LM339B, LM2901B, LM339, LM239, LM139, LM2901 Quad Differential Comparators

1 Features

- NEW LM339B and LM2901B
- Improved specifications of B-version
  - Maximum rating: up to 38 V
  - ESD rating (HBM): 2k V
  - Low input offset: 0.37 mV
  - Low input bias current: 3.5 nA
  - Low supply-current: 200 µA per comparator
  - Faster response time of 1 µsec
  - Extended temperature range for LM339B
- B-version is drop-in replacement for LM239, LM339 and LM2901, A and V versions
- Common-mode input voltage range includes ground
- Differential input voltage range equal to maximum-rated supply voltage: ±38 V
- Low output saturation voltage
- Output compatible with TTL, MOS, and CMOS
- For single version, see the TL331B
- For dual version, see the LM393B or LM2903B

2 Applications

- Vacuum robot
- Single phase UPS
- Server PSU
- Cordless power tool
- Wireless infrastructure
- Applicances
- Building automation
- Factory automation & control
- Motor drives
- Infotainment & cluster

3 Description

The LM339B and LM2901B devices are the next generation versions of the industry-standard LM339 and LM2901 comparator family. These next generation B-version comparators feature lower offset voltage, higher supply voltage capability, lower supply current, lower input bias current, lower propagation delay, and improved 2 kV ESD performance and input ruggedness through dedicated ESD clamps. The LM339B and LM2901B can drop-in replace the LM239, LM339 and LM2901, for both "A" and "V" grades.

All devices consist of four independent voltage comparators that are designed to operate from a single power supply over a wide range of voltages.

Device Information

PART NUMBER	PACKAGE (1)	BODY SIZE (NOM)
LM139x	CDIP (14)	21.30 mm × 7.60 mm
LM139x, LM239x, LM339x, LM2901x, LM339B, LM2901B	SOIC (14)	8.70 mm × 3.90 mm
LM239, LM339x, LM2901	PDIP (14)	19.30 mm × 6.40 mm
LM239, LM2901, LM339B, LM2901B	TSSOP (14)	5.00 mm × 4.40 mm
LM339x, LM2901, LM339B, LM2901B	SO (14)	10.20 mm × 5.30 mm
LM339x, LM339B	SSOP (14)	6.50 mm × 5.30 mm
LM2901B	SOT-23 (14)	4.20 mm x 2.00 mm
	WQFN (16)	3.00 mm x 3.00 mm

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

Family Comparison Table

Specification	LM339B	LM2901B	LM339 LM339A	LM2901 LM2901A	LM2901V LM2901AV	LM139 LM139A	LM239 LM239A	Units
Supply Voltage	2 to 36	2 to 36	2 to 30	2 to 30	2 to 32	2 to 30	2 to 30	V
Total Supply Current (5V to 36V max)	0.8 to 1	0.8 to 1	1 to 2.5	1 to 2.5	1 to 2.5	1 to 2.5	1 to 2.5	mA
Temperature Range	−40 to 85	−40 to 125	0 to 70	−40 to 125	−40 to 125	−55 to 125	−25 to 85	°C
ESD (HBM)	2000	2000	1000	1000	1000	1000	1000	V
Offset Voltage (Max over temp)	± 5.5	± 5.5	± 9 ± 4	± 15 ± 4	± 15 ± 4	± 9 ± 4	± 9 ± 4	mV
Input Bias Current (typ / max)	3.5 / 25	3.5 / 25	25 / 250	25 / 250	25 / 250	25 / 100	25 / 250	nA
Response Time (typ)	1	1	1.3	1.3	1.3	1.3	1.3	µsec

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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 U (November 2018) to Revision V (December 2022) **Page**

- Updated the numbering format for tables, figures, and cross-references throughout the document. 1
- Added "B" version throughout. Added Device Family Table. 1

Changes from Revision T (June 2015) to Revision U (November 2018) **Page**

- Changed LM239x temperature range from 125°C to 85°C in *Description* section.. 1
- Changed data sheet title 1
- Changed LM293AD to LM239AD in *Device Comparison Table* 4
- Added Input Current and related footnote in *Absolute Maximum Ratings* 6
- Changed layout of *Recommended Operating Conditions* temperatures to separate rows.................................7
- Changed values in the Thermal Information table to align with JEDEC standards.. 8
- Added LM2901V and LMV2901AV to LM2901 Elect Char Table title to make more clear which devices are covered.. 12
- Changed "Dual" to "Quad" and removed "Absolute Maximum" wording and mention of Q100 in *Overview* section text...22
- Changed and corrected text in *Feature Description* section...22
- Changed Example Values in *Typical Application Design Parameters* table 23
- Added *Receiving Notification of Documentation Updates* section..27

Changes from Revision S (August 2012) to Revision T (June 2015) **Page**

- Deleted *Ordering Information* table. 1
- Added Military Disclaimer to *Features* list...1
- Added *Applications*, *Device Information* table, *Pin Configuration and Functions* section, *ESD Ratings* table, *Thermal Information* table, *Feature Description* section, *Device Functional Modes*, *Application and Implementation* section, *Power Supply Recommendations* section, *Layout* section, *Device and Documentation Support* section, and *Mechanical, Packaging, and Orderable Information* section. No specification changes.. 1

5 Other Versions

OTHER QUALIFIED VERSIONS OF LM139-SP, LM239A, LM2901, LM2901AV, LM2901V:

- Automotive Q100: LM239A-Q1, LM2901B-Q1, LM2901-Q1, LM2901AV-Q1, LM2901V-Q1
- Enhanced Product: LM239A-EP
- Space: LM139-SP

6 Pin Configuration and Functions

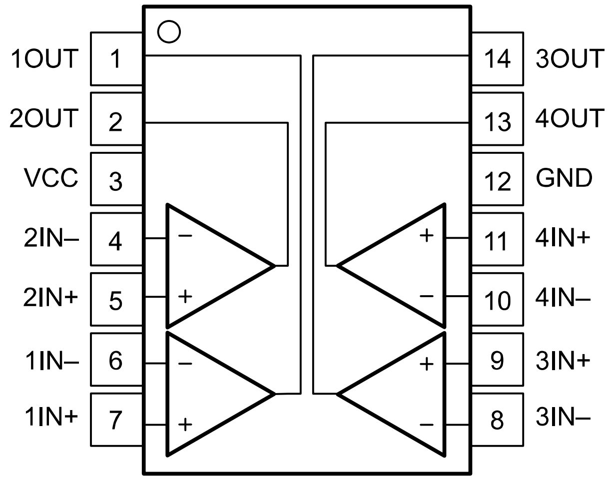
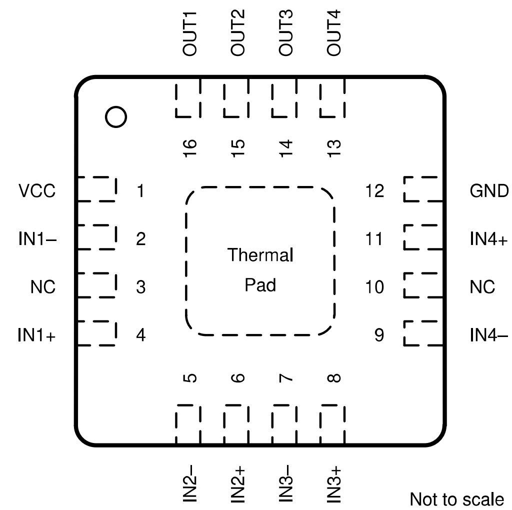


Figure 6-1. D, DB, N, NS, PW, DYY, J Packages 14-Pin SOIC, SSOP, PDIP, SO, TSSOP, SOT-23, CDIP Top View



NOTE: Connect exposed thermal pad directly to GND pin.

Figure 6-2. RTE Package 16-Pad WQFN With Exposed Thermal Pad Top View

Table 6-1. Pin Functions

PIN			I/O	DESCRIPTION
NAME(1)	D, DB, N, NS, PW, DYY, J	WQFN		
OUT1 (1)	1	16	Output	Output pin of the comparator 2
OUT2 (1)	2	15	Output	Output pin of the comparator 1
V_{CC}	3	1	—	Positive supply
IN2– (1)	4	5	Input	Negative input pin of the comparator 1
IN2+ (1)	5	6	Input	Positive input pin of the comparator 1
IN1– (1)	6	2	Input	Negative input pin of the comparator 2
IN1+ (1)	7	4	Input	Positive input pin of the comparator 2
IN3–	8	7	Input	Negative input pin of the comparator 3
IN3+	9	8	Input	Positive input pin of the comparator 3
IN4–	10	9	Input	Negative input pin of the comparator 4
IN4+	11	11	Input	Positive input pin of the comparator 4
GND	12	12	—	Negative supply
OUT4	13	13	Output	Output pin of the comparator 4
OUT3	14	14	Output	Output pin of the comparator 3
NC	—	3	—	No Internal Connection - Leave floating or GND
NC	—	10	—	No Internal Connection - Leave floating or GND
Thermal Pad	—	PAD	—	Connect directly to GND pin

(1) Some manufacturers transpose the names of channels 1 & 2. Electrically the pinouts are identical, just a difference in the channel naming convention.

7 Specifications

7.1 Absolute Maximum Ratings for LM339B and LM2901B

over operating free-air temperature range (unless otherwise noted)(1)

	MIN	MAX	UNIT
Supply voltage: V_S = (V+) – (V–)	-0.3	38	V
Differential input voltage : V_{ID} (2)		±38	V
Input pins (IN+, IN–)	-0.3	38	V
Current into input pins (IN+, IN–)		-50	mA
Output pin (OUT)	-0.3	38	V
Output sink current		25	mA
Output short-circuit duration(3)		Unlimited	s
Junction temperature, T_J	TBD	150	°C
Storage temperature, T_{stg}	-65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) Differential voltages are at IN+ with respect to IN-
(3) Short circuits from outputs to V+ can cause excessive heating and eventual destruction.

7.2 Absolute Maximum Ratings for Non-B Versions

over operating free-air temperature range (unless otherwise noted)(1)

			MIN	MAX	UNIT
V_{CC}	Supply voltage(2)			36	V
V_{ID}	Differential input voltage(3)			±36	V
V_I	Input voltage range (either input)		–0.3	36	V
I_K	Input current(5)			–50	mA
V_O	Output voltage			36	V
I_O	Output current			20	mA
	Duration of output short circuit to ground(4)		Unlimited		
T_J	Operating virtual-junction temperature			150	°C
	Case temperature for 60 s	FK package		260	°C
	Lead temperature 1.6 mm (1/16 in) from case for 60 s	J package		300	°C
T_{stg}	Storage temperature		–65	150	°C

(1) 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 under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) All voltage values, except differential voltages, are with respect to network ground.
(3) Differential voltages are at xIN+ with respect to xIN–.
(4) Short circuits from outputs to V_{CC} can cause excessive heating and eventual destruction.
(5) Input current flows through parasitic diode to ground and will turn on parasitic transistors that will increase I_{CC} and may cause output to be incorrect. Normal operation resumes when input is removed.

7.3 ESD Ratings for LM339B and LM2901B

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)]	±2000	V
		Human-body model (HBM), per ANSI/ESDA/JEDEC JS-002[(2)]	±1000	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process

7.4 ESD Ratings, Non-B Versions

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001[(1)]	±500	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101[(2)]	±750	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

7.5 Recommended Operating Conditions for LM339B and LM2901B

over operating free-air temperature range (unless otherwise noted)

	MIN	MAX	UNIT
Supply voltage: V_S = (V+) – (V–)	2	36	V
Ambient temperature, T_A, LM339B	–40	85	°C
Ambient temperature, T_A, LM2901B	–40	125	°C
Input Voltage Range, V_{IVR}	(V–) – 0.1	(V+) – 2.0	V

7.6 Recommended Operating Conditions, Non-B Versions

over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V_{CC}	Supply voltage	Non-V devices	2	30	V
		V devices	2	32	V
T_J	Junction temperature	LM139x	–55	125	°C
		LM239x	–25	85	
		LM339x	–0	70	
		LM2901x	–40	125	

7.7 Thermal Information for LM339B and LM2901B

THERMAL METRIC[(1)]		LM339B, LM2901B					UNIT
		D (SOIC)	PW (TSSOP)	DDY (SOT-23)	RUC (QFN)	RTE (QFN)	
		14 PINS	14 PINS	14 PINS	14 PINS	16 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	111.2	136.6				°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	66.9	66.6				°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	67.8	79.8				°C/W
Ψ_{JT}	Junction-to-top characterization parameter	28.0	17.8				°C/W
Ψ_{JB}	Junction-to-board characterization parameter	67.4	79.3				°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	-	-	-			°C/W

(1) For more information about traditional and new thermal metrics, see the Semicondctor and IC Package Thermal Metrics report, SPRA953.

7.8 Thermal Information for Non-B Versions

THERMAL METRIC[(1)]		LMx39, LM2901x							UNIT
		D (SOIC)	DB (SSOP)	N (PDIP)	NS (SO)	PW (TSSOP)	J (CDIP)	W (CFP)	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	98.8	111.8	79	96.2	120	89.5	156.2	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	64.3	63.6	73.4	56.1	59	46.1	86.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	59.7	60.5	58.7	56.9	68.8	78.7	154.6	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	25.7	26.2	48.3	24.8	9.9	3	56.5	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	59.3	59.8	58.5	56.4	68.2	71.8	133.5	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	—	—	—	—	—	24.2	14.3	°C/W

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

7.9 Electrical Characteristics for LM339B

V_S = 5 V, V_{CM} = (V–) ; T_A = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	V_S = 5 to 36V	–3.5	±0.37	3.5	mV
		V_S = 5 to 36V, T_A = –40°C to +85°C	–5.5		5.5	
I_B	Input bias current			–3	–25	nA
		T_A = –40°C to +85°C			–50	nA
I_{OS}	Input offset current		–25	±0.5	25	nA
		T_A = –40°C to +85°C	–50		50	nA
V_{CM}	Common mode range (1)	V_S = 3 to 36V	(V–)		(V+) – 1.5	V
		V_S = 3 to 36V, T_A = –40°C to +85°C	(V–)		(V+) – 2.0	V
A_{VD}	Large signal differential voltage amplification (2)	V_S = 15V, V_O = 1.4V to 11.4V; R_L ≥ 15k to (V+)	50	200		V/mV
V_{OL}	Low level output Voltage {swing from (V–)}	I_{SINK} ≤ 4mA, V_{ID} = -1V		110	400	mV
		I_{SINK} ≤ 4mA, V_{ID} = -1V T_A = –40°C to +85°C			550	mV
I_{OH-LKG}	High-level output leakage current	(V+) = V_O = 5 V; V_{ID} = 1V		0.1	50	nA
		(V+) = V_O = 36V; V_{ID} = 1V			100	nA
I_{OL}	Low level output current	V_{OL} = 1.5V; V_{ID} = -1V; V_S = 5V	6	21		mA
I_Q	Quiescent current (all comparators)	V_S = 5 V, no load		0.8	1.2	mA
		V_S = 36 V, no load, T_A = –40°C to +85°C		1	1.6	mA

(1) The voltage at either input should not be allowed to go negative by more than 0.3 V otherwise output may be incorrect and excessive input current can flow. The upper end of the common-mode voltage range is limited by V_{CC} – 2V. However only one input needs to be in the valid common mode range, the other input can go up the maximum V_{CC} level and the comparator provides a proper output state. Either or both inputs can go to maximum V_{CC} level without damage.
(2) This parameter is ensured by design and/or characterization and is not tested in production.

7.10 Electrical Characteristics for LM2901B

V_S = 5 V, V_{CM} = (V–) ; T_A = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{IO}	Input offset voltage	V_S = 5 to 36V	–3.5	±0.37	3.5	mV
		V_S = 5 to 36V, T_A = –40°C to +125°C	–5.5		5.5	
I_B	Input bias current			–3	–25	nA
		T_A = –40°C to +125°C			–50	nA
I_{OS}	Input offset current		–25	±0.5	25	nA
		T_A = –40°C to +125°C	–50		50	nA
V_{CM}	Common mode range (1)	V_S = 3 to 36V	(V–)		(V+) – 1.5	V
		V_S = 3 to 36V, T_A = –40°C to +125°C	(V–)		(V+) – 2.0	V
A_{VD}	Large signal differential voltage amplification (2)	V_S = 15V, V_O = 1.4V to 11.4V; R_L ≥ 15k to (V+)	50	200		V/mV
V_{OL}	Low level output Voltage {swing from (V–)}	I_{SINK} ≤ 4mA, V_{ID} = -1V		110	400	mV
		I_{SINK} ≤ 4mA, V_{ID} = -1V T_A = –40°C to +125°C			550	mV
I_{OH-LKG}	High-level output leakage current	(V+) = V_O = 5 V; V_{ID} = 1V		0.1	50	nA
		(V+) = V_O = 36V; V_{ID} = 1V			100	nA
I_{OL}	Low level output current	V_{OL} = 1.5V; V_{ID} = -1V; V_S = 5V	6	21		mA
I_Q	Quiescent current (all comparators)	V_S = 5 V, no load		0.8	1.2	mA
		V_S = 36 V, no load, T_A = –40°C to +125°C		1	1.6	mA

(1) The voltage at either input should not be allowed to go negative by more than 0.3 V otherwise output may be incorrect and excessive input current can flow. The upper end of the common-mode voltage range is limited by V_{CC} – 2V. However only one input needs to be in the valid common mode range, the other input can go up the maximum V_{CC} level and the comparator provides a proper output state. Either or both inputs can go to maximum V_{CC} level without damage.
(2) This parameter is ensured by design and/or characterization and is not tested in production.

7.11 Electrical Characteristics for LM139 and LM139A

at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS[1]		T_A [2]	LM139			LM139A			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to 30 V, V_{IC} = V_{ICR} min, V_O = 1.4 V		25°C		2	5		1	2	mV
				Full range			9			4	
I_{IO}	Input offset current	V_O = 1.4 V		25°C		3	25		3	25	nA
				Full range			100			100	
I_{IB}	Input bias current	V_O = 1.4 V		25°C		–25	–100		–25	–100	nA
				Full range			–300			–300	
V_{ICR}	Common-mode input-voltage range[3]			25°C	0 to V_{CC} – 1.5			0 to V_{CC} – 1.5			V
				Full range	0 to V_{CC} – 2			0 to V_{CC} – 2			
A_{VD}	Large-signal differential-voltage amplification	V_{CC+} = ±7.5 V, V_O = –5 V to 5 V		25°C		200		50	200		V/mV
I_{OH}	High-level output current	V_{ID} = 1 V	V_{OH} = 5 V	25°C		0.1			0.1		nA
			V_{OH} = 30 V	Full range			1			1	μA
V_{OL}	Low-level output voltage	V_{ID} = –1 V,	I_{OL} = 4 mA	25°C		150	400		150	400	mV
				Full range			700			700	
I_{OL}	Low-level output current	V_{ID} = –1 V,	V_{OL} = 1.5 V	25°C	6	16		6	16		mA
I_{CC}	Supply current (four comparators)	V_O = 2.5 V,	No load	25°C		0.8	2		0.8	2	mA

(1) All characteristics are measured with zero common-mode input voltage, unless otherwise specified.
(2) Full range (MIN to MAX) for LM139 and LM139A is –55°C to +125°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.
(3) The voltage at either input or common-mode must not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is V_{CC+} – 1.5 V; however, one input can exceed V_{CC}, and the comparator will provide a proper output state as long as the other input remains in the common-mode range. Either or both inputs can go to 30 V without damage.

7.12 Electrical Characteristics for LMx39 and LMx39A

at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS(1)		T_A (2)	LM239 LM339			LM239A LM339A			UNIT
					MIN	TYP	MAX	MIN	TYP	MAX	
V_{IO}	Input offset voltage	V_{CC} = 5 V to 30 V, V_{IC} = V_{ICR} min, V_O = 1.4 V		25°C		2	5		1	3	mV
				Full range			9			4	
I_{IO}	Input offset current	V_O = 1.4 V		25°C		5	50		5	50	nA
				Full range			150			150	
I_{IB}	Input bias current	V_O = 1.4 V		25°C		–25	–250		–25	–250	nA
				Full range			–400			–400	
V_{ICR}	Common-mode input-voltage range(3)			25°C	0 to V_{CC} – 1.5			0 to V_{CC} – 1.5			V
				Full range	0 to V_{CC} – 2			0 to V_{CC} – 2			
A_{VD}	Large-signal differential-voltage amplification	V_{CC} = 15 V, V_O = 1.4 V to 11.4 V, R_L ≥ 15 kΩ to V_{CC}		25°C	50	200		50	200		V/mV
I_{OH}	High-level output current	V_{ID} = 1 V	V_{OH} = 5 V	25°C		0.1	50		0.1	50	nA
			V_{OH} = 30 V	Full range			1			1	µA
V_{OL}	Low-level output voltage	V_{ID} = –1 V,	I_{OL} = 4 mA	25°C		150	400		150	400	mV
				Full range			700			700	
I_{OL}	Low-level output current	V_{ID} = –1 V,	V_{OL} = 1.5 V	25°C	6	16		6	16		mA
I_{CC}	Supply current (four comparators)	V_O = 2.5 V,	No load	25°C		0.8	2		0.8	2	mA

(1) All characteristics are measured with zero common-mode input voltage, unless otherwise specified.
(2) Full range (MIN to MAX) for LM239/LM239A is –25°C to +85°C, and for LM339/LM339A is 0°C to 70°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.
(3) The voltage at either input or common-mode must not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is V_{CC+} – 1.5 V; however, one input can exceed V_{CC}, and the comparator will provide a proper output state as long as the other input remains in the common-mode range. Either or both inputs can go to 30 V without damage.

7.13 Electrical Characteristics for LM2901, LM2901V and LM2901AV

at specified free-air temperature, V_{CC} = 5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS(1)		T_A (2)	LM2901			UNIT
					MIN	TYP	MAX	
V_{IO}	Input offset voltage	$V_{IC} = V_{ICR}$ min, V_O = 1.4 V, V_{CC} = 5 V to MAX(3)	Non-A devices	25°C		2	7	mV
				Full range			15	
			A-suffix devices	25°C		1	2	
				Full range			4	
I_{IO}	Input offset current	V_O = 1.4 V		25°C		5	50	nA
				Full range			200	
I_{IB}	Input bias current	V_O = 1.4 V		25°C		–25	–250	nA
				Full range			–500	
V_{ICR}	Common-mode input-voltage range(4)			25°C	0 to V_{CC} – 1.5			V
				Full range	0 to V_{CC} – 2			
A_{VD}	Large-signal differential-voltage amplification	V_{CC} = 15 V, V_O = 1.4 V to 11.4 V, R_L ≥ 15 kΩ to V_{CC}		25°C	25	100		V/mV
I_{OH}	High-level output current	V_{ID} = 1 V	V_{OH} = 5 V	25°C		0.1	50	nA
			$V_{OH} = V_{CC}$ MAX(3)	Full range			1	μA
V_{OL}	Low-level output voltage	V_{ID} = –1 V, I_{OL} = 4 mA	Non-V devices	25°C		150	500	mV
			V-suffix devices			150	400	
			All devices	Full range			700	
I_{OL}	Low-level output current	V_{ID} = –1 V,	V_{OL} = 1.5 V	25°C	6	16		mA
I_{CC}	Supply current (four comparators)	V_O = 2.5 V, No load	V_{CC} = 5 V	25°C		0.8	2	mA
			V_{CC} = MAX(3)			1	2.5	

(1) All characteristics are measured with zero common-mode input voltage, unless otherwise specified.
(2) Full range (MIN to MAX) for LM2901 is –40°C to +125°C. All characteristics are measured with zero common-mode input voltage, unless otherwise specified.
(3) V_{CC} MAX = 30 V for non-V devices, and 32 V for V-suffix devices
(4) The voltage at either input or common-mode must not be allowed to go negative by more than 0.3 V. The upper end of the common-mode voltage range is V_{CC+} – 1.5 V; however, one input can exceed V_{CC}, and the comparator will provide a proper output state as long as the other input remains in the common-mode range. Either or both inputs can go to V_{CC} MAX without damage.

7.14 Switching Characteristics for LM139 and LM139A

V_{CC} = 5 V, T_A = 25°C

PARAMETER	TEST CONDITIONS		LM139 LM139A TYP	UNIT
Response time	R_L connected to 5 V through 5.1 kΩ, C_L = 15 pF(1) (2)	100-mV input step with 5-mV overdrive	1.3	μs
		TTL-level input step	0.3	

(1) C_L includes probe and jig capacitance.
(2) The response time specified is the interval between the input step function and the instant when the output crosses 1.4 V.

7.15 Switching Characteristics for LM339B and LM2901B

V_S = 5V, V_{O_PULLUP} = 5V, V_{CM} = V_S/2, C_L = 15pF, R_L = 5.1k Ohm, T_A = 25°C (unless otherwise noted).

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{response}$	Propagation delay time, high-to-low; Small scale input signal (1)	Input overdrive = 5mV, Input step = 100mV		1000		ns
$t_{response}$	Propagation delay time, high-to-low; TTL input signal (1)	TTL input with V_{ref} = 1.4V		300		ns

(1) High-to-low and low-to-high refers to the transition at the input.

7.16 Switching Characteristics for LMx39 and LMx39A

V_{CC} = 5 V, T_A = 25°C

PARAMETER	TEST CONDITIONS		LM239 LM239A LM339 LM339A TYP	UNIT
Response time	R_L connected to 5 V through 5.1 kΩ, C_L = 15 pF(1) (2)	100-mV input step with 5-mV overdrive	1.3	μs
		TTL-level input step	0.3	

(1) C_L includes probe and jig capacitance.
(2) The response time specified is the interval between the input step function and the instant when the output crosses 1.4 V.

7.17 Switching Characteristics for LM2901

V_{CC} = 5 V, T_A = 25°C

PARAMETER	TEST CONDITIONS		LM2901 TYP	UNIT
Response time	R_L connected to 5 V through 5.1 kΩ, C_L = 15 pF(1) (2)	100-mV input step with 5-mV overdrive	1.3	μs
		TTL-level input step	0.3	

(1) C_L includes probe and jig capacitance.
(2) The response time specified is the interval between the input step function and the instant when the output crosses 1.4 V.

7.18 Typical Characteristics for LM339B and LM2901B Only

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

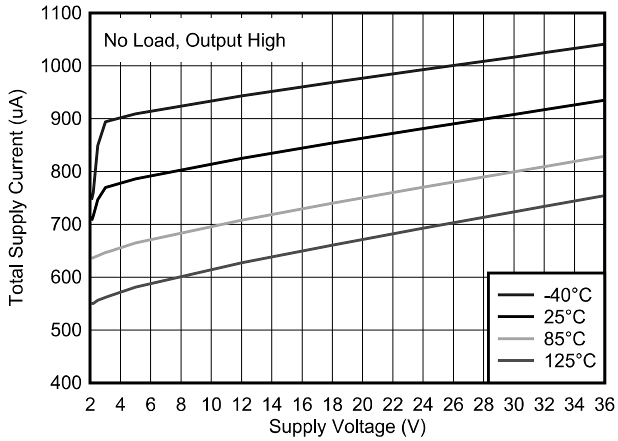


Figure 7-1. Total Supply Current vs. Supply Voltage

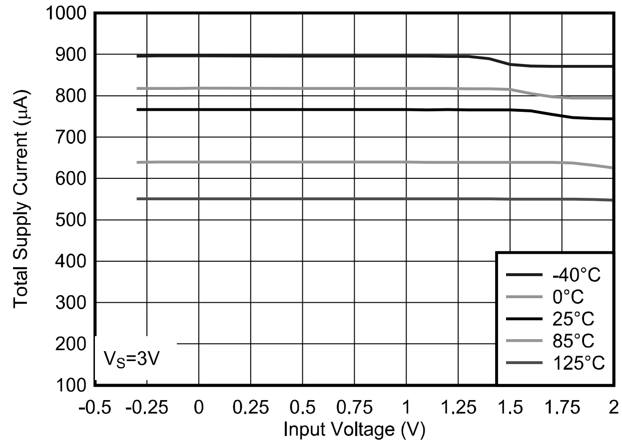


Figure 7-2. Total Supply Current vs. Input Voltage at 3V

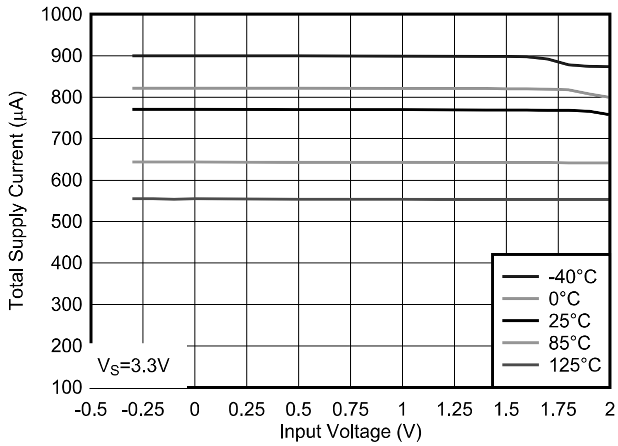


Figure 7-3. Total Supply Current vs. Input Voltage at 3.3V

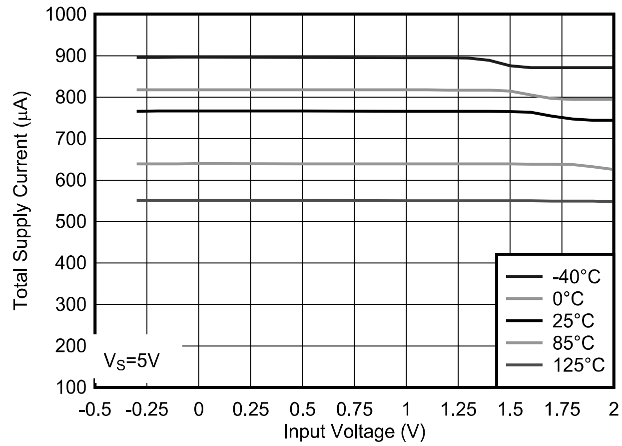


Figure 7-4. Total Supply Current vs. Input Voltage at 5V

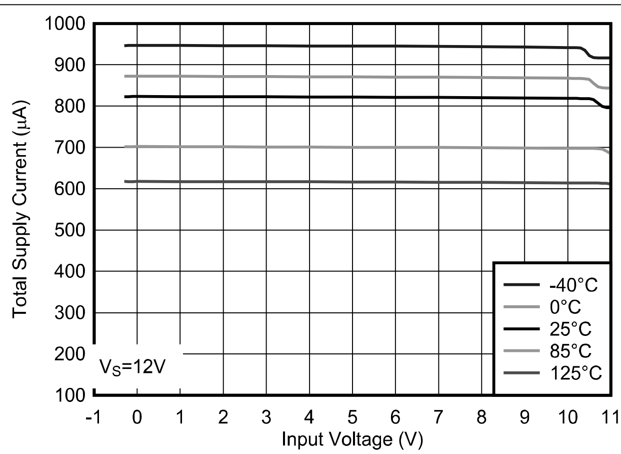


Figure 7-5. Total Supply Current vs. Input Voltage at 12V

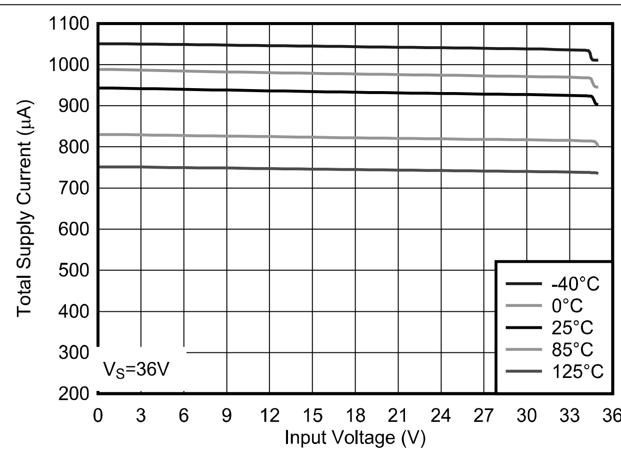


Figure 7-6. Total Supply Current vs. Input Voltage at 36V

7.18 Typical Characteristics for LM339B and LM2901B Only (continued)

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

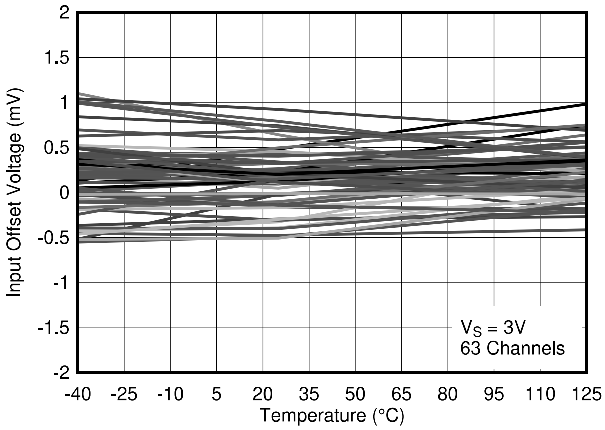


Figure 7-7. Input Offset Voltage vs. Temperature at 3V

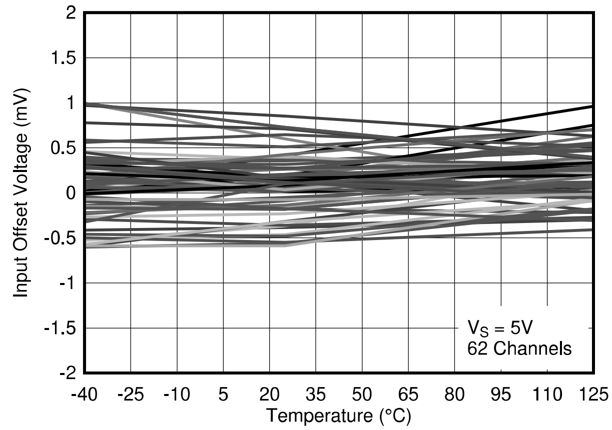


Figure 7-8. Input Offset Voltage vs. Temperature at 5V

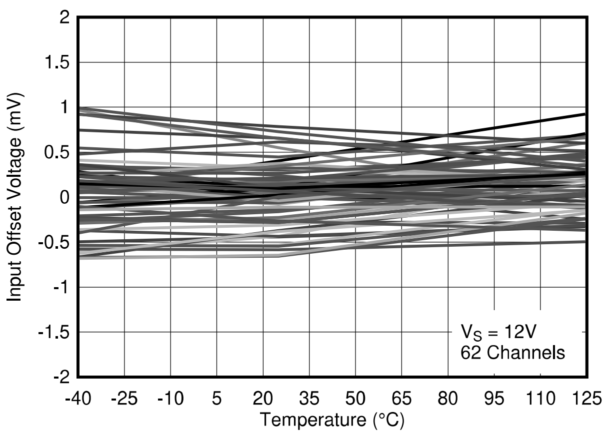


Figure 7-9. Input Offset Voltage vs. Temperature at 12V

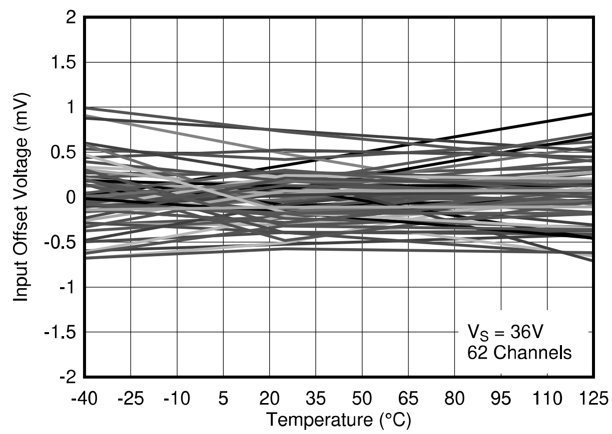


Figure 7-10. Input Offset Voltage vs. Temperature at 36

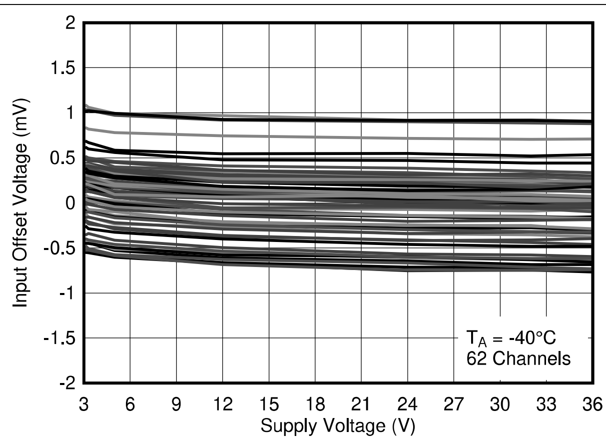


Figure 7-11. Input Offset Voltage vs. Supply Voltage at -40°C

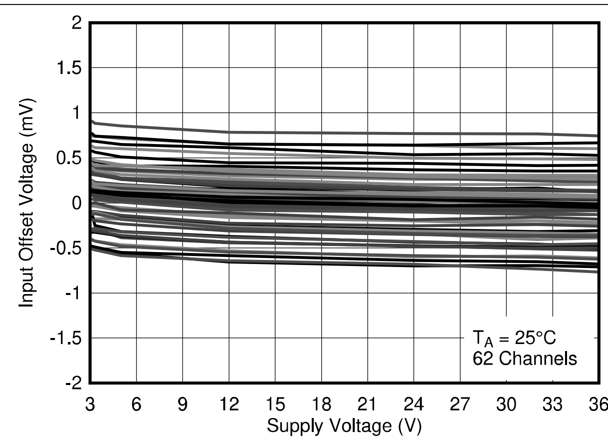


Figure 7-12. Input Offset Voltage vs. Supply Voltage at 25°C

7.18 Typical Characteristics for LM339B and LM2901B Only (continued)

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

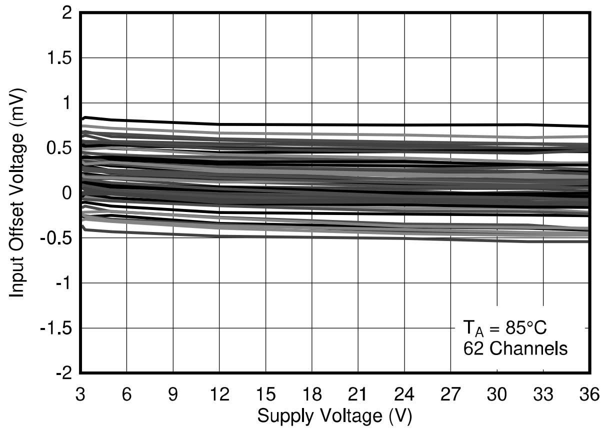


Figure 7-13. Input Offset Voltage vs. Supply Voltage at 85°C

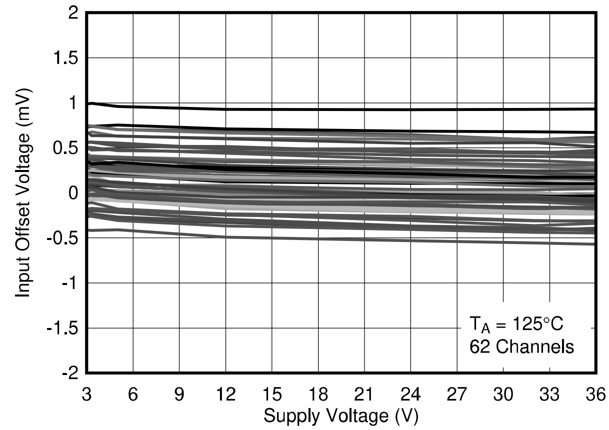


Figure 7-14. Input Offset Voltage vs. Supply Voltage at 125°C

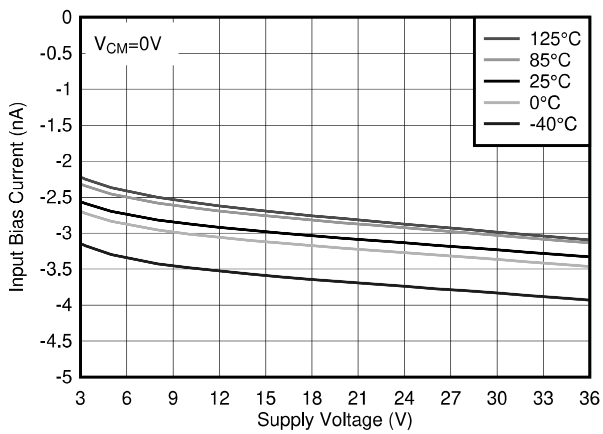


Figure 7-15. Input Bias Current vs. Supply Voltage

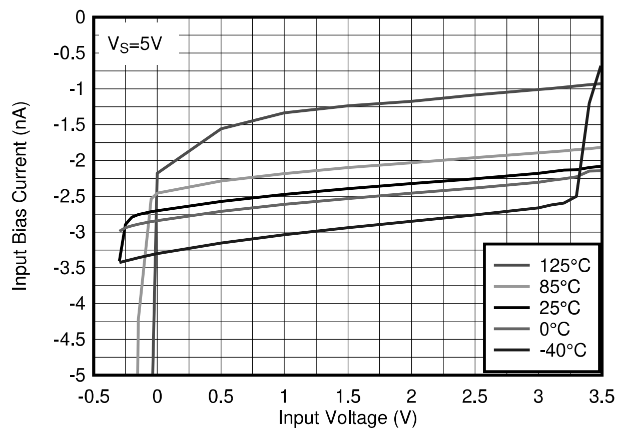


Figure 7-16. Input Bias Current vs. Input Voltage at 5V

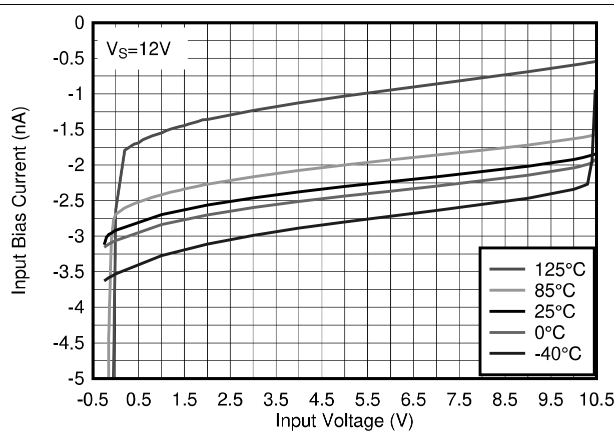


Figure 7-17. Input Bias Current vs. Input Voltage at 12V

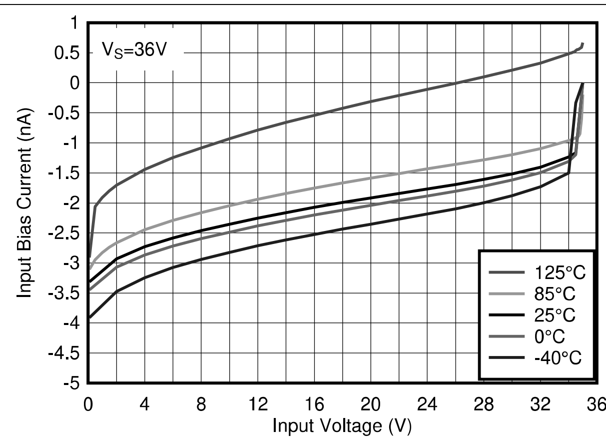


Figure 7-18. Input Bias Current vs. Input Voltage at 36V

7.18 Typical Characteristics for LM339B and LM2901B Only (continued)

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

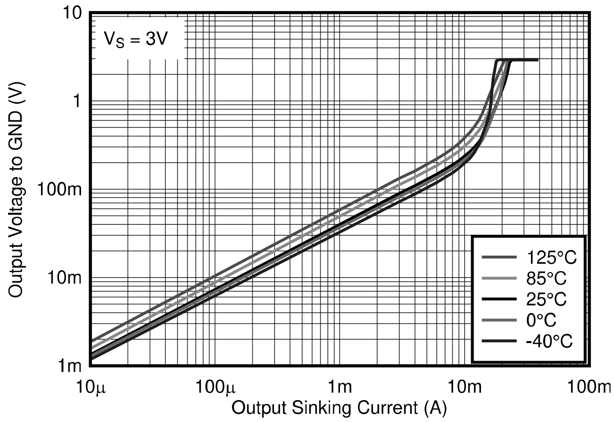


Figure 7-19. Output Low Voltage vs. Output Sinking Current at 3V

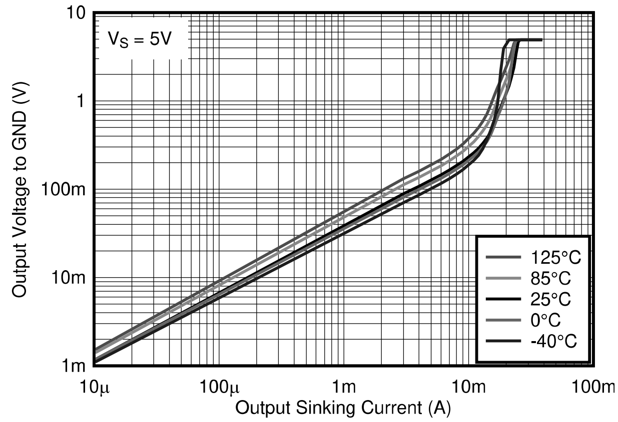


Figure 7-20. Output Low Voltage vs. Output Sinking Current at 5V

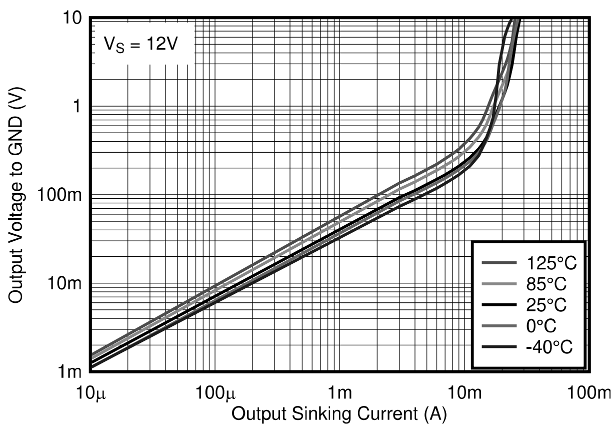


Figure 7-21. Output Low Voltage vs. Output Sinking Current at 12V

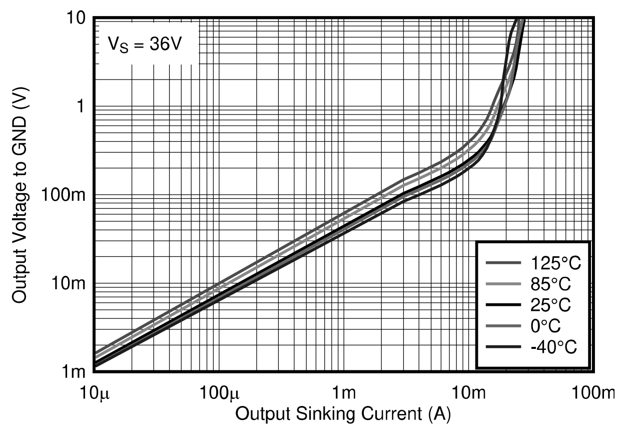


Figure 7-22. Output Low Voltage vs.Output Sinking Current at 36V

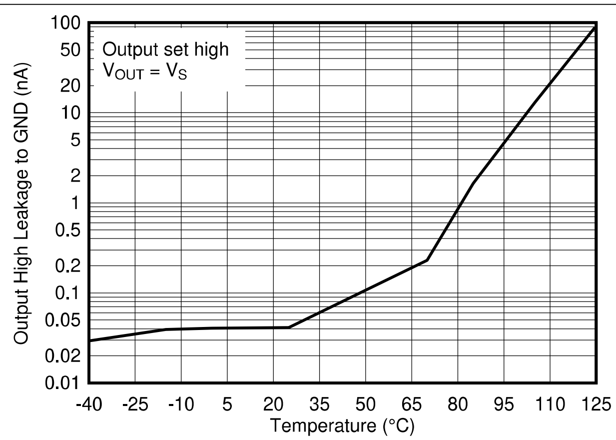


Figure 7-23. Output High Leakage Current vs.Temperature at 5V

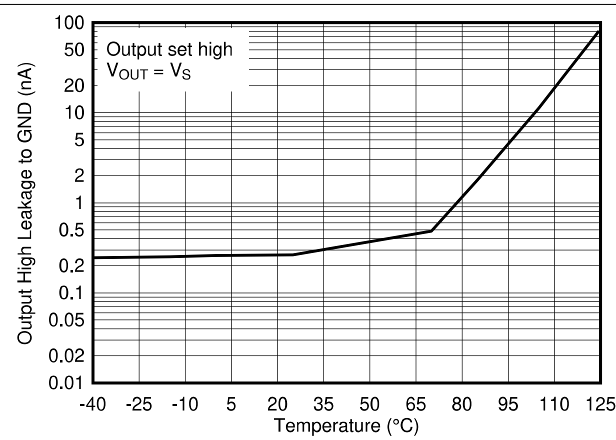


Figure 7-24. Output High Leakage Current vs. Temperature at 36V

7.18 Typical Characteristics for LM339B and LM2901B Only (continued)

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

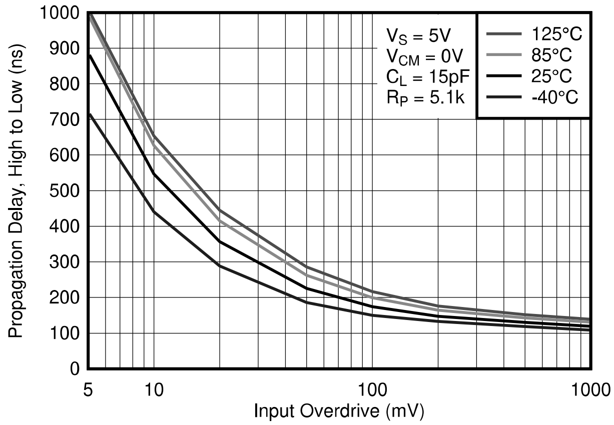


Figure 7-25. High to Low Propagation Delay vs. Input Overdrive Voltage, 5V

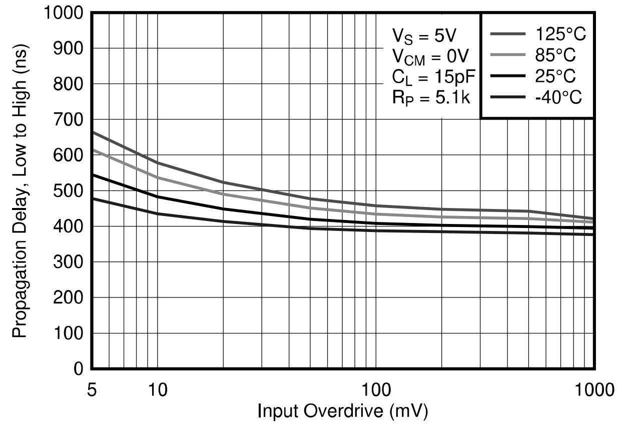


Figure 7-26. Low to High Propagation Delay vs. Input Overdrive Voltage, 5V

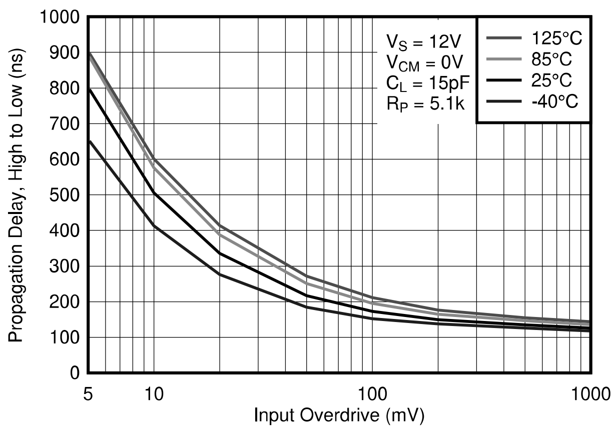


Figure 7-27. High to Low Propagation Delay vs. Input Overdrive Voltage, 12V

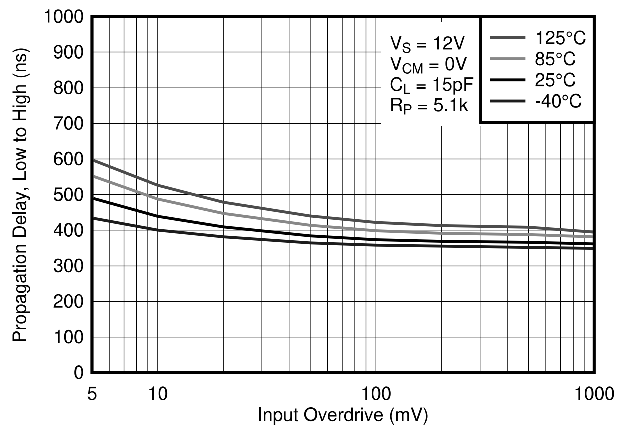


Figure 7-28. Low to High Propagation Delay vs. Input Overdrive Voltage, 12V

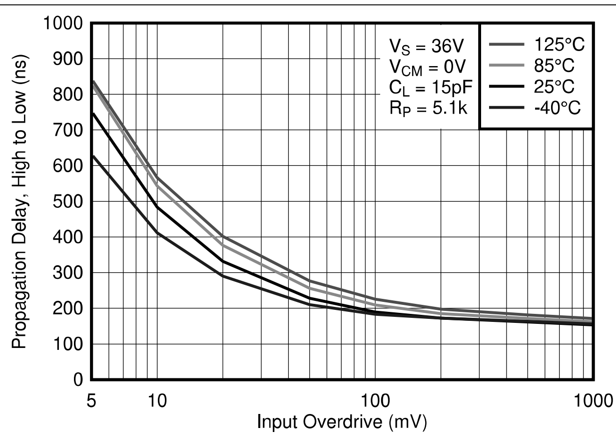


Figure 7-29. High to Low Propagation Delay vs. Input Overdrive Voltage, 36V

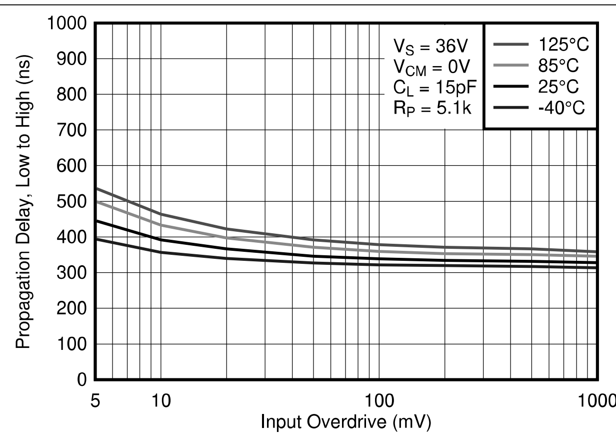


Figure 7-30. Low to High Propagation Delay vs. Input Overdrive Voltage, 36V

7.18 Typical Characteristics for LM339B and LM2901B Only (continued)

T_A = 25°C, V_S = 5 V, R_{PULLUP} = 5.1k, C_L = 15 pF, V_{CM} = 0 V, $V_{UNDERDRIVE}$ = 100 mV, $V_{OVERDRIVE}$ = 100 mV unless otherwise noted.

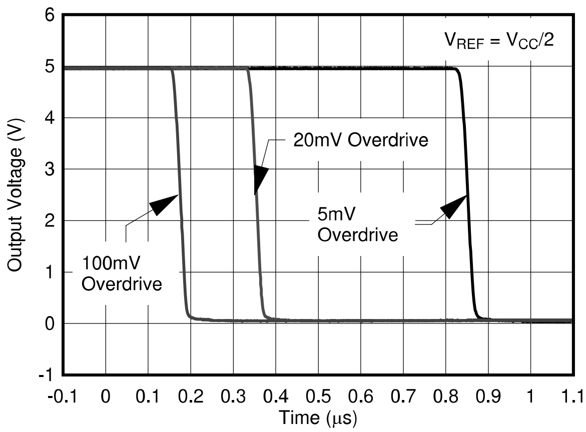


Figure 7-31. Response Time for Various Overdrives, High-to-Low Transition

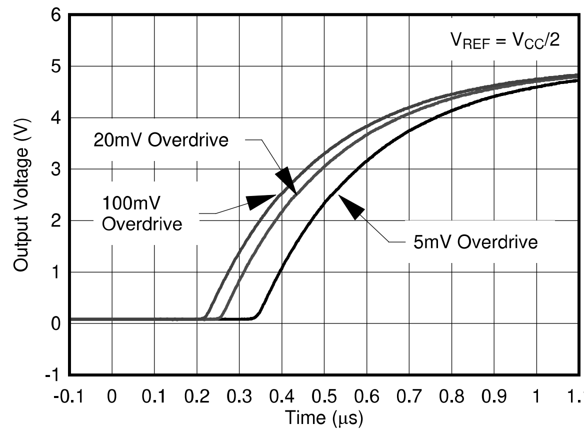


Figure 7-32. Response Time for Various Overdrives, Low-to-High Transition

7.19 Typical Characteristics, Non-B Versions

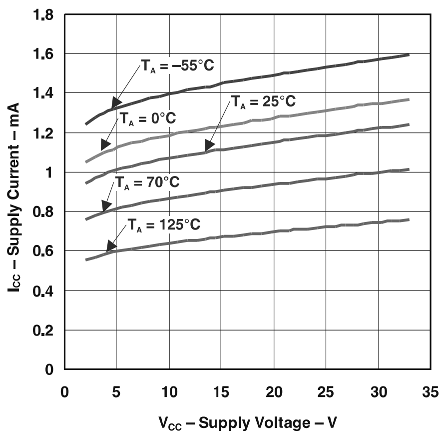


Figure 7-33. Supply Current vs Supply Voltage

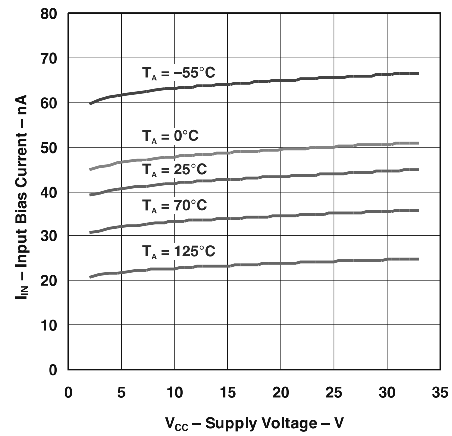


Figure 7-34. Input Bias Current vs Supply Voltage

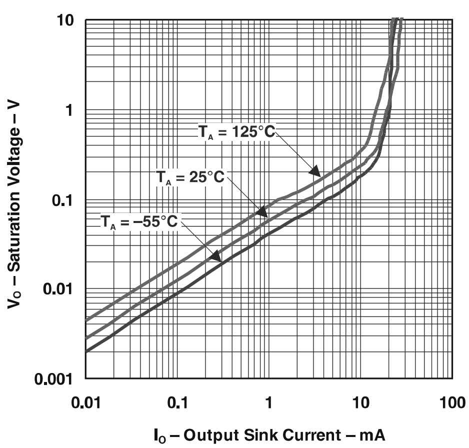


Figure 7-35. Output Saturation Voltage

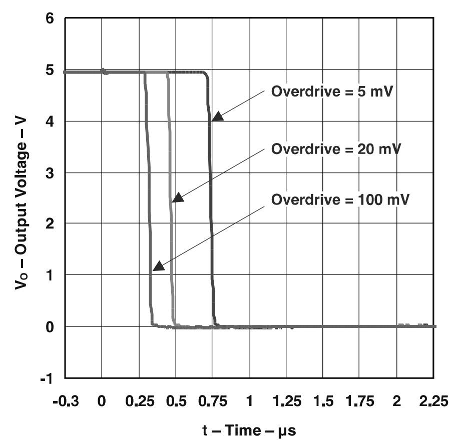


Figure 7-36. Response Time for Various Overdrives Negative Transition

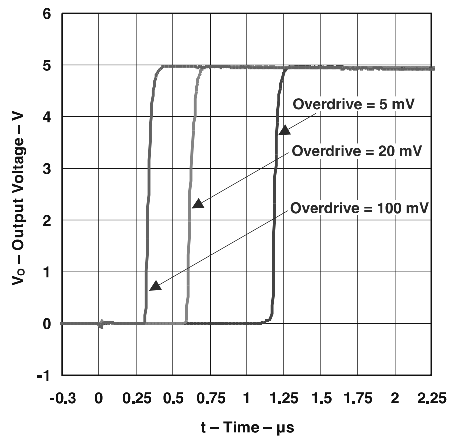


Figure 7-37. Response Time for Various Overdrives Positive Transition

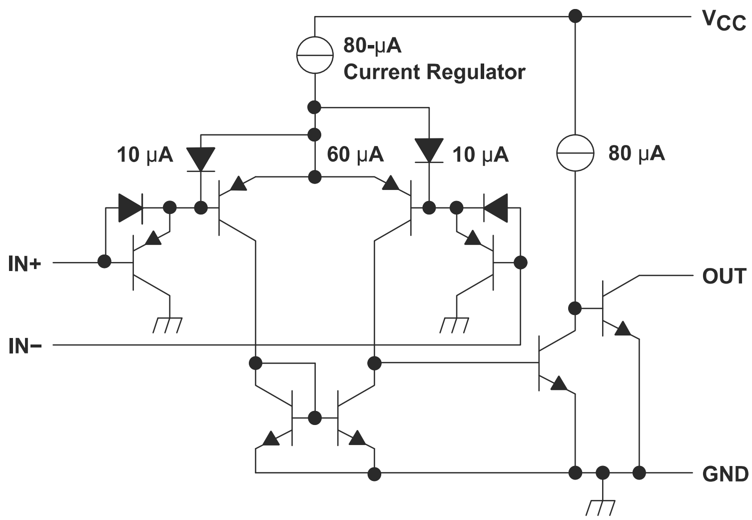
8 Detailed Description

8.1 Overview

The LMx39 and LM2901x are quad comparators with the ability to operate up to an absolute maximum of 36 V on the supply pin. This standard device has proven ubiquity and versatility across a wide range of applications. This is due to very wide supply voltages range (2 V up to 32 V), low Iq, and fast response of the device.

The open-drain output allows the user to configure the output logic low voltage (V_{OL}) and allows the comparator to be used in AND functionality.

8.2 Functional Block Diagram



COMPONENT COUNT	
Epi-FET	1
Diodes	2
Resistors	2
Transistors	30

Figure 8-1. Schematic (Each Comparator)

8.3 Feature Description

The comparator consists of a PNP Darlington pair input, allowing the device to operate with very high gain and fast response with minimal input bias current. The input Darlington pair creates a limit on the input common-mode voltage capability, allowing the comparator to accurately function from ground to (V_{CC} – 1.5 V) differential input. Allow for (V_{CC} – 2 V) at cold temperature.

The output consists of an open-collector NPN (pulldown or low-side) transistor. The output NPN sinks current when the negative input voltage is higher than the positive input voltage and the offset voltage. The VOL is resistive and scales with the output current. See the *Section 7* section for V_{OL} values with respect to the output current.

8.4 Device Functional Modes

8.4.1 Voltage Comparison

The comparator operates solely as a voltage comparator, comparing the differential voltage between the positive and negative pins and outputting a logic low or high impedance (logic high with pullup) based on the input differential polarity.

9 Application and Implementation

Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes, as well as validating and testing their design implementation to confirm system functionality.

9.1 Application Information

Typically, a comparator compares either a single signal to a reference, or to two differnt signals. Many users take advantage of the open-drain output to drive the comparison logic output to a logic voltage level to an MCU or logic device. The wide supply range and high voltage capability makes LMx39 or LM2901x optimal for level shifting to a higher or lower voltage.

9.2 Typical Application

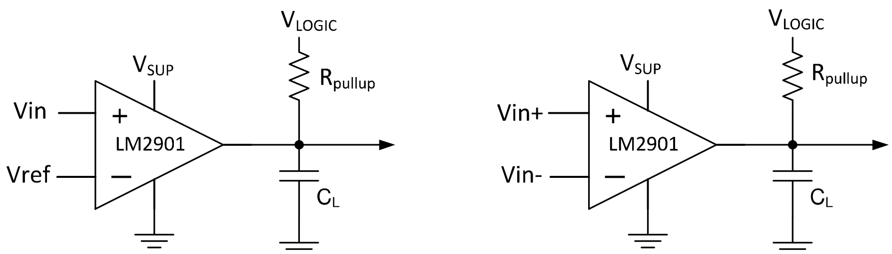


Figure 9-1. Single-ended and Differential Comparator Configurations

9.2.1 Design Requirements

For this design example, use the parameters listed in Table 9-1 as the input parameters.

Table 9-1. Design Parameters

DESIGN PARAMETER	EXAMPLE VALUE
Input Voltage Range	0 V to Vsup-1.5 V
Supply Voltage	4.5 V to V_{CC} maximum
Logic Supply Voltage	0 V to V_{CC} maximum
Output Current (R_{PULLUP})	1 µA to 4 mA
Input Overdrive Voltage	100 mV
Reference Voltage	2.5 V
Load Capacitance (C_L)	15 pF

9.2.2 Detailed Design Procedure

When using the LMx39 in a general comparator application, determine the following:

- Input voltage range
- Minimum overdrive voltage
- Output and drive current
- Response time

9.2.2.1 Input Voltage Range

When choosing the input voltage range, the input common-mode voltage range (V_{ICR}) must be taken in to account. If temperature operation is above or below 25°C the V_{ICR} can range from 0 V to V_{CC}– 2 V. This limits the input voltage range to as high as V_{CC}– 2 V and as low as 0 V. Operation outside of this range can yield incorrect comparisons.

The following list describes the outcomes of some input voltage situations.

- When both IN– and IN+ are both within the common-mode range:
  - If IN– is higher than IN+ and the offset voltage, the output is low and the output transistor is sinking current
  - If IN– is lower than IN+ and the offset voltage, the output is high impedance and the output transistor is not conducting
- When IN– is higher than common mode and IN+ is within common mode, the output is low and the output transistor is sinking current
- When IN+ is higher than common mode and IN– is within common mode, the output is high impedance and the output transistor is not conducting
- When IN– and IN+ are both higher than common mode, the output is low and the output transistor is sinking current

9.2.2.2 Minimum Overdrive Voltage

Overdrive voltage is the differential voltage produced between the positive and negative inputs of the comparator over the offset voltage (V_{IO}). To make an accurate comparison, the overdrive voltage (V_{OD}) must be higher than the input offset voltage (V_{IO}). Overdrive voltage can also determine the response time of the comparator, with the response time decreasing with increasing overdrive. Figure 9-2 and Figure 9-3 show positive and negative response times with respect to overdrive voltage.

9.2.2.3 Output and Drive Current

Output current is determined by the load and pullup resistance and logic and pullup voltage. The output current produces a low-level output voltage (V_{OL}) from the comparator, where V_{OL} is proportional to the output current.

The output current can also effect the transient response.

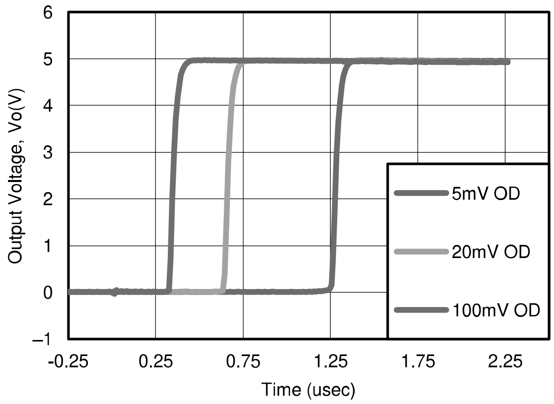
9.2.2.4 Response Time

Response time is a function of input over-drive. See the *Section 7.19* graphs for typical response times. The rise and fall times can be determined by the load capacitance (C_L), load/pull-up resistance (R_{PULLUP}) and equivalent collector-emitter resistance (R_{CE}).

- The rise time (τ_R) is approximately $\tau_R \sim R_{PULLUP} \times C_L$
- The fall time (τ_F) is approximately $\tau_F \sim R_{CE} \times C_L$
  - R_{CE} can be determined by taking the slope of Figure 7-35 in its linear region at the desired temperature, or by dividing the V_{OL} by I_{OUT}

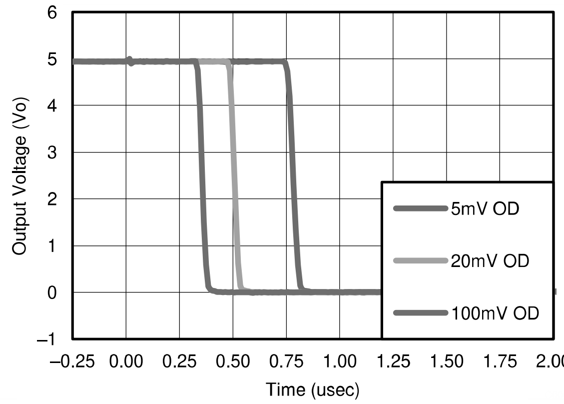
9.2.3 Application Curves

Figure 9-2 and Figure 9-3 were generated with scope probe parasitic capacitance of 50 pF.



V_{CC} = 5 V V_{Logic} = 5 V R_{PULLUP} = 5.1 kΩ

Figure 9-2. Response Time vs Output Voltage (Positive Transition)



V_{CC} = 5 V V_{Logic} = 5 V R_{PULLUP} = 5.1 kΩ

Figure 9-3. Response Time vs Output Voltage (Negative Transition)

10 Power Supply Recommendations

For fast response and comparison applications with noisy or AC inputs, use a bypass capacitor on the supply pin to reject any variation on the supply voltage. This variation can affect the common-mode range of the comparator input and create an inaccurate comparison.

11 Layout

11.1 Layout Guidelines

To create an accurate comparator application without hysteresis, maintain a stable power supply with minimized noise and glitches, which can affect the high level input common-mode voltage range. To achieve this accuracy, add a bypass capacitor between the supply voltage and ground. Place a bypass capacitor on the positive power supply and negative supply (if available).

Note

If a negative supply is not being used, do not place a capacitor between the GND pin of the device and system ground.

11.2 Layout Example

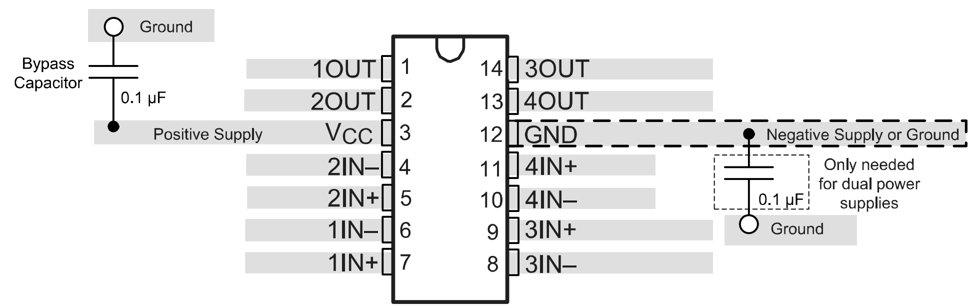


Figure 11-1. LMx39 Layout Example