

# LMV321/LMV358/LMV324 Single/Dual/Quad General Purpose, Low Voltage, Rail-to-Rail Output Operational Amplifiers

## General Description

The LMV358/LMV324 are low voltage (2.7–5.5V) versions of the dual and quad commodity op amps, LM358/LMV324, which currently operate at 5–30V. The LMV321 is the single version.

The LMV321/LMV358/LMV324 are the most cost effective solutions for the applications where low voltage operation, space saving and low price are needed. They offer specifications that meet or exceed the familiar LM358/LMV324. The LMV321/LMV358/LMV324 have rail-to-rail output swing capability and the input common-mode voltage range includes ground. They all exhibit excellent speed to power ratio, achieving 1 MHz of bandwidth and 1 V/ $\mu$ s of slew rate with low supply current.

The LMV321 is available in the space saving 5-Pin SC70, which is approximately half the size of the 5-Pin SOT23. The small package saves space on PC boards, and enables the design of small portable electronic devices. It also allows the designer to place the device closer to the signal source to reduce noise pickup and increase signal integrity.

The chips are built with National's advanced submicron silicon-gate BiCMOS process. The LMV321/LMV358/LMV324 have bipolar input and output stages for improved noise performance and higher output current drive.

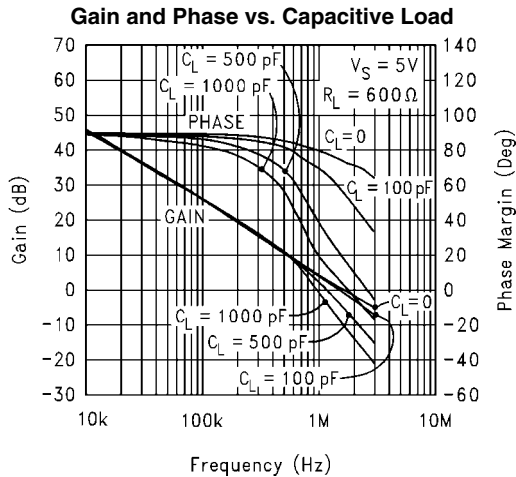
## Features

(For  $V^+ = 5V$  and  $V^- = 0V$ , unless otherwise specified)

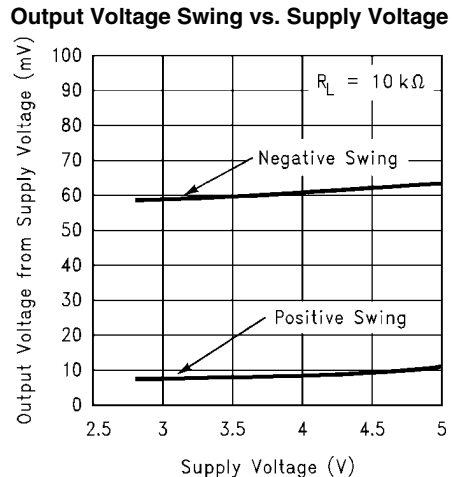
- Guaranteed 2.7V and 5V performance
- No crossover distortion
- Industrial temperature range –40°C to +85°C
- Gain-bandwidth product 1 MHz
- Low supply current
  - LMV321 130  $\mu$ A
  - LMV358 210  $\mu$ A
  - LMV324 410  $\mu$ A
- Rail-to-rail output swing @ 10 k $\Omega$ 
  - $V^+ - 10$  mV
  - $V^- + 65$  mV
- $V_{CM}$  –0.2V to  $V^+ - 0.8V$

## Applications

- Active filters
- General purpose low voltage applications
- General purpose portable devices



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### Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

ESD Tolerance (Note 2)	
Human Body Model	
LMV358/LMV324	2000V
LMV321	900V
Machine Model	100V
Differential Input Voltage	±Supply Voltage
Supply Voltage (V <sup>+</sup> -V <sup>-</sup> )	5.5V
Output Short Circuit to V <sup>+</sup>	(Note 3)
Output Short Circuit to V <sup>-</sup>	(Note 4)
Soldering Information	
Infrared or Convection (20 sec)	235°C

Storage Temp. Range	-65°C to 150°C
Junction Temperature (Note 5)	150°C

### Operating Ratings (Note 1)

Supply Voltage	2.7V to 5.5V
Temperature Range (Note 5)	
LMV321/LMV358/LMV324	-40°C to +85°C
Thermal Resistance (θ <sub>JA</sub> ) (Note 10)	
5-pin SC70	478°C/W
5-pin SOT23	265°C/W
8-Pin SOIC	190°C/W
8-Pin MSOP	235°C/W
14-Pin SOIC	145°C/W
14-Pin TSSOP	155°C/W

### 2.7V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T<sub>J</sub> = 25°C, V<sup>+</sup> = 2.7V, V<sup>-</sup> = 0V, V<sub>CM</sub> = 1.0V, V<sub>O</sub> = V<sup>+</sup>/2 and R<sub>L</sub> > 1 MΩ.

Symbol	Parameter	Conditions	Min (Note 7)	Typ (Note 6)	Max (Note 7)	Units
V <sub>OS</sub>	Input Offset Voltage			1.7	7	mV
TCV <sub>OS</sub>	Input Offset Voltage Average Drift			5		μV/°C
I <sub>B</sub>	Input Bias Current			11	250	nA
I <sub>OS</sub>	Input Offset Current			5	50	nA
CMRR	Common Mode Rejection Ratio	0V ≤ V <sub>CM</sub> ≤ 1.7V	50	63		dB
PSRR	Power Supply Rejection Ratio	2.7V ≤ V <sup>+</sup> ≤ 5V V <sub>O</sub> = 1V	50	60		dB
V <sub>CM</sub>	Input Common-Mode Voltage Range	For CMRR ≥ 50 dB	0	-0.2		V
				1.9	1.7	V
V <sub>O</sub>	Output Swing	R <sub>L</sub> = 10 kΩ to 1.35V	V <sup>+</sup> -100	V <sup>+</sup> -10		mV
				60	180	mV
I <sub>S</sub>	Supply Current	LMV321		80	170	μA
		LMV358 Both amplifiers		140	340	μA
		LMV324 All four amplifiers		260	680	μA

### 2.7V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T<sub>J</sub> = 25°C, V<sup>+</sup> = 2.7V, V<sup>-</sup> = 0V, V<sub>CM</sub> = 1.0V, V<sub>O</sub> = V<sup>+</sup>/2 and R<sub>L</sub> > 1 MΩ.

Symbol	Parameter	Conditions	Min (Note 7)	Typ (Note 6)	Max (Note 7)	Units
GBWP	Gain-Bandwidth Product	C <sub>L</sub> = 200 pF		1		MHz
Φ <sub>m</sub>	Phase Margin			60		Deg
G <sub>m</sub>	Gain Margin			10		dB
e <sub>n</sub>	Input-Referred Voltage Noise	f = 1 kHz		46		$\frac{nV}{\sqrt{Hz}}$
i <sub>n</sub>	Input-Referred Current Noise	f = 1 kHz		0.17		$\frac{pA}{\sqrt{Hz}}$

## 5V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ ,  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = 2.0\text{V}$ ,  $V_O = V^+/2$  and  $R_L > 1\text{M}\Omega$ .

**Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 7)	Typ (Note 6)	Max (Note 7)	Units
$V_{\text{OS}}$	Input Offset Voltage			1.7	<b>7</b> <b>9</b>	mV
$\text{TCV}_{\text{OS}}$	Input Offset Voltage Average Drift			5		$\mu\text{V}/^\circ\text{C}$
$I_{\text{B}}$	Input Bias Current			15	250 <b>500</b>	nA
$I_{\text{OS}}$	Input Offset Current			5	50 <b>150</b>	nA
CMRR	Common Mode Rejection Ratio	$0\text{V} \leq V_{\text{CM}} \leq 4\text{V}$	50	65		dB
PSRR	Power Supply Rejection Ratio	$2.7\text{V} \leq V^+ \leq 5\text{V}$ $V_O = 1\text{V}$ , $V_{\text{CM}} = 1\text{V}$	50	60		dB
$V_{\text{CM}}$	Input Common-Mode Voltage Range	For CMRR $\geq 50$ dB	0	-0.2		V
				4.2	4	V
$A_v$	Large Signal Voltage Gain (Note 8)	$R_L = 2\text{k}\Omega$	15 <b>10</b>	100		V/mV
$V_O$	Output Swing	$R_L = 2\text{k}\Omega$ to 2.5V	$V^+ - 300$ <b><math>V^+ - 400</math></b>	$V^+ - 40$		mV
				120	300 <b>400</b>	mV
		$R_L = 10\text{k}\Omega$ to 2.5V	$V^+ - 100$ <b><math>V^+ - 200</math></b>	$V^+ - 10$		mV
				65	180 <b>280</b>	mV
$I_O$	Output Short Circuit Current	Sourcing, $V_O = 0\text{V}$	5	60		mA
		Sinking, $V_O = 5\text{V}$	10	160		
$I_S$	Supply Current	LMV321		130	250 <b>350</b>	$\mu\text{A}$
		LMV358		210	440	$\mu\text{A}$
		Both amplifiers			<b>615</b>	
		LMV324		410	830	$\mu\text{A}$
All four amplifiers			<b>1160</b>			

## 5V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for  $T_J = 25^\circ\text{C}$ ,  $V^+ = 5\text{V}$ ,  $V^- = 0\text{V}$ ,  $V_{\text{CM}} = 2.0\text{V}$ ,  $V_O = V^+/2$  and  $R_L > 1\text{M}\Omega$ .

**Boldface** limits apply at the temperature extremes.

Symbol	Parameter	Conditions	Min (Note 7)	Typ (Note 6)	Max (Note 7)	Units
SR	Slew Rate	(Note 9)		1		V/ $\mu\text{s}$
GBWP	Gain-Bandwidth Product	$C_L = 200\text{pF}$		1		MHz
$\Phi_m$	Phase Margin			60		Deg
$G_m$	Gain Margin			10		dB
$e_n$	Input-Referred Voltage Noise	$f = 1\text{kHz}$		39		$\frac{\text{nV}}{\sqrt{\text{Hz}}}$
$i_n$	Input-Referred Current Noise	$f = 1\text{kHz}$		0.21		$\frac{\text{pA}}{\sqrt{\text{Hz}}}$

**Note 1:** Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is intended to be functional, but specific performance is not guaranteed. For guaranteed specifications and the test conditions, see the Electrical Characteristics.

**Note 2:** Human Body Model, applicable std. MIL-STD-883, Method 3015.7. Machine Model, applicable std. JESD22-A115-A (ESD MM std. of JEDEC) Field-Induced Charge-Device Model, applicable std. JESD22-C101-C (ESD FICDM std. of JEDEC)

**Note 3:** Shorting output to V<sup>+</sup> will adversely affect reliability.

**Note 4:** Shorting output to V<sup>-</sup> will adversely affect reliability.

**Note 5:** The maximum power dissipation is a function of T<sub>J(MAX)</sub>, θ<sub>JA</sub>. The maximum allowable power dissipation at any ambient temperature is P<sub>D</sub> = (T<sub>J(MAX)</sub> - T<sub>A</sub>) / θ<sub>JA</sub>. All numbers apply for packages soldered directly onto a PC Board.

**Note 6:** Typical values represent the most likely parametric norm as determined at the time of characterization. Actual typical values may vary over time and will also depend on the application and configuration. The typical values are not tested and are not guaranteed on shipped production material.

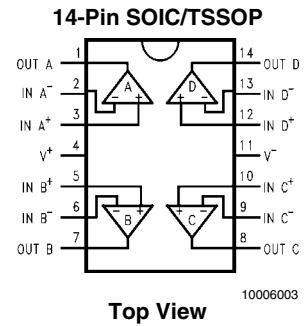
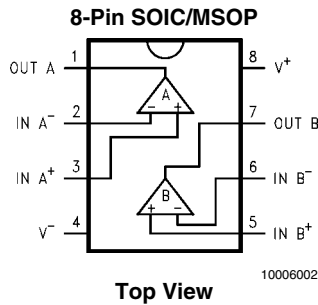
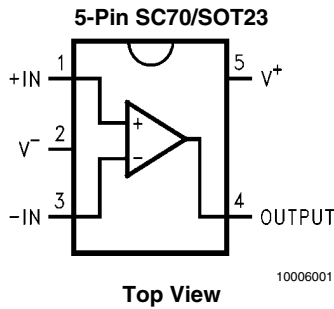
**Note 7:** All limits are guaranteed by testing or statistical analysis.

**Note 8:** R<sub>L</sub> is connected to V<sup>-</sup>. The output voltage is 0.5V ≤ V<sub>O</sub> ≤ 4.5V.

**Note 9:** Connected as voltage follower with 3V step input. Number specified is the slower of the positive and negative slew rates.

**Note 10:** All numbers are typical, and apply for packages soldered directly onto a PC board in still air.

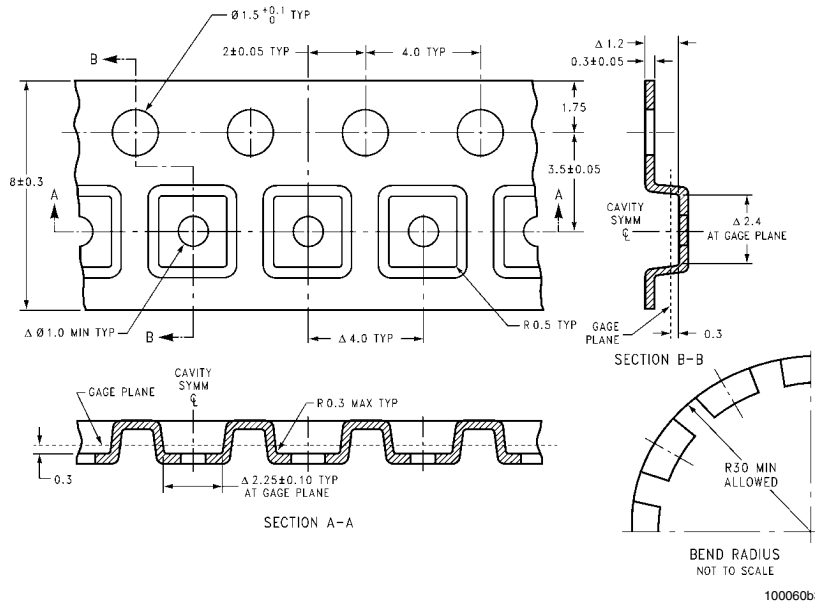
## Connection Diagrams



## Ordering Information

Package	Temperature Range	Packaging Marking	Transport Media	NSC Drawing
	Industrial -40°C to +85°C			
5-Pin SC70	LMV321M7	A12	1k Units Tape and Reel	MAA05A
	LMV321M7X		3k Units Tape and Reel	
5-Pin SOT23	LMV321M5	A13	1k Units Tape and Reel	MF05A
	LMV321M5X		3k Units Tape and Reel	
8-Pin SOIC	LMV358M	LMV358M	Rails	M08A
	LMV358MX		2.5k Units Tape and Reel	
8-Pin MSOP	LMV358MM	LMV358	1k Units Tape and Reel	MUA08A
	LMV358MMX		3.5k Units Tape and Reel	
14-Pin SOIC	LMV324M	LMV324M	Rails	M14A
	LMV324MX		2.5k Units Tape and Reel	
14-Pin TSSOP	LMV324MT	LMV324MT	Rails	MTC14
	LMV324MTX		2.5k Units Tape and Reel	

# SC70-5 Tape and Reel Specification

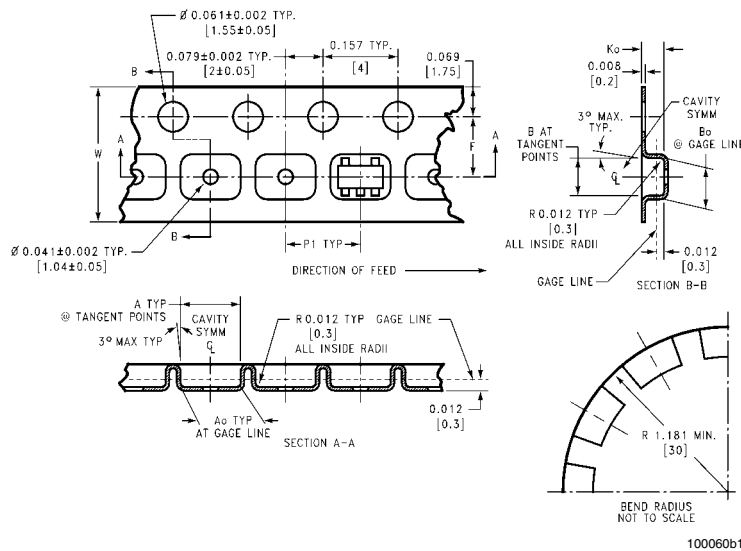


# SOT-23-5 Tape and Reel Specification

## TAPE FORMAT

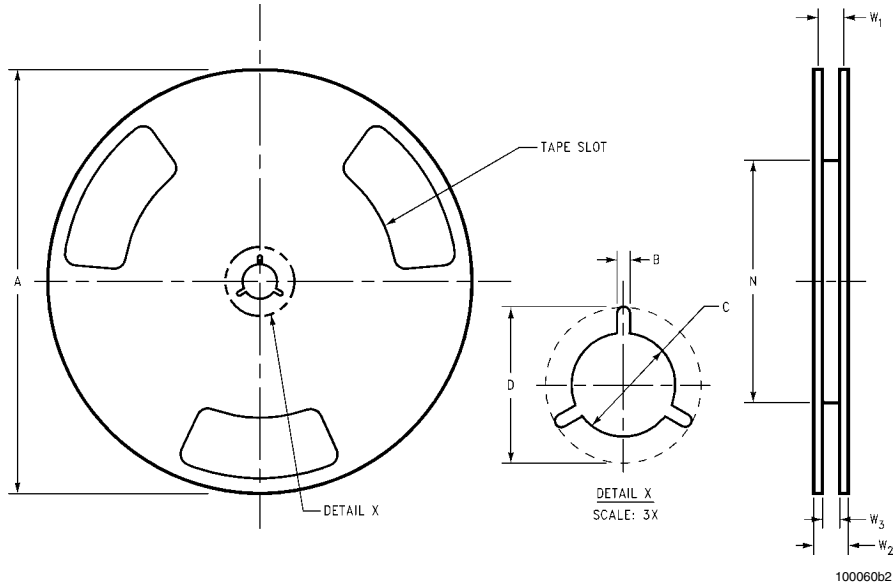
Tape Section	# Cavities	Cavity Status	Cover Tape Status
Leader (Start End)	0 (min)	Empty	Sealed
	75 (min)	Empty	Sealed
Carrier	3000	Filled	Sealed
	250	Filled	Sealed
Trailer (Hub End)	125 (min)	Empty	Sealed
	0 (min)	Empty	Sealed

## TAPE DIMENSIONS

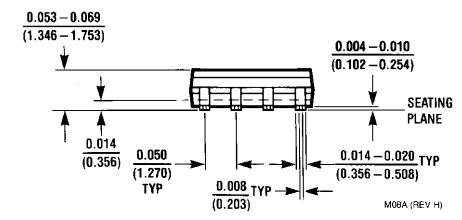
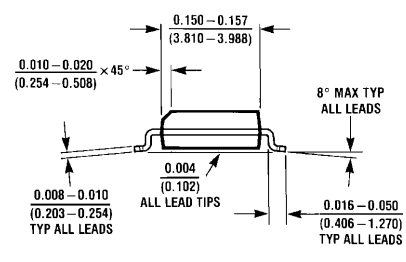
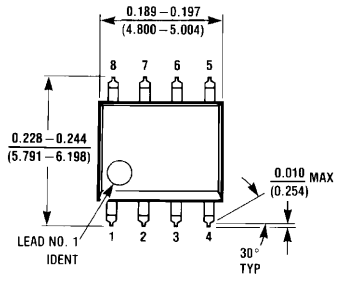


<b>8 mm</b>	<b>0.130</b> <b>(3.3)</b>	<b>0.124</b> <b>(3.15)</b>	<b>0.130</b> <b>(3.3)</b>	<b>0.126</b> <b>(3.2)</b>	<b>0.138 ±0.002</b> <b>(3.5 ±0.05)</b>	<b>0.055 ±0.004</b> <b>(1.4 ±0.11)</b>	<b>0.157</b> <b>(4)</b>	<b>0.315 ±0.012</b> <b>(8 ±0.3)</b>
Tape Size	DIM A	DIM Ao	DIM B	DIM Bo	DIM F	DIM Ko	DIM P1	DIM W

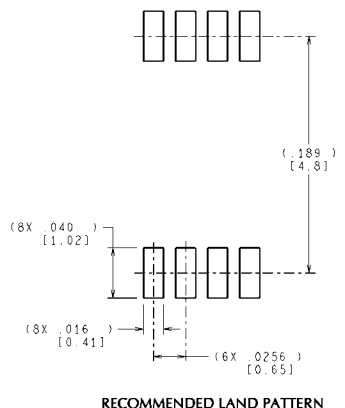
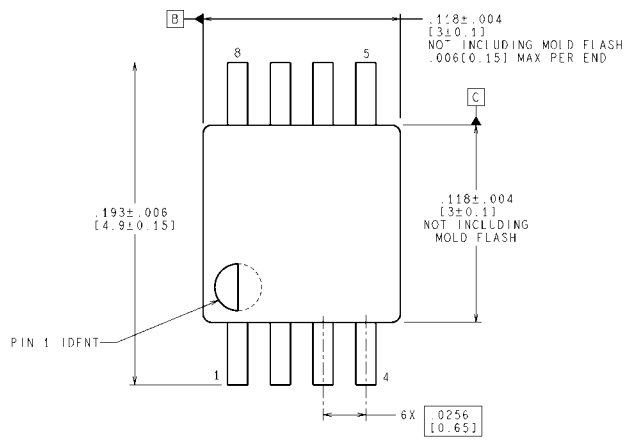
**REEL DIMENSIONS**



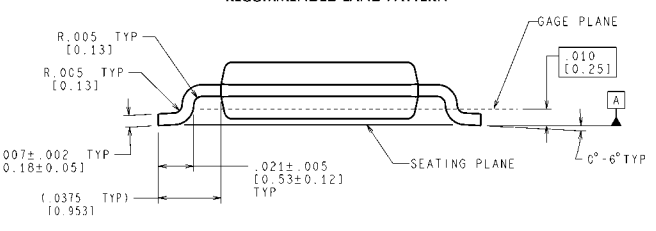
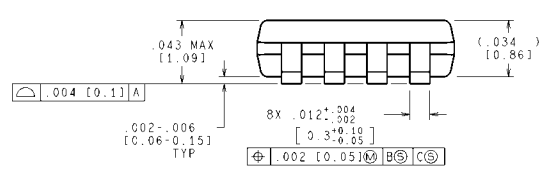
<b>8 mm</b>	<b>7.00</b> <b>330.00</b>	<b>0.059</b> <b>1.50</b>	<b>0.512</b> <b>13.00</b>	<b>0.795</b> <b>20.20</b>	<b>2.165</b> <b>55.00</b>	<b>0.331 + 0.059/-0.000</b> <b>8.40 + 1.50/-0.00</b>	<b>0.567</b> <b>14.40</b>	<b>W1 + 0.078/-0.039</b> <b>W1 + 2.00/-1.00</b>
Tape Size	A	B	C	D	N	W1	W2	W3



8-Pin SOIC  
NS Package Number M08A

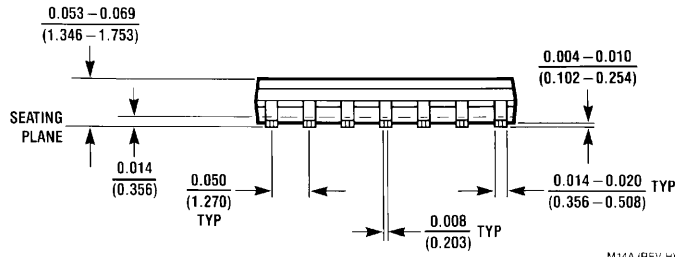
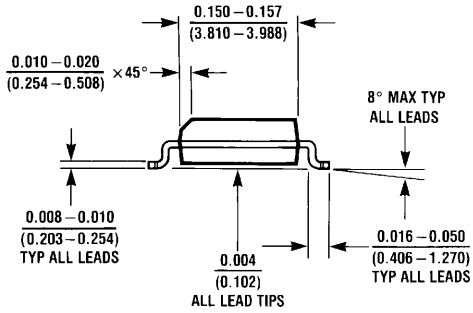
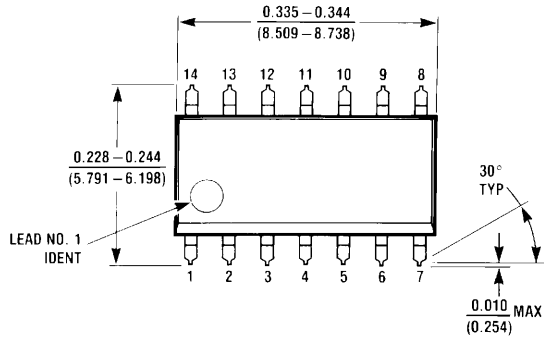


RECOMMENDED LAND PATTERN



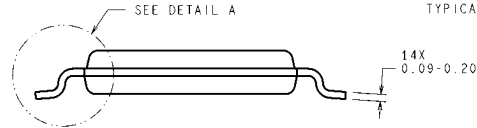
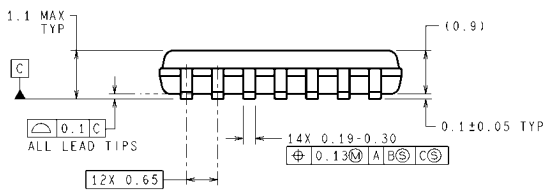
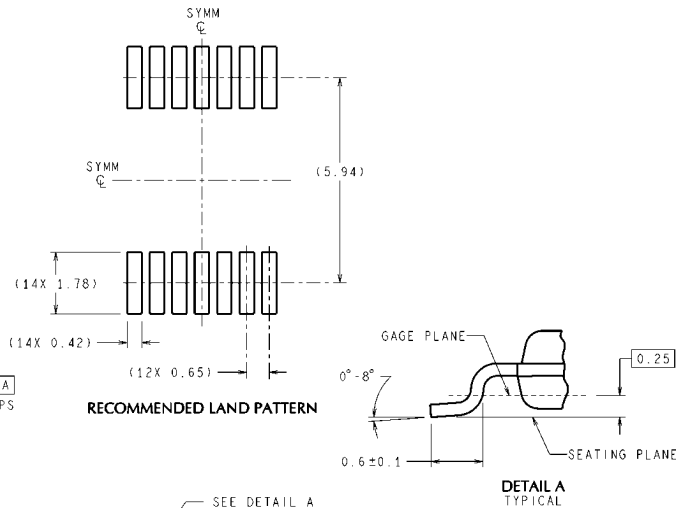
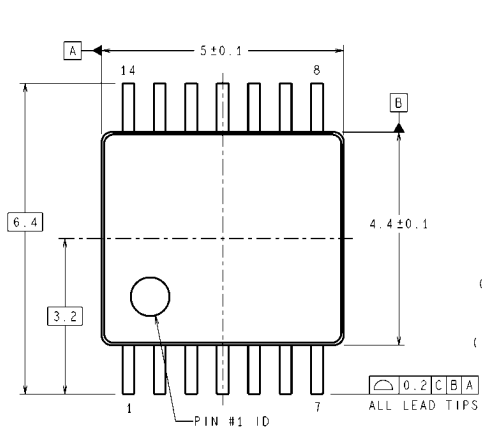
CONTROLLING DIMENSION IS INCH  
VALUES IN [ ] ARE MILLIMETERS  
8-Pin MSOP  
NS Package Number MUA08A

MUA08A (Rev F)



M14A (REV H)

**14-Pin SOIC  
NS Package Number M14A**



DIMENSIONS ARE IN MILLIMETERS  
DIMENSIONS IN ( ) FOR REFERENCE ONLY

**14-Pin TSSOP  
NS Package Number MTC14**

MTC14 (Rev D)