

SN54190, SN54191, SN54LS190, SN54LS191, SN74190, SN74191, SN74LS190, SN74LS191 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 Presetable with Load Control
- Parallel Outputs
- Cascadable for n-Bit Applications

SN54190, SN54191, SN54LS190,
SN54LS191 . . . J PACKAGE
SN74190, SN74191 . . . N PACKAGE
SN74LS190, SN74LS191 . . . D OR N PACKAGE

(TOP VIEW)



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

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 .

PRODUCTION DATA information is 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.

 **TEXAS
INSTRUMENTS**

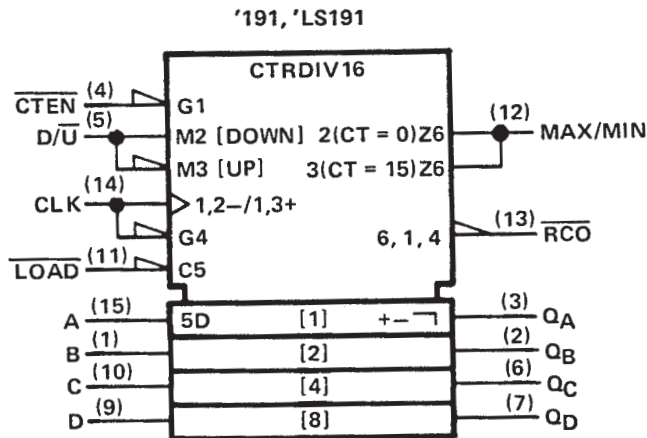
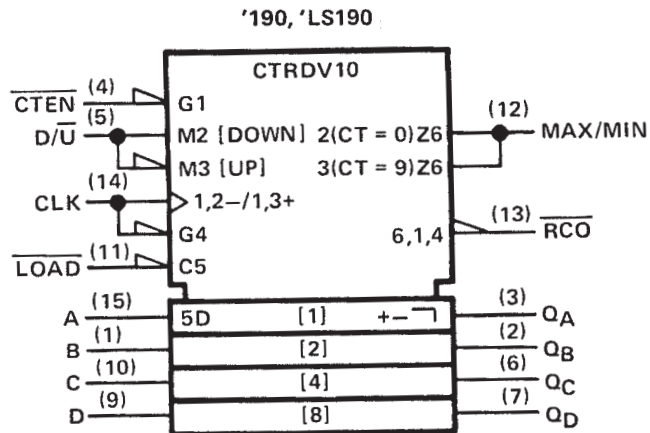
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SN54190, SN54191, SN54LS190, SN54LS191,
 SN74190, SN74191, SN74LS190, SN74LS191
 SYNCHRONOUS UP/DOWN COUNTERS WITH DOWN/UP MODE CONTROL

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logic symbols†



† 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.

SN54190, SN54LS190, SN74190, SN74LS190

SYNCHRONOUS UP/DOWN COUNTERS WITH DOWN/UP MODE CONTROL

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logic diagram (positive logic)



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



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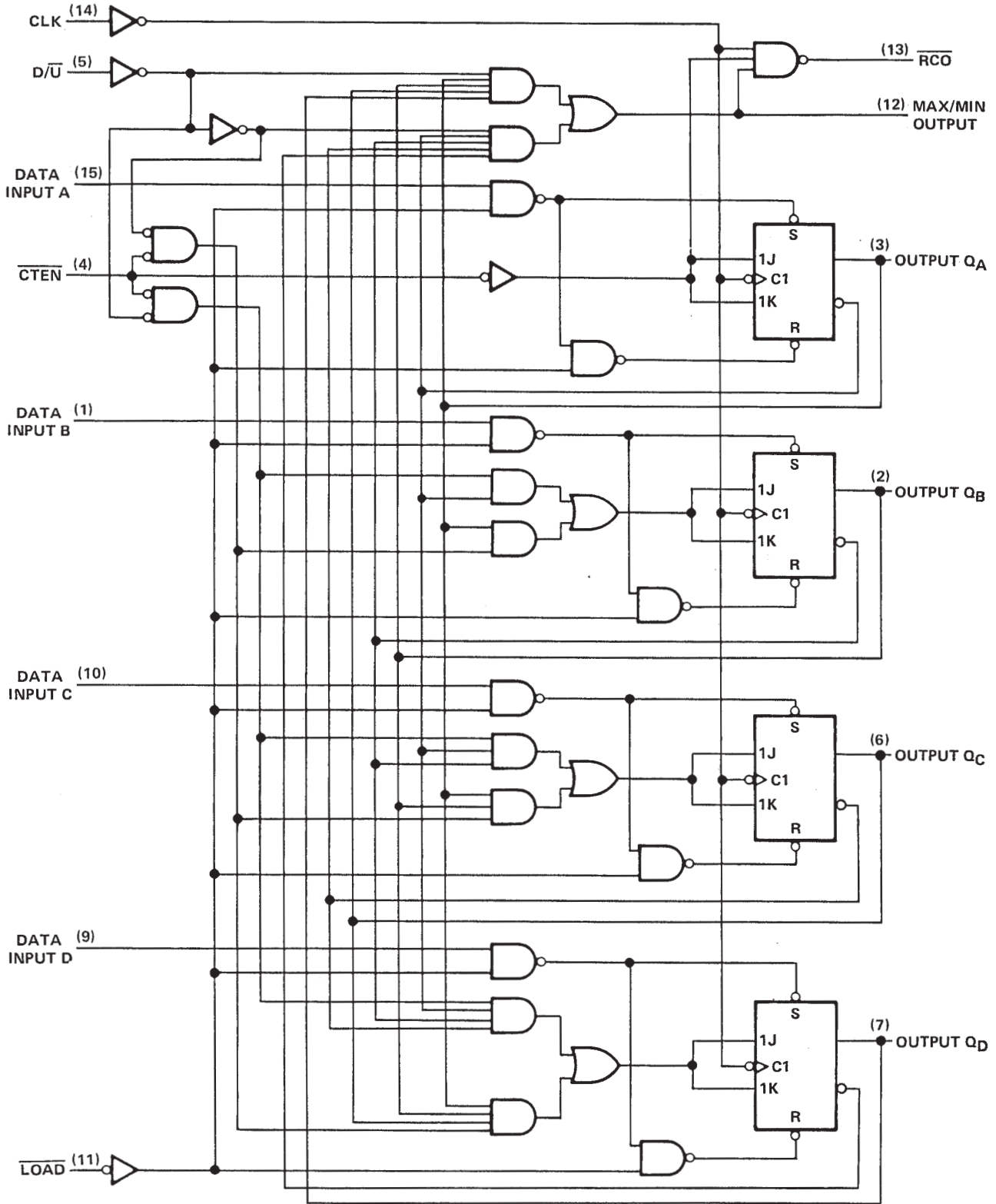
SN54191, SN54LS191, SN74191, SN74LS191

SYNCHRONOUS UP/DOWN COUNTERS WITH DOWN/UP MODE CONTROL

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logic diagram (positive logic)

'191, 'LS191 BINARY COUNTERS



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



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SN54190, SN54LS190, SN74190, SN74LS190 SYNCHRONOUS UP/DOWN COUNTERS WITH DOWN/UP MODE CONTROL

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'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.



SN54191, SN54LS191, SN74191, SN74LS191 SYNCHRONOUS UP/DOWN COUNTERS WITH DOWN/UP MODE CONTROL

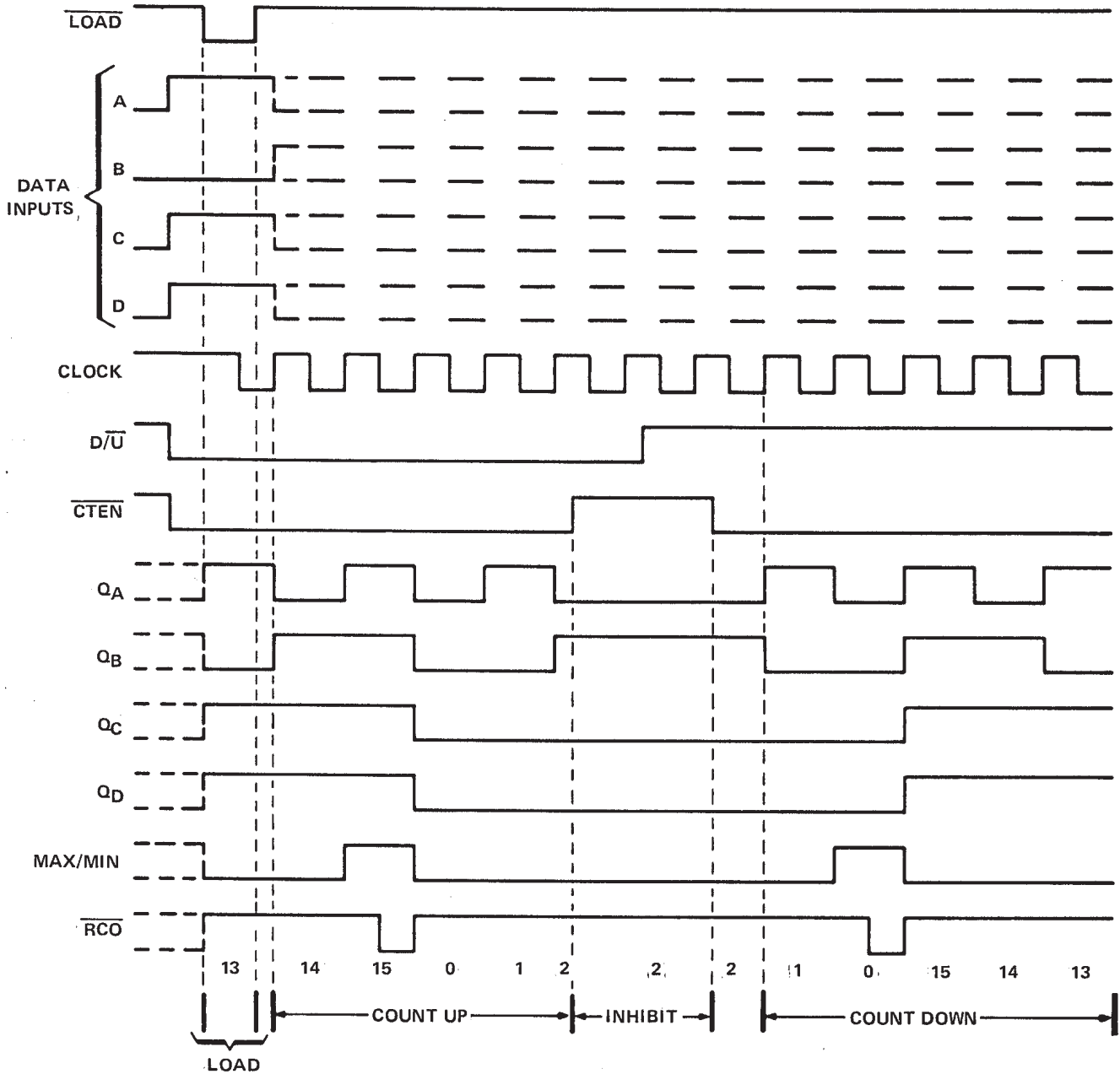
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'191, 'LS191 BINARY COUNTERS

typical 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.



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SN54190, SN54191, SN54LS190, SN54LS191, SN74190, SN74191, SN74LS190, SN74LS191 SYNCHRONOUS UP/DOWN COUNTERS WITH DOWN/UP MODE CONTROL

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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 | | | ns |
| | | Load inactive state | | | 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 | $V_{CC} = \text{MIN}$ | | | 2 | | | V | |
| V_{IL} | Low-level input voltage | $V_{CC} = \text{MIN}$ | | | 0.8 | | | V | |
| V_{IK} | Input clamp voltage | $V_{CC} = \text{MIN}, I_I = -12 \text{ mA}$ | | | -1.5 | | | V | |
| V_{OH} | High-level output voltage | $V_{CC} = \text{MIN}, V_{IH} = 2 \text{ V}, V_{IL} = 0.8 \text{ V}, I_{OH} = -0.8 \text{ mA}$ | | | 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 | | V | |
| I_I | High-level input current at maximum input voltage | $V_{CC} = \text{MAX}, V_I = 5.5 \text{ V}$ | | | 1 | | | mA | |
| I_{IH} | High-level input current at any input except enable | $V_{CC} = \text{MAX}, V_I = 2.4 \text{ V}$ | | | 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 | $V_{CC} = \text{MAX}, V_I = 0.4 \text{ V}$ | | | -1.6 | | | mA | |
| I_{IL} | Low-level input current at enable input | | | | -4.8 | | | -4.8 | mA |
| I_{OS} | Short-circuit output current§ | $V_{CC} = \text{MAX}$ | | | -20 | -65 | -18 | -65 | mA |
| I_{CC} | Supply current | $V_{CC} = \text{MAX},$ 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 $V_{CC} = 5 \text{ V}, T_A = 25^\circ\text{C}$.

§ 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.



SN54190, SN54191, SN74190, SN74191 SYNCHRONOUS UP/DOWN COUNTERS WITH DOWN/UP MODE CONTROL

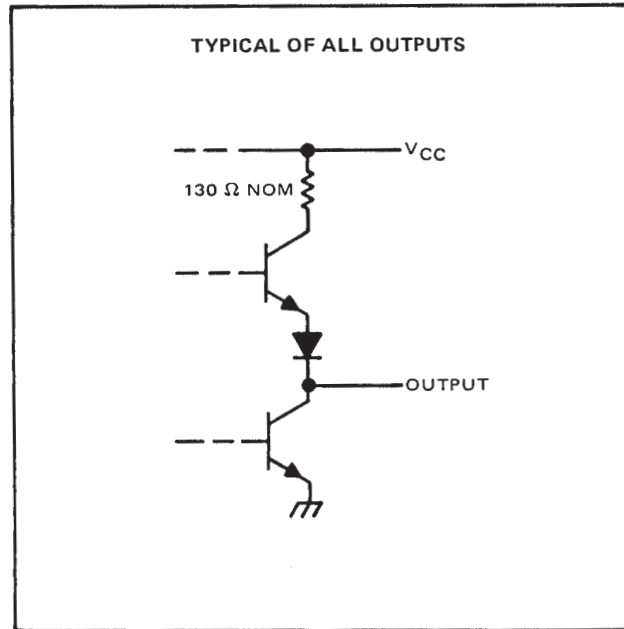
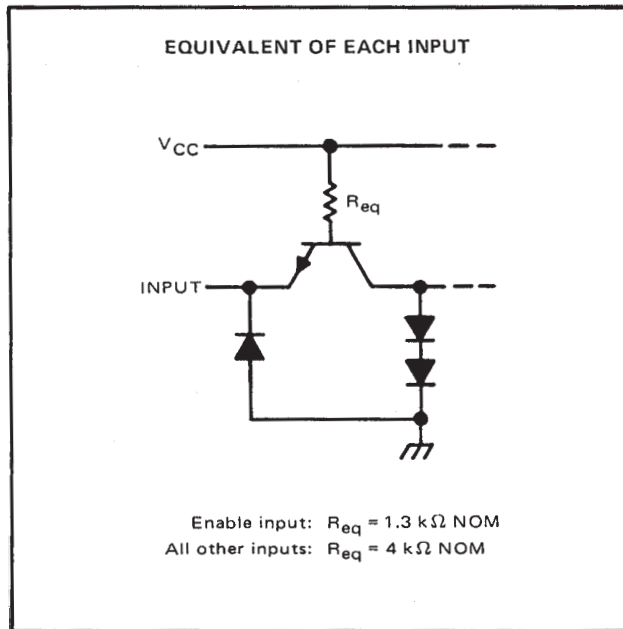
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switching characteristics, $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$

| PARAMETER† | FROM (INPUT) | TO (OUTPUT) | TEST CONDITIONS | '190, '191 | | | UNIT |
|------------|--------------------------|-------------------------|--|------------|-----|-----|------|
| | | | | MIN | TYP | MAX | |
| f_{\max} | | | $C_L = 15\text{ pF}$, $R_L = 400\ \Omega$, See Figures 1 and 3 thru 7 | 20 | 25 | | MHz |
| t_{PLH} | $\overline{\text{Load}}$ | 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 | $\overline{\text{RCO}}$ | | | 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} | $\overline{\text{RCO}}$ | | | 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



SN54LS190, SN54LS191, SN74LS190, SN74LS191 SYNCHRONOUS UP/DOWN COUNTERS WITH DOWN/UP MODE CONTROL

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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 _{IK} | Input clamp voltage | V _{CC} = MIN, I _I = -18 mA | | | -1.5 | | | -1.5 | |
| 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 | | | 0.25 | 0.4 | 0.25 | 0.4 | |
| | | | | | | | 0.35 | 0.5 | |
| I _I | High-level input current at maximum input voltage | Enable | | | 0.3 | | | 0.3 | |
| | | Others | V _{CC} = MAX, V _I = 7 V | | | 0.1 | | 0.1 | |
| I _{IH} | High-level input current | Enable | | | 60 | | | 60 | |
| | | Others | V _{CC} = MAX, V _I = 2.7 V | | | 20 | | 20 | |
| I _{IL} | Low-level input current | Enable | | | -1.2 | | | -1.2 | |
| | | Others | V _{CC} = MAX, V _I = 0.4 V | | | -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 preceding the rising edge of the clock pulse during which interval the count enable input must be low to ensure counting.



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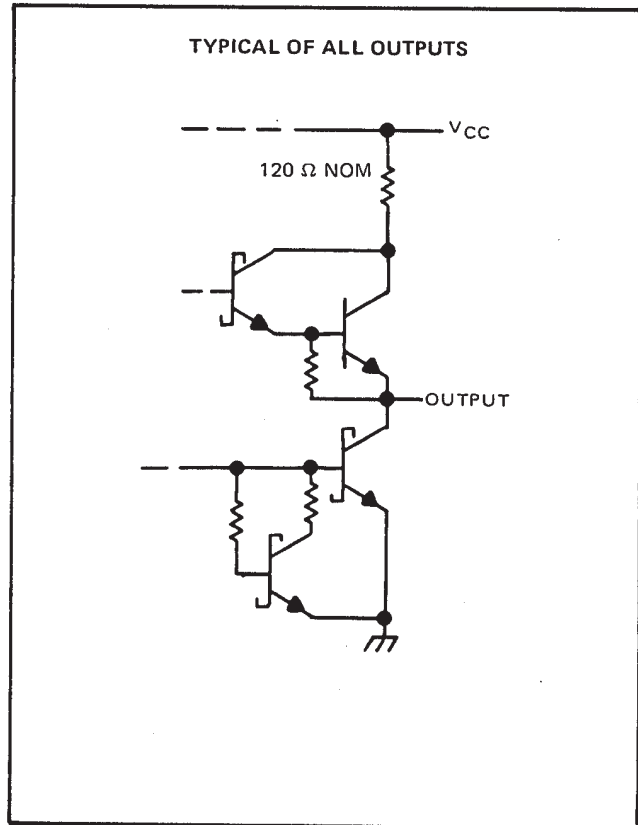
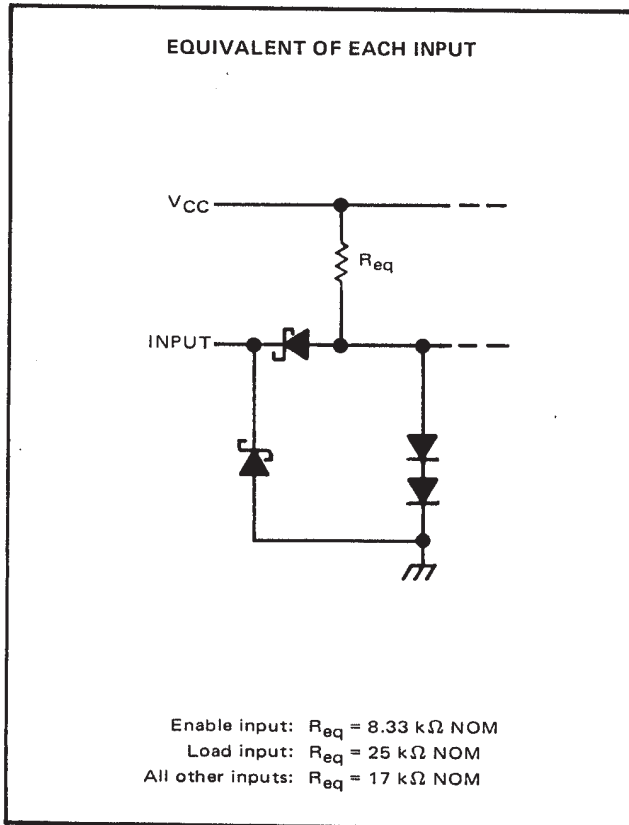
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switching characteristics, $V_{CC} = 5\text{ V}$, $T_A = 25^\circ\text{C}$

| PARAMETER† | FROM (INPUT) | TO (OUTPUT) | TEST CONDITIONS | 'LS190, 'LS191 | | | UNIT |
|------------|-------------------|----------------------|---|----------------|-----|-----|------|
| | | | | MIN | TYP | MAX | |
| f_{max} | | | $C_L = 15\text{ pF}$, $R_L = 2\text{ k}\Omega$, See Figures 1 and 3 thru 7 | 20 | 25 | | MHz |
| t_{PLH} | 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



SN54190, SN54191, SN54LS190, SN54LS191,
SN74190, SN74191, SN74LS190, SN74LS191
SYNCHRONOUS UP/DOWN COUNTERS WITH DOWN/UP MODE CONTROL

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PARAMETER MEASUREMENT INFORMATION



**FIGURE 1—LOAD CIRCUIT
FOR SWITCHING TIME MEASUREMENT**



FIGURE 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 simplification, pulse rise times, reference levels, etc., have not been shown in figures 4 through 7.

FIGURE 3—GENERAL VOLTAGE WAVEFORMS FOR PROPAGATION TIMES

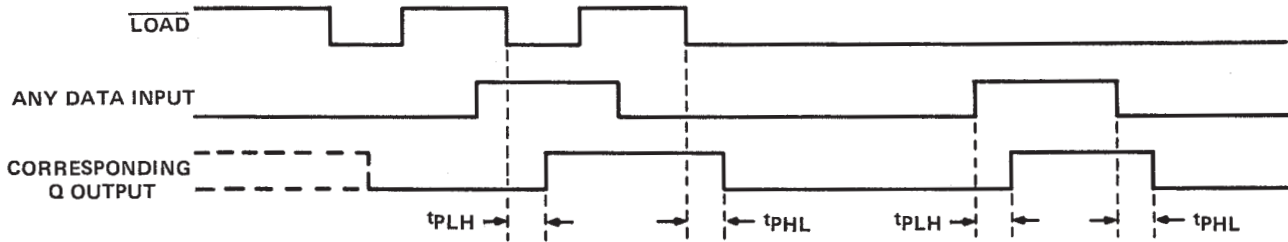
- NOTES: A. C_L includes probe and jig capacitance.
 B. All diodes are 1N3064 or equivalent.
 C. The input pulses are supplied by generators having the following characteristics: $Z_{out} = 50 \Omega$, duty cycle $\leq 50\%$, PRR $\leq 1\text{ MHz}$.
 D. $V_{ref} = 1.5\text{ V}$ for '190 and '191; 1.3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



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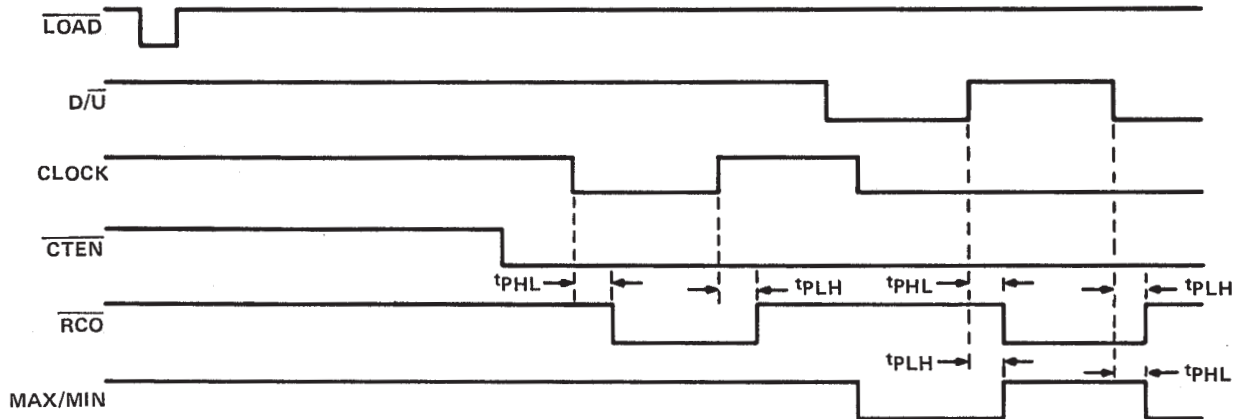
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PARAMETER MEASUREMENT INFORMATION (continued)



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

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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

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