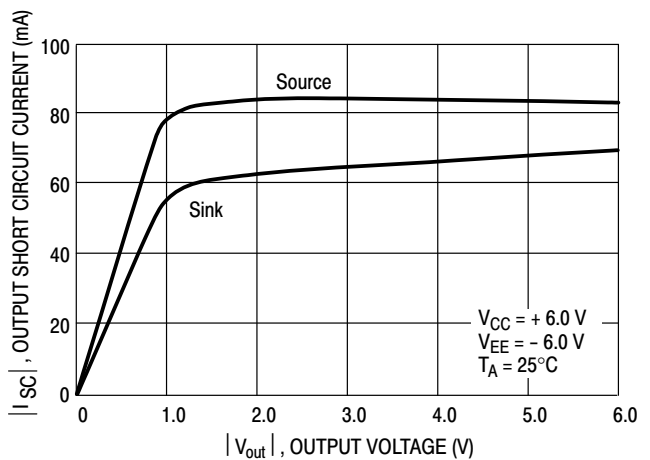
**Figure 13. Output Short Circuit Current
versus Output Voltage**
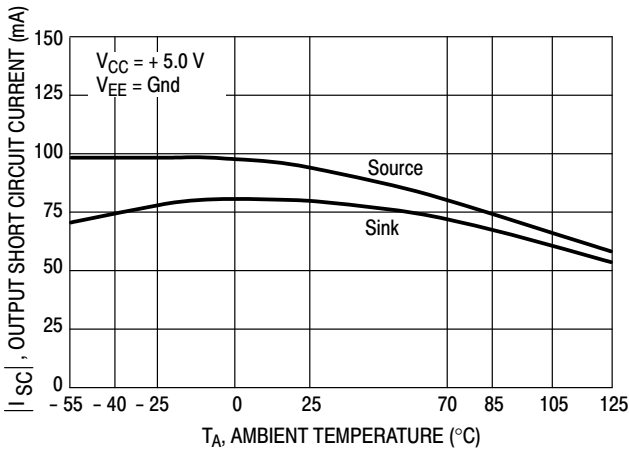
Figure 14. Output Short Circuit Current versus Temperature
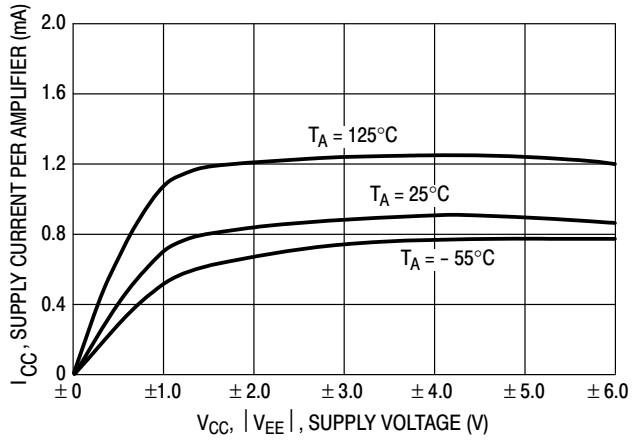
Figure 15. Supply Current per Amplifier versus Supply Voltage with No Load
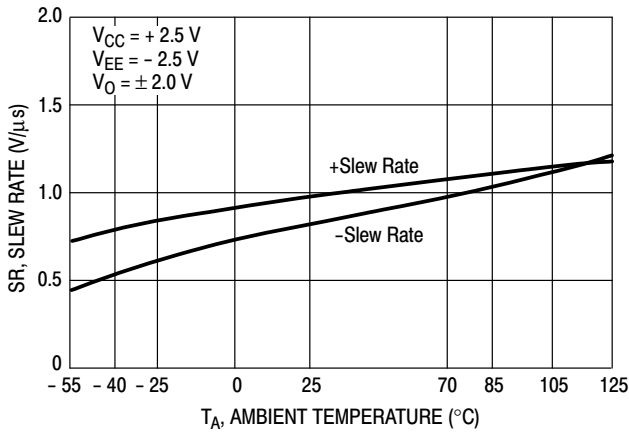
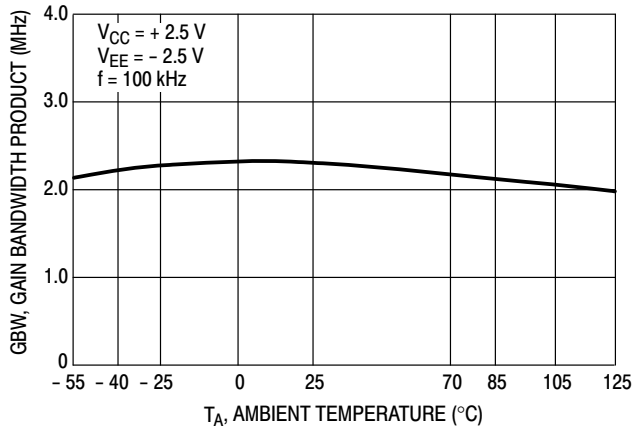

Figure 16. Slew Rate versus Temperature

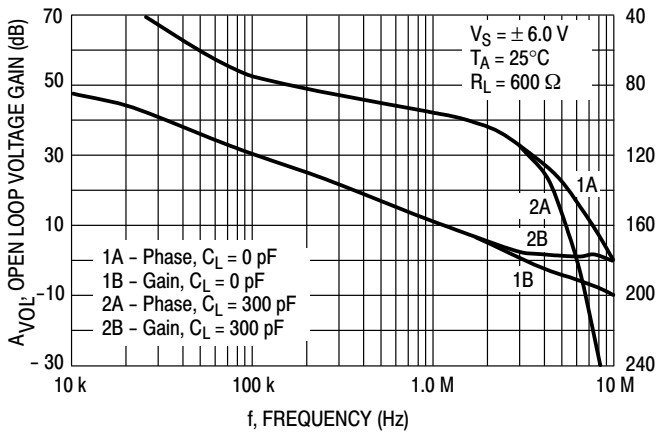**Figure 17. Gain Bandwidth Product versus Temperature**

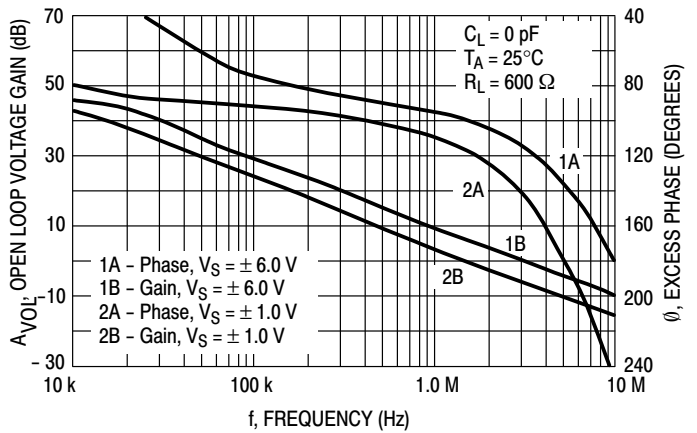**Figure 18. Voltage Gain and Phase versus Frequency**

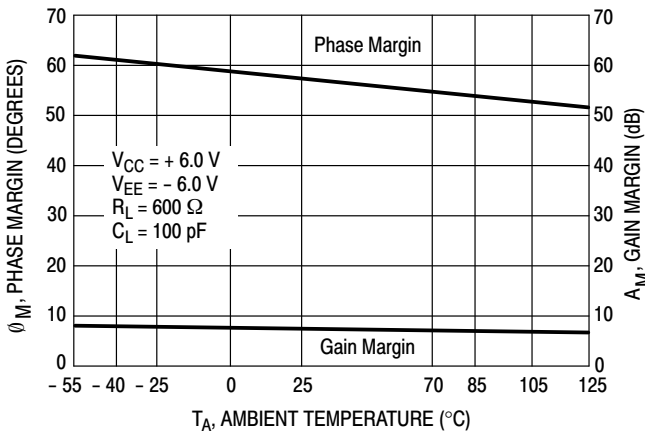**Figure 19. Voltage Gain and Phase versus Frequency**

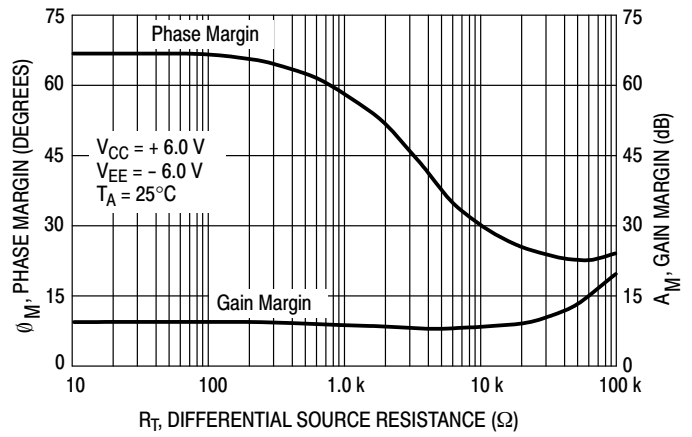**Figure 20. Gain and Phase Margin versus Temperature**

Figure 21. Gain and Phase Margin versus Differential Source Resistance
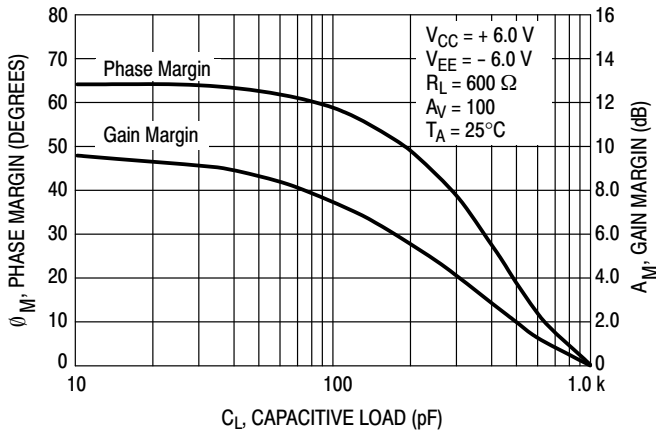

Figure 22. Gain and Phase Margin versus Capacitive Load
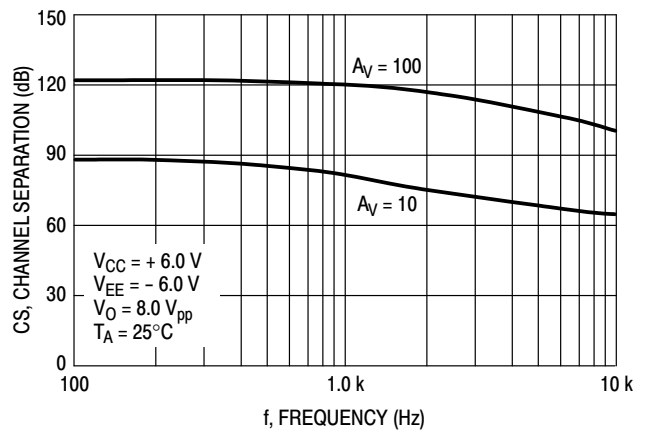

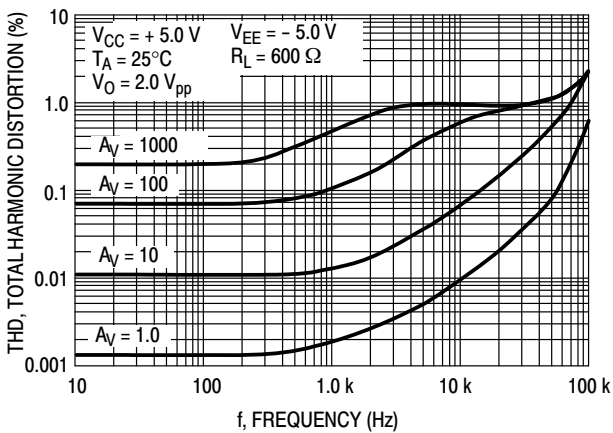**Figure 23. Channel Separation versus Frequency**

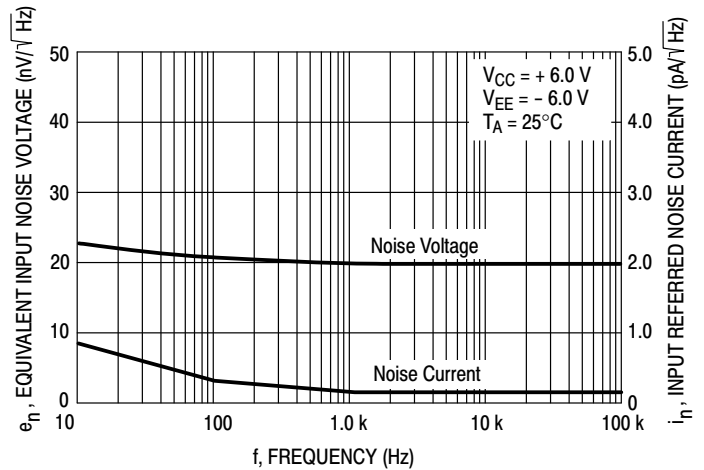**Figure 24. Total Harmonic Distortion versus Frequency**

Figure 25. Equivalent Input Noise Voltage and Current versus Frequency

DETAILED OPERATING DESCRIPTION

General Information

The MC33201/2/4 family of operational amplifiers are unique in their ability to swing rail−to−rail on both the input and the output with a completely bipolar design. This offers low noise, high output current capability and a wide common mode input voltage range even with low supply voltages. Operation is guaranteed over an extended temperature range and at supply voltages of 2.0 V, 3.3 V and 5.0 V and ground.

Since the common mode input voltage range extends from V_{CC} to V_{EE}, it can be operated with either single or split voltage supplies. The MC33201/2/4 are guaranteed not to latch or phase reverse over the entire common mode range, however, the inputs should not be allowed to exceed maximum ratings.

Circuit Information

Rail−to−rail performance is achieved at the input of the amplifiers by using parallel NPN−PNP differential input stages. When the inputs are within 800 mV of the negative rail, the PNP stage is on. When the inputs are more than 800 mV greater than V_{EE}, the NPN stage is on. This switching of input pairs will cause a reversal of input bias currents (see Figure 6). Also, slight differences in offset voltage may be noted between the NPN and PNP pairs. Cross−coupling techniques have been used to keep this change to a minimum.

In addition to its rail−to−rail performance, the output stage is current boosted to provide 80 mA of output current, enabling the op amp to drive 600 Ω loads. Because of this high output current capability, care should be taken not to exceed the 150°C maximum junction temperature.
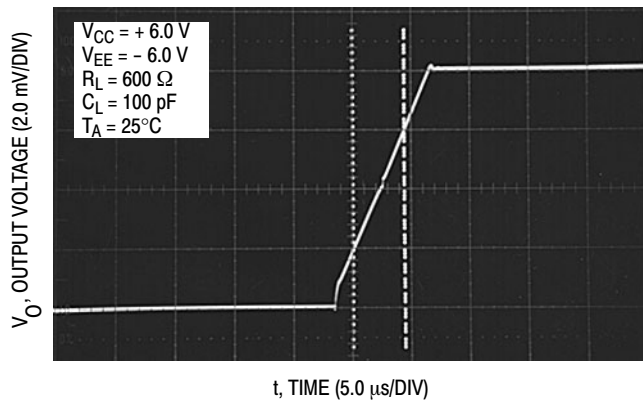
Figure 26. Noninverting Amplifier Slew Rate

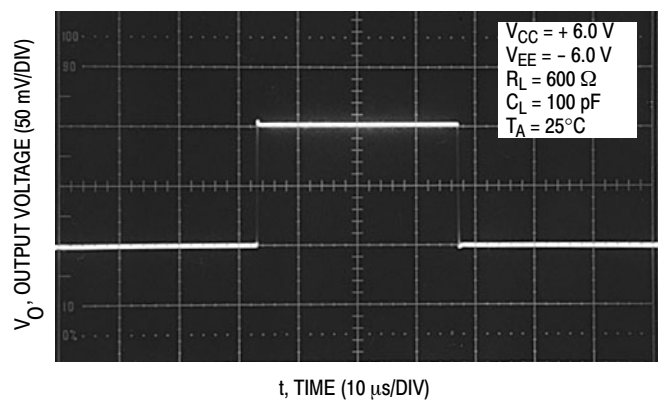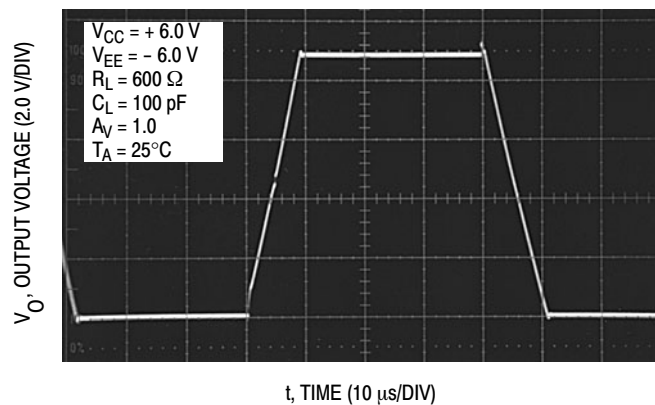Figure 27. Small Signal Transient Response

Figure 28. Large Signal Transient Response

Surface mount board layout is a critical portion of the total design. The footprint for the semiconductor packages must be the correct size to ensure proper solder connection interface between the board and the package. With the correct pad geometry, the packages will self−align when subjected to a solder reflow process.

ORDERING INFORMATION

Operational Amplifier Function	Device	Operating Temperature Range	Package	Shipping[†]
Single	MC33201DR2G	$T_A = -40°$ to $+105°C$	SOIC−8 (Pb−Free)	2500 / Tape & Reel
	MC33201VDR2G	$T_A = -55°$ to $125°C$		2500 / Tape & Reel
	NCV33201VDR2G			2500 / Tape & Reel
Dual	MC33202DR2G	$T_A = -40°$ to $+105°C$	SOIC−8 (Pb−Free)	2500 / Tape & Reel
	MC33202DMR2G		Micro−8 (Pb−Free)	4000 / Tape & Reel
	NCV33202DMR2G*			
	MC33202VDR2G	$T_A = -55°$ to $125°C$	SOIC−8 (Pb−Free)	2500 / Tape & Reel
	NCV33202VDR2G*			
Quad	MC33204DR2G	$T_A = -40°$ to $+105°C$	SO−14 (Pb−Free)	2500 Units / Tape & Reel
	MC33204DTBR2G		TSSOP−14 (Pb−Free)	2500 Units / Tape & Reel
	NCV33204DR2G*	$T_A = -55°$ to $125°C$	SO−14 (Pb−Free)	2500 Units / Tape & Reel
	NCV33204DTBR2G*		TSSOP−14 (Pb−Free)	2500 Units / Tape & Reel

†For information on tape and reel specifications, including part orientation and tape sizes, please refer to our Tape and Reel Packaging Specifications Brochure, BRD8011/D.
*NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable.

MARKING DIAGRAMS

SOIC−8
D SUFFIX
CASE 751

3320x
ALYW

SOIC−8
VD SUFFIX
CASE 751

 *

320xV
ALYW

TSSOP−14
DTB SUFFIX
CASE 948G

MC33
204
ALYW▪

 *

MC33
204V
ALYW▪

Micro−8
DM SUFFIX
CASE 846A

 **

3202
AYW▪

SO−14
D SUFFIX
CASE 751A

MC33204DG
AWLYWW

SO−14
VD SUFFIX
CASE 751A

 *

MC33204VDG
AWLYWW
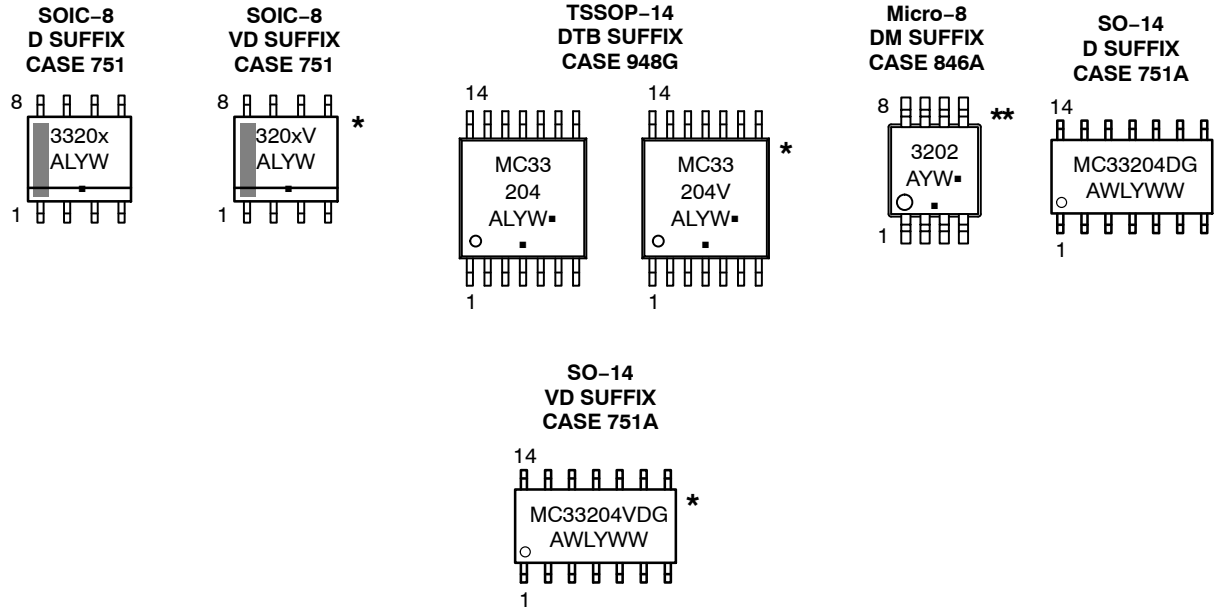
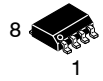|	
x	= 1 or 2
A	= Assembly Location
WL, L	= Wafer Lot
YY, Y	= Year
WW, W	= Work Week
G	= Pb−Free Package
▪	= Pb−Free Package

(Note: Microdot may be in either location)
*This marking diagram applies to NCV3320xV
**This marking diagram applies to NCV33202DMR2G
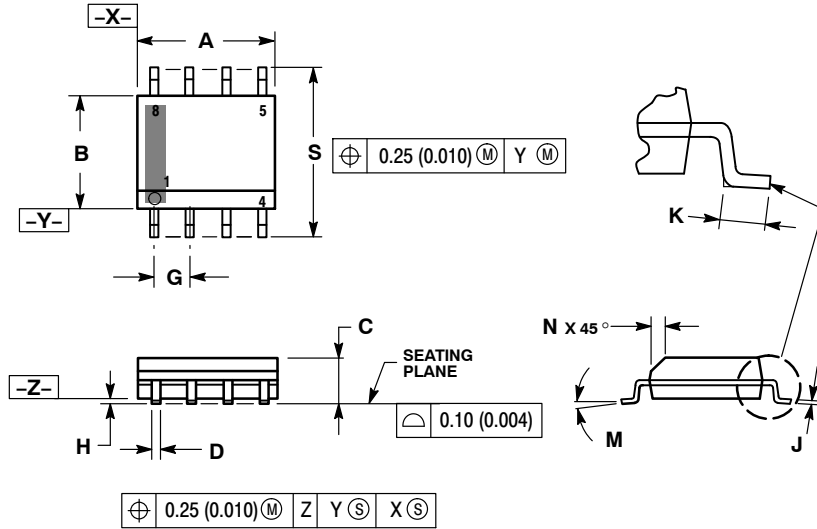
MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS
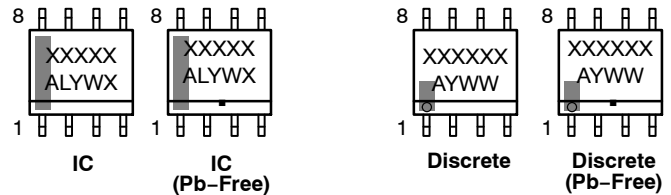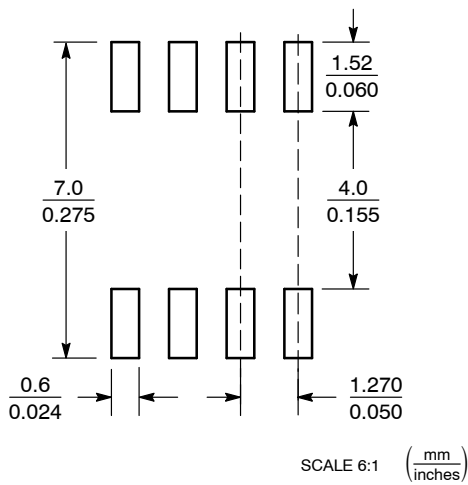
SOIC−8 NB
CASE 751−07
ISSUE AK

SCALE 1:1

8

1

DATE 16 FEB 2011

$\oplus$ | 0.25 (0.010) Ⓜ | Y | Ⓜ

$\oplus$ | 0.10 (0.004)

$\oplus$ | 0.25 (0.010) Ⓜ | Z | Y Ⓢ | X Ⓢ

N X 45°

SEATING PLANE

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0 °	8 °	0 °	8 °
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

SOLDERING FOOTPRINT*

1.52 / 0.060

7.0 / 0.275

4.0 / 0.155

0.6 / 0.024

1.270 / 0.050

SCALE 6:1 $\left(\dfrac{mm}{inches}\right)$

GENERIC MARKING DIAGRAM*

8 | XXXXX ALYWX | 1

IC

8 | XXXXX ALYWX | 1

IC (Pb−Free)

8 | XXXXXX AYWW | 1

Discrete

8 | XXXXXX AYWW | 1

Discrete (Pb−Free)

XXXXX = Specific Device Code
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb−Free Package

XXXXXX = Specific Device Code
A = Assembly Location
Y = Year
WW = Work Week
▪ = Pb−Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, "G" or microdot "▪", may or may not be present. Some products may not follow the Generic Marking.

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

STYLES ON PAGE 2

SOIC−8 NB
CASE 751−07
ISSUE AK

STYLE 1:
PIN 1. EMITTER
2. COLLECTOR
3. COLLECTOR
4. EMITTER
5. EMITTER
6. BASE
7. BASE
8. EMITTER

STYLE 2:
PIN 1. COLLECTOR, DIE, #1
2. COLLECTOR, #1
3. COLLECTOR, #2
4. COLLECTOR, #2
5. BASE, #2
6. EMITTER, #2
7. BASE, #1
8. EMITTER, #1

STYLE 3:
PIN 1. DRAIN, DIE #1
2. DRAIN, #1
3. DRAIN, #2
4. DRAIN, #2
5. GATE, #2
6. SOURCE, #2
7. GATE, #1
8. SOURCE, #1

STYLE 4:
PIN 1. ANODE
2. ANODE
3. ANODE
4. ANODE
5. ANODE
6. ANODE
7. ANODE
8. COMMON CATHODE

STYLE 5:
PIN 1. DRAIN
2. DRAIN
3. DRAIN
4. DRAIN
5. GATE
6. GATE
7. SOURCE
8. SOURCE

STYLE 6:
PIN 1. SOURCE
2. DRAIN
3. DRAIN
4. SOURCE
5. SOURCE
6. GATE
7. GATE
8. SOURCE

STYLE 7:
PIN 1. INPUT
2. EXTERNAL BYPASS
3. THIRD STAGE SOURCE
4. GROUND
5. DRAIN
6. GATE 3
7. SECOND STAGE Vd
8. FIRST STAGE Vd

STYLE 8:
PIN 1. COLLECTOR, DIE #1
2. BASE, #1
3. BASE, #2
4. COLLECTOR, #2
5. COLLECTOR, #2
6. EMITTER, #2
7. EMITTER, #1
8. COLLECTOR, #1

STYLE 9:
PIN 1. EMITTER, COMMON
2. COLLECTOR, DIE #1
3. COLLECTOR, DIE #2
4. EMITTER, COMMON
5. EMITTER, COMMON
6. BASE, DIE #2
7. BASE, DIE #1
8. EMITTER, COMMON

STYLE 10:
PIN 1. GROUND
2. BIAS 1
3. OUTPUT
4. GROUND
5. GROUND
6. BIAS 2
7. INPUT
8. GROUND

STYLE 11:
PIN 1. SOURCE 1
2. GATE 1
3. SOURCE 2
4. GATE 2
5. DRAIN 2
6. DRAIN 2
7. DRAIN 1
8. DRAIN 1

STYLE 12:
PIN 1. SOURCE
2. SOURCE
3. SOURCE
4. GATE
5. DRAIN
6. DRAIN
7. DRAIN
8. DRAIN

STYLE 13:
PIN 1. N.C.
2. SOURCE
3. SOURCE
4. GATE
5. DRAIN
6. DRAIN
7. DRAIN
8. DRAIN

STYLE 14:
PIN 1. N−SOURCE
2. N−GATE
3. P−SOURCE
4. P−GATE
5. P−DRAIN
6. P−DRAIN
7. N−DRAIN
8. N−DRAIN

STYLE 15:
PIN 1. ANODE 1
2. ANODE 1
3. ANODE 1
4. ANODE 1
5. CATHODE, COMMON
6. CATHODE, COMMON
7. CATHODE, COMMON
8. CATHODE, COMMON

STYLE 16:
PIN 1. EMITTER, DIE #1
2. BASE, DIE #1
3. EMITTER, DIE #2
4. BASE, DIE #2
5. COLLECTOR, DIE #2
6. COLLECTOR, DIE #2
7. COLLECTOR, DIE #1
8. COLLECTOR, DIE #1

STYLE 17:
PIN 1. VCC
2. V2OUT
3. V1OUT
4. TXE
5. RXE
6. VEE
7. GND
8. ACC

STYLE 18:
PIN 1. ANODE
2. ANODE
3. SOURCE
4. GATE
5. DRAIN
6. DRAIN
7. CATHODE
8. CATHODE

STYLE 19:
PIN 1. SOURCE 1
2. GATE 1
3. SOURCE 2
4. GATE 2
5. DRAIN 2
6. MIRROR 2
7. DRAIN 1
8. MIRROR 1

STYLE 20:
PIN 1. SOURCE (N)
2. GATE (N)
3. SOURCE (P)
4. GATE (P)
5. DRAIN
6. DRAIN
7. DRAIN
8. DRAIN

STYLE 21:
PIN 1. CATHODE 1
2. CATHODE 2
3. CATHODE 3
4. CATHODE 4
5. CATHODE 5
6. COMMON ANODE
7. COMMON ANODE
8. CATHODE 6

STYLE 22:
PIN 1. I/O LINE 1
2. COMMON CATHODE/VCC
3. COMMON CATHODE/VCC
4. I/O LINE 3
5. COMMON ANODE/GND
6. I/O LINE 4
7. I/O LINE 5
8. COMMON ANODE/GND

STYLE 23:
PIN 1. LINE 1 IN
2. COMMON ANODE/GND
3. COMMON ANODE/GND
4. LINE 2 IN
5. LINE 2 OUT
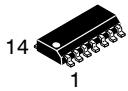6. COMMON ANODE/GND
7. COMMON ANODE/GND
8. LINE 1 OUT

STYLE 24:
PIN 1. BASE
2. EMITTER
3. COLLECTOR/ANODE
4. COLLECTOR/ANODE
5. CATHODE
6. CATHODE
7. COLLECTOR/ANODE
8. COLLECTOR/ANODE

STYLE 25:
PIN 1. VIN
2. N/C
3. REXT
4. GND
5. IOUT
6. IOUT
7. IOUT
8. IOUT

STYLE 26:
PIN 1. GND
2. dv/dt
3. ENABLE
4. ILIMIT
5. SOURCE
6. SOURCE
7. SOURCE
8. VCC

STYLE 27:
PIN 1. ILIMIT
2. OVLO
3. UVLO
4. INPUT+
5. SOURCE
6. SOURCE
7. SOURCE
8. DRAIN

STYLE 28:
PIN 1. SW_TO_GND
2. DASIC_OFF
3. DASIC_SW_DET
4. GND
5. V_MON
6. VBULK
7. VBULK
8. VIN

STYLE 29:
PIN 1. BASE, DIE #1
2. EMITTER, #1
3. BASE, #2
4. EMITTER, #2
5. COLLECTOR, #2
6. COLLECTOR, #2
7. COLLECTOR, #1
8. COLLECTOR, #1

STYLE 30:
PIN 1. DRAIN 1
2. DRAIN 1
3. GATE 2
4. SOURCE 2
5. SOURCE 1/DRAIN 2
6. SOURCE 1/DRAIN 2
7. SOURCE 1/DRAIN 2
8. GATE 1

MECHANICAL CASE OUTLINE
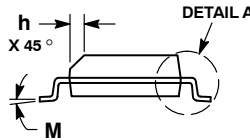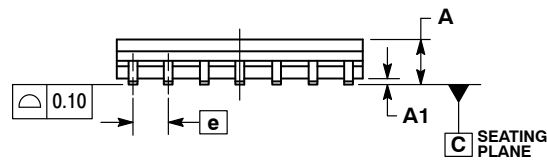## PACKAGE DIMENSIONS

SOIC−14 NB
CASE 751A−03
ISSUE L

DATE 03 FEB 2016

14

1

SCALE 1:1
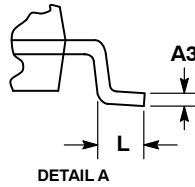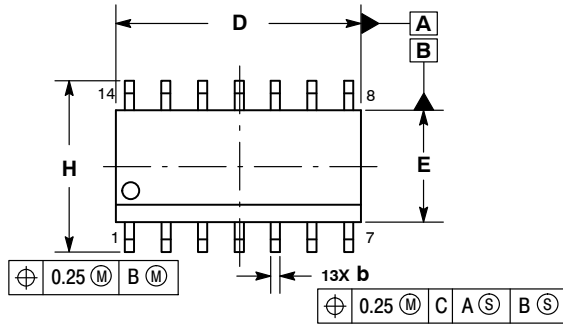
NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE PROTRUSION SHALL BE 0.13 TOTAL IN EXCESS OF AT MAXIMUM MATERIAL CONDITION.
4. DIMENSIONS D AND E DO NOT INCLUDE MOLD PROTRUSIONS.
5. MAXIMUM MOLD PROTRUSION 0.15 PER SIDE.

D

A
B

14   8

H   E

1   7

⊕ 0.25 Ⓜ B Ⓜ

13X b

⊕ 0.25 Ⓜ C A Ⓢ B Ⓢ

A3

DETAIL A

L

A

⌓ 0.10

e

A1

C **SEATING PLANE**

h
X 45°

DETAIL A

M

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	1.35	1.75	0.054	0.068
A1	0.10	0.25	0.004	0.010
A3	0.19	0.25	0.008	0.010
b	0.35	0.49	0.014	0.019
D	8.55	8.75	0.337	0.344
E	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
H	5.80	6.20	0.228	0.244
h	0.25	0.50	0.010	0.019
L	0.40	1.25	0.016	0.049
M	0°	7°	0°	7°

SOLDERING FOOTPRINT*

6.50

14X
1.18

1

1.27
PITCH

14X
0.58
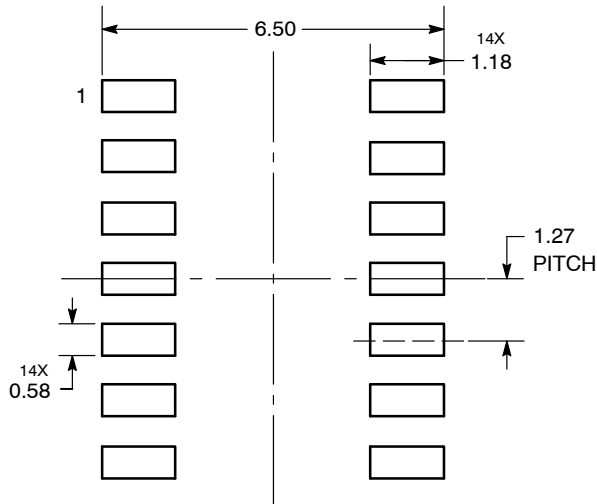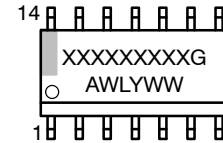
DIMENSIONS: MILLIMETERS

*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

GENERIC MARKING DIAGRAM*

14

XXXXXXXXXG
AWLYWW

1

XXXXX = Specific Device Code
A   = Assembly Location
WL   = Wafer Lot
Y   = Year
WW   = Work Week
G   = Pb−Free Package

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, "G" or microdot " ▪", may or may not be present.

STYLES ON PAGE 2

SOIC−14
CASE 751A−03
ISSUE L

DATE 03 FEB 2016

STYLE 1:
PIN 1. COMMON CATHODE
2. ANODE/CATHODE
3. ANODE/CATHODE
4. NO CONNECTION
5. ANODE/CATHODE
6. NO CONNECTION
7. ANODE/CATHODE
8. ANODE/CATHODE
9. ANODE/CATHODE
10. NO CONNECTION
11. ANODE/CATHODE
12. ANODE/CATHODE
13. NO CONNECTION
14. COMMON ANODE

STYLE 2:
CANCELLED

STYLE 3:
PIN 1. NO CONNECTION
2. ANODE
3. ANODE
4. NO CONNECTION
5. ANODE
6. NO CONNECTION
7. ANODE
8. ANODE
9. ANODE
10. NO CONNECTION
11. ANODE
12. ANODE
13. NO CONNECTION
14. COMMON CATHODE

STYLE 4:
PIN 1. NO CONNECTION
2. CATHODE
3. CATHODE
4. NO CONNECTION
5. CATHODE
6. NO CONNECTION
7. CATHODE
8. CATHODE
9. CATHODE
10. NO CONNECTION
11. CATHODE
12. CATHODE
13. NO CONNECTION
14. COMMON ANODE

STYLE 5:
PIN 1. COMMON CATHODE
2. ANODE/CATHODE
3. ANODE/CATHODE
4. ANODE/CATHODE
5. ANODE/CATHODE
6. NO CONNECTION
7. COMMON ANODE
8. COMMON CATHODE
9. ANODE/CATHODE
10. ANODE/CATHODE
11. ANODE/CATHODE
12. ANODE/CATHODE
13. NO CONNECTION
14. COMMON ANODE

STYLE 6:
PIN 1. CATHODE
2. CATHODE
3. CATHODE
4. CATHODE
5. CATHODE
6. CATHODE
7. CATHODE
8. ANODE
9. ANODE
10. ANODE
11. ANODE
12. ANODE
13. ANODE
14. ANODE

STYLE 7:
PIN 1. ANODE/CATHODE
2. COMMON ANODE
3. COMMON CATHODE
4. ANODE/CATHODE
5. ANODE/CATHODE
6. ANODE/CATHODE
7. ANODE/CATHODE
8. ANODE/CATHODE
9. ANODE/CATHODE
10. ANODE/CATHODE
11. COMMON CATHODE
12. COMMON ANODE
13. ANODE/CATHODE
14. ANODE/CATHODE

STYLE 8:
PIN 1. COMMON CATHODE
2. ANODE/CATHODE
3. ANODE/CATHODE
4. NO CONNECTION
5. ANODE/CATHODE
6. ANODE/CATHODE
7. COMMON ANODE
8. COMMON ANODE
9. ANODE/CATHODE
10. ANODE/CATHODE
11. NO CONNECTION
12. ANODE/CATHODE
13. ANODE/CATHODE
14. COMMON CATHODE

MECHANICAL CASE OUTLINE
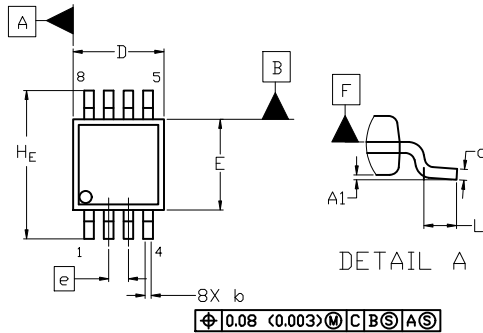## PACKAGE DIMENSIONS

Micro8
CASE 846A−02
ISSUE K

SCALE 2:1

DATE 16 JUL 2020

TOP VIEW

⊕ |0.08 (0.003)|Ⓜ|C|B|Ⓢ|A|Ⓢ|

NOTE 3

DETAIL A

SIDE VIEW

△ |0.038 (0.0015)|C|

END VIEW

DETAIL A

RECOMMENDED MOUNTING FOOTPRINT
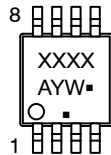
8X 0.48
8X 0.80
5.25
0.65 PITCH

NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 2009.

2. CONTROLLING DIMENSION: MILLIMETERS

3. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE PROTRUSION SHALL BE 0.10 mm IN EXCESS OF MAXIMUM MATERIAL CONDITION.

4. DIMENSIONS D AND E DO NOT INCLUDE MOLD FLASH, PROTRUSION OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 mm PER SIDE. DIMENSION E DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 mm PER SIDE. DIMENSIONS D AND E ARE DETERMINED AT DATUM F.

5. DATUMS A AND B ARE TO BE DETERMINED AT DATUM F.

6. A1 IS DEFINED AS THE VERTICAL DISTANCE FROM THE SEATING PLANE TO THE LOWEST POINT ON THE PACKAGE BODY.
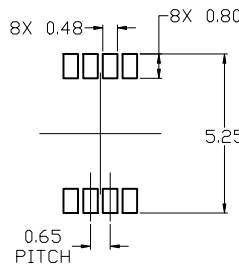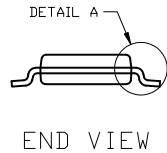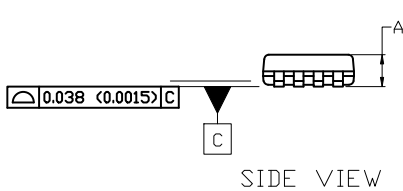
DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	---	---	1.10
A1	0.05	0.08	0.15
b	0.25	0.33	0.40
c	0.13	0.18	0.23
D	2.90	3.00	3.10
E	2.90	3.00	3.10
e	0.65 BSC		
H_E	4.75	4.90	5.05
L	0.40	0.55	0.70

∎ For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

GENERIC MARKING DIAGRAM*

XXXX = Specific Device Code
A = Assembly Location
Y = Year
W = Work Week
∎ = Pb−Free Package

(Note: Microdot may be in either location)

*This information is generic. Please refer to device data sheet for actual part marking. Pb−Free indicator, "G" or microdot "∎", may or may not be present. Some products may not follow the Generic Marking.

STYLE 1:
PIN 1. SOURCE
2. SOURCE
3. SOURCE
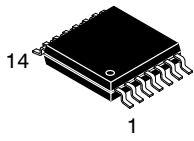4. GATE
5. DRAIN
6. DRAIN
7. DRAIN
8. DRAIN

STYLE 2:
PIN 1. SOURCE 1
2. GATE 1
3. SOURCE 2
4. GATE 2
5. DRAIN 2
6. DRAIN 2
7. DRAIN 1
8. DRAIN 1

STYLE 3:
PIN 1. N−SOURCE
2. N−GATE
3. P−SOURCE
4. P−GATE
5. P−DRAIN
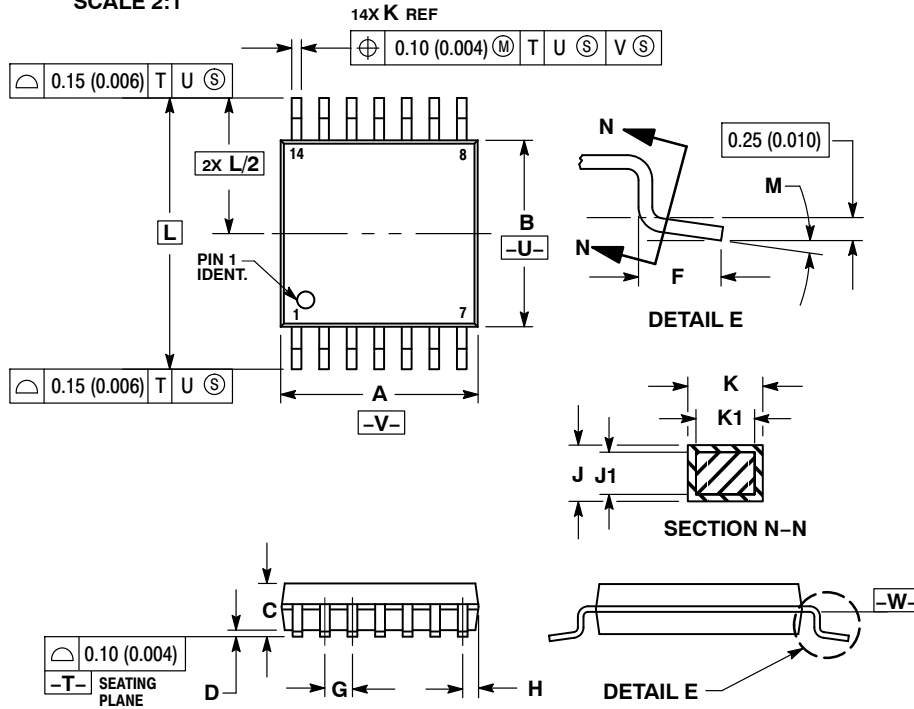6. P−DRAIN
7. N−DRAIN
8. N−DRAIN

MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS

TSSOP−14 WB
CASE 948G
ISSUE C

DATE 17 FEB 2016

14

1

SCALE 2:1

14X **K** REF

⊕ | 0.10 (0.004) Ⓜ | T | U Ⓢ | V Ⓢ

◯ | 0.15 (0.006) | T | U Ⓢ

2X **L/2**

L

PIN 1
IDENT.

14   8

1   7

◯ | 0.15 (0.006) | T | U Ⓢ

A

−V−

B

−U−

N

0.25 (0.010)

M

N

F

DETAIL E

K

K1

J J1

SECTION N−N

C

◯ | 0.10 (0.004)

−T− SEATING
PLANE

D

G

H

DETAIL E

−W−

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	4.90	5.10	0.193	0.200
B	4.30	4.50	0.169	0.177
C	−−−	1.20	−−−	0.047
D	0.05	0.15	0.002	0.006
F	0.50	0.75	0.020	0.030
G	0.65 BSC		0.026 BSC	
H	0.50	0.60	0.020	0.024
J	0.09	0.20	0.004	0.008
J1	0.09	0.16	0.004	0.006
K	0.19	0.30	0.007	0.012
K1	0.19	0.25	0.007	0.010
L	6.40 BSC		0.252 BSC	
M	0 °	8 °	0 °	8 °

**GENERIC
MARKING DIAGRAM***
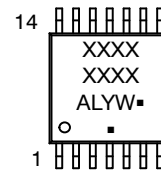
14

XXXX
XXXX
ALYW▪

1

A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb−Free Package

(Note: Microdot may be in either location)

*This information is generic. Please refer to
device data sheet for actual part marking.
Pb−Free indicator, "G" or microdot " ▪",
may or may not be present.

SOLDERING FOOTPRINT

7.06

1

0.65
PITCH

14X
0.36

14X
1.26

DIMENSIONS: MILLIMETERS