Operational Amplifier, Zero-Drift, 10 μV Offset, 0.07 μV/°C

NCS333A, NCV333A, NCS2333, NCV2333, NCS4333, NCV4333, NCS333

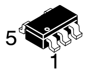
The NCS333/2333/4333 family of zero−drift op amps feature offset voltage as low as 10 μV over the 1.8 V to 5.5 V supply voltage range. The zero−drift architecture reduces the offset drift to as low as 0.07 μV/°C and enables high precision measurements over both time and temperature. This family has low power consumption over a wide dynamic range and is available in space saving packages. These features make it well suited for signal conditioning circuits in portable, industrial, automotive, medical and consumer markets.

Features

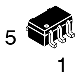
- Gain−Bandwidth Product:
  - 270 kHz (NCx2333)
  - 350 kHz (NCx333, NCx333A, NCx4333)
- Low Supply Current: 17 μA (typ at 3.3 V)
- Low Offset Voltage:
  - 10 μV max for NCS333, NCS333A
  - 30 μV max for NCV333A, NCx2333 and NCx4333
- Low Offset Drift: 0.07 μV/°C max for NCS333/A
- Wide Supply Range: 1.8 V to 5.5 V
- Wide Temperature Range: −40°C to +125°C
- Rail−to−Rail Input and Output
- Available in Single, Dual and Quad Packages
- NCV Prefix for Automotive and Other Applications Requiring Unique Site and Control Change Requirements; AEC−Q100 Qualified and PPAP Capable

Applications

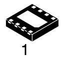
- Automotive
- Battery Powered/ Portable Application
- Sensor Signal Conditioning
- Low Voltage Current Sensing
- Filter Circuits
- Bridge Circuits
- Medical Instrumentation



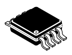
**SOT23−5
SN SUFFIX
CASE 483**



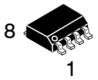
**SC70−5
SQ SUFFIX
CASE 419A**



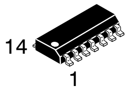
**UDFN8
MU SUFFIX
CASE 517AW**



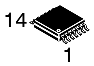
**MSOP−8
DM SUFFIX
CASE 846A−02**



**SOIC−8
D SUFFIX
CASE 751**



**SOIC−14
D SUFFIX
CASE 751A**



**TSSOP−14 WB
DT SUFFIX
CASE 948G**

DEVICE MARKING INFORMATION

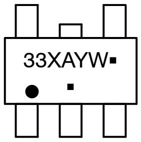
See general marking information in the device marking section on page 2 of this data sheet.

ORDERING INFORMATION

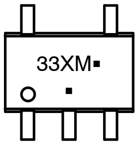
See detailed ordering and shipping information on page 3 of this data sheet.

DEVICE MARKING INFORMATION

Single Channel Configuration
NCS333, NCS333A, NCV333A

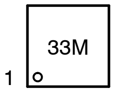


TSOP−5/SOT23−5
CASE 483

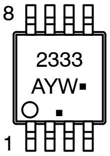


SC70−5
CASE 419A

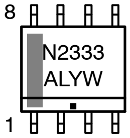
Dual Channel Configuration
NCS2333, NCV2333



UDFN8, 2x2, 0.5P
CASE 517AW

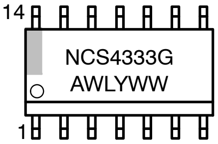


Micro8/MSOP8
CASE 846A−02

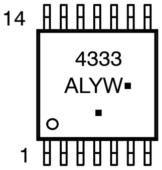


SOIC−8
CASE 751

Quad Channel Configuration
NCS4333, NCV4333



SOIC−14
CASE 751A



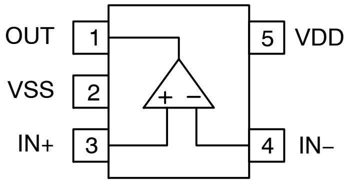
TSSOP−14
CASE 948G

X = Specific Device Code
  E = NCS333 (SOT23−5)
  H = NCS333 (SC70−5)
  G = NCS333A (SOT23−5)
  K = NCS333A (SC70−5)
  M = NCV333A (SOT23−5)
  N = NCV333A (SC70−5)
A = Assembly Location
Y = Year
W = Work Week
M = Date Code
G or ▪ = Pb−Free Package

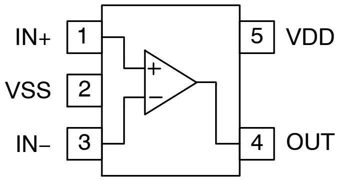
(Note: Microdot may be in either location)

PIN CONNECTIONS

Single Channel Configuration
NCS333, NCS333A, NCV333A

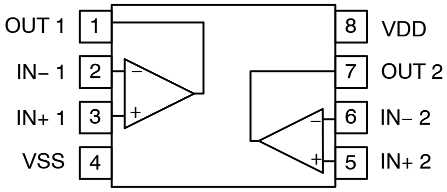


SOT23−5 / TSOP−5



SC70−5 / SC−88−5 / SOT−353−5

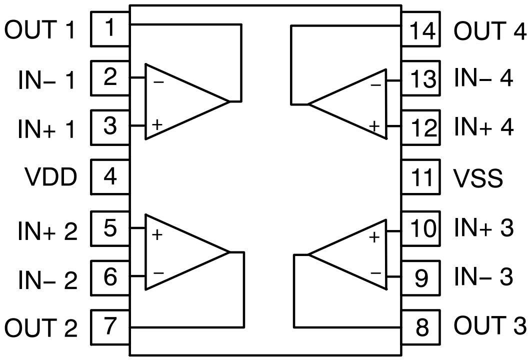
Dual Channel Configuration
NCS2333, NCV2333



UDFN8* / Micro8 / SOIC−8

*The exposed pad of the UDFN8 package can be floated or connected to VSS.

Quad Channel Configuration
NCS4333, NCV4333



SOIC−14 / TSSOP−14

ORDERING INFORMATION

Channels	Device	Package	Shipping †
Single	NCS333SN2T1G	SOT23−5 / TSOP−5	3000 / Tape & Reel
	NCS333ASN2T1G		3000 / Tape & Reel
	NCS333SQ3T2G	SC70−5 / SC−88−5 / SOT−353−5	3000 / Tape & Reel
	NCS333ASQ3T2G		3000 / Tape & Reel
Dual	NCS2333MUTBG	UDFN8	3000 / Tape & Reel
	NCS2333DR2G	SOIC−8	3000 / Tape & Reel
	NCS2333DMR2G	MICRO−8	4000 / Tape & Reel
Quad	NCS4333DR2G	SOIC−14	2500 / Tape & Reel
	NCS4333DTBR2G	TSSOP−14	2500 / Tape & Reel

Automotive Qualified

Channels	Device	Package	Shipping †
Single	NCV333ASN2T1G	SOT23−5 / TSOP−5	3000 / Tape & Reel
	NCV333ASQ3T2G	SC70−5 / SC−88−5 / SOT−353−5	3000 / Tape & Reel
Dual	NCV2333DR2G	SOIC−8	3000 / Tape & Reel
	NCV2333DMR2G	MICRO−8	4000 / Tape & Reel
Quad	NCV4333DR2G	SOIC−14	2500 / Tape & Reel
	NCV4333DTBR2G	TSSOP−14	2500 / 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.

ABSOLUTE MAXIMUM RATINGS

Over operating free−air temperature, unless otherwise stated.

Parameter	Rating	Unit
Supply Voltage	7	V
INPUT AND OUTPUT PINS		
Input Voltage (Note 1)	(VSS) − 0.3 to (VDD) + 0.3	V
Input Current (Note 1)	±10	mA
Output Short Circuit Current (Note 2)	Continuous	
TEMPERATURE		
Operating Temperature Range	−40 to +125	°C
Storage Temperature Range	−65 to +150	°C
Junction Temperature	+150	°C
ESD RATINGS (Note 3)		
Human Body Model (HBM)	±4000	V
Machine Model (MM)	±200	V
Charged Device Model (CDM)	±2000	V
OTHER RATINGS		
Latch−up Current (Note 4)	100	mA
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. Input terminals are diode−clamped to the power−supply rails. Input signals that can swing more than 0.3 V beyond the supply rails should be current limited to 10 mA or less
2. Short−circuit to ground.
3. This device series incorporates ESD protection and is tested by the following methods:
    ESD Human Body Model tested per JEDEC standard JS−001 (AEC−Q100−002)
    ESD Machine Model tested per JEDEC standard JESD22−A115 (AEC−Q100−003)
    ESD Charged Device Model tested per JEDEC standard JESD22−C101 (AEC−Q100−011)
4. Latch−up Current tested per JEDEC standard: JESD78.

THERMAL INFORMATION (Note 5)

Parameter	Symbol	Package	Value	Unit
Thermal Resistance, Junction to Ambient	θ_{JA}	SOT23−5 / TSOP5	290	°C/W
		SC70−5 / SC−88−5 / SOT−353−5	425	
		Micro8 / MSOP8	298	
		SOIC−8	250	
		UDFN8	228	
		SOIC−14	216	
		TSSOP−14	155	

5. As mounted on an 80x80x1.5 mm FR4 PCB with 650 mm^2 and 2 oz (0.07 mm) thick copper heat spreader. Following JEDEC JESD/EIA 51.1, 51.2, 51.3 test guidelines

RECOMMENDED OPERATING CONDITIONS

Parameter		Symbol	Range	Unit
Supply Voltage (V_{DD} − V_{SS})		V_S	1.8 to 5.5	V
Specified Operating Temperature Range	NCS333	T_A	−40 to 105	°C
	NCx333A, NCx2333, NCx4333		−40 to 125	
Input Common Mode Voltage Range		V_{CM}	V_{SS}−0.1 to V_{DD}+0.1	V

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.

ELECTRICAL CHARACTERISTICS: V_S = 1.8 V to 5.5 V
At T_A = +25°C, R_L = 10 kΩ connected to midsupply, V_{CM} = V_{OUT} = midsupply, unless otherwise noted.
Boldface limits apply over the specified operating temperature range, guaranteed by characterization and/or design.

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
INPUT CHARACTERISTICS							
Offset Voltage	V_{OS}	V_S = +5 V	NCS333, NCS333A		3.5	10	µV
			NCV333A, NCx2333, NCx4333		6.0	30	
Offset Voltage Drift vs Temp	$\Delta V_{OS}/\Delta T$	NCS333, NCS333A			**0.03**	**0.07**	µV/°C
		NCV333A, V_S = 5 V			**0.03**	**0.14**	
		NCx2333, V_S = 5 V			**0.04**	**0.07**	
		NCx4333, V_S = 5 V			**0.095**	**0.19**	
Offset Voltage Drift vs Supply	$\Delta V_{OS}/\Delta V_S$	NCS333, NCS333A	Full temperature range		**0.32**	**5**	µV/V
		NCV333A	T_A = +25°C		0.40	5	
			Full temperature range			**8**	
		NCx2333, NCx4333	T_A = +25°C		0.32	5	
			Full temperature range			**12.6**	
Input Bias Current (Note 6)	I_{IB}	T_A = +25°C	NCS333, NCx333A		±60	±200	pA
			NCx2333, NCx4333		±60	±400	
		Full temperature range			**±400**		
Input Offset Current (Note 6)	I_{OS}	T_A = +25°C	NCS333, NCx333A		±50	±400	pA
			NCx2333, NCx4333		±50	±800	
Common Mode Rejection Ratio (Note 7)	CMRR	V_S = 1.8 V			111		dB
		V_S = 3.3 V			118		
		V_S = 5.0 V	NCS333, NCS333A, NCx2333, NCx4333	106	123		
			NCV333A	103	123		
		V_S = 5.5 V			127		
Input Resistance	R_{IN}	Differential			180		GΩ
		Common Mode			90		
Input Capacitance	C_{IN}	NCS333	Differential		2.3		pF
			Common Mode		4.6		
		NCx2333, NCx4333, NCx333A	Differential		4.1		
			Common Mode		7.9		
OUTPUT CHARACTERISTICS							
Open Loop Voltage Gain (Note 6)	A_{VOL}	V_{SS} + 100 mV < V_O < V_{DD} − 100 mV		**106**	145		dB
Open Loop Output Impedance	Z_{out-OL}	f = UGBW, I_O = 0 mA			300		Ω
Output Voltage High, Referenced to V_{DD}	V_{OH}	T_A = +25°C			10	50	mV
		Full temperature range				**70**	
Output Voltage Low, Referenced to V_{SS}	V_{OL}	T_A = +25°C			10	50	mV
		Full temperature range				**70**	

6. Guaranteed by characterization and/or design
7. Specified over the full common mode range: $V_{SS} - 0.1 < V_{CM} < V_{DD} + 0.1$

ELECTRICAL CHARACTERISTICS: V_S = 1.8 V to 5.5 V
At T_A = +25°C, R_L = 10 kΩ connected to midsupply, V_{CM} = V_{OUT} = midsupply, unless otherwise noted.
Boldface limits apply over the specified operating temperature range, guaranteed by characterization and/or design.

Parameter	Symbol	Conditions		Min	Typ	Max	Unit
OUTPUT CHARACTERISTICS							
Output Current Capability	I_O	Sinking Current	NCS333		25		mA
			NCx333A, NCx2333, NCx4333		11		
		Sourcing Current			5.0		
Capacitive Load Drive	C_L			See Figure 13			
NOISE PERFORMANCE							
Voltage Noise Density	e_N	f_{IN} = 1 kHz			62		nV / √Hz
Voltage Noise	e_{P-P}	f_{IN} = 0.1 Hz to 10 Hz			1.1		μV_{PP}
		f_{IN} = 0.01 Hz to 1 Hz			0.5		
Current Noise Density	i_N	f_{IN} = 10 Hz			350		fA / √Hz
Channel Separation		NCx2333, NCx4333			135		dB
DYNAMIC PERFORMANCE							
Gain Bandwidth Product	GBWP	C_L = 100 pF	NCS333, NCx333A, NCx4333		350		kHz
			NCx2333		270		
Gain Margin	A_M	C_L = 100 pF			18		dB
Phase Margin	ϕ_M	C_L = 100 pF			55		°
Slew Rate	SR	G = +1			0.15		V/μs
POWER SUPPLY							
Power Supply Rejection Ratio	PSRR	NCS333, NCS333A	Full temperature range	**106**	130		dB
		NCx2333, NCx4333, NCV333A	T_A = +25°C	106	130		
			Full temperature range	**98**			
Turn−on Time	t_{ON}	V_S = 5 V			100		μs
Quiescent Current (Note 8)	I_Q	NCS333, NCS333A, NCx2333, NCx4333	1.8 V ≤ V_S ≤ 3.3 V		17	25	μA
						27	
			3.3 V < V_S ≤ 5.5 V		21	33	
						35	
		NCV333A	1.8 V ≤ V_S ≤ 3.3 V		20	30	
						35	
			3.3 V < V_S ≤ 5.5 V		28	40	
						45	

8. No load, per channel

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 CHARACTERISTICS

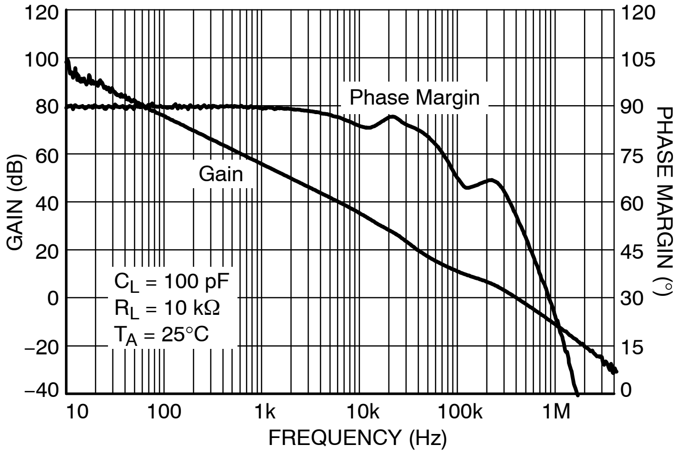


Figure 1. Open Loop Gain and Phase Margin vs. Frequency

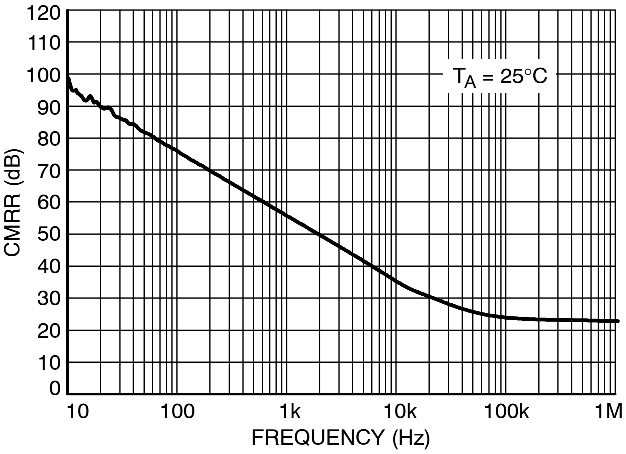


Figure 2. CMRR vs. Frequency

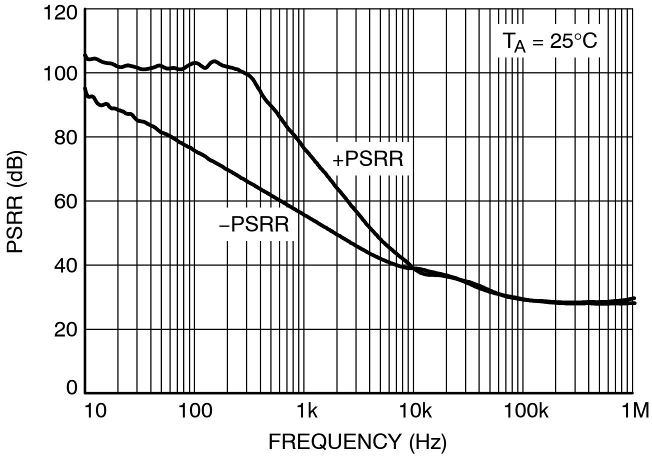


Figure 3. PSRR vs. Frequency

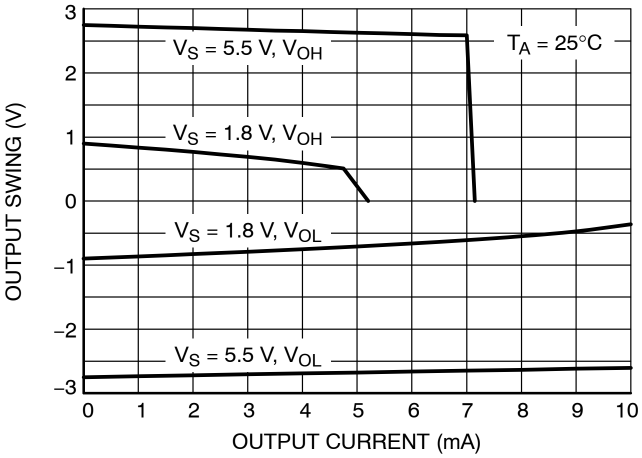


Figure 4. Output Voltage Swing vs. Output Current

TYPICAL CHARACTERISTICS

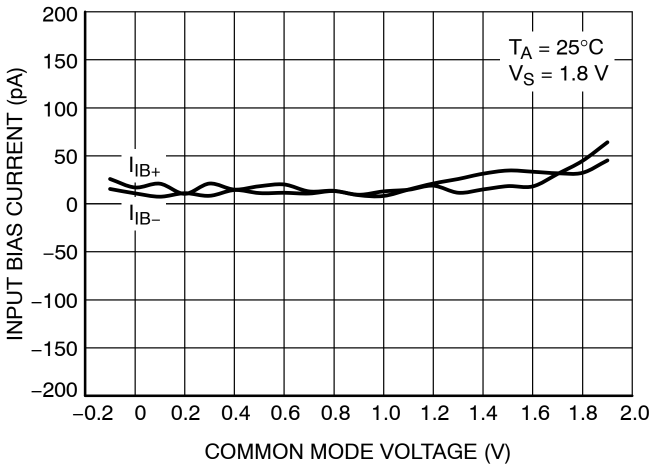


Figure 5. Input Bias Current vs. Common Mode Voltage

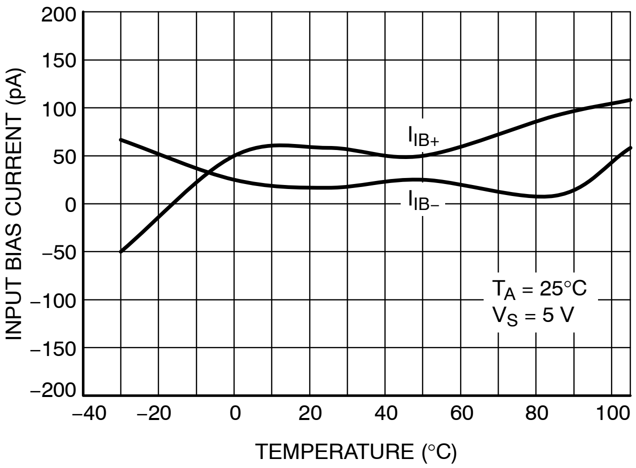


Figure 6. Input Bias Current vs. Temperature

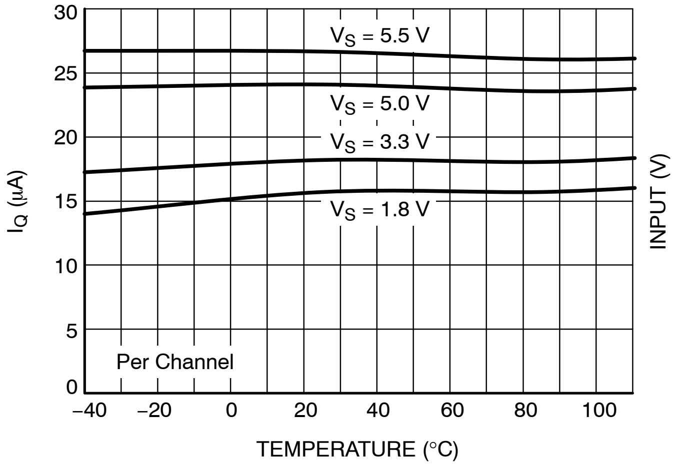


Figure 7. Quiescent Current vs. Temperature

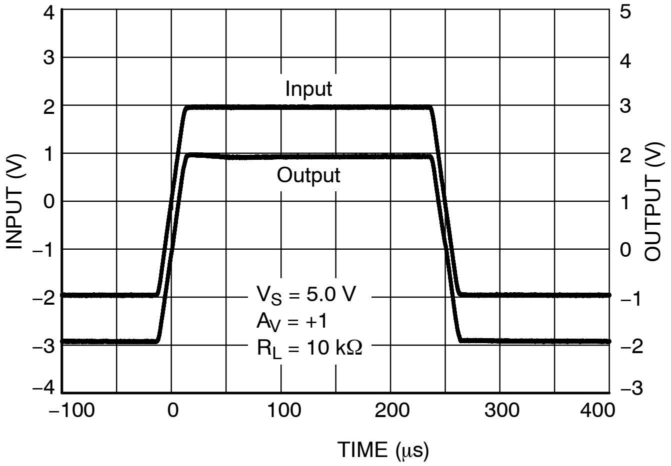


Figure 8. Large Signal Step Response

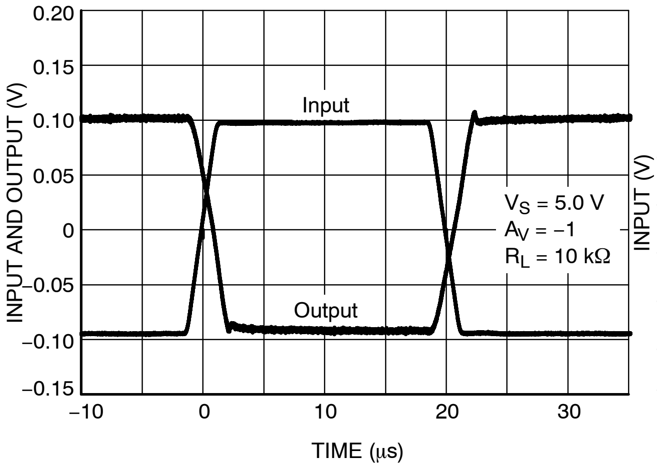


Figure 9. Small Signal Step Response

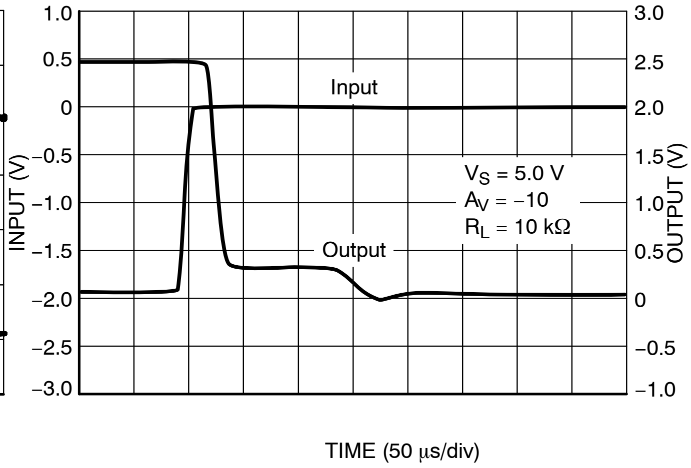


Figure 10. Positive Overvoltage Recovery

TYPICAL CHARACTERISTICS

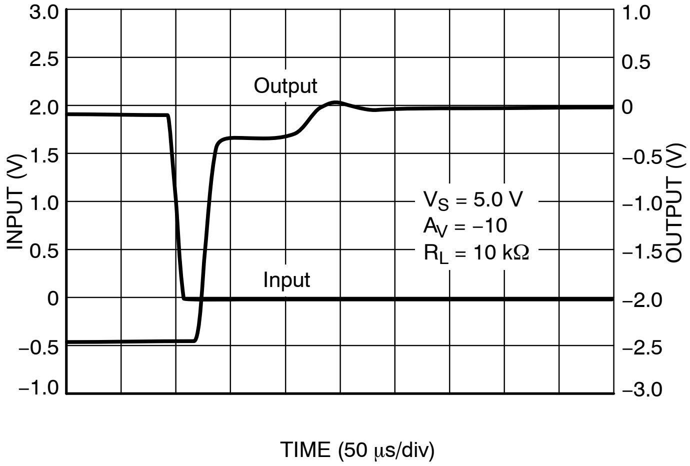


Figure 11. Negative Overvoltage Recovery

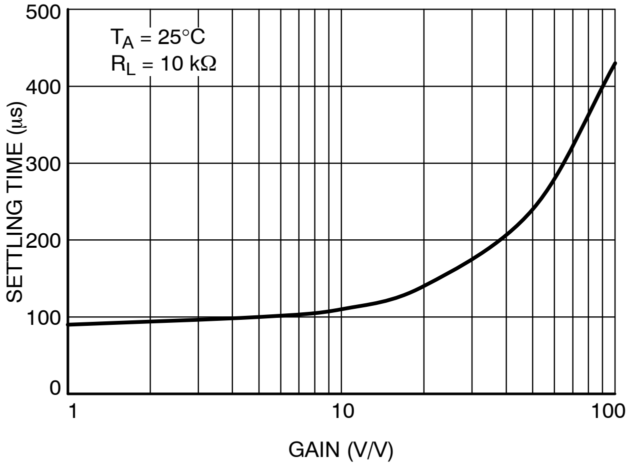


Figure 12. Setting Time to 0.1% vs. Closed−Loop Gain

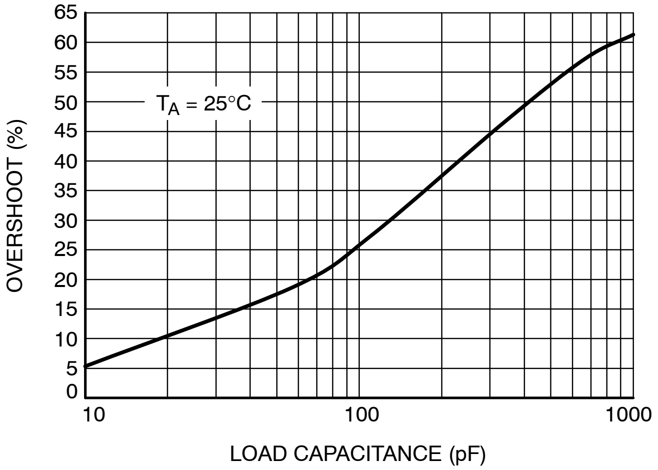


Figure 13. Small−Signal Overshoot vs. Load Capacitance

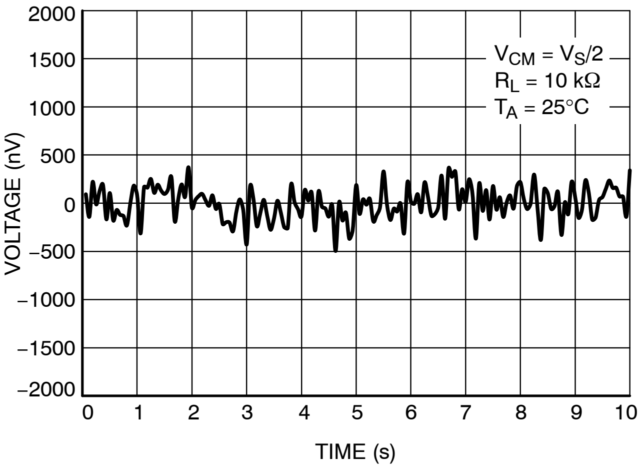


Figure 14. 0.1 Hz to 10 Hz Noise

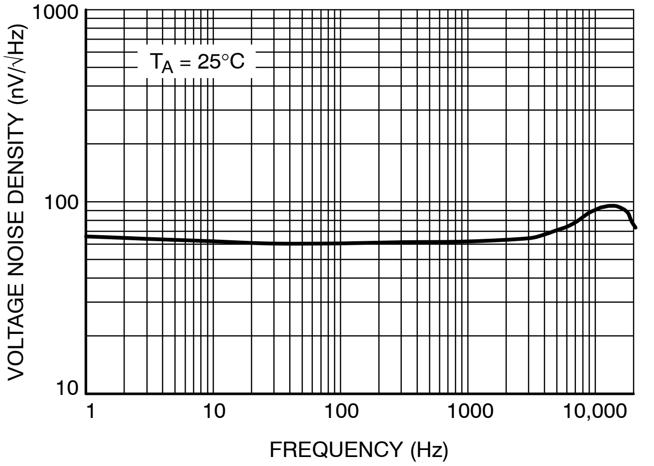


Figure 15. Voltage Noise Density vs. Frequency

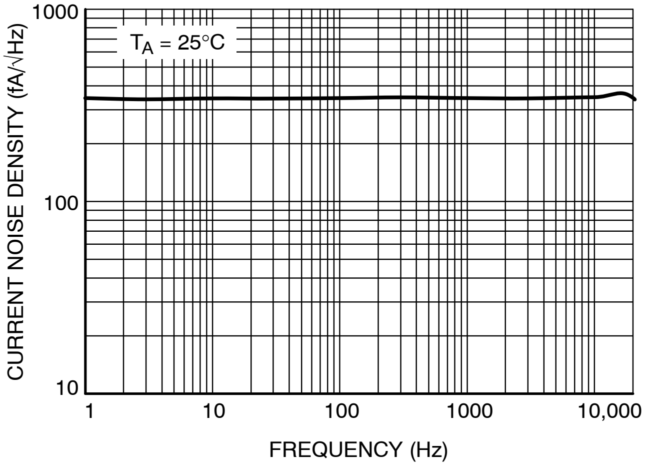


Figure 16. Current Noise Density vs. Frequency

APPLICATIONS INFORMATION

OVERVIEW

The NCS333, NCS333A, NCS2333, and NCS4333 precision op amps provide low offset voltage and zero drift over temperature. The input common mode voltage range extends 100 mV beyond the supply rails to allow for sensing near ground or VDD. These features make the NCS333 series well−suited for applications where precision is required, such as current sensing and interfacing with sensors.

NCS333 series of precision op amps uses a chopper−stabilized architecture, which provides the advantage of minimizing offset voltage drift over temperature and time. The simplified block diagram is shown in Figure 17. Unlike the classical chopper architecture, the chopper stabilized architecture has two signal paths.

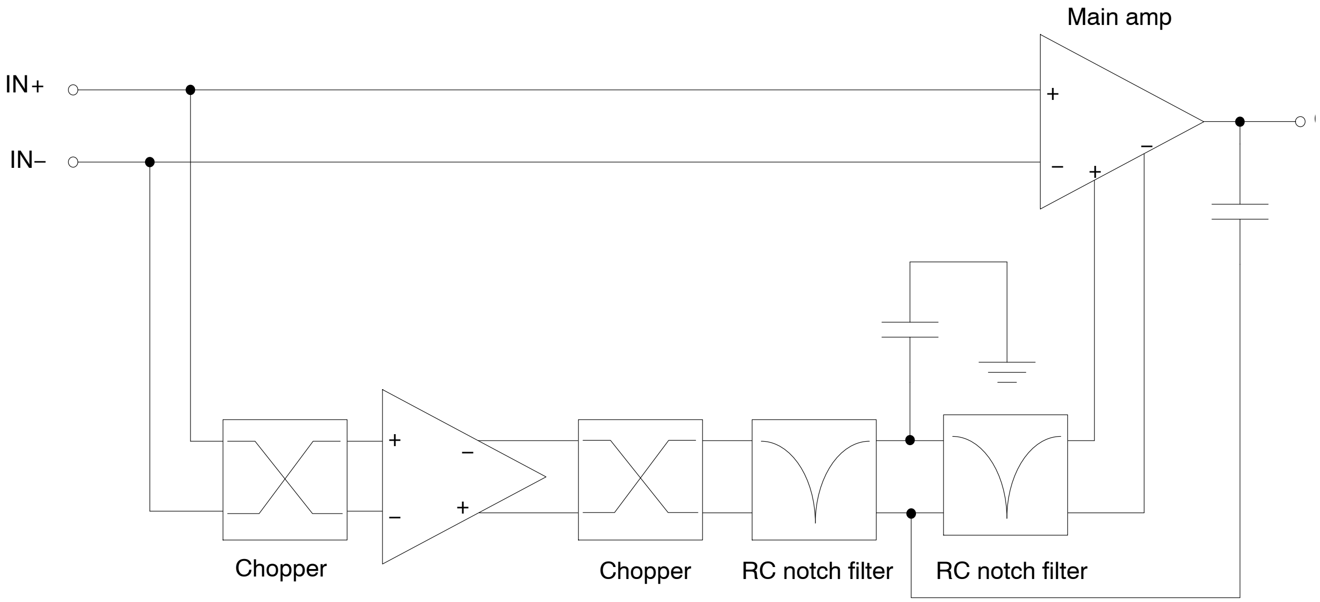


Figure 17. Simplified NCS333 Block Diagram

In Figure 17, the lower signal path is where the chopper samples the input offset voltage, which is then used to correct the offset at the output. The offset correction occurs at a frequency of 125 kHz. The chopper−stabilized architecture is optimized for best performance at frequencies up to the related Nyquist frequency (1/2 of the offset correction frequency). As the signal frequency exceeds the Nyquist frequency, 62.5 kHz, aliasing may occur at the output. This is an inherent limitation of all chopper and chopper−stabilized architectures. Nevertheless, the NCS333 op amps have minimal aliasing up to 125 kHz and low aliasing up to 190 kHz when compared to competitor parts from other manufacturers. ON Semiconductor’s patented approach utilizes two cascaded, symmetrical, RC notch filters tuned to the chopper frequency and its fifth harmonic to reduce aliasing effects.

The chopper−stabilized architecture also benefits from the feed−forward path, which is shown as the upper signal path of the block diagram in Figure 17. This is the high speed signal path that extends the gain bandwidth up to 350 kHz. Not only does this help retain high frequency components of the input signal, but it also improves the loop gain at low frequencies. This is especially useful for low−side current sensing and sensor interface applications where the signal is low frequency and the differential voltage is relatively small.

APPLICATION CIRCUITS

Low−Side Current Sensing

Low−side current sensing is used to monitor the current through a load. This method can be used to detect over−current conditions and is often used in feedback control, as shown in Figure 18. A sense resistor is placed in series with the load to ground. Typically, the value of the sense resistor is less than 100 mΩ to reduce power loss across the resistor. The op amp amplifies the voltage drop across the sense resistor with a gain set by external resistors R1, R2, R3, and R4 (where R1 = R2, R3 = R4). Precision resistors are required for high accuracy, and the gain is set to utilize the full scale of the ADC for the highest resolution.

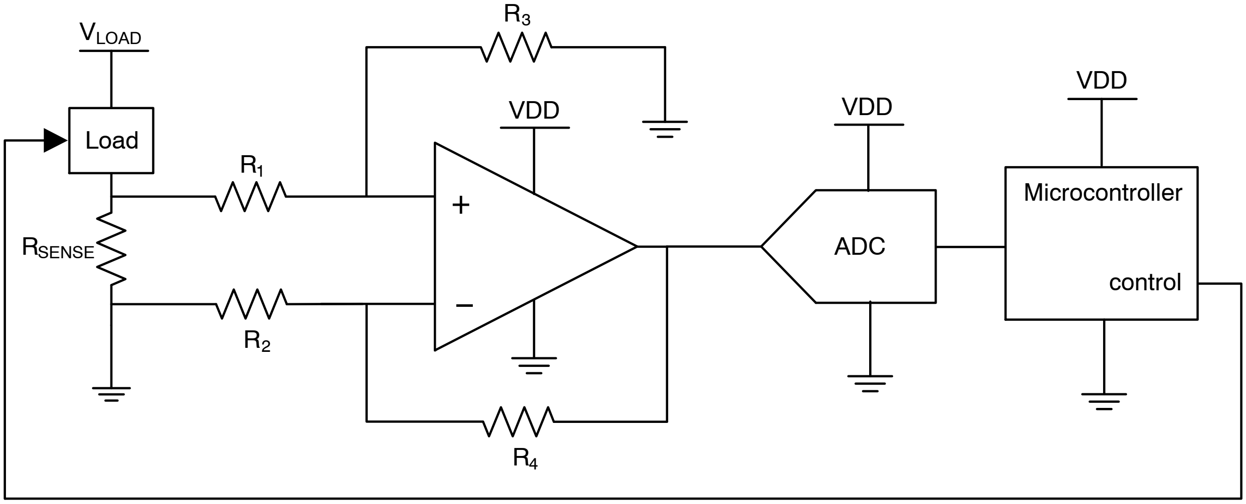


Figure 18. Low−Side Current Sensing

Differential Amplifier for Bridged Circuits

Sensors to measure strain, pressure, and temperature are often configured in a Wheatstone bridge circuit as shown in Figure 19. In the measurement, the voltage change that is produced is relatively small and needs to be amplified before going into an ADC. Precision amplifiers are recommended in these types of applications due to their high gain, low noise, and low offset voltage.

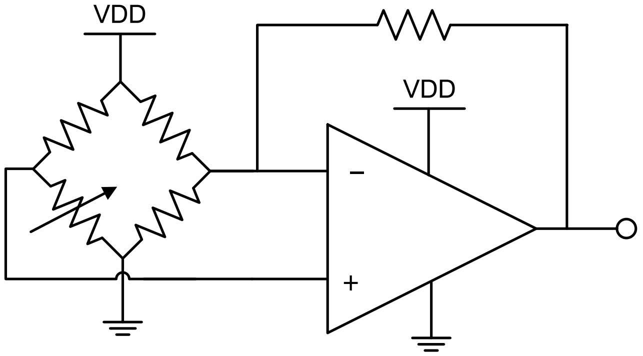


Figure 19. Bridge Circuit Amplification

EMI Susceptibility and Input Filtering

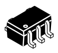
Op amps have varying amounts of EMI susceptibility. Semiconductor junctions can pick up and rectify EMI signals, creating an EMI−induced voltage offset at the output, adding another component to the total error. Input pins are the most sensitive to EMI. The NCS333 op amp family integrates low−pass filters to decrease sensitivity to EMI.

General Layout Guidelines

To ensure optimum device performance, it is important to follow good PCB design practices. Place 0.1 μF decoupling capacitors as close as possible to the supply pins. Keep traces short, utilize a ground plane, choose surface−mount components, and place components as close as possible to the device pins. These techniques will reduce susceptibility to electromagnetic interference (EMI). Thermoelectric effects can create an additional temperature dependent offset voltage at the input pins. To reduce these effects, use metals with low thermoelectric−coefficients and prevent temperature gradients from heat sources or cooling fans.

UDFN8 Package Guidelines

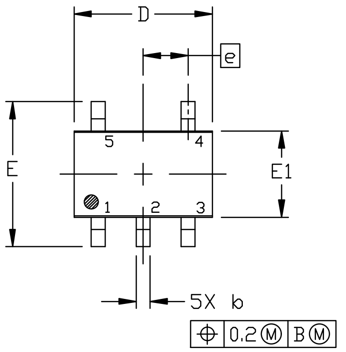
The UDFN8 package has an exposed leadframe die pad on the underside of the package. This pad should be soldered to the PCB, as shown in the recommended soldering footprint in the Package Dimensions section of this datasheet. The center pad can be electrically connected to VSS or it may be left floating. When connected to VSS, the center pad acts as a heat sink, improving the thermal resistance of the part.



SCALE 2:1

SC−88A (SC−70−5/SOT−353)
CASE 419A−02
ISSUE M

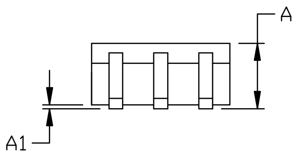
DATE 11 APR 2023

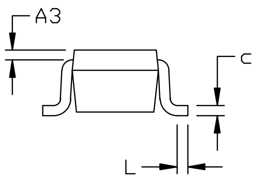


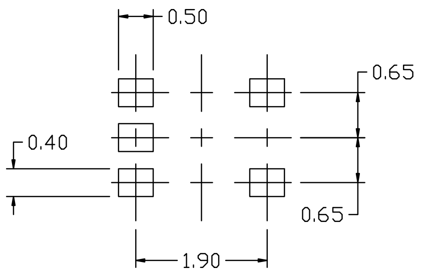
NOTES:

1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETERS
3. 419A-01 OBSOLETE. NEW STANDARD 419A-02
4. DIMENSIONS D AND E1 DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.1016MM PER SIDE.

DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	0.80	0.95	1.10
A1	---	---	0.10
A3	0.20 REF		
b	0.10	0.20	0.30
c	0.10	---	0.25
D	1.80	2.00	2.20
E	2.00	2.10	2.20
E1	1.15	1.25	1.35
e	0.65 BSC		
L	0.10	0.15	0.30



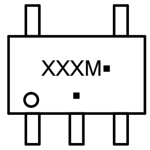




RECOMMENDED
MOUNTING FOOTPRINT

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

GENERIC MARKING DIAGRAM*



*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.

XXX = Specific Device Code
M = Date Code
▪ = Pb−Free Package

(Note: Microdot may be in either location)

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

STYLE 2:
PIN 1. ANODE
2. EMITTER
3. BASE
4. COLLECTOR
5. CATHODE

STYLE 3:
PIN 1. ANODE 1
2. N/C
3. ANODE 2
4. CATHODE 2
5. CATHODE 1

STYLE 4:
PIN 1. SOURCE 1
2. DRAIN 1/2
3. SOURCE 1
4. GATE 1
5. GATE 2

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

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

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

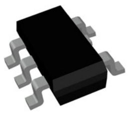
STYLE 8:
PIN 1. CATHODE
2. COLLECTOR
3. N/C
4. BASE
5. EMITTER

STYLE 9:
PIN 1. ANODE
2. CATHODE
3. ANODE
4. ANODE
5. ANODE

Note: Please refer to datasheet for style callout. If style type is not called out in the datasheet refer to the device datasheet pinout or pin assignment.

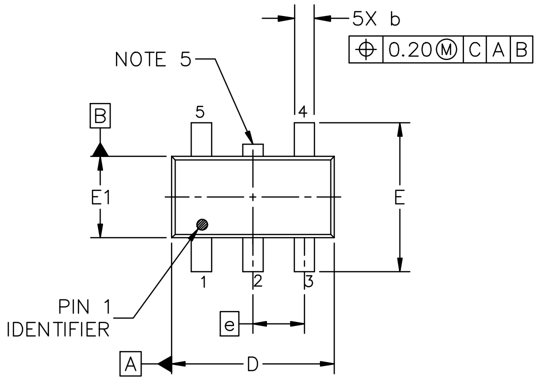
DOCUMENT NUMBER:	**98ASB42984B**	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped “CONTROLLED COPY” in red.
DESCRIPTION:	**SC−88A (SC−70−5/SOT−353)**	**PAGE 1 OF 1**

MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS

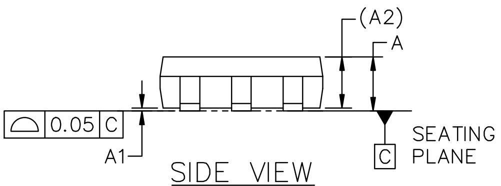


TSOP−5 3.00x1.50x0.95, 0.95P
CASE 483
ISSUE P

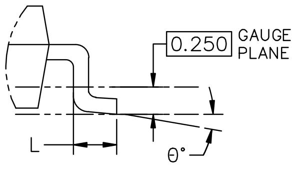
DATE 01 APR 2024



TOP VIEW



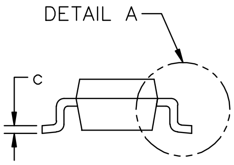
SIDE VIEW



DETAIL "A"
SCALE 2:1

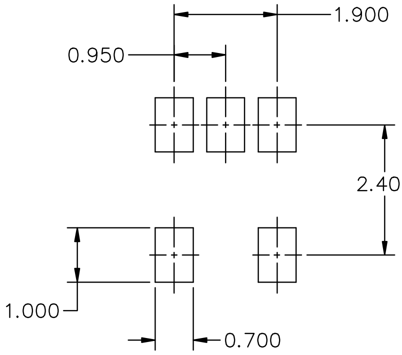
NOTES:

1. DIMENSIONING AND TOLERANCING CONFORM TO ASME Y14.5−2018.
2. ALL DIMENSION ARE IN MILLIMETERS (ANGLES IN DEGREES).
3. MAXIMUM LEAD THICKNESS INCLUDES LEAD FINISH THICKNESS. MINIMUM LEAD THICKNESS IS THE MINIMUM THICKNESS OF BASE MATERIAL.
4. DIMENSIONS D AND E1 DO NOT INCLUDE MOLD FLASH, PROTRUSIONS OF GATE BURRS. MOLD FLASH, PROTRUSIONS, OR GATE BURRS SHALL NOT EXCEED 0.15 PER SIDE. DIMENSION D.
5. OPTIONAL CONSTRUCTION: AN ADDITIONAL TRIMMED LEAD IS ALLOWED IN THIS LOCATION. TRIMMED LEAD NOT TO EXTEND MORE THAN 0.2 FROM BODY.



END VIEW

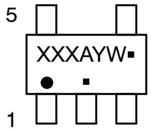
DIM	MILLIMETERS		
	MIN.	NOM.	MAX.
A	0.900	1.000	1.100
A1	0.010	0.055	0.100
A2	0.950 REF.		
b	0.250	0.375	0.500
c	0.100	0.180	0.260
D	2.850	3.000	3.150
E	2.500	2.750	3.000
E1	1.350	1.500	1.650
e	0.950 BSC		
L	0.200	0.400	0.600
θ	0°	5°	10°



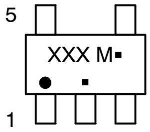
RECOMMENDED MOUNTING FOOTPRINT*

* FOR ADDITIONAL INFORMATION ON OUR Pb−FREE STRATEGY AND SOLDERING DETAILS, PLEASE DOWNLOAD THE ON SEMICONDUCTOR SOLDERING AND MOUNTING TECHNIQUES REFERENCE MANUAL, SOLDERRM/D.

GENERIC MARKING DIAGRAM*



Analog



Discrete/Logic

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

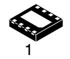
(Note: Microdot may be in either location)

XXX	= Specific Device Code
M	= Date Code
▪	= 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.

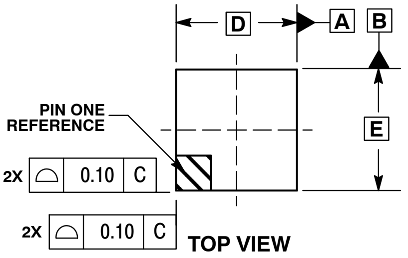
DOCUMENT NUMBER:	**98ARB18753C**	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped "CONTROLLED COPY" in red.	
DESCRIPTION:	**TSOP−5 3.00x1.50x0.95, 0.95P**		**PAGE 1 OF 1**

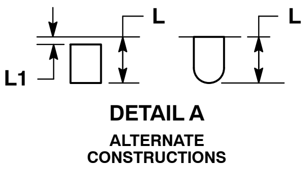
UDFN8, 2x2
CASE 517AW
ISSUE A

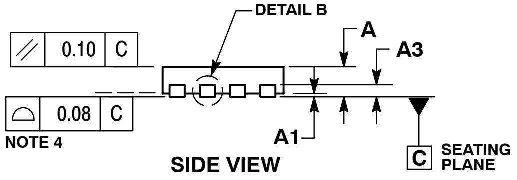


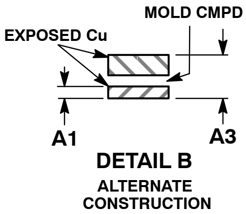
SCALE 2:1

DATE 13 NOV 2015



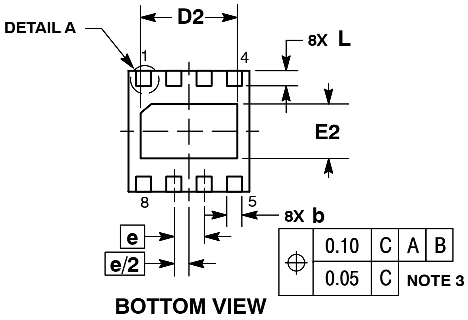




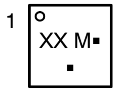


NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINALS AND IS MEASURED BETWEEN 0.15 AND 0.30 MM FROM THE TERMINAL TIP.
4. COPLANARITY APPLIES TO THE EXPOSED PAD AS WELL AS THE TERMINALS.
5. FOR DEVICE OPN CONTAINING W OPTION, DETAIL B ALTERNATE CONSTRUCTION IS NOT APPLICABLE.

	MILLIMETERS	
DIM	MIN	MAX
A	0.45	0.55
A1	0.00	0.05
A3	0.13 REF	
b	0.18	0.30
D	2.00 BSC	
D2	1.50	1.70
E	2.00 BSC	
E2	0.80	1.00
e	0.50 BSC	
L	0.20	0.45
L1	---	0.15



GENERIC MARKING DIAGRAM*

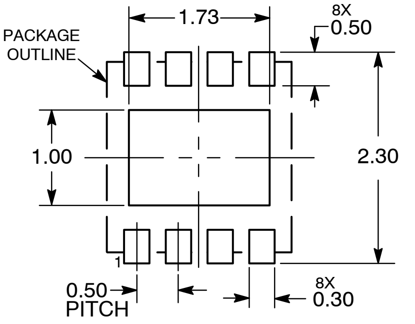


XX = Specific Device Code
M = Date Code
▪ = Pb−Free Package

(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.

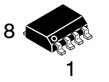
RECOMMENDED SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

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

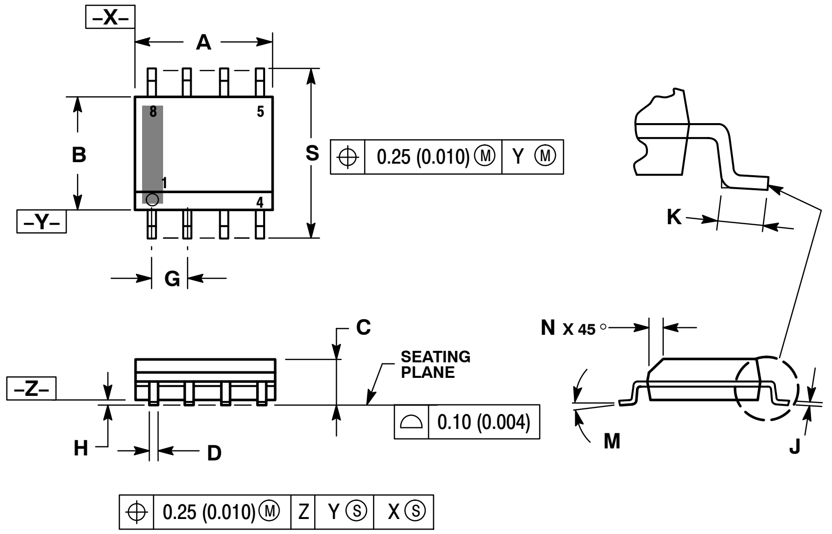
DOCUMENT NUMBER:	**98AON34462E**	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped “CONTROLLED COPY” in red.
DESCRIPTION:	**UDFN8, 2X2**	**PAGE 1 OF 1**



SCALE 1:1

SOIC−8 NB
CASE 751−07
ISSUE AK

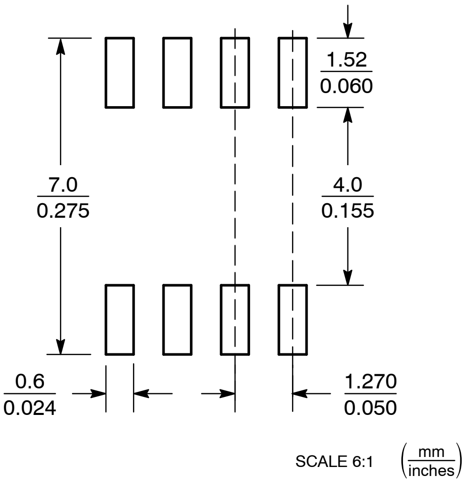
DATE 16 FEB 2011



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.

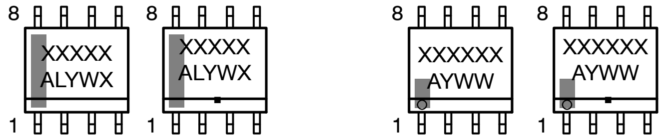
	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	4.80	5.00	0.189	0.197
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.053	0.069
D	0.33	0.51	0.013	0.020
G	1.27 BSC		0.050 BSC	
H	0.10	0.25	0.004	0.010
J	0.19	0.25	0.007	0.010
K	0.40	1.27	0.016	0.050
M	0 °	8 °	0 °	8 °
N	0.25	0.50	0.010	0.020
S	5.80	6.20	0.228	0.244

SOLDERING FOOTPRINT*



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

GENERIC MARKING DIAGRAM*



IC **IC (Pb−Free)** **Discrete** **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.

STYLES ON PAGE 2

DOCUMENT NUMBER:	**98ASB42564B**	Electronic versions are uncontrolled except when accessed directly from the Document Repository. Printed versions are uncontrolled except when stamped “CONTROLLED COPY” in red.
DESCRIPTION:	**SOIC−8 NB**	**PAGE 1 OF 2**

SOIC−8 NB
CASE 751−07
ISSUE AK

DATE 16 FEB 2011

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:

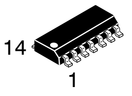
PIN 1.	SW_TO_GND
2.	DASIC_OFF
3.	DASIC_SW_DET
4.	GND
5.	V_MON
6.	VBULK
7.	VBULK
8.	VIN

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:

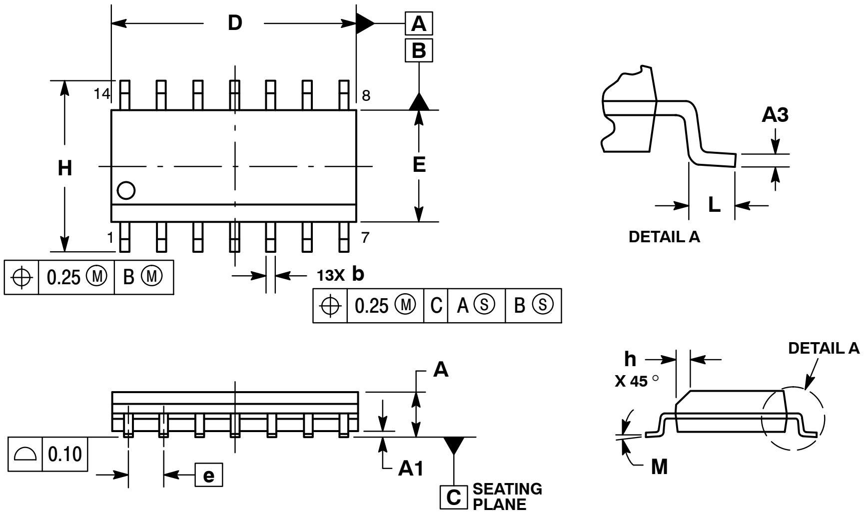
PIN 1.	DRAIN 1
2.	DRAIN 1
3.	GATE 2
4.	SOURCE 2
5.	SOURCE 1/DRAIN 2
6.	SOURCE 1/DRAIN 2
7.	SOURCE 1/DRAIN 2
8.	GATE 1



SCALE 1:1

SOIC−14 NB
CASE 751A−03
ISSUE L

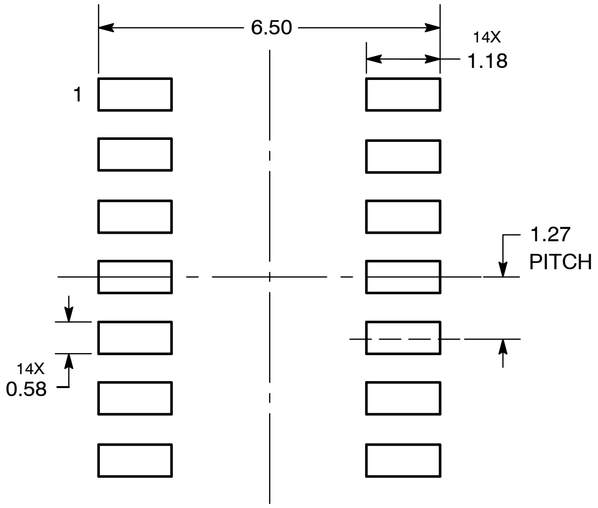
DATE 03 FEB 2016



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.

	MILLIMETERS		INCHES	
DIM	**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 °

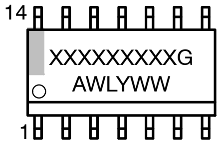
SOLDERING FOOTPRINT*



DIMENSIONS: MILLIMETERS

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

GENERIC MARKING DIAGRAM*



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. Some products may not follow the Generic Marking.

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

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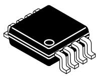
DESCRIPTION:	**SOIC−14 NB**	**PAGE 2 OF 2**

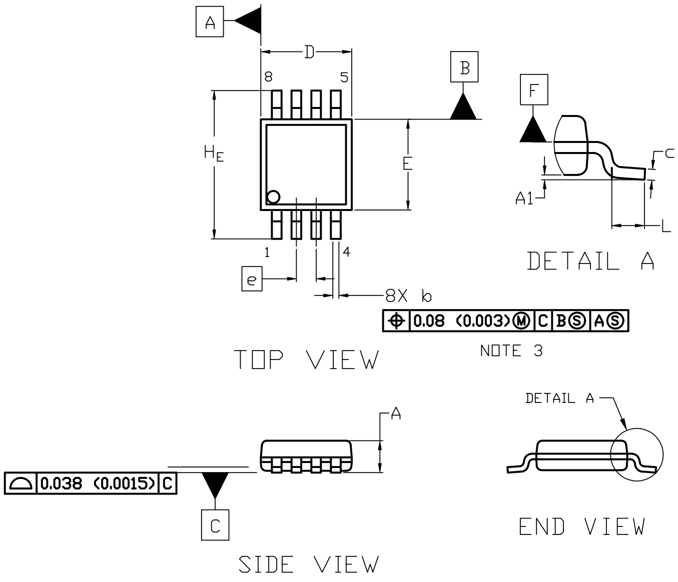
MECHANICAL CASE OUTLINE
PACKAGE DIMENSIONS



SCALE 2:1

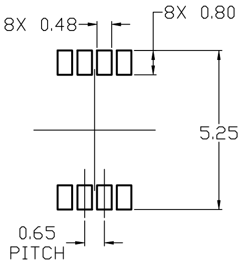
Micro8
CASE 846A−02
ISSUE K

DATE 16 JUL 2020



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.

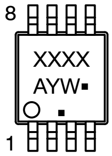


RECOMMENDED MOUNTING FOOTPRINT

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

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

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

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DESCRIPTION:	**MICRO8**	**PAGE 1 OF 1**

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