

LMV93x-N/-N-Q1 Single/Dual/Quad 1.8V, RRIO Operational Amplifiers

1 Features

- Typical 1.8V Supply Values; Unless Otherwise Noted
- Available in Automotive AEC-Q100 Grade 1
- Specified at 1.8V, 2.7V and 5V
- 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

2 Applications

- Mobile Phones
- Tablets
- Wearables
- Health Monitoring
- Portable/Battery-powered Electronic Equipment
- Battery Monitoring

3 Description

The LMV93x-N family (LMV931-N single, LMV932-N dual and LMV934-N quad) are low voltage, low power operational amplifiers. The LMV93x-N family operates from +1.8V to +5.5V supply voltages and have rail-to-rail input and output. The 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 LMV93x-N family are optimized to work at 1.8V which make them ideal for portable two-cell battery powered systems and single cell Li-Ion systems.

LMV93x-N family exhibit an excellent speed-power ratio, achieving 1.4MHz gain bandwidth product at 1.8V supply voltage with very low supply current. The LMV93x-N family are capable of driving a 600Ω load and up to 1000pF capacitive load with minimal ringing. They also have a high DC gain of 101dB, making them suitable for low frequency applications.

The single LMV93x-N is offered in space saving 5-Pin SC70 and SOT-23 packages. The dual LMV932-N are in 8-Pin VSSOP and SOIC packages and the quad LMV934-N are in 14-Pin TSSOP and SOIC packages. These small packages are ideal solutions for area constrained PC boards and portable electronics such as mobile phones and tablets.

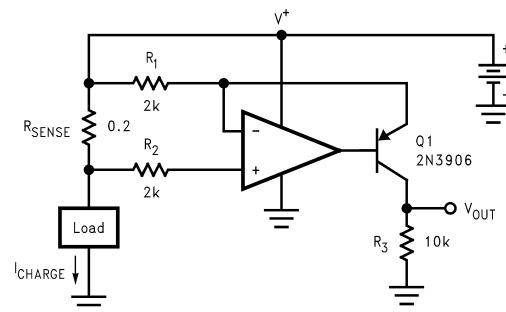
The LMV93x-N-Q1 family retains all the LMV93x-N family features while adding AEC-Q100 Grade 1 qualification for automotive applications.

Device Information⁽¹⁾

PART NUMBER	PACKAGE	BODY SIZE (NOM)
LMV931-N	SOT-23 (5)	2.90 mm x 1.60 mm
LMV931-N-Q1	SC-70 (5)	2.00 mm x 1.25 mm
LMV932-N	VSSOP (8)	3.00 mm x 3.00 mm
LMV932-N-Q1	SOIC (8)	4.90 mm x 3.91 mm
LMV934-N	TSSOP (8)	5.00 mm x 4.40 mm
LMV934-N-Q1	SOIC (14)	8.60 mm x 3.90 mm

(1) For all available packages, see the orderable addendum at the end of the datasheet.

High-Side Current Sense Amplifier



$$V_{OUT} = \frac{R_{SENSE} \cdot R_3}{R_1} \cdot I_{CHARGE} = 1.0 \cdot I_{CHARGE}$$



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4 Revision History

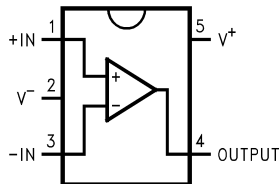
NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Revision M (November 2013) to Revision N	Page
• Complete rewrite for GDS standard.	1
• Added LMV934-N-Q1. The other Q grades were added in previous revision.....	1

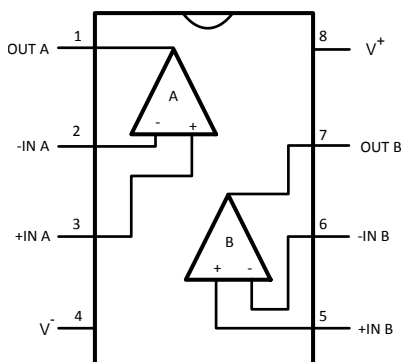
Changes from Revision L (March 2013) to Revision M	Page
• Added Automotive Q Grade.	1
• Added Output Swing for Q-Grade in all Electrical Tables	6

5 Pin Configuration and Functions

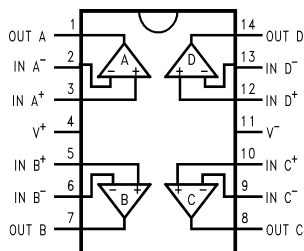
**LMV931 5-Pin SC-70 or SOT-23
DCK and DBV Packages
Top View**



**LMV932 8-Pin VSSOP/SOIC
D and DGK Packages
Top View**



**LMV934 14-Pin TSSOP/SOIC
D, PW and DGV Packages
Top View**



Pin Functions

PIN		DESCRIPTION
NAME	I/O	
+IN	I	Non-Inverting Input
-IN	I	Inverting Input
OUT	O	Output
V-	P	Negative Supply
V+	P	Positive Supply

6 Specifications

6.1 Absolute Maximum Ratings ⁽¹⁾⁽²⁾

	MIN	MAX	UNIT
Supply Voltage Range ($V^+ - V^-$)	-0.3	+6	V
Differential Input Voltage	V^-	V^+	
Voltage at Input/Output Pins	(V^-) - 0.3	(V^+) + 0.3	
Junction Temperature ⁽³⁾	-40	+150°C	°C

- (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 specified. For specifications and the test conditions, see the Electrical Characteristics.
- (2) If Military/Aerospace specified devices are required, please contact the TI Sales Office/Distributors for availability and specifications.
- (3) The maximum power dissipation is a function of $T_{J(max)}$, θ_{JA} , and T_A . 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 into a PC board.

6.2 Handling Ratings

	MIN	MAX	UNIT	
T_{stg} Storage temperature range	-65	+150	°C	
$V_{(ESD)}$ Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins ^{(1) (2)}	-2000	+2000	V
	Charged device model (CDM), per JEDEC specification JESD22-C101, all pins ⁽³⁾	-750	+750	
	Machine Model (MM) ⁽⁴⁾	-200	+200	

- (1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
- (2) AEC Q100-002 indicates HBM stressing is done in accordance with the ANSI/ESDA/JEDEC JS-001 specification.
- (3) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.
- (4) Machine model, 200Ω in series with 100 pF.

6.3 Recommended Operating Ratings ⁽¹⁾

	MIN	MAX	UNIT
Supply Voltage Range ($V^+ - V^-$)	+1.8	+5.5	V
Temperature Range	-40	+125	°C

- (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 specified. For specifications and the test conditions, see the Electrical Characteristics.

6.4 Thermal Information 5 Pins

THERMAL METRIC ⁽¹⁾	LMV921	LMV921	UNIT
	SC-70-5	SOT-23-5	
	DCK0005A	DBV0005A	
$R_{\theta JA}$ Junction-to-ambient thermal resistance	414	265	°C/W

- (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

6.5 Thermal Information 8 Pins

THERMAL METRIC ⁽¹⁾	LMV922	LMV922	UNIT
	VSSOP-8	SOIC-8	
	DGK0008A	D0008A	
$R_{\theta JA}$ Junction-to-ambient thermal resistance	235	175	°C/W

- (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

6.6 Thermal Information 14 Pins

THERMAL METRIC ⁽¹⁾	LMV924	LMV924	UNIT
	TSSOP-14	SOIC-14	
	DGK0014A	D0014A	
$R_{\theta JA}$ Junction-to-ambient thermal resistance	155	127	°C/W

(1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).

6.7 DC Electrical Characteristics 1.8V

Unless otherwise specified, all limits specified for $T_J = 25^\circ\text{C}$. $V^+ = 1.8\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = V^+/2$, $V_O = V^+/2$ and $R_L > 1\text{M}\Omega$.

SYMBOL	PARAMETERS	TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT
V_{OS}	Input Offset Voltage	LMV931 (Single)	25°C	1	4	mV
			Full Range		6	
		LMV932 (Dual), LMV934 (Quad)	25°C	1	5.5	mV
			Full Range		7.5	
TCV_{OS}	Input Offset Voltage Average Drift	Full Range		5.5		$\mu\text{V}/^\circ\text{C}$
I_B	Input Bias Current	25°C		15	35	nA
		Full Range			50	
I_{OS}	Input Offset Current	25°C		13	25	nA
		Full Range			40	
I_S	Supply Current (per channel)	25°C		103	185	μA
		Full Range			205	
CMRR	Common Mode Rejection Ratio	LMV931, $0 \leq V_{\text{CM}} \leq 0.6\text{V}$ $1.4\text{V} \leq V_{\text{CM}} \leq 1.8\text{V}^{(2)}$	25°C	60	78	dB
			Full Range		55	
		LMV932 and LMV934 $0 \leq V_{\text{CM}} \leq 0.6\text{V}$ $1.4\text{V} \leq V_{\text{CM}} \leq 1.8\text{V}^{(2)}$	25°C	55	76	dB
			Full Range		50	
		$-0.2\text{V} \leq V_{\text{CM}} \leq 0\text{V}$ $1.8\text{V} \leq V_{\text{CM}} \leq 2.0\text{V}$	25°C	50	72	dB
			Full Range			
PSRR	Power Supply Rejection Ratio	$1.8\text{V} \leq V^+ \leq 5\text{V}$	25°C	75	100	dB
			Full Range		70	
CMVR	Input Common-Mode Voltage Range	For CMRR Range $\geq 50\text{dB}$	25°C	$V^- - 0.2$	-0.2 to V^+	V
			-40°C to 85°C	V^-	2.1	
			125°C	$V^- + 0.2$	$V^+ - 0.2$	
A_V	Large Signal Voltage Gain LMV931-N (Single) LMV931-N-Q1 (Single)	$R_L = 600\Omega$ to 0.9V, $V_O = 0.2\text{V}$ to 1.6V, $V_{\text{CM}} = 0.5\text{V}$	25°C	77	101	dB
			Full Range		73	
		$R_L = 2\text{k}\Omega$ to 0.9V, $V_O = 0.2\text{V}$ to 1.6V, $V_{\text{CM}} = 0.5\text{V}$	25°C	80	105	dB
			Full Range		75	
	Large Signal Voltage Gain LMV932-N (Dual) LMV932-N-Q1 (Dual) LMV934-N (Quad) LMV934-N-Q1 (Quad)	$R_L = 600\Omega$ to 0.9V, $V_O = 0.2\text{V}$ to 1.6V, $V_{\text{CM}} = 0.5\text{V}$	25°C	75	90	dB
			Full Range		72	
$R_L = 2\text{k}\Omega$ to 0.9V, $V_O = 0.2\text{V}$ to 1.6V, $V_{\text{CM}} = 0.5\text{V}$		25°C	78	100	dB	
		Full Range		75		
V_O	Output Swing	$R_L = 600\Omega$ to 0.9V $V_{\text{IN}} = \pm 100\text{mV}$	25°C	1.65	1.72	V
				0.077	0.105	
			Full Range		1.63	0.120
				$R_L = 2\text{k}\Omega$ to 0.9V $V_{\text{IN}} = \pm 100\text{mV}$	25°C	1.75
		0.024	0.035			
		Full Range			1.74	0.04
V_O	Output Swing LMV932-N-Q1 (Dual) LMV934-N-Q1 (Quad)		$R_L = 600\Omega$ to 0.9V $V_{\text{IN}} = \pm 100\text{mV}$		25°C	1.65
		0.077		0.105		
		Full Range			1.63	0.173
				$R_L = 2\text{k}\Omega$ to 0.9V $V_{\text{IN}} = \pm 100\text{mV}$	25°C	1.75
		0.024	0.035			
		Full Range			1.74	0.055

- (1) 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.
- (2) For specified temperature ranges, see Input Common-Mode Voltage Range specifications.

DC Electrical Characteristics 1.8V (continued)

Unless otherwise specified, all limits specified for $T_J = 25^\circ\text{C}$. $V^+ = 1.8\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = V^+/2$, $V_O = V^+/2$ and $R_L > 1\text{M}\Omega$.

SYMBOL	PARAMETERS	TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT
I_O	Output Short Circuit Current ⁽³⁾	Sourcing, $V_O = 0\text{V}$ $V_{\text{IN}} = +100\text{mV}$	25°C	4	8	mA
			Full Range	3.3		
		Sinking, $V_O = 1.8\text{V}$ $V_{\text{IN}} = -100\text{mV}$	25°C	7	9	mA
			Full Range	5		

(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.

6.8 AC Electrical Characteristics 1.8V

Unless otherwise specified, all limits specified for $T_J = 25^\circ\text{C}$. $V^+ = 1.8\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = V^+/2$, $V_O = V^+/2$ and $R_L > 1\text{M}\Omega$.

SYMBOL	PARAMETERS	TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT
SR	Slew Rate	See ⁽²⁾		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	$f = 10\text{kHz}$, $V_{\text{CM}} = 0.5\text{V}$		60		nV/ $\sqrt{\text{Hz}}$
i_n	Input-Referred Current Noise	$f = 10\text{kHz}$		0.08		pA/ $\sqrt{\text{Hz}}$
THD	Total Harmonic Distortion	$f = 1\text{kHz}$, $A_V = +1$ $R_L = 600\Omega$, $V_{\text{IN}} = 1\text{V}_{\text{PP}}$		0.023		%
	Amp-to-Amp Isolation	See ⁽³⁾		123		dB

- (1) 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.
- (2) Connected as voltage follower with input step from V^- to V^+ . Number specified is the slower of the positive and negative slew rates.
- (3) Input referred, $R_L = 100\text{k}\Omega$ connected to $V^+/2$. Each amp excited in turn with 1kHz to produce $V_O = 3V_{\text{PP}}$ (For Supply Voltages $< 3\text{V}$, $V_O = V^+$).

6.9 DC Electrical Characteristics 2.7V

Unless otherwise specified, all limits specified for $T_J = 25^\circ\text{C}$. $V^+ = 2.7\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = V^+/2$, $V_O = V^+/2$ and $R_L > 1\text{M}\Omega$.

SYMBOL	PARAMETERS	TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT	
V_{OS}	Input Offset Voltage	LMV931 (Single)	25°C	1	4	mV	
			Full Range		6		
		LMV932 (Dual) LMV934 (Quad)	25°C	1	5.5	mV	
			Full Range		7.5		
TCV_{OS}	Input Offset Voltage Average Drift	Full Range		5.5		$\mu\text{V}/^\circ\text{C}$	
I_B	Input Bias Current	25°C		15	35	nA	
		Full Range			50		
I_{OS}	Input Offset Current	25°C		8	25	nA	
		Full Range			40		
I_S	Supply Current (per channel)	25°C		105	190	μA	
		Full Range			210		
CMRR	Common Mode Rejection Ratio	LMV931, $0 \leq V_{\text{CM}} \leq 1.5\text{V}$ $2.3\text{V} \leq V_{\text{CM}} \leq 2.7\text{V}^{(2)}$	25°C	60	81	dB	
			Full Range		55		
		LMV932 and LMV934 $0 \leq V_{\text{CM}} \leq 1.5\text{V}$ $2.3\text{V} \leq V_{\text{CM}} \leq 2.7\text{V}^{(2)}$	25°C	55	80	dB	
			Full Range		50		
		$-0.2\text{V} \leq V_{\text{CM}} \leq 0\text{V}$ $2.7\text{V} \leq V_{\text{CM}} \leq 2.9\text{V}$	25°C	50	74	dB	
			Full Range				
PSRR	Power Supply Rejection Ratio	$1.8\text{V} \leq V^+ \leq 5\text{V}$ $V_{\text{CM}} = 0.5\text{V}$	25°C	75	100	dB	
			Full Range		70		
V_{CM}	Input Common-Mode Voltage Range	For CMRR Range $\geq 50\text{dB}$	25°C	$V^- - 0.2$	-0.2 to 3.0	$V^+ + 0.2$ to V^+	V
			-40°C to 85°C	V^-			
			125°C	$V^- + 0.2$		$V^+ - 0.2$	
A_V	Large Signal Voltage Gain LMV931-N (Single) LMV931-N-Q1 (Single)	$R_L = 600\Omega$ to 1.35V , $V_O = 0.2\text{V}$ to 2.5V	25°C	87	104	dB	
			Full Range		86		
		$R_L = 2\text{k}\Omega$ to 1.35V , $V_O = 0.2\text{V}$ to 2.5V	25°C	92	110	dB	
			Full Range		91		
	Large Signal Voltage Gain LMV932-N (Dual) LMV932-N-Q1 (Dual) LMV934-N (Quad) LMV934-N-Q1 (Quad)	$R_L = 600\Omega$ to 1.35V , $V_O = 0.2\text{V}$ to 2.5V	25°C	78	90	dB	
			Full Range		75		
$R_L = 2\text{k}\Omega$ to 1.35V , $V_O = 0.2\text{V}$ to 2.5V		25°C	81	100	dB		
		Full Range		78			
V_O	Output Swing	$R_L = 600\Omega$ to 1.35V $V_{\text{IN}} = \pm 100\text{mV}$	25°C	2.55	2.62	V	
				0.083	0.110		
			Full Range	2.53	0.130		
		$R_L = 2\text{k}\Omega$ to 1.35V $V_{\text{IN}} = \pm 100\text{mV}$	25°C	2.65	2.675	V	
				0.025	0.04		
			Full Range	2.64	0.045		
V_O	Output Swing LMV932-N-Q1 (Dual) LMV934-N-Q1 (Quad)	$R_L = 600\Omega$ to 1.35V $V_{\text{IN}} = \pm 100\text{mV}$	25°C	2.55	2.62	V	
				0.083	0.110		
			Full Range	2.53	0.187		
		$R_L = 2\text{k}\Omega$ to 1.35V $V_{\text{IN}} = \pm 100\text{mV}$	25°C	2.65	2.675	V	
				0.025	0.04		
			Full Range	2.64	0.059		

(1) 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.

(2) For specified temperature ranges, see Input Common-Mode Voltage Range specifications.

DC Electrical Characteristics 2.7V (continued)

Unless otherwise specified, all limits specified for $T_J = 25^\circ\text{C}$. $V^+ = 2.7\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = V^+/2$, $V_O = V^+/2$ and $R_L > 1\text{ M}\Omega$.

SYMBOL	PARAMETERS	TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT
I_O	Output Short Circuit Current ⁽³⁾	Sourcing, $V_O = 0\text{V}$ $V_{\text{IN}} = +100\text{mV}$	25°C	20	30	mA
			Full Range	15		
		Sinking, $V_O = 2.7\text{V}$ $V_{\text{IN}} = -100\text{mV}$	25°C	18	25	mA
			Full Range	12		

(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.

6.10 AC Electrical Characteristics 2.7V

Unless otherwise specified, all limits specified for $T_J = 25^\circ\text{C}$. $V^+ = 2.7\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = 1.0\text{V}$, $V_O = 1.35\text{V}$ and $R_L > 1\text{ M}\Omega$.

SYMBOL	PARAMETERS	TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT
SR	Slew Rate	See ⁽²⁾		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	$f = 10\text{ kHz}$, $V_{\text{CM}} = 0.5\text{V}$		57		nV/ $\sqrt{\text{Hz}}$
i_n	Input-Referred Current Noise	$f = 10\text{ kHz}$		0.08		pA/ $\sqrt{\text{Hz}}$
THD	Total Harmonic Distortion	$f = 1\text{ kHz}$, $A_V = +1$ $R_L = 600\Omega$, $V_{\text{IN}} = 1\text{V}_{\text{PP}}$		0.022		%
	Amp-to-Amp Isolation	See ⁽³⁾		123		dB

(1) 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.

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

(3) Input referred, $R_L = 100\text{k}\Omega$ connected to $V^+/2$. Each amp excited in turn with 1kHz to produce $V_O = 3\text{V}_{\text{PP}}$ (For Supply Voltages $< 3\text{V}$, $V_O = V^+$).

6.11 Electrical Characteristics 5V DC

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

SYMBOL	PARAMETERS	TEST CONDITIONS		MIN	TYP (1)	MAX	UNIT
V_{OS}	Input Offset Voltage	LMV931 (Single)	25°C		1	4	mV
			Full Range			6	
		LMV932 (Dual) LMV934 (Quad)	25°C		1	5.5	mV
			Full Range			7.5	
TCV_{OS}	Input Offset Voltage Average Drift			5.5		$\mu\text{V}/^\circ\text{C}$	
I_B	Input Bias Current		25°C		14	35	nA
			Full Range			50	
I_{OS}	Input Offset Current		25°C		9	25	nA
			Full Range			40	
I_S	Supply Current (per channel)		25°C		116	210	μA
			Full Range			230	
CMRR	Common Mode Rejection Ratio	$0 \leq V_{CM} \leq 3.8\text{V}$ $4.6\text{V} \leq V_{CM} \leq 5.0\text{V}^{(2)}$	25°C	60	86	dB	
			Full Range	55			
		$-0.2\text{V} \leq V_{CM} \leq 0\text{V}$ $5.0\text{V} \leq V_{CM} \leq 5.2\text{V}$	25°C	50	78	dB	
			Full Range				
PSRR	Power Supply Rejection Ratio	$1.8\text{V} \leq V^+ \leq 5\text{V}$ $V_{CM} = 0.5\text{V}$	25°C	75	100	dB	
			Full Range	70			
CMVR	Input Common-Mode Voltage Range	For CMRR Range $\geq 50\text{dB}$	25°C	$V^- - 0.2$	-0.2	$V^+ + 0.2$	V
			-40°C to 85°C	V^-	to	V^+	
			125°C	$V^- + 0.3$	5.3	$V^+ - 0.3$	
A_V	Large Signal Voltage Gain LMV931-N (Single) LMV931-N-Q1 (Single)	$R_L = 600\Omega$ to 2.5V, $V_O = 0.2\text{V}$ to 4.8V	25°C	88	102	dB	
			Full Range	87			
		$R_L = 2\text{k}\Omega$ to 2.5V, $V_O = 0.2\text{V}$ to 4.8V	25°C	94	113	dB	
			Full Range	93			
	Large Signal Voltage Gain LMV932-N (Dual) LMV932-N-Q1 (Dual) LMV934-N (Quad) LMV934-N-Q1 (Quad)	$R_L = 600\Omega$ to 2.5V, $V_O = 0.2\text{V}$ to 4.8V	25°C	81	90	dB	
			Full Range	78			
$R_L = 2\text{k}\Omega$ to 2.5V, $V_O = 0.2\text{V}$ to 4.8V		25°C	85	100	dB		
		Full Range	82				
V_O	Output Swing	$R_L = 600\Omega$ to 2.5V $V_{IN} = \pm 100\text{mV}$	25°C	4.855	4.890	V	
				0.120	0.160		
			Full Range	4.835	0.180		
		$R_L = 2\text{k}\Omega$ to 2.5V $V_{IN} = \pm 100\text{mV}$	25°C	4.945	4.967	V	
				0.037	0.065		
Full Range	4.935	0.075					
V_O	Output Swing LMV932-N-Q1 (Dual) LMV934-N-Q1 (Quad)	$R_L = 600\Omega$ to 2.5V $V_{IN} = \pm 100\text{mV}$	25°C	4.855	4.890	V	
				0.120	0.160		
			Full Range	4.807	0.218		
		$R_L = 2\text{k}\Omega$ to 2.5V $V_{IN} = \pm 100\text{mV}$	25°C	4.945	4.967	V	
				0.037	0.065		
Full Range	4.935	0.075					

(1) 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.

(2) For specified temperature ranges, see Input Common-Mode Voltage Range specifications.

Electrical Characteristics 5V DC (continued)

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

SYMBOL	PARAMETERS	TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT
I_O	Output Short Circuit Current ⁽³⁾	LMV931, Sourcing, $V_O = 0\text{V}$ $V_{\text{IN}} = +100\text{mV}$	25°C	80	100	mA
			Full Range	68		
		Sinking, $V_O = 5\text{V}$ $V_{\text{IN}} = -100\text{mV}$	25°C	58	65	mA
			Full Range	45		

(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.

6.12 AC Electrical Characteristics 5V

Unless otherwise specified, all limits specified for $T_J = 25^\circ\text{C}$. $V^+ = 5\text{V}$, $V^- = 0\text{V}$, $V_{\text{CM}} = V^+/2$, $V_O = 2.5\text{V}$ and $R_L > 1\text{ M}\Omega$.

SYMBOL	PARAMETERS	TEST CONDITIONS	MIN	TYP (1)	MAX	UNIT
SR	Slew Rate	See ⁽²⁾		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	$f = 10\text{ kHz}$, $V_{\text{CM}} = 1\text{V}$		50		nV/ $\sqrt{\text{Hz}}$
i_n	Input-Referred Current Noise	$f = 10\text{ kHz}$		0.08		pA/ $\sqrt{\text{Hz}}$
THD	Total Harmonic Distortion	$f = 1\text{kHz}$, $A_V = +1$ $R_L = 600\Omega$, $V_O = 1\text{V}_{\text{PP}}$		0.022		%
	Amp-to-Amp Isolation	See ⁽³⁾		123		dB

(1) 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.

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

(3) Input referred, $R_L = 100\text{k}\Omega$ connected to $V^+/2$. Each amp excited in turn with 1kHz to produce $V_O = 3\text{V}_{\text{PP}}$ (For Supply Voltages $< 3\text{V}$, $V_O = V^+$).

6.13 Typical Performance Characteristics

Unless otherwise specified, $V_S = +5V$, single supply, $T_A = 25^\circ C$.

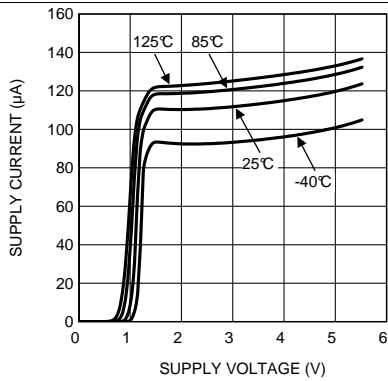


Figure 1. Supply Current vs. Supply Voltage (LMV931-N)

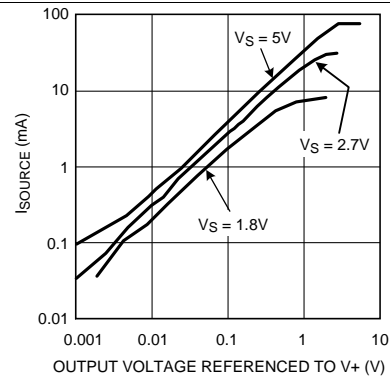


Figure 2. Sourcing Current vs. Output Voltage

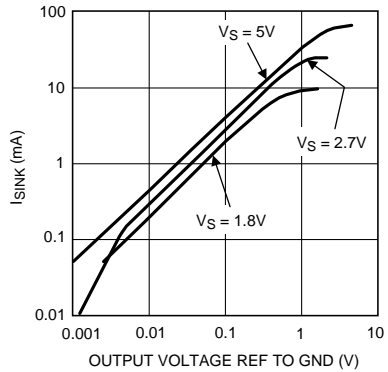


Figure 3. Sinking Current vs. Output Voltage

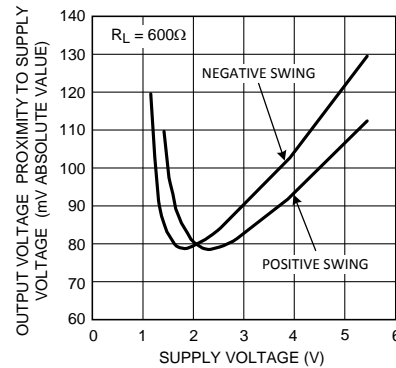


Figure 4. Output Voltage Swing vs. Supply Voltage

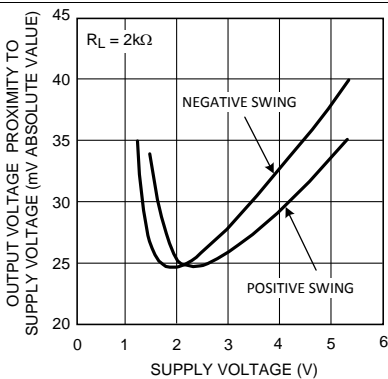


Figure 5. Output Voltage Swing vs. Supply Voltage

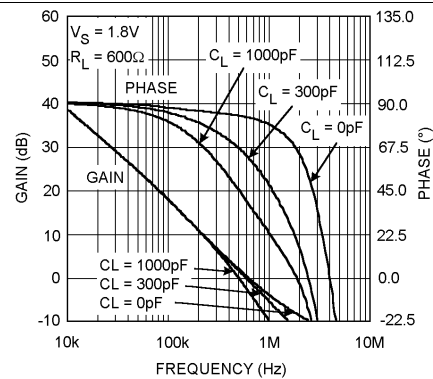


Figure 6. Gain and Phase vs. Frequency

Typical Performance Characteristics (continued)

Unless otherwise specified, $V_S = +5V$, single supply, $T_A = 25^\circ C$.

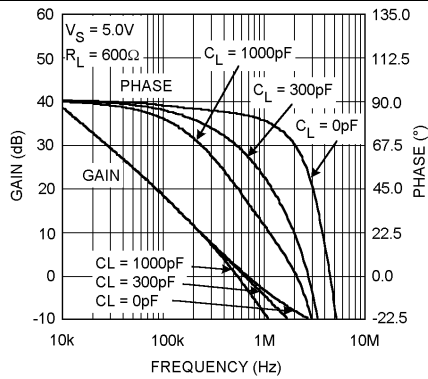


Figure 7. Gain and Phase vs. Frequency

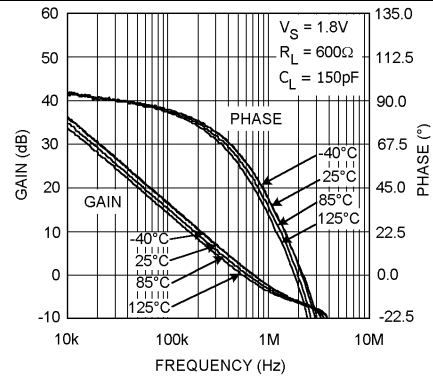


Figure 8. Gain and Phase vs. Frequency

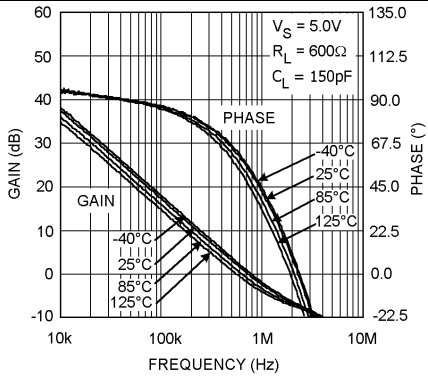


Figure 9. Gain and Phase vs. Frequency

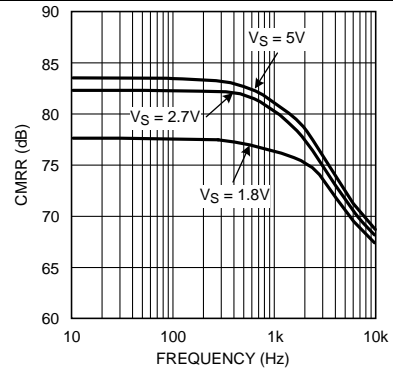


Figure 10. CMRR vs. Frequency

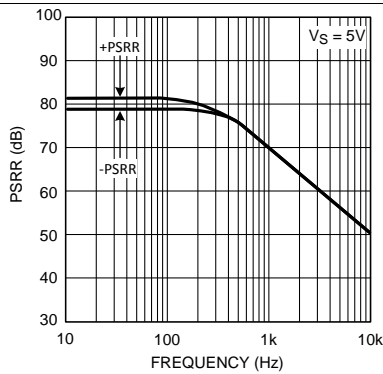


Figure 11. PSRR vs. Frequency

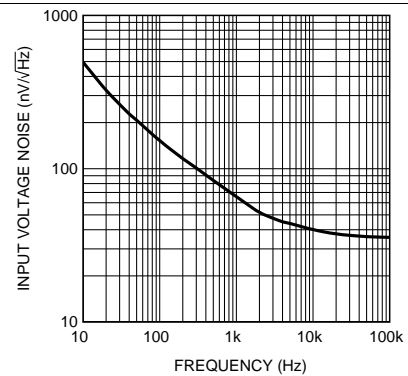


Figure 12. Input Voltage Noise vs. Frequency

Typical Performance Characteristics (continued)

Unless otherwise specified, $V_S = +5V$, single supply, $T_A = 25^\circ C$.

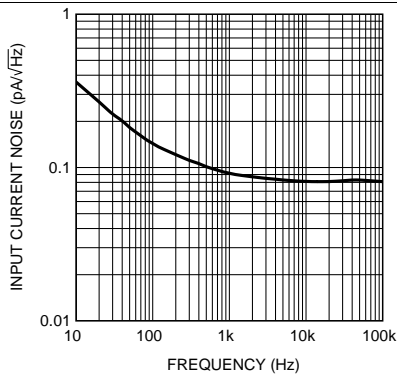


Figure 13. Input Current Noise vs. Frequency

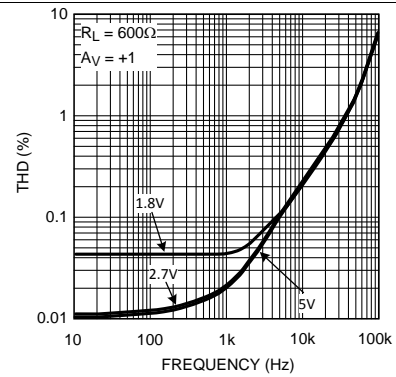


Figure 14. THD vs. Frequency

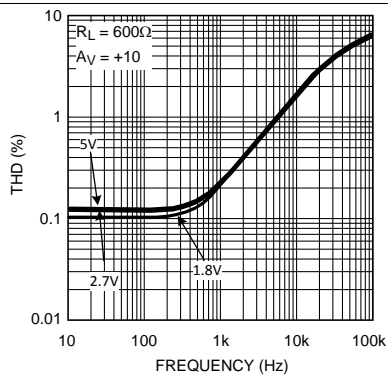


Figure 15. THD vs. Frequency

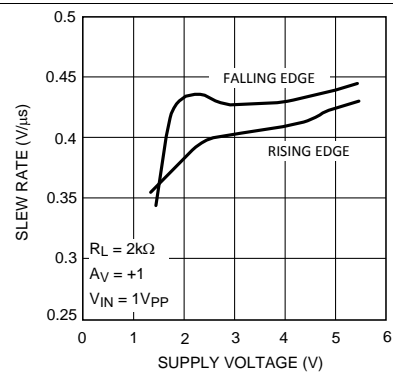


Figure 16. Slew Rate vs. Supply Voltage

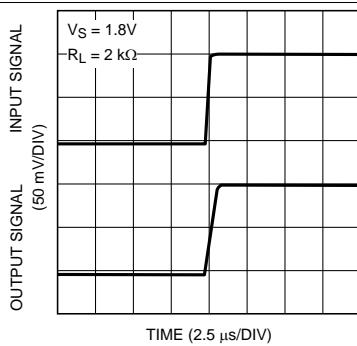


Figure 17. Small Signal Non-Inverting Response

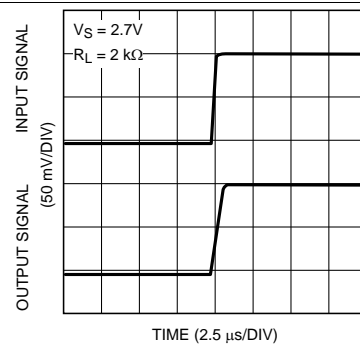


Figure 18. Small Signal Non-Inverting Response

Typical Performance Characteristics (continued)

Unless otherwise specified, $V_S = +5V$, single supply, $T_A = 25^\circ C$.

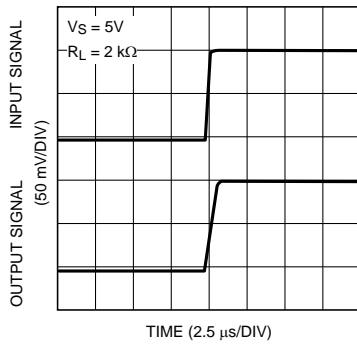


Figure 19. Small Signal Non-Inverting Response

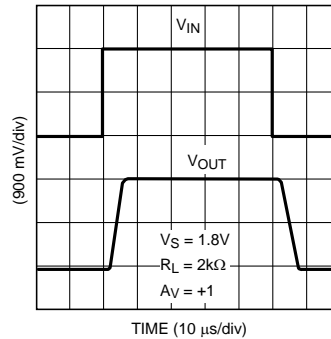


Figure 20. Large Signal Non-Inverting Response

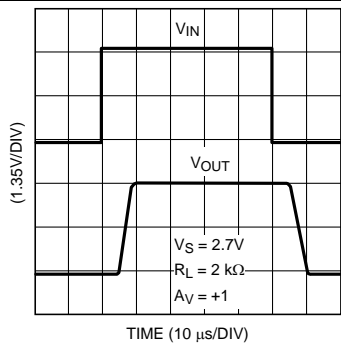


Figure 21. Large Signal Non-Inverting Response

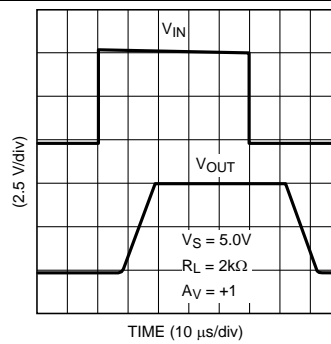


Figure 22. Large Signal Non-Inverting Response

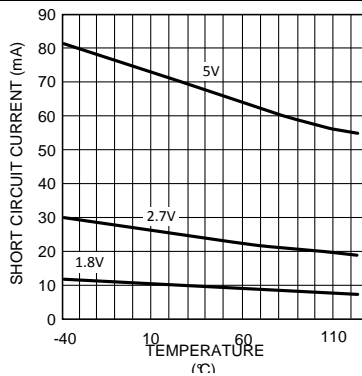


Figure 23. Short Circuit Current vs. Temperature (Sinking)

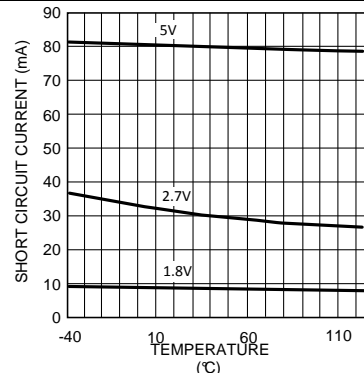


Figure 24. Short Circuit Current vs. Temperature (Sourcing)

Typical Performance Characteristics (continued)

Unless otherwise specified, $V_S = +5V$, single supply, $T_A = 25^\circ C$.

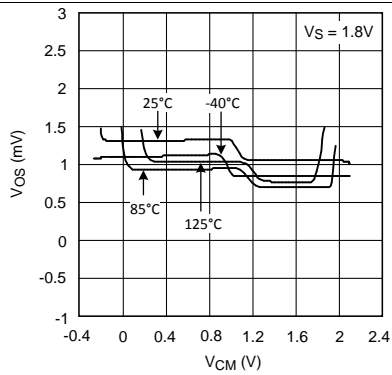


Figure 25. Offset Voltage vs. Common Mode Range

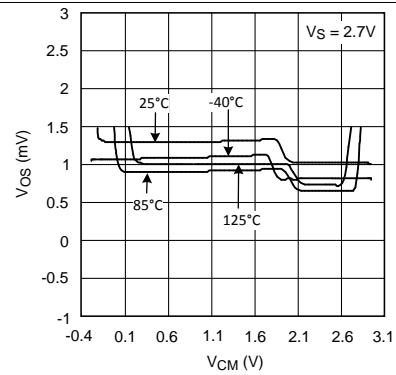


Figure 26. Offset Voltage vs. Common Mode Range

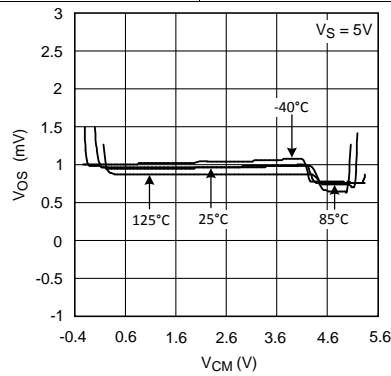


Figure 27. Offset Voltage vs. Common Mode Range

7 Detailed Description

7.1 Overview

The LMV93x-N are low voltage, low power operational amplifiers operating from +1.8V to +5.5V supply voltages and have rail-to-rail input and output. LMV93x-N input common mode voltage extends 200mV beyond the supplies which enables user enhanced functionality beyond the supply voltage range.

7.2 Functional Block Diagrams

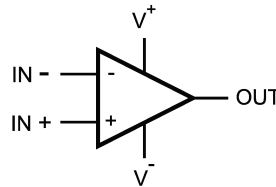


Figure 28. (Each Amplifier)

7.3 Feature Description

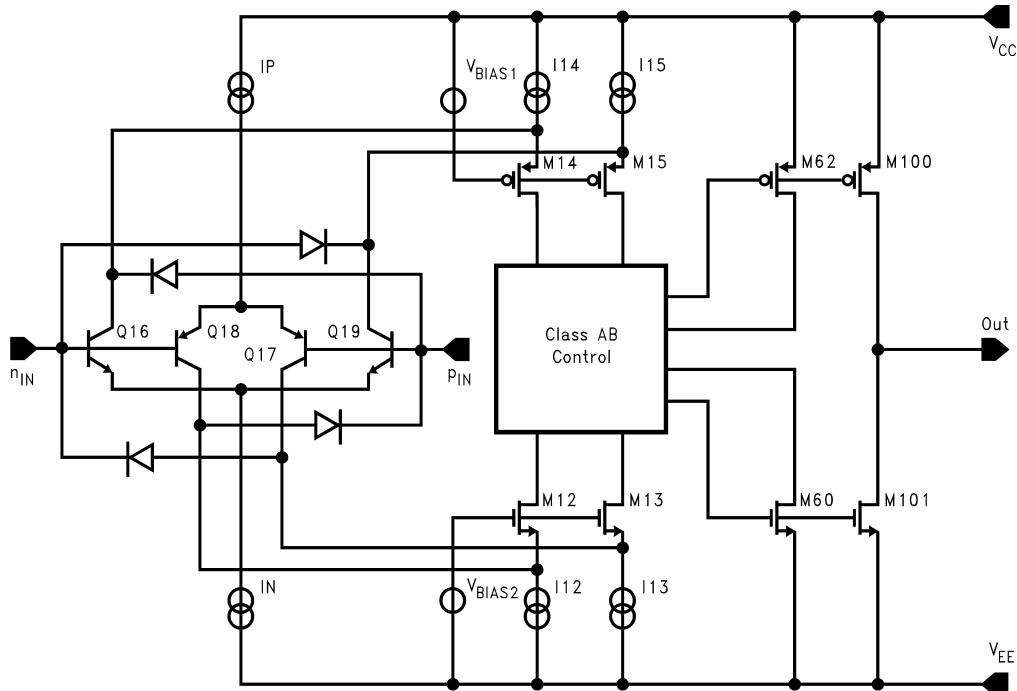
The amplifier's differential inputs consist of a non-inverting input (+IN) and an inverting input (–IN). The amplifier amplifies only the difference in voltage between the two inputs, which is called the differential input voltage. The output voltage of the op-amp V_{out} is given by Equation 1:

$$V_{OUT} = A_{OL} (IN^+ - IN^-) \quad (1)$$

where A_{OL} is the open-loop gain of the amplifier, typically around 100dB (100,000x, or 10uV per Volt).

7.4 Device Functional Modes

7.4.1 Input and Output Stage



Device Functional Modes (continued)

The rail-to-rail input stage of this family provides more flexibility for the designer. The LMV93x-N use a complimentary PNP and NPN input stage in which the PNP stage senses common mode voltage near V^- and the NPN stage senses common mode voltage near V^+ . The transition from the PNP stage to NPN stage occurs 1V below V^+ . Since both input stages have their own offset voltage, the offset of the amplifier becomes a function of the input common mode voltage and has a crossover point at 1V below V^+ .

This V_{OS} crossover point can create problems for both DC and AC coupled signals if proper care is not taken. Large input signals that include the V_{OS} crossover point will cause distortion in the output signal. One way to avoid such distortion is to keep the signal away from the crossover. For example, in a unity gain buffer configuration and with $V_S = 5V$, a 5V peak-to-peak signal will contain input-crossover distortion while a 3V peak-to-peak signal centered at 1.5V will not contain input-crossover distortion as it avoids the crossover point. Another way to avoid large signal distortion is to use a gain of -1 circuit which avoids any voltage excursions at the input terminals of the amplifier. In that circuit, the common mode DC voltage can be set at a level away from the V_{OS} cross-over point. For small signals, this transition in V_{OS} shows up as a V_{CM} dependent spurious signal in series with the input signal and can effectively degrade small signal parameters such as gain and common mode rejection ratio. To resolve this problem, the small signal should be placed such that it avoids the V_{OS} crossover point. In addition to the rail-to-rail performance, the output stage can provide enough output current to drive 600 Ω loads. Because of the high current capability, care should be taken not to exceed the 150°C maximum junction temperature specification.

7.4.2 Input Bias Current Consideration

The LMV93x-N family has a complementary bipolar input stage. The typical input bias current (I_B) is 15nA. The input bias current can develop a significant offset voltage. This offset is primarily due to I_B flowing through the negative feedback resistor, R_F . For example, if I_B is 50nA and R_F is 100k Ω , then an offset voltage of 5mV will develop ($V_{OS} = I_B \times R_F$). Using a compensation resistor (R_C), as shown in [Figure 29](#), cancels this effect. But the input offset current (I_{OS}) will still contribute to an offset voltage in the same manner.

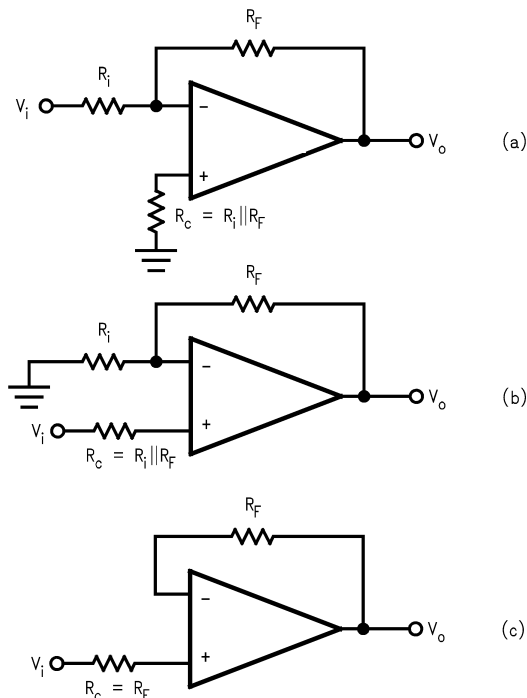


Figure 29. Canceling the Offset Voltage due to Input Bias Current

8 Application and Implementation

8.1 Application Information

The LMV93x-N family bring performance, economy and ease-of-use to low voltage, low power systems. They provide rail-to-rail input and rail-to-rail output output swings into heavy loads.

8.2 Typical Applications

8.2.1 High Side Current Sensing Application

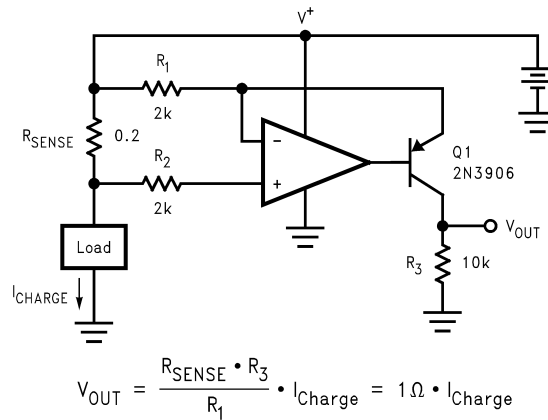


Figure 30. High Side Current Sensing

8.2.1.1 Design Requirements

The high side current sensing circuit (Figure 30) is commonly used in a battery charger to monitor charging current to prevent over charging. A sense resistor R_{SENSE} is connected to the battery directly. This system requires an op amp with rail-to-rail input. The LMV93x-N are ideal for this application because its common mode input range extends up to the positive supply.

8.2.1.2 Detailed Design Procedure

As seen in Figure 30, the I_{CHARGE} current flowing through sense resistor R_{SENSE} develops a voltage drop equal to V_{SENSE} . The voltage at the negative sense point will now be less than the positive sense point by an amount proportional to the V_{SENSE} voltage.

The low bias currents of the LMV93x cause little voltage drop through R_2 , so the negative input of the LMV93x amplifier is at essentially the same potential as the negative sense input.

The LMV93x will detect this voltage error between its inputs and servo the transistor base to conduct more current through Q1, increasing the voltage drop across R_1 until the LMV93x inverting input matches the non-inverting input. At this point, the voltage drop across R_1 now matches V_{SENSE} .

I_G , a current proportional to I_{CHARGE} , will flow according to the following relation:

$$I_G = V_{SENSE} / R_1 = (R_{SENSE} \cdot I_{CHARGE}) / R_1 \quad (2)$$

I_G also flows through the gain resistor R_3 developing a voltage drop equal to:

$$V_3 = I_G \cdot R_3 = (V_{SENSE} / R_1) \cdot R_3 = ((R_{SENSE} \cdot I_{CHARGE}) / R_1) \cdot R_3 \quad (3)$$

$$V_{OUT} = (R_{SENSE} \cdot I_{CHARGE}) \cdot G,$$

where

$$\bullet \quad G = R_3 / R_1 \quad (4)$$

The other channel of the LMV93x may be used to buffer the voltage across R_3 to drive the following stages.

8.2.1.3 Application Performance Plots

Figure 31 shows the results of the example current sense circuit.

Typical Applications (continued)

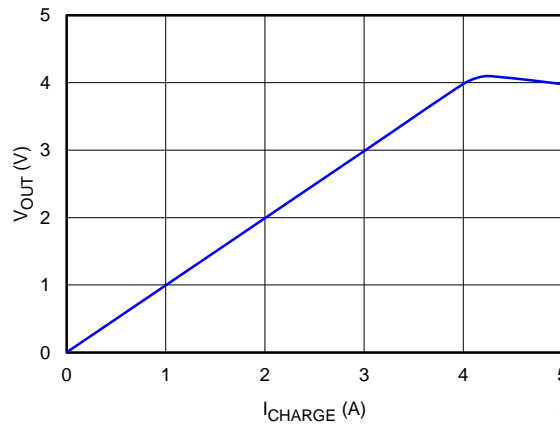


Figure 31. Current Sense Amplifier Results

Note the error after 4V where transistor Q1 runs out of headroom and saturates, limiting the upper output swing.

8.2.2 Half-Wave Rectifier Applications

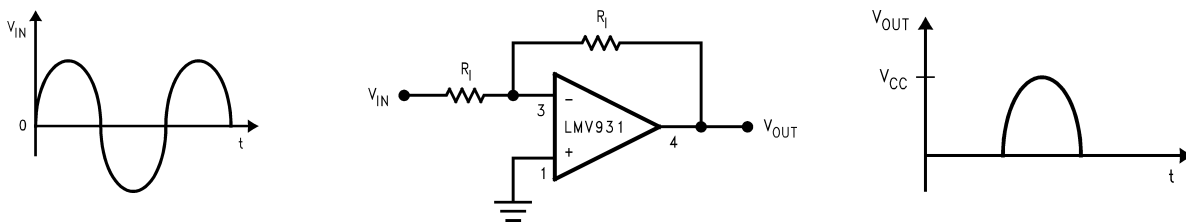


Figure 32. Half-Wave Rectifier with Rail-To-Ground Output Swing Referenced to Ground

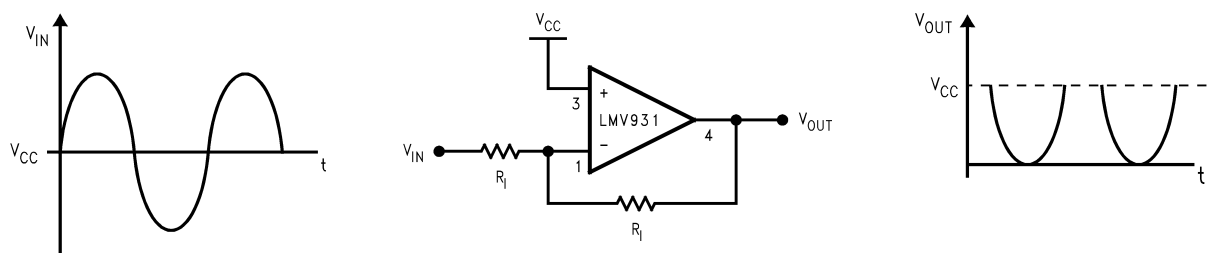


Figure 33. Half-Wave Rectifier with Negative-Going Output Referenced to V_{CC}

Typical Applications (continued)

8.2.2.1 Design Requirements

Since the LMV931-N/LMV932-N/LMV934-N input common mode range includes both positive and negative supply rails and the output can also swing to either supply, achieving half-wave rectifier functions in either direction is an easy task. All that is needed are two external resistors; there is no need for diodes or matched resistors. The half wave rectifier can have either positive or negative going outputs, depending on the way the circuit is arranged.

8.2.2.2 Design Procedure

In [Figure 32](#) the circuit is referenced to ground, while in [Figure 33](#) the circuit is biased to the positive supply. These configurations implement the half wave rectifier since the LMV93x-N can not respond to one-half of the incoming waveform. It can not respond to one-half of the incoming because the amplifier can not swing the output beyond either rail therefore the output disengages during this half cycle. During the other half cycle, however, the amplifier achieves a half wave that can have a peak equal to the total supply voltage. R_1 should be large enough not to load the LMV93x-N.

8.2.2.3 Application Curves

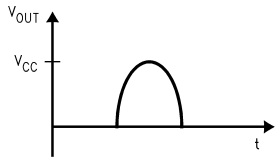


Figure 34. Output of Ground to Rail Circuit

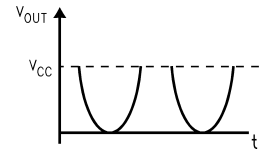


Figure 35. Output of Rail to Ground Circuit

8.2.3 Instrumentation Amplifier with Rail-to-Rail Input and Output Application

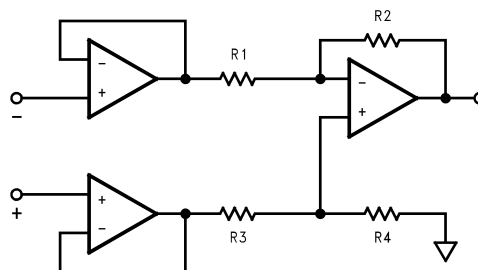


Figure 36. Rail-to-Rail Instrumentation Amplifier

8.2.3.1 Design Requirements

Using three of the LMV93x-N amplifiers, an instrumentation amplifier with rail-to-rail inputs and outputs can be made as shown in [Figure 36](#).

8.2.3.2 Detailed Design Procedure

In this example, amplifiers on the left side act as buffers to the differential stage. These buffers assure that the input impedance is very high. They also assure that the difference amp is driven from a voltage source. This is necessary to maintain the CMRR set by the matching R_1 - R_2 with R_3 - R_4 . The gain is set by the ratio of R_2/R_1 and R_3 should equal R_1 and R_4 equal R_2 . With both rail-to-rail input and output ranges, the input and output are only limited by the supply voltages. Remember that even with rail-to-rail outputs, the output can not swing past the supplies so the combined common mode voltages plus the signal should not be greater than the supplies or limiting will occur.

For additional applications, see Texas Instruments application notes AN-29 ([SNOA625](#)), AN-31 ([SNLA140](#)), AN-71 ([SNOA652](#)), and AN-127 ([SNVA516](#)).

Typical Applications (continued)

8.2.3.3 Application Performance Plots

Figure 37 shows the results of the instrumentation amplifier with R_1 & $R_3 = 1K$ and R_2 & $R_4 = 100K\Omega$ for a gain of 100, running on a single 5V supply with a input of $V_{CM} = V_S/2$. Note that the combined effects of the individual offset voltages can be seen as a shift in the offset of the curve.

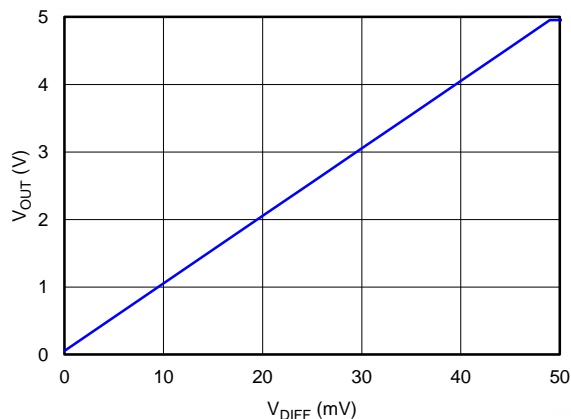


Figure 37. Instrumentation Amplifier Output Results

8.3 Do's and Don'ts

Do properly bypass the power supplies.

Do add series resistance to the output when driving capacitive loads, particularly cables, Muxes and ADC inputs.

Do add series current limiting resistors and external schottky clamp diodes if input voltage is expected to exceed the supplies. Limit the current to 1mA or less (1K Ω per volt).

9 Power Supply Recommendations

For proper operation, the power supplies must be properly decoupled. For decoupling the supply lines it is suggested that 10 nF capacitors be placed as close as possible to the op amp power supply pins. For single supply, place a capacitor between V^+ and V^- supply leads. For dual supplies, place one capacitor between V^+ and ground, and one capacitor between V^- and ground.

10 Layout

10.1 Layout Guidelines

The V+ pin should be bypassed to ground with a low ESR capacitor.

The optimum placement is closest to the V+ and ground pins.

Care should be taken to minimize the loop area formed by the bypass capacitor connection between V+ and ground.

The ground pin should be connected to the PCB ground plane at the pin of the device.

The feedback components should be placed as close to the device as possible minimizing strays.

10.2 Layout Example

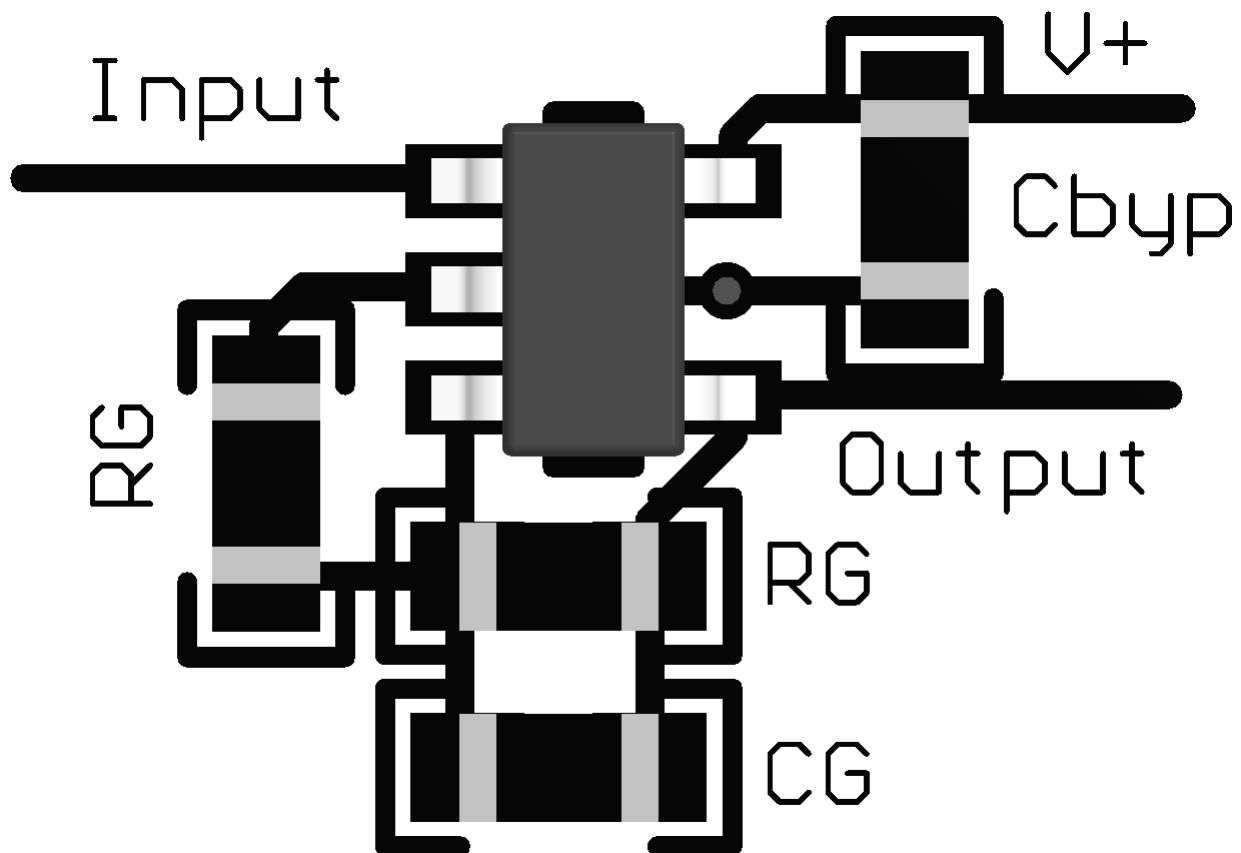


Figure 38. SOT-23 Layout Example

11 Device and Documentation Support

11.1 Device Support

11.1.1 Development Support

LMV931 PSPICE Model (also applicable to the LMV932 and LMV934), <http://www.ti.com/lit/zip/snom028>

TINA-TI SPICE-Based Analog Simulation Program, <http://www.ti.com/tool/tina-ti>

DIP Adapter Evaluation Module, <http://www.ti.com/tool/dip-adapter-evm>

TI Universal Operational Amplifier Evaluation Module, <http://www.ti.com/tool/opampevm>

11.2 Documentation Support

11.2.1 Related Documentation

For related documantation, see the following:

TI Filterpro Software, <http://www.ti.com/tool/filterpro>

11.3 Related Links

The table below lists quick access links. Categories include technical documents, support and community resources, tools and software, and quick access to sample or buy.

Table 1. Related Links

PARTS	PRODUCT FOLDER	SAMPLE & BUY	TECHNICAL DOCUMENTS	TOOLS & SOFTWARE	SUPPORT & COMMUNITY
LMV931-N	Click here	Click here	Click here	Click here	Click here
LMV931-N-Q1	Click here	Click here	Click here	Click here	Click here
LMV932-N	Click here	Click here	Click here	Click here	Click here
LMV932-N-Q1	Click here	Click here	Click here	Click here	Click here
LMV934-N	Click here	Click here	Click here	Click here	Click here
LMV934-N-Q1	Click here	Click here	Click here	Click here	Click here

11.4 Trademarks

All trademarks are the property of their respective owners.

11.5 Electrostatic Discharge Caution



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

11.6 Glossary

[SLYZ022](#) — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LMV931MF	NRND	SOT-23	DBV	5	1000	TBD	Call TI	Call TI	-40 to 125	A79A	
LMV931MF/NOPB	ACTIVE	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	A79A	Samples
LMV931MFX	NRND	SOT-23	DBV	5	3000	TBD	Call TI	Call TI	-40 to 125	A79A	
LMV931MFX/NOPB	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	A79A	Samples
LMV931MG	NRND	SC70	DCK	5	1000	TBD	Call TI	Call TI	-40 to 125	A74	
LMV931MG/NOPB	ACTIVE	SC70	DCK	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	A74	Samples
LMV931MGX/NOPB	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	A74	Samples
LMV931Q1MF/NOPB	ACTIVE	SOT-23	DBV	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	ALAA	Samples
LMV931Q1MFX/NOPB	ACTIVE	SOT-23	DBV	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	ALAA	Samples
LMV931Q1MG/NOPB	ACTIVE	SC70	DCK	5	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	BBA	Samples
LMV931Q1MGX/NOPB	ACTIVE	SC70	DCK	5	3000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	BBA	Samples
LMV932MA	NRND	SOIC	D	8	95	TBD	Call TI	Call TI	-40 to 125	LMV9 32MA	
LMV932MA/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	LMV9 32MA	Samples
LMV932MAX	NRND	SOIC	D	8	2500	TBD	Call TI	Call TI	-40 to 125	LMV9 32MA	
LMV932MAX/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	LMV9 32MA	Samples
LMV932MM	NRND	VSSOP	DGK	8	1000	TBD	Call TI	Call TI	-40 to 125	A86A	
LMV932MM/NOPB	ACTIVE	VSSOP	DGK	8	1000	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	A86A	Samples
LMV932MMX/NOPB	ACTIVE	VSSOP	DGK	8	3500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	A86A	Samples
LMV932Q1MA/NOPB	ACTIVE	SOIC	D	8	95	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	LMV93 2Q1MA	Samples

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
LMV932Q1MAX/NOPB	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	LMV93 2Q1MA	Samples
LMV934MA	NRND	SOIC	D	14	55	TBD	Call TI	Call TI	-40 to 125	LMV934MA	
LMV934MA/NOPB	ACTIVE	SOIC	D	14	55	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	LMV934MA	Samples
LMV934MAX	NRND	SOIC	D	14	2500	TBD	Call TI	Call TI	-40 to 125	LMV934MA	
LMV934MAX/NOPB	ACTIVE	SOIC	D	14	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	LMV934MA	Samples
LMV934MT/NOPB	ACTIVE	TSSOP	PW	14	94	Green (RoHS & no Sb/Br)	CU NIPDAU CU SN	Level-1-260C-UNLIM	-40 to 125	LMV93 4MT	Samples
LMV934MTX	NRND	TSSOP	PW	14	2500	TBD	Call TI	Call TI	-40 to 125	LMV93 4MT	
LMV934MTX/NOPB	ACTIVE	TSSOP	PW	14	2500	Green (RoHS & no Sb/Br)	CU NIPDAU CU SN	Level-1-260C-UNLIM	-40 to 125	LMV93 4MT	Samples
LMV934Q1MT/NOPB	ACTIVE	TSSOP	PW	14	94	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	LMV934 Q1MT	Samples
LMV934Q1MTX/NOPB	ACTIVE	TSSOP	PW	14	2500	Green (RoHS & no Sb/Br)	CU SN	Level-1-260C-UNLIM	-40 to 125	LMV934 Q1MT	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSELETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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OTHER QUALIFIED VERSIONS OF LMV931-N, LMV931-N-Q1, LMV932-N, LMV932-N-Q1, LMV934-N, LMV934-N-Q1 :

- Catalog: [LMV931-N](#), [LMV932-N](#), [LMV934-N](#)
- Automotive: [LMV931-N-Q1](#), [LMV932-N-Q1](#), [LMV934-N-Q1](#)

NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

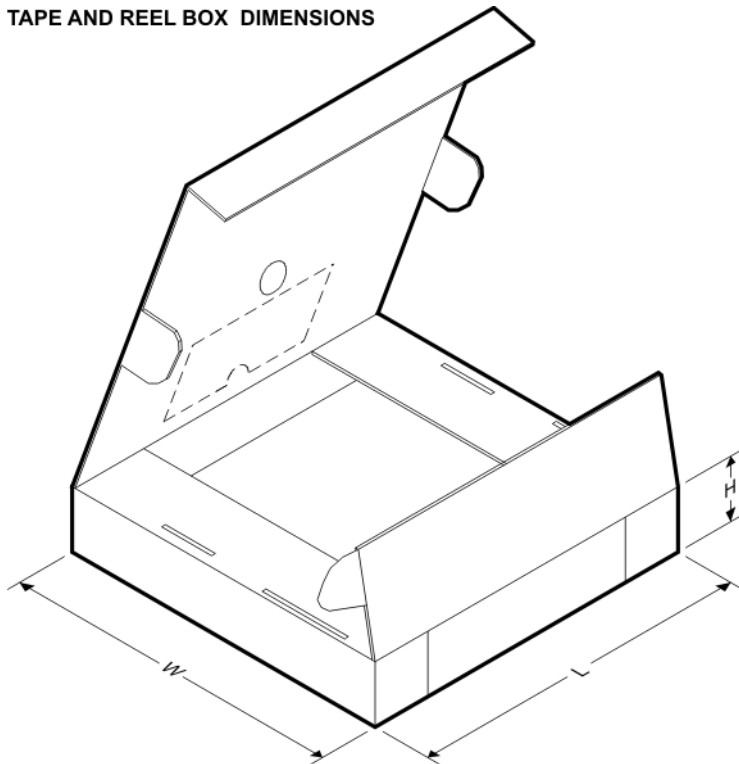
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LMV931MF	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMV931MF/NOPB	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMV931MFX	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMV931MFX/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMV931MG	SC70	DCK	5	1000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LMV931MG/NOPB	SC70	DCK	5	1000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LMV931MGX/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LMV931Q1MF/NOPB	SOT-23	DBV	5	1000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMV931Q1MFX/NOPB	SOT-23	DBV	5	3000	178.0	8.4	3.2	3.2	1.4	4.0	8.0	Q3
LMV931Q1MG/NOPB	SC70	DCK	5	1000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LMV931Q1MGX/NOPB	SC70	DCK	5	3000	178.0	8.4	2.25	2.45	1.2	4.0	8.0	Q3
LMV932MAX	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LMV932MAX/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LMV932MM	VSSOP	DGK	8	1000	178.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LMV932MM/NOPB	VSSOP	DGK	8	1000	178.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LMV932MMX/NOPB	VSSOP	DGK	8	3500	330.0	12.4	5.3	3.4	1.4	8.0	12.0	Q1
LMV932Q1MAX/NOPB	SOIC	D	8	2500	330.0	12.4	6.5	5.4	2.0	8.0	12.0	Q1
LMV934MAX	SOIC	D	14	2500	330.0	16.4	6.5	9.35	2.3	8.0	16.0	Q1

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
LMV934MAX/NOPB	SOIC	D	14	2500	330.0	16.4	6.5	9.35	2.3	8.0	16.0	Q1
LMV934MTX	TSSOP	PW	14	2500	330.0	12.4	6.95	8.3	1.6	8.0	12.0	Q1
LMV934MTX/NOPB	TSSOP	PW	14	2500	330.0	12.4	6.95	8.3	1.6	8.0	12.0	Q1
LMV934Q1MTX/NOPB	TSSOP	PW	14	2500	330.0	12.4	6.95	8.3	1.6	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

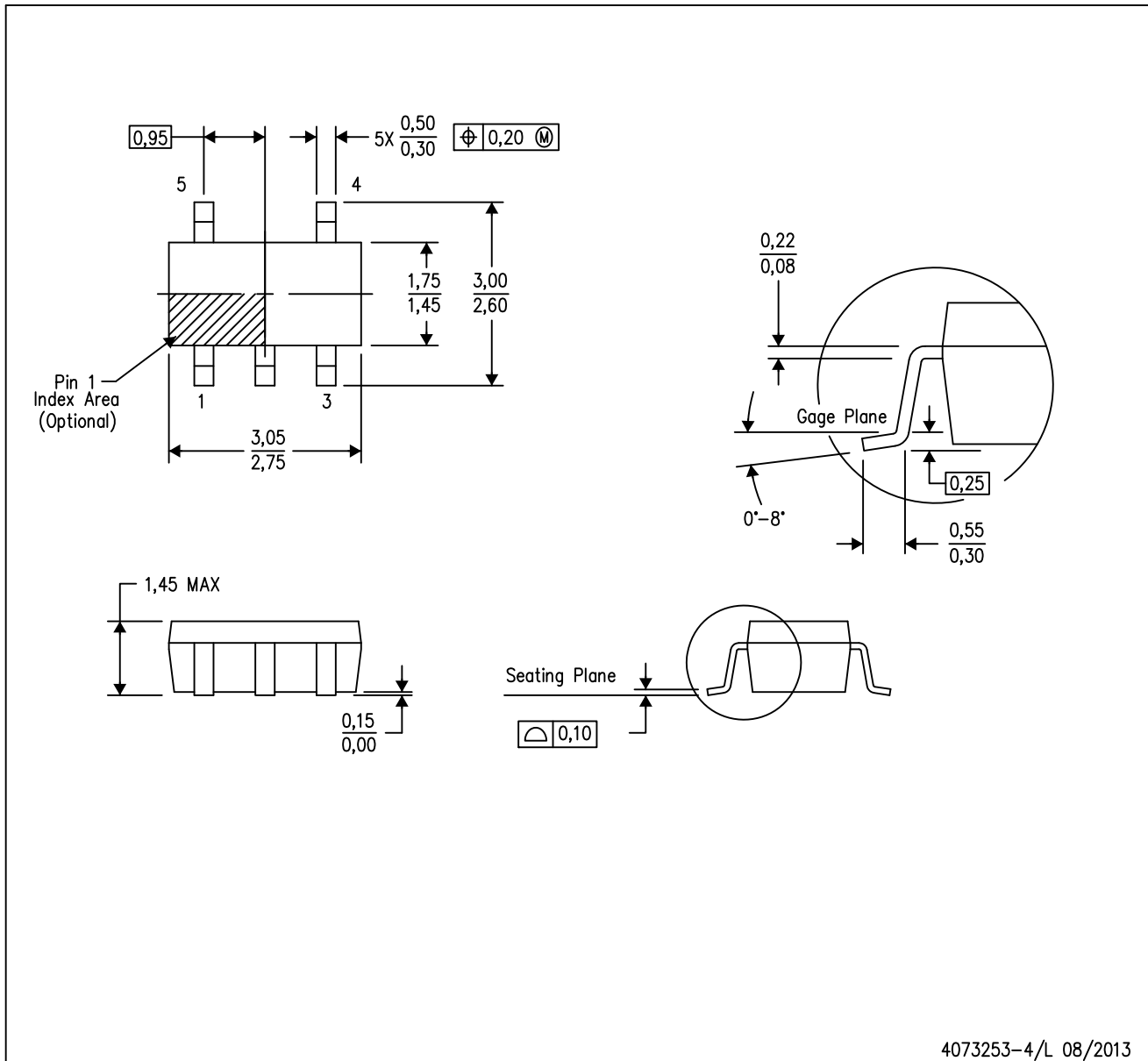
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMV931MF	SOT-23	DBV	5	1000	210.0	185.0	35.0
LMV931MF/NOPB	SOT-23	DBV	5	1000	210.0	185.0	35.0
LMV931MFX	SOT-23	DBV	5	3000	210.0	185.0	35.0
LMV931MFX/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0
LMV931MG	SC70	DCK	5	1000	210.0	185.0	35.0
LMV931MG/NOPB	SC70	DCK	5	1000	210.0	185.0	35.0
LMV931MGX/NOPB	SC70	DCK	5	3000	210.0	185.0	35.0
LMV931Q1MF/NOPB	SOT-23	DBV	5	1000	210.0	185.0	35.0
LMV931Q1MFX/NOPB	SOT-23	DBV	5	3000	210.0	185.0	35.0
LMV931Q1MG/NOPB	SC70	DCK	5	1000	210.0	185.0	35.0
LMV931Q1MGX/NOPB	SC70	DCK	5	3000	210.0	185.0	35.0
LMV932MAX	SOIC	D	8	2500	367.0	367.0	35.0
LMV932MAX/NOPB	SOIC	D	8	2500	367.0	367.0	35.0

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
LMV932MM	VSSOP	DGK	8	1000	210.0	185.0	35.0
LMV932MM/NOPB	VSSOP	DGK	8	1000	210.0	185.0	35.0
LMV932MMX/NOPB	VSSOP	DGK	8	3500	367.0	367.0	35.0
LMV932Q1MAX/NOPB	SOIC	D	8	2500	367.0	367.0	35.0
LMV934MAX	SOIC	D	14	2500	367.0	367.0	35.0
LMV934MAX/NOPB	SOIC	D	14	2500	367.0	367.0	35.0
LMV934MTX	TSSOP	PW	14	2500	367.0	367.0	35.0
LMV934MTX/NOPB	TSSOP	PW	14	2500	367.0	367.0	35.0
LMV934Q1MTX/NOPB	TSSOP	PW	14	2500	367.0	367.0	35.0

MECHANICAL DATA

DBV (R-PDSO-G5)

PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
 - D. Falls within JEDEC MO-178 Variation AA.

DBV (R-PDSO-G5)

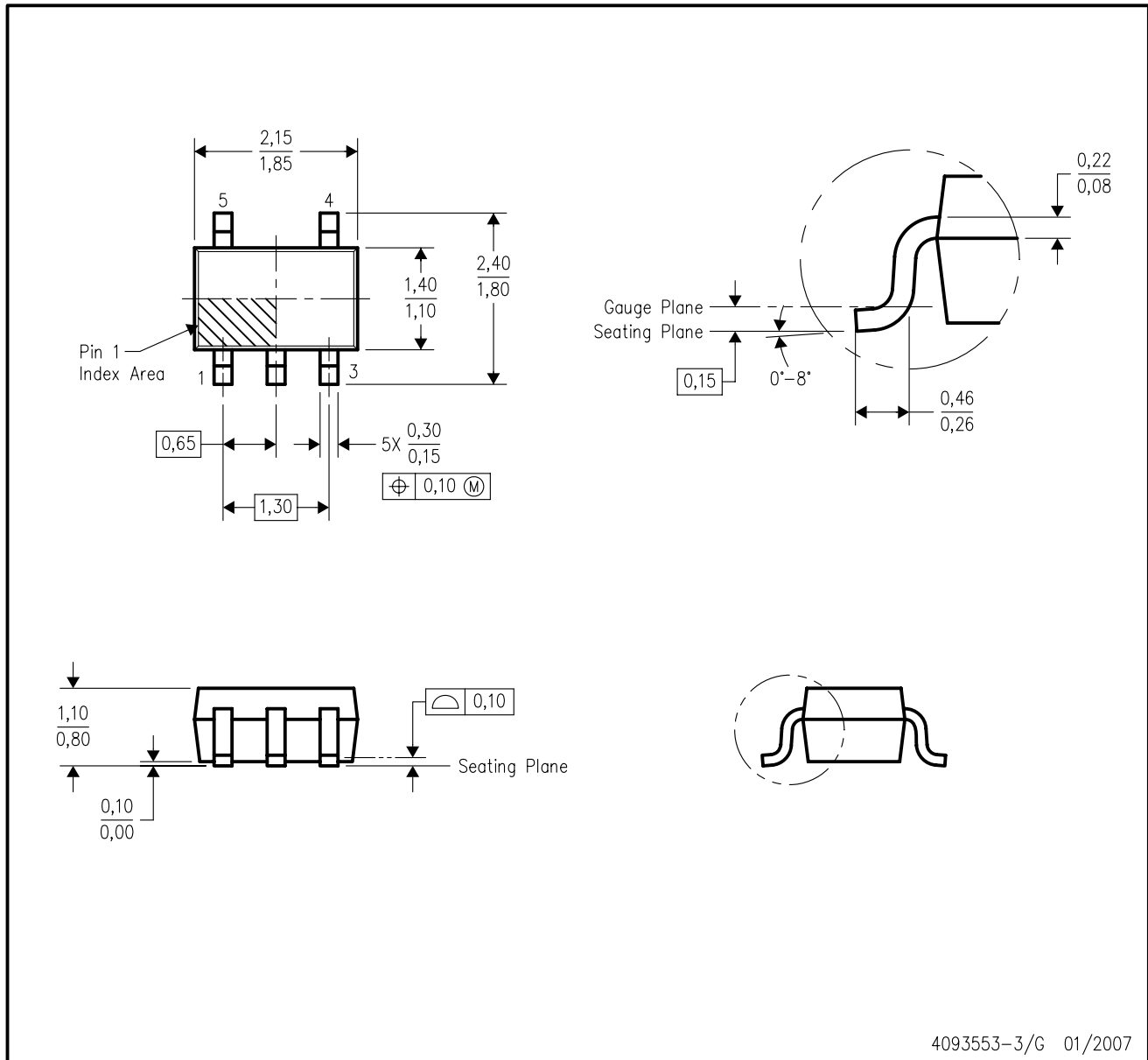
PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Customers should place a note on the circuit board fabrication drawing not to alter the center solder mask defined pad.
 - D. Publication IPC-7351 is recommended for alternate designs.
 - E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Example stencil design based on a 50% volumetric metal load solder paste. Refer to IPC-7525 for other stencil recommendations.

DCK (R-PDSO-G5)

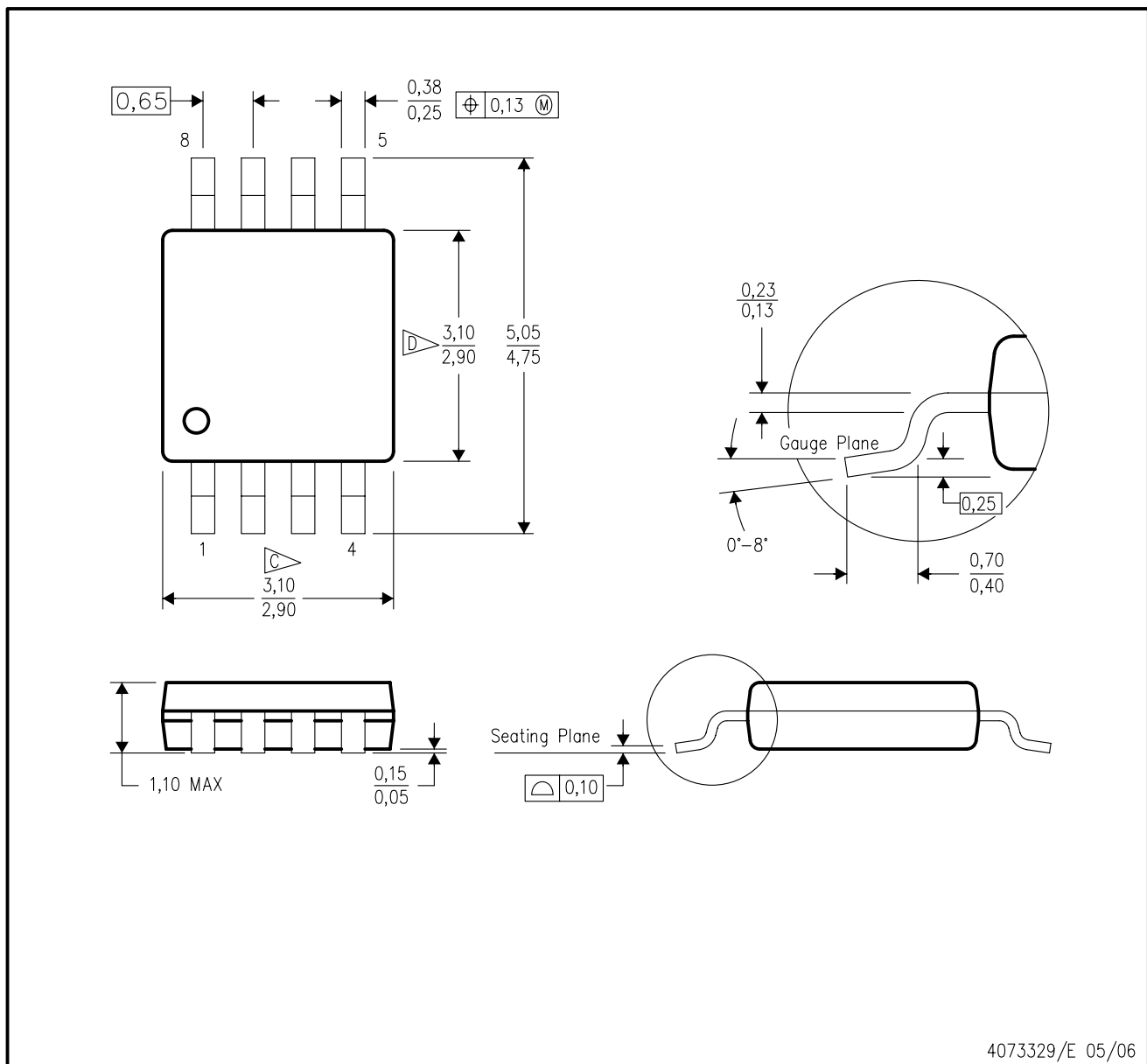
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
 - D. Falls within JEDEC MO-203 variation AA.

DGK (S-PDSO-G8)

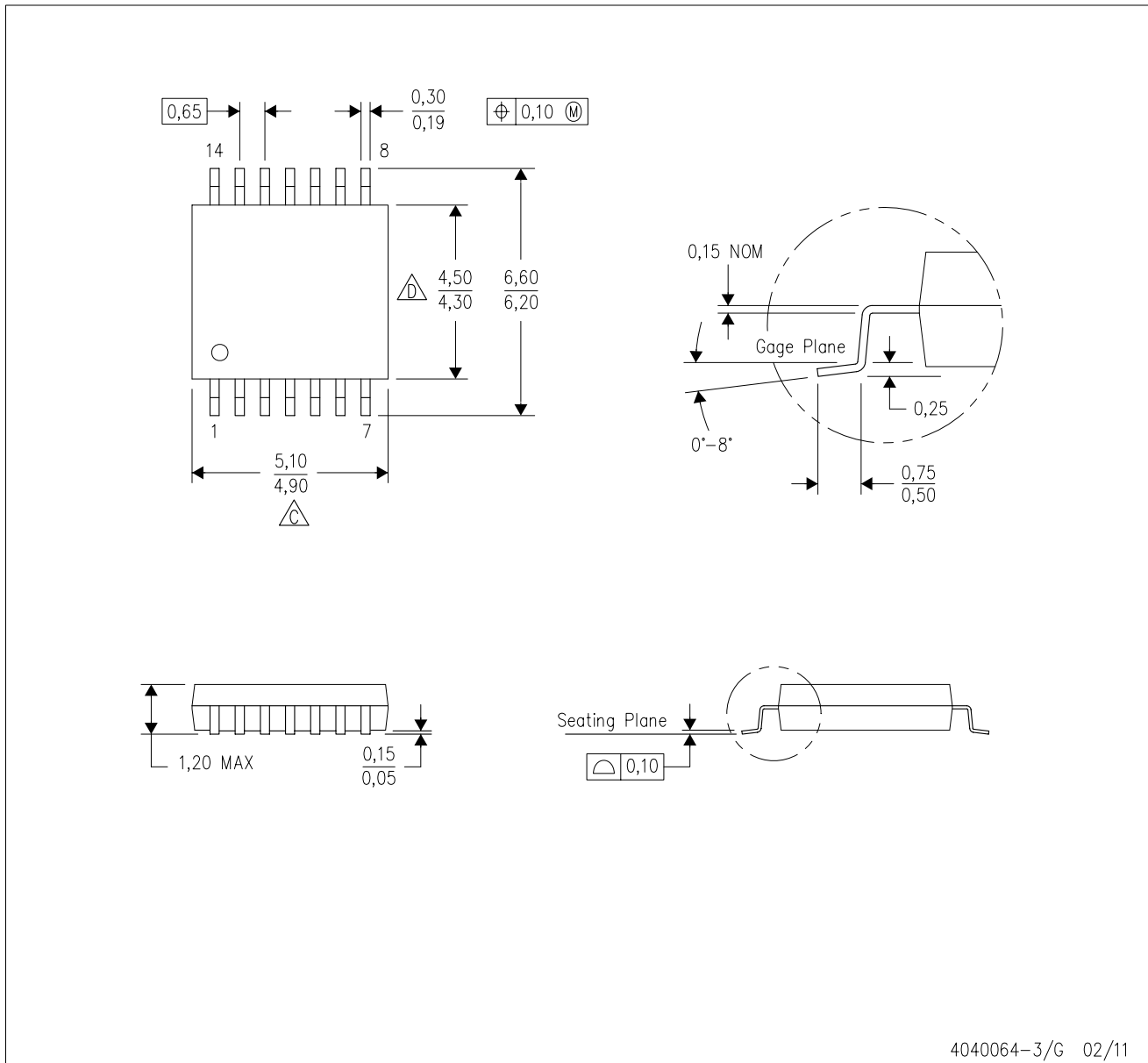
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.15 per end.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed 0.50 per side.
 - E. Falls within JEDEC MO-187 variation AA, except interlead flash.

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE

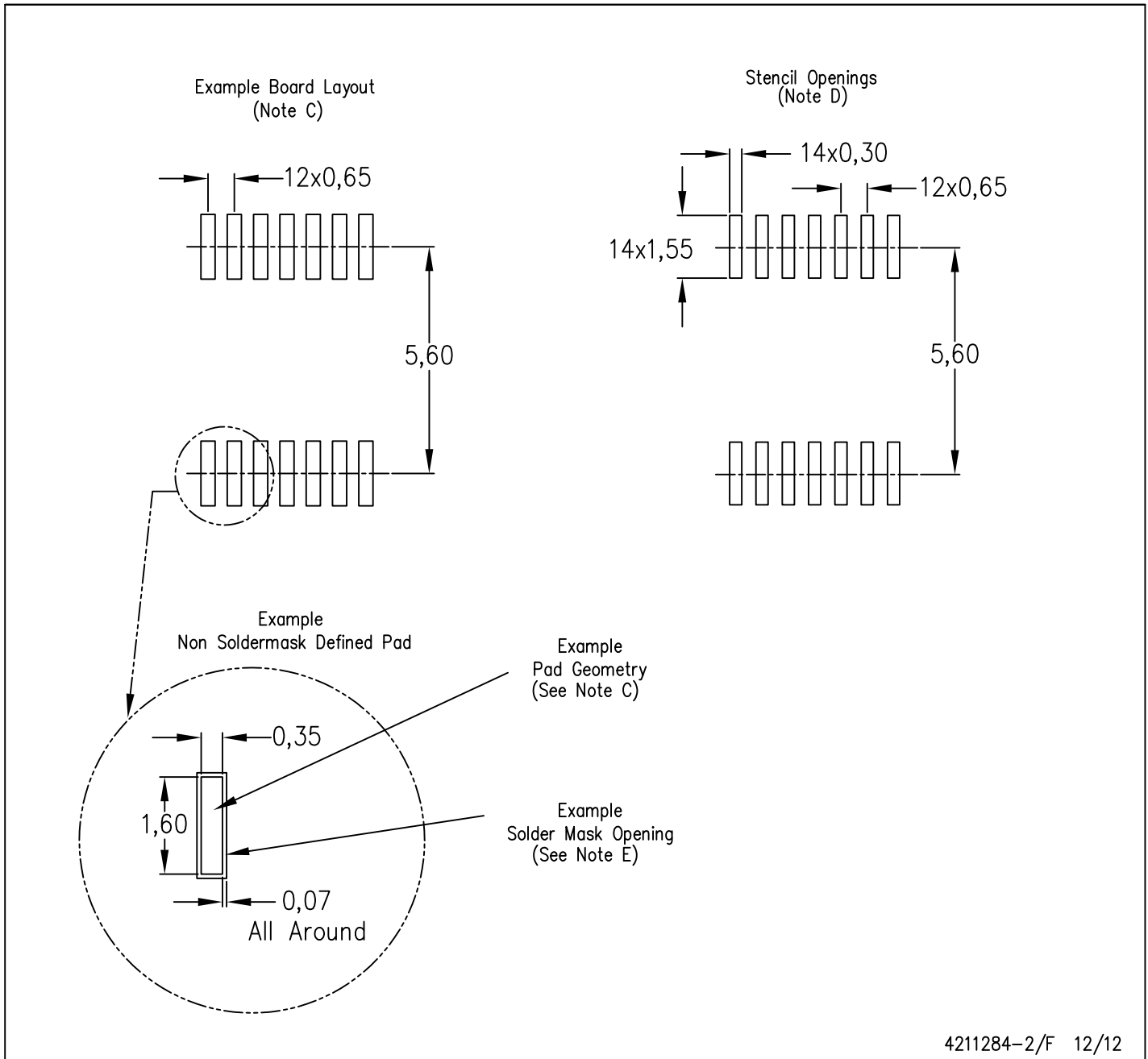


4040064-3/G 02/11

- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0,15 each side.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed 0,25 each side.
 - E. Falls within JEDEC MO-153

PW (R-PDSO-G14)

PLASTIC SMALL OUTLINE



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Publication IPC-7351 is recommended for alternate designs.
 - Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 - Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
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