19-1958; Rev 4; 5/11

General-Purpose, Low-Voltage, Single/Dual/Quad, Tiny-Pack Comparators

General Description

The LMX331/LMX393/LMX339 single/dual/quad comparators are drop-in, pin-for-pin-compatible replacements for the LMV331/LMV393/LMV339. The LMX331H/LMX393H/LMX339H offer the performance of the LMX331/LMX393/LMX339 with the added benefit of internal hysteresis to provide noise immunity, preventing output oscillations even with slow-moving input signals.

Advantages of the LMX331/LMX393/LMX339 series include low supply voltage, small package, and low cost. The LMX331 is available in both 5-pin SC70 and SOT23 packages, LMX393 is available in both 8-pin µMAX® and smaller SOT23 packages, and the LMX339 is available in 14-pin TSSOP and SO packages. They are manufactured using advanced submicron CMOS technology. Designed with the most modern techniques, the LMX331/LMX393/LMX339 achieve superior performance over BiCMOS or bipolar versions on the market.

The LMX331/LMX393/LMX339 offer performance advantages such as wider supply voltage range, wider operating temperature range, better CMRR and PSRR, improved response time characteristics, reduced offset, reduced output saturation voltage, reduced input bias current, and improved RF immunity.

µMAX is a registered trademark of Maxim Integrated Products, Inc.

Applications

Mobile Communications

Notebooks and PDAs

Automotive Applications

Battery-Powered Electronics

General-Purpose Portable Devices

General-Purpose Low-Voltage Applications

Features

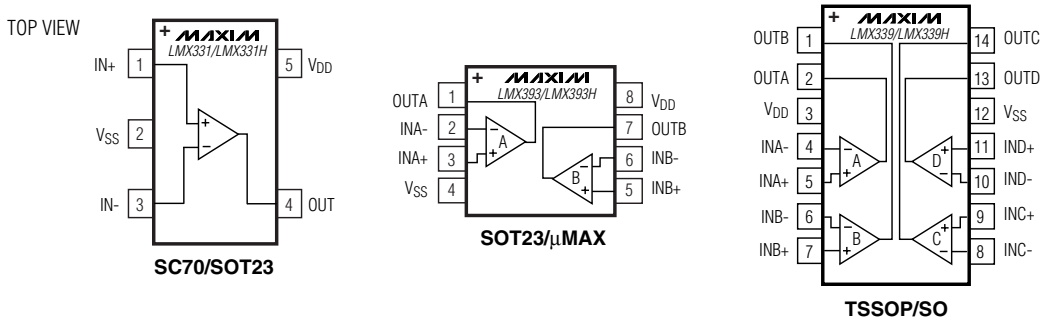
- **Guaranteed 1.8V to 5.5V Performance**
- **-40°C to +125°C Automotive Temperature Range**
- **Low Supply Current (60µA/Comparator at V_{DD} = 5.0V)**
- **Input Common-Mode Voltage Range Includes Ground**
- **No Phase Reversal for Overdriven Inputs**
- **Low Output Saturation Voltage (100mV)**
- **Internal 2mV Hysteresis (LMX331H/LMX393H/LMX339H)**
- **5-Pin SC70 Space-Saving Package (2.0mm × 2.1mm × 1.0mm) (LMX331/LMX331H)**

Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	TOP MARK
LMX331AXK+T	-40°C to +125°C	5 SC70	ACD
LMX331AUK+T	-40°C to +125°C	5 SOT23	ADQR
LMX331HAXK+T	-40°C to +125°C	5 SC70	ACE
LMX331HAUK+T	-40°C to +125°C	5 SOT23	ADQS
LMX393AKA+T	-40°C to +125°C	8 SOT23	AAIF
LMX393AUA+T	-40°C to +125°C	8 µMAX	—
LMX393HAKA+T	-40°C to +125°C	8 SOT23	AAIG
LMX393HAUA+T	-40°C to +125°C	8 µMAX	—
LMX339AUD+T	-40°C to +125°C	14 TSSOP	—
LMX339ASD+T	-40°C to +125°C	14 SO	—
LMX339HAUD+T	-40°C to +125°C	14 TSSOP	—
LMX339HASD+T	-40°C to +125°C	14 SO	—

+Denotes a lead(Pb)-free/RoHS-compliant package.
T = Tape and reel.

Pin Configurations



For pricing, delivery, and ordering information, please contact Maxim/Dallas Direct! at 1-888-629-4642, or visit Maxim's website at www.maxim-ic.com.

General-Purpose, Low-Voltage, Single/Dual/Quad, Tiny-Pack Comparators

ABSOLUTE MAXIMUM RATINGS

Supply Voltage (V_{DD} to V_{SS}).....-0.3V to +6V
All Other Pins ..... (V_{SS} - 0.3V) to (V_{DD} + 0.3V)
Continuous Power Dissipation (T_A = +70°C)
5-Pin SC70 (derate 3.1mW/°C above +70°C).....247mW
5-Pin SOT23 (derate 7.1mW/°C above +70°C).....571mW
8-Pin SOT23 (derate 8.9mW/°C above +70°C).....714mW
8-Pin µMAX (derate 10.3mW/°C above +70°C).....825mW
14-Pin TSSOP (derate 9.1mW/°C above +70°C).....727mW
14-Pin SO (derate 8.3mW/°C above +70°C).....666.7mW
Operating Temperature Range .....-40°C to +125°C
Junction Temperature.....+150°C
Storage Temperature Range .....-65°C to +150°C
Lead Temperature (soldering, 10s) .....+300°C
Soldering Temperature (reflow) .....+260°C

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

DC ELECTRICAL CHARACTERISTICS—2.7V OPERATION

(V_{DD} = 2.7V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1kΩ connected to V_{DD}. Typical values are at T_A = +25°C. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	V_{OS}			0.2	7	mV
Input Voltage Hysteresis	V_{HYST}	LMX331H/LMX393H/LMX339H only		2		mV
Input Offset Voltage Average Temperature Drift	TCV_{OS}			5		µV/°C
Input Bias Current	I_B	T_A = +25°C		±0.05	±250	nA
		T_A = -40°C to +85°C			**±400**	
		T_A = -40°C to +125°C			**±400**	
Input Offset Current	I_{OS}	T_A = +25°C		±0.05	±50	nA
		T_A = -40°C to +85°C			**±150**	
		T_A = -40°C to +125°C			**±150**	
Input Voltage Range	V_{CM}			-0.1		V
				2.0		
Voltage Gain	A_V	LMX331/LMX393/LMX339 only		50		V/mV
Output Saturation Voltage	V_{SAT}	I_{SINK} ≤ 1mA		50		mV
Output Sink Current	I_O	V_O ≤ 1.5V	5	37		mA
Supply Current (Note 2)	I_S	LMX331/LMX331H		50	100	µA
		LMX393/LMX393H (both comparators)		70	140	
		LMX339/LMX339H (all four comparators)		140	200	
Output Leakage Current		T_A = +25°C		0.003		µA
		T_A = -40°C to +85°C			**1**	
		T_A = -40°C to +125°C			**2**	

AC ELECTRICAL CHARACTERISTICS—2.7V OPERATION

(V_{DD} = 2.7V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1kΩ connected to V_{DD}. Typical values are at T_A = +25°C. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Propagation Delay Output High to Low	t_{PHL}	Input overdrive = 10mV (Note 3)		500		ns
		Input overdrive = 100mV (Note 3)		100		
Propagation Delay Output Low to High	t_{PLH}	Input overdrive = 10mV (Note 3)		500		ns
		Input overdrive = 100mV (Note 3)		100		

DC ELECTRICAL CHARACTERISTICS—5.0V OPERATION

(V_{DD} = 5V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1kΩ connected to V_{DD}. Typical values are at T_A = +25°C. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Input Offset Voltage	V_{OS}	T_A = +25°C			0.25	7	mV
		T_A = -40°C to +85°C				**9**	
		T_A = -40°C to +125°C				**9**	
Input Voltage Hysteresis		LMX331H/LMX393H/LMX339H only			2		mV
Input Offset Voltage Average Temperature Drift	TCV_{OS}				5		µV/°C
Input Bias Current	I_B	T_A = +25°C			±0.05	±250	nA
		T_A = -40°C to +85°C				**±400**	
		T_A = -40°C to +125°C				**±400**	
Input Offset Current	I_{OS}	T_A = +25°C			±0.05	±50	nA
		T_A = -40°C to +85°C				**±150**	
		T_A = -40°C to +125°C				**±150**	
Input Voltage Range	V_{CM}				-0.1		V
					4.2		
Voltage Gain	A_V	LMX331/LMX393/LMX339 only		20	50		V/mV
Output Saturation Voltage	V_{SAT}	I_{SINK} ≤ 4mA	T_A = +25°C		70	400	mV
			T_A = -40°C to +85°C			**700**	
			T_A = -40°C to +125°C			**700**	
Output Sink Current	I_O	V_O ≤ 1.5V		10	73		mA
Supply Current (Note 2)	I_S	LMX331/LMX331H	T_A = +25°C		60	120	µA
			T_A = -40°C to +85°C			**150**	
			T_A = -40°C to +125°C			**170**	
		LMX393/LMX393H (both comparators)	T_A = +25°C		100	200	
			T_A = -40°C to +85°C			**250**	
			T_A = -40°C to +125°C			**300**	
		LMX339/LMX339H (all four comparators)	T_A = +25°C		170	300	
			T_A = -40°C to +85°C			**350**	
			T_A = -40°C to +125°C			**430**	
Output Leakage Current		T_A = +25°C			0.003		µA
		T_A = -40°C to +85°C				**1**	
		T_A = -40°C to +125°C				**2**	

AC ELECTRICAL CHARACTERISTICS—5.0V OPERATION

(V_{DD} = 5V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1kΩ connected to V_{DD}. Typical values are at T_A = +25°C. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Propagation Delay Output High to Low	t_{PHL}	Input overdrive = 10mV (Note 3)		400		ns
		Input overdrive = 100mV (Note 3)		90		
Propagation Delay Output Low to High	t_{PLH}	Input overdrive = 10mV (Note 3)		600		ns
		Input overdrive = 100mV (Note 3)		200		

General-Purpose, Low-Voltage, Single/Dual/Quad, Tiny-Pack Comparators

DC ELECTRICAL CHARACTERISTICS—1.8V OPERATION

(V_{DD} = 1.8V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1kΩ connected to V_{DD}. Typical values are at T_A = +25°C. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Input Offset Voltage	V_{OS}			0.2	5	mV
Input Voltage Hysteresis		LMX331H/LMX393H/LMX339H only		2		mV
Input Offset Voltage Average Temperature Drift	TCV_{OS}			5		µV/°C
Input Bias Current	I_B			0.05		nA
Input Offset Current	I_{OS}			0.05		nA
Input Voltage Range	V_{CM}			-0.1		V
				1		
Output Saturation Voltage	V_{SAT}	I_{SINK} ≤ 1mA		35		mV
Power-Supply Rejection Ratio	PSRR	V_{DD} = 1.8V to 5.5V	60	70		dB
Output Sink Current	I_O	V_O ≤ 1.5V		15		mA
Supply Current (Note 2)	I_S	LMX331/LMX331H		40	100	µA
		LMX393/LMX393H (both comparators)		65	140	
		LMX339/LMX339H (all four comparators)		120	200	
Output Leakage Current				0.003		µA

AC ELECTRICAL CHARACTERISTICS—1.8V OPERATION

(V_{DD} = 1.8V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1kΩ connected to V_{DD}. Typical values are at T_A = +25°C. **Boldface** limits apply at the defined temperature extremes.) (Note 1)

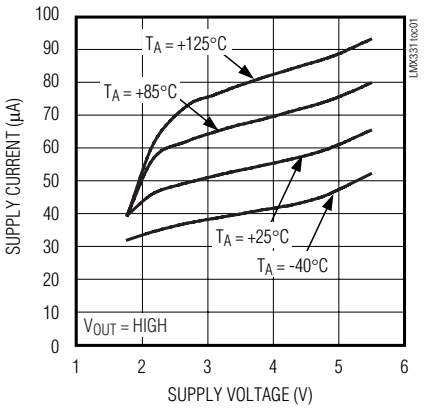
PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
Propagation Delay Output High to Low	t_{PHL}	Input overdrive = 10mV (Note 3)		500		ns
		Input overdrive = 100mV (Note 3)		100		
Propagation Delay Output Low to High	t_{PLH}	Input overdrive = 10mV (Note 3)		500		ns
		Input overdrive = 100mV (Note 3)		100		

Note 1: All devices are production tested at +25°C. All temperature limits are guaranteed by design.
Note 2: Supply current when output is high.
Note 3: Input overdrive is the overdrive voltage beyond the offset and hysteresis-determined trip points.

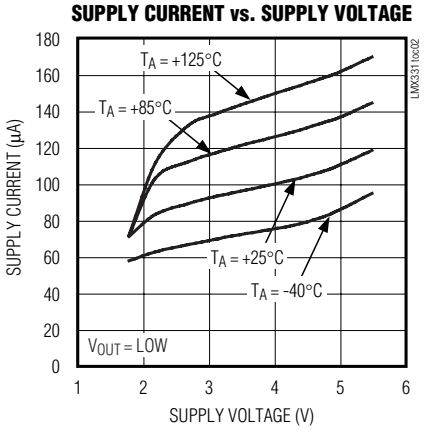
Typical Operating Characteristics

(V_{DD} = 5V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1kΩ, C_L = 10pF, overdrive = 100mV, T_A = +25°C, unless otherwise noted.)

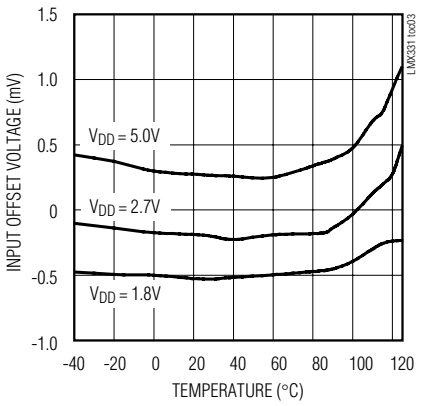
LMX331
SUPPLY CURRENT vs. SUPPLY VOLTAGE



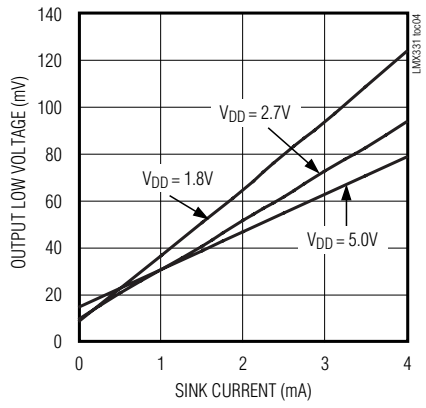
LMX331
SUPPLY CURRENT vs. SUPPLY VOLTAGE



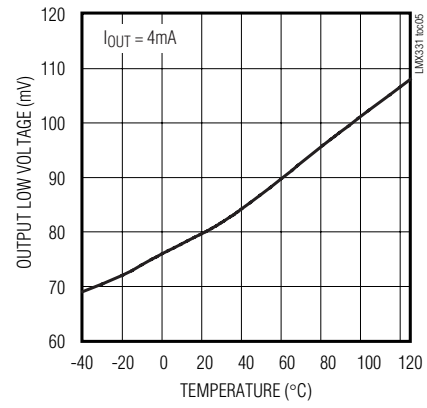
INPUT OFFSET VOLTAGE
vs. TEMPERATURE



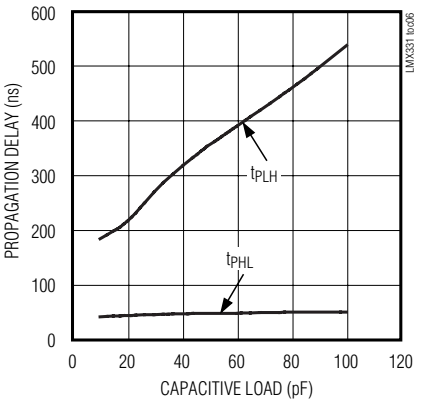
OUTPUT LOW VOLTAGE vs. SINK CURRENT



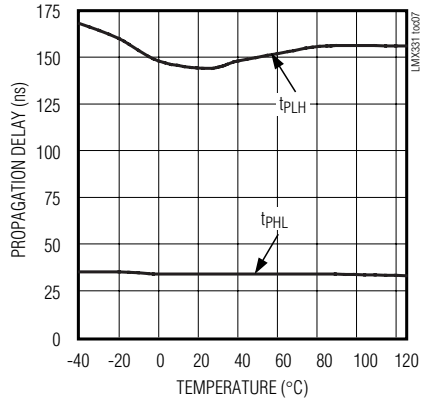
OUTPUT LOW VOLTAGE vs. TEMPERATURE



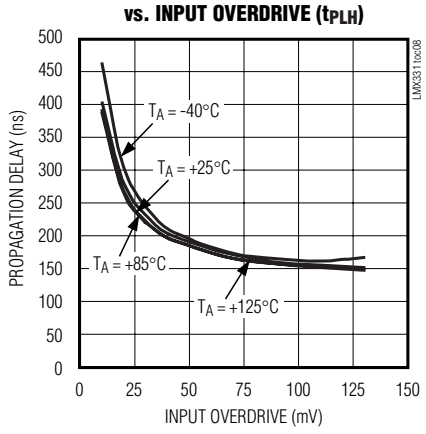
PROPAGATION DELAY vs. CAPACITIVE LOAD



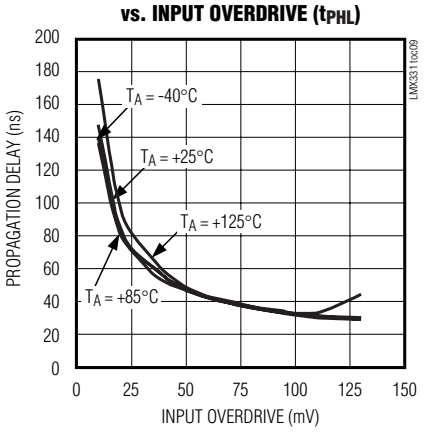
PROPAGATION DELAY vs. TEMPERATURE



PROPAGATION DELAY
vs. INPUT OVERDRIVE (t_{PLH})



PROPAGATION DELAY
vs. INPUT OVERDRIVE (t_{PHL})

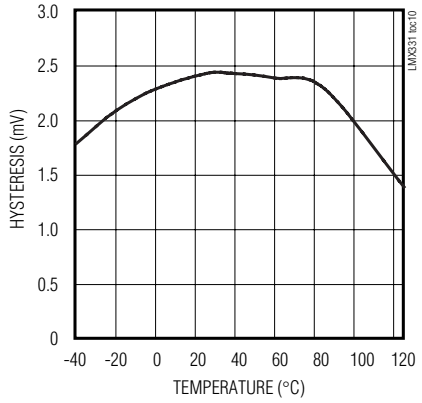


General-Purpose, Low-Voltage, Single/Dual/Quad, Tiny-Pack Comparators

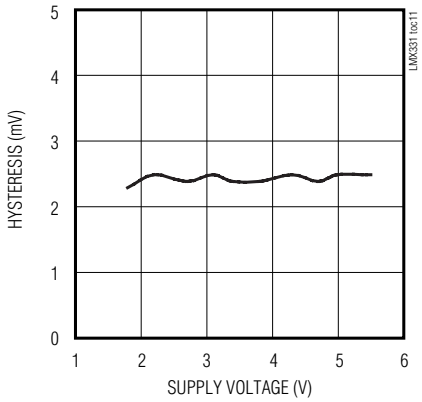
Typical Operating Characteristics (continued)

(V_{DD} = 5V, V_{SS} = 0V, V_{CM} = 0V, R_L = 5.1kΩ, C_L = 10pF, overdrive = 100mV, T_A = +25°C, unless otherwise noted.)

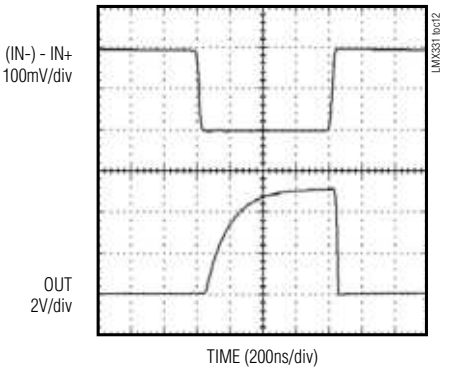
LMX331H/LMX393H/LMX339H HYSTERESIS vs. TEMPERATURE



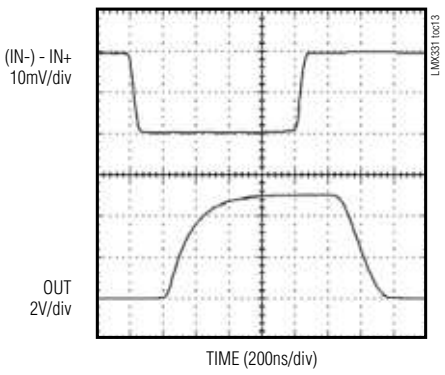
LMX331H/LMX393H/LMX339H HYSTERESIS vs. SUPPLY VOLTAGE



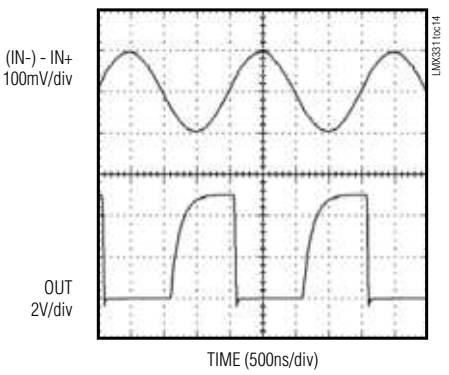
PROPAGATION DELAY 100mV OVERDRIVE



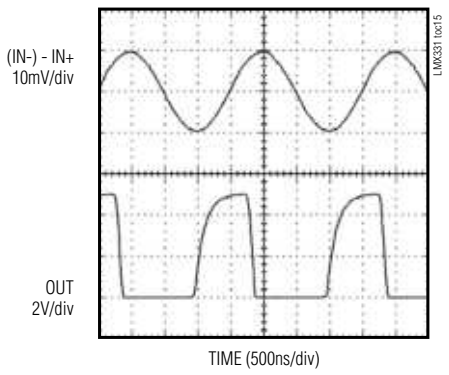
PROPAGATION DELAY 10mV OVERDRIVE



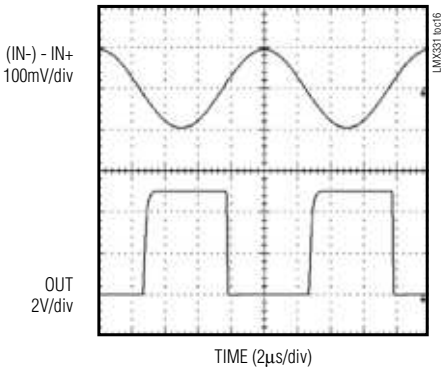
500kHz RESPONSE 100mV OVERDRIVE



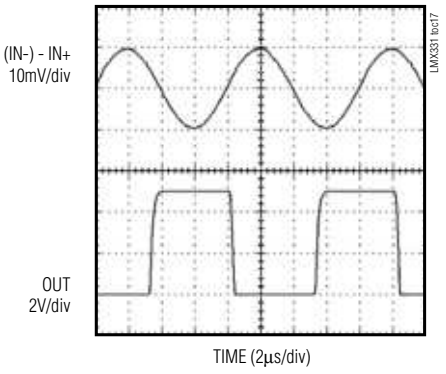
500kHz RESPONSE 10mV OVERDRIVE



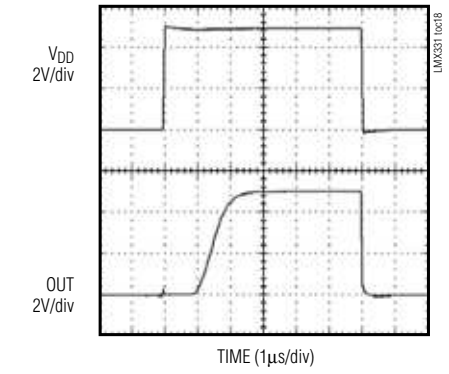
100kHz RESPONSE 100mV OVERDRIVE



100kHz RESPONSE 10mV OVERDRIVE



POWER-UP RESPONSE



Pin Description

PIN			NAME	FUNCTION
LMX331	LMX393	LMX339		
1	—	—	IN+	Noninverting Input
2	4	12	V_{SS}	Negative Supply (Connect to GND)
3	—	—	IN-	Inverting Input
4	—	—	OUT	Comparator Output (Open-Drain)
5	8	3	V_{DD}	Positive Supply
—	1	2	OUTA	Comparator A Output (Open-Drain)
—	7	1	OUTB	Comparator B Output (Open-Drain)
—	2	4	INA-	Comparator A Inverting Input
—	3	5	INA+	Comparator A Noninverting Input
—	5	7	INB+	Comparator B Noninverting Input
—	6	6	INB-	Comparator B Inverting Input
—	—	8	INC-	Comparator C Inverting Input
—	—	9	INC+	Comparator C Noninverting Input
—	—	10	IND-	Comparator D Inverting Input
—	—	11	IND+	Comparator D Noninverting Input
—	—	13	OUTD	Comparator D Output (Open-Drain)
—	—	14	OUTC	Comparator C Output (Open-Drain)

Detailed Description

The LMX331/LMX393/LMX339 are single/dual/quad, low-cost, general-purpose comparators. They have a single-supply operating voltage of 1.8V to 5V. The common-mode input range extends from -0.1V below the negative supply to within 0.7V of the positive supply. They require approximately 60µA per comparator with a 5V supply and 40µA with a 2.7V supply.

The LMX331H/LMX393H/LMX339H have 2mV of hysteresis for noise immunity. This significantly reduces the chance of output oscillations even with slow-moving input signals. The LMX331/LMX393/LMX339 and LMX331H/LMX393H/LMX339H are ideal for automotive applications because they operate from -40°C to +125°C (see *Typical Operating Characteristics*).

Applications Information

Hysteresis

Many comparators oscillate in the linear region of operation because of noise or undesired parasitic feedback. This tends to occur when the voltage on one input is equal or very close to the voltage on the other input. The LMX331H/LMX393H/LMX339H have internal hysteresis to counter parasitic effects and noise.

The hysteresis in a comparator creates two trip points: one for the rising input voltage and one for the falling input voltage (Figure 1). The difference between the trip points is the hysteresis. When the comparator's input voltages are equal, the hysteresis effectively causes one comparator input to move quickly past the other, thus taking the input out of the region where oscillation occurs. This provides clean output transitions for noisy, slow-moving input signals.

Additional hysteresis can be generated with two resistors, using positive feedback (Figure 2). Use the following procedure to calculate resistor values:

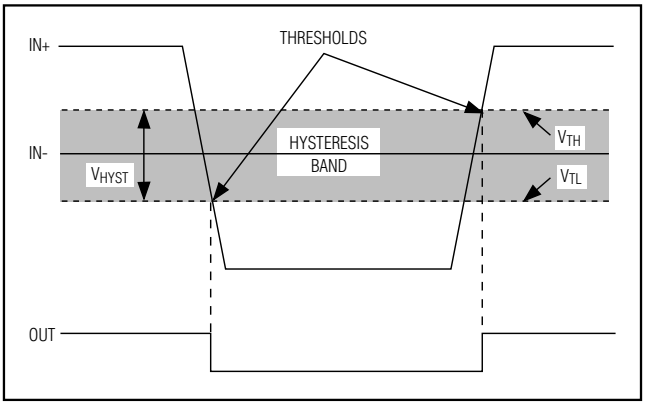


Figure 1. Threshold Hysteresis Band (Not to Scale)

General-Purpose, Low-Voltage, Single/Dual/Quad, Tiny-Pack Comparators

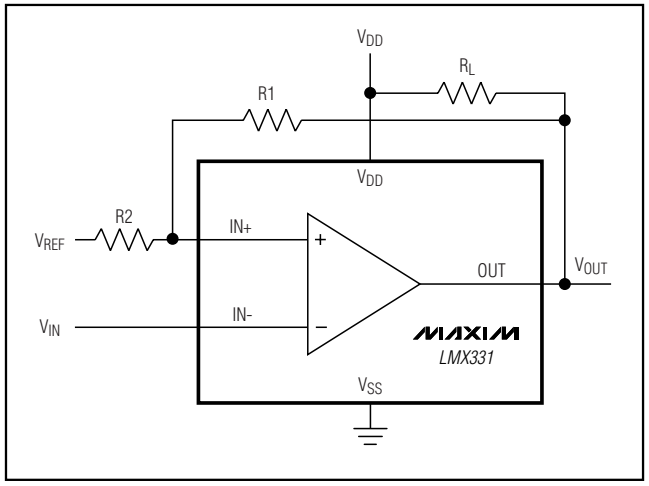


Figure 2. Adding Hysteresis with External Resistors

1) Find output voltage when output is high:

$$V_{OUT(HIGH)} = V_{DD} - I_{LOAD} \times R_L$$

2) Find the trip points of the comparator using these formulas:

$$V_{TH} = V_{REF} + ((V_{OUT(HIGH)} - V_{REF})R2) / (R1 + R2)$$

$$V_{TL} = V_{REF}(1 - (R2 / (R1 + R2)))$$

where V_{TH} is the threshold voltage at which the comparator switches its output from high to low as V_{IN} rises above the trip point, and V_{TL} is the threshold voltage at which the comparator switches its output from low to high as V_{IN} drops below the trip point.

3) The hysteresis band will be:

$$V_{HYST} = V_{TH} - V_{TL} = V_{DD}(R2 / (R1 + R2))$$

In this example, let V_{DD} = 5V, V_{REF} = 2.5V, I_{LOAD} = 50nA, R_L = 5.1kΩ:

$$V_{OUT(HIGH)} = 5.0V - (50 \times 10^{-9} \times 5.1 \times 10^{3}\Omega) \approx 5.0V$$

$$V_{TH} = 2.5V + 2.5V(R2 / (R1 + R2))$$

$$V_{TL} = 2.5V(1 - (R2 / (R1 + R2)))$$

Select R2. In this example, we will choose 1kΩ.

Select V_{HYST}. In this example, we will choose 50mV.

Solve for R1:

$$V_{HYST} = V_{OUT(HIGH)}(R2 / (R1 + R2))\ V$$

$$0.050V = 5(1000 / (R1 + 1000))\ V$$

where R1 ≈ 100kΩ, V_{TH} = 2.525V, and V_{TL} = 2.475V.

Choose R1 and R2 to be large enough as not to exceed the amount of current the reference can supply.

The source current required is V_{REF} / (R1 + R2).

The sink current is ($V_{OUT(HIGH)}$ - V_{REF}) × (R1 + R2).

Choose R_L to be large enough to avoid drawing excess current, yet small enough to supply the necessary current to drive the load. R_L should be between 1kΩ and 10kΩ.

Board Layout and Bypassing

Use 0.1µF bypass capacitors from V_{DD} to V_{SS}. To maximize performance, minimize stray inductance by putting this capacitor close to the V_{DD} pin and reducing trace lengths. For slow-moving input signals (rise time > 1ms), use a 1nF capacitor between IN+ and IN- to reduce high-frequency noise.

Chip Information

LMX331/LMX331H TRANSISTOR COUNT: 112

LMX393/LMX393H TRANSISTOR COUNT: 211

LMX339/LMX339H TRANSISTOR COUNT: 411

Package Information

For the latest package outline information and land patterns, go to **www.maxim-ic.com/packages**. Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

PACKAGE TYPE	PACKAGE CODE	DOCUMENT NO.	LAND PATTERN NO.
5 SC70	X5+1	21-0076	90-0188
5 SOT23	U5+2	21-0057	90-0174
8 SOT23	K8F+4	21-0078	90-0176
8 µMAX	U8+1	21-0036	90-0092
14 TSSOP	U16M+1	21-0066	90-0117
14 SOIC	S8+4	21-0041	90-0041

Revision History

REVISION NUMBER	REVISION DATE	DESCRIPTION	PAGES CHANGED
3	8/10	Added lead-free parts	1
4	5/11	Added thermal data	2, 3, 4

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