

# SN74LVC166A 8-Bit Parallel-Load Shift Registers with Clear

## 1 Features

- Operating range from 1.1V to 3.6V
- Over-voltage tolerant inputs support up to 5.5V independent of  $V_{CC}$
- Supports **partial-power-down** with back drive protection ( $I_{off}$ )
- High push-pull output drive strength:
  - $\pm 24\text{mA}$  at 3.3V
  - $\pm 8\text{mA}$  at 2.3V
  - $\pm 4\text{mA}$  at 1.65V
- Maximum propagation delay of 11.2ns at 3.3V supply
- Latch-up performance exceeds 100mA per JESD78

## 2 Applications

- [Increase the number of inputs on a microcontroller](#)
- Read in board revision

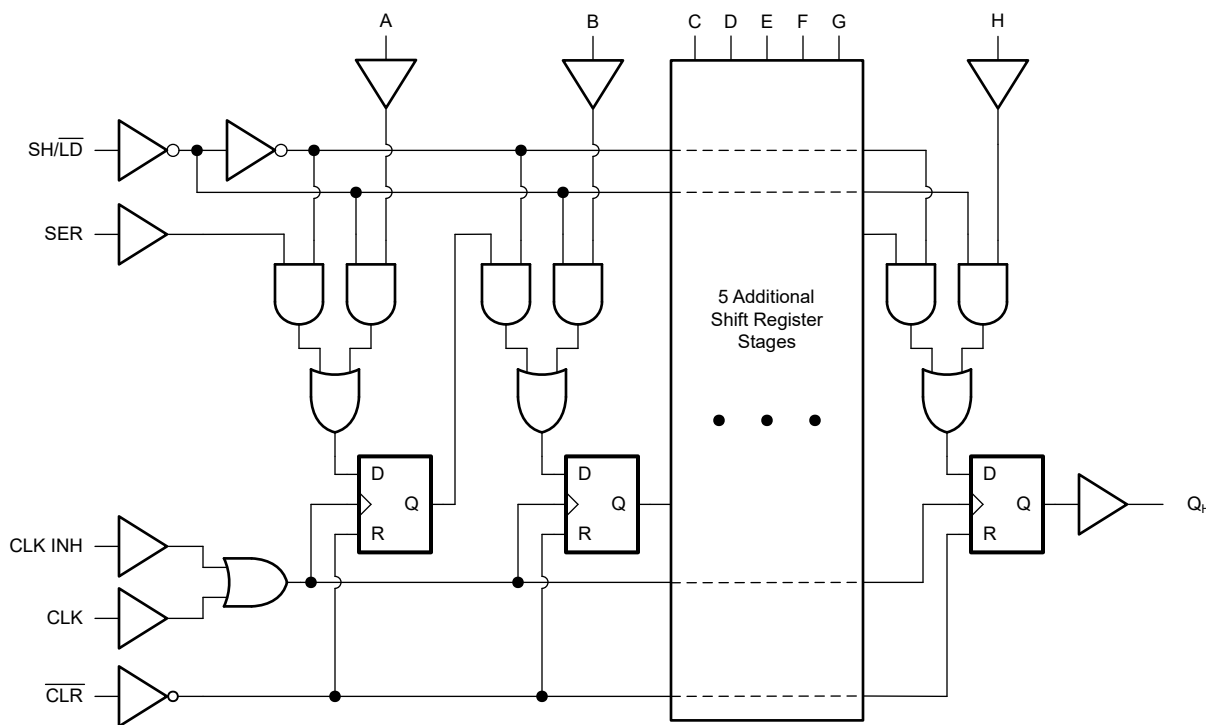
## 3 Description

The SN74LVC166A contains one 8-bit parallel-load shift register. Data is loaded synchronously using the shift or load (SH/LD) select and clock (CLK) inputs. The device includes a serial (SER) input to allow for daisy chaining and an asynchronous clear (CLR) input.

### Package Information

PART NUMBER	PACKAGE <sup>(1)</sup>	PACKAGE SIZE <sup>(2)</sup>	BODY SIZE (NOM) <sup>(3)</sup>
SN74LVC166A	BQB (WQFN, 16)	3.5mm × 2.5mm	3.5mm × 2.5mm
	D (SOIC, 16)	9.9mm × 6mm	9.9mm × 3.9mm
	PW (TSSOP, 16)	5mm × 6.4mm	5mm × 4.4mm

- (1) For more information, see [Section 11](#).
- (2) The package size (length × width) is a nominal value and includes pins, where applicable
- (3) The body size (length × width) is a nominal value and does not include pins.



Functional Diagram



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## 4 Pin Configuration and Functions

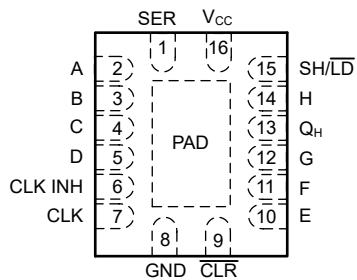


Figure 4-1. BQB Package, 16-Pin WQFN (Top View)

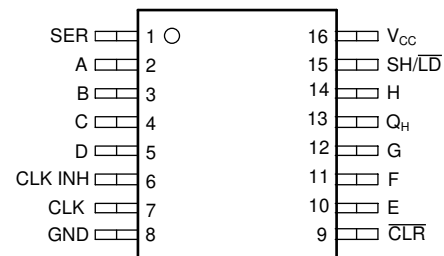


Figure 4-2. D or PW Package, 16-Pin SOIC or TSSOP (Top View)

Table 4-1. Pin Functions

PIN		TYPE <sup>(1)</sup>	DESCRIPTION
NAME	NO.		
SER	1	I	Serial data input
A	2	I	Parallel input A
B	3	I	Parallel input B
C	4	I	Parallel input C
D	5	I	Parallel input D
CLK INH	6	I	Clock inhibit input
CLK	7	I	Clock input
GND	8	G	Ground
CLR	9	I	Clock for Channel 2, rising edge triggered
E	10	O	Parallel input E
F	11	I	Parallel input F
G	12	I	Parallel input G
Q <sub>H</sub>	13	I	Serial output
H	14	I	Parallel input H
SH/LD	15	I	Enable shifting when input is high, enable loading data when input is low
V <sub>CC</sub>	16	P	Positive supply
Thermal Pad <sup>(2)</sup>		—	The thermal pad can be connected to GND or left floating. Do not connect to any other signal or supply.

(1) I = Input, O = Output, I/O = Input or Output, G = Ground, P = Power.

(2) BQB package only

## 5 Specifications

### 5.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)<sup>(1)</sup>

		MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage range	-0.5	6.5	V
V <sub>I</sub>	Input voltage range <sup>(2)</sup>	-0.5	6.5	V
V <sub>O</sub>	Output voltage range <sup>(2)</sup>	-0.5	V <sub>CC</sub> + 0.5	V
I <sub>IK</sub>	Input clamp current	V <sub>I</sub> < 0V		-50 mA
I <sub>OK</sub>	Output clamp current	V <sub>O</sub> < 0V		-50 mA
I <sub>O</sub>	Continuous output current			±50 mA
	Continuous current through V <sub>CC</sub> or GND			±100 mA
T <sub>J</sub>	Junction temperature			150 °C
T <sub>stg</sub>	Storage temperature	-65	150	°C

- (1) Operation outside the *Absolute Maximum Ratings* may cause permanent device damage. Absolute maximum ratings do not imply functional operation of the device at these or any other conditions beyond those listed under *Recommended Operating Conditions*. If briefly operating outside the *Recommended Operating Conditions* but within the *Absolute Maximum Ratings*, the device may not sustain damage, but it may not be fully functional. Operating the device in this manner may affect device reliability, functionality, performance, and shorten the device lifetime.
- (2) The input and output voltage ratings may be exceeded if the input and output current ratings are observed.

### 5.2 ESD Ratings

			VALUE	UNIT
V <sub>(ESD)</sub>	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	±2000	V
		Charged-device model (CDM), per ANSI/ESDA/JEDEC JS-002 <sup>(2)</sup>	±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.

### 5.3 Recommended Operating Conditions

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

			MIN	MAX	UNIT
V <sub>CC</sub>	Supply voltage	Operating	1.1	3.6	V
V <sub>I</sub>	Input voltage		0	5.5	V
V <sub>O</sub>	Output voltage	High or low state	0	V <sub>CC</sub>	V
I <sub>OH</sub>	High-level output current	V <sub>CC</sub> = 1.8 V			-4
		V <sub>CC</sub> = 2.3 V			-8
		V <sub>CC</sub> = 2.7 V			-12
		V <sub>CC</sub> = 3 V			-24
I <sub>OL</sub>	Low-level output current	V <sub>CC</sub> = 1.8 V			4
		V <sub>CC</sub> = 2.3 V			8
		V <sub>CC</sub> = 2.7 V			12
		V <sub>CC</sub> = 3 V			24
Δt/Δv	Input transition rise or fall rate				10 ns/V
T <sub>A</sub>	Operating free-air temperature		-40	125	°C

## 5.4 Thermal Information

PACKAGE	PINS	THERMAL METRIC <sup>(1)</sup>						UNIT
		R <sub>θJA</sub>	R <sub>θJC(top)</sub>	R <sub>θJB</sub>	Ψ <sub>JT</sub>	Ψ <sub>JB</sub>	R <sub>θJC(bot)</sub>	
PW (TSSOP)	16	141.8	74	87.1	22.3	86.6	-	°C/W
BQB (WQFN)	16	98.8	94.3	67.6	15.4	67.6	46.2	°C/W
DYY (SOT-23-THN)	16	196.3	117.4	122.9	22.3	122.7	-	°C/W

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

## 5.5 Electrical Characteristics

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

PARAMETER	TEST CONDITIONS	V <sub>CC</sub>	-40°C to 125°C			UNIT
			MIN	TYP	MAX	
V <sub>OH</sub>	I <sub>OH</sub> = -100μA	1.1V to 3.6V	V <sub>CC</sub> - 0.2	V <sub>CC</sub> - 0.01		V
V <sub>OH</sub>	I <sub>OH</sub> = -4mA	1.65V		1.2		V
V <sub>OH</sub>	I <sub>OH</sub> = -8mA	2.3V		1.75		V
V <sub>OH</sub>	I <sub>OH</sub> = -12mA	2.7V		2.2		V
V <sub>OH</sub>		3V		2.4		V
V <sub>OH</sub>	I <sub>OH</sub> = -24mA	3V		2.2		V
V <sub>OL</sub>	I <sub>OL</sub> = 100μA	1.1V to 3.6V		0.01	0.2	V
V <sub>OL</sub>	I <sub>OL</sub> = 4mA	1.65V			0.45	V
V <sub>OL</sub>	I <sub>OL</sub> = 8mA	2.3V			0.7	V
V <sub>OL</sub>	I <sub>OL</sub> = 12mA	2.7V			0.4	V
V <sub>OL</sub>	I <sub>OL</sub> = 24mA	3V			0.55	V
I <sub>I</sub>	V <sub>I</sub> = V <sub>CC</sub> or GND	3.6V			±5	μA
I <sub>off</sub>	V <sub>I</sub> or V <sub>O</sub> = V <sub>CC</sub>	0V			±10	μA
I <sub>CC</sub>	V <sub>I</sub> = V <sub>CC</sub> or GND, I <sub>O</sub> = 0	3.6V			40	μA
ΔI <sub>CC</sub>	One input at V <sub>CC</sub> - 0.6V, other inputs at V <sub>CC</sub> or GND	2.7V to 3.6V			5000	μA
C <sub>I</sub>	V <sub>I</sub> = V <sub>CC</sub> or GND	3.3V		4.9		pF
C <sub>O</sub>	V <sub>O</sub> = V <sub>CC</sub> or GND	3.3V		6.3		pF
C <sub>PD</sub>	f = 10MHz	1.8V		12		pF
C <sub>PD</sub>	f = 10MHz	2.5V		15		pF
C <sub>PD</sub>	f = 10MHz	3.3V		17		pF

## 5.6 Timing Characteristics

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

PARAMETER	DESCRIPTION	CONDITION	V <sub>CC</sub>	-40°C to 125°C		UNIT
				MIN	MAX	
F <sub>clock</sub>	Clock frequency		1.2 V ± 0.1 V		59	MHz
			1.5 V ± 0.15 V		64	MHz
			1.8 V ± 0.15 V		64	MHz
			2.5 V ± 0.2 V		100	MHz
			3.3 V ± 0.3 V		104	MHz
t <sub>W</sub>	Pulse duration	CLR low	1.2 V ± 0.1 V		6.9	ns
t <sub>W</sub>	Pulse duration	SH/LD low	1.2 V ± 0.1 V		6.9	ns

## 5.6 Timing Characteristics (continued)

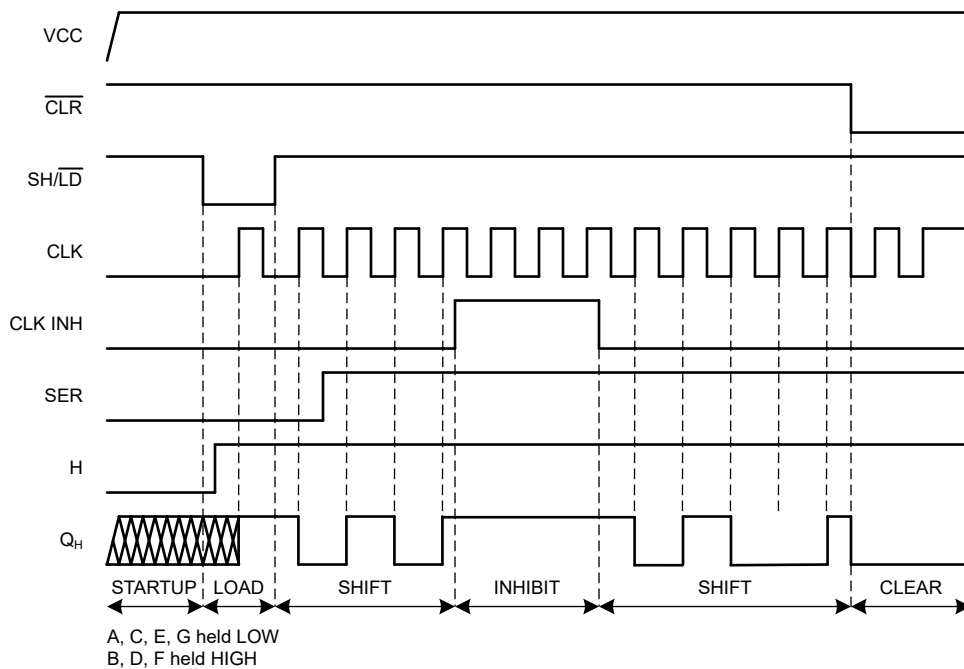
over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	DESCRIPTION	CONDITION	V <sub>CC</sub>	-40°C to 125°C		UNIT
				MIN	MAX	
t <sub>W</sub>	Pulse duration	CLK	1.2 V ± 0.1 V	7		ns
t <sub>SU</sub>	Setup time	SH/ $\overline{\text{LD}}$ high before CLK↑	1.2 V ± 0.1 V	16.5		ns
t <sub>SU</sub>	Setup time	SER before CLK↑	1.2 V ± 0.1 V	10.1		ns
t <sub>SU</sub>	Setup time	CLK INH before CLK↑	1.2 V ± 0.1 V	1		ns
t <sub>SU</sub>	Setup time	Data before CLK↑	1.2 V ± 0.1 V	10		ns
t <sub>SU</sub>	Setup time	$\overline{\text{CLR}}$ inactive before CLK↑	1.2 V ± 0.1 V	10.1		ns
t <sub>H</sub>	Hold time	SER data after CLK↑	1.2 V ± 0.1 V	0.4		ns
t <sub>H</sub>	Hold time	Parallel data after SH/ $\overline{\text{LD}}$ ↓	1.2 V ± 0.1 V	1.8		ns
t <sub>H</sub>	Hold time	SH/ $\overline{\text{LD}}$ high after CLK↑	1.2 V ± 0.1 V	0		ns
t <sub>H</sub>	Hold time	CLK INH high after CLK↑	1.2 V ± 0.1 V	0.4		ns
t <sub>H</sub>	Hold time	Data after CLK↑	1.2 V ± 0.1 V	1		ns
t <sub>W</sub>	Pulse duration	$\overline{\text{CLR}}$ low	1.5 V ± 0.15 V	6.9		ns
t <sub>W</sub>	Pulse duration	SH/ $\overline{\text{LD}}$ low	1.5 V ± 0.15 V	6.9		ns
t <sub>W</sub>	Pulse duration	CLK	1.5 V ± 0.15 V	7		ns
t <sub>SU</sub>	Setup time	SH/ $\overline{\text{LD}}$ high before CLK↑	1.5 V ± 0.15 V	10		ns
t <sub>SU</sub>	Setup time	SER before CLK↑	1.5 V ± 0.15 V	10.1		ns
t <sub>SU</sub>	Setup time	CLK INH before CLK↑	1.5 V ± 0.15 V	1		ns
t <sub>SU</sub>	Setup time	Data before CLK↑	1.5 V ± 0.15 V	10		ns
t <sub>SU</sub>	Setup time	$\overline{\text{CLR}}$ inactive before CLK↑	1.5 V ± 0.15 V	10.1		ns
t <sub>H</sub>	Hold time	SER data after CLK↑	1.5 V ± 0.15 V	1.2		ns
t <sub>H</sub>	Hold time	Parallel data after SH/ $\overline{\text{LD}}$ ↓	1.5 V ± 0.15 V	1.9		ns
t <sub>H</sub>	Hold time	SH/ $\overline{\text{LD}}$ high after CLK↑	1.5 V ± 0.15 V	1		ns
t <sub>H</sub>	Hold time	CLK INH high after CLK↑	1.5 V ± 0.15 V	0.6		ns
t <sub>H</sub>	Hold time	Data after CLK↑	1.5 V ± 0.15 V	1.8		ns
t <sub>W</sub>	Pulse duration	$\overline{\text{CLR}}$ low	1.8 V ± 0.15 V	6.9		ns
t <sub>W</sub>	Pulse duration	SH/ $\overline{\text{LD}}$ low	1.8 V ± 0.15 V	6.9		ns
t <sub>W</sub>	Pulse duration	CLK	1.8 V ± 0.15 V	7		ns
t <sub>SU</sub>	Setup time	SH/ $\overline{\text{LD}}$ high before CLK↑	1.8 V ± 0.15 V	8		ns
t <sub>SU</sub>	Setup time	SER before CLK↑	1.8 V ± 0.15 V	10.1		ns
t <sub>SU</sub>	Setup time	CLK INH before CLK↑	1.8 V ± 0.15 V	1		ns
t <sub>SU</sub>	Setup time	Data before CLK↑	1.8 V ± 0.15 V	8		ns
t <sub>SU</sub>	Setup time	$\overline{\text{CLR}}$ inactive before CLK↑	1.8 V ± 0.15 V	10.1		ns
t <sub>H</sub>	Hold time	SER data after CLK↑	1.8 V ± 0.15 V	0.2		ns
t <sub>H</sub>	Hold time	Parallel data after SH/ $\overline{\text{LD}}$ ↓	1.8 V ± 0.15 V	0.8		ns
t <sub>H</sub>	Hold time	SH/ $\overline{\text{LD}}$ high after CLK↑	1.8 V ± 0.15 V	0		ns
t <sub>H</sub>	Hold time	CLK INH high after CLK↑	1.8 V ± 0.15 V	0.3		ns
t <sub>H</sub>	Hold time	Data after CLK↑	1.8 V ± 0.15 V	1		ns
t <sub>W</sub>	Pulse duration	$\overline{\text{CLR}}$ low	2.5 V ± 0.2 V	5.4		ns
t <sub>W</sub>	Pulse duration	SH/ $\overline{\text{LD}}$ low	2.5 V ± 0.2 V	5.4		ns
t <sub>W</sub>	Pulse duration	CLK	2.5 V ± 0.2 V	4.5		ns
t <sub>SU</sub>	Setup time	SH/ $\overline{\text{LD}}$ high before CLK↑	2.5 V ± 0.2 V	4.5		ns
t <sub>SU</sub>	Setup time	SER before CLK↑	2.5 V ± 0.2 V	5.9		ns
t <sub>SU</sub>	Setup time	CLK INH before CLK↑	2.5 V ± 0.2 V	1		ns

### 5.6 Timing Characteristics (continued)

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

PARAMETER	DESCRIPTION	CONDITION	V <sub>CC</sub>	-40°C to 125°C		UNIT
				MIN	MAX	
t <sub>SU</sub>	Setup time	Data before CLK↑	2.5 V ± 0.2 V	4.5		ns
t <sub>SU</sub>	Setup time	CLR inactive before CLK↑	2.5 V ± 0.2 V	5.9		ns
t <sub>H</sub>	Hold time	SER data after CLK↑	2.5 V ± 0.2 V	0.5		ns
t <sub>H</sub>	Hold time	Parallel data after SH/LD↓	2.5 V ± 0.2 V	0		ns
t <sub>H</sub>	Hold time	SH/LD high after CLK↑	2.5 V ± 0.2 V	0.1		ns
t <sub>H</sub>	Hold time	CLK INH high after CLK↑	2.5 V ± 0.2 V	0.3		ns
t <sub>H</sub>	Hold time	Data after CLK↑	2.5 V ± 0.2 V	1.5		ns
t <sub>W</sub>	Pulse duration	CLR low	3.3 V ± 0.3 V	4.3		ns
t <sub>W</sub>	Pulse duration	SH/LD low	3.3 V ± 0.3 V	4.3		ns
t <sub>W</sub>	Pulse duration	CLK	3.3 V ± 0.3 V	4.3		ns
t <sub>SU</sub>	Setup time	SH/LD high before CLK↑	3.3 V ± 0.3 V	3.5		ns
t <sub>SU</sub>	Setup time	SER before CLK↑	3.3 V ± 0.3 V	4		ns
t <sub>SU</sub>	Setup time	CLK INH before CLK↑	3.3 V ± 0.3 V	1		ns
t <sub>SU</sub>	Setup time	Data before CLK↑	3.3 V ± 0.3 V	2.9		ns
t <sub>SU</sub>	Setup time	CLR inactive before CLK↑	3.3 V ± 0.3 V	4		ns
t <sub>H</sub>	Hold time	SER data after CLK↑	3.3 V ± 0.3 V	0.5		ns
t <sub>H</sub>	Hold time	Parallel data after SH/LD↓	3.3 V ± 0.3 V	0		ns
t <sub>H</sub>	Hold time	SH/LD high after CLK↑	3.3 V ± 0.3 V	0.2		ns
t <sub>H</sub>	Hold time	CLK INH high after CLK↑	3.3 V ± 0.3 V	0.5		ns
t <sub>H</sub>	Hold time	Data after CLK↑	3.3 V ± 0.3 V	1.5		ns



**Figure 5-1. Timing Diagram**

## 5.7 Switching Characteristics

over operating free-air temperature range(unless otherwise noted). See *Parameter Measurement Information*

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAPACITANCE	V <sub>CC</sub>	-40°C to 125°C			UNIT
					MIN	TYP	MAX	
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.2V ± 0.1V	1	27.6	ns	
t <sub>pd</sub>	$\overline{\text{CLR}}$	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.2V ± 0.1V	1	27.6	ns	
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.2V ± 0.1V	1	36.3	ns	
t <sub>pd</sub>	SH/ $\overline{\text{LD}}$	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.2V ± 0.1V	1	40.2	ns	
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.2V ± 0.1V	1	27.6	ns	
t <sub>pd</sub>	$\overline{\text{CLR}}$	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.2V ± 0.1V	1	27.6	ns	
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.2V ± 0.1V	1	36.3	ns	
t <sub>pd</sub>	SH/ $\overline{\text{LD}}$	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.2V ± 0.1V	1	40.2	ns	
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.2V ± 0.1V	1	32.8	ns	
t <sub>pd</sub>	$\overline{\text{CLR}}$	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.2V ± 0.1V	1	32.8	ns	
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.2V ± 0.1V	1	38.5	ns	
t <sub>pd</sub>	SH/ $\overline{\text{LD}}$	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.2V ± 0.1V	1	45.4	ns	
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.5V ± 0.15V	1	27.6	ns	
t <sub>pd</sub>	$\overline{\text{CLR}}$	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.5V ± 0.15V	1	27.6	ns	
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.5V ± 0.15V	1	36.3	ns	
t <sub>pd</sub>	SH/ $\overline{\text{LD}}$	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.5V ± 0.15V	1	40.2	ns	
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.5V ± 0.15V	1	27.6	ns	
t <sub>pd</sub>	$\overline{\text{CLR}}$	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.5V ± 0.15V	1	27.6	ns	
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.5V ± 0.15V	1	36.3	ns	
t <sub>pd</sub>	SH/ $\overline{\text{LD}}$	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.5V ± 0.15V	1	40.2	ns	
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.5V ± 0.15V	1	32.8	ns	
t <sub>pd</sub>	$\overline{\text{CLR}}$	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.5V ± 0.15V	1	32.8	ns	
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.5V ± 0.15V	1	41.5	ns	
t <sub>pd</sub>	SH/ $\overline{\text{LD}}$	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.5V ± 0.15V	1	45.4	ns	
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.8V ± 0.15V	1	27.6	ns	
t <sub>pd</sub>	$\overline{\text{CLR}}$	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.8V ± 0.15V	1	27.6	ns	
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.8V ± 0.15V	1	36.3	ns	
t <sub>pd</sub>	SH/ $\overline{\text{LD}}$	Q <sub>H</sub>	C <sub>L</sub> = 15pF	1.8V ± 0.15V	1	40.2	ns	
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.8V ± 0.15V	1	27.6	ns	
t <sub>pd</sub>	$\overline{\text{CLR}}$	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.8V ± 0.15V	1	27.6	ns	
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.8V ± 0.15V	1	36.3	ns	
t <sub>pd</sub>	SH/ $\overline{\text{LD}}$	Q <sub>H</sub>	C <sub>L</sub> = 30pF	1.8V ± 0.15V	1	40.2	ns	
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.8V ± 0.15V	1	32.8	ns	
t <sub>pd</sub>	$\overline{\text{CLR}}$	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.8V ± 0.15V	1	32.8	ns	
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.8V ± 0.15V	1	41.5	ns	
t <sub>pd</sub>	SH/ $\overline{\text{LD}}$	Q <sub>H</sub>	C <sub>L</sub> = 50pF	1.8V ± 0.15V	1	45.4	ns	
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 15pF	2.5V ± 0.2V	1	16	ns	
t <sub>pd</sub>	$\overline{\text{CLR}}$	Q <sub>H</sub>	C <sub>L</sub> = 15pF	2.5V ± 0.2V	1	16	ns	
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 15pF	2.5V ± 0.2V	1	21	ns	
t <sub>pd</sub>	SH/ $\overline{\text{LD}}$	Q <sub>H</sub>	C <sub>L</sub> = 15pF	2.5V ± 0.2V	1	23.8	ns	
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 30pF	2.5V ± 0.2V	1	16	ns	
t <sub>pd</sub>	$\overline{\text{CLR}}$	Q <sub>H</sub>	C <sub>L</sub> = 30pF	2.5V ± 0.2V	1	16	ns	
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 30pF	2.5V ± 0.2V	1	21	ns	



### 5.7 Switching Characteristics (continued)

over operating free-air temperature range(unless otherwise noted). See *Parameter Measurement Information*

PARAMETER	FROM (INPUT)	TO (OUTPUT)	LOAD CAPACITANCE	V <sub>CC</sub>	-40°C to 125°C			UNIT
					MIN	TYP	MAX	
t <sub>pd</sub>	SH/LD	Q <sub>H</sub>	C <sub>L</sub> = 30pF	2.5V ± 0.2V	1		23.8	ns
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 50pF	2.5V ± 0.2V	1		20	ns
t <sub>pd</sub>	CLR	Q <sub>H</sub>	C <sub>L</sub> = 50pF	2.5V ± 0.2V	1		20	ns
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 50pF	2.5V ± 0.2V	1		25	ns
t <sub>pd</sub>	SH/LD	Q <sub>H</sub>	C <sub>L</sub> = 50pF	2.5V ± 0.2V	1		27.7	ns
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 15pF	3.3V ± 0.3V	1		11.2	ns
t <sub>pd</sub>	CLR	Q <sub>H</sub>	C <sub>L</sub> = 15pF	3.3V ± 0.3V	1		11.2	ns
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 15pF	3.3V ± 0.3V	1		14.5	ns
t <sub>pd</sub>	SH/LD	Q <sub>H</sub>	C <sub>L</sub> = 15pF	3.3V ± 0.3V	1		16.6	ns
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 30pF	3.3V ± 0.3V	1		11.2	ns
t <sub>pd</sub>	CLR	Q <sub>H</sub>	C <sub>L</sub> = 30pF	3.3V ± 0.3V	1		11.2	ns
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 30pF	3.3V ± 0.3V	1		14.5	ns
t <sub>pd</sub>	SH/LD	Q <sub>H</sub>	C <sub>L</sub> = 30pF	3.3V ± 0.3V	1		16.6	ns
t <sub>pd</sub>	CLK	Q <sub>H</sub>	C <sub>L</sub> = 50pF	3.3V ± 0.3V	1		14.5	ns
t <sub>pd</sub>	CLR	Q <sub>H</sub>	C <sub>L</sub> = 50pF	3.3V ± 0.3V	1		14.5	ns
t <sub>pd</sub>	H	Q <sub>H</sub>	C <sub>L</sub> = 50pF	3.3V ± 0.3V	1		17.8	ns
t <sub>pd</sub>	SH/LD	Q <sub>H</sub>	C <sub>L</sub> = 50pF	3.3V ± 0.3V	1		19.9	ns

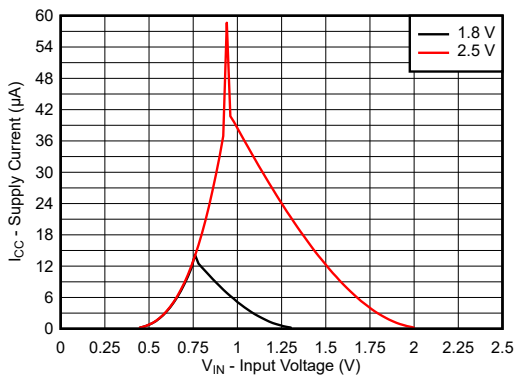
### 5.8 Noise Characteristics

V<sub>CC</sub> = 3.3 V, C<sub>L</sub> = 50 pF, T<sub>A</sub> = 25°C

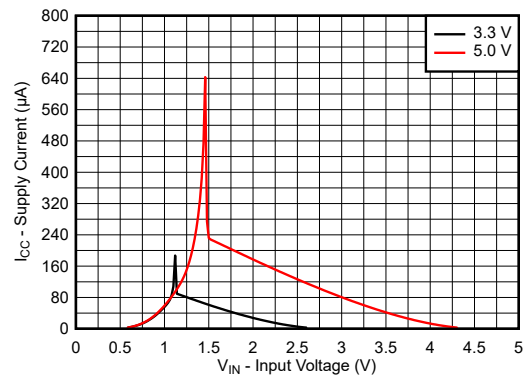
PARAMETER	DESCRIPTION	MIN	TYP	MAX	UNIT
V <sub>OL(P)</sub>	Quiet output, maximum dynamic V <sub>OL</sub>			0.8	V
V <sub>OL(V)</sub>	Quiet output, minimum dynamic V <sub>OL</sub>	-0.8	-0.3		V
V <sub>OH(V)</sub>	Quiet output, minimum dynamic V <sub>OH</sub>	2.2	3.3		V
V <sub>IH(D)</sub>	High-level dynamic input voltage	2.0			V
V <sub>IL(D)</sub>	Low-level dynamic input voltage			0.8	V

### 5.9 Typical Characteristics

T<sub>A</sub> = 25°C (unless otherwise noted)



**Figure 5-2. Supply Current Across Input Voltage 1.8V and 2.5V Supply**



**Figure 5-3. Supply Current Across Input Voltage 3.3V and 5.0V Supply**

## 5.9 Typical Characteristics (continued)

$T_A = 25^\circ\text{C}$  (unless otherwise noted)

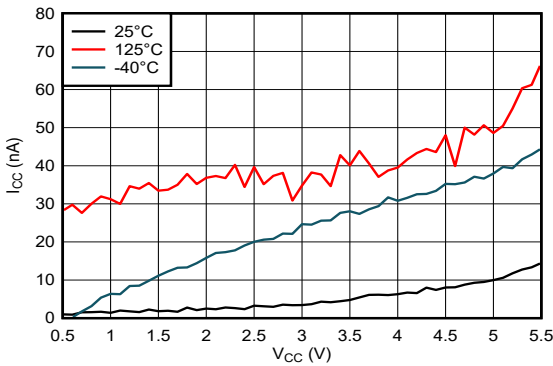


Figure 5-4. Supply Current Across Supply Voltage

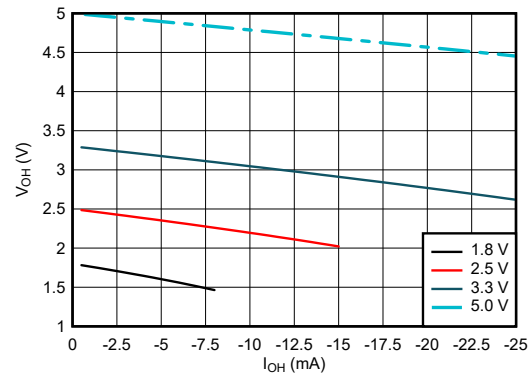


Figure 5-5. Output Voltage vs Current in HIGH State

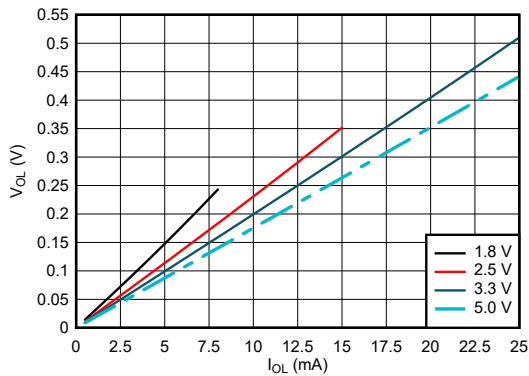


Figure 5-6. Output Voltage vs Current in LOW State

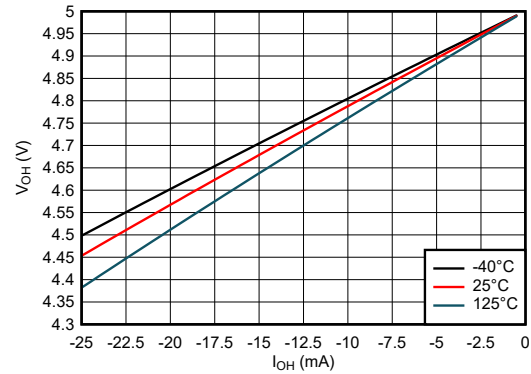


Figure 5-7. Output Voltage vs Current in HIGH State; 5V Supply

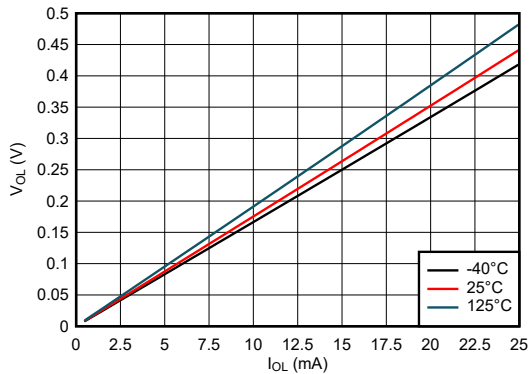


Figure 5-8. Output Voltage vs Current in LOW State; 5V Supply

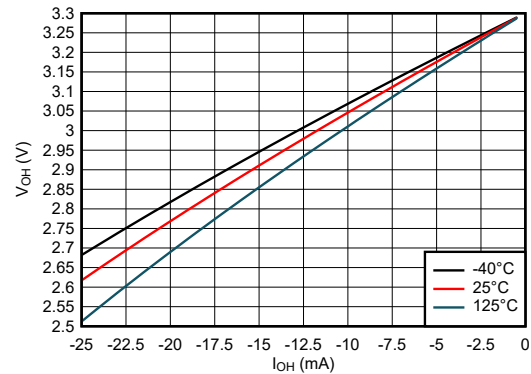
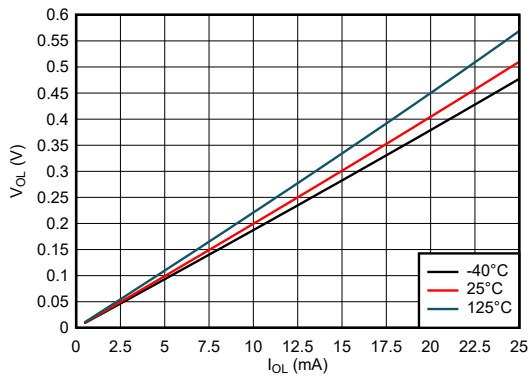


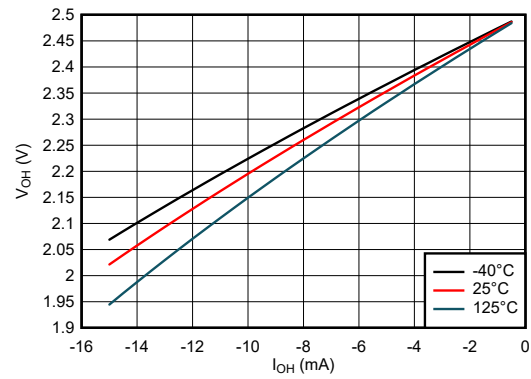
Figure 5-9. Output Voltage vs Current in HIGH State; 3.3V Supply

## 5.9 Typical Characteristics (continued)

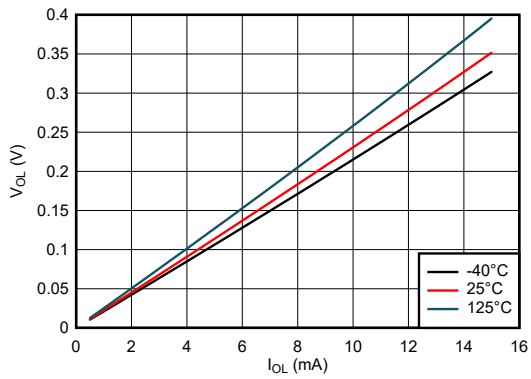
$T_A = 25^\circ\text{C}$  (unless otherwise noted)



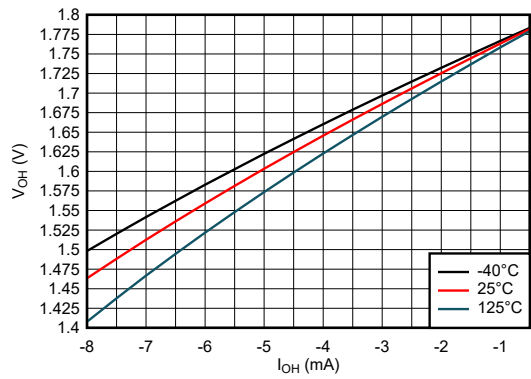
**Figure 5-10. Output Voltage vs Current in LOW State; 3.3V Supply**



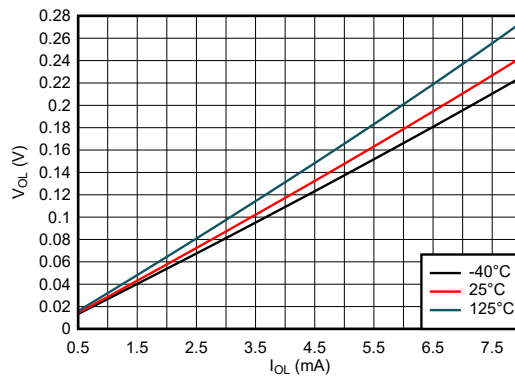
**Figure 5-11. Output Voltage vs Current in HIGH State; 2.5V Supply**



**Figure 5-12. Output Voltage vs Current in LOW State; 2.5V Supply**



**Figure 5-13. Output Voltage vs Current in HIGH State; 1.8V Supply**



**Figure 5-14. Output Voltage vs Current in LOW State; 1.8V Supply**

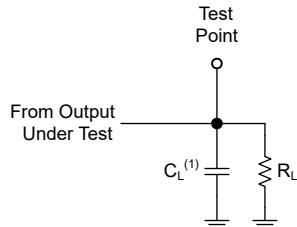
## 6 Parameter Measurement Information

Phase relationships between waveforms were chosen arbitrarily for the examples listed in the following table. All input pulses are supplied by generators having the following characteristics:  $PRR \leq 1\text{MHz}$ ,  $Z_O = 50\Omega$ ,  $t_f \leq 2.5\text{ns}$ .

For clock inputs,  $f_{\text{max}}$  is measured when the input duty cycle is 50%.

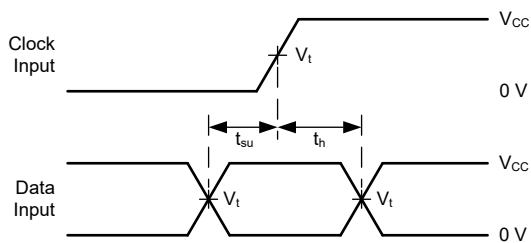
The outputs are measured individually with one input transition per measurement.

$V_{CC}$	$V_t$	$R_L$	$C_L$	$\Delta V$
$1.2\text{V} \pm 0.1\text{V}$	$V_{CC}/2$	$2\text{k}\Omega$	$15\text{pF}$	$0.1\text{V}$
$1.5\text{V} \pm 0.12\text{V}$	$V_{CC}/2$	$2\text{k}\Omega$	$15\text{pF}$	$0.1\text{V}$
$1.8\text{V} \pm 0.15\text{V}$	$V_{CC}/2$	$1\text{k}\Omega$	$30\text{pF}$	$0.15\text{V}$
$2.5\text{V} \pm 0.2\text{V}$	$V_{CC}/2$	$500\Omega$	$30\text{pF}$	$0.15\text{V}$
$2.7\text{V}$	$1.5\text{V}$	$500\Omega$	$50\text{pF}$	$0.3\text{V}$
$3.3\text{V} \pm 0.3\text{V}$	$1.5\text{V}$	$500\Omega$	$50\text{pF}$	$0.3\text{V}$

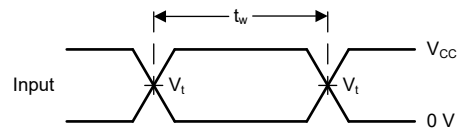


(1)  $C_L$  includes probe and test-fixture capacitance.

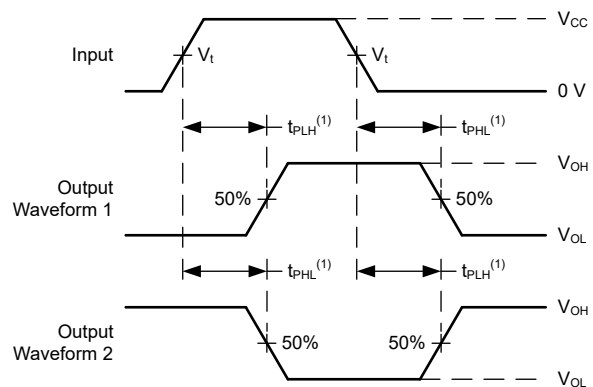
**Figure 6-1. Load Circuit for Push-Pull Outputs**



**Figure 6-3. Voltage Waveforms, Setup and Hold Times**

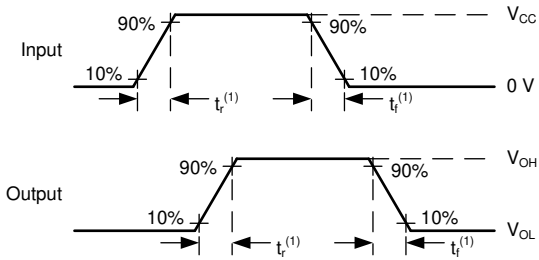


**Figure 6-2. Voltage Waveforms, Pulse Duration**



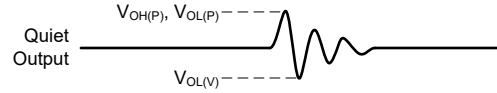
(1) The greater between  $t_{PLH}$  and  $t_{PHL}$  is the same as  $t_{pd}$ .

**Figure 6-4. Voltage Waveforms Propagation Delays**



(1) The greater between  $t_r$  and  $t_f$  is the same as  $t_t$ .

**Figure 6-5. Voltage Waveforms, Input and Output Transition Times**



Noise values measured with all other outputs simultaneously switching.

**Figure 6-6. Voltage Waveforms, Noise**

## 7 Detailed Description

### 7.1 Overview

The SN74LVC166A is a parallel-load 8-bit shift register with asynchronous clear ( $\overline{\text{CLR}}$ ). This parallel-in or serial-in, serial-out shift register features gated clock (CLK, CLK INH) inputs and an overriding clear ( $\overline{\text{CLR}}$ ) input. The parallel-in or serial-in modes are established by the mode select (SH/ $\overline{\text{LD}}$ ) input. When high, SH/ $\overline{\text{LD}}$  enables the serial (SER) data input and couples the eight flip-flops for serial shifting with each clock (CLK) pulse. When low, the parallel (A through H) data inputs are enabled, and synchronous loading occurs on the next clock pulse.

During parallel loading, serial data flow is inhibited. Clocking is accomplished on the rising edge of CLK or CLK INH, permitting one input to be used as a clock-enable or clock-inhibit function. Holding either CLK or CLK INH high inhibits clocking; holding either low enables the other clock input. CLK INH should be changed to the high level only when CLK is high.

$\overline{\text{CLR}}$  overrides all other inputs, including CLK, and resets all flip-flops to zero.

### 7.2 Functional Block Diagram

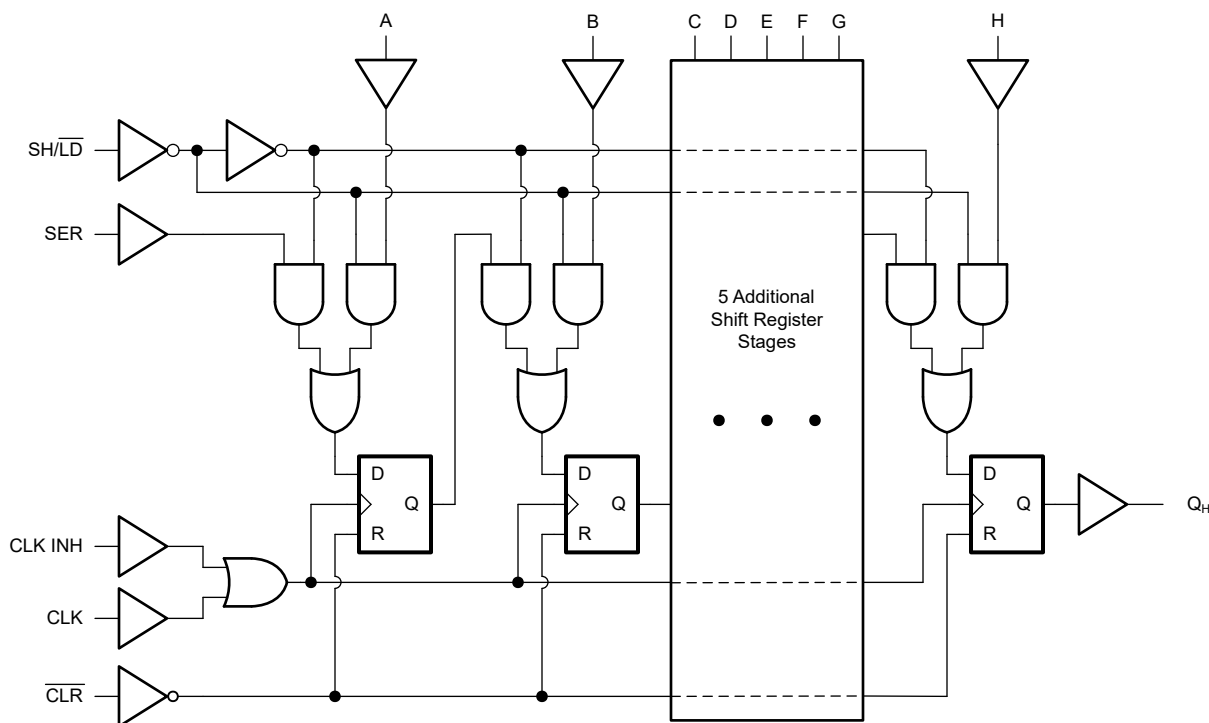


Figure 7-1. Logic Diagram (Positive Logic) for SN74LVC166A

### 7.3 Feature Description

#### 7.3.1 Balanced CMOS Push-Pull Outputs

This device includes balanced CMOS push-pull outputs. The term *balanced* indicates that the device can sink and source similar currents. The drive capability of this device may create fast edges into light loads, so routing and load conditions should be considered to prevent ringing. Additionally, the outputs of this device are capable of driving larger currents than the device can sustain without being damaged. It is important to limit the output power of the device to avoid damage due to overcurrent. The electrical and thermal limits defined in the *Absolute Maximum Ratings* must be followed at all times.

Unused push-pull CMOS outputs must be left disconnected.

### 7.3.2 Latching Logic

This device includes latching logic circuitry. Latching circuits commonly include D-type latches and D-type flip-flops, but include all logic circuits that act as volatile memory.

When the device is powered on, the state of each latch is unknown. There is no default state for each latch at start-up.

The output state of each latching logic circuit only remains stable as long as power is applied to the device within the supply voltage range specified in the *Recommended Operating Conditions* table.

### 7.3.3 Partial Power Down ( $I_{off}$ )

This device includes circuitry to disable all outputs when the supply pin is held at 0V. When disabled, the outputs will neither source nor sink current, regardless of the input voltages applied. The amount of leakage current at each output is defined by the  $I_{off}$  specification in the *Electrical Characteristics* table.

### 7.3.4 Standard CMOS Inputs

This device includes standard CMOS inputs. Standard CMOS inputs are high impedance and are typically modeled as a resistor in parallel with the input capacitance given in the *Electrical Characteristics*. The worst case resistance is calculated with the maximum input voltage, given in the *Absolute Maximum Ratings*, and the maximum input leakage current, given in the *Electrical Characteristics*, using Ohm's law ( $R = V \div I$ ).

Standard CMOS inputs require that input signals transition between valid logic states quickly, as defined by the input transition time or rate in the *Recommended Operating Conditions* table. Failing to meet this specification will result in excessive power consumption and could cause oscillations. More details can be found in [Implications of Slow or Floating CMOS Inputs](#).

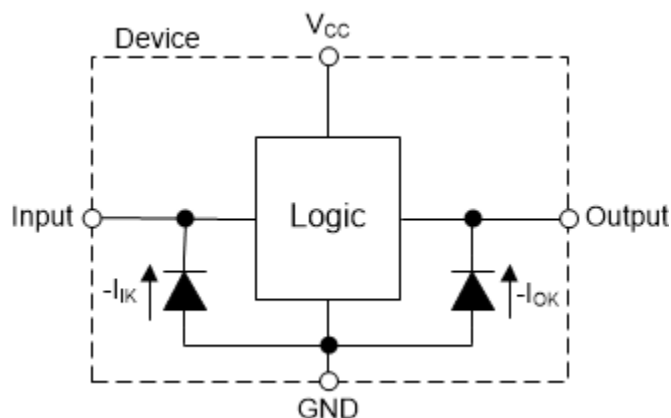
Do not leave standard CMOS inputs floating at any time during operation. Unused inputs must be terminated at  $V_{CC}$  or GND. If a system will not be actively driving an input at all times, then a pull-up or pull-down resistor can be added to provide a valid input voltage during these times. The resistor value will depend on multiple factors; a 10k $\Omega$  resistor, however, is recommended and will typically meet all requirements.

### 7.3.5 Clamp Diode Structure

Figure 7-2 shows the inputs and outputs to this device have negative clamping diodes only.

**CAUTION**

Voltages beyond the values specified in the *Absolute Maximum Ratings* table can cause damage to the device. The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.



**Figure 7-2. Electrical Placement of Clamping Diodes for Each Input and Output**

## 7.4 Device Functional Modes

Table 7-1 lists the functional modes of the SN74LVC166A.

**Table 7-1. Operating Mode Table**

INPUTS <sup>(1)</sup>			FUNCTION
SH/LD	CLK	CLK INH	
L	X	X	Parallel load <sup>(2)</sup>
H	H	X	No change
H	X	H	No change
H	L	↑	Shift <sup>(3)</sup>
H	↑	L	Shift <sup>(3)</sup>

- (1) H = High voltage level, L = Low voltage level, X = Don't care, ↑ = Low to high transition
- (2) Parallel load : Values at inputs A through H are loaded to respective internal registers synchronously with the clock.
- (3) Shift : Content of each internal register shifts towards serial output Q<sub>H</sub> synchronously with the clock. Data at SER is shifted into the first register.

**Table 7-2. Output Function Table**

INTERNAL REGISTERS <sup>(1) (2)</sup>		OUTPUTS <sup>(3)</sup>
A — G	H	Q
X	L	L
X	H	H

- (1) Internal registers refer to the shift registers inside the device. These values are set by loading data from the parallel or serial inputs.
- (2) H = High voltage level, L = Low voltage level, X = Don't care
- (3) H = Driving high, L = Driving low



## 8 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.

### 8.1 Application Information

In this application, the SN74LVC166A is used to increase the number of inputs on a microcontroller. Unlike other I/O expanders, the SN74LVC166A does not need a communication interface for control. It can be easily operated with simple GPIO pins.

At power-up, the initial states of the internal shift registers are unknown. To give them a defined state of zero, the device can be cleared by applying a low signal to the clear ( $\overline{\text{CLR}}$ ) input. Alternatively, data can be loaded in directly by switching to load mode ( $\text{SH}/\overline{\text{LD}}$  = low), then pulsing the clock (CLK) input once.

### 8.2 Typical Application

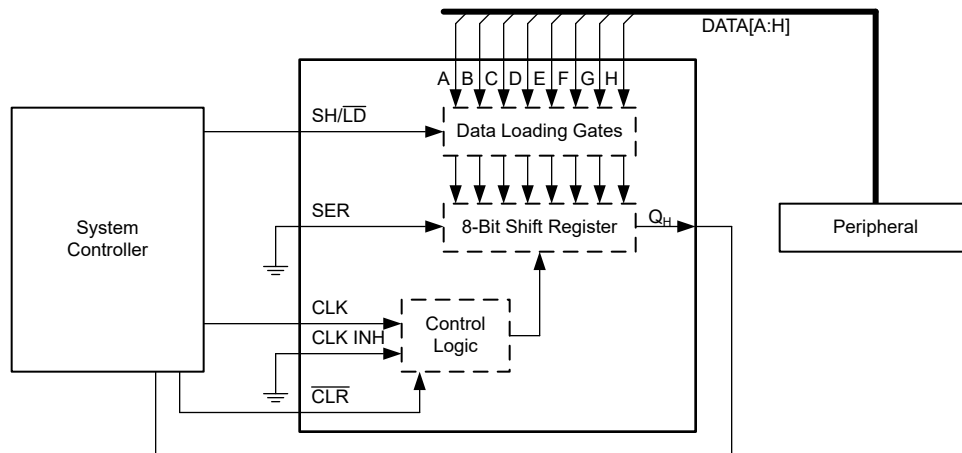


Figure 8-1. Typical Application Block Diagram

#### 8.2.1 Design Requirements

##### 8.2.1.1 Power Considerations

Ensure the desired supply voltage is within the range specified in the *Recommended Operating Conditions*. The supply voltage sets the device's electrical characteristics of the device as described in the *Electrical Characteristics* section.

The positive voltage supply must be capable of sourcing current equal to the total current to be sourced by all outputs of the SN74LVC166A plus the maximum static supply current,  $I_{CC}$ , listed in the *Electrical Characteristics*, and any transient current required for switching. The logic device can only source as much current that is provided by the positive supply source. Ensure the maximum total current through  $V_{CC}$  listed in the *Absolute Maximum Ratings* is not exceeded.

The ground must be capable of sinking current equal to the total current to be sunk by all outputs of the SN74LVC166A plus the maximum supply current,  $I_{CC}$ , listed in the *Electrical Characteristics*, and any transient current required for switching. The logic device can only sink as much current that can be sunk into its ground connection. Ensure the maximum total current through GND listed in the *Absolute Maximum Ratings* is not exceeded.

The SN74LVC166A can drive a load with a total capacitance less than or equal to 50pF while still meeting all of the data sheet specifications. Larger capacitive loads can be applied; however, it is not recommended to exceed 50pF.

The SN74LVC166A can drive a load with total resistance described by  $R_L \geq V_O / I_O$ , with the output voltage and current defined in the *Electrical Characteristics* table with  $V_{OH}$  and  $V_{OL}$ . When outputting in the HIGH state, the output voltage in the equation is defined as the difference between the measured output voltage and the supply voltage at the  $V_{CC}$  pin.

Total power consumption can be calculated using the information provided in [CMOS Power Consumption and Cpd Calculation](#).

Thermal increase can be calculated using the information provided in [Thermal Characteristics of Standard Linear and Logic \(SLL\) Packages and Devices](#).

#### CAUTION

The maximum junction temperature,  $T_{J(max)}$  listed in the *Absolute Maximum Ratings*, is an additional limitation to prevent damage to the device. Do not violate any values listed in the *Absolute Maximum Ratings*. These limits are provided to prevent damage to the device.

#### 8.2.1.2 Input Considerations

Input signals must cross  $V_{IL(max)}$  to be considered a logic LOW, and  $V_{IH(min)}$  to be considered a logic HIGH. Do not exceed the maximum input voltage range found in the *Absolute Maximum Ratings*.

Unused inputs must be terminated to either  $V_{CC}$  or ground. The unused inputs can be directly terminated if the input is completely unused, or they can be connected with a pull-up or pull-down resistor if the input will be used sometimes, but not always. A pull-up resistor is used for a default state of HIGH, and a pull-down resistor is used for a default state of LOW. The drive current of the controller, leakage current into the SN74LVC166A (as specified in the *Electrical Characteristics*), and the desired input transition rate limits the resistor size. A 10k $\Omega$  resistor value is often used due to these factors.

The SN74LVC166A has CMOS inputs and thus requires fast input transitions to operate correctly, as defined in the *Recommended Operating Conditions* table. Slow input transitions can cause oscillations, additional power consumption, and reduction in device reliability.

Refer to the *Feature Description* section for additional information regarding the inputs for this device.

#### 8.2.1.3 Output Considerations

The positive supply voltage is used to produce the output HIGH voltage. Drawing current from the output will decrease the output voltage as specified by the  $V_{OH}$  specification in the *Electrical Characteristics*. The ground voltage is used to produce the output LOW voltage. Sinking current into the output will increase the output voltage as specified by the  $V_{OL}$  specification in the *Electrical Characteristics*.

Push-pull outputs that could be in opposite states, even for a very short time period, should never be connected directly together. This can cause excessive current and damage to the device.

Two channels within the same device with the same input signals can be connected in parallel for additional output drive strength.

Unused outputs can be left floating. Do not connect outputs directly to  $V_{CC}$  or ground.

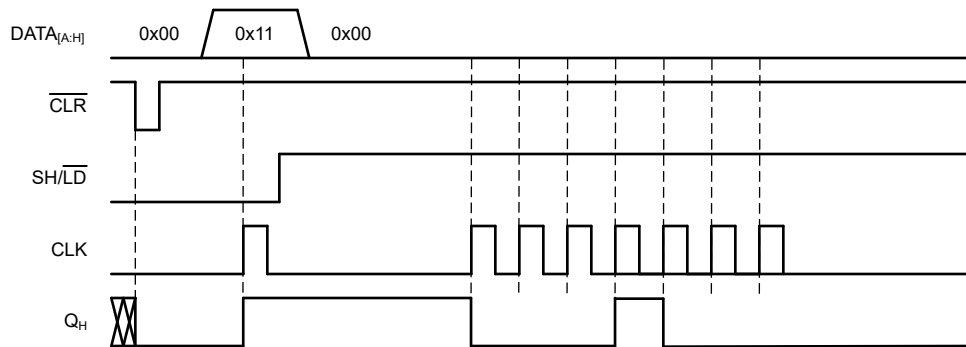
Refer to the *Feature Description* section for additional information regarding the outputs for this device.

### 8.2.2 Detailed Design Procedure

1. Add a decoupling capacitor from  $V_{CC}$  to GND. The capacitor needs to be placed physically close to the device and electrically close to both the  $V_{CC}$  and GND pins. An example layout is shown in the *Layout* section.

2. Ensure the capacitive load at the output is  $\leq 50\text{pF}$ . This is not a hard limit; by design, however, it will optimize performance. This can be accomplished by providing short, appropriately sized traces from the SN74LVC166A to one or more of the receiving devices.
3. Ensure the resistive load at the output is larger than  $(V_{CC} / I_{O(max)})\Omega$ . Doing this will prevent the maximum output current from the *Absolute Maximum Ratings* from being violated. Most CMOS inputs have a resistive load measured in  $\text{M}\Omega$ ; much larger than the minimum calculated previously.
4. Thermal issues are rarely a concern for logic gates; the power consumption and thermal increase, however, can be calculated using the steps provided in the application report, [CMOS Power Consumption and Cpd Calculation](#).

### 8.2.3 Application Curves



**Figure 8-2. Application Timing Diagram**

### 8.3 Power Supply Recommendations

The power supply can be any voltage between the minimum and maximum supply voltage rating listed in the *Recommended Operating Conditions*.

During startup, the power supply should ramp within the provided power-up ramp rate range in the *Recommended Operating Conditions* table.

Each  $V_{CC}$  terminal should have a good bypass capacitor to prevent power disturbance. For the SN74LVC166A, a  $0.1\mu\text{F}$  bypass capacitor is recommended. To reject different frequencies of noise, use multiple bypass capacitors in parallel. Capacitors with values of  $0.1\mu\text{F}$  and  $1\mu\text{F}$  are commonly used in parallel.

### 8.4 Layout

#### 8.4.1 Layout Guidelines

When using multiple-input and multiple-channel logic devices, inputs must never be left floating. In many cases, functions or parts of functions of digital logic devices are unused; for example, when only two inputs of a triple-input AND gate are used or only 3 of the 4 buffer gates are used. Such unused input pins must not be left unconnected because the undefined voltages at the outside connections result in undefined operational states. All unused inputs of digital logic devices must be connected to a logic high or logic low voltage, as defined by the input voltage specifications, to prevent them from floating. The logic level that must be applied to any particular unused input depends on the function of the device. Generally, the inputs are tied to GND or  $V_{CC}$ , whichever makes more sense for the logic function or is more convenient.

### 8.4.2 Layout Example

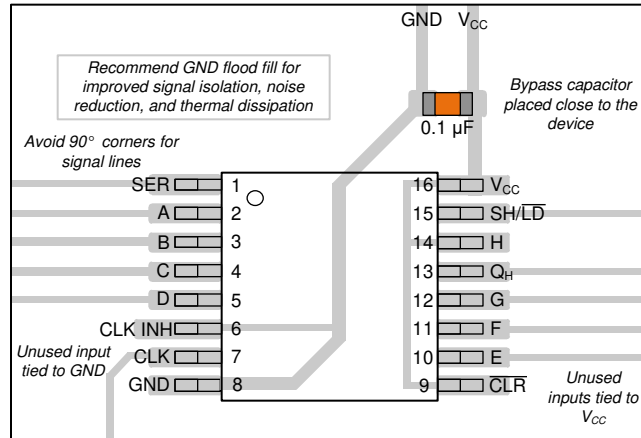


Figure 8-3. Example Layout for the SN74LVC166A

## 9 Device and Documentation Support

TI offers an extensive line of development tools. Tools and software to evaluate the performance of the device, generate code, and develop solutions are listed below.

### 9.1 Documentation Support

#### 9.1.1 Related Documentation

For related documentation, see the following:

- Texas Instruments, [CMOS Power Consumption and Cpd Calculation application note](#)
- Texas Instruments, [Designing With Logic application note](#)
- Texas Instruments, [Thermal Characteristics of Standard Linear and Logic \(SLL\) Packages and Devices application note](#)
- Texas Instruments, [Implications of Slow or Floating CMOS Inputs application note](#)

### 9.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on [ti.com](http://ti.com). Click on *Notifications* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 9.3 Support Resources

TI E2E™ [support forums](#) are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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### 9.4 Trademarks

TI E2E™ is a trademark of Texas Instruments.  
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### 9.5 Electrostatic Discharge Caution



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

### 9.6 Glossary

[TI Glossary](#) This glossary lists and explains terms, acronyms, and definitions.

## 10 Revision History

DATE	REVISION	NOTES
May 2024	*	Initial Release

## 11 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 finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN74LVC166ABQBR	ACTIVE	WQFN	BQB	16	3000	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-40 to 125	LC166A	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.

**OBSOLETE:** TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

**RoHS Exempt:** TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

**Green:** TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

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

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