National Semiconductor

LMV931 Single/LMV932 Dual/LMV934 Quad 1.8V, RRIO Operational Amplifiers

General Description

The LMV931/LMV932/LMV934 are low voltage, low power operational amplifiers. LMV931/LMV932/LMV934 are guaranteed to operate from +1.8V to +5.5V supply voltages and have rail-to-rail input and output. LMV931/LMV932/LMV934 input common mode voltage extends 200mV beyond the supplies which enables user enhanced functionality beyond the supply voltage range. The output can swing rail-to-rail unloaded and within 105mV from the rail with 600Ω load at 1.8V supply. The LMV931/LMV932/LMV934 are optimized to work at 1.8V which make them ideal for portable two-cell battery powered systems and single cell Li-Ion systems.

LMV931/LMV932/LMV934 exhibit excellent speed-power ratio, achieving 1.4MHz gain bandwidth product at 1.8V supply voltage with very low supply current. The LMV931/LMV932/LMV934 are capable of driving a 600Ω load and up to 1000pF capacitive load with minimal ringing. LMV931/LMV932/LMV934 have a high DC gain of 101dB, making them suitable for low frequency applications.

The single LMV931 is offered in space saving 5-Pin SC70 and SOT23 packages. The dual LMV932 are in 8-Pin MSOP and SOIC packages and the quad LMV934 are in 14-Pin TSSOP and SOIC packages. These small packages are ideal solutions for area constrained PC boards and portable electronics such as cellular phones and PDAs.

Features

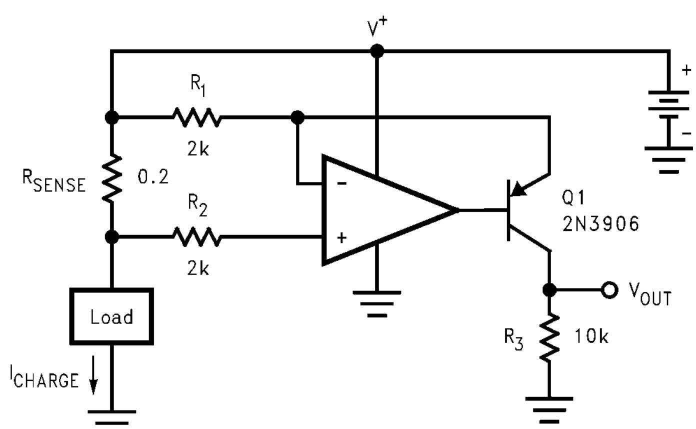
(Typical 1.8V Supply Values; Unless Otherwise Noted)

- Guaranteed 1.8V, 2.7V and 5V specifications
- Output swing
  - w/600Ω load — 80mV from rail
  - w/2kΩ load — 30mV from rail
- V_{CM} — 200mV beyond rails
- Supply current (per channel) — 100μA
- Gain bandwidth product — 1.4MHz
- Maximum V_{OS} — 4.0mV
- Ultra tiny packages
- Temperature range — −40°C to 125°C

Applications

- Consumer communication
- Consumer computing
- PDAs
- Audio pre-amp
- Portable/battery-powered electronic equipment
- Supply current monitoring
- Battery monitoring

Typical Application



$$V_{OUT} = \frac{R_{SENSE} \cdot R_3}{R_1} \cdot I_{Charge} = 1\Omega \cdot I_{Charge}$$

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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)	
Machine Model	200V
Human Body Model	2000V
Differential Input Voltage	± Supply Voltage
Supply Voltage (V^+–V^-)	6V
Output Short Circuit to V^+ (Note 3)	
Output Short Circuit to V^- (Note 3)	
Storage Temperature Range	−65°C to 150°C
Junction Temperature (Note 4)	150°C
Mounting Temp.	
Infrared or Convection (20 sec)	235°C

Operating Ratings (Note 1)

Supply Voltage Range	1.8V to 5.5V
Temperature Range	−40°C to 125°C
Thermal Resistance (θ_{JA})	
5-Pin SC70	414°C/W
5-Pin SOT23	265°C/W
8-Pin MSOP	235°C/W
8-Pin SOIC	175°C/W
14-Pin TSSOP	155°C/W
14-Pin SOIC	127°C/W

1.8V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25°C. V^+ = 1.8V, V^- = 0V, V_{CM} = V^+/2, V_O = V^+/2 and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes. See (Note 10)

Symbol	Parameter	Condition		Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
V_{OS}	Input Offset Voltage	LMV931 (Single)			1	4 **6**	mV
		LMV932 (Dual) LMV934 (Quad)			1	5.5 **7.5**	mV
TCV_{OS}	Input Offset Voltage Average Drift				5.5		μV/°C
I_B	Input Bias Current				15	35 **50**	nA
I_{OS}	Input Offset Current				13	25 **40**	nA
I_S	Supply Current (per channel)				103	185 **205**	μA
CMRR	Common Mode Rejection Ratio	LMV931, 0 ≤ V_{CM} ≤ 0.6V 1.4V ≤ V_{CM} ≤ 1.8V (Note 8)		60 **55**	78		dB
		LMV932 and LMV934 0 ≤ V_{CM} ≤ 0.6V 1.4V ≤ V_{CM} ≤ 1.8V (Note 8)		55 **50**	76		
		−0.2V ≤ V_{CM} ≤ 0V 1.8V ≤ V_{CM} ≤ 2.0V		50	72		
PSRR	Power Supply Rejection Ratio	1.8V ≤ V^+ ≤ 5V		75 **70**	100		dB
CMVR	Input Common-Mode Voltage Range	For CMRR Range ≥ 50dB	T_A = 25°C	V^- −0.2	−0.2 to 2.1	V^+ +0.2	V
			T_A −40°C to 85°C	V^-		V^+	
			T_A = 125°C	V^- +0.2		V^+ −0.2	
A_V	Large Signal Voltage Gain LMV931 (Single)	R_L = 600Ω to 0.9V, V_O = 0.2V to 1.6V, V_{CM} = 0.5V		77 **73**	101		dB
		R_L = 2kΩ to 0.9V, V_O = 0.2V to 1.6V, V_{CM} = 0.5V		80 **75**	105		
	Large Signal Voltage Gain LMV932 (Dual) LMV934 (Quad)	R_L = 600Ω to 0.9V, V_O = 0.2V to 1.6V, V_{CM} = 0.5V		75 **72**	90		dB
		R_L = 2kΩ to 0.9V, V_O = 0.2V to 1.6V, V_{CM} = 0.5V		78 **75**	100		

Symbol	Parameter	Condition	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
V_O	Output Swing	$R_L = 600\Omega$ to 0.9V $V_{IN} = \pm 100mV$	1.65 **1.63**	1.72		V
				0.077	0.105 **0.120**	
		$R_L = 2k\Omega$ to 0.9V $V_{IN} = \pm 100mV$	1.75 **1.74**	1.77		
				0.024	0.035 **0.04**	
I_O	Output Short Circuit Current	Sourcing, $V_O = 0V$ $V_{IN} = 100mV$	4 **3.3**	8		mA
		Sinking, $V_O = 1.8V$ $V_{IN} = -100mV$	7 **5**	9		

1.8V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for $T_J = 25°C$. $V^+ = 1.8V$, $V^- = 0V$, $V_{CM} = V^+/2$, $V_O = V^+/2$ and $R_L > 1\ M\Omega$. **Boldface** limits apply at the temperature extremes. See (Note 10)

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
SR	Slew Rate	(Note 7)		0.35		V/µs
GBW	Gain-Bandwidth Product			1.4		MHz
Φ_m	Phase Margin			67		deg
G_m	Gain Margin			7		dB
e_n	Input-Referred Voltage Noise	f = 1kHz, $V_{CM} = 0.5V$		60		$\frac{nV}{\sqrt{Hz}}$
i_n	Input-Referred Current Noise	f = 1kHz		0.06		$\frac{pA}{\sqrt{Hz}}$
THD	Total Harmonic Distortion	f = 1kHz, $A_V = +1$ $R_L = 600\Omega$, $V_{IN} = 1\ V_{PP}$		0.023		%
	Amp-to-Amp Isolation	(Note 9)		123		dB

2.7V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25°C. V^+ = 2.7V, V^- = 0V, V_{CM} = $V^+/2$, V_O = $V^+/2$ and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes. See (Note 10)

Symbol	Parameter	Condition		Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
V_{OS}	Input Offset Voltage	LMV931 (Single)			1	4 **6**	mV
		LMV932 (Dual) LMV934 (Quad)			1	5.5 **7.5**	mV
TCV_{OS}	Input Offset Voltage Average Drift				5.5		μV/°C
I_B	Input Bias Current				15	35 **50**	nA
I_{OS}	Input Offset Current				8	25 **40**	nA
I_S	Supply Current (per channel)				105	190 **210**	μA
CMRR	Common Mode Rejection Ratio	LMV931, 0 ≤ V_{CM} ≤ 1.5V 2.3V ≤ V_{CM} ≤ 2.7V (Note 8)		60 **55**	81		dB
		LMV932 and LMV934 0 ≤ V_{CM} ≤ 1.5V 2.3V ≤ V_{CM} ≤ 2.7V (Note 8)		55 **50**	80		
		−0.2V ≤ V_{CM} ≤ 0V 2.7V ≤ V_{CM} ≤ 2.9V		50	74		
PSRR	Power Supply Rejection Ratio	1.8V ≤ V^+ ≤ 5V V_{CM} = 0.5V		75 **70**	100		dB
V_{CM}	Input Common-Mode Voltage Range	For CMRR Range ≥ 50dB	T_A = 25°C	V^- −0.2	−0.2 to 3.0	V^+ +0.2	V
			T_A = −40°C to 85°C	V^-		V^+	
			T_A = 125°C	V^- +0.2		V^+ −0.2	
A_V	Large Signal Voltage Gain LMV931 (Single)	R_L = 600Ω to 1.35V, V_O = 0.2V to 2.5V		87 **86**	104		dB
		R_L = 2kΩ to 1.35V, V_O = 0.2V to 2.5V		92 **91**	110		
	Large Signal Voltage Gain LMV932 (Dual) LMV934 (Quad)	R_L = 600Ω to 1.35V, V_O = 0.2V to 2.5V		78 **75**	90		dB
		R_L = 2kΩ to 1.35V, V_O = 0.2V to 2.5V		81 **78**	100		
V_O	Output Swing	R_L = 600Ω to 1.35V V_{IN} = ±100mV		2.55 **2.53**	2.62		V
					0.083	0.110 **0.130**	
		R_L = 2kΩ to 1.35V V_{IN} = ±100mV		2.65 **2.64**	2.675		
					0.025	0.04 **0.045**	
I_O	Output Short Circuit Current	Sourcing, V_O = 0V V_{IN} = 100mV		20 **15**	30		mA
		Sinking, V_O = 0V V_{IN} = −100mV		18 **12**	25		

2.7V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25°C. V^+ = 2.7V, V^- = 0V, V_{CM} = 1.0V, V_O = 1.35V and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes. See (Note 10)

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
SR	Slew Rate	(Note 7)		0.4		V/μs
GBW	Gain-Bandwidth Product			1.4		MHz
Φ_m	Phase Margin			70		deg
G_m	Gain Margin			7.5		dB
e_n	Input-Referred Voltage Noise	f = 1kHz, V_{CM} = 0.5V		57		$\frac{nV}{\sqrt{Hz}}$
i_n	Input-Referred Current Noise	f = 1kHz		0.082		$\frac{pA}{\sqrt{Hz}}$
THD	Total Harmonic Distortion	f = 1kHz, A_V = +1 R_L = 600Ω, V_{IN} = 1V_{PP}		0.022		%
	Amp-to-Amp Isolation	(Note 9)		123		dB

5V DC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25°C. V^+ = 5V, V^- = 0V, V_{CM} = $V^+/2$, V_O = $V^+/2$ and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes. See (Note 10)

Symbol	Parameter	Condition	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
V_{OS}	Input Offset Voltage	LMV931 (Single)		1	4 **6**	mV
		LMV932 (Dual) LMV934 (Quad)		1	5.5 **7.5**	mV
TCV_{OS}	Input Offset Voltage Average Drift			5.5		μV/°C
I_B	Input Bias Current			14	35 **50**	nA
I_{OS}	Input Offset Current			9	25 **40**	nA
I_S	Supply Current (per channel)			116	210 **230**	μA
CMRR	Common Mode Rejection Ratio	0 ≤ V_{CM} ≤ 3.8V 4.6V ≤ V_{CM} ≤ 5.0V (Note 8)	60 **55**	86		dB
		−0.2V ≤ V_{CM} ≤ 0V 5.0V ≤ V_{CM} ≤ 5.2V	50	78		dB
PSRR	Power Supply Rejection Ratio	1.8V ≤ V^+ ≤ 5V V_{CM} = 0.5V	75 70	100		dB
CMVR	Input Common-Mode Voltage Range	For CMRR Range ≥ 50dB, T_A = 25°C	V^- −0.2	−0.2 to 5.3	V^+ +0.2	V
		For CMRR Range ≥ 50dB, T_A = −40°C to 85°C	V^-		V^+	V
		For CMRR Range ≥ 50dB, T_A = 125°C	V^- +0.3		V^+ −0.3	V
A_V	Large Signal Voltage Gain LMV931 (Single)	R_L = 600Ω to 2.5V, V_O = 0.2V to 4.8V	88 **87**	102		dB
		R_L = 2kΩ to 2.5V, V_O = 0.2V to 4.8V	94 **93**	113		dB
	Large Signal Voltage Gain LMV932 (Dual) LMV934 (Quad)	R_L = 600Ω to 2.5V, V_O = 0.2V to 4.8V	81 **78**	90		dB
		R_L = 2kΩ to 2.5V, V_O = 0.2V to 4.8V	85 **82**	100		dB
V_O	Output Swing	R_L = 600Ω to 2.5V V_{IN} = ±100mV	4.855 4.835	4.890		V
				0.120	0.160 **0.180**	V
		R_L = 2kΩ to 2.5V V_{IN} = ±100mV	4.945 **4.935**	4.967		V
				0.037	0.065 **0.075**	V
I_O	Output Short Circuit Current	LMV931, Sourcing, V_O = 0V V_{IN} = 100mV	80 **68**	100		mA
		Sinking, V_O = 5V V_{IN} = −100mV	58 **45**	65		mA

5V AC Electrical Characteristics

Unless otherwise specified, all limits guaranteed for T_J = 25°C. V^+ = 5V, V^- = 0V, V_{CM} = $V^+/2$, V_O = 2.5V and R_L > 1 MΩ. **Boldface** limits apply at the temperature extremes. See (Note 10)

Symbol	Parameter	Conditions	Min (Note 6)	Typ (Note 5)	Max (Note 6)	Units
SR	Slew Rate	(Note 7)		0.42		V/µs
GBW	Gain-Bandwidth Product			1.5		MHz
Φ_m	Phase Margin			71		deg
G_m	Gain Margin			8		dB
e_n	Input-Referred Voltage Noise	f = 1kHz, V_{CM} = 1V		50		$\frac{nV}{\sqrt{Hz}}$
i_n	Input-Referred Current Noise	f = 1kHz		0.07		$\frac{pA}{\sqrt{Hz}}$
THD	Total Harmonic Distortion	f = 1kHz, A_V = +1 R_L = 600Ω, V_O = 1 V_{PP}		0.022		%
	Amp-to-Amp Isolation	(Note 9)		123		dB

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: Applies to both single-supply and split-supply operation. Continuous short circuit operation at elevated ambient temperature can result in exceeding the maximum allowed junction temperature of 150°C. Output currents in excess of 45mA over long term may adversely affect reliability.

Note 4: The maximum power dissipation is a function of $T_{J(MAX)}$, θ_{JA}. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A)/\theta_{JA}$. All numbers apply for packages soldered directly onto a PC Board.

Note 5: 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 6: All limits are guaranteed by testing or statistical analysis.

Note 7: Connected as voltage follower with input step from V^- to V^+. Number specified is the slower of the positive and negative slew rates.

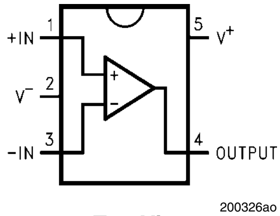
Note 8: For guaranteed temperature ranges, see Input Common-Mode Voltage Range specifications.

Note 9: Input referred, R_L = 100kΩ connected to $V^+/2$. Each amp excited in turn with 1kHz to produce V_O = $3V_{PP}$ (For Supply Voltages <3V, V_O = V^+).

Note 10: Electrical Table values apply only for factory testing conditions at the temperature indicated. Factory testing conditions result in very limited self-heating of the device such that $T_J = T_A$. No guarantee of parametric performance is indicated in the electrical tables under conditions of internal self-heating where $T_J > T_A$. See Applications section for information of temperature derating of the device. Absolute Maximum Ratings indicated junction temperature limits beyond which the device may be permanently degraded, either mechanically or electrically.

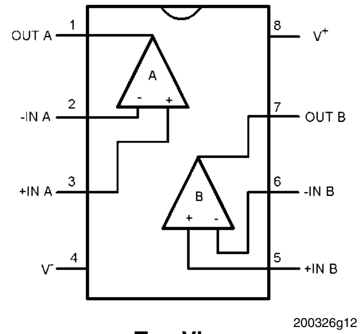
Connection Diagrams

5-Pin SC70-5/SOT23-5 (LMV931)



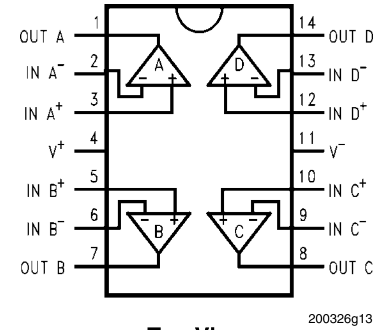
Top View

8-Pin MSOP/SOIC (LMV932)



Top View

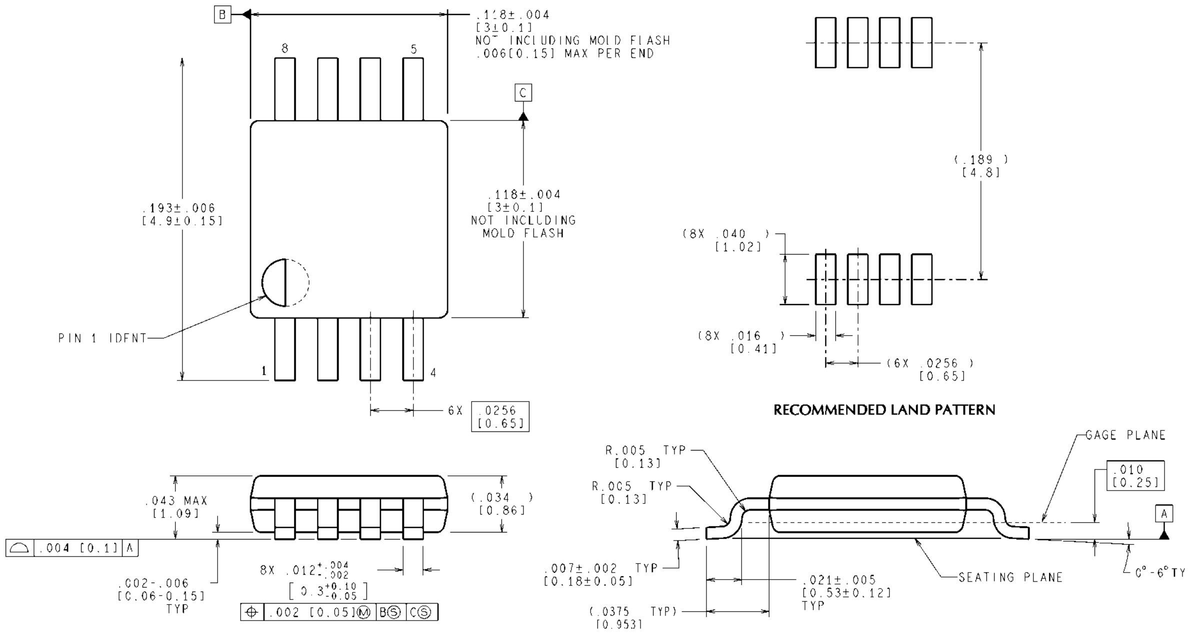
14-Pin TSSOP/SOIC (LMV934)



Top View

Ordering Information

Package	Part Number	Packaging Marking	Transport Media	NSC Drawing
5-Pin SC70	LMV931MG	A74	1k Units Tape and Reel	MAA05A
	LMV931MGX		3k Units Tape and Reel	
5-Pin SOT23	LMV931MF	A79A	1k Units Tape and Reel	MF05A
	LMV931MFX		3k Units Tape and Reel	
8-Pin MSOP	LMV932MM	A86A	1k Units Tape and Reel	MUA08A
	LMV932MMX		3.5k Units Tape and Reel	
8-Pin SOIC	LMV932MA	LMV932MA	Rails	M08A
	LMV932MAX		2.5k Units Tape and Reel	
14-Pin TSSOP	LMV934MT	LMV934MT	Rails	MTC14
	LMV934MTX		2.5k Units Tape and Reel	
14-Pin SOIC	LMV934MA	LMV934MA	Rails	M14A
	LMV934MAX		2.5k Units Tape and Reel	



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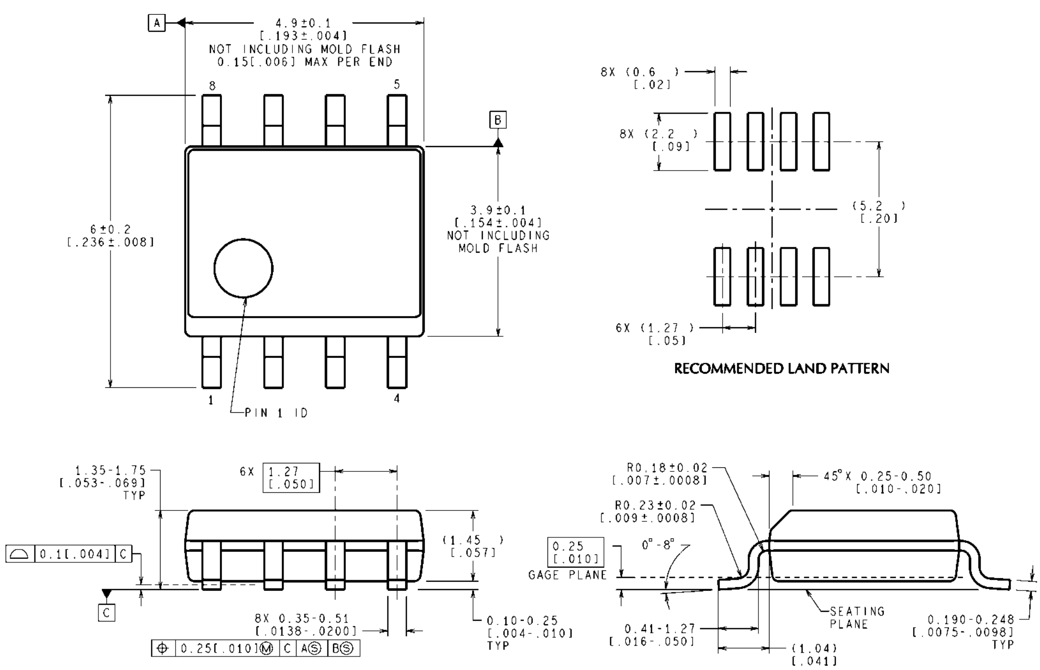
VALUES IN [ ] ARE MILLIMETERS

MUA08A (Rev F)

8-Pin MSOP
NS Package Number MUA08A



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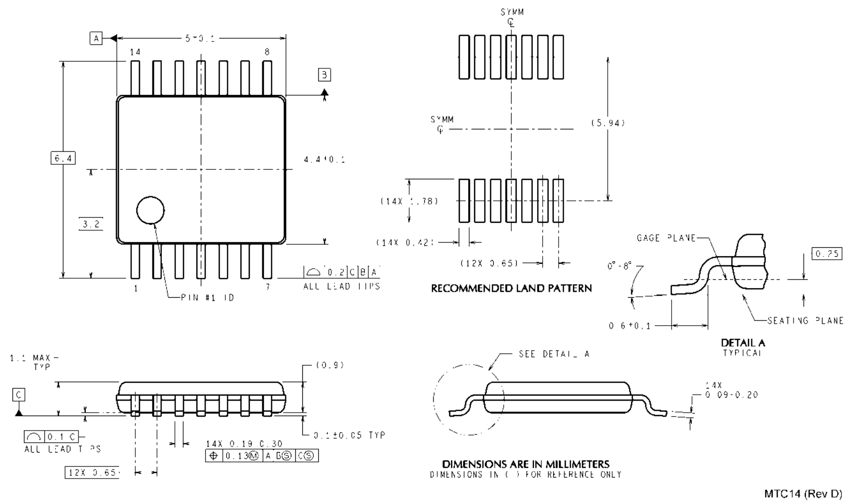
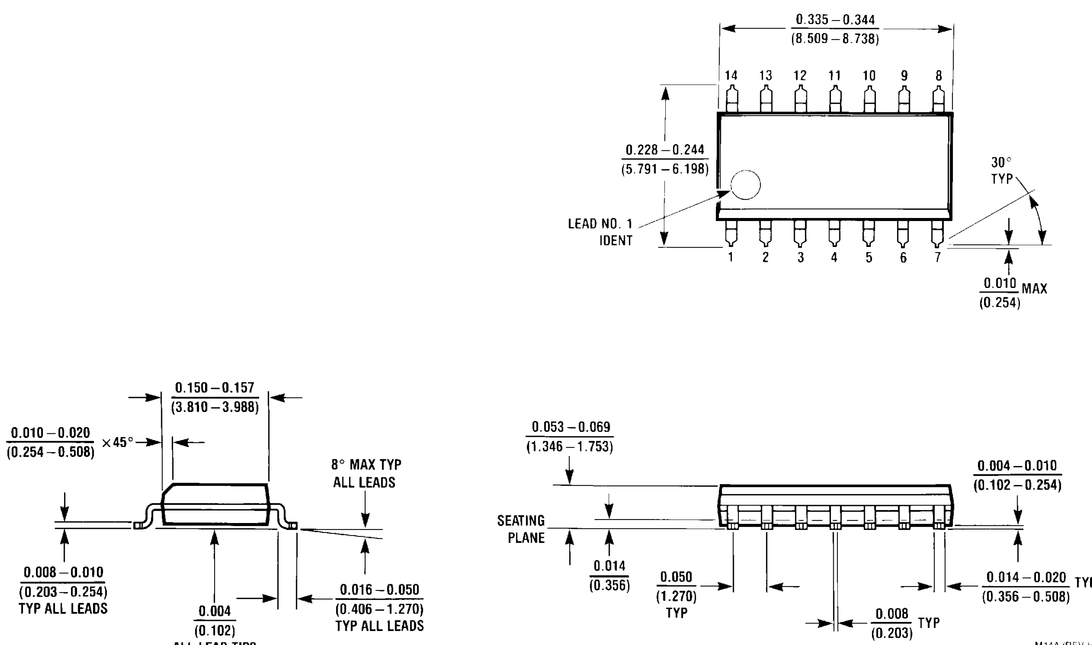
VALUES IN [ ] ARE INCHES
DIMENSIONS IN ( ) FOR REFERENCE ONLY

M08A (Rev L)

8-Pin SOIC
NS Package Number M08A



14-Pin TSSOP
NS Package Number MTC14



14-Pin SOIC
NS Package Number M14A