

NCS20091, NCV20091, NCS20092, NCV20092, NCS20094, NCV20094

Operational Amplifier, Rail-to-Rail Input and Output, 350 kHz

The NCS2009 series operational amplifiers provide rail-to-rail input and output operation, 350 kHz bandwidth, and are available in single, dual, and quad configurations. Rail-to-rail operation gives designers use of the entire supply voltage range while taking advantage of the 350 kHz bandwidth. The NCS2009 can operate on supply voltages from 1.8 to 5.5 V over a temperature range from -40 to 125°C. At a 1.8 V supply, this device has a slew rate of 0.17 V/μs while consuming only 20 μA of quiescent current per channel. Since this is a CMOS device, high input impedance and low bias currents make it ideal for interfacing to a wide variety of signal sensors. The NCS2009 devices are available in a variety of compact packages.

Features

- Rail-to-Rail Input and Output
- Wide Supply Range: 1.8 to 5.5 V
- Wide Bandwidth: 350 kHz
- Slew Rate: 0.17 V/μs at $V_S = 1.8$ V
- Low Supply Current: 20 μA per Channel at $V_S = 1.8$ V
- Low Input Bias Current: 1 pA Typical
- Wide Temperature Range: -40 to 125°C
- Available in a Variety of Packages
- 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, Halogen Free/BFR Free and are RoHS Compliant

Applications

- Unity Gain Buffer
- Battery Powered / Low Quiescent Current Applications
- Low Cost Current Sensing
- Automotive



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SC70-5
CASE 419A



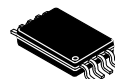
TSOP-5/SOT23-5
CASE 483



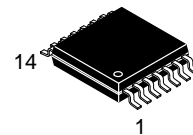
Micro8™/MSOP8
CASE 846A



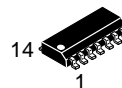
SOIC-8
CASE 751



TSSOP-8
CASE 948S



TSSOP-14
CASE 948G



SOIC-14
CASE 751A



UDFN6
CASE 517AP

DEVICE MARKING INFORMATION

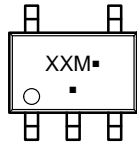
See general marking information in the device marking section on page 2 of this data sheet.

ORDERING INFORMATION

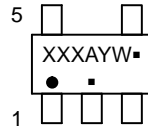
See detailed ordering and shipping information on page 3 of this data sheet.

MARKING DIAGRAMS

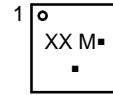
Single Channel Configuration
NCS20091, NCV20091



SC70-5
CASE 419A

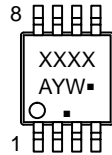


TSOP-5/SOT23-5
CASE 483

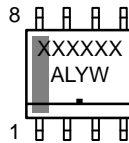


UDFN6
CASE 517AP

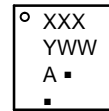
Dual Channel Configuration
NCS20092, NCV20092



Micro8™/MSOP8
CASE 846A

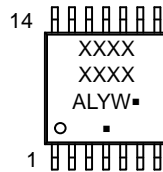


SOIC-8
CASE 751

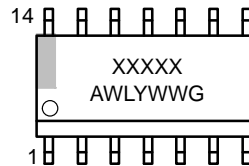


TSSOP-8
CASE 948S

Quad Channel Configuration
NCS20094, NCV20094



TSSOP-14
CASE 948G



SOIC-14
CASE 751A

XXXXX = Specific Device Code
A = Assembly Location
WL, L = Wafer Lot
Y = Year
WW, W = Work Week
G or ■ = Pb-Free Package

(Note: Microdot may be in either location)

NCS20091, NCV20091, NCS20092, NCV20092, NCS20094, NCV20094

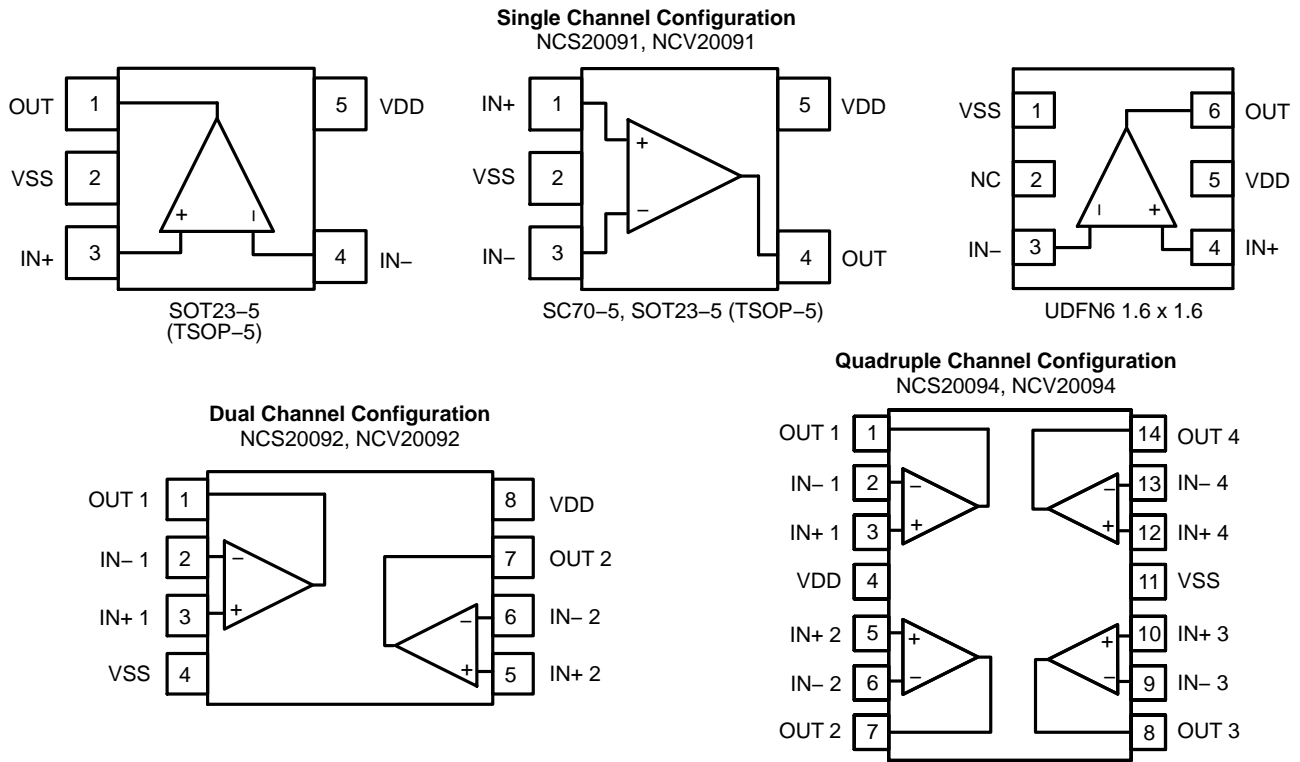


Figure 1. Pin Connections

ORDERING INFORMATION

Device	Configuration	Automotive	Marking	Package	Shipping†
NCS20091_	Single	No	TBD	SC70	Contact local sales office for more information
NCS20091_			TBD	SOT23-5/TSOP-5	
NCS20091_			TBD	SOT23-5/TSOP-5	
NCS20091_			TBD	UDFN6	
NCV20091_		Yes	TBD	SC70	
NCV20091_			TBD	SOT23-5/TSOP-5	
NCV20091_			TBD	SOT23-5/TSOP-5	
NCV20091_			TBD	UDFN6	
NCS20092DMR2G	Dual	No	2K92	Micro8/MSOP8	
NCS20092DR2G			NCS20092	SOIC-8	
NCS20092DTBR2G			K92	TSSOP-8	
NCV20092DMR2G		Yes	2K92	Micro8/MSOP8	
NCV20092DR2G			NCS20092	SOIC-8	
NCV20092DTBR2G			K92	TSSOP-8	
NCS20094_	Quad	No	TBD	SOIC-14	
NCS20094_			TBD	SOP-14	
NCS20094_			TBD	TSSOP-14	
NCV20094_		Yes	TBD	SOIC-14	
NCV20094_			TBD	SOP-14	
NCV20094_			TBD	TSSOP-14	

†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.

ABSOLUTE MAXIMUM RATINGS (Note 1)

Rating	Symbol	Limit	Unit	
Supply Voltage ($V_{DD} - V_{SS}$) (Note 2)	V_S	7	V	
Input Voltage	V_I	$V_{SS} - 0.5$ to $V_{DD} + 0.5$	V	
Differential Input Voltage	V_{ID}	$\pm V_S$	V	
Maximum Input Current	I_I	± 10	mA	
Maximum Output Current	I_O	± 100	mA	
Continuous Total Power Dissipation (Note 2)	P_D	200	mW	
Maximum Junction Temperature	T_J	150	$^{\circ}\text{C}$	
Storage Temperature Range	T_{STG}	-65 to 150	$^{\circ}\text{C}$	
Mounting Temperature (Infrared or Convection – 20 sec)	T_{mount}	260	$^{\circ}\text{C}$	
ESD Capability (Note 3)	Human Body Model	ESD _{HBM}	2000	V
	Machine Model	ESD _{MM}	100	
	Charge Device Model	ESD _{CDM}	2000	
Latch-Up Current (Note 4)	I_{LU}	100	mA	
Moisture Sensitivity Level (Note 5)	MSL	Level 1		

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. Refer to ELECTRICAL CHARACTERISTICS for Safe Operating Area.
2. Continuous short circuit operation to ground at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150 $^{\circ}\text{C}$. Output currents in excess of the maximum output current rating over the long term may adversely affect reliability. Shorting output to either VDD or VSS will adversely affect reliability.
3. This device series incorporates ESD protection and is tested by the following methods:
 ESD Human Body Model tested per AEC-Q100-002 (JEDEC standard: JESD22-A114)
 ESD Machine Model tested per AEC-Q100-003 (JEDEC standard: JESD22-A115)
4. Latch-up Current tested per JEDEC standard: JESD78
5. Moisture Sensitivity Level tested per IPC/JEDEC standard: J-STD-020A

THERMAL INFORMATION

Parameter	Symbol	Channels	Package	Single Layer Board (Note 6)	Multi-Layer Board (Note 7)	Unit
Junction to Ambient Thermal Resistance	θ_{JA}	Single	SC-70			$^{\circ}\text{C}/\text{W}$
			SOT23-5/TSOP-5			
			UDFN6			
		Dual	Micro8/MSOP8	236	167	
			SOIC-8	190	131	
			TSSOP-8	253	194	
		Quad	SOIC-14			
			SOP-14			
			TSSOP-14			

6. Value based on 1S standard PCB according to JEDEC51-3 with 1.0 oz copper and a 300 mm² copper area
7. Value based on 1S2P standard PCB according to JEDEC51-7 with 1.0 oz copper and a 100 mm² copper area

OPERATING RANGES

Parameter	Symbol	Min	Max	Unit
Operating Supply Voltage	V_S	1.8	5.5	V
Differential Input Voltage	V_{ID}		V_S	V
Input Common Mode Range	V_{ICM}	$V_{SS} - 0.2$	$V_{DD} + 0.2$	V
Ambient Temperature	T_A	-40	125	$^{\circ}\text{C}$

Functional operation above the stresses listed in the Recommended Operating Ranges is not implied. Extended exposure to stresses beyond the Recommended Operating Ranges limits may affect device reliability.

NCS20091, NCV20091, NCS20092, NCV20092, NCS20094, NCV20094

ELECTRICAL CHARACTERISTICS AT $V_S = 1.8\text{ V}$

$T_A = 25^\circ\text{C}$; $R_L \geq 10\text{ k}\Omega$; $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise noted.

Boldface limits apply over the specified temperature range, $T_A = -40^\circ\text{C}$ to 125°C . (Note 8)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Input Offset Voltage	V_{OS}			0.5	3.5	mV
					4	mV
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$			1		$\mu\text{V}/^\circ\text{C}$
Input Bias Current (Note 8)	I_{IB}			1		pA
					1500	pA
Input Offset Current (Note 8)	I_{OS}			1		pA
					1100	pA
Channel Separation	XTLK	DC		125		dB
Differential Input Resistance	R_{ID}			10		$\text{G}\Omega$
Common Mode Input Resistance	R_{IN}			10		$\text{G}\Omega$
Differential Input Capacitance	C_{ID}			1		pF
Common Mode Input Capacitance	C_{CM}			5		pF
Common Mode Rejection Ratio	CMRR	$V_{CM} = V_{SS} - 0.2$ to $V_{DD} + 0.2$	48	73		dB
		$V_{CM} = V_{SS} + 0.2$ to $V_{DD} - 0.2$	45			

OUTPUT CHARACTERISTICS

Open Loop Voltage Gain	A_{VOL}		85	120		dB
			73			
Short Circuit Current	I_{SC}	Output to positive rail, sinking current		8.5		mA
		Output to negative rail, sourcing current		7.5		
Output Voltage High	V_{OH}	Voltage output swing from positive rail		3	19	mV
					20	
Output Voltage Low	V_{OL}	Voltage output swing from negative rail		3	19	mV
					20	

AC CHARACTERISTICS

Unity Gain Bandwidth	UGBW			350		kHz
Slew Rate at Unity Gain	SR	$V_{ID} = 1.2\text{ Vpp}$, Gain = 1		0.17		$\text{V}/\mu\text{s}$
Phase Margin	ψ_m			60		$^\circ$
Gain Margin	A_m			15		dB
Settling Time	t_S	$V_{IN} = 1.2\text{ Vpp}$, Gain = 1	Settling time to 0.1%	21		μs
			Settling time to 0.01%	27		
Open Loop Output Impedance	Z_{OL}	$f = 100\text{ Hz}$		1		Ω

NOISE CHARACTERISTICS

Total Harmonic Distortion plus Noise	THD+N	$V_{IN} = 1.2\text{ Vpp}$, $f = 1\text{ kHz}$, $A_v = 1$		0.04		%
Input Referred Voltage Noise	e_n		$f = 1\text{ kHz}$	40		$\text{nV}/\sqrt{\text{Hz}}$
			$f = 10\text{ kHz}$	30		
Input Referred Current Noise	i_n	$f = 1\text{ kHz}$		300		$\text{fA}/\sqrt{\text{Hz}}$

SUPPLY CHARACTERISTICS

Power Supply Rejection Ratio	PSRR	No Load	63	90		dB
			60			
Power Supply Quiescent Current	I_{DD}	Per channel, no load		20	29	μA

8. Performance guaranteed over the indicated operating temperature range by design and/or characterization.

NCS20091, NCV20091, NCS20092, NCV20092, NCS20094, NCV20094

ELECTRICAL CHARACTERISTICS AT $V_S = 3.3\text{ V}$

$T_A = 25^\circ\text{C}$; $R_L \geq 10\text{ k}\Omega$; $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise noted.

Boldface limits apply over the specified temperature range, $T_A = -40^\circ\text{C}$ to 125°C . (Note 9)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Input Offset Voltage	V_{OS}			0.5	3.5	mV
					4	mV
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$			1		$\mu\text{V}/^\circ\text{C}$
Input Bias Current (Note 9)	I_{IB}			1		pA
					1500	pA
Input Offset Current (Note 9)	I_{OS}			1		pA
					1100	pA
Channel Separation	XTLK	DC		125		dB
Differential Input Resistance	R_{ID}			10		$\text{G}\Omega$
Common Mode Input Resistance	R_{IN}			10		$\text{G}\Omega$
Differential Input Capacitance	C_{ID}			1		pF
Common Mode Input Capacitance	C_{CM}			5		pF
Common Mode Rejection Ratio	CMRR	$V_{CM} = V_{SS} - 0.2$ to $V_{DD} + 0.2$	53	76		dB
		$V_{CM} = V_{SS} + 0.2$ to $V_{DD} - 0.2$	48			

OUTPUT CHARACTERISTICS						
Open Loop Voltage Gain	A_{VOL}		85	120		dB
			73			
Short Circuit Current	I_{SC}	Output to positive rail, sinking current		8.5		mA
		Output to negative rail, sourcing current		7.5		
Output Voltage High	V_{OH}	Voltage output swing from positive rail		3	24	mV
					25	
Output Voltage Low	V_{OL}	Voltage output swing from negative rail		3	24	mV
					25	

AC CHARACTERISTICS						
Unity Gain Bandwidth	UGBW			350		kHz
Slew Rate at Unity Gain	SR	$V_{IN} = 2.5\text{ Vpp}$, Gain = 1		0.17		$\text{V}/\mu\text{s}$
Phase Margin	ψ_m			60		$^\circ$
Gain Margin	A_m			15		dB
Settling Time	t_S	$V_{IN} = 2.5\text{ Vpp}$, Gain = 1	Settling time to 0.1%	21		μs
			Settling time to 0.01%	27		
Open Loop Output Impedance	Z_{OL}	$f = 100\text{ Hz}$		1		Ω

NOISE CHARACTERISTICS						
Total Harmonic Distortion plus Noise	THD+N	$V_{IN} = 2.5\text{ Vpp}$, $f = 1\text{ kHz}$, $A_v = 1$		0.04		%
Input Referred Voltage Noise	e_n		$f = 1\text{ kHz}$	40		$\text{nV}/\sqrt{\text{Hz}}$
			$f = 10\text{ kHz}$	30		
Input Referred Current Noise	i_n		$f = 1\text{ kHz}$	300		$\text{fA}/\sqrt{\text{Hz}}$

SUPPLY CHARACTERISTICS						
Power Supply Rejection Ratio	PSRR	No Load	63	90		dB
			60			
Power Supply Quiescent Current	I_{DD}	Per channel, no load		21	31	μA

9. Performance guaranteed over the indicated operating temperature range by design and/or characterization.

NCS20091, NCV20091, NCS20092, NCV20092, NCS20094, NCV20094

ELECTRICAL CHARACTERISTICS AT $V_S = 5.5\text{ V}$

$T_A = 25^\circ\text{C}$; $R_L \geq 10\text{ k}\Omega$; $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise noted.

Boldface limits apply over the specified temperature range, $T_A = -40^\circ\text{C}$ to 125°C . (Note 10)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
INPUT CHARACTERISTICS						
Input Offset Voltage	V_{OS}			0.5	4	mV
					5	mV
Offset Voltage Drift	$\Delta V_{OS}/\Delta T$			1		$\mu\text{V}/^\circ\text{C}$
Input Bias Current (Note 10)	I_{IB}			1		pA
					1500	pA
Input Offset Current (Note 10)	I_{OS}			1		pA
					1100	pA
Channel Separation	XTLK	DC		125		dB
Differential Input Resistance	R_{ID}			10		$\text{G}\Omega$
Common Mode Input Resistance	R_{IN}			10		$\text{G}\Omega$
Differential Input Capacitance	C_{ID}			1		pF
Common Mode Input Capacitance	C_{CM}			5		pF
Common Mode Rejection Ratio	CMRR	$V_{CM} = V_{SS} - 0.2$ to $V_{DD} + 0.2$	55	79		dB
		$V_{CM} = V_{SS} + 0.2$ to $V_{DD} - 0.2$	58			

OUTPUT CHARACTERISTICS						
Open Loop Voltage Gain	A_{VOL}		90	120		dB
			78			
Short Circuit Current	I_{SC}	Output to positive rail, sinking current		8.5		mA
		Output to negative rail, sourcing current		7.5		
Output Voltage High	V_{OH}	Voltage output swing from positive rail		3	24	mV
					25	
Output Voltage Low	V_{OL}	Voltage output swing from negative rail		3	24	mV
					25	

AC CHARACTERISTICS						
Unity Gain Bandwidth	UGBW			350		kHz
Slew Rate at Unity Gain	SR	$V_{ID} = 5\text{ Vpp}$, Gain = 1		0.17		$\text{V}/\mu\text{s}$
Phase Margin	ψ_m			60		$^\circ$
Gain Margin	A_m			15		dB
Settling Time	t_S	$V_{IN} = 5\text{ Vpp}$, Gain = 1	Settling time to 0.1%	21		μs
			Settling time to 0.01%	27		
Open Loop Output Impedance	Z_{OL}	$f = 100\text{ Hz}$		1		Ω

NOISE CHARACTERISTICS						
Total Harmonic Distortion plus Noise	THD+N	$V_{IN} = 5\text{ Vpp}$, $f = 1\text{ kHz}$, $A_v = 1$		0.04		%
Input Referred Voltage Noise	e_n		$f = 1\text{ kHz}$	40		$\text{nV}/\sqrt{\text{Hz}}$
			$f = 10\text{ kHz}$	30		
Input Referred Current Noise	i_n		$f = 1\text{ kHz}$	300		$\text{fA}/\sqrt{\text{Hz}}$

SUPPLY CHARACTERISTICS						
Power Supply Rejection Ratio	PSRR	No Load		63	90	dB
				60		
Power Supply Quiescent Current	I_{DD}	Per channel, no load		23	33	μA

10. Performance guaranteed over the indicated operating temperature range by design and/or characterization. Product parametric performance is indicated in the Electrical Characteristics for the listed test conditions, unless otherwise noted. Product performance may not be indicated by the Electrical Characteristics if operated under different conditions.

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$, $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise specified

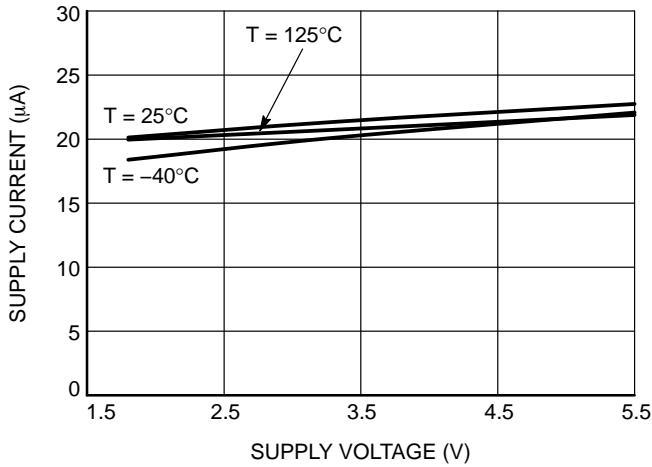


Figure 2. Quiescent Current per Channel vs. Supply Voltage

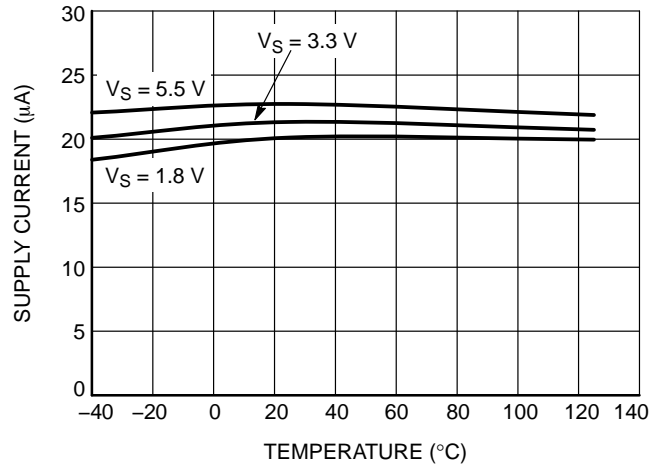


Figure 3. Quiescent Current vs. Temperature

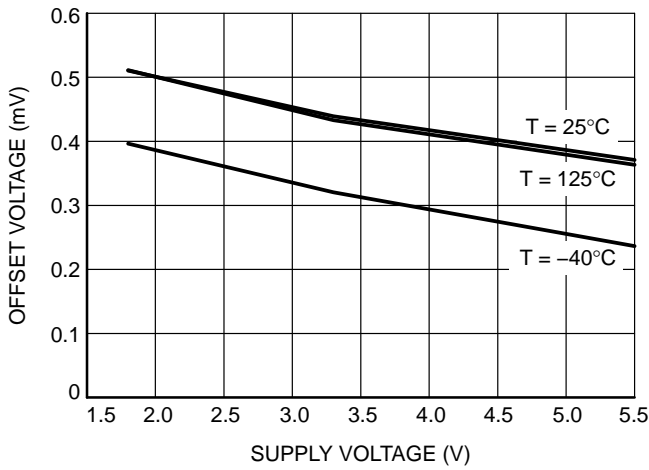


Figure 4. Offset Voltage vs. Supply Voltage

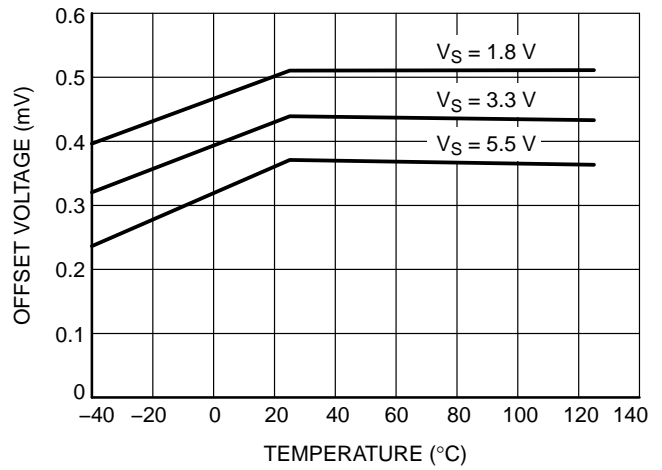


Figure 5. Offset Voltage vs. Temperature

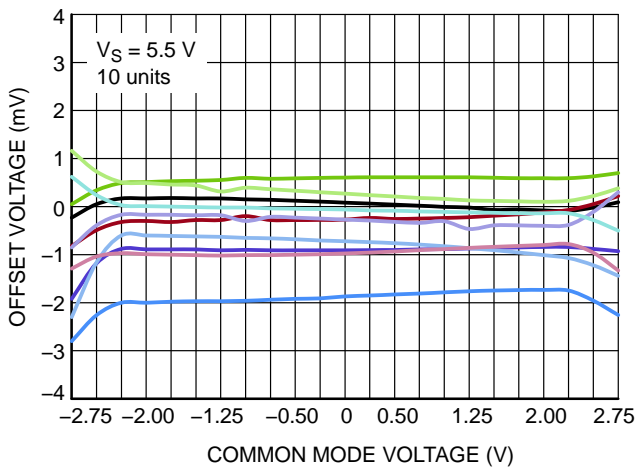


Figure 6. Offset Voltage vs. Common Mode Voltage

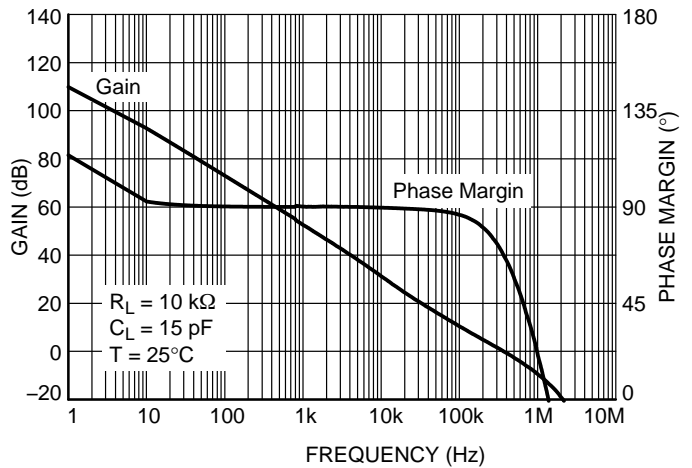


Figure 7. Open-loop Gain and Phase Margin vs. Frequency

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$, $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise specified

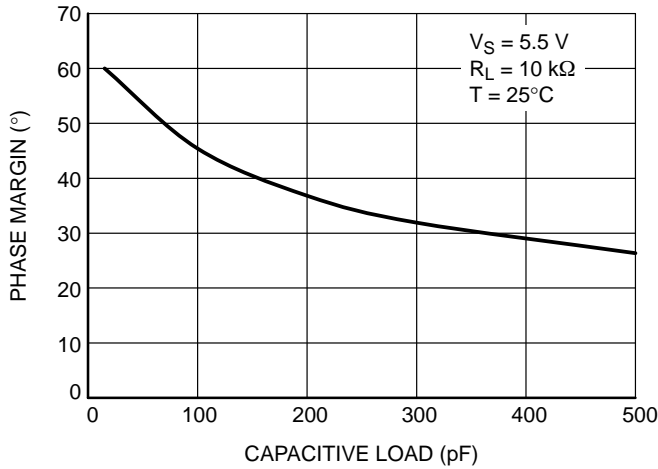


Figure 8. Phase Margin vs. Capacitive Load

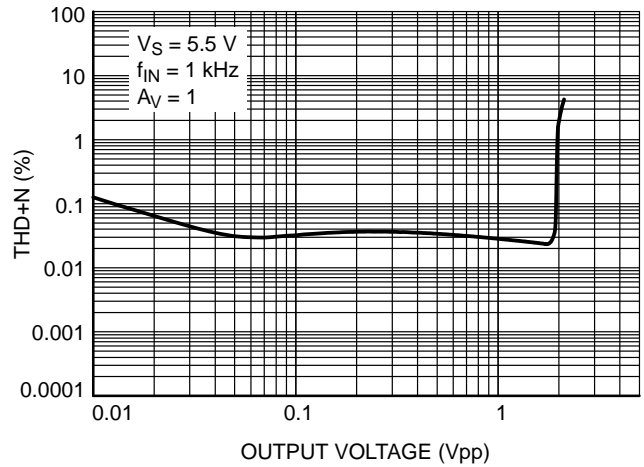


Figure 9. THD + N vs. Output Voltage

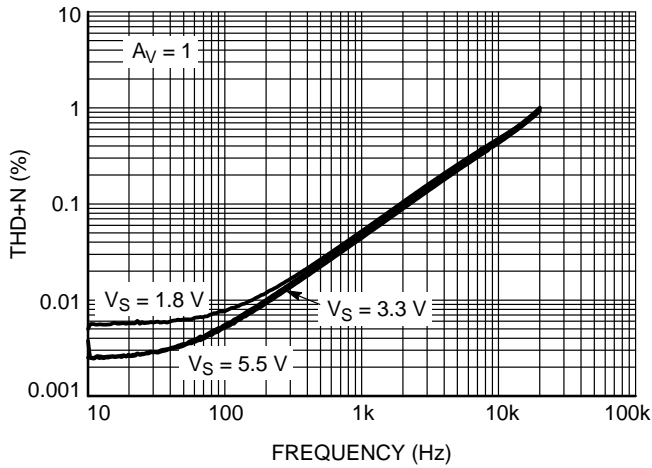


Figure 10. THD + N vs. Frequency

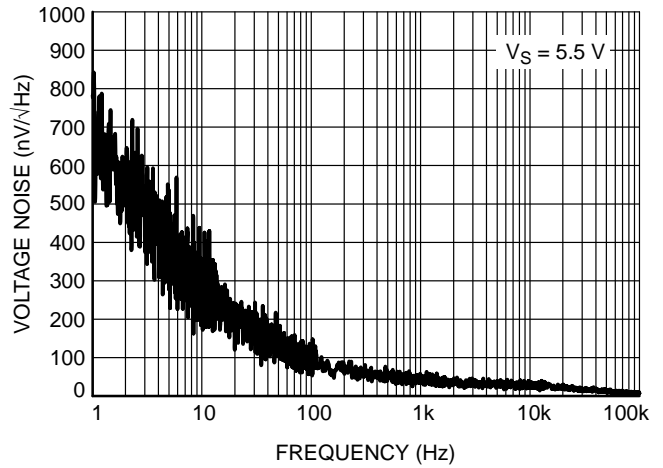


Figure 11. Input Voltage Noise vs. Frequency

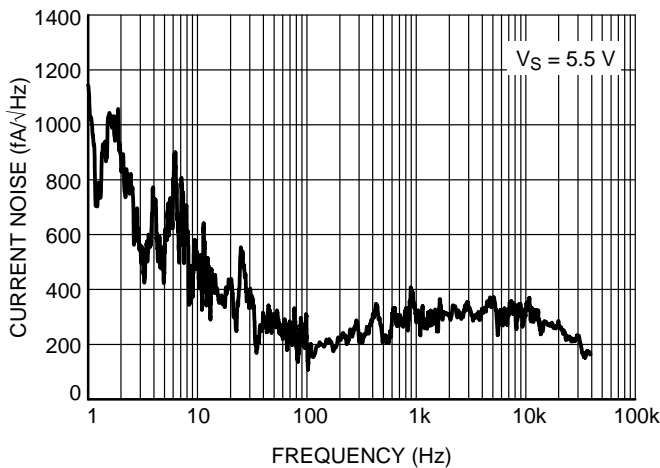


Figure 12. Input Current Noise vs. Frequency

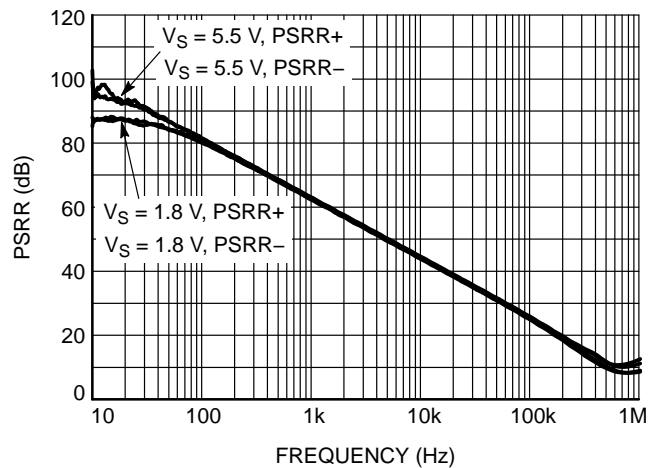


Figure 13. PSRR vs. Frequency

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$, $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise specified

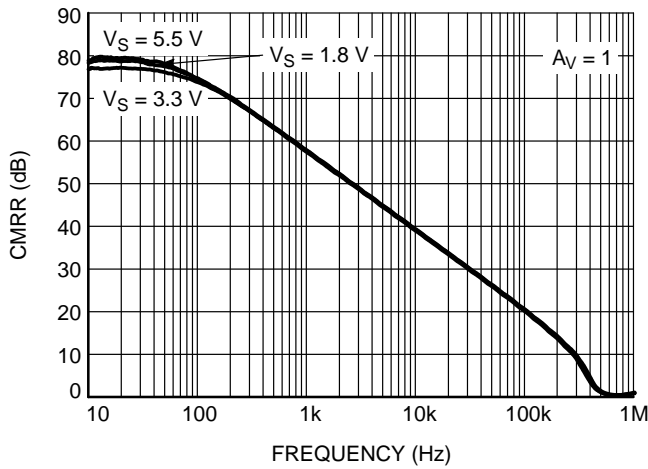


Figure 14. CMRR vs. Frequency

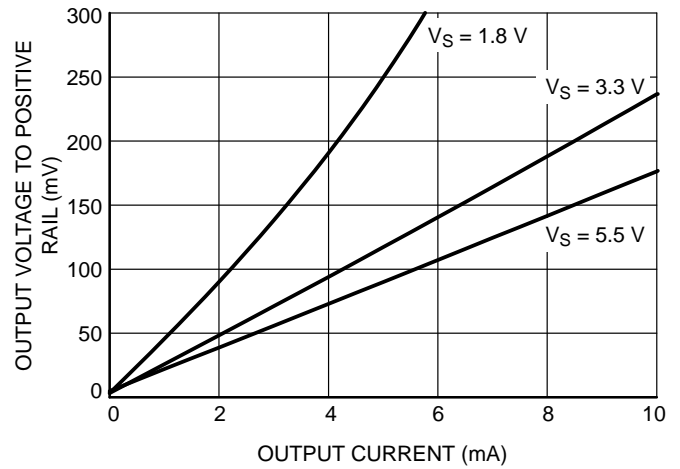


Figure 15. Output Voltage High to Rail

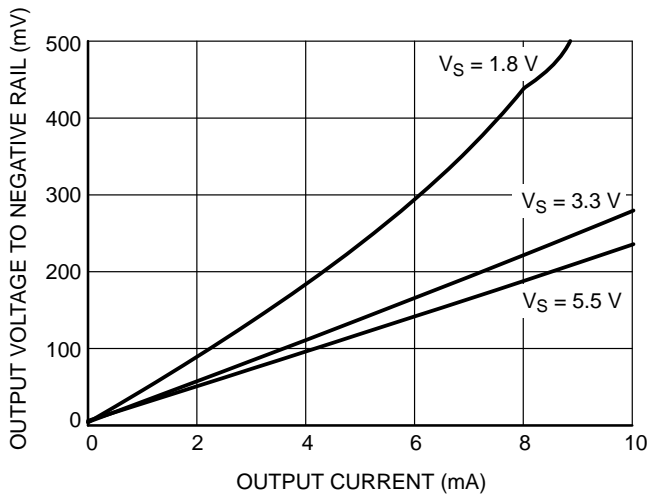


Figure 16. Output Voltage Low to Rail

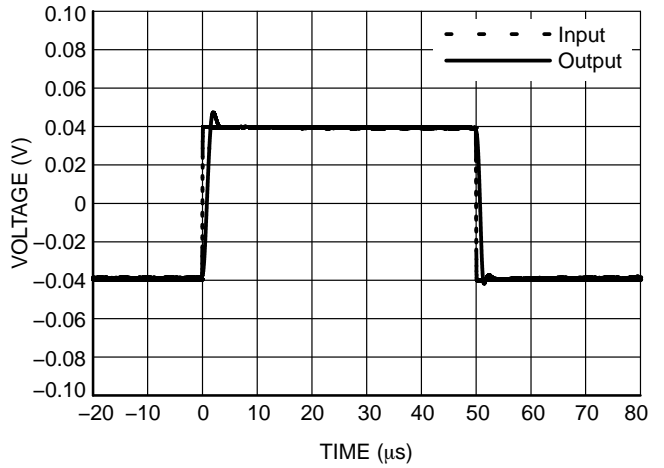


Figure 17. Non-Inverting Small Signal Transient Response

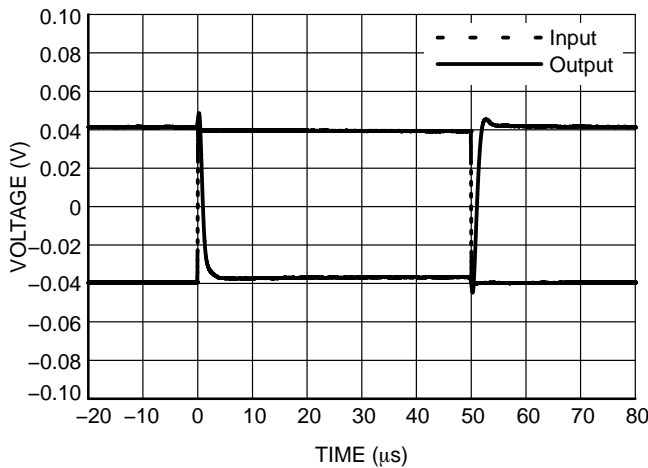


Figure 18. Inverting Small Signal Transient Response

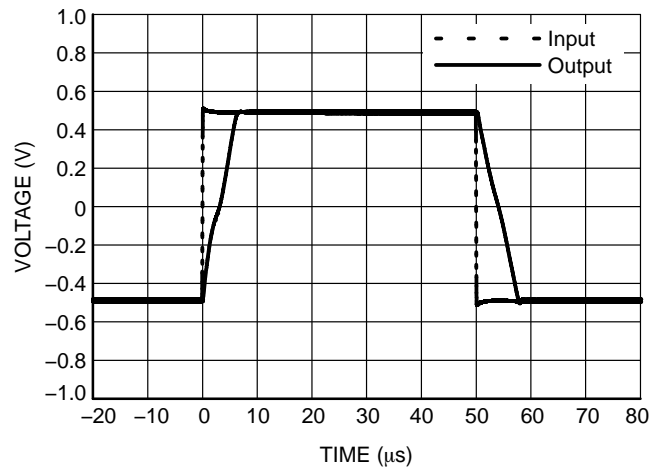


Figure 19. Non-Inverting Large Signal Transient Response

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$, $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise specified

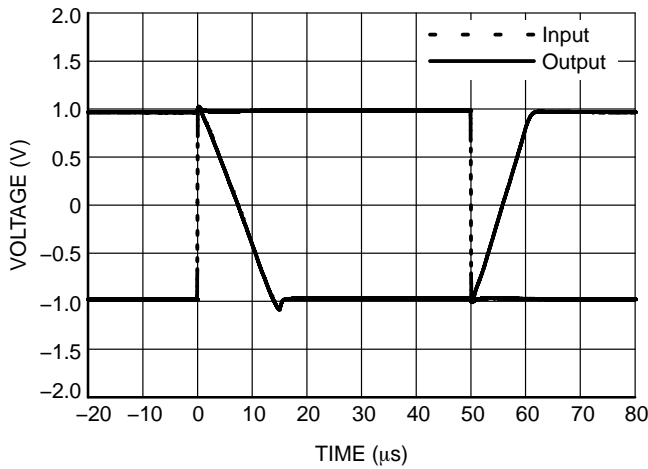


Figure 20. Inverting Large Signal Transient Response

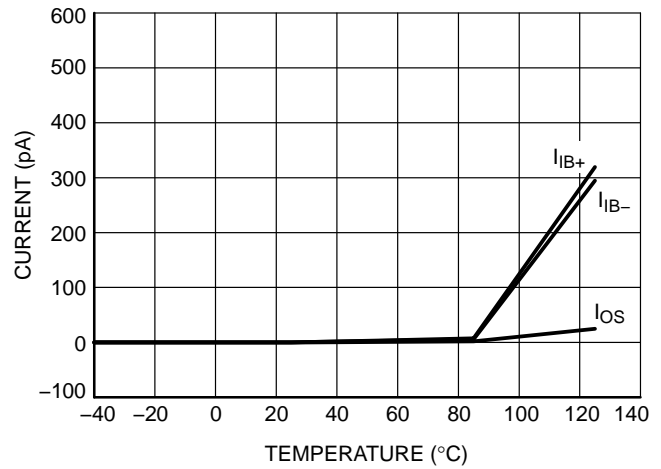


Figure 21. Input Bias and Offset Current vs. Temperature

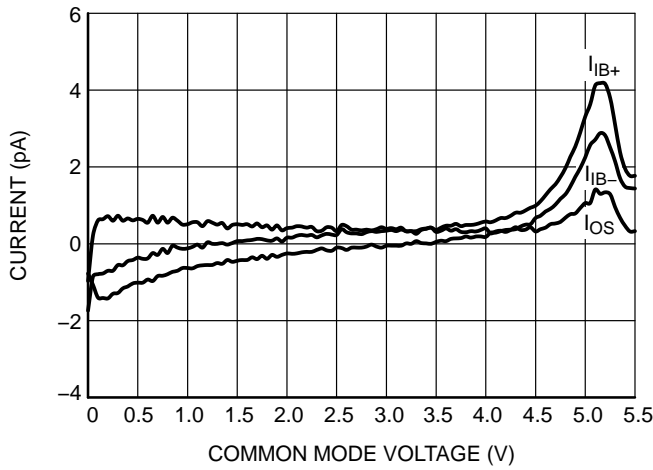


Figure 22. Input Bias Current vs. Common Mode Voltage

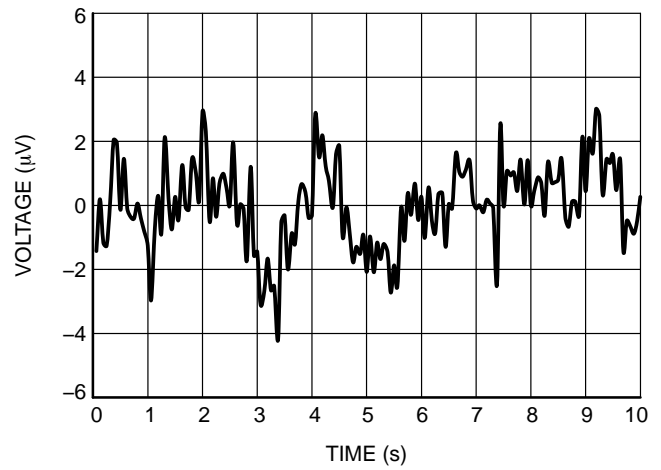


Figure 23. 0.1 Hz to 10 Hz Noise

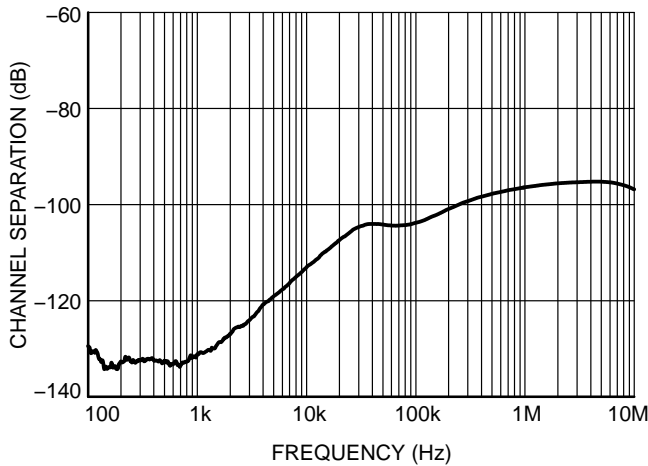


Figure 24. Channel Separation vs. Frequency

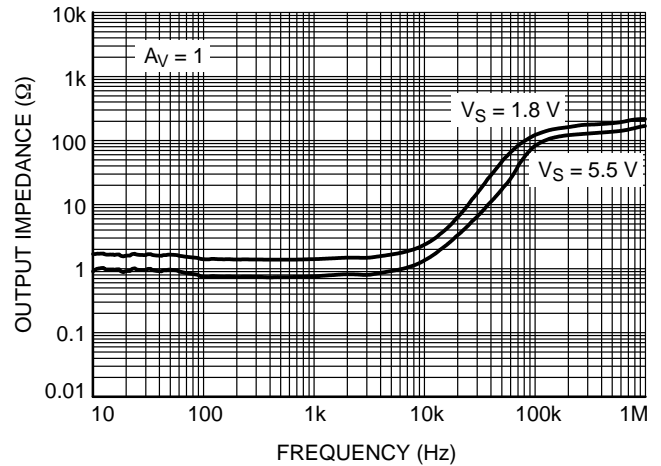


Figure 25. Output Impedance vs. Frequency

TYPICAL PERFORMANCE CHARACTERISTICS

$T_A = 25^\circ\text{C}$, $R_L \geq 10\text{ k}\Omega$, $V_{CM} = V_{OUT} = \text{mid-supply}$ unless otherwise specified

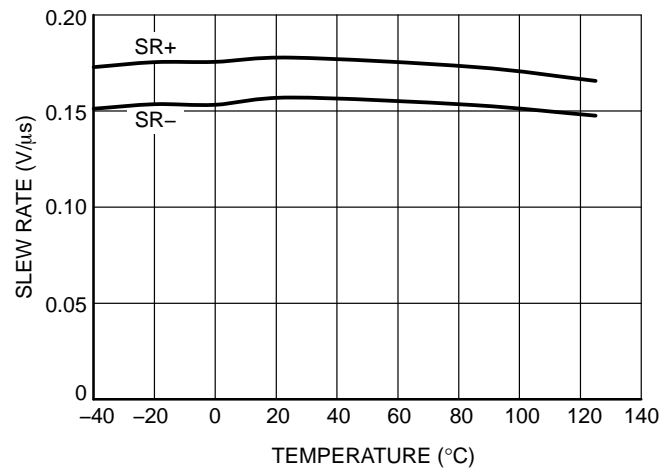
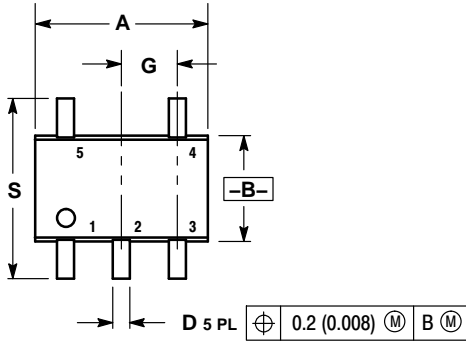


Figure 26. Slew Rate vs. Temperature

PACKAGE DIMENSIONS

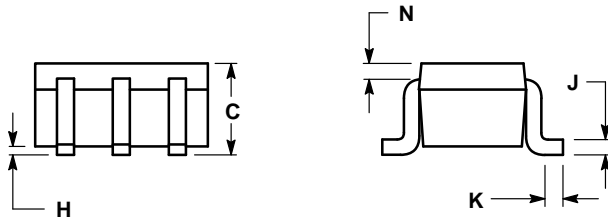
SC-88A (SC-70-5/SOT-353)
CASE 419A-02
ISSUE L



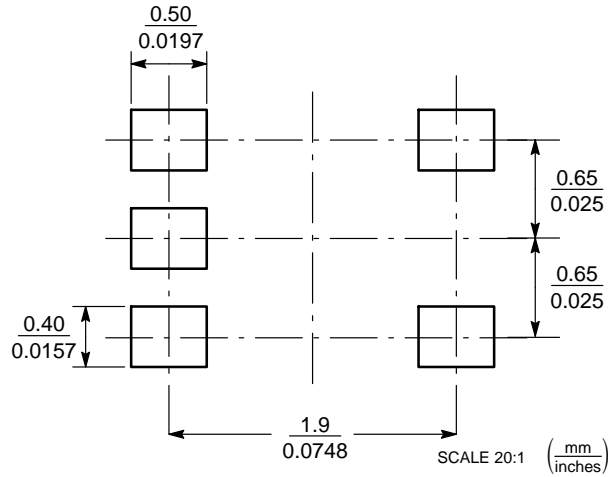
NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. 419A-01 OBSOLETE. NEW STANDARD 419A-02.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

DIM	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.071	0.087	1.80	2.20
B	0.045	0.053	1.15	1.35
C	0.031	0.043	0.80	1.10
D	0.004	0.012	0.10	0.30
G	0.026 BSC		0.65 BSC	
H	---	0.004	---	0.10
J	0.004	0.010	0.10	0.25
K	0.004	0.012	0.10	0.30
N	0.008 REF		0.20 REF	
S	0.079	0.087	2.00	2.20

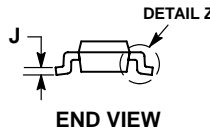
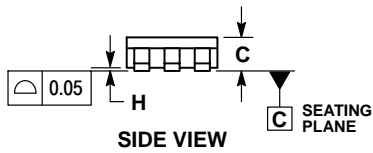
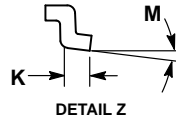
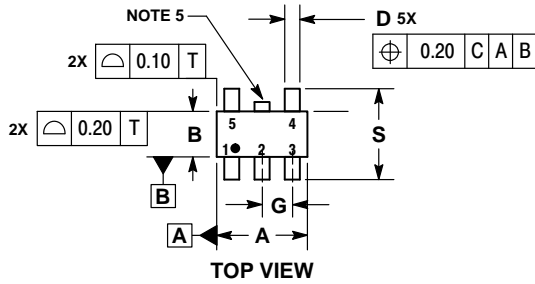


SOLDER FOOTPRINT



PACKAGE DIMENSIONS

TSOP-5
CASE 483
ISSUE L

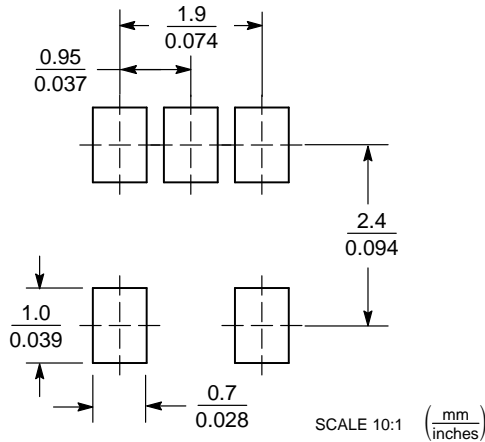


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE. DIMENSION A.
5. OPTIONAL CONSTRUCTION: AN ADDITIONAL TRIMMED LEAD IS ALLOWED IN THIS LOCATION. TRIMMED LEAD NOT TO EXTEND MORE THAN 0.2 FROM BODY.

DIM	MILLIMETERS	
	MIN	MAX
A	3.00 BSC	
B	1.50 BSC	
C	0.90	1.10
D	0.25	0.50
G	0.95 BSC	
H	0.01	0.10
J	0.10	0.26
K	0.20	0.60
M	0°	10°
S	2.50	3.00

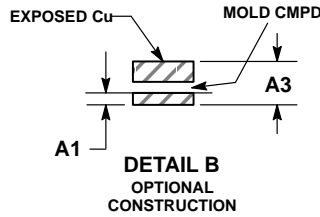
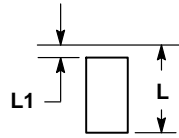
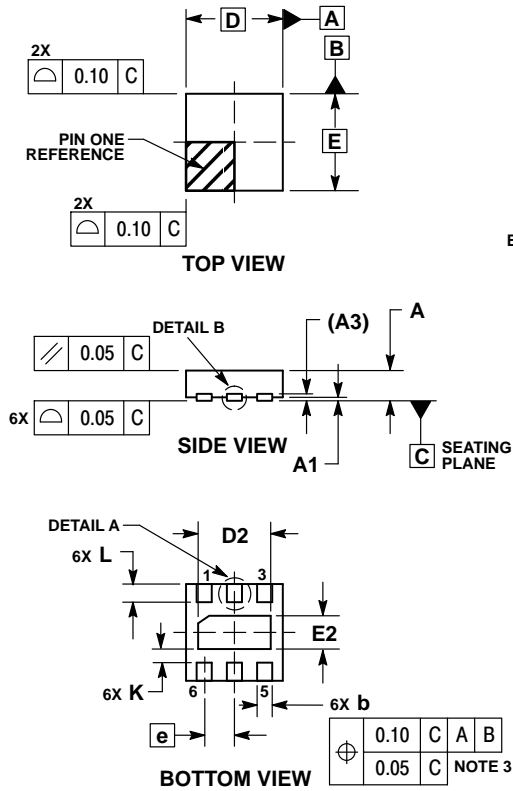
SOLDERING FOOTPRINT*



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

PACKAGE DIMENSIONS

UDFN6 1.6x1.6, 0.5P
CASE 517AP
ISSUE O

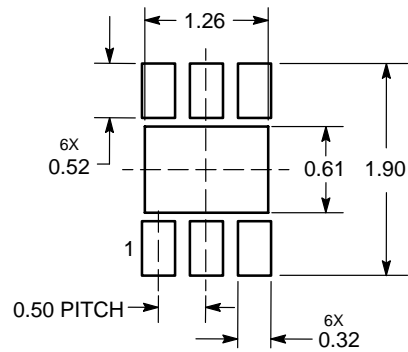


NOTES:

1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 mm FROM TERMINAL.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.

MILLIMETERS		
DIM	MIN	MAX
A	0.45	0.55
A1	0.00	0.05
A3	0.13	REF
b	0.20	0.30
D	1.60	BSC
E	1.60	BSC
e	0.50	BSC
D2	1.10	1.30
E2	0.45	0.65
K	0.20	---
L	0.20	0.40
L1	0.00	0.15

SOLDERMASK DEFINED MOUNTING FOOTPRINT*

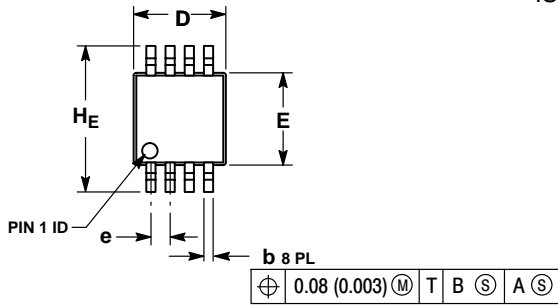


DIMENSIONS: MILLIMETERS

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

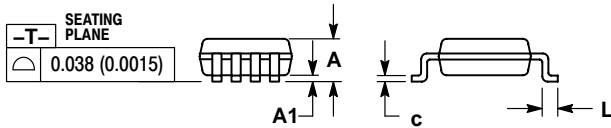
PACKAGE DIMENSIONS

Micro8™
CASE 846A-02
ISSUE J

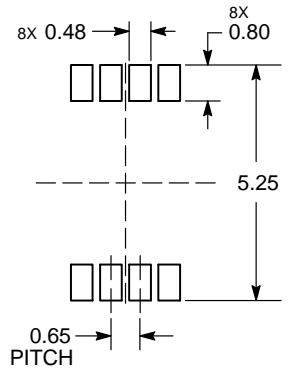


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: MILLIMETER.
 3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH, PROTRUSIONS OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
 4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
 5. 846A-01 OBSOLETE, NEW STANDARD 846A-02.

DIM	MILLIMETERS			INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	—	—	1.10	—	—	0.043
A1	0.05	0.08	0.15	0.002	0.003	0.006
b	0.25	0.33	0.40	0.010	0.013	0.016
c	0.13	0.18	0.23	0.005	0.007	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	2.90	3.00	3.10	0.114	0.118	0.122
e	0.65 BSC			0.026 BSC		
L	0.40	0.55	0.70	0.016	0.021	0.028
HE	4.75	4.90	5.05	0.187	0.193	0.199



RECOMMENDED
SOLDERING FOOTPRINT*

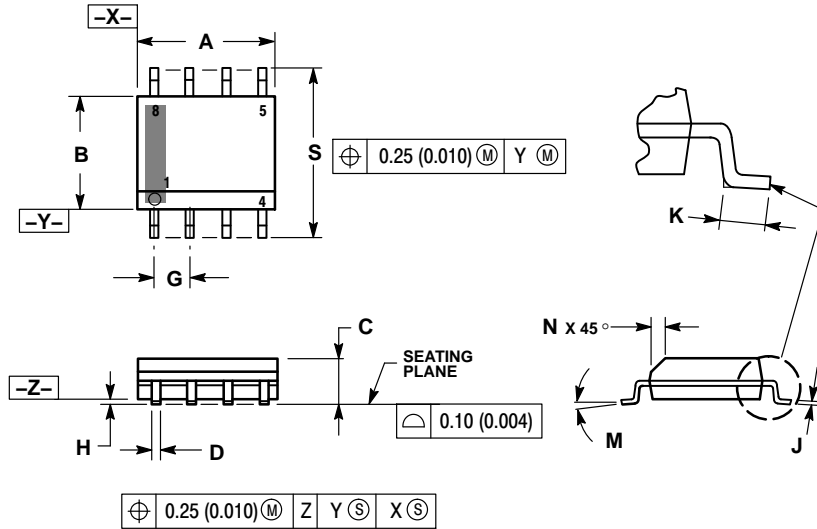


DIMENSION: MILLIMETERS

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

PACKAGE DIMENSIONS

SOIC-8 NB
CASE 751-07
ISSUE AK

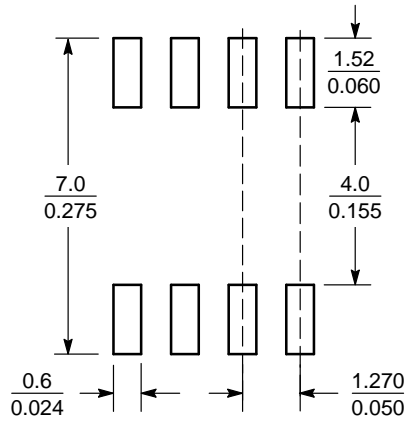


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: MILLIMETER.
 3. DIMENSION A AND B DO NOT INCLUDE MOLD PROTRUSION.
 4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
 5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.127 (0.005) TOTAL IN EXCESS OF THE D DIMENSION AT MAXIMUM MATERIAL CONDITION.
 6. 751-01 THRU 751-06 ARE OBSOLETE. NEW STANDARD IS 751-07.

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

- 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

SOLDERING FOOTPRINT*

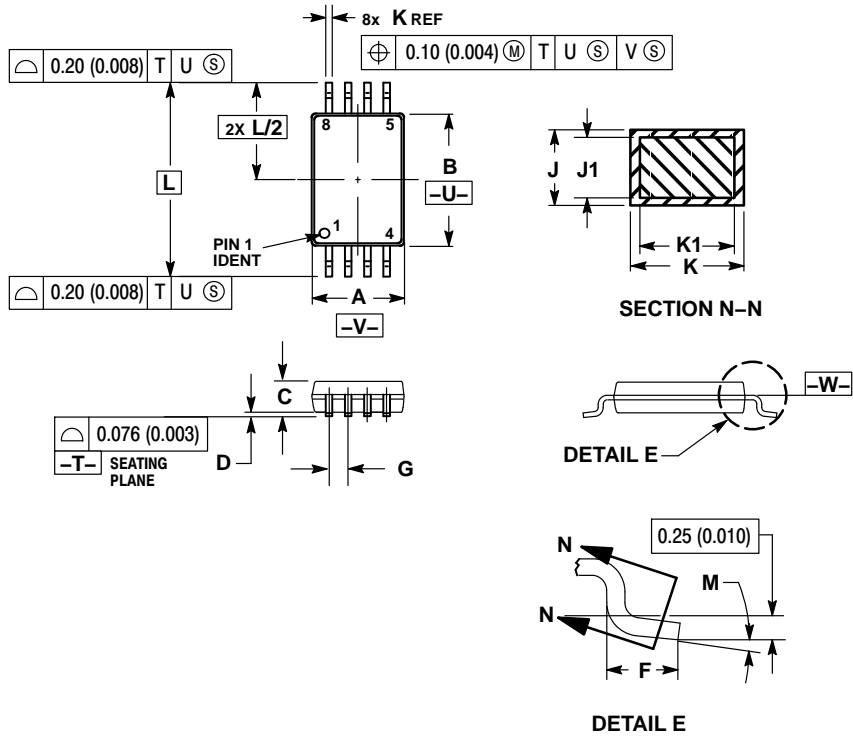


SCALE 6:1 (mm/inches)

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

PACKAGE DIMENSIONS

TSSOP-8
CASE 948S
ISSUE C

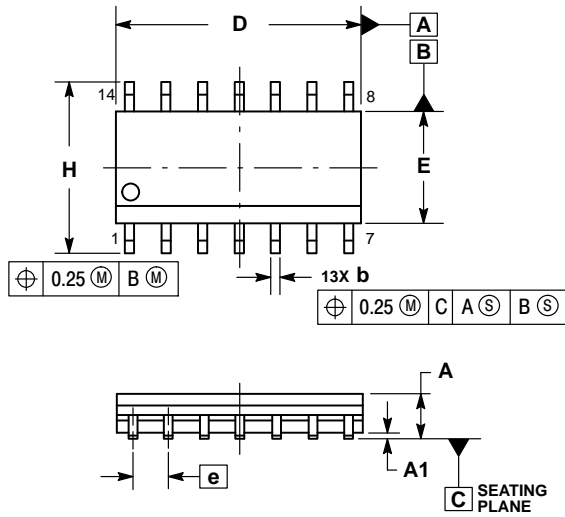


- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: MILLIMETER.
 3. DIMENSION A DOES NOT INCLUDE MOLD FLASH. PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
 4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
 5. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
 6. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -W-.

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	2.90	3.10	0.114	0.122
B	4.30	4.50	0.169	0.177
C	---	1.10	---	0.043
D	0.05	0.15	0.002	0.006
F	0.50	0.70	0.020	0.028
G	0.65 BSC		0.026 BSC	
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°

PACKAGE DIMENSIONS

SOIC-14 NB
CASE 751A-03
ISSUE K

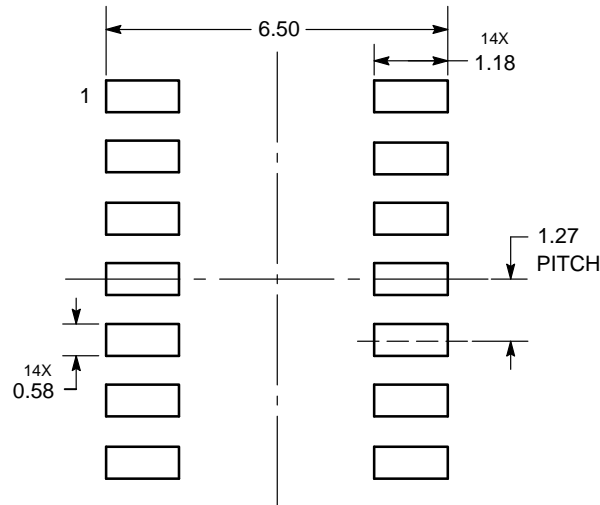


NOTES:

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.

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*

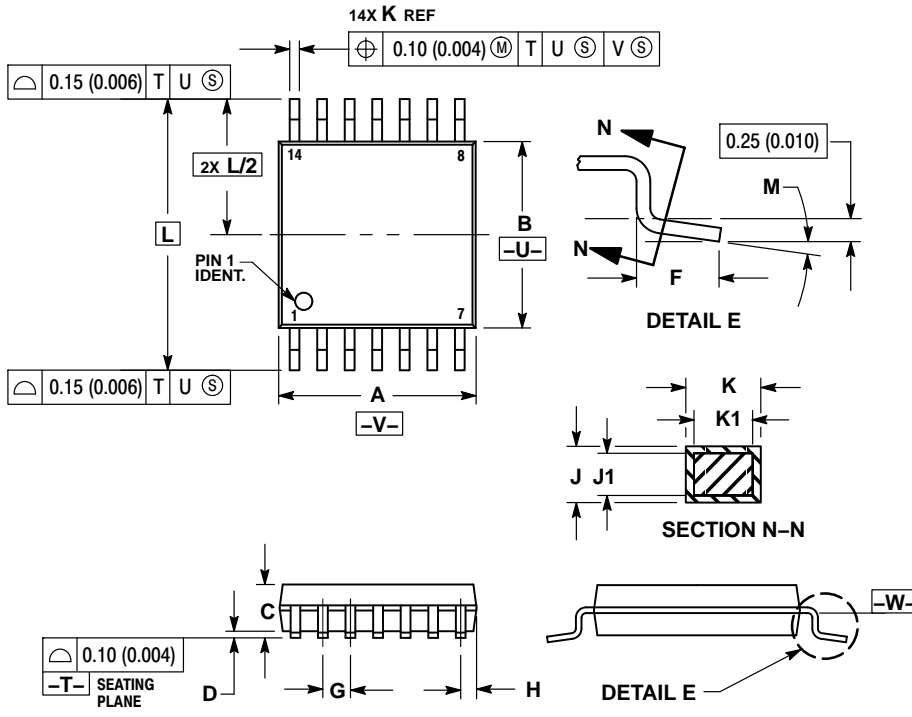


DIMENSIONS: MILLIMETERS

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

PACKAGE DIMENSIONS

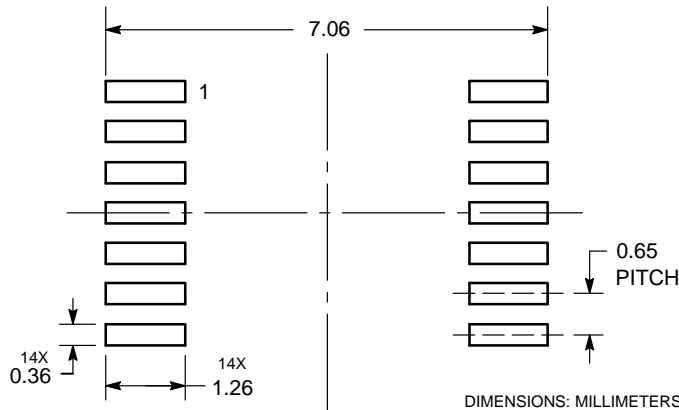
TSSOP-14
CASE 948G
ISSUE B



- NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
 2. CONTROLLING DIMENSION: MILLIMETER.
 3. DIMENSION A DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS. MOLD FLASH OR GATE BURRS SHALL NOT EXCEED 0.15 (0.006) PER SIDE.
 4. DIMENSION B DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSION. INTERLEAD FLASH OR PROTRUSION SHALL NOT EXCEED 0.25 (0.010) PER SIDE.
 5. DIMENSION K DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 (0.003) TOTAL IN EXCESS OF THE K DIMENSION AT MAXIMUM MATERIAL CONDITION.
 6. TERMINAL NUMBERS ARE SHOWN FOR REFERENCE ONLY.
 7. DIMENSION A AND B ARE TO BE DETERMINED AT DATUM PLANE -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°

SOLDERING FOOTPRINT



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