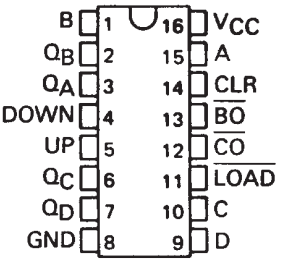
SN54192, SN54193, SN54LS192, SN54LS193, SN74192, SN74193, SN74LS192, SN74LS193
SYNCHRONOUS 4-BIT UP/DOWN COUNTERS (DUAL CLOCK WITH CLEAR)

SDLS074 – DECMEBER 1972 – REVISED MARCH 1988

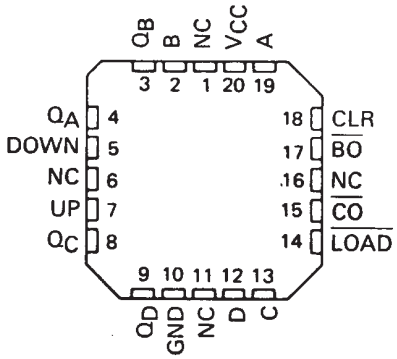
- **Cascading Circuitry Provided Internally**
- **Synchronous Operation**
- **Individual Preset to Each Flip-Flop**
- **Fully Independent Clear Input**

TYPES	TYPICAL MAXIMUM COUNT FREQUENCY	TYPICAL POWER DISSIPATION
'192,'193	32 MHz	325 mW
'LS192,'LS193	32 MHz	95 mW

SN54192, SN54193, SN54LS192, SN54LS193 . . . J OR W PACKAGE
SN74192, SN74193 . . . N PACKAGE
SN74LS192, SN74LS193 . . . D OR N PACKAGE
(TOP VIEW)



SN54LS192, SN54LS193 . . . FK PACKAGE
(TOP VIEW)



NC - No internal connection

description

These monolithic circuits are synchronous reversible (up/down) counters having a complexity of 55 equivalent gates. The '192 and 'LS192 circuits are BCD counters and the '193 and 'LS193 are 4-bit binary counters. Synchronous operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincidently with each other when so instructed by the steering logic. This mode of operation eliminates the output counting spikes which are normally associated with asynchronous (ripple-clock) counters.

The outputs of the four master-slave flip-flops are triggered by a low-to-high-level transition of either count (clock) input. The direction of counting is determined by which count input is pulsed while the other count input is high.

All four counters are fully programmable; that is, each output may be preset to either level by entering the desired data at the data inputs while the load input is low. The output will change to agree with the data inputs independently of the count pulses. This feature allows the counters to be used as modulo-N dividers by simply modifying the count length with the preset inputs.

A clear input has been provided which forces all outputs to the low level when a high level is applied. The clear function is independent of the count and load inputs. The clear, count, and load inputs are buffered to lower the drive requirements. This reduces the number of clock drivers, etc., required for long words.

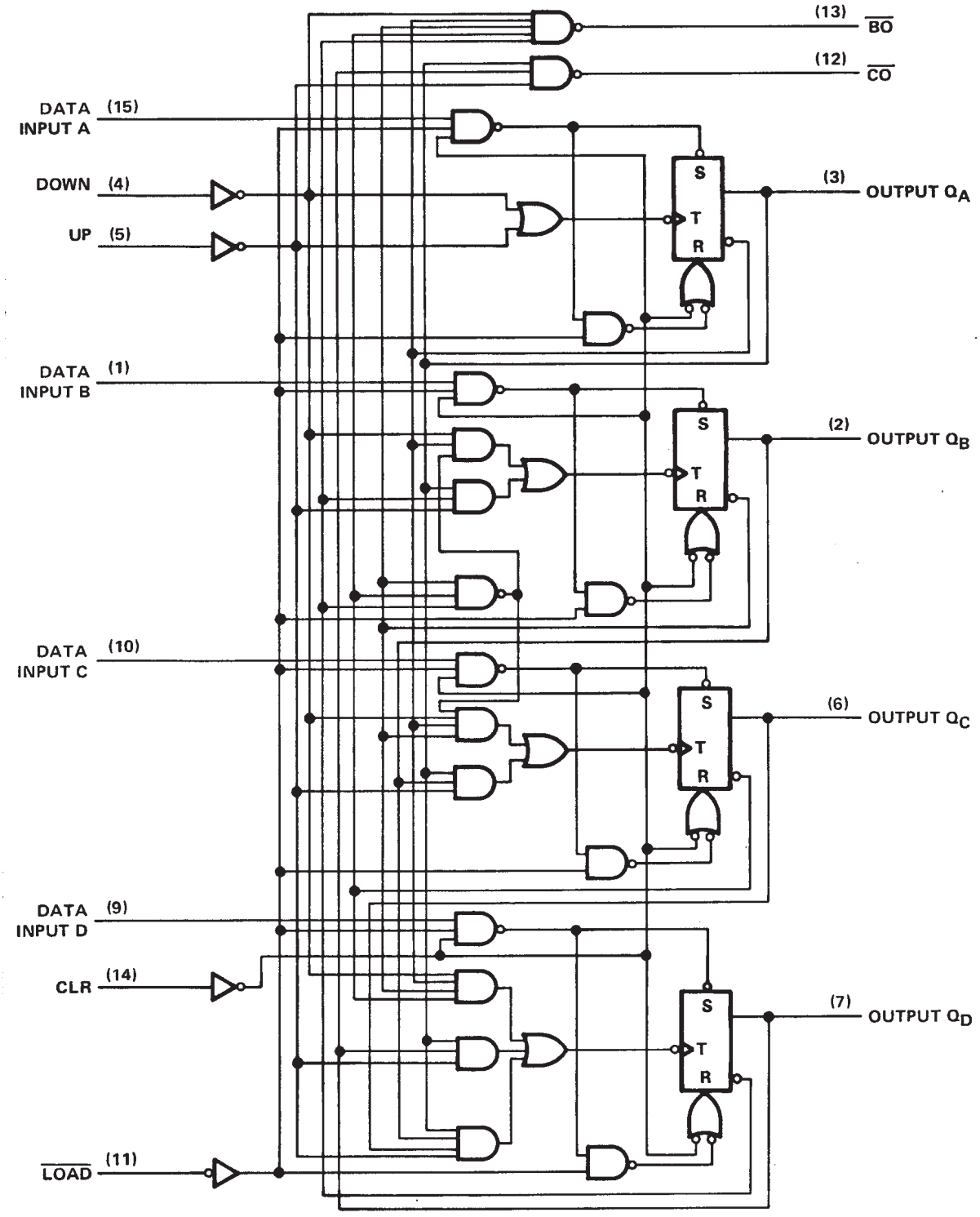
These counters were designed to be cascaded without the need for external circuitry. Both borrow and carry outputs are available to cascade both the up- and down-counting functions. The borrow output produces a pulse equal in width to the count-down input when the counter underflows. Similarly, the carry output produces a pulse equal in width to the count-up input when an overflow condition exists. The counters can then be easily cascaded by feeding the borrow and carry outputs to the count-down and count-up inputs respectively of the succeeding counter.

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

	SN54'	SN54LS'	SN74'	SN74LS'	UNIT
Supply voltage, V_{CC} (see Note 1)	7	7	7	7	V
Input voltage	5.5	7	5.5	7	V
Operating free-air temperature range	−55 to 125		0 to 70		°C
Storage temperature range	−65 to 150		−65 to 150		°C

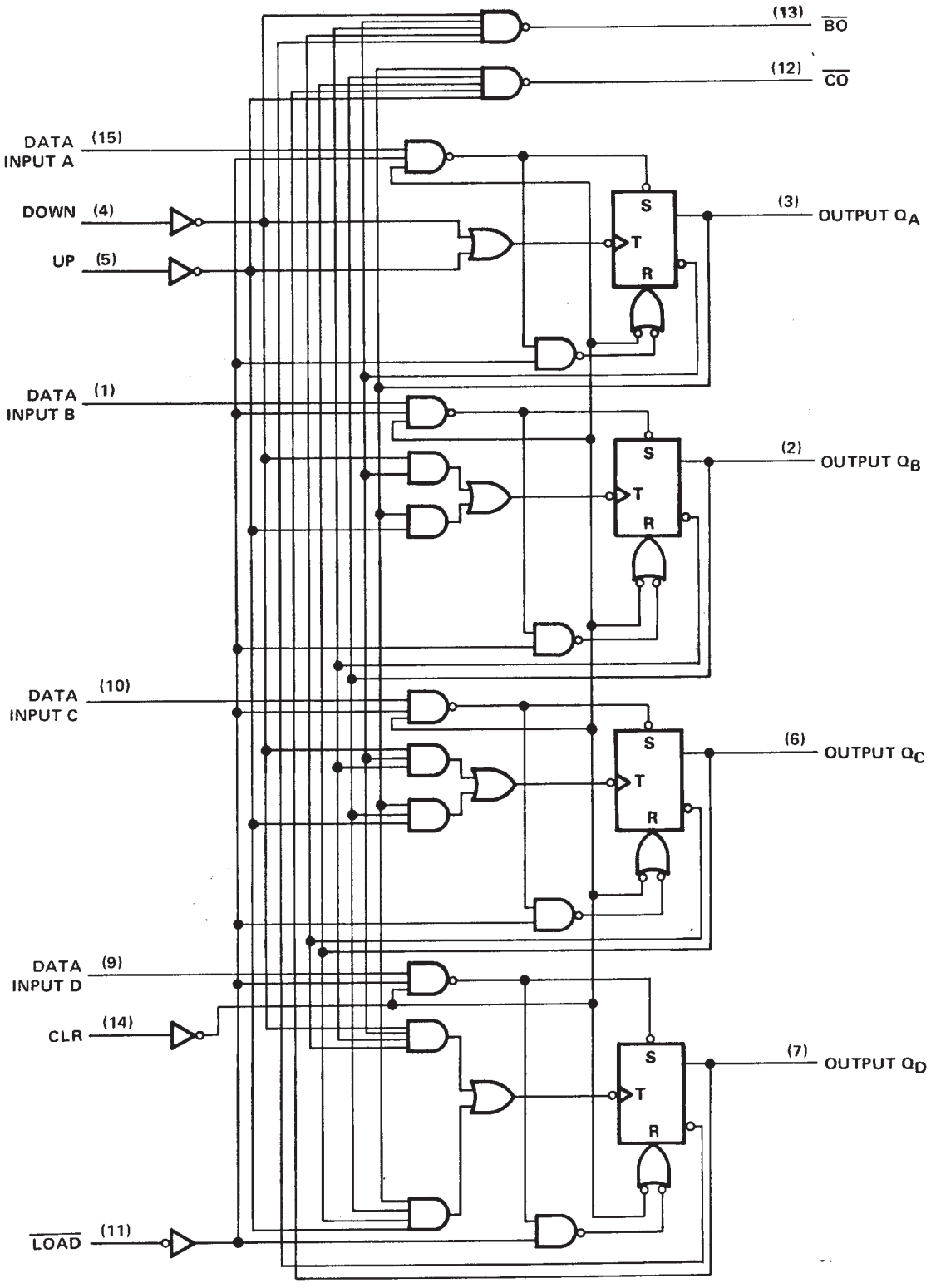
NOTE 1: Voltage values are with respect to network ground terminal.

logic diagram (positive logic)



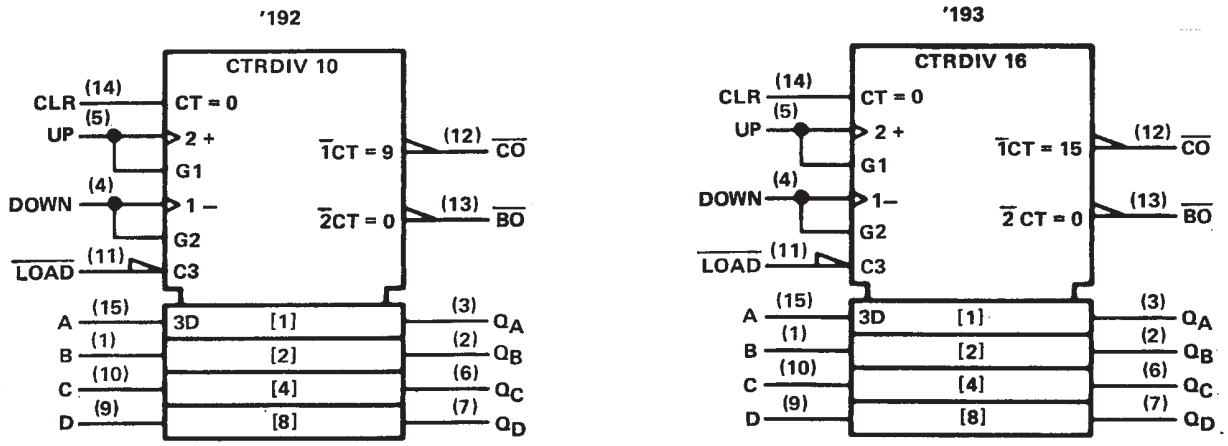
Pin numbers shown are for D, J, N, and W packages.

logic diagram (positive logic)



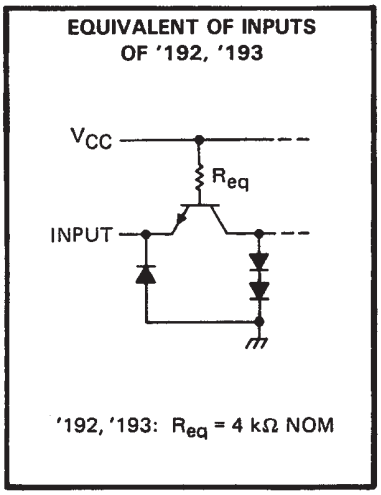
Pin numbers shown are for D, J, N, and W packages.

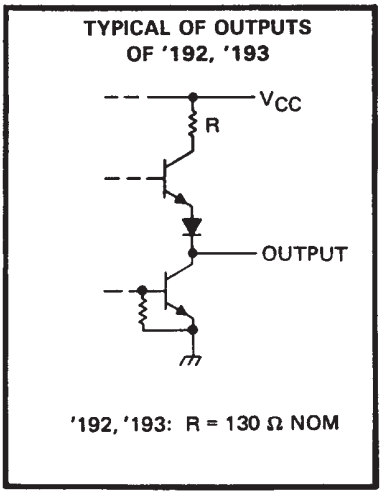
logic symbols†

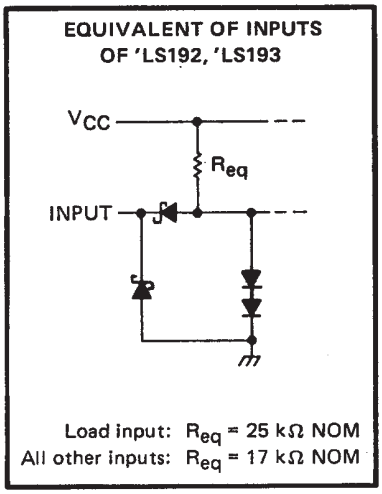


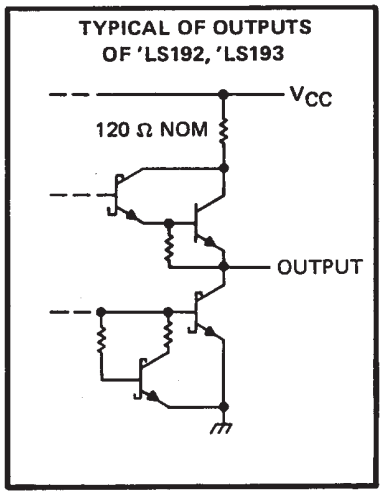
†These symbols are in accordance with ANSI/IEEE Std. 91-1984 and IEC Publication 617-12.
Pin numbers shown are for D, J, N, and W packages.

schematics of inputs and outputs







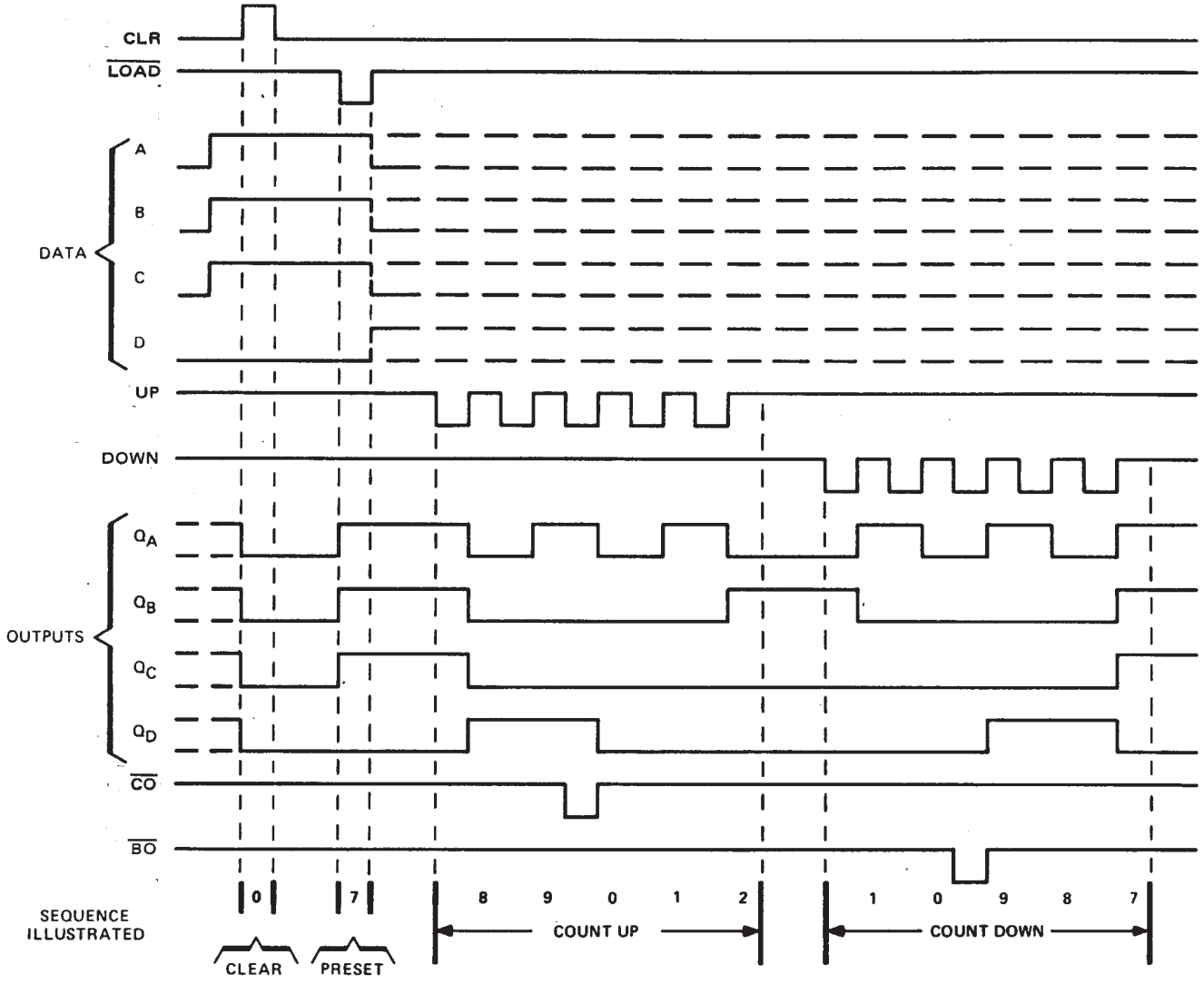


'192, 'LS192 DECADE COUNTERS

typical clear, load, and count sequences

Illustrated below is the following sequence:

1. Clear outputs to zero.
2. Load (preset) to BCD seven.
3. Count up to eight, nine, carry, zero, one, and two.
4. Count down to one, zero, borrow, nine, eight, and seven.



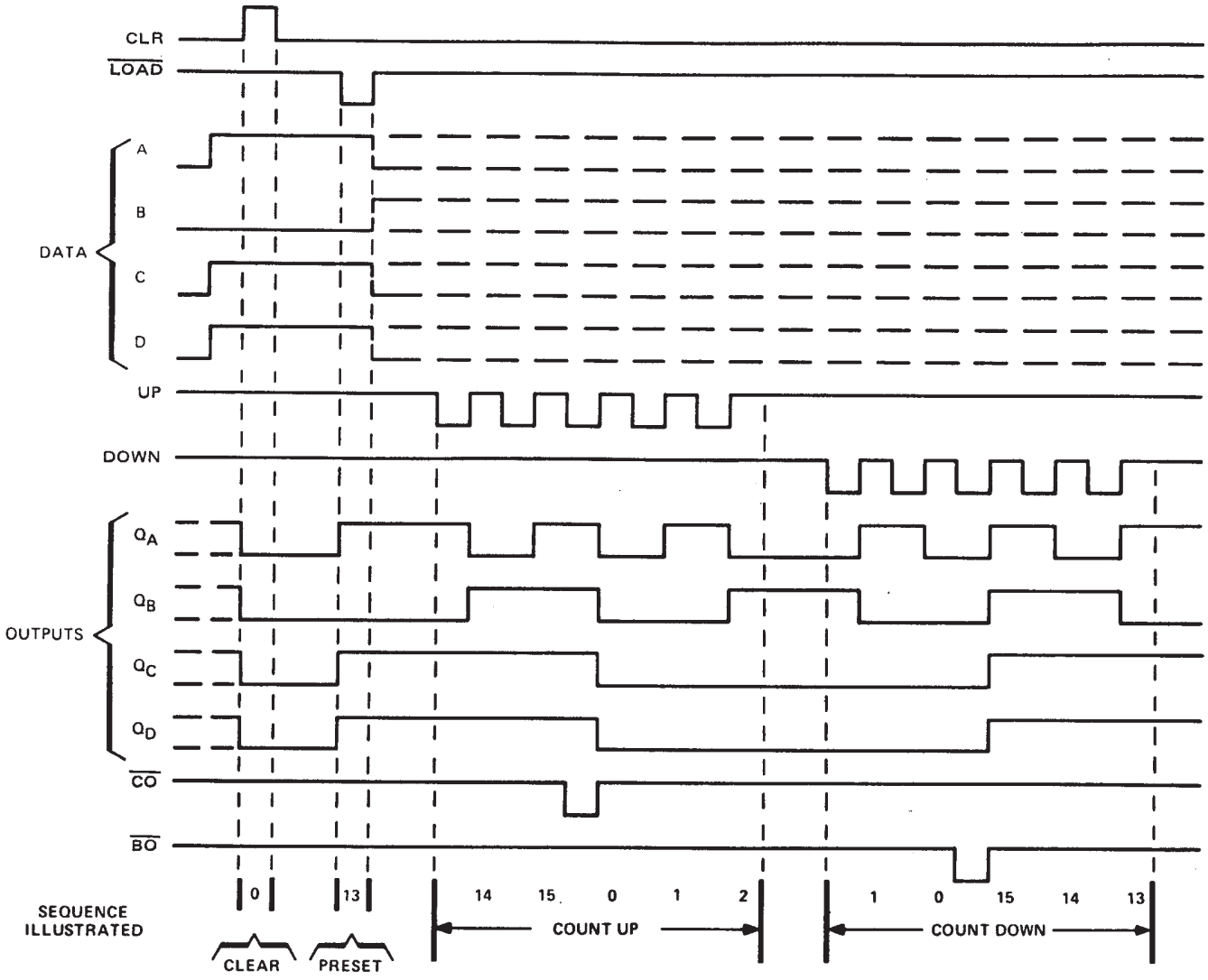
NOTES: A. Clear overrides load, data, and count inputs.
B. When counting up, count-down input must be high; when counting down, count-up input must be high.

'193, 'LS193 BINARY COUNTERS

typical clear, load, and count sequences

Illustrated below is the following sequence:

1. Clear outputs to zero.
2. Load (preset) to binary thirteen.
3. Count up to fourteen, fifteen, carry, zero, one, and two.
4. Count down to one, zero, borrow, fifteen, fourteen, and thirteen.



NOTES: A. Clear overrides load, data, and count inputs.

B. When counting up, count-down input must be high; when counting down, count-up input must be high.

recommended operating conditions

			SN54192 SN54193			SN74192 SN74193			UNIT
			MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage		4.5	5	5.5	4.75	5	5.25	V
I_{OH}	High-level output current				−0.4			−0.4	mA
I_{OL}	Low-level output current				16			16	mA
f_{clock}	Clock frequency		0		25	0		25	MHz
t_w	Width of any input pulse		20			20			ns
t_{su}	Data setup time, (see Figure 1)		20			20			ns
t_h	Hold time	Data, high or low	0			0			ns
		$\overline{LOAD}$	3			3			
T_A	Operating free-air temperature		−55		125	0		70	°C

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

PARAMETER		TEST CONDITIONS†	SN54192 SN54193			SN74192 SN74193			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} = MIN, I_I = −12 mA			−1.5			−1.5	V
V_{OH}	High-level output voltage	V_{CC} = MIN, V_{IH} = 2 V, V_{IL} = 0.8 V, I_{OH} = −0.4 mA	2.4	3.4		2.4	3.4		V
V_{OL}	Low-level output voltage	V_{CC} = MIN, V_{IH} = 2 V, V_{IL} = 0.8 V, I_{OL} = 16 mA		0.2	0.4		0.2	0.4	V
I_I	Input current at maximum input voltage	V_{CC} = MAX, V_I = 5.5 V			1			1	mA
I_{IH}	High-level input current	V_{CC} = MAX, V_I = 2.4 V			40			40	μA
I_{IL}	Low-level input current	V_{CC} = MAX, V_I = 0.4 V			−1.6			−1.6	mA
I_{OS}	Short-circuit output current§	V_{CC} = MAX	−20		−65	−18		−65	mA
I_{CC}	Supply current	V_{CC} = MAX, See Note 2		65	89		65	102	mA

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable type.
‡All typical values are at V_{CC} = 5 V, T_A = 25°C.
§Not more than one output should be shorted at a time.
NOTE 2: I_{CC} is measured with all outputs open, clear and load inputs grounded, and all other inputs at 4.5 V.

switching characteristics, V_{CC} = 5 V, T_A = 25°C

PARAMETER¶	FROM INPUT	TO OUTPUT	TEST CONDITIONS	MIN	TYP	MAX	UNIT
f_{max}			C_L = 15 pF, R_L = 400 Ω, See Figures 1 and 2	25	32		MHz
t_{PLH}	UP	$\overline{CO}$			17	26	ns
t_{PHL}					16	24	
t_{PLH}	DOWN	$\overline{BO}$			16	24	ns
t_{PHL}					16	24	
t_{PLH}	UP OR DOWN	Q			25	38	ns
t_{PHL}					31	47	
t_{PLH}	$\overline{LOAD}$	Q			27	40	ns
t_{PHL}					29	40	
t_{PHL}	CLR	Q			22	35	ns

¶f_{max} ≡ maximum clock frequency
t_{PLH} ≡ propagation delay time, low-to-high-level output
t_{PHL} ≡ propagation delay time, high-to-low-level output

recommended operating conditions

		SN54LS192 SN54LS193			SN74LS192 SN74LS193			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage	4.5	5	5.5	4.75	5	5.25	V
I_{OH}	High-level output current			−400			−400	μA
I_{OL}	Low-level output current			4			8	mA
f_{clock}	Clock frequency	0		25	0		25	MHz
t_w	Width of any input pulse	20			20			ns
t_{su}	Clear inactive-state setup time	15			15			ns
	Load inactive-state setup time	15			15			ns
	Data setup time (see Figure 1)	20			20			ns
t_h	Data hold time	5			5			ns
T_A	Operating free-air temperature range	−55		125	0		70	°C

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

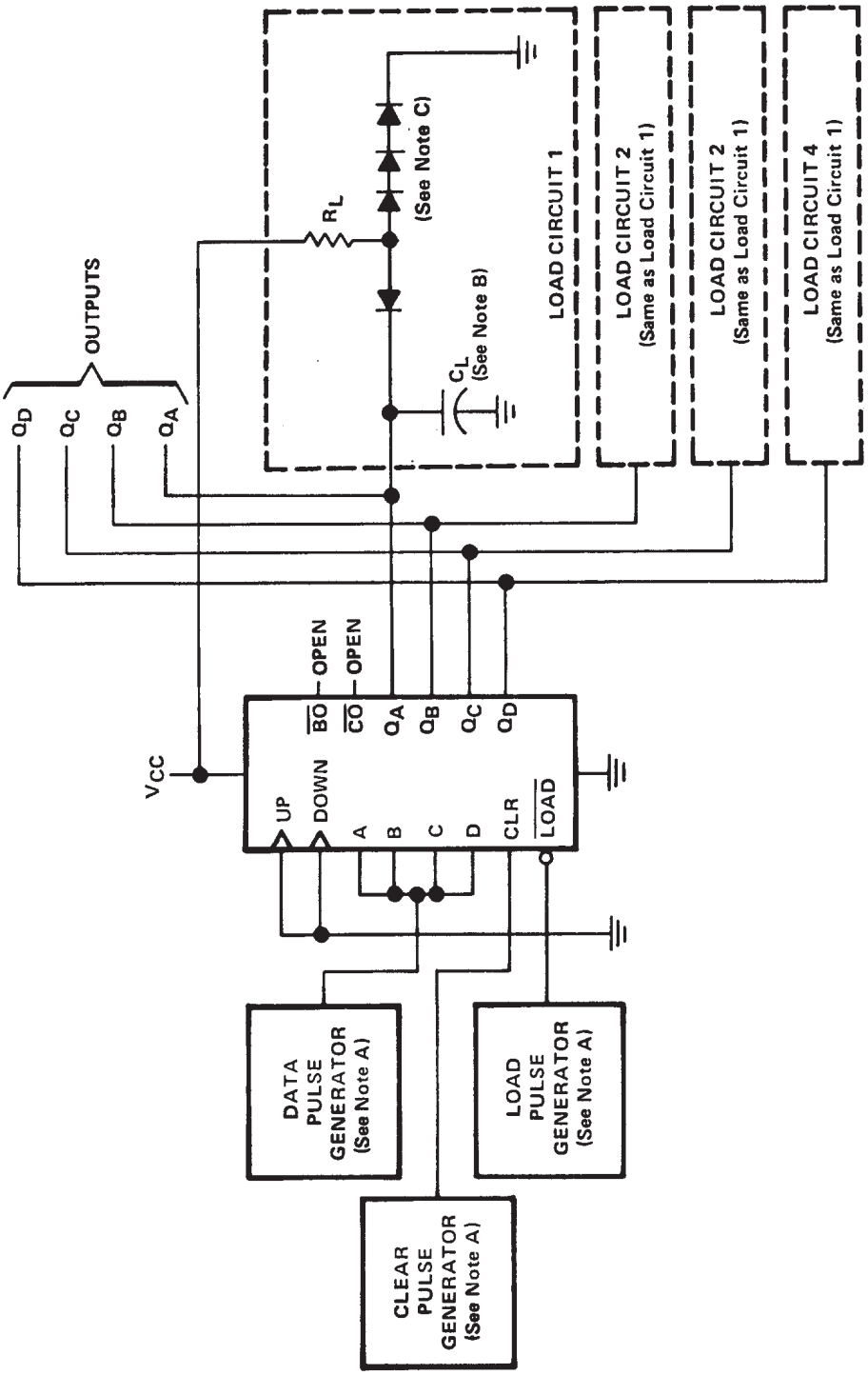
PARAMETER		TEST CONDITIONS†		SN54LS192 SN54LS193			SN74LS192 SN74LS193			UNIT
				MIN	TYP‡	MAX	MIN	TYP‡	MAX	
V_{IH}	High-level input voltage			2			2			V
V_{IL}	Low-level input voltage					0.7			0.8	V
V_{IK}	Input clamp voltage	V_{CC} = MIN, I_I = −18 mA				−1.5			−1.5	V
V_{OH}	High-level output voltage	V_{CC} = MIN, V_{IH} = 2 V, V_{IL} = V_{IL} max, I_{OH} = −400 μA		2.5	3.4		2.7	3.4		V
V_{OL}	Low-level output voltage	V_{CC} = MIN, V_{IH} = 2 V, V_{IL} = V_{IL} max	I_{OL} = 4 mA		0.25	0.4		0.15	0.4	V
			I_{OL} = 8 mA					0.35	0.5	
I_I	Input current at maximum input voltage	V_{CC} = MAX, V_I = 7 V				0.1			0.1	mA
I_{IH}	High-level input current	V_{CC} = MAX, V_I = 2.7 V				20			20	μA
I_{IL}	Low-level input current	V_{CC} = MAX, V_I = 0.4 V				−0.4			−0.4	mA
I_{OS}	Short-circuit output current§	V_{CC} = MAX		−20		−100	−20		−100	mA
I_{CC}	Supply current	V_{CC} = MAX, See Note 2			19	34		19	34	mA

†For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable type.
‡All typical values are at V_{CC} = 5 V, T_A = 25°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: I_{CC} is measured with all outputs open, clear and load inputs grounded, and all other inputs at 4.5 V.

switching characteristics, V_{CC} = 5 V, T_A = 25°C

PARAMETER	FROM INPUT	TO OUTPUT	TEST CONDITIONS	MIN	TYP	MAX	UNIT
f_{max}			C_L = 15 pF, R_L = 2 kΩ, See Figures 1 and 2	25	32		MHz
t_{PLH}	UP	$\overline{CO}$			17	26	ns
t_{PHL}					18	24	
t_{PLH}	DOWN	$\overline{BO}$			16	24	ns
t_{PHL}					15	24	
t_{PLH}	UP OR DOWN	Q			27	38	ns
t_{PHL}					30	47	
t_{PLH}	$\overline{LOAD}$	Q			24	40	ns
t_{PHL}					25	40	
t_{PHL}	CLR	Q			23	35	ns

PARAMETER MEASUREMENT INFORMATION



TEST CIRCUIT

NOTES: A. The pulse generators have the following characteristics: $Z_{out} \approx 50\ \Omega$ and for the data pulse generator PRR $\leq$ 500 kHz, duty cycle = 50%; for the load pulse generator PRR is two times data PRR, duty cycle = 50%

B. C_L includes probe and jig capacitance.

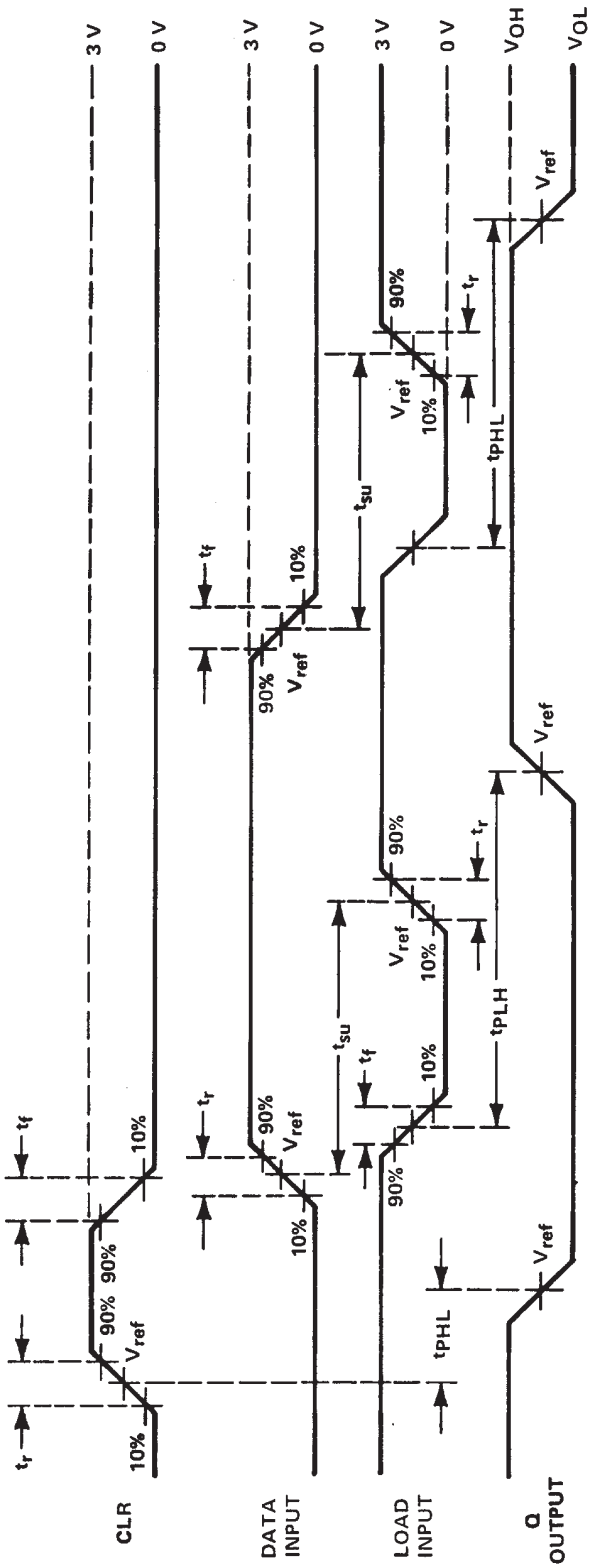
C. Diodes are 1N3064 or equivalent.

D. t_r and $t_f \leq 7$ ns.

E. V_{ref} is 1.5 V for '192 and '193, 1.3 V for 'LS192 and 'LS193.

FIGURE 1A – CLEAR, SETUP AND LOAD TIMES

PARAMETER MEASUREMENT INFORMATION

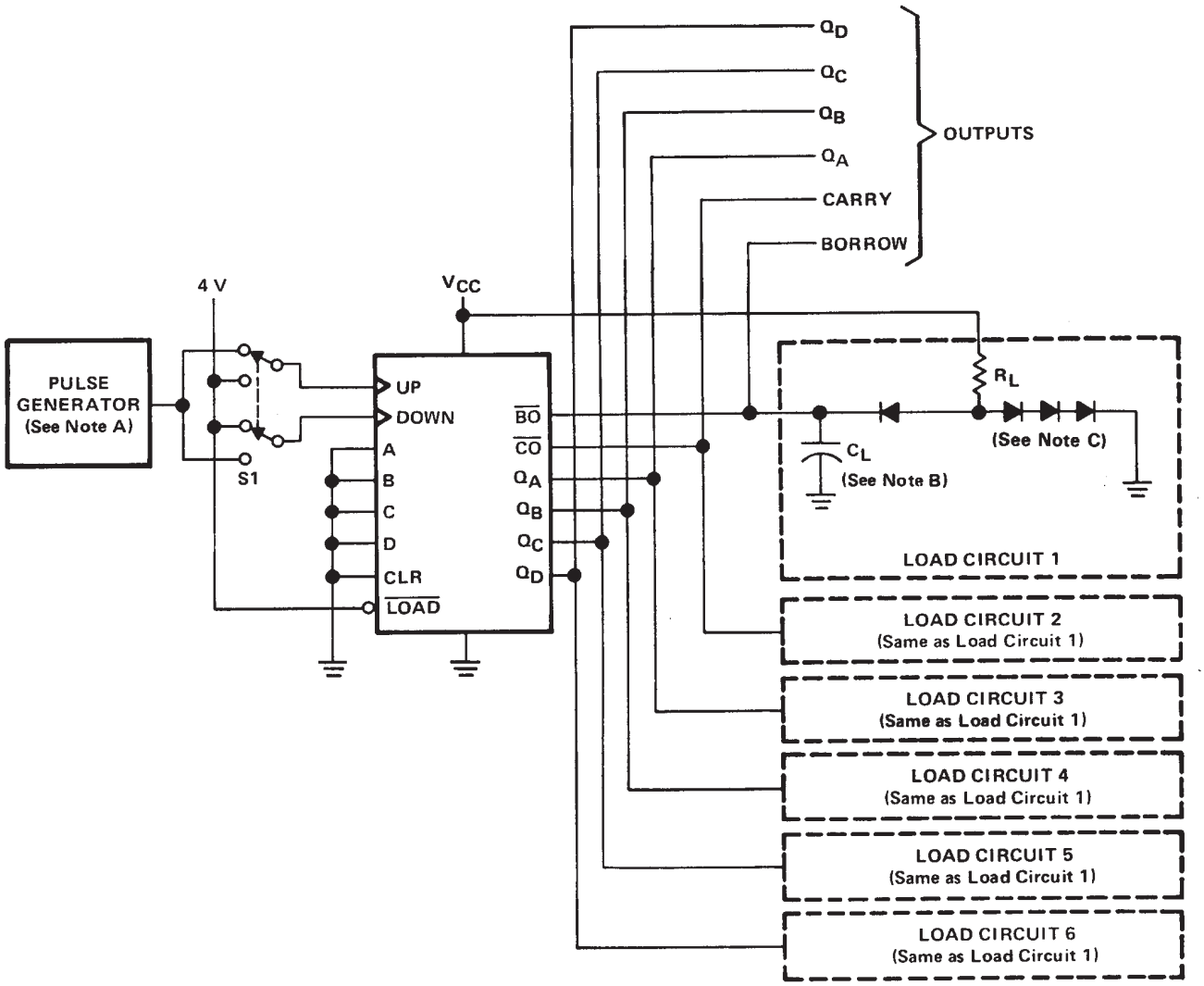


VOLTAGE WAVEFORMS

NOTES: A. The pulse generators have the following characteristics: $Z_{out} \approx 50\ \Omega$ and for the data pulse generator PRR ≤ 500 kHz, duty cycle = 50%; for the load pulse generator PRR is two times data PRR, duty cycle = 50%
B. C_L includes probe and jig capacitance.
C. Diodes are 1N3064 or equivalent.
D. t_r and $t_f \leq 7$ ns.
E. V_{ref} is 1.5 V for '192 and '193, 1.3 V for 'LS192 and 'LS193.

FIGURE 1B – CLEAR, SETUP, AND LOAD TIMES

PARAMETER MEASUREMENT INFORMATION

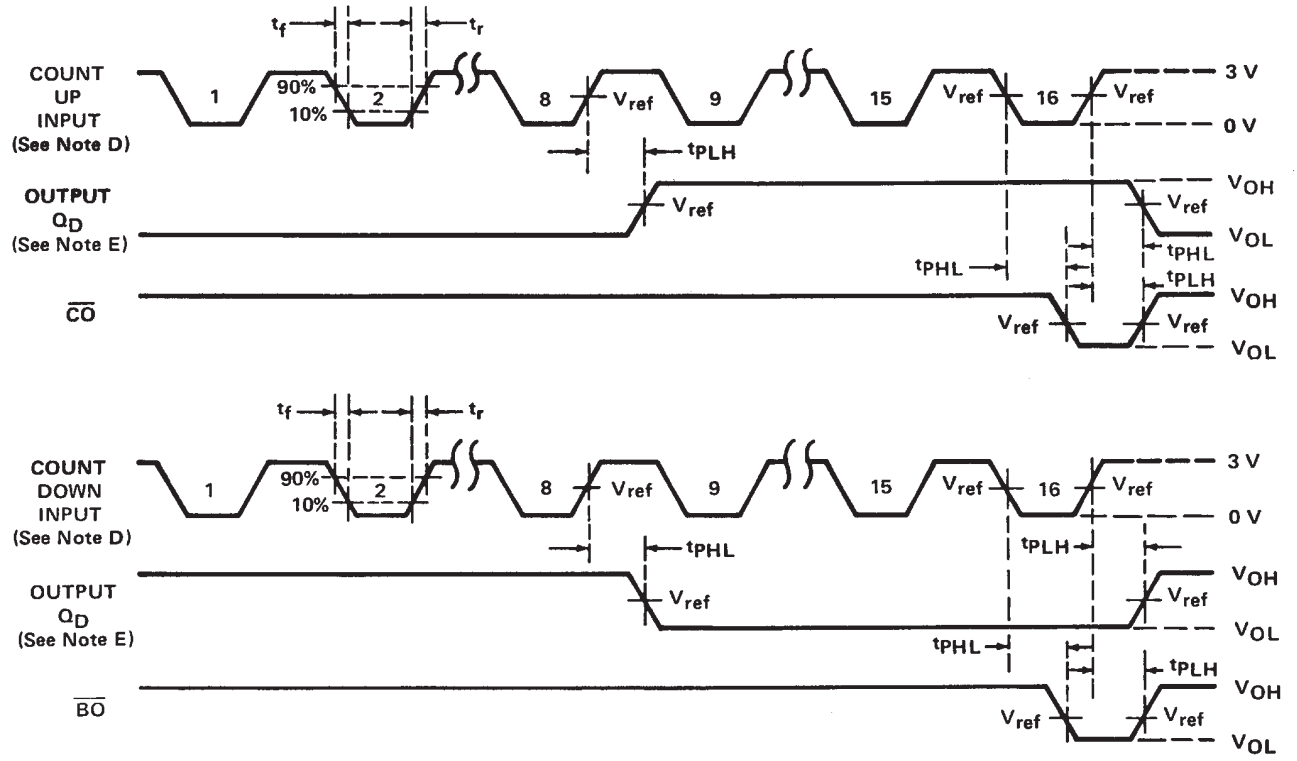


TEST CIRCUIT

NOTES: A. The pulse generators have the following characteristics: PRR ≈ 1 MHz, Z_{out} ≈ 50 Ω, duty cycle = 50%.
B. C_L includes probe and jig capacitance.
C. Diodes are 1N3064 or equivalent.
D. Cout-up and dount-down pulse shown are for the '193 and 'LS193 binary counters. Count cycle for '192 and 'LS192 decade counters is 1 through 10.
E. Waveforms for outputs Q_A, Q_B, and Q_C are omitted to simplify the drawing.
F. t_r and t_f ≤ 7 ns.
G. V_{ref} is 1.5 V for '192 and '193, 1.3 V for 'LS192 and 'LS193.

FIGURE 2A – PROPAGATION DELAY TIMES

PARAMETER MEASUREMENT INFORMATION



VOLTAGE WAVEFORMS

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B. C_L includes probe and jig capacitance.
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D. Cout-up and dount-down pulse shown are for the '193 and 'LS193 binary counters. Count cycle for '192 and 'LS192 decade counters is 1 through 10.
E. Waveforms for outputs Q_A, Q_B, and Q_C are omitted to simplify the drawing.
F. t_r and t_f ≤ 7 ns.
G. V_{ref} is 1.5 V for '192 and '193, 1.3 V for 'LS192 and 'LS193.

FIGURE 2B – PROPAGATION DELAY TIMES

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