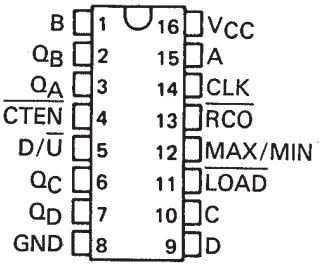
SYNCHRONOUS UP/DOWN COUNTERS WITH DOWN/UP MODE CONTROL

SDLS072 – DECEMBER 1972 – REVISED MARCH 1988

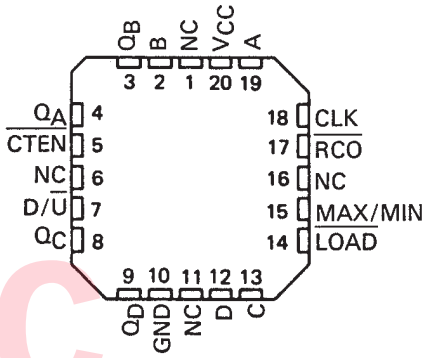
- Counts 8-4-2-1 BCD or Binary
- Single Down/Up Count Control Line
- Count Enable Control Input
- Ripple Clock Output for Cascading
- Asynchronously Presettable with Load Control
- Parallel Outputs
- Cascadable for n-Bit Applications

TYPE	AVERAGE PROPAGATION DELAY	TYPICAL MAXIMUM CLOCK FREQUENCY	TYPICAL POWER DISSIPATION
'190,'191	20ns	25MHz	325mW
'LS190,'LS191	20ns	25MHz	100mW

SN54190, SN54191, SN54LS190,
SN54LS191 . . . J PACKAGE
SN74190, SN74191 . . . N PACKAGE
SN74LS190, SN74LS191 . . . D OR N PACKAGE
(TOP VIEW)



SN54LS190, SN54LS191 . . . FK PACKAGE
(TOP VIEW)



NC - No internal connection

description

The '190, 'LS190, '191, and 'LS191 are synchronous, reversible up/down counters having a complexity of 58 equivalent gates. The '191 and 'LS191 are 4-bit binary counters and the '190 and 'LS190 are BCD counters. Synchronous operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincident with each other when so instructed by the steering logic. This mode of operation eliminates the output counting spikes normally associated with asynchronous (ripple clock) counters.

The outputs of the four master-slave flip-flops are triggered on a low-to-high transition of the clock input if the enable input is low. A high at the enable input inhibits counting. Level changes at the enable input should be made only when the clock input is high. The direction of the count is determined by the level of the down/up input. When low, the counter count up and when high, it counts down. A false clock may occur if the down/up input changes while the clock is low. A false ripple carry may occur if both the clock and enable are low and the down/up input is high during a load pulse.

These counters are fully programmable; that is, the outputs may be preset to either level by placing a low on the load input and entering the desired data at the data inputs. The output will change to agree with the data inputs independently of the level of the clock input. This feature allows the counters to be used as modulo-N dividers by simply modifying the count length with the preset inputs.

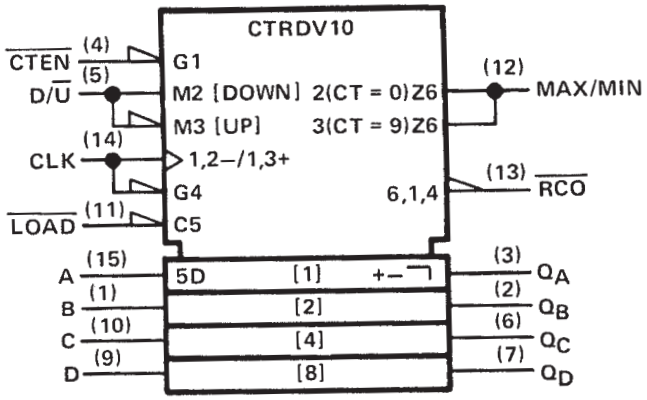
The clock, down/up, and load inputs are buffered to lower the drive requirement which significantly reduces the number of clock drivers, etc., required for long parallel words.

Two outputs have been made available to perform the cascading function: ripple clock and maximum/minimum count. The latter output produces a high-level output pulse with a duration approximately equal to one complete cycle of the clock when the counter overflows or underflows. The ripple clock output produces a low-level output pulse equal in width to the low-level portion of the clock input when an overflow or underflow condition exists. The counters can be easily cascaded by feeding the ripple clock output to the enable input of the succeeding counter if parallel clocking is used, or to the clock input if parallel enabling is used. The maximum/minimum count output can be used to accomplish look-ahead for high-speed operation.

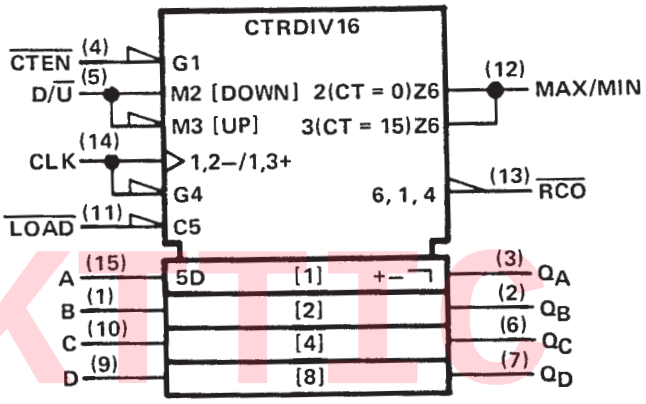
Series 54' and 54LS' are characterized for operation over the full military temperature range of −55°C to 125°C; Series 74' and 74LS' are characterized for operation from 0°C to 70°C.

logic symbols†

'190, 'LS190



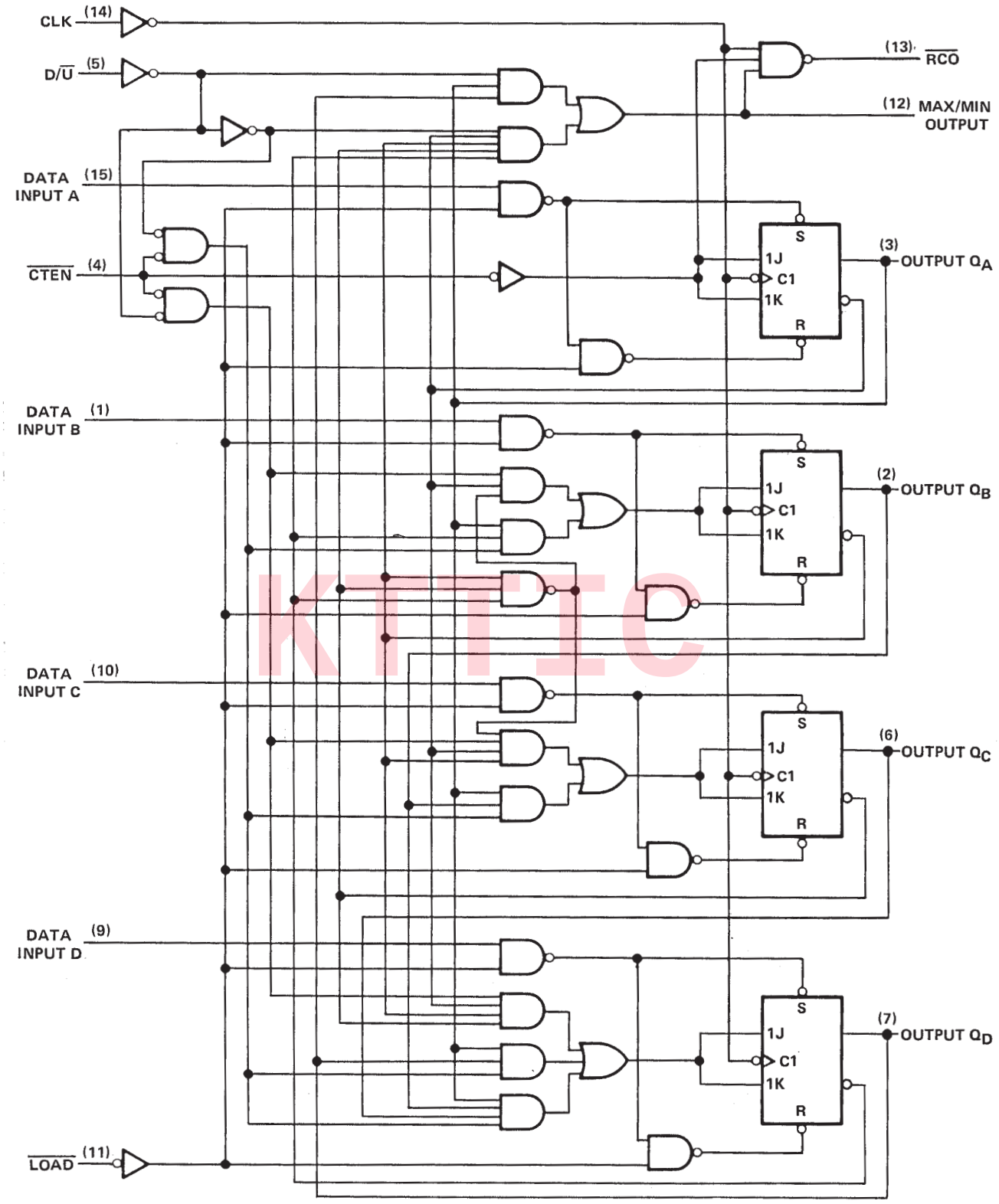
'191, 'LS191



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

logic diagram (positive logic)

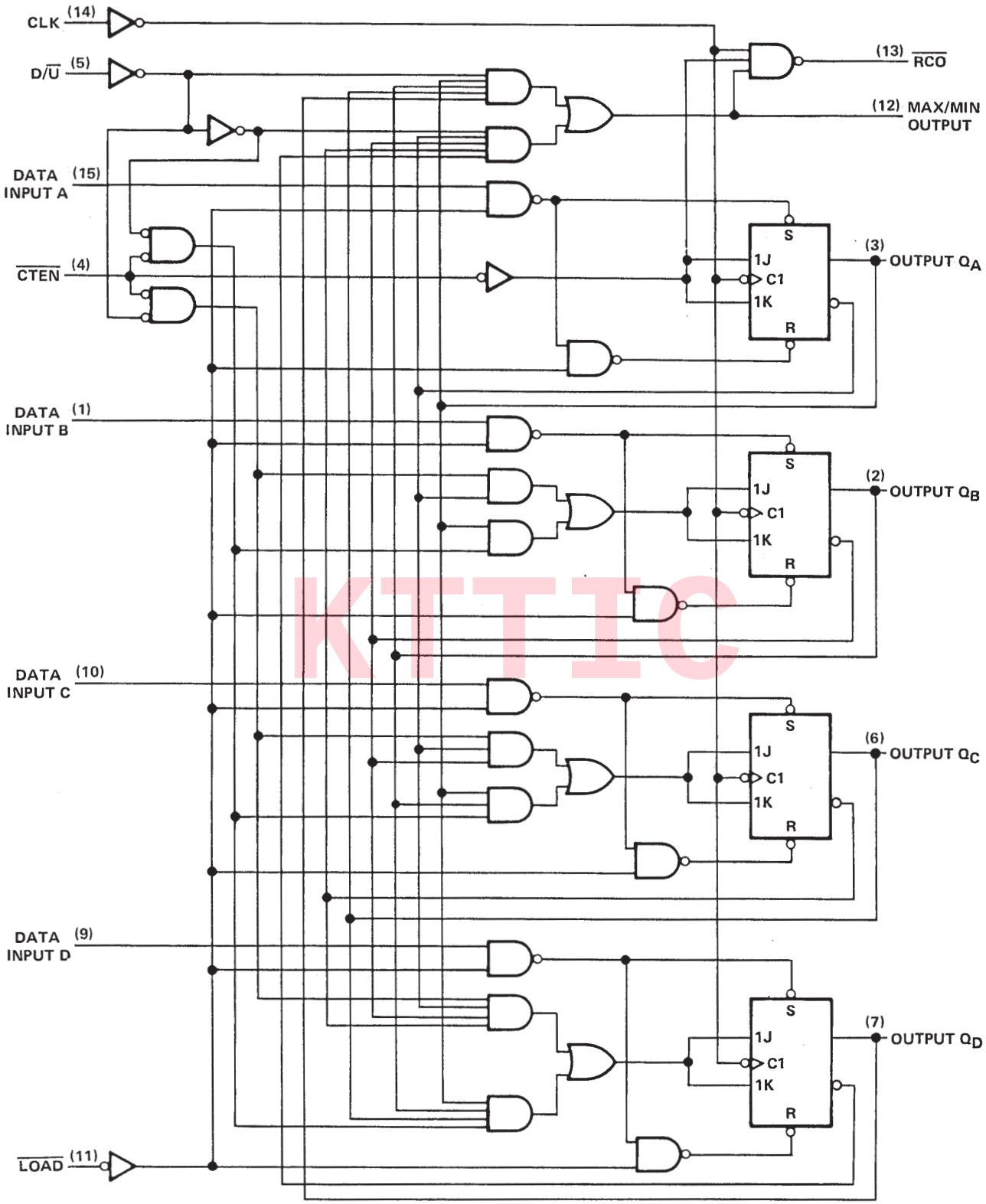
'190, 'LS190 DECADE COUNTERS



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

logic diagram (positive logic)

'191, 'LS191 BINARY COUNTERS



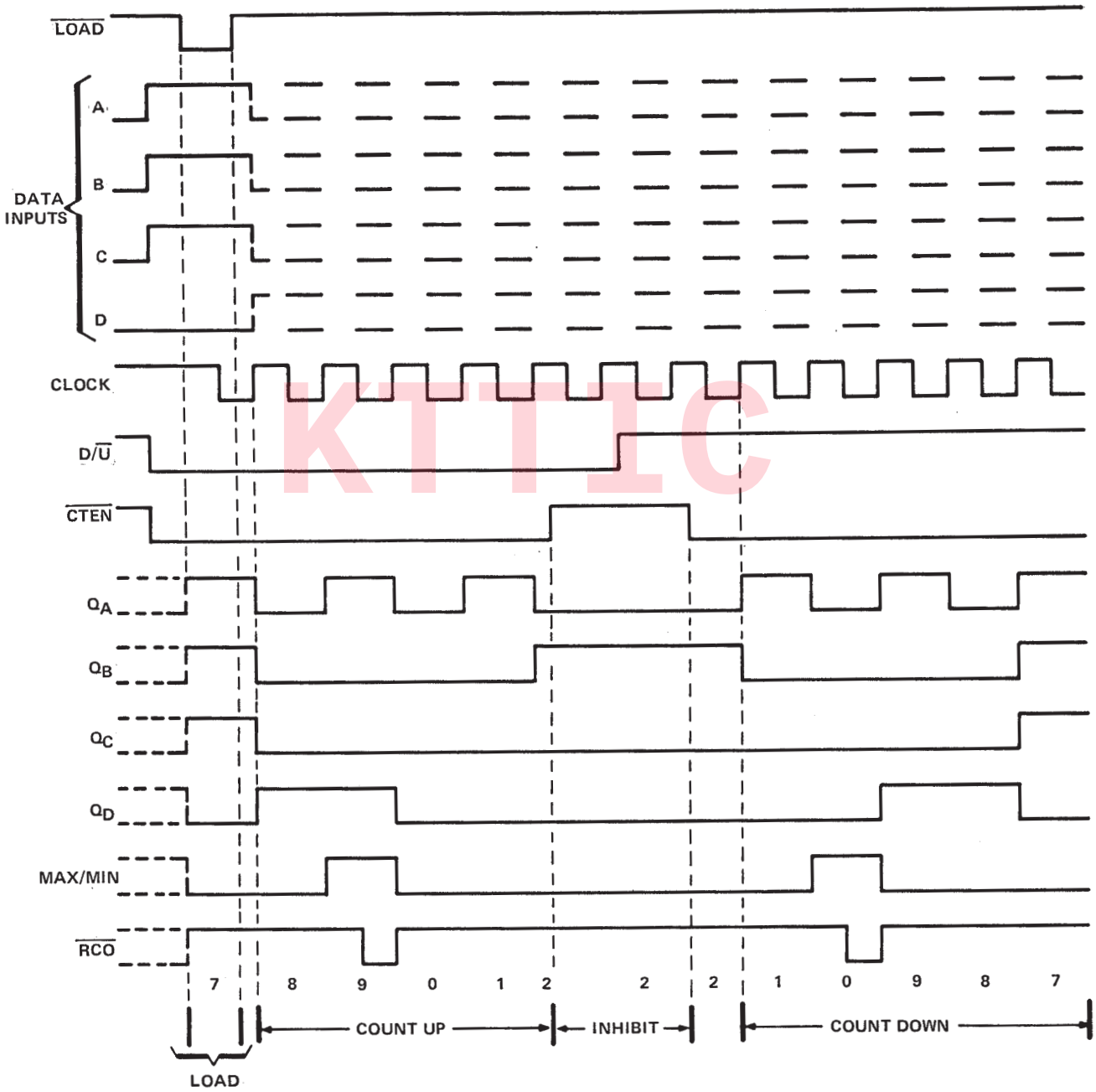
Pin numbers shown are for D, J, and N packages.

'190, 'LS190 DECADE COUNTERS

typical load, count, and inhibit sequences

Illustrated below is the following sequence:

1. Load (preset) to BCD seven.
2. Count up to eight, nine (maximum), zero, one, and two.
3. Inhibit.
4. Count down to one, zero (minimum), nine, eight, and seven.

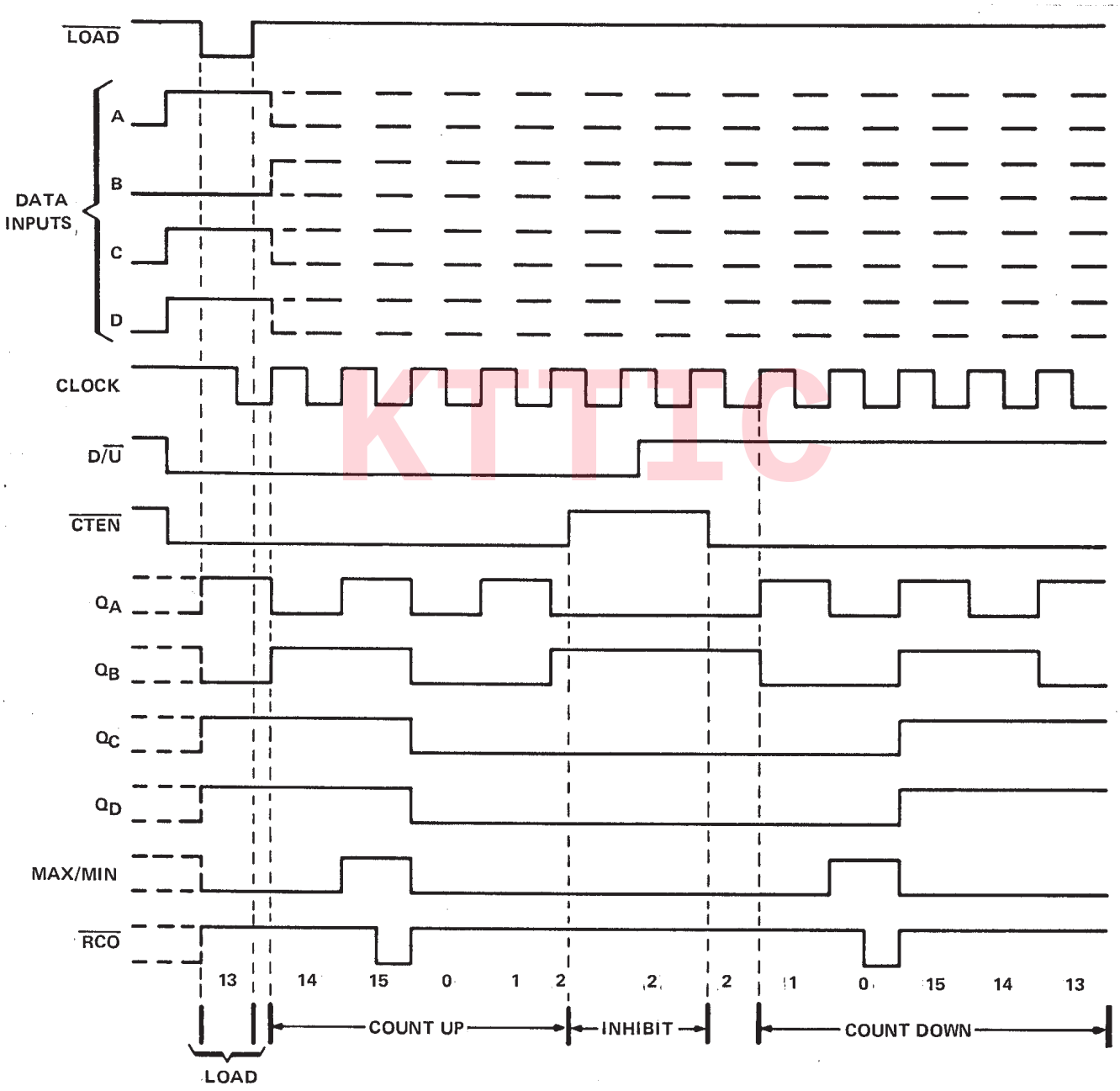


'191, 'LS191 BINARY COUNTERS

pical load, count, and inhibit sequences

Illustrated below is the following sequence:

1. Load (preset) to binary thirteen.
2. Count up to fourteen, fifteen (maximum), zero, one, and two.
3. Inhibit.
4. Count down to one, zero (minimum), fifteen, fourteen, and thirteen.



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

Supply voltage, V_{CC} (see Note 1) . . . . . 7 V
Input voltage: SN54', SN74' Circuits . . . . . 5.5 V
SN54LS', SN74LS' Circuits . . . . . 7 V
Operating free-air temperature range: SN54', SN54LS' Circuits . . . . . −55°C to 125°C
SN74', SN74LS' Circuits . . . . . 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

			SN54190, SN54191			SN74190, SN74191			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				−0.8			−0.8	mA
I_{OL}	Low-level output current				16			16	mA
f_{clock}	Input clock frequency		0		20	0		20	MHz
$t_{w(clock)}$	Width of clock input pulse		25			25			ns
$t_{w(load)}$	Width of load input pulse		35			35			ns
t_{su}	Setup time	Data, high or low (See Figure 1 and 2)	20			20			ns
		Load inactive state	20			20			
t_{hold}	Data hold time		0			0			ns
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†	SN54190, SN54191			SN74190, SN74191			UNIT
			MIN	TYP‡	MAX	MIN	TYP‡	MAX	
V_{IH}	High-level input voltage	V_{CC} = MIN	2			2			V
V_{IL}	Low-level input voltage	V_{CC} = MIN			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} = −0.8 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	High-level input current at maximum input voltage	V_{CC} = MAX, V_I = 5.5 V			1			1	mA
I_{IH}	High-level input current at any input except enable	V_{CC} = MAX, V_I = 2.4 V			40			40	μA
I_{IH}	High-level input current at enable input				120			120	μA
I_{IL}	Low-level input current at any input except enable	V_{CC} = MAX, V_I = 0.4 V			−1.6			−1.6	mA
I_{IL}	Low-level input current at enable input				−4.8			−4.8	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	99		65	105	mA

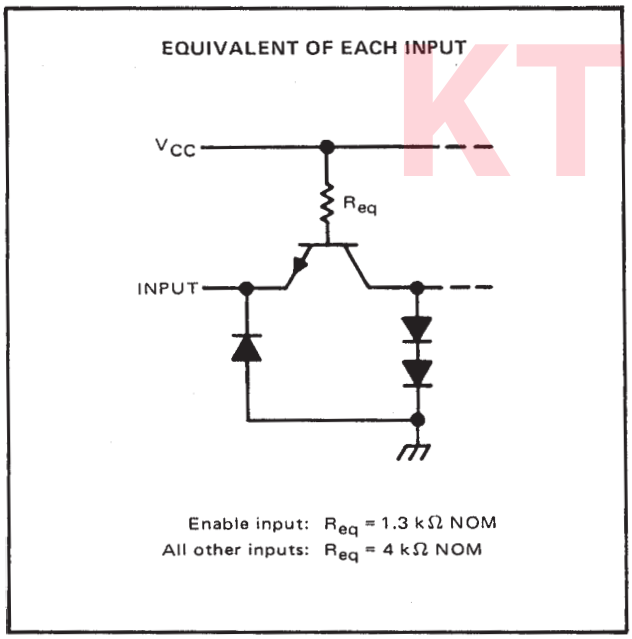
† For conditions shown as MAX or MIN, use appropriate value specified under recommended operating conditions.
‡ All typical values are at V_{CC} = 5 V, T_A = 25°C.
§ Not more than one output should be shorted at a time.
NOTE 2: I_{CC} is measured with all inputs grounded and all outputs open.

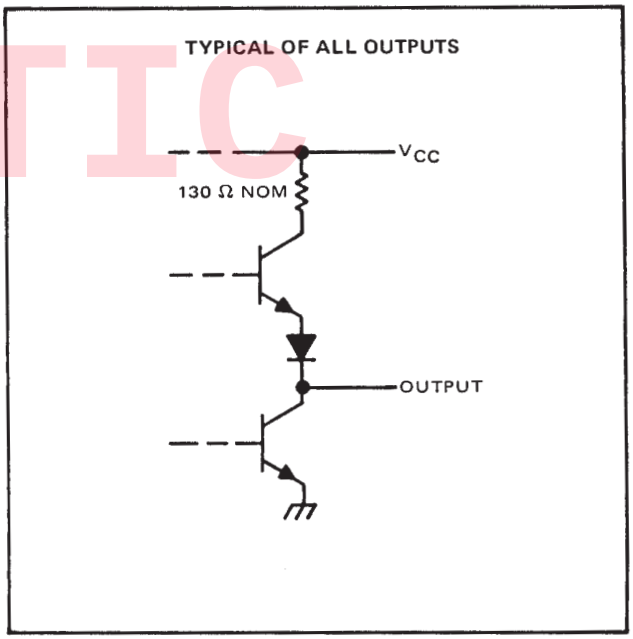
switching characteristics, V_{CC} = 5 V, T_A = 25°C

PARAMETER†	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS	'190, '191			UNIT
				MIN	TYP	MAX	
f_{max}			C_L = 15 pF, R_L = 400 Ω, See Figures 1 and 3 thru 7	20	25		MHz
t_{PLH}	$\overline{Load}$	Q_A, Q_B, Q_C, Q_D			22	33	ns
t_{PHL}					33	50	
t_{PLH}	Data A, B, C, D	Q_A, Q_B, Q_C, Q_D			14	22	ns
t_{PHL}					35	50	
t_{PLH}	CLK	$\overline{RCO}$			13	20	ns
t_{PHL}					16	24	
t_{PLH}	CLK	Q_A, Q_B, Q_C, Q_D			16	24	ns
t_{PHL}					24	36	
t_{PLH}	CLK	Max/Min			28	42	ns
t_{PHL}					37	52	
t_{PLH}	D/$\overline{U}$	$\overline{RCO}$			30	45	ns
t_{PHL}					30	45	
t_{PLH}	D/$\overline{U}$	Max/Min			21	33	ns
t_{PHL}					22	33	

† 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

schematics of inputs and outputs





recommended operating conditions

		SN54LS190 SN54LS191			SN74LS190 SN74LS191			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			4			8	mA
f_{clock}	Clock frequency	0		20	0		20	MHz
$t_{w(clock)}$	Width of clock input pulse	25			25			ns
$t_{w(load)}$	Width of load input pulse	35			35			ns
t_{su}	Data setup time (See Figures 1 and 2)	20			20			ns
t_{su}	Load inactive state setup time	30			30			ns
t_h	Data hold time	5			5			ns
t_h	Enable hold time	0			0			ns
t_{enable}	Count enable time (see Note 3)	40			40			ns
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†		SN54LS190 SN54LS191			SN74LS190 SN74LS191			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_{IL} = V_{IL} max,	V_{IH} = 2 V, I_{OH} = −400 μA	2.5	3.4		2.7	3.4		V
V_{OL}	Low-level output voltage		V_{CC} = MIN, V_{IL} = V_{IL} max,	V_{IH} = 2 V, I_{OL} = 4 mA		0.25	0.4		0.25	0.4	V
				I_{OL} = 8 mA					0.35	0.5	
I_I	High-level input current at maximum input voltage	Enable	V_{CC} = MAX,	V_I = 7 V			0.3			0.3	mA
		Others					0.1			0.1	
I_{IH}	High-level input current	Enable	V_{CC} = MAX,	V_I = 2.7 V			60			60	μA
		Others					20			20	
I_{IL}	Low-level input current	Enable	V_{CC} = MAX,	V_I = 0.4 V			−1.2			−1.2	mA
		Others					−0.4			−0.4	
I_{OS}	Short-circuit output current§		V_{CC} = MAX,		−20		−100	−20		−100	mA
I_{CC}	Supply current		V_{CC} = MAX,	See Note 2		20	35		20	35	mA

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

NOTES: 2. I_{CC} is measured with all inputs grounded and all outputs open.

3. Minimum count enable time is the interval immediately preceeding the rising edge of the clock pulse during which interval the count enable input must be low to ensure counting.

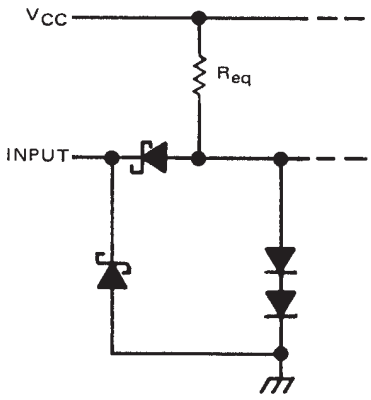
switching characteristics, V_{CC} = 5 V, T_A = 25°C

PARAMETER†	FROM (INPUT)	TO (OUTPUT)	TEST CONDITIONS	'LS190, 'LS191 MIN	TYP	MAX	UNIT
f_{max}			C_L = 15 pF, R_L = 2 kΩ, See Figures 1 and 3 thru 7	20	25		MHz
t_{PLH}	$\overline{Load}$	Q_A, Q_B, Q_C, Q_D			22	33	ns
t_{PHL}					33	50	
t_{PLH}	Data A, B, C, D	Q_A, Q_B, Q_C, Q_D			20	32	ns
t_{PHL}					27	40	
t_{PLH}	CLK	$\overline{RCO}$			13	20	ns
t_{PHL}					16	24	
t_{PLH}	CLK	Q_A, Q_B, Q_C, Q_D			16	24	ns
t_{PHL}					24	36	
t_{PLH}	CLK	Max/Min			28	42	ns
t_{PHL}					37	52	
t_{PLH}	D/$\overline{U}$	$\overline{RCO}$			30	45	ns
t_{PHL}					30	45	
t_{PLH}	D/$\overline{U}$	Max/Min			21	33	ns
t_{PHL}					22	33	
t_{PLH}	$\overline{CTEN}$	$\overline{RCO}$			21	33	ns
t_{PHL}					22	33	

† 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

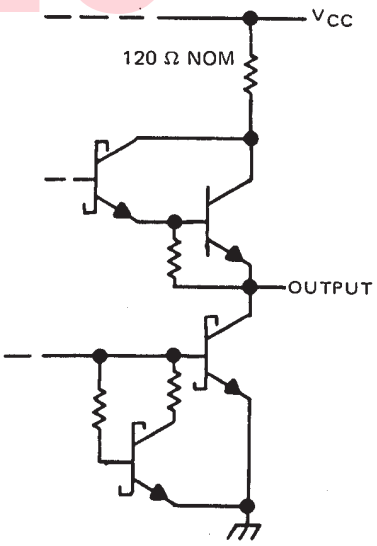
schematics of inputs and outputs

EQUIVALENT OF EACH INPUT



Enable input: R_{eq} = 8.33 kΩ NOM
Load input: R_{eq} = 25 kΩ NOM
All other inputs: R_{eq} = 17 kΩ NOM

TYPICAL OF ALL OUTPUTS



PARAMETER MEASUREMENT INFORMATION

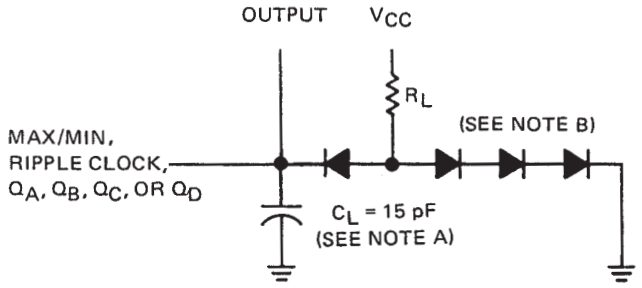
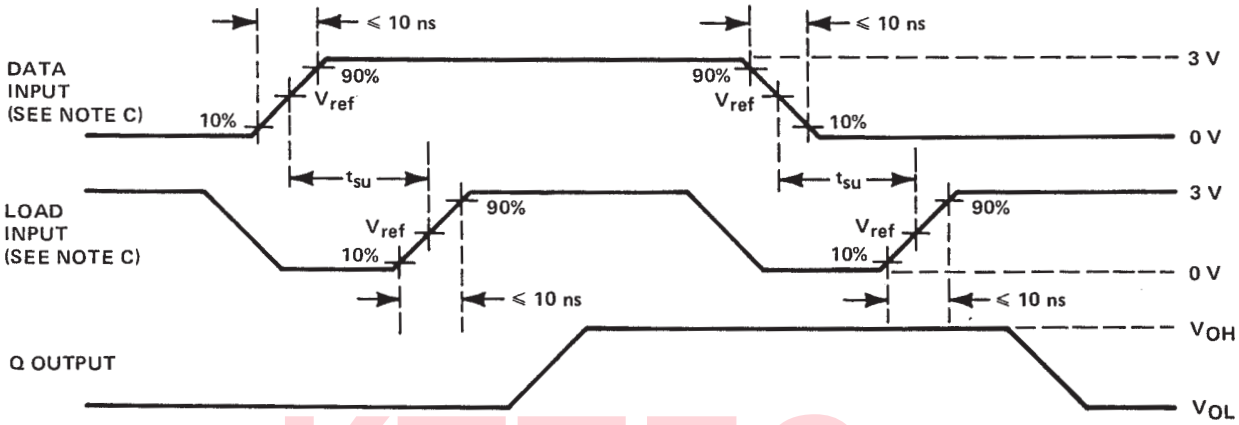
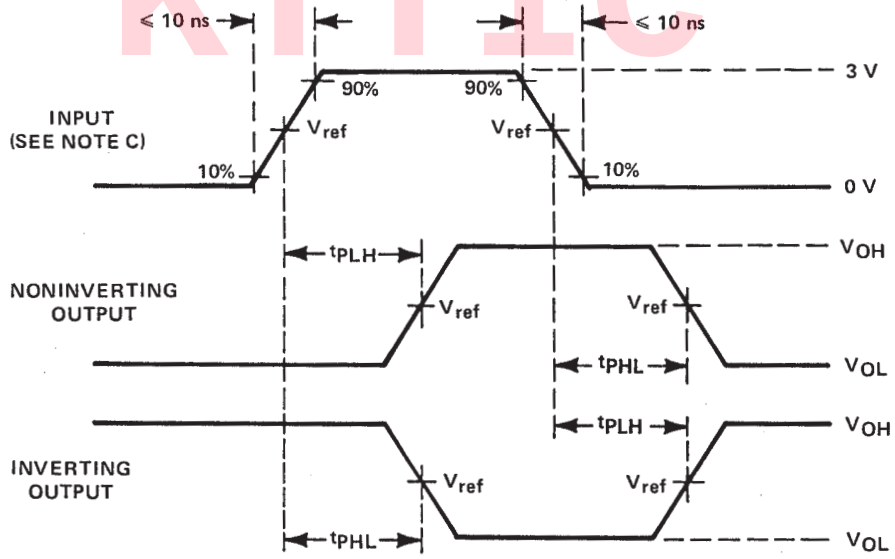


FIGURE 1–LOAD CIRCUIT
FOR SWITCHING TIME MEASUREMENT



FIGUTE 2-DATA SETUP TIME VOLTAGE WAVEFORMS

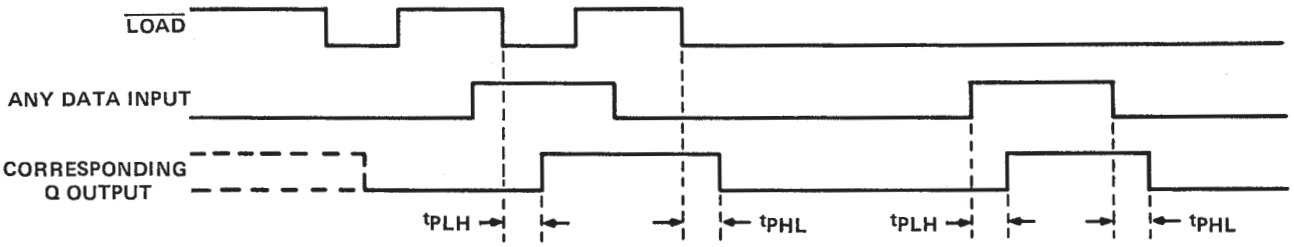


See waveform sequences in figures 4 through 7 for propagation times from a specific input to a specific output. For simplication, pulse rise times, reference levels, etc., have not been shown in figures 4 through 7.

FIGURE 3-GENERAL VOLTAGE WAVEFORMS FOR PROPAGATION TIMES

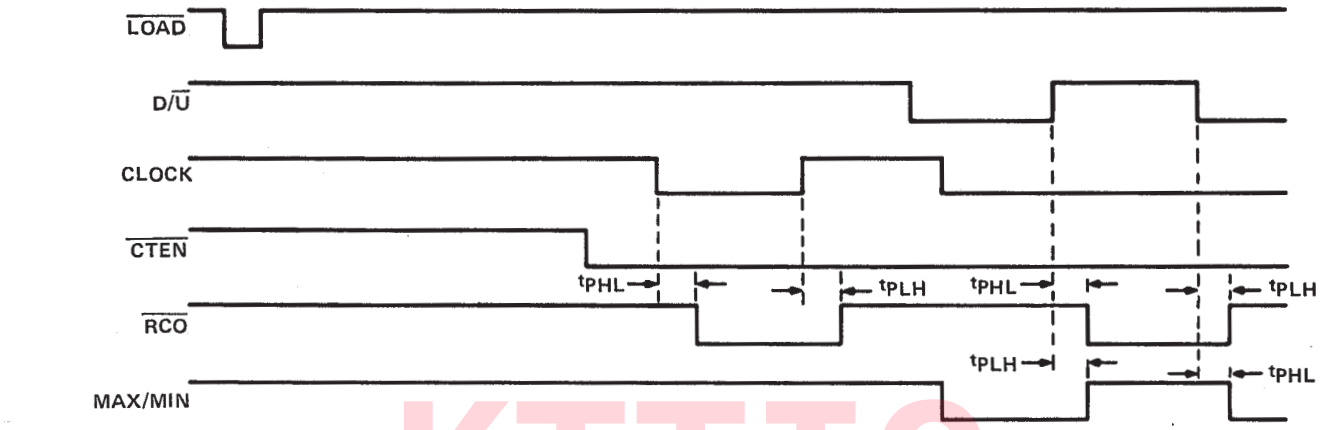
NOTES: A. C_L includes probe and jig capacitance.
B. All diodes are 1N3064 or equivalent.
C. The input pulses are supplied by generators having the following characteristics: Z_{out} = 50 Ω, duty cycle ⩽ 50%, PRR ⩽ 1 MHz.
D. V_{ref} = 1.5 V for '190 and '191; 1.3 V for 'LS190 and 'LS191.

PARAMETER MEASUREMENT INFORMATION (continued)



NOTE E: Conditions on other inputs are irrelevant.

FIGURE 4–LOAD TO OUTPUT AND DATA TO OUTPUT

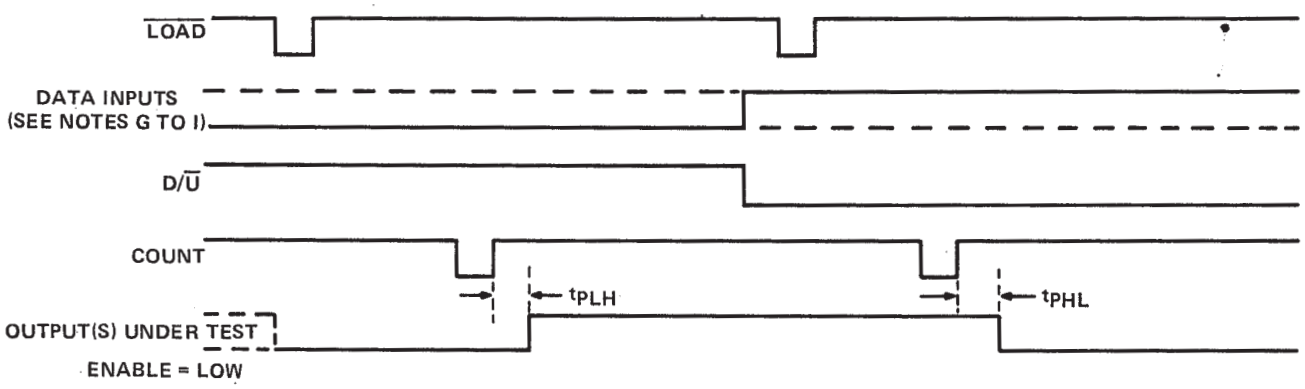


NOTE F: All data inputs are low.

FIGURE 5–ENABLE TO RIPPLE CLOCK, CLOCK TO RIPPLE CLOCK, DOWN/UP TO RIPPLE CLOCK, AND DOWN/UP TO MAX/MIN

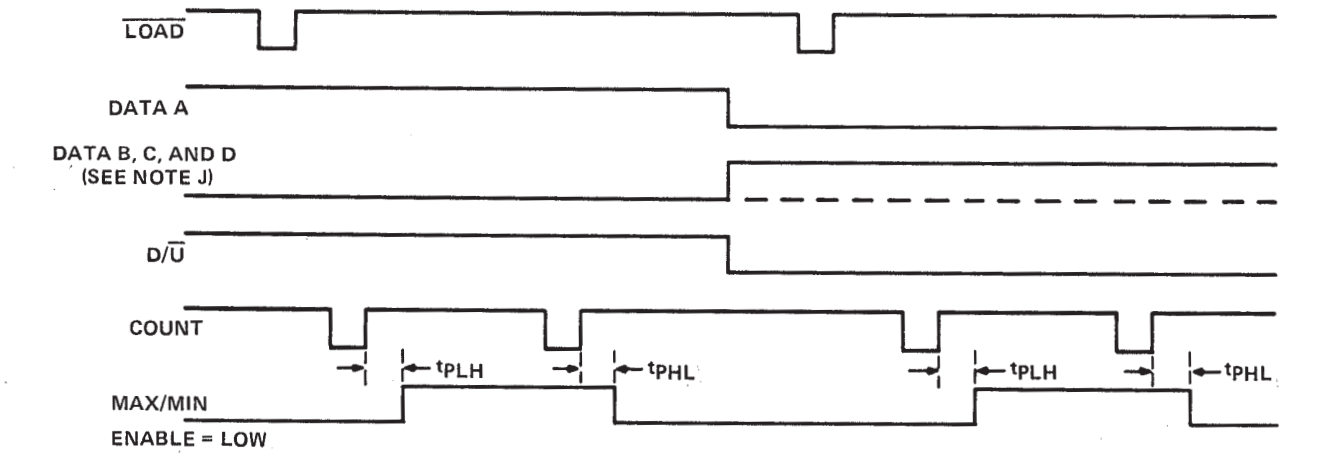
PARAMETER MEASUREMENT INFORMATION (continued)

switching characteristics (continued)



NOTES: G. To test Q_A, Q_B, and Q_C outputs of '190 and 'LS190: Data inputs A, B, and C are shown by the solid line. Data input D is shown by the dashed line.
H. To test Q_D output of '190 and 'LS190: Data inputs A and D are shown by the solid line. Data inputs B and C are held at the low logic level.
I. To test Q_A, Q_B, Q_C, and Q_D outputs of '191 and 'LS191: All four data inputs are shown by the solid line.

FIGURE 6-CLOCK TO OUTPUT

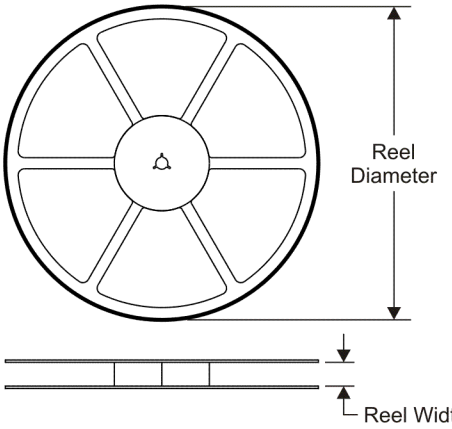


NOTE J: Data inputs B and C are shown by the dashed line for the '190 and 'LS190 and the solid line for the '191 and 'LS191: Data input D is shown by the solid line for both devices.

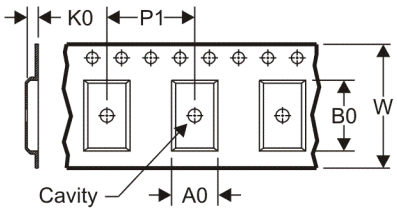
FIGURE 7-CLOCK TO MAX/MIN

TAPE AND REEL INFORMATION

REEL DIMENSIONS

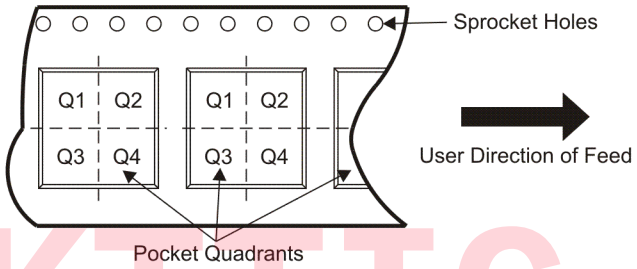


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

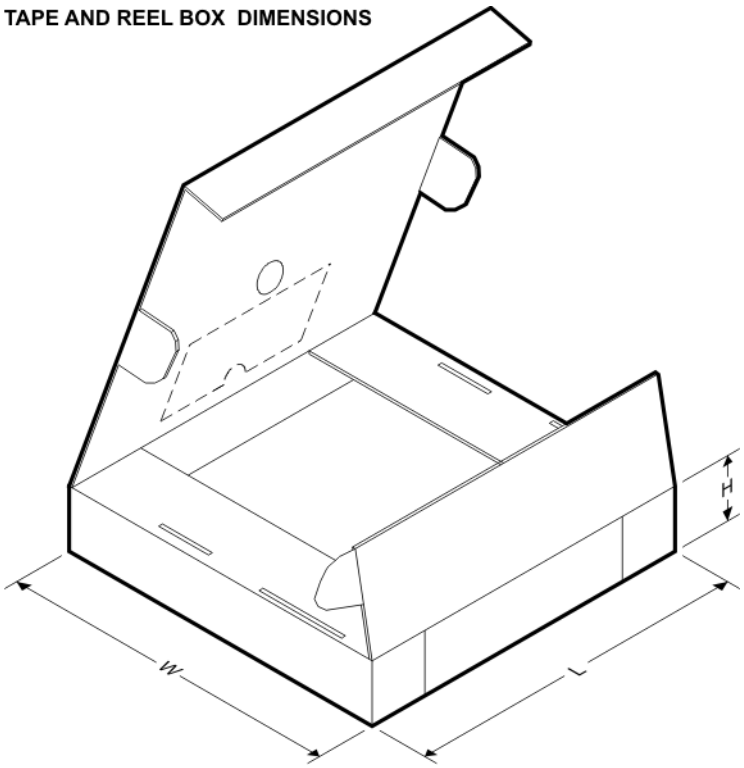
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SN74LS191DR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
SN74LS191NSR	SO	NS	16	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74LS191DR	SOIC	D	16	2500	333.2	345.9	28.6
SN74LS191NSR	SO	NS	16	2000	346.0	346.0	33.0

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