

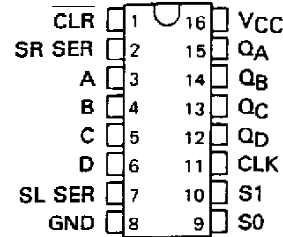
**SN54194, SN54LS194A, SN54S194,  
SN74194, SN74LS194A, SN74S194**  
**4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS**

MARCH 1974—REVISED MARCH 1988

- Parallel Inputs and Outputs
- Four Operating Modes:  
Synchronous Parallel Load  
Right Shift  
Left Shift  
Do Nothing
- Positive Edge-Triggered Clocking
- Direct Overriding Clear

SN54194, SN54LS194A, SN54S194 . . . J OR W PACKAGE  
SN74194 . . . N PACKAGE  
SN74LS194A, SN74S194 . . . D OR N PACKAGE

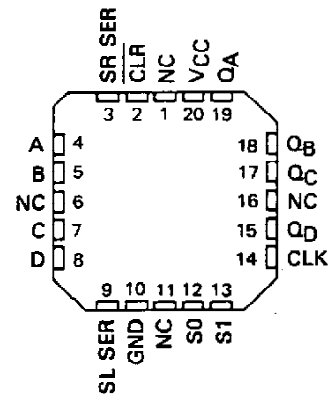
(TOP VIEW)



TYPE	TYPICAL MAXIMUM CLOCK FREQUENCY	TYPICAL POWER DISSIPATION
'194	36 MHz	195 mW
'LS194A	36 MHz	75 mW
'S194	105 MHz	425 mW

SN54LS194A, SN54S194 . . . FK PACKAGE

(TOP VIEW)



NC - No internal connection

**description**

These bidirectional shift registers are designed to incorporate virtually all of the features a system designer may want in a shift register. The circuit contains 46 equivalent gates and features parallel inputs, parallel outputs, right-shift and left-shift serial inputs, operating-mode-control inputs, and a direct overriding clear line. The register has four distinct modes of operation, namely:

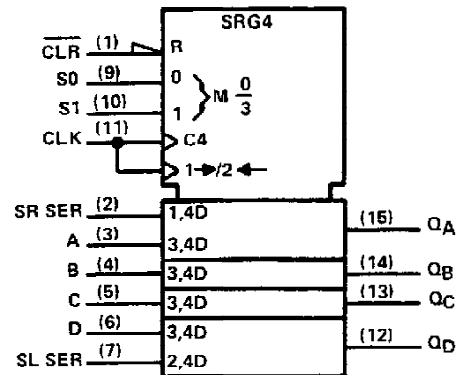
- Inhibit clock (do nothing)
- Shift right (in the direction Q<sub>A</sub> toward Q<sub>D</sub>)
- Shift left (in the direction Q<sub>D</sub> toward Q<sub>A</sub>)
- Parallel (broadside) load

Synchronous parallel loading is accomplished by applying the four bits of data and taking both mode control inputs, S0 and S1, high. The data are loaded into the associated flip-flops and appear at the outputs after the positive transition of the clock input. During loading, serial data flow is inhibited.

Shift right is accomplished synchronously with the rising edge of the clock pulse when S0 is high and S1 is low. Serial data for this mode is entered at the shift-right data input. When S0 is low and S1 is high, data shifts left synchronously and new data is entered at the shift-left serial input.

Clocking of the shift register is inhibited when both mode control inputs are low. The mode controls of the SN54194/SN74194 should be changed only while the clock input is high.

**logic symbol†**



†This symbol is in accordance with ANSI/IEEE Std. 91-1984 and IEC Publication 617-12. Pin numbers shown are for D, J, N, and W packages.

PRODUCTION DATA documents contain information current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.



POST OFFICE BOX 655012 • DALLAS, TEXAS 75265

**SN54194, SN54LS194A, SN54S194  
SN74194, SN74LS194A, SN74S194  
4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS**

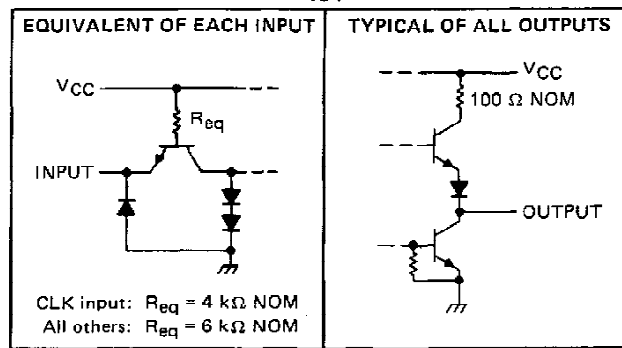
**FUNCTION TABLE**

CLEAR	MODE		CLOCK	INPUTS				OUTPUTS					
				SERIAL		PARALLEL		Q <sub>A</sub>	Q <sub>B</sub>	Q <sub>C</sub>	Q <sub>D</sub>		
	LEFT	RIGHT		A	B	C	D						
L	X	X	X	X	X	X	X	X	X	L	L	L	L
H	X	X	L	X	X	X	X	X	X	Q <sub>A0</sub>	Q <sub>B0</sub>	Q <sub>C0</sub>	Q <sub>D0</sub>
H	H	H	↑	X	X	a	b	c	d	a	b	c	d
H	L	H	↑	X	H	x	x	x	x	H	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Cn</sub>
H	L	H	↑	X	L	X	X	X	X	L	Q <sub>An</sub>	Q <sub>Bn</sub>	Q <sub>Cn</sub>
H	H	L	↑	H	X	X	X	X	X	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	H
H	H	L	↑	L	X	X	X	X	X	Q <sub>Bn</sub>	Q <sub>Cn</sub>	Q <sub>Dn</sub>	L
H	L	L	X	X	X	X	X	X	X	Q <sub>A0</sub>	Q <sub>B0</sub>	Q <sub>C0</sub>	Q <sub>D0</sub>

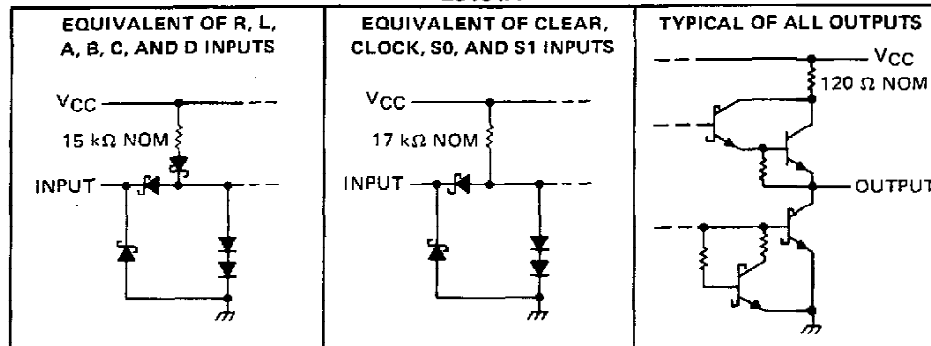
H = high level (steady state)  
L = low level (steady state)  
X = irrelevant (any input, including transitions)  
↑ = transition from low to high level  
a, b, c, d = the level of steady-state input at inputs A, B, C, or D, respectively.  
Q<sub>A0</sub>, Q<sub>B0</sub>, Q<sub>C0</sub>, Q<sub>D0</sub> = the level of Q<sub>A</sub>, Q<sub>B</sub>, Q<sub>C</sub>, or Q<sub>D</sub>, respectively, before the indicated steady-state input conditions were established.  
Q<sub>An</sub>, Q<sub>Bn</sub>, Q<sub>Cn</sub>, Q<sub>Dn</sub> = the level of Q<sub>A</sub>, Q<sub>B</sub>, Q<sub>C</sub>, respectively, before the most-recent ↑ transition of the clock.

schematics of inputs and outputs

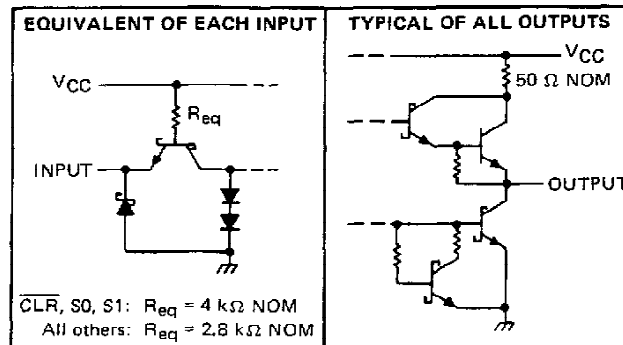
'194



'LS194A



'S194

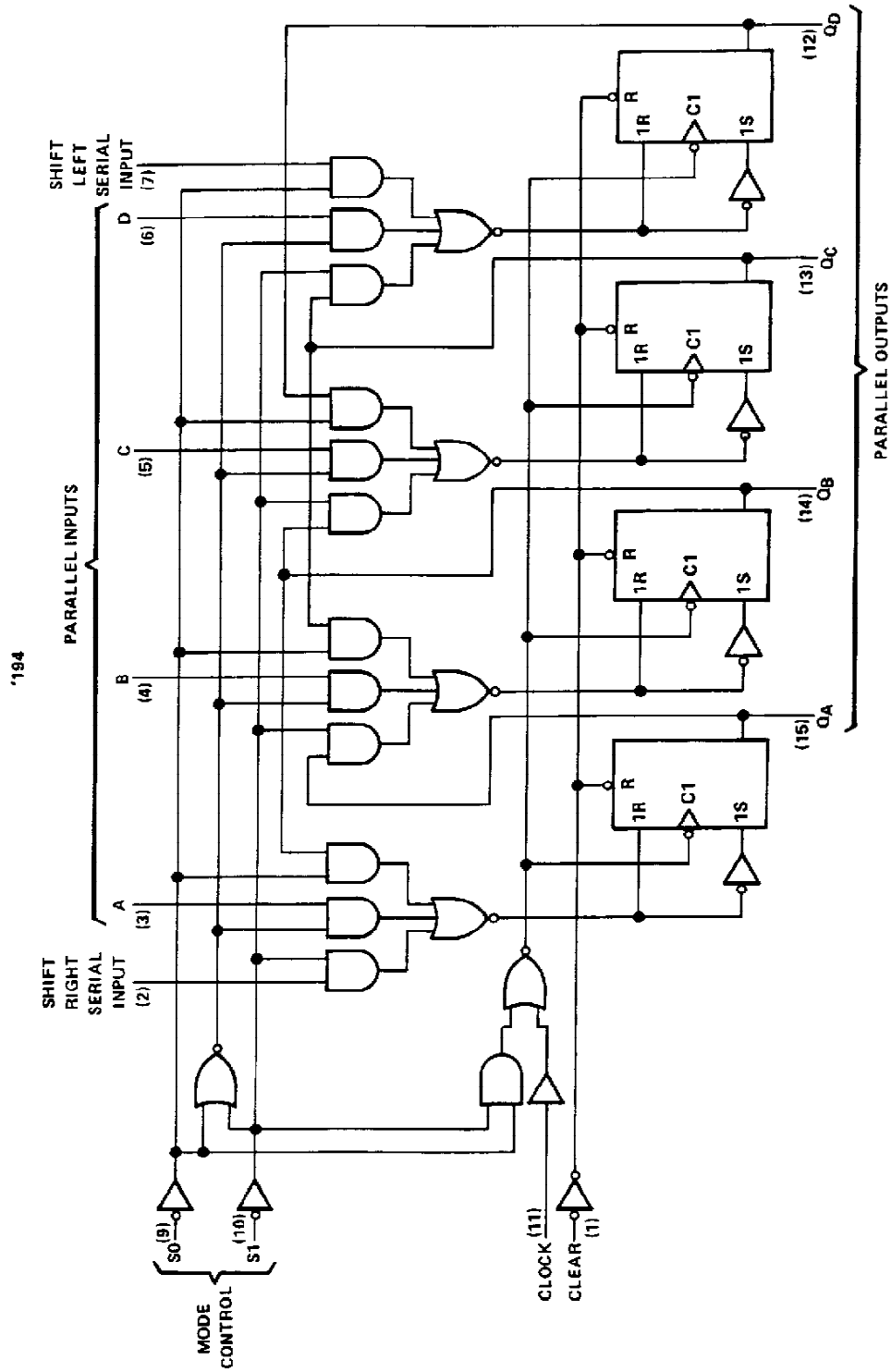


**TEXAS INSTRUMENTS**

POST OFFICE BOX 655012 • DALLAS, TEXAS 75265

SN54194, SN74194  
4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS

logic diagrams (positive logic)



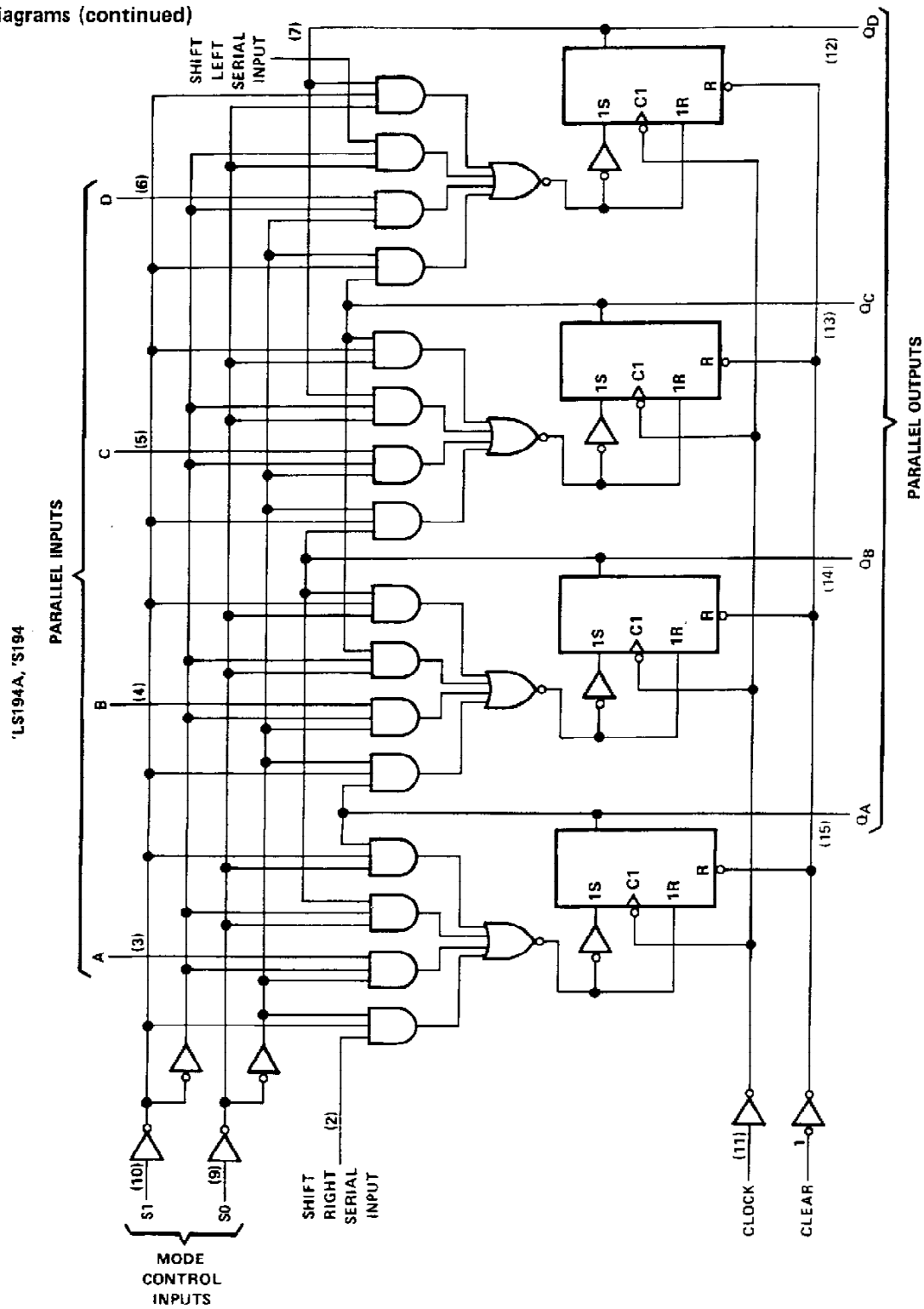
Pin numbers shown are for D, J, N, and W packages.

TEXAS  
INSTRUMENTS

POST OFFICE BOX 655012 • DALLAS, TEXAS 75265

**SN54LS194A, SN54S194  
SN74LS194A, SN74S194  
4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS**

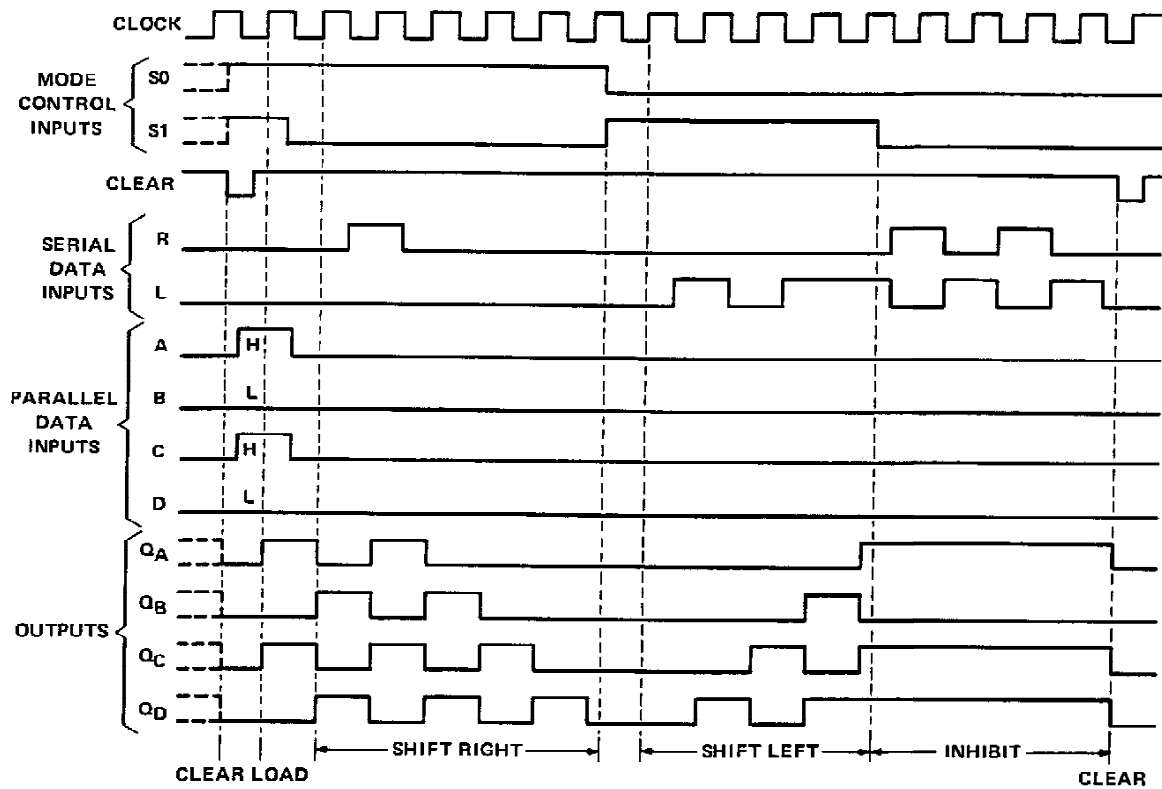
logic diagrams (continued)



Pin numbers shown on logic notation are for D, J, or N, and W packages.

SN54194, SN54LS194A, SN54S194,  
SN74194, SN74LS194A, SN74S194  
4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS

typical clear, load, right-shift, left-shift, inhibit, and clear sequences



TEXAS  
INSTRUMENTS

POST OFFICE BOX 655012 • DALLAS, TEXAS 75265

# SN54194, SN74194 4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS

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

Supply voltage, $V_{CC}$ (see Note 1)	7 V
Input voltage	5.5 V
Operating free-air temperature range: SN54194	-55°C to 125°C
SN74194	0°C to 70°C
Storage temperature range	-65°C to 150°C

NOTE 1: Voltage values are with respect to network ground terminal.

recommended operating conditions

	SN54194			SN74194			UNIT
	MIN	NOM	MAX	MIN	NOM	MAX	
Supply voltage, $V_{CC}$	4.5	5	5.5	4.75	5	5.25	V
High-level output current, $I_{OH}$			-800			-800	$\mu$ A
Low-level output current, $I_{OL}$			16			16	mA
Clock frequency, $f_{clock}$	0		25	0		25	MHz
Width of clock or clear pulse, $t_w$	20			20			ns
Setup time, $t_{SU}$	Mode control			30			ns
	Serial and parallel data			20			ns
	Clear inactive-state			25			ns
Hold time at any input, $t_H$	0			0			ns
Operating free-air temperature, $T_A$	-55		125	0		70	°C

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

PARAMETER	TEST CONDITIONS†	SN54194			SN74194			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
$V_{IH}$ High-level input voltage		2			2			V
$V_{IL}$ Low-level input voltage				0.8			0.8	V
$V_{IK}$ Input clamp voltage	$V_{CC} = \text{MIN}, I_I = -12 \text{ mA}$			-1.5			-1.5	V
$V_{OH}$ High-level output voltage	$V_{CC} = \text{MIN}, V_{IH} = 2 \text{ V}, V_{IL} = 0.8 \text{ V}, I_{OH} = -800 \mu\text{A}$	2.4	3.4		2.4	3.4		V
$V_{OL}$ Low-level output voltage	$V_{CC} = \text{MIN}, V_{IH} = 2 \text{ V}, V_{IL} = 0.8 \text{ V}, I_{OL} = 16 \text{ mA}$		0.2	0.4		0.2	0.4	V
$I_I$ Input current at maximum input voltage	$V_{CC} = \text{MAX}, V_I = 5.5 \text{ V}$			1			1	mA
$I_{IH}$ High-level input current	$V_{CC} = \text{MAX}, V_I = 2.4 \text{ V}$			40			40	$\mu$ A
$I_{IL}$ Low-level input current	$V_{CC} = \text{MAX}, V_I = 0.4 \text{ V}$			-1.6			-1.6	mA
$I_{OS}$ Short-circuit output current§	$V_{CC} = \text{MAX}$	-20		-57	-18		-57	mA
$I_{CC}$ Supply current	$V_{CC} = \text{MAX}, \text{ See Note 2}$		39	63		39	63	mA

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡All typical values are at  $V_{CC} = 5 \text{ V}, T_A = 25^\circ\text{C}$ .

§Not more than one output should be shorted at a time.

NOTE 2: With all outputs open, inputs A through D grounded, and 4.5 V applied to S0, S1, clear, and the serial inputs,  $I_{CC}$  is tested with a momentary GND, then 4.5 V applied to clock.

switching characteristics,  $V_{CC} = 5 \text{ V}, T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$f_{max}$ Maximum clock frequency		25	36		MHz
$t_{PHL}$ Propagation delay time, high-to-low-level output from clear	$C_L = 15 \text{ pF}, R_L = 400 \Omega, \text{ See Figure 1}$		19	30	ns
$t_{PLH}$ Propagation delay time, low-to-high-level output from clock			14	22	ns
$t_{PHL}$ Propagation delay time, high-to-low-level output from clock			17	26	ns

TEXAS  
INSTRUMENTS

POST OFFICE BOX 655012 • DALLAS, TEXAS 75265

# SN54LS194A, SN74LS194A

## 4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS

### absolute maximum ratings over operating free-air temperature range (unless otherwise noted)

Supply voltage, $V_{CC}$ (see Note 1)	7 V
Input voltage	7 V
Operating free-air temperature range: SN54LS194A	$-55^{\circ}\text{C}$ to $125^{\circ}\text{C}$
SN74LS194A	$0^{\circ}\text{C}$ to $70^{\circ}\text{C}$
Storage temperature range	$-65^{\circ}\text{C}$ to $150^{\circ}\text{C}$

NOTE 1: Voltage values are with respect to network ground terminal.

### recommended operating conditions

	SN54LS194A			SN74LS194A			UNIT
	MIN	NOM	MAX	MIN	NOM	MAX	
Supply voltage, $V_{CC}$	4.5	5	5.5	4.75	5	5.25	V
High-level output current, $I_{OH}$			-400			-400	$\mu\text{A}$
Low-level output current, $I_{OL}$			4			8	mA
Clock frequency, $f_{\text{clock}}$	0		25	0		25	MHz
Width of clock or clear pulse, $t_w$	20			20			ns
Setup time, $t_{su}$	Mode control			30			ns
	Serial and parallel data			20			ns
	Clear inactive-state			25			ns
Hold time at any input, $t_h$	0			0			ns
Operating free-air temperature, $T_A$	-55		125	0		70	$^{\circ}\text{C}$

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

PARAMETER	TEST CONDITIONS <sup>†</sup>	SN54LS194A			SN74LS194A			UNIT
		MIN	TYP <sup>‡</sup>	MAX	MIN	TYP <sup>‡</sup>	MAX	
$V_{IH}$ High-level input voltage		2			2			V
$V_{IL}$ Low-level input voltage				0.7			0.8	V
$V_I$ Input clamp voltage	$V_{CC} = \text{MIN}$ , $I_I = -18 \text{ mA}$			-1.5			-1.5	V
$V_{OH}$ High-level output voltage	$V_{CC} = \text{MIN}$ , $V_{IH} = 2 \text{ V}$ , $V_{IL} = V_{IL \text{ max}}$ , $I_{OH} = -400 \mu\text{A}$	2.5	3.5		2.7	3.5		V
$V_{OL}$ Low-level output voltage	$V_{CC} = \text{MIN}$ , $V_{IH} = 2 \text{ V}$ , $V_{IL} = V_{IL \text{ max}}$		0.25	0.4		0.25	0.4	V
						0.35	0.5	
$I_I$ Input current at maximum input voltage	$V_{CC} = \text{MAX}$ , $V_I = 7 \text{ V}$			0.1			0.1	mA
$I_{IH}$ High-level input current	$V_{CC} = \text{MAX}$ , $V_I = 2.7 \text{ V}$			20			20	$\mu\text{A}$
$I_{IL}$ Low-level input current	$V_{CC} = \text{MAX}$ , $V_I = 0.4 \text{ V}$			-0.4			-0.4	mA
$I_{OS}$ Short-circuit output current <sup>§</sup>	$V_{CC} = \text{MAX}$	-20		-100	-20		-100	mA
$I_{CC}$ Supply current	$V_{CC} = \text{MAX}$ , See Note 2		15	23		15	23	mA

<sup>†</sup> For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

<sup>‡</sup> All typical values are at  $V_{CC} = 5 \text{ V}$ ,  $T_A = 25^{\circ}\text{C}$ .

<sup>§</sup> Not more than one output should be shorted at a time, and duration of the short-circuit should not exceed one second.

NOTE 2: With all outputs open, inputs A through D grounded, and 4.5 V applied to S0, S1, clear, and the serial inputs,  $I_{CC}$  is tested with a momentary GND, then 4.5 V, applied to clock.

### switching characteristics, $V_{CC} = 5 \text{ V}$ , $T_A = 25^{\circ}\text{C}$

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
$f_{\text{max}}$ Maximum clock frequency	$C_L = 15 \text{ pF}$ , $R_L = 2 \text{ k}\Omega$ , See Figure 1	25	36		MHz
$t_{PHL}$ Propagation delay time, high-to-low-level output from clear			19	30	ns
$t_{PLH}$ Propagation delay time, low-to-high level output from clock			14	22	ns
$t_{PHL}$ Propagation delay time, high-to-low level output from clock			17	26	ns



# SN54S194, SN74S194 4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS

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

Supply voltage, $V_{CC}$ (see Note 1)	7 V
Input voltage	5.5 V
Operating free-air temperature range: SN54S194	-55°C to 125°C
SN74S194	0°C to 70°C
Storage temperature range	-65°C to 150°C

NOTE 1: Voltage values are with respect to network ground terminal.

recommended operating conditions

	SN54S194			SN74S194			UNIT
	MIN	NOM	MAX	MIN	NOM	MAX	
Supply voltage, $V_{CC}$	4.5	5	5.5	4.75	5	5.25	V
High-level output current, $I_{OH}$			-1			-1	mA
Low-level output current, $I_{OL}$			20			20	mA
Clock frequency, $f_{clock}$	0		70	0		70	MHz
Width of clock pulse, $t_w(\text{clock})$	7			7			ns
Width of clear pulse, $t_w(\text{clear})$	12			12			ns
Setup time, $t_{su}$	Mode control		11			11	ns
	Serial and parallel data		5			5	ns
	Clear inactive-state		9			9	ns
Hold time at any input, $t_h$		3			3		ns
Operating free-air temperature, $T_A$		-55	125		0	70	°C

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

PARAMETER	TEST CONDITIONS†	SN54S194			SN74S194			UNIT
		MIN	TYP‡	MAX	MIN	TYP‡	MAX	
$V_{IH}$ High-level input voltage		2			2			V
$V_{IL}$ Low-level input voltage				0.8			0.8	V
$V_{IK}$ Input clamp voltage	$V_{CC} = \text{MIN}$ , $I_I = -18 \text{ mA}$			-1.2			-1.2	V
$V_{OH}$ High-level output voltage	$V_{CC} = \text{MIN}$ , $V_{IH} = 2 \text{ V}$ , $V_{IL} = 0.8 \text{ V}$ , $I_{OH} = -1 \text{ mA}$	2.5	3.4		2.7	3.4		V
$V_{OL}$ Low-level output voltage	$V_{CC} = \text{MIN}$ , $V_{IH} = 2 \text{ V}$ , $V_{IL} = 0.8 \text{ V}$ , $I_{OL} = 20 \text{ mA}$			0.5			0.5	V
$I_I$ Input current at maximum input voltage	$V_{CC} = \text{MAX}$ , $V_I = 5.5 \text{ V}$			1			1	mA
$I_{IH}$ High-level input current	$V_{CC} = \text{MAX}$ , $V_I = 2.7 \text{ V}$			50			50	µA
$I_{IL}$ Low-level input current	$V_{CC} = \text{MAX}$ , $V_I = 0.5 \text{ V}$			-2			-2	mA
$I_{OS}$ Short-circuit output current§	$V_{CC} = \text{MAX}$	-40		-100	-40		-100	mA
$I_{CC}$ Supply current	$V_{CC} = \text{MAX}$ , See Note 2		85	135		85	135	mA
	$V_{CC} = \text{MAX}$ , $T_A = 125^\circ\text{C}$ , See Note 2			110				
	W package							

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

‡ All typical values are at  $V_{CC} = 5 \text{ V}$ ,  $T_A = 25^\circ\text{C}$ .

§ Not more than one output should be shorted at a time, and duration of the short-circuit should not exceed one second.

NOTE 2: With all outputs open, inputs A through D grounded, and 4.5 V applies to S0, S1, clear, and the serial inputs,  $I_{CC}$  is tested with a momentary GND, then 4.5 V, applied to clock.

switching characteristics,  $V_{CC} = 5 \text{ V}$ ,  $T_A = 25^\circ\text{C}$

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT	
$f_{max}$ Maximum clock frequency	$C_L = 15 \text{ pF}$ , $R_L = 280 \Omega$ , See Figure 1	70	106		MHz	
$t_{PHL}$ Propagation delay time, high-to-low-level output from clear			12.5	18.5	ns	
$t_{PLH}$ Propagation delay time, low-to-high-level output from clock			4	8	12	ns
$t_{PHL}$ Propagation delay time, high-to-low-level output from clock			4	11	16.5	ns

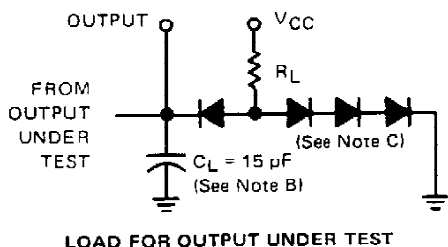
TEXAS  
INSTRUMENTS

POST OFFICE BOX 655012 • DALLAS, TEXAS 75265



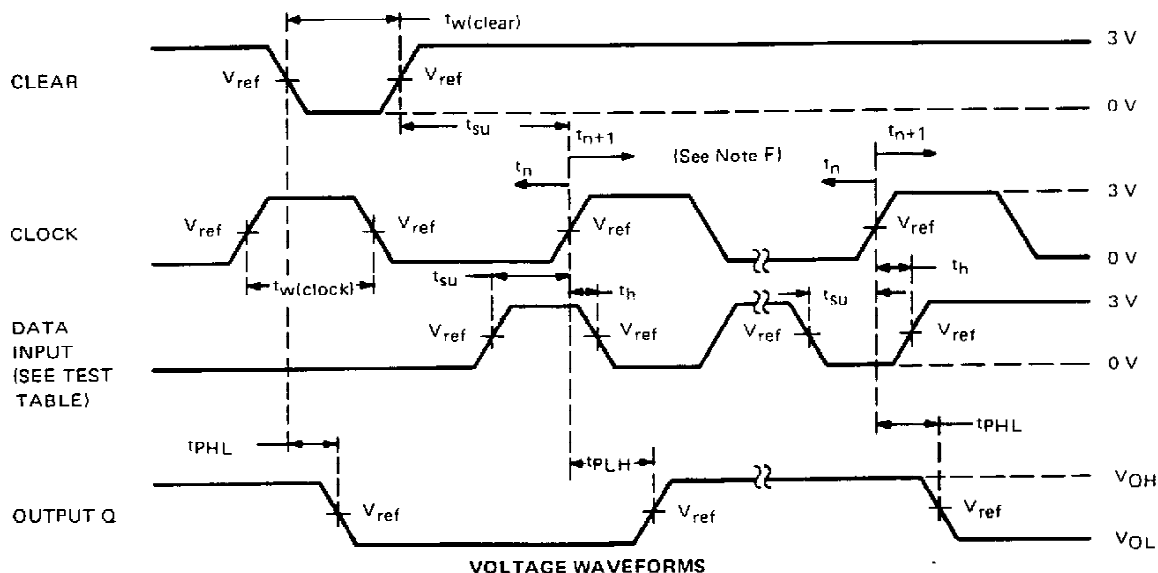
# SN54194, SN54LS194A, SN54S194, SN74194, SN74LS194A, SN74S194 4-BIT BIDIRECTIONAL UNIVERSAL SHIFT REGISTERS

## PARAMETER MEASUREMENT INFORMATION



TEST TABLE FOR SYNCHRONOUS INPUTS

DATA INPUT FOR TEST	S1	S0	OUTPUT TESTED (SEE NOTE E)
A	4.5 V	4.5 V	QA at $t_{n+1}$
B	4.5 V	4.5 V	QB at $t_{n+1}$
C	4.5 V	4.5 V	QC at $t_{n+1}$
D	4.5 V	4.5 V	QD at $t_{n+1}$
L Serial Input	4.5 V	0 V	QA at $t_{n+4}$
R Serial Input	0 V	4.5 V	QD at $t_{n+4}$



- NOTES:**
- A. The clock pulse generator has the following characteristics:  $Z_{out} \approx 50 \Omega$  and  $PRR \leq 1 \text{ MHz}$ . For '194,  $t_r \leq 7 \text{ ns}$  and  $t_f \leq 7 \text{ ns}$ . For 'LS194A,  $t_r \leq 15 \text{ ns}$  and  $t_f \leq 6 \text{ ns}$ . For 'S194,  $t_r \leq 2.5 \text{ ns}$  and  $t_f \leq 2.5 \text{ ns}$ . When testing  $f_{max}$ , vary PRR.
  - B.  $C_L$  includes probe and jig capacitance.
  - C. All diodes are 1N3064 or 1N916.
  - D. A clear pulse is applied prior to each test.
  - E. For '194 and 'S194,  $V_{ref} = 1.5 \text{ V}$ ; for 'LS194A,  $V_{ref} = 1.3 \text{ V}$ .
  - F. Propagation delay times ( $t_{PLH}$  and  $t_{PHL}$ ) are measured at  $t_{n+1}$ . Proper shifting of data is verified at  $t_{n+4}$  with a functional test.
  - G.  $t_n$  = bit time before clocking transition.  
 $t_{n+1}$  = bit time after one clocking transition.  
 $t_{n+4}$  = bit time after four clocking transitions.

FIGURE 1—SWITCHING TIMES



## IMPORTANT NOTICE

Texas Instruments (TI) reserves the right to make changes to its products or to discontinue any semiconductor product or service without notice, and advises its customers to obtain the latest version of relevant information to verify, before placing orders, that the information being relied on is current.

TI warrants performance of its semiconductor products and related software to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

Certain applications using semiconductor products may involve potential risks of death, personal injury, or severe property or environmental damage ("Critical Applications").

TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, INTENDED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT APPLICATIONS, DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS.

Inclusion of TI products in such applications is understood to be fully at the risk of the customer. Use of TI products in such applications requires the written approval of an appropriate TI officer. Questions concerning potential risk applications should be directed to TI through a local SC sales office.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards should be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein. Nor does TI warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used.

## IMPORTANT NOTICE

Texas Instruments and its subsidiaries (TI) reserve the right to make changes to their products or to discontinue any product or service without notice, and advise customers to obtain the latest version of relevant information to verify, before placing orders, that information being relied on is current and complete. All products are sold subject to the terms and conditions of sale supplied at the time of order acknowledgement, including those pertaining to warranty, patent infringement, and limitation of liability.

TI warrants performance of its semiconductor products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are utilized to the extent TI deems necessary to support this warranty. Specific testing of all parameters of each device is not necessarily performed, except those mandated by government requirements.

CERTAIN APPLICATIONS USING SEMICONDUCTOR PRODUCTS MAY INVOLVE POTENTIAL RISKS OF DEATH, PERSONAL INJURY, OR SEVERE PROPERTY OR ENVIRONMENTAL DAMAGE ("CRITICAL APPLICATIONS"). TI SEMICONDUCTOR PRODUCTS ARE NOT DESIGNED, AUTHORIZED, OR WARRANTED TO BE SUITABLE FOR USE IN LIFE-SUPPORT DEVICES OR SYSTEMS OR OTHER CRITICAL APPLICATIONS. INCLUSION OF TI PRODUCTS IN SUCH APPLICATIONS IS UNDERSTOOD TO BE FULLY AT THE CUSTOMER'S RISK.

In order to minimize risks associated with the customer's applications, adequate design and operating safeguards must be provided by the customer to minimize inherent or procedural hazards.

TI assumes no liability for applications assistance or customer product design. TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right of TI covering or relating to any combination, machine, or process in which such semiconductor products or services might be or are used. TI's publication of information regarding any third party's products or services does not constitute TI's approval, warranty or endorsement thereof.