



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 μ MAX 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.

Applications

Mobile Communications
Notebooks and PDAs
Automotive Applications
Battery-Powered Electronics
General-Purpose Portable Devices
General-Purpose Low-Voltage Applications

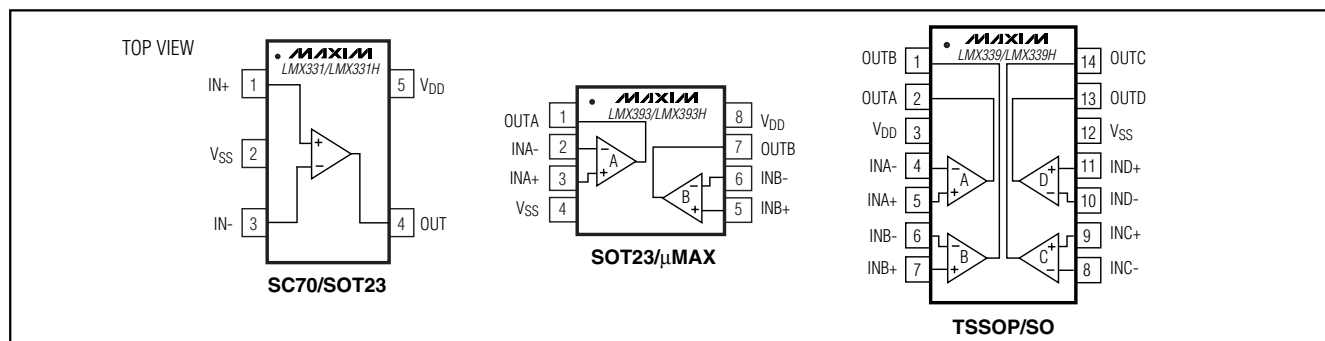
Features

- ◆ Guaranteed 1.8V to 5.5V Performance
- ◆ -40°C to $+125^{\circ}\text{C}$ Automotive Temperature Range
- ◆ Low Supply Current (60 μA /Comparator at $V_{\text{DD}} = 5.0\text{V}$)
- ◆ 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 \times 2.1mm \times 1.0mm) (LMX331/LMX331H)

Ordering Information

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

Pin Configurations



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 ($T_A = +70^\circ\text{C}$)
 5-Pin SC70 (derate 3.1mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$).....247mW
 5-Pin SOT23 (derate 7.1mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$).....571mW
 8-Pin SOT23 (derate 8.9mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$).....714mW
 8-Pin μMAX (derate 10.3mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$).....825mW

14-Pin TSSOP (derate 9.1mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$)727mW
 14-Pin SO (derate 8.3mW/ $^\circ\text{C}$ above $+70^\circ\text{C}$).....666.7mW
 Operating Temperature Range-40 $^\circ\text{C}$ to +125 $^\circ\text{C}$
 Junction Temperature+150 $^\circ\text{C}$
 Storage Temperature Range-65 $^\circ\text{C}$ to +150 $^\circ\text{C}$
 Lead Temperature (soldering, 10s)+300 $^\circ\text{C}$

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

($V_{DD} = 2.7V$, $V_{SS} = 0$, $V_{CM} = 0$, $R_L = 5.1k\Omega$ connected to V_{DD} . Typical values are at $T_A = +25^\circ\text{C}$.) (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		$\mu\text{V}/^\circ\text{C}$
Input Bias Current	I_B	$T_A = +25^\circ\text{C}$		± 0.05	± 250	nA
		$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			± 400	
		$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			± 400	
Input Offset Current	I_{OS}	$T_A = +25^\circ\text{C}$		± 0.05	± 50	nA
		$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			± 150	
		$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			± 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}	$I_{SINK} \leq 1\text{mA}$		50		mV
Output Sink Current	I_O	$V_O \leq 1.5V$	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		$T_A = +25^\circ\text{C}$		0.003		μA
		$T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$			1	
		$T_A = -40^\circ\text{C}$ to $+125^\circ\text{C}$			2	

AC ELECTRICAL CHARACTERISTICS—2.7V OPERATION

($V_{DD} = 2.7V$, $V_{SS} = 0$, $V_{CM} = 0$, $R_L = 5.1k\Omega$ connected to V_{DD} . Typical values are at $T_A = +25^\circ\text{C}$.) (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		

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LMX331/LMX393/LMX339

DC ELECTRICAL CHARACTERISTICS—5.0V OPERATION

(V_{DD} = 5V, V_{SS} = 0, V_{CM} = 0, R_L = 5.1k Ω connected to V_{DD}. Typical values are at T_A = +25°C.) (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		μ V/°C
Input Bias Current	I _B	T _A = +25°C		\pm 0.05	\pm 250	nA
		T _A = -40°C to +85°C			\pm 400	
		T _A = -40°C to +125°C			\pm 400	
Input Offset Current	I _{OS}	T _A = +25°C		\pm 0.05	\pm 50	nA
		T _A = -40°C to +85°C			\pm 150	
		T _A = -40°C to +125°C			\pm 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} \leq 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 \leq 1.5V	10	73		mA
Supply Current (Note 2)	I _S	LMX331/LMX331H	T _A = +25°C	60	120	μ A
			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		μ A
		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} = 0, V_{CM} = 0, R_L = 5.1k Ω connected to V_{DD}. Typical values are at T_A = +25°C.) (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		

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DC ELECTRICAL CHARACTERISTICS—1.8V OPERATION

($V_{DD} = 1.8V$, $V_{SS} = 0$, $V_{CM} = 0$, $R_L = 5.1k\Omega$ connected to V_{DD} . Typical values are at $T_A = +25^\circ C$.)

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		$\mu V/^\circ C$
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}	$I_{SINK} \leq 1mA$		35		mV
Power-Supply Rejection Ratio	PSRR	$V_{DD} = 1.8V$ to $5.5V$	60	70		dB
Output Sink Current	I_O	$V_O \leq 1.5V$		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

($V_{DD} = 1.8V$, $V_{SS} = 0$, $V_{CM} = 0$, $R_L = 5.1k\Omega$ connected to V_{DD} . Typical values are at $T_A = +25^\circ C$.)

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 $+25^\circ C$. All temperature limits are guaranteed by design.

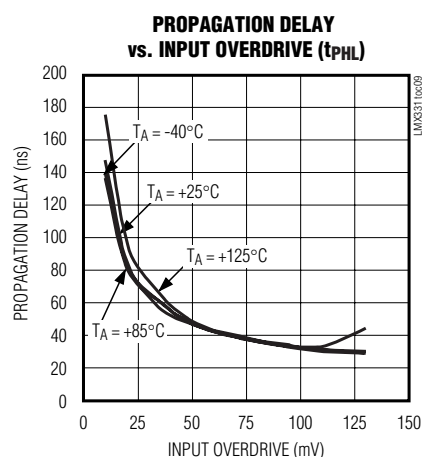
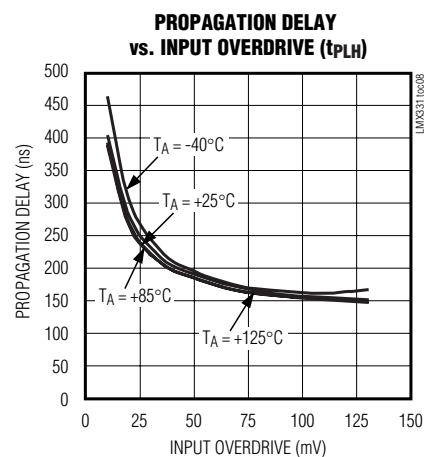
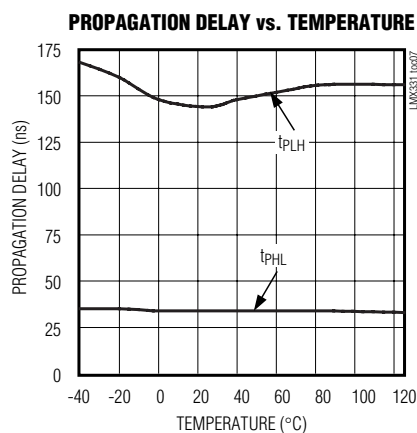
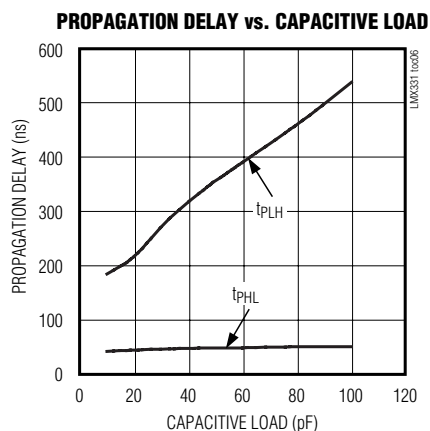
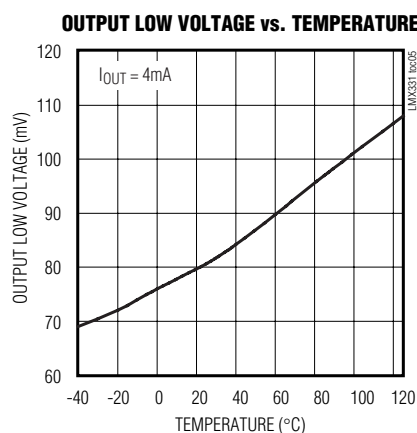
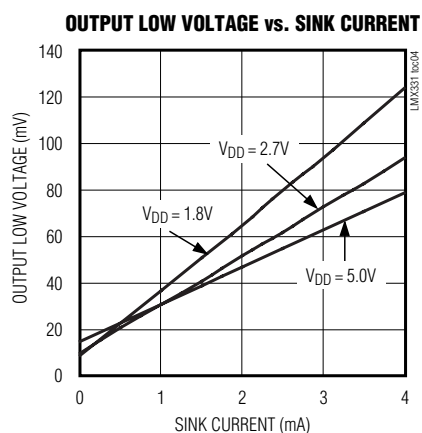
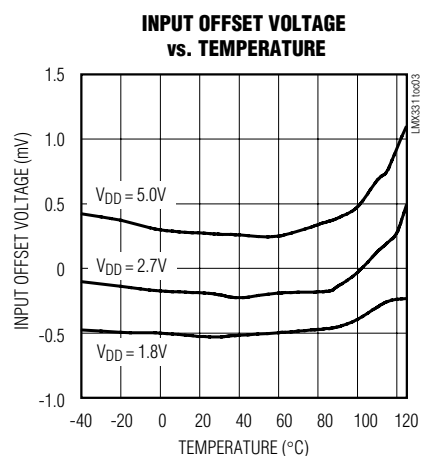
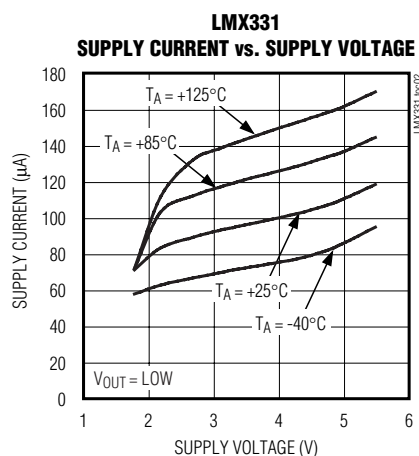
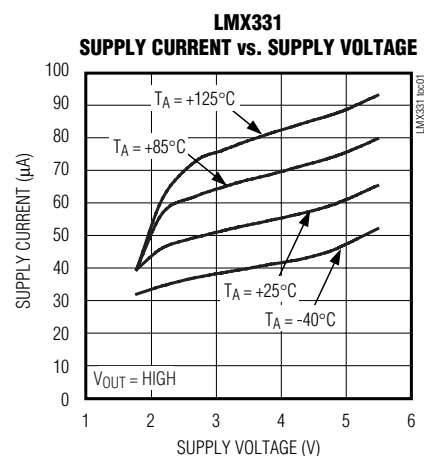
Note 2: Supply current when output is high.

Note 3: Input overdrive is the overdrive voltage beyond the offset and hysteresis-determined trip points.

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

Typical Operating Characteristics

($V_{DD} = 5V$, $V_{SS} = 0$, $V_{CM} = 0$, $R_L = 5.1k\Omega$, $C_L = 10pF$, overdrive = 100mV, $T_A = +25^\circ C$, unless otherwise noted.)



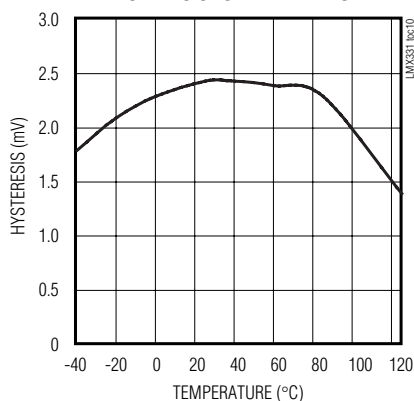
LMX331/LMX3393/LMX339

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

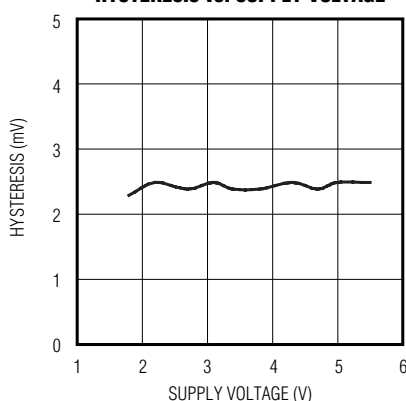
Typical Operating Characteristics (continued)

($V_{DD} = 5V$, $V_{SS} = 0$, $V_{CM} = 0$, $R_L = 5.1k\Omega$, $C_L = 10pF$, overdrive = 100mV, $T_A = +25^\circ C$, unless otherwise noted.)

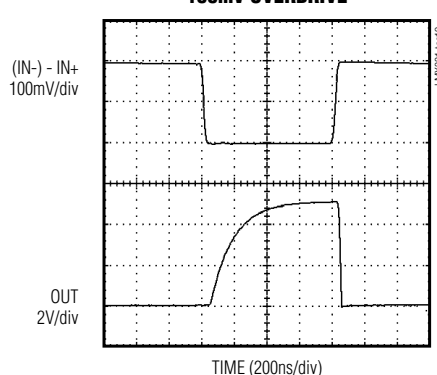
**LMX331H/LMX393H/LMX339H
HYSTERESIS vs. TEMPERATURE**



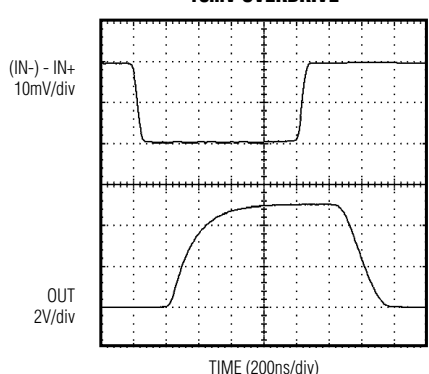
**LMX331H/LMX393H/LMX339H
HYSTERESIS vs. SUPPLY VOLTAGE**



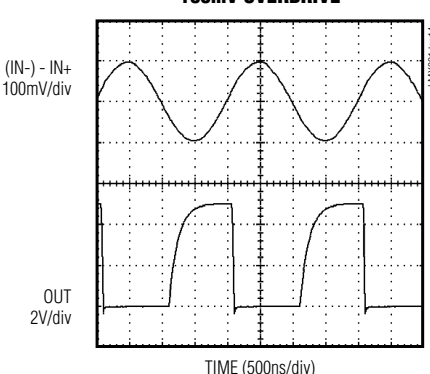
**PROPAGATION DELAY
100mV OVERDRIVE**



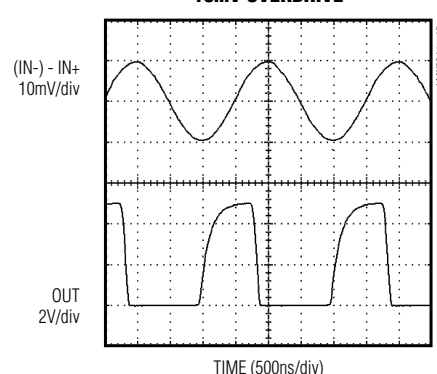
**PROPAGATION DELAY
10mV OVERDRIVE**



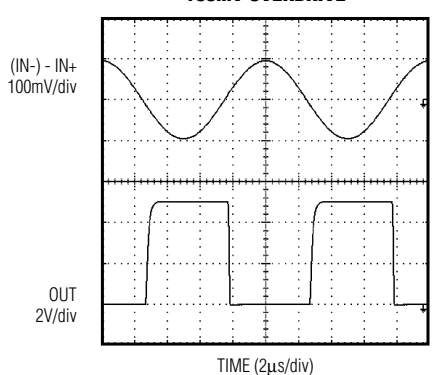
**500kHz RESPONSE
100mV OVERDRIVE**



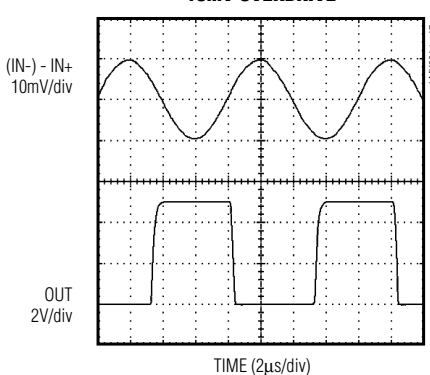
**500kHz RESPONSE
10mV OVERDRIVE**



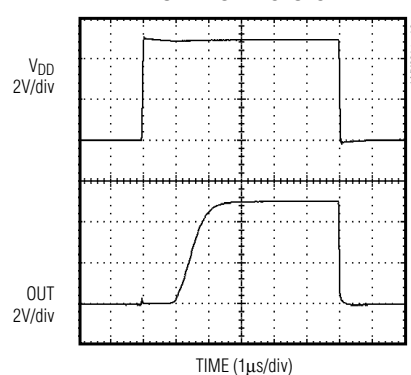
**100kHz RESPONSE
100mV OVERDRIVE**



**100kHz RESPONSE
10mV OVERDRIVE**



POWER-UP RESPONSE



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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:

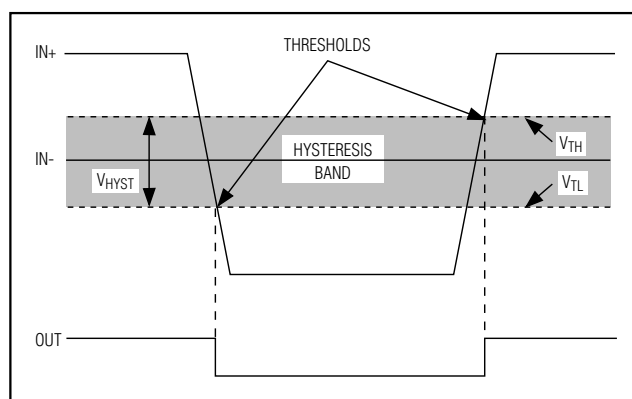


Figure 1. Threshold Hysteresis Band (Not to Scale)

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

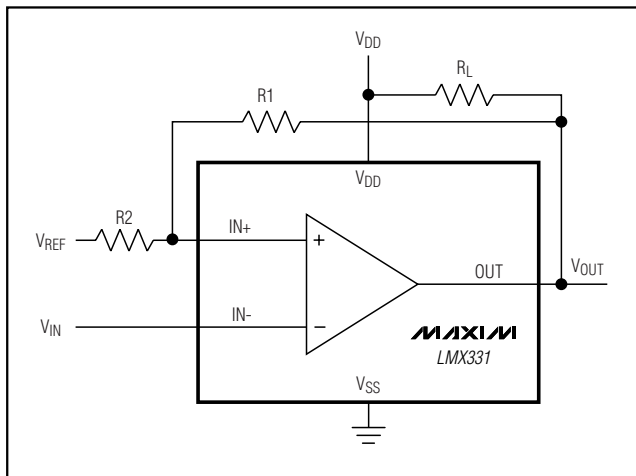


Figure 2. Adding Hysteresis with External Resistors

- 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:

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

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

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

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:

$$V_{HYST} = V_{TH} - V_{TL} = V_{DD}(R_2 / (R_1 + R_2))$$

In this example, let $V_{DD} = 5V$, $V_{REF} = 2.5V$, $I_{LOAD} = 50nA$, $R_I = 5.1k\Omega$:

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

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

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

Select R2. In this example, we will choose $1\text{k}\Omega$.

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

Solve for R1:

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

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

where $R1 \approx 100k\Omega$, $V_{TH} = 2.525V$, 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 $(V_{OUT(HIGH)} - V_{BEF}) \times (R1 + R2)$.

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 $1k\Omega$ and $10k\Omega$.

Board Layout and Bypassing

Use 0.1 μ F bypass capacitors from VDD to VSS. To maximize performance, minimize stray inductance by putting this capacitor close to the VDD 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

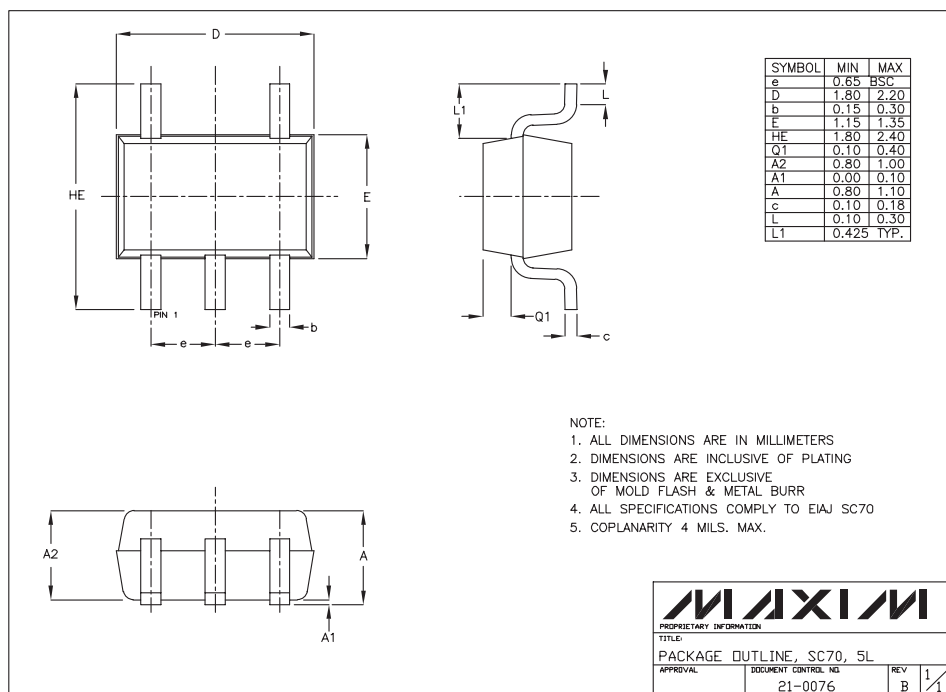
LMX393/LMX393H TRANSISTOR COUNT: 211

LMX339/LMX339H TRANSISTOR COUNT: 411

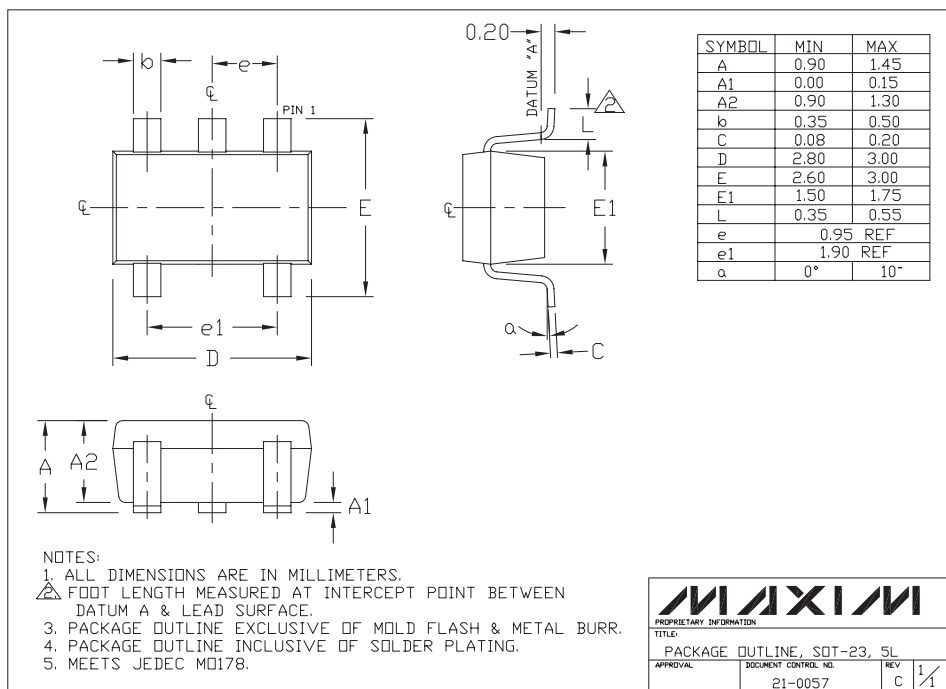
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Package Information

LMX331/LMX393/LMX339



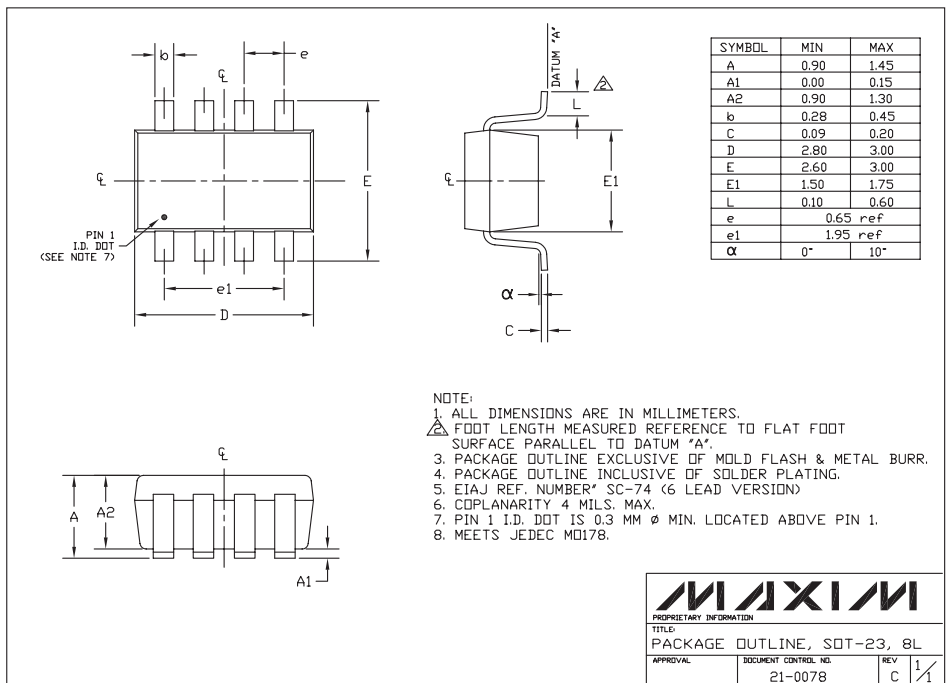
SC70-5L EPS



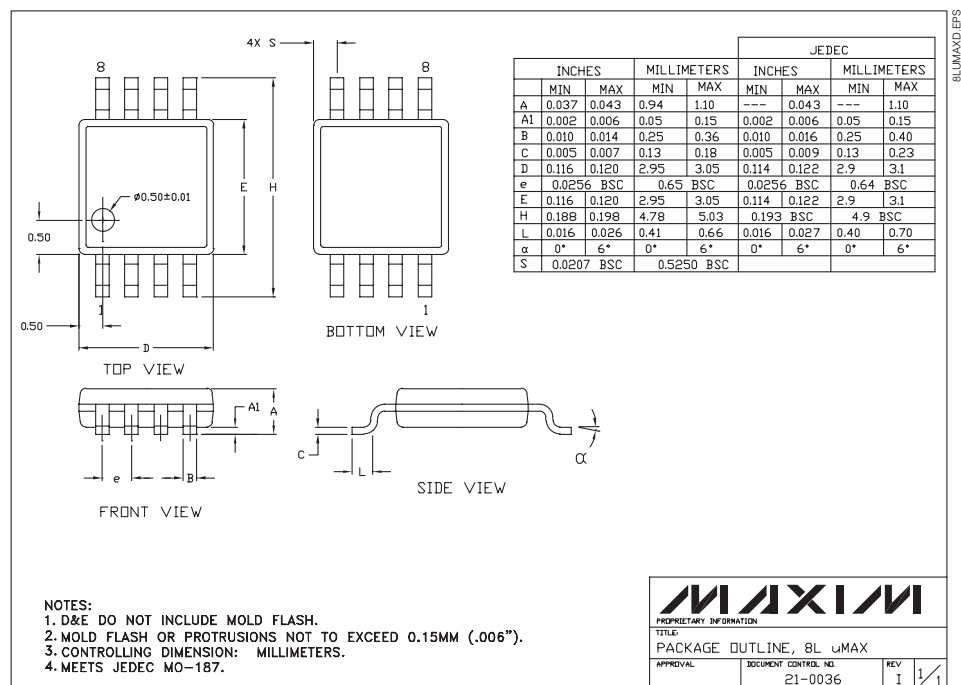
SOT-23-5L EPS

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

Package Information (continued)



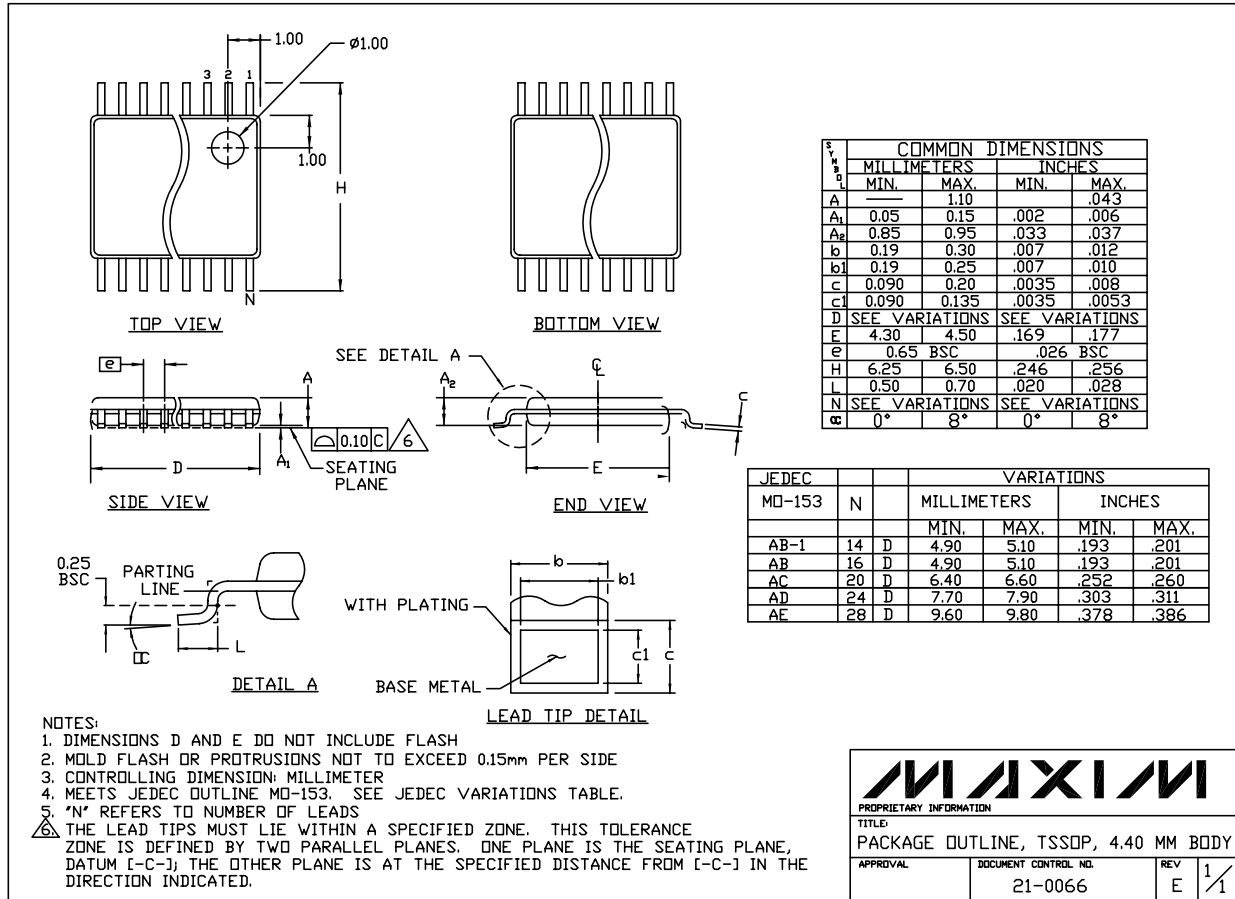
SOT23, 8L EPS



8LUMAXD EPS

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

Package Information (continued)

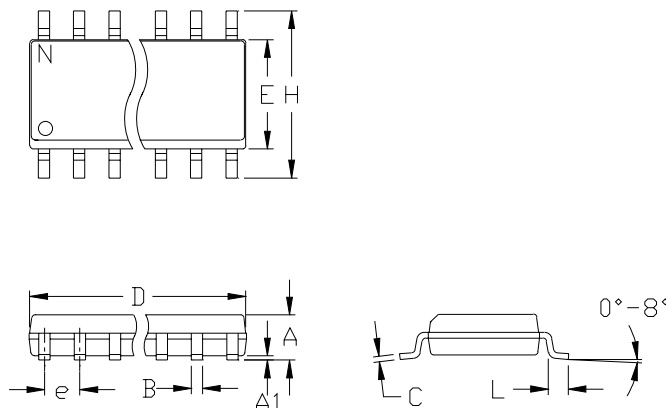


TSSOP: NO PADS: EPS

LMX331/LMX393/LMX339

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

Package Information (continued)



	INCHES		MILLIMETERS	
	MIN	MAX	MIN	MAX
A	0.053	0.069	1.35	1.75
A1	0.004	0.010	0.10	0.25
B	0.014	0.019	0.35	0.49
C	0.007	0.010	0.19	0.25
e	0.050		1.27	
E	0.150	0.157	3.80	4.00
H	0.228	0.244	5.80	6.20
h	0.010	0.020	0.25	0.50
L	0.016	0.050	0.40	1.27

	INCHES		MILLIMETERS			
	MIN	MAX	MIN	MAX	N	MS012
D	0.189	0.197	4.80	5.00	8	A
D	0.337	0.344	8.55	8.75	14	B
D	0.386	0.394	9.80	10.00	16	C

- NOTES:
1. D&E DO NOT INCLUDE MOLD FLASH
 2. MOLD FLASH OR PROTRUSIONS NOT TO EXCEED .15mm (.006")
 3. LEADS TO BE COPLANAR WITHIN .102mm (.004")
 4. CONTROLLING DIMENSION: MILLIMETER
 5. MEETS JEDEC MS012-XX AS SHOWN IN ABOVE TABLE
 6. N = NUMBER OF PINS



PACKAGE FAMILY OUTLINE: SOIC .150"



21-0041 A
DOCUMENT CONTROL NUMBER REV

Maxim cannot assume responsibility for use of any circuitry other than circuitry entirely embodied in a Maxim product. No circuit patent licenses are implied. Maxim reserves the right to change the circuitry and specifications without notice at any time.

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