LMV321, LMV358, LMV324

Single, Dual, Quad Low-Voltage, Rail-to-Rail Operational Amplifiers

The LMV321, LMV358, and LMV324 are CMOS single, dual, and quad low voltage operational amplifiers with rail−to−rail output swing. These amplifiers are a cost−effective solution for applications where low power consumption and space saving packages are critical. Specification tables are provided for operation from power supply voltages at 2.7 V and 5 V. Rail−to−Rail operation provides improved signal−to−noise preformance. Ultra low quiescent current makes this series of amplifiers ideal for portable, battery operated equipment. The common mode input range includes ground making the device useful for low−side current−shunt measurements. The ultra small packages allow for placement on the PCB in close proximity to the signal source thereby reducing noise pickup.

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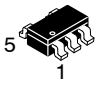
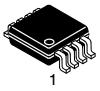
SC−70
CASE 419A



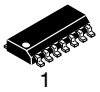
TSOP−5
CASE 483



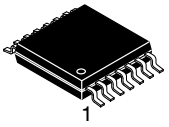
Micro8™
CASE 846A

SOIC−8
CASE 751

UDFN8
CASE 517AJ



SOIC−14
CASE 751A



TSSOP−14
CASE 948G

Features

- Operation from 2.7 V to 5.0 V Single−Sided Power Supply
- LMV321 Single Available in Ultra Small 5 Pin SC70 Package
- No Output Crossover Distortion
- Industrial temperature Range: −40°C to +85°C
- Rail−to−Rail Output
- Low Quiescent Current: LMV358 Dual − 220 μA, Max per Channel
- No Output Phase−Reversal from Overdriven Input
- These are Pb−Free Devices

Typical Applications

- Notebook Computers and PDA's
- Portable Battery−Operated Instruments
- Active Filters

ORDERING AND MARKING INFORMATION

See detailed ordering and shipping information in the package dimensions section on page 12 of this data sheet.

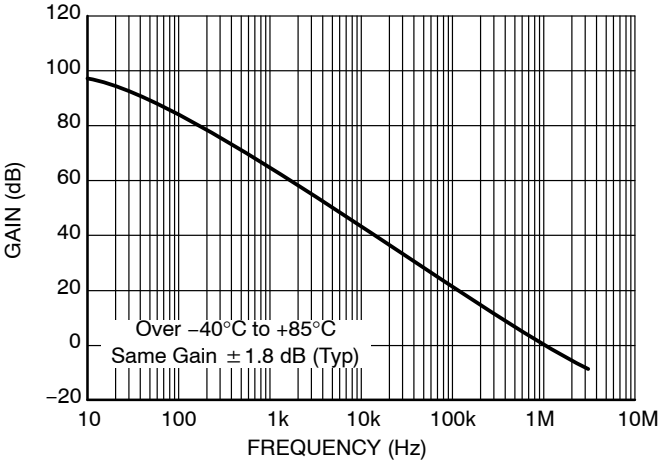


Figure 1. Open Loop Frequency Response (R_L = 2 kΩ, T_A = 25°C, V_S = 5 V)

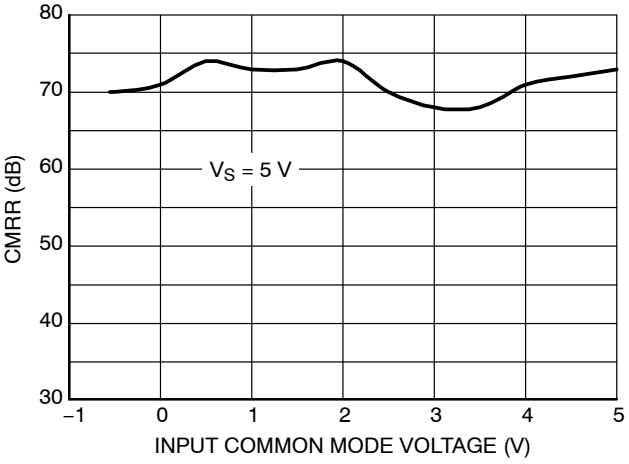


Figure 2. CMRR vs. Input Common Mode Voltage

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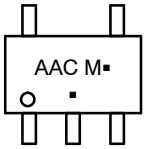
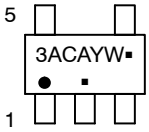
MARKING DIAGRAMS

SC−70



AAC = Specific Device Code
M = Date Code
▪ = Pb−Free Package
(Note: Microdot may be in either location)

TSOP−5

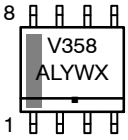


3AC = Specific Device Code
A = Assembly Location
Y = Year
W = Work Week
▪ = Pb−Free Package
(Note: Microdot may be in either location)

Micro8

V358 = Specific Device Code
A = Assembly Location
Y = Year
W = Work Week
▪ = Pb−Free Package
(Note: Microdot may be in either location)

SOIC−8

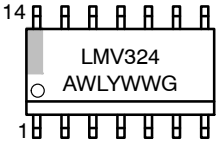


V358 = Specific Device Code
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb−Free Package

UDFN8

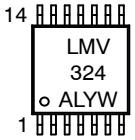
AC = Specific Device Code
M = Date Code
▪ = Pb−Free Package

SOIC−14



LMV324 = Specific Device Code
A = Assembly Location
WL = Wafer Lot
Y = Year
WW = Work Week
G = Pb−Free Package

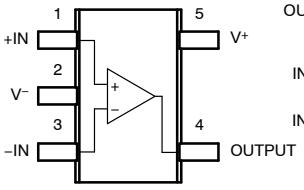
TSSOP−14



LMV324 = Specific Device Code
A = Assembly Location
L = Wafer Lot
Y = Year
W = Work Week
▪ = Pb−Free Package

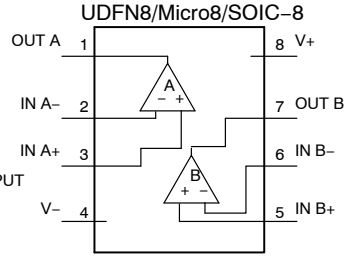
PIN CONNECTIONS

SC70−5/TSOP−5



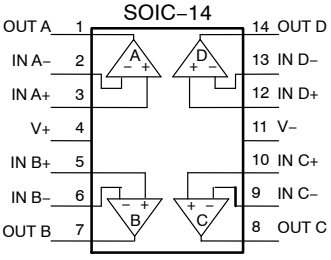
(Top View)

UDFN8/Micro8/SOIC−8



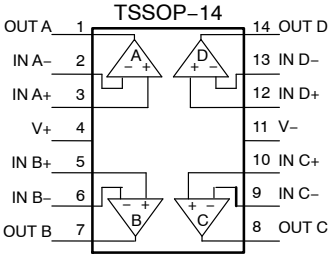
(Top View)

SOIC−14



(Top View)

TSSOP−14



(Top View)

MAXIMUM RATINGS

Symbol	Rating	Value	Unit
V_S	Supply Voltage (Operating Range V_S = 2.7 V to 5.5 V)	5.5	V
V_{IDR}	Input Differential Voltage	± Supply Voltage	V
V_{ICR}	Input Common Mode Voltage Range	−0.5 to (V+) + 0.5	V
	Maximum Input Current	10	mA
t_{So}	Output Short Circuit (Note 1)	Continuous	
T_J	Maximum Junction Temperature (Operating Range −40°C to 85°C)	150	°C
θ_{JA}	Thermal Resistance:		°C/W
	SC−70	280	
	Micro8	238	
	TSOP−5	333	
	UDFN8 (1.2 mm x 1.8 mm x 0.5 mm)	350	
	SOIC−8	212	
	SOIC−14	156	
	TSSOP−14	190	
T_{stg}	Storage Temperature	−65 to 150	°C
	Mounting Temperature (Infrared or Convection −20 sec)	235	°C
V_{ESD}	ESD Tolerance LMV321 Machine Model Human Body Model LMV358/324 Machine Model Human Body Mode	 100 1000 100 2000	V

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

1. Continuous short−circuit operation to ground at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150°C. Output currents in excess of 45 mA over long term may adversely affect reliability. Shorting output to either V+ or V− will adversely affect reliability.

2.7 V DC ELECTRICAL CHARACTERISTICS (Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = 2.7 V, R_L = 1 MΩ, V^- = 0 V, V_O = V+/2)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input Offset Voltage	V_{IO}	T_A = −40°C to +85°C		1.7	9	mV
Input Offset Voltage Average Drift	ICV_{OS}	T_A = −40°C to +85°C		5		μV/°C
Input Bias Current	I_B	T_A = −40°C to +85°C		<1		nA
Input Offset Current	I_{IO}	T_A = −40°C to +85°C		<1		nA
Common Mode Rejection Ratio	CMRR	0 V ≤ V_{CM} ≤ 1.7 V	50	63		dB
Power Supply Rejection Ratio	PSRR	2.7 V ≤ V+ ≤ 5 V, V_O = 1 V	50	60		dB
Input Common−Mode Voltage Range	V_{CM}	For CMRR ≥ 50 dB	0 to 1.7	−0.2 to 1.9		V
Output Swing	V_{OH}	R_L = 10 kΩ to 1.35 V	V_{CC} − 100	V_{CC} − 10		mV
	V_{OL}	R_L = 10 kΩ to 1.35 V (Note 2)		60	180	mV
Supply Current LMV321 LMV358 (Both Amplifiers) LMV324 (4 Amplifiers)	I_{CC}			80 140 260	185 340 680	μA

2.7 V AC ELECTRICAL CHARACTERISTICS (Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = 2.7 V, R_L = 1 MΩ, V^- = 0 V, V_O = V+/2)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Gain Bandwidth Product	GBWP	C_L = 200 pF		1		MHz
Phase Margin	Θ_m			60		°
Gain Margin	G_m			10		dB
Input−Referred Voltage Noise	e_n	f = 50 kHz		50		nV/√Hz

2. Guaranteed by design and/or characterization.

5.0 V DC ELECTRICAL CHARACTERISTICS (Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = 5.0 V, R_L = 1 MΩ, V^- = 0 V, V_O = V+/2)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Input Offset Voltage	V_{IO}	T_A = −40°C to +85°C		1.7	9	mV
Input Offset Voltage Average Drift	T_CV_{IO}	T_A = −40°C to +85°C		5		μV/°C
Input Bias Current (Note 3)	I_B	T_A = −40°C to +85°C		< 1		nA
Input Offset Current (Note 3)	I_{IO}	T_A = −40°C to +85°C		< 1		nA
Common Mode Rejection Ratio	CMRR	0 V ≤ V_{CM} ≤ 4 V	50	65		dB
Power Supply Rejection Ratio	PSRR	2.7 V ≤ V+ ≤ 5 V, V_O = 1 V, V_{CM} = 1 V	50	60		dB
Input Common−Mode Voltage Range	V_{CM}	For CMRR ≥ 50 dB	0 to 4	−0.2 to 4.2		V
Large Signal Voltage Gain (Note 3)	A_V	R_L = 2 kΩ	15	100		V/mV
		T_A = −40°C to +85°C	10			
Output Swing	V_{OH}	R_L = 2 kΩ to 2.5 V T_A = −40°C to +85°C	V_{CC} − 300 V_{CC} − 400	V_{CC} − 40		V
	V_{OL}	R_L = 2 kΩ to 2.5 V (Note 3) T_A = −40°C to +85°C		120	300 400	mV
	V_{OH}	R_L = 10 kΩ to 2.5 V (Note 3) T_A = −40°C to +85°C	V_{CC} − 100 V_{CC} − 200			V
	V_{OL}	R_L = 10 kΩ to 2.5 V T_A = −40°C to +85°C		65	180 280	mV
Output Short Circuit Current	I_O	Sourcing = V_O = 0 V (Note 3) Sinking = V_O = 5 V (Note 3)	10 10	60 160		mA
Supply Current	I_{CC}	LMV321 T_A = −40°C to +85°C		130	250 350	μA
		LMV358 Both Amplifiers T_A = −40°C to +85°C		210	440 615	
		LMV324 All Four Amplifiers T_A = −40°C to +85°C		410	830 1160	

5.0 V AC ELECTRICAL CHARACTERISTICS (Unless otherwise specified, all limits are guaranteed for T_A = 25°C, V^+ = 5.0 V, R_L = 1 MΩ, V^- = 0 V, V_O = V+/2)

Parameter	Symbol	Condition	Min	Typ	Max	Unit
Slew Rate	S_R			1		V/μs
Gain Bandwidth Product	GBWP	C_L = 200 pF		1		MHz
Phase Margin	Θ_m			60		°
Gain Margin	G_m			10		dB
Input−Referred Voltage Noise	e_n	f = 50 kHz		50		nV/$\sqrt{Hz}$

3. Guaranteed by design and/or characterization.

TYPICAL CHARACTERISTICS

(T_A = 25°C and V_S = 5 V unless otherwise specified)

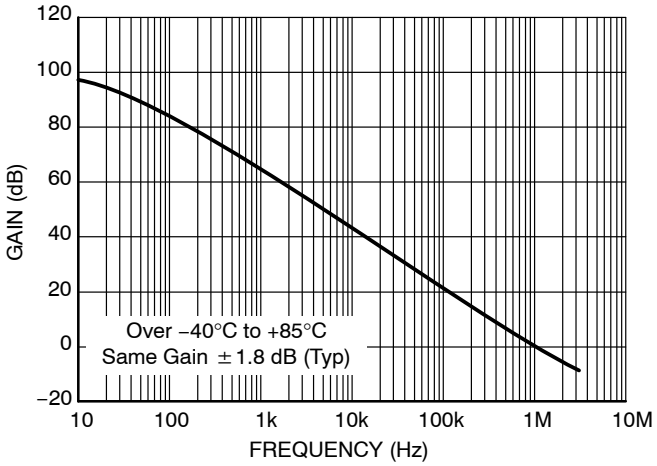


Figure 3. Open Loop Frequency Response (R_L = 2 kΩ, T_A = 25°C, V_S = 5 V)

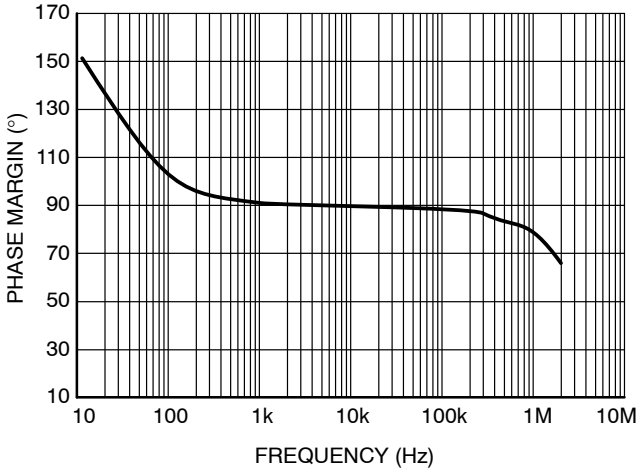


Figure 4. Open Loop Phase Margin (R_L = 2 kΩ, T_A = 25°C, V_S = 5 V)

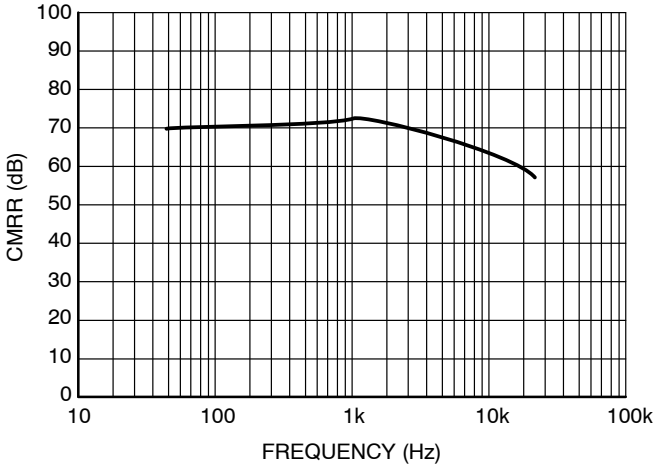


Figure 5. CMRR vs. Frequency (R_L = 5 kΩ, V_S = 5 V)

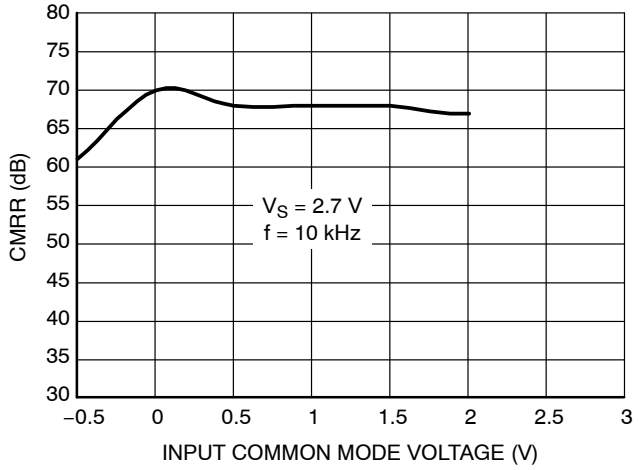


Figure 6. CMRR vs. Input Common Mode Voltage

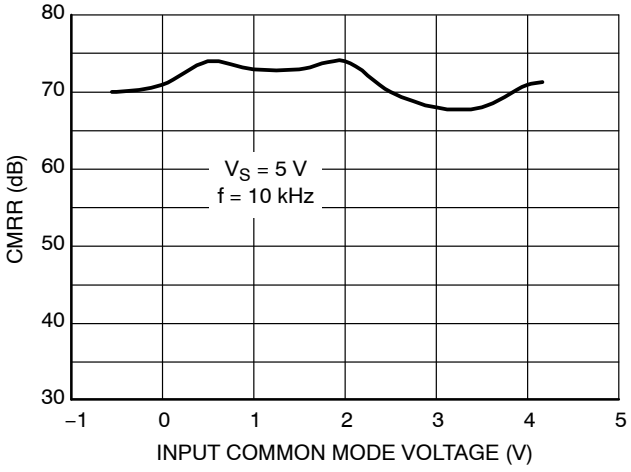


Figure 7. CMRR vs. Input Common Mode Voltage

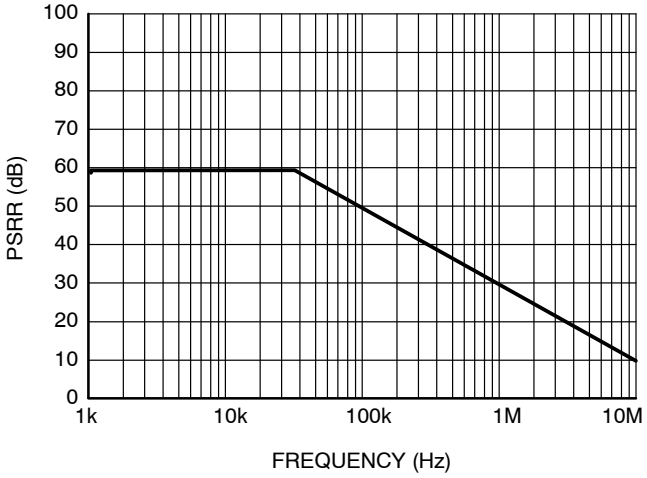


Figure 8. PSRR vs. Frequency (R_L = 5 kΩ, V_S = 2.7 V, +PSRR)

TYPICAL CHARACTERISTICS

(T_A = 25°C and V_S = 5 V unless otherwise specified)

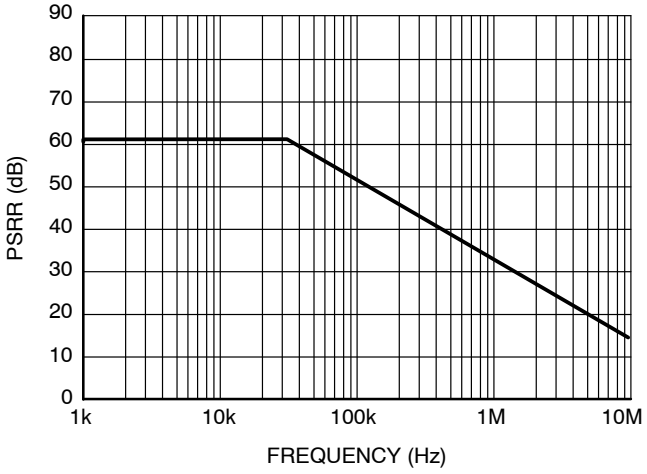


Figure 9. PSRR vs. Frequency (R_L = 5 kΩ, V_S = 2.7 V, −PSRR)

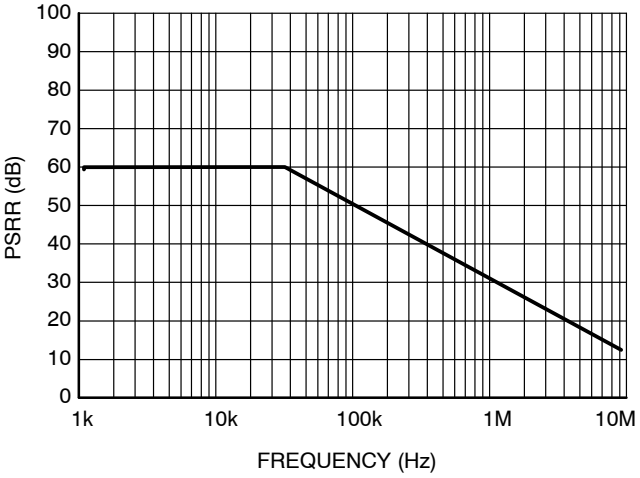


Figure 10. PSRR vs. Frequency (R_L = 5 kΩ, V_S = 5 V, +PSRR)

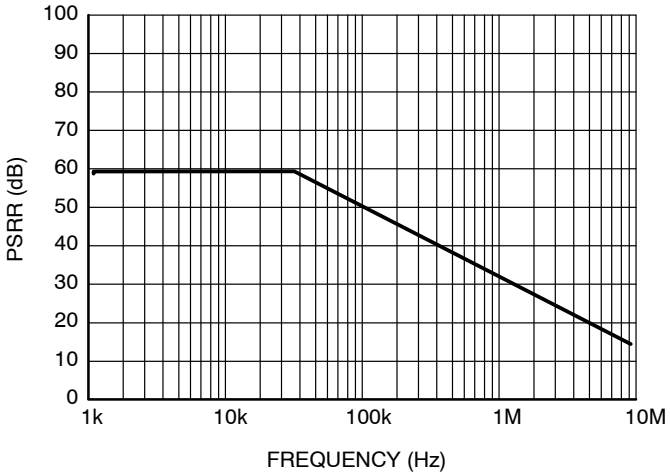


Figure 11. PSRR vs. Frequency (R_L = 5 kΩ, V_S = 5 V, −PSRR)

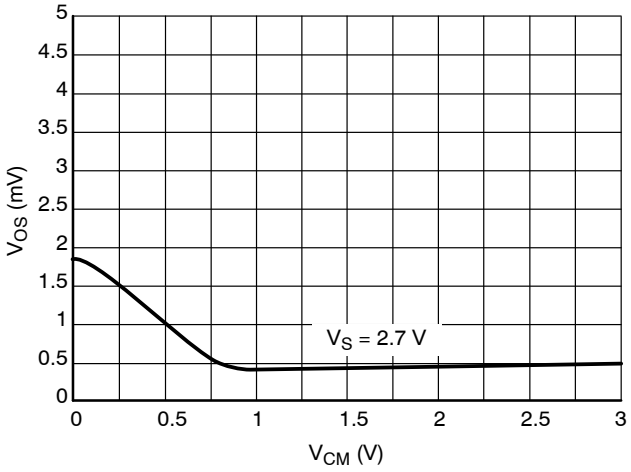


Figure 12. V_{OS} vs CMR

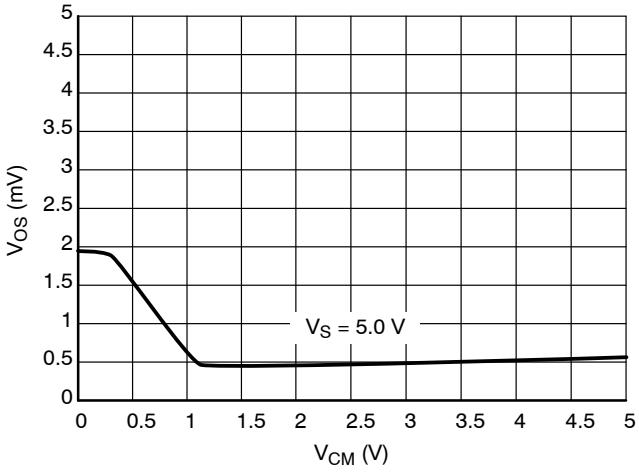


Figure 13. V_{OS} vs CMR

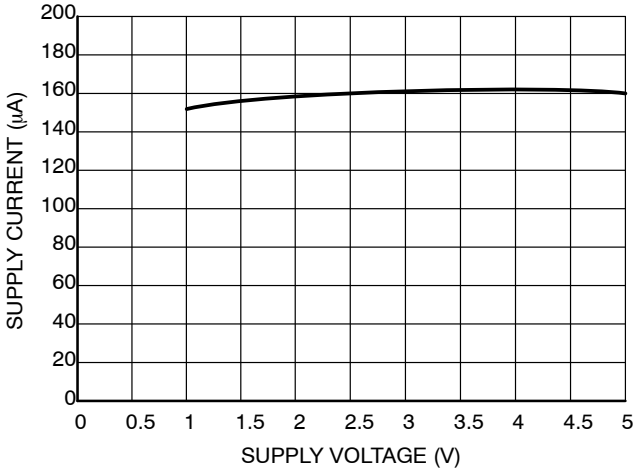


Figure 14. Supply Current vs. Supply Voltage

TYPICAL CHARACTERISTICS

(T_A = 25°C and V_S = 5 V unless otherwise specified)

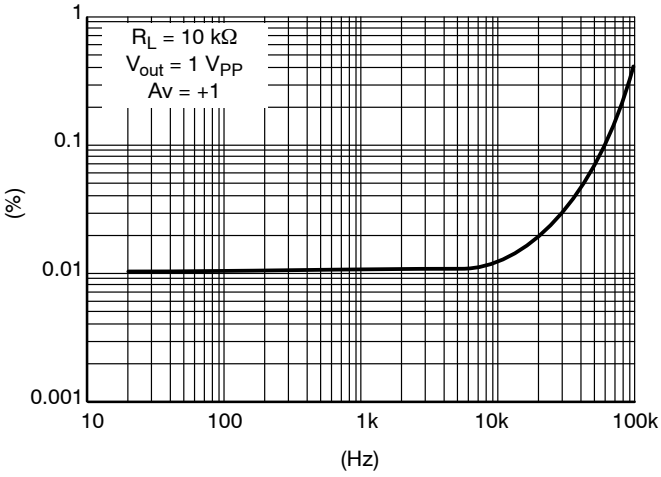


Figure 15. THD+N vs Frequency

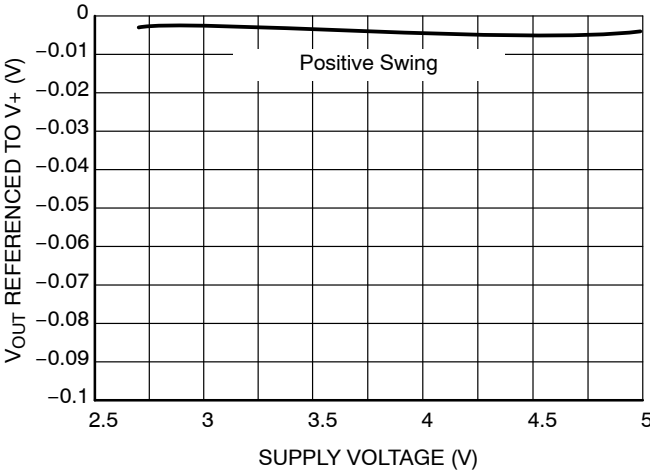


Figure 16. Output Voltage Swing vs Supply Voltage (R_L = 10k)

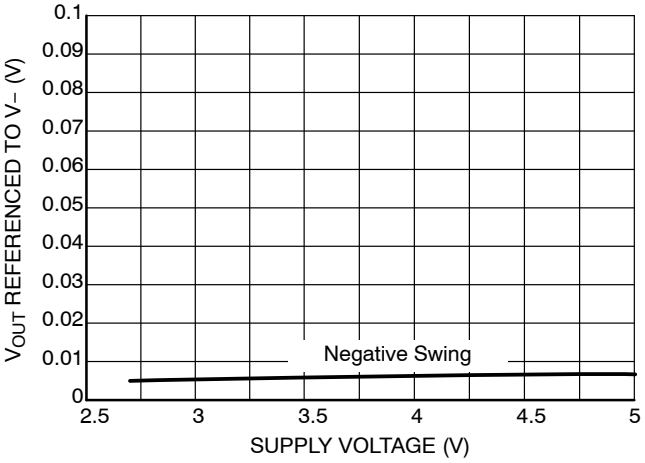


Figure 17. Output Voltage Swing vs Supply Voltage (R_L = 10k)

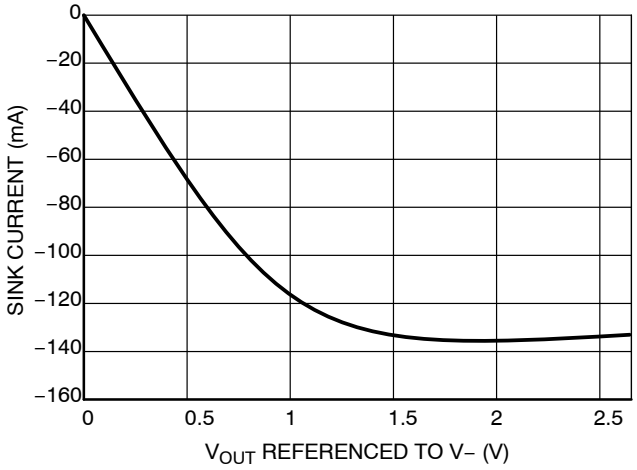


Figure 18. Sink Current vs. Output Voltage V_S = 2.7 V

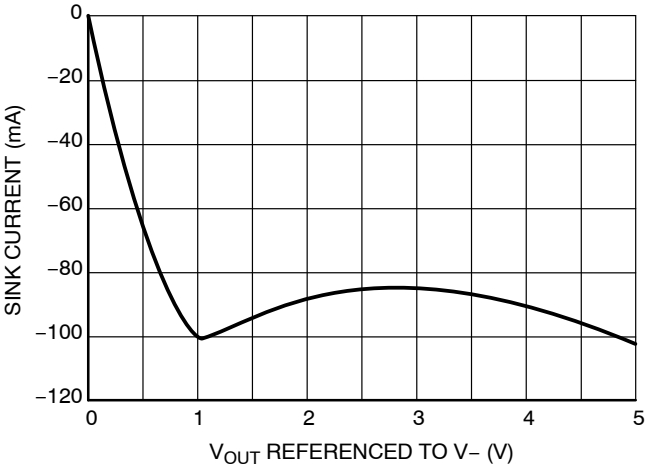


Figure 19. Sink Current vs. Output Voltage V_S = 5.0 V

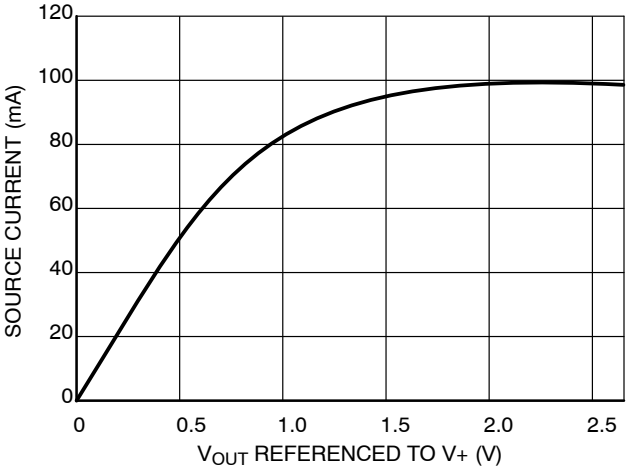


Figure 20. Source Current vs. Output Voltage V_S = 2.7 V

TYPICAL CHARACTERISTICS

(T_A = 25°C and V_S = 5 V unless otherwise specified)

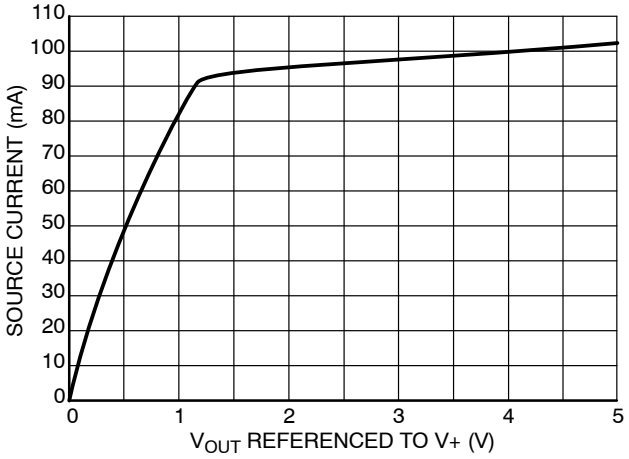


Figure 21. Source Current vs. Output Voltage V_S = 5.0 V

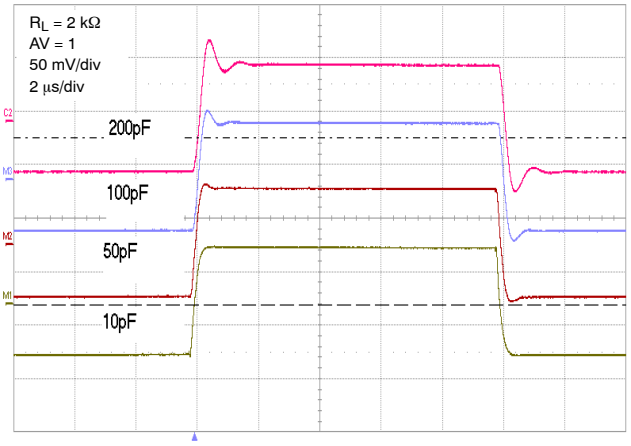


Figure 22. Settling Time vs. Capacitive Load

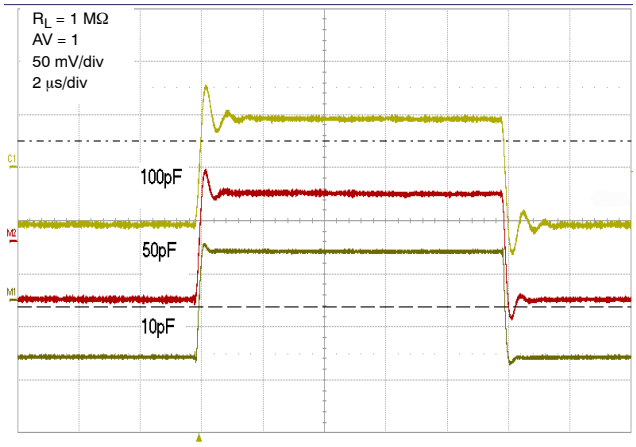


Figure 23. Settling Time vs. Capacitive Load

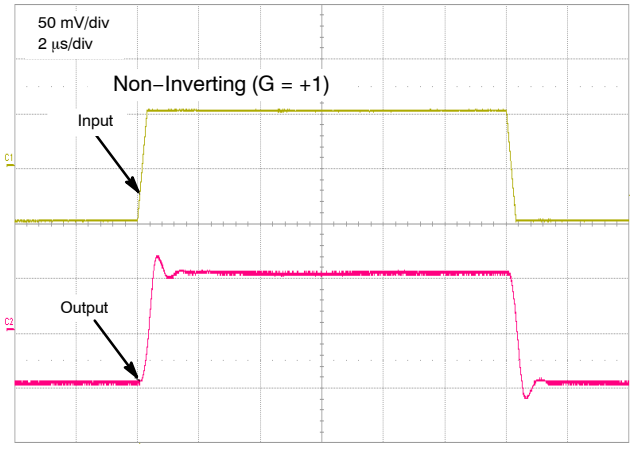


Figure 24. Step Response − Small Signal

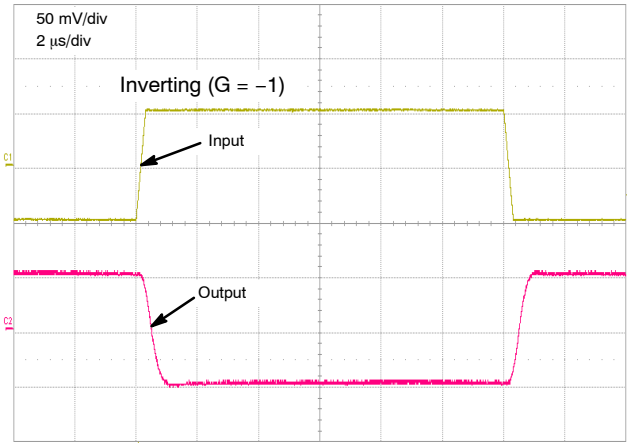


Figure 25. Step Response − Small Signal

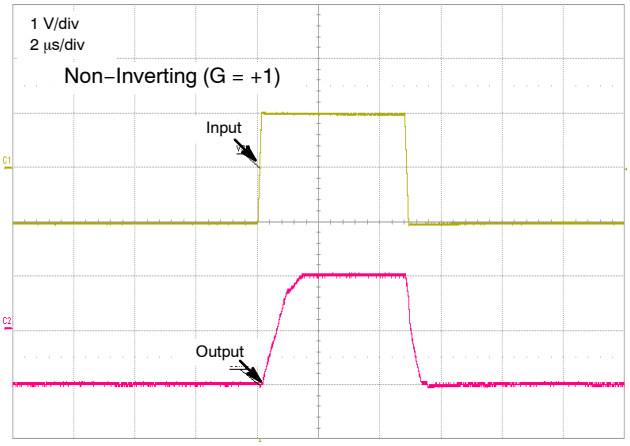


Figure 26. Step Response − Large Signal

TYPICAL CHARACTERISTICS

(T_A = 25°C and V_S = 5 V unless otherwise specified)

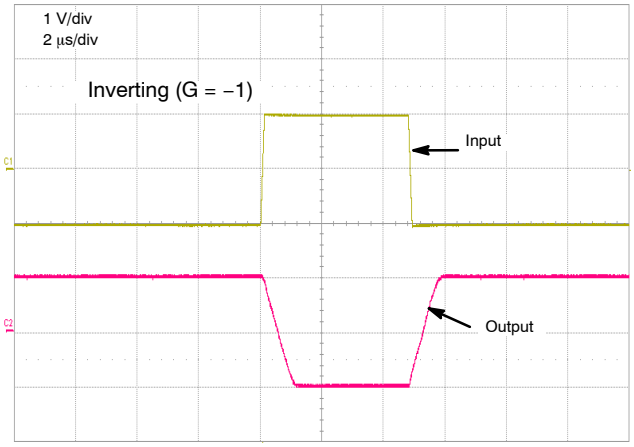


Figure 27. Step Response − Large Signal

APPLICATIONS

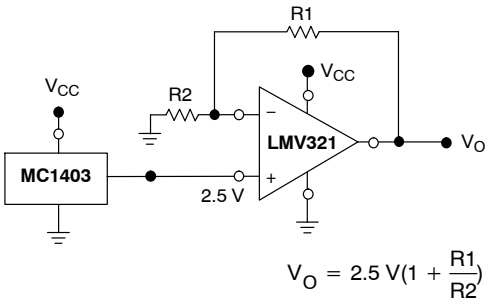


Figure 28. Voltage Reference

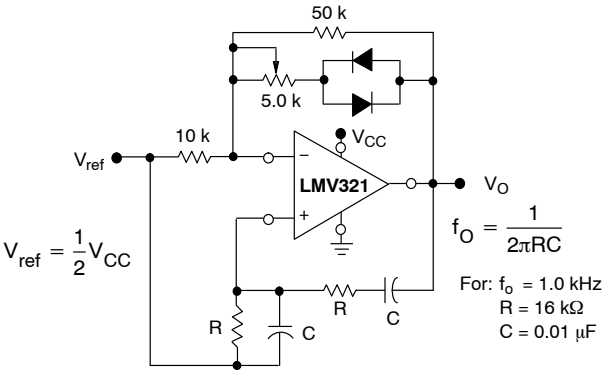
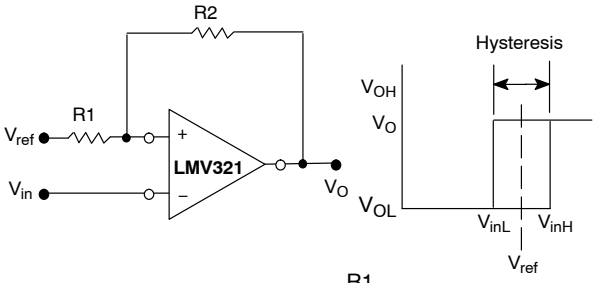


Figure 29. Wien Bridge Oscillator

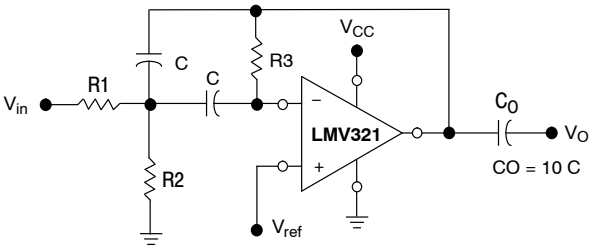


$$V_{in}L = \frac{R1}{R1 + R2}\ (V_{OL} - V_{ref}) + V_{ref}$$

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

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

Figure 30. Comparator with Hysteresis



Given: f_o = center frequency
$A(f_o)$ = gain at center frequency

Choose value f_o, C

Then : $R3 = \frac{Q}{\pi f_O C}$

$$R1 = \frac{R3}{2\,A(f_O)}$$

$$R2 = \frac{R1\ R3}{4Q^2\ R1 - R3}$$

For less than 10% error from operational amplifier, $((Q_O\ f_O)/BW) < 0.1$ where f_o and BW are expressed in Hz. If source impedance varies, filter may be preceded with voltage follower buffer to stabilize filter parameters.

Figure 31. Multiple Feedback Bandpass Filter

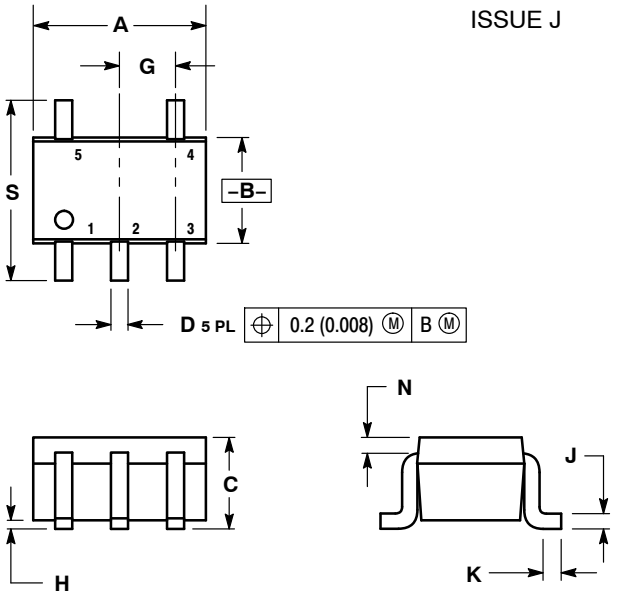
ORDERING INFORMATION

Order Number	Number of Channels	Specific Device Marking	Package Type	Shipping†
LMV321SQ3T2G	Single	AAC	SC−70 (Pb−Free)	3000 / Tape & Reel
LMV321SN3T1G*	Single	3AC	TSOP−5 (Pb−Free)	3000 / Tape & Reel
LMV358DMR2G	Dual	V358	Micro8 (Pb−Free)	4000 / Tape & Reel
LMV358MUTAG	Dual	AC	UDFN8 (Pb−Free)	3000 / Tape & Reel
LMV358DR2G	Dual	V358	SOIC−8 (Pb−Free)	2500 / Tape & Reel
LMV324DR2G	Quad	LMV324	SOIC−14 (Pb−Free)	2500 / Tape & Reel
LMV324DTBR2G	Quad	LMV 324	TSSOP−14 (Pb−Free)	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.
*Contact factory.

PACKAGE DIMENSIONS

SC−88A, SOT−353, SC−70
CASE 419A−02
ISSUE J

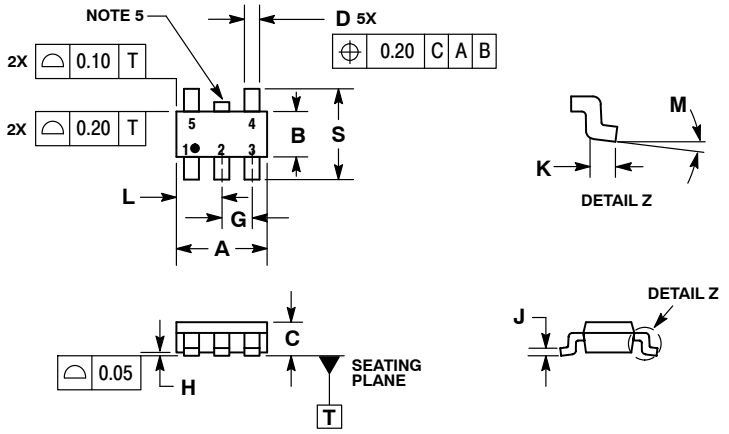


NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: INCH.
3. 419A−01 OBSOLETE. NEW STANDARD 419A−02.
4. DIMENSIONS A AND B DO NOT INCLUDE MOLD FLASH, PROTRUSIONS, OR GATE BURRS.

	INCHES		MILLIMETERS	
DIM	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

PACKAGE DIMENSIONS

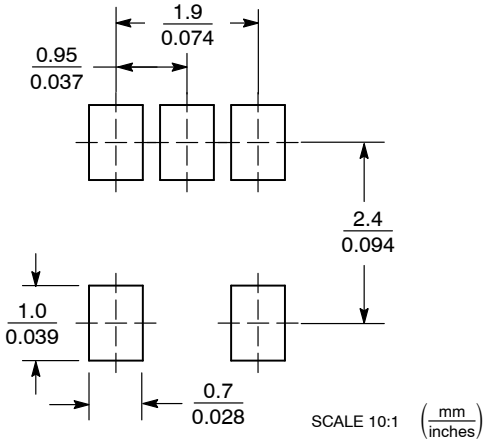
TSOP−5
CASE 483−02
ISSUE H



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.
5. OPTIONAL CONSTRUCTION: AN ADDITIONAL TRIMMED LEAD IS ALLOWED IN THIS LOCATION. TRIMMED LEAD NOT TO EXTEND MORE THAN 0.2 FROM BODY.

	MILLIMETERS	
DIM	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
L	1.25	1.55
M	0 °	10 °
S	2.50	3.00

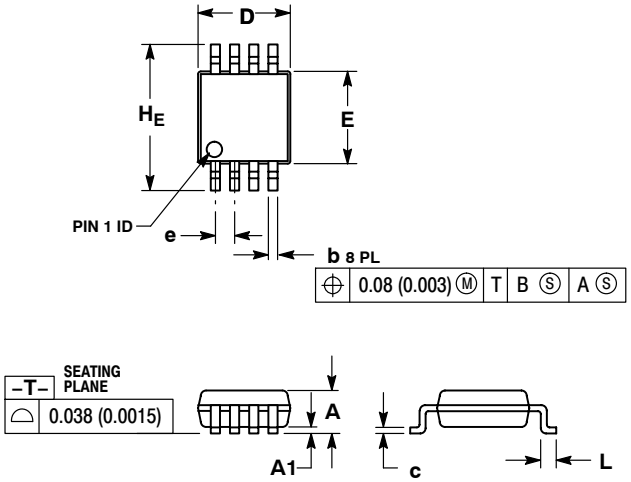
SOLDERING FOOTPRINT*



*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

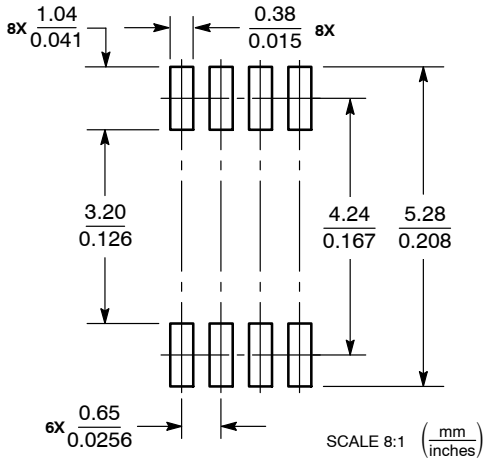
Micro8™
CASE 846A−02
ISSUE H



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.

	MILLIMETERS			INCHES		
DIM	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
H_E	4.75	4.90	5.05	0.187	0.193	0.199

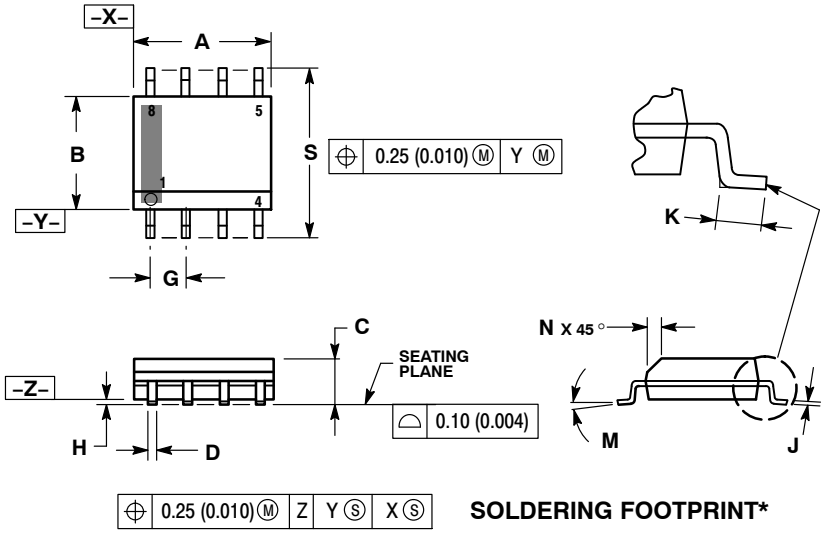
SOLDERING FOOTPRINT*



*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

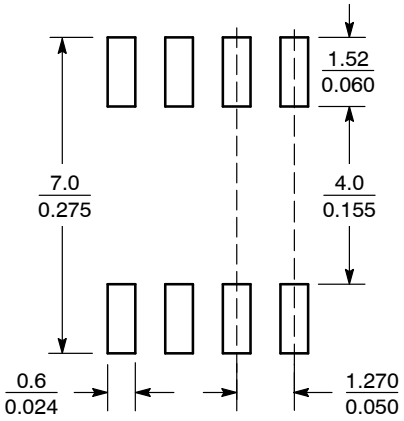
SOIC−8 NB
CASE 751−07
ISSUE AJ



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*

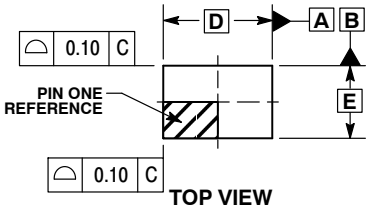


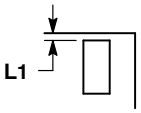
SCALE 6:1 $\left(\frac{\text{mm}}{\text{inches}}\right)$

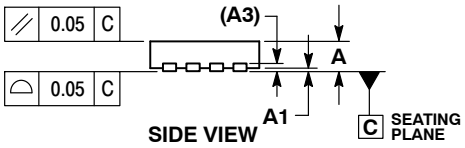
*For additional information on our Pb−Free strategy and soldering details, please download the ON Semiconductor Soldering and Mounting Techniques Reference Manual, SOLDERRM/D.

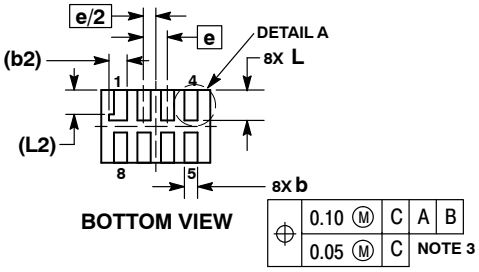
PACKAGE DIMENSIONS

UDFN8 1.8x1.2, 0.4P
CASE 517AJ−01
ISSUE O





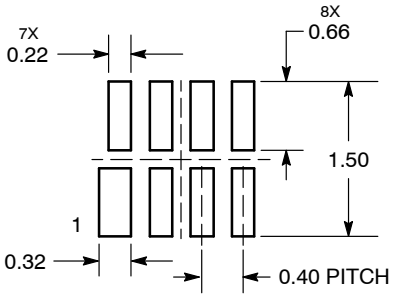




NOTES:
1. DIMENSIONING AND TOLERANCING PER ASME Y14.5M, 1994.
2. CONTROLLING DIMENSION: MILLIMETERS.
3. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.15 AND 0.30 mm FROM TERMINAL TIP.
4. MOLD FLASH ALLOWED ON TERMINALS ALONG EDGE OF PACKAGE. FLASH MAY NOT EXCEED 0.03 ONTO BOTTOM SURFACE OF TERMINALS.
5. DETAIL A SHOWS OPTIONAL CONSTRUCTION FOR TERMINALS.

	MILLIMETERS	
DIM	MIN	MAX
A	0.45	0.55
A1	0.00	0.05
A3	0.127 REF	
b	0.15	0.25
b2	0.30 REF	
D	1.80 BSC	
E	1.20 BSC	
e	0.40 BSC	
L	0.45	0.55
L1	0.00	0.03
L2	0.40 REF	

MOUNTING FOOTPRINT*
SOLDERMASK DEFINED

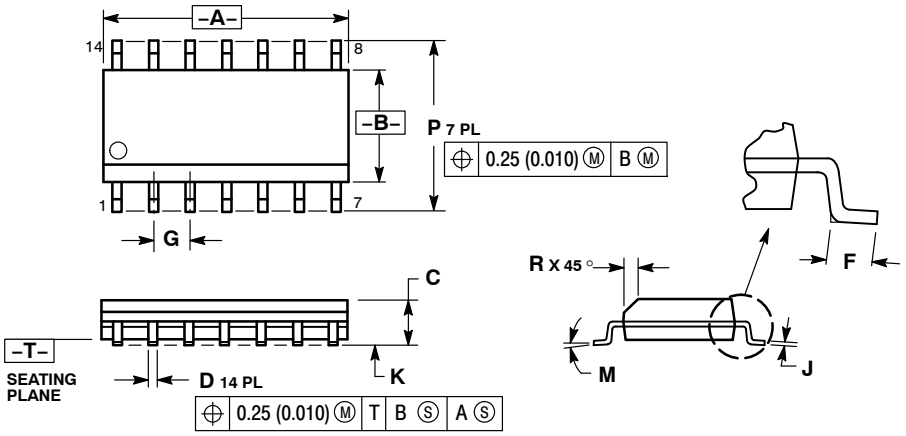


DIMENSIONS: MILLIMETERS

*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

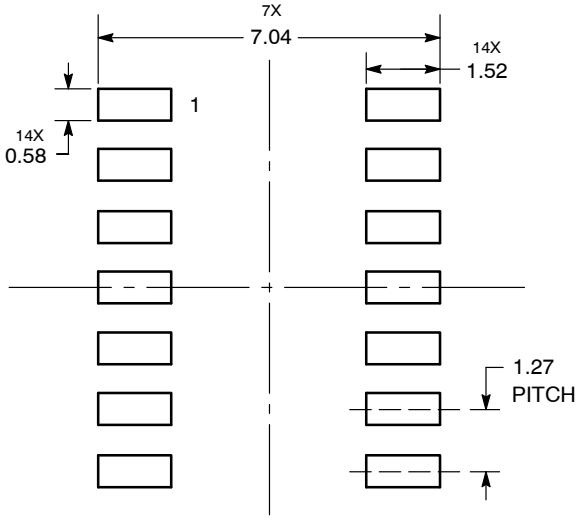
SOIC−14
CASE 751A−03
ISSUE J



NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS 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.

	MILLIMETERS		INCHES	
DIM	MIN	MAX	MIN	MAX
A	8.55	8.75	0.337	0.344
B	3.80	4.00	0.150	0.157
C	1.35	1.75	0.054	0.068
D	0.35	0.49	0.014	0.019
F	0.40	1.25	0.016	0.049
G	1.27 BSC		0.050 BSC	
J	0.19	0.25	0.008	0.009
K	0.10	0.25	0.004	0.009
M	0 °	7 °	0 °	7 °
P	5.80	6.20	0.228	0.244
R	0.25	0.50	0.010	0.019

SOLDERING FOOTPRINT

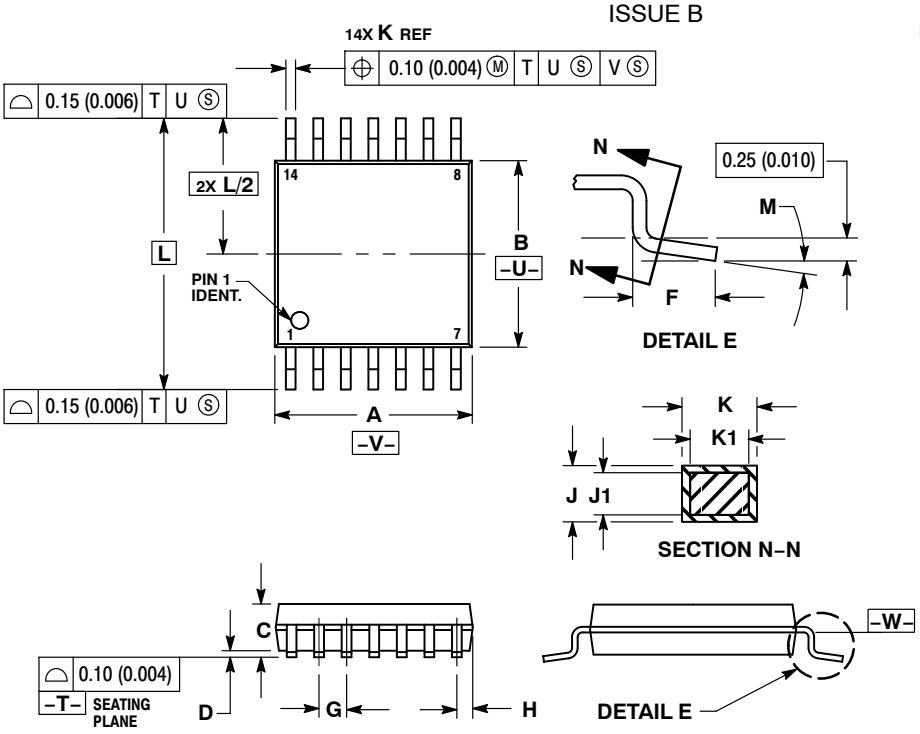


DIMENSIONS: MILLIMETERS

*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

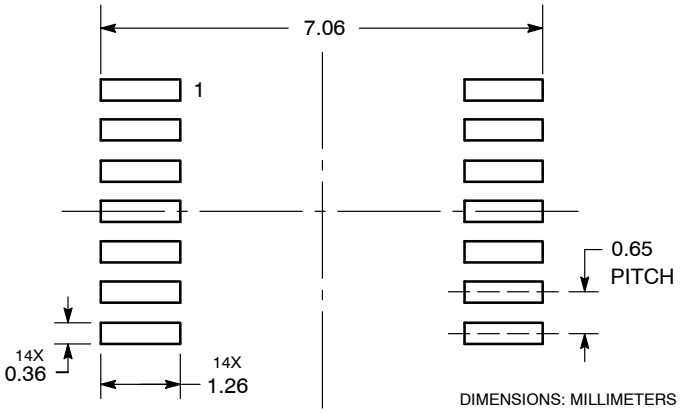
TSSOP−14
CASE 948G−01
ISSUE B



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−.

	MILLIMETERS		INCHES	
DIM	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*



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

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