

# MM54HC190/MM74HC190 Synchronous Decade Up/Down Counters with Mode Control MM54HC191/MM74HC191 Synchronous Binary Up/Down Counters with Mode Control

## General Description

These high speed synchronous counters utilize advanced silicon-gate CMOS technology. They possess the high noise immunity and low power consumption of CMOS technology, along with the speeds of low power Schottky TTL.

These circuits are synchronous, reversible, up/down counters. The MM54HC191/MM74HC191 are 4-bit binary counters and the MM54HC190/MM74HC190 are BCD counters. Synchronous operation is provided by having all flip-flops clocked simultaneously, so that the outputs change simultaneously 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 level transition of the clock input, if the enable input is low. A high at the enable input inhibits counting. The direction of the count is determined by the level of the down/up input. When low, the counter counts up and when high, it counts down.

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 independent of the level of the clock input. This feature allows the counters to be used as modulo-

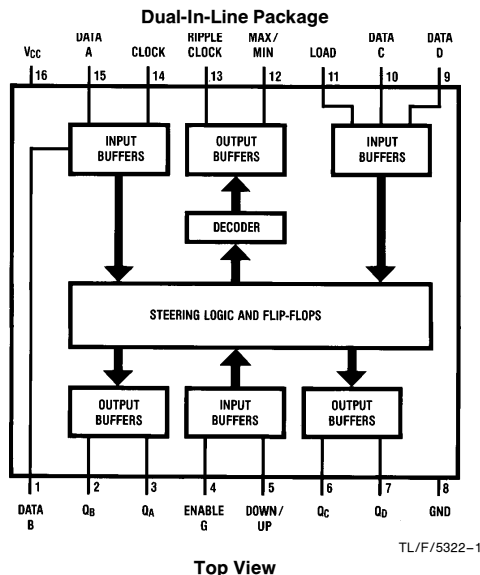
N dividers by simply modifying the count length with the preset inputs.

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.

## Features

- Level changes on Enable or Down/Up can be made regardless of the level of the clock input
- Wide power supply range: 2–6V
- Low quiescent supply current: 80  $\mu$ A maximum (74HC Series)
- Low input current: 1  $\mu$ A maximum

## Connection Diagram



Load	Enable G	Down/Up	Clock	Function
H	L	L	↑	Count Up
H	L	H	↑	Count Down
L	X	X	X	Load
H	H	X	X	No Change

Asynchronous inputs Low input to load sets  $Q_A = A$ ,  
 $Q_B = B$ ,  $Q_C = C$ , and  $Q_D = D$

Order Number MM54HC190/191 or MM74HC190/191

MM54HC190/MM74HC190/MM54HC191/MM74HC191

## Absolute Maximum Ratings (Notes 1 & 2)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage ( $V_{CC}$ )	-0.5 to +7.0V
DC Input Voltage ( $V_{IN}$ )	-1.5 to $V_{CC} + 1.5V$
DC Output Voltage ( $V_{OUT}$ )	-0.5 to $V_{CC} + 0.5V$
Clamp Diode Current ( $I_{IK}, I_{OK}$ )	$\pm 20$ mA
DC Output Current, per pin ( $I_{OUT}$ )	$\pm 25$ mA
DC $V_{CC}$ or GND Current, per pin ( $I_{CC}$ )	$\pm 50$ mA
Storage Temperature Range ( $T_{STG}$ )	-65°C to +150°C
Power Dissipation ( $P_D$ )	
(Note 3)	600 mW
S.O. Package only	500 mW
Lead Temp. ( $T_L$ ) (Soldering 10 seconds)	260°C

## Operating Conditions

	Min	Max	Units
Supply Voltage ( $V_{CC}$ )	2	6	V
DC Input or Output Voltage ( $V_{IN}, V_{OUT}$ )	0	$V_{CC}$	V
Operating Temp. Range ( $T_A$ )			
MM74HC	-40	+85	°C
MM54HC	-55	+125	°C
Input Rise or Fall Times ( $t_r, t_f$ )			
$V_{CC} = 2.0V$		1000	ns
$V_{CC} = 4.5V$		500	ns
$V_{CC} = 6.0V$		400	ns

## DC Electrical Characteristics (Note 4)

Symbol	Parameter	Conditions	$V_{CC}$	$T_A = 25^\circ C$			Units	
				74HC $T_A = -40$ to $85^\circ C$	54HC $T_A = -55$ to $125^\circ C$			
				Typ	Guaranteed Limits			
$V_{IH}$	Minimum High Level Input Voltage		2.0V		1.5	1.5	V	
			4.5V		3.15	3.15	V	
			6.0V		4.2	4.2	V	
$V_{IL}$	Maximum Low Level Input Voltage**		2.0V		0.5	0.5	V	
			4.5V		1.35	1.35	V	
			6.0V		1.8	1.8	V	
$V_{OH}$	Minimum High Level Output Voltage	$V_{IN} = V_{IH}$ or $V_{IL}$ $ I_{OUT}  \leq 20 \mu A$	2.0V	2.0	1.9	1.9	V	
			4.5V	4.5	4.4	4.4	V	
			6.0V	6.0	5.9	5.9	V	
		$V_{IN} = V_{IH}$ or $V_{IL}$ $ I_{OUT}  \leq 4.0$ mA $ I_{OUT}  \leq 5.2$ mA	4.5V	4.2	3.98	3.84	3.7	V
			6.0V	5.7	5.48	5.34	5.2	V
$V_{OL}$	Maximum Low Level Output Voltage	$V_{IN} = V_{IH}$ or $V_{IL}$ $ I_{OUT}  \leq 20 \mu A$	2.0V	0	0.1	0.1	V	
			4.5V	0	0.1	0.1	V	
			6.0V	0	0.1	0.1	V	
		$V_{IN} = V_{IH}$ or $V_{IL}$ $ I_{OUT}  \leq 4.0$ mA $ I_{OUT}  \leq 5.2$ mA	4.5V	0.2	0.26	0.33	0.4	V
			6.0V	0.2	0.26	0.33	0.4	V
$I_{IN}$	Maximum Input Current	$V_{IN} = V_{CC}$ or GND	6.0V		$\pm 0.1$	$\pm 1.0$	$\mu A$	
$I_{CC}$	Maximum Quiescent Supply Current	$V_{IN} = V_{CC}$ or GND $I_{OUT} = 0 \mu A$	6.0V		8.0	80	$\mu A$	

**Note 1:** Absolute Maximum Ratings are those values beyond which damage to the device may occur.

**Note 2:** Unless otherwise specified all voltages are referenced to ground.

**Note 3:** Power Dissipation temperature derating — plastic "N" package: -12 mW/°C from 65°C to 85°C; ceramic "J" package: -12 mW/°C from 100°C to 125°C.

**Note 4:** For a power supply of 5V  $\pm 10\%$  the worst case output voltages ( $V_{OH}$ , and  $V_{OL}$ ) occur for HC at 4.5V. Thus the 4.5V values should be used when designing with this supply. Worst case  $V_{IH}$  and  $V_{IL}$  occur at  $V_{CC} = 5.5V$  and 4.5V respectively. (The  $V_{IH}$  value at 5.5V is 3.85V.) The worst case leakage current ( $I_{IN}$ ,  $I_{CC}$ , and  $I_{OZ}$ ) occur for CMOS at the higher voltage and so the 6.0V values should be used.

\*\* $V_{IL}$  limits are currently tested at 20% of  $V_{CC}$ . The above  $V_{IL}$  specification (30% of  $V_{CC}$ ) will be implemented no later than Q1, CY'89.

**AC Electrical Characteristics**  $T_A = 25^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V}$ ,  $t_r = t_f = 6\text{ ns}$ ,  $C_L = 15\text{ pF}$  (unless otherwise specified)

Symbol	Parameter	From (Input)	To (Output)	Typ	Units
$f_{MAX}$	Maximum Clock Frequency			40	MHz
$t_{PLH}$ , $t_{PHL}$	Maximum Propagation Delay Time	Load	$Q_A$ , $Q_B$ $Q_C$ , $Q_D$	30	ns
$t_{PLH}$ , $t_{PHL}$	Maximum Propagation Delay Time	Data A, B, C, D	$Q_A$ , $Q_B$ $Q_C$ , $Q_D$	27	ns
$t_{PLH}$ , $t_{PHL}$	Maximum Propagation Delay Time	Clock	Ripple Clock	16	ns
$t_{PLH}$ , $t_{PHL}$	Maximum Propagation Delay Time	Clock	$Q_A$ , $Q_B$ $Q_C$ , $Q_D$	24	ns
$t_{PLH}$ , $t_{PHL}$	Maximum Propagation Delay Time	Clock	Max/Min	30	ns
$t_{PLH}$ , $t_{PHL}$	Maximum Propagation Delay Time	Down/Up	Ripple Clock	29	ns
$t_{PLH}$ , $t_{PHL}$	Maximum Propagation Delay Time	Down/Up	Max/Min	22	ns
$t_{PHL}$ , $t_{PLH}$	Maximum Propagation Delay Time	Enable	Ripple Clock	22	ns
$t_W$	Minimum Clock, Clear or Load Input Pulse Width			10	ns

**AC Electrical Characteristics**  $V_{CC} = 2.0\text{V}$  to  $6.0\text{V}$ ,  $C_L = 50\text{ pF}$ ,  $t_r = t_f = 6\text{ ns}$  (unless otherwise specified)

Symbol	Parameter	From (Input)	To (Output)	$V_{CC}$	$T_A = 25^\circ\text{C}$		74HC	54HC	Units
							$T_A = -40\text{ to }85^\circ\text{C}$	$T_A = -55\text{ to }125^\circ\text{C}$	
					Typ	Guaranteed Limits			
$f_{MAX}$	Maximum Clock Frequency			2.0V	9	4.0	3.5	2.6	MHz
				4.5V	30	20	16	13	MHz
				6.0V	36	24	19	15	MHz
$t_{PLH}$ , $t_{PHL}$	Maximum Propagation Delay Time	Load	$Q_A$ , $Q_B$ $Q_C$ , $Q_D$	2.0V	80	220	275	330	ns
				4.5V	27	44	55	66	ns
				6.0V	21	37	47	56	ns
$t_{PLH}$ , $t_{PHL}$	Maximum Propagation Delay Time	Data A, B, C, D	$Q_A$ , $Q_B$ $Q_C$ , $Q_D$	2.0V	71	200	250	300	ns
				4.5V	25	40	50	60	ns
				6.0V	19	34	43	51	ns
$t_{PLH}$ , $t_{PHL}$	Maximum Propagation Delay Time	Clock	Ripple Clock	2.0V	44	125	155	190	ns
				4.5V	25	25	31	38	ns
				6.0V	14	21	26	32	ns
$t_{PLH}$ , $t_{PHL}$	Maximum Propagation Delay Time	Clock	$Q_A$ , $Q_B$ $Q_C$ , $Q_D$	2.0V	83	215	270	325	ns
				4.5V	29	43	54	65	ns
				6.0V	22	37	46	55	ns

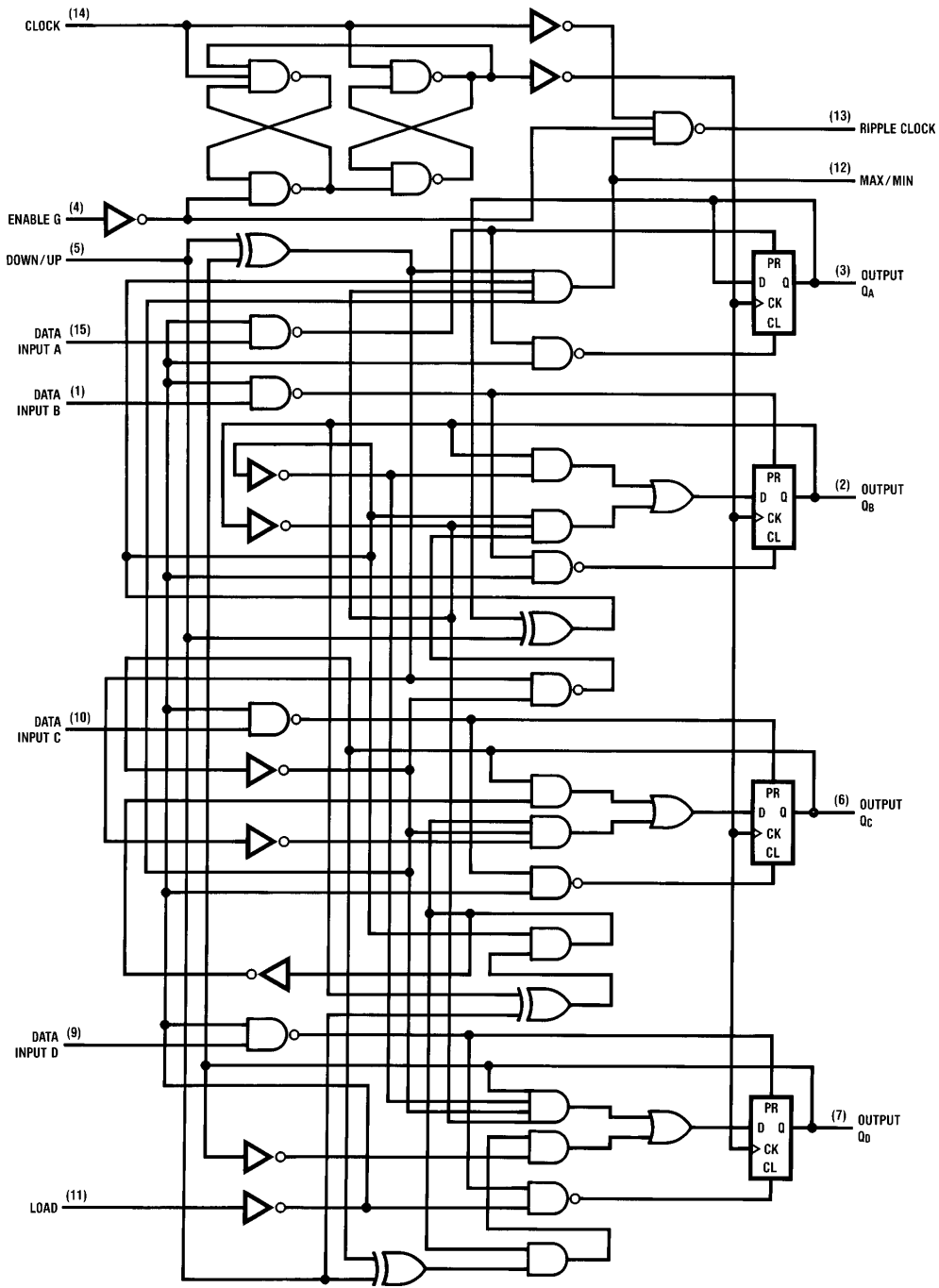
## AC Electrical Characteristics (Continued)

Symbol	Parameter	From (Input)	To (Output)	Conditions	V <sub>CC</sub>	T <sub>A</sub> = 25°C		74HC	54HC	Units
								T <sub>A</sub> = -40 to 85°C	T <sub>A</sub> = -55 to 125°C	
						Typ	Guaranteed Limits			
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay Time	Clock	Max/Min		2.0V	125	255	320	385	ns
					4.5V	41	51	64	77	ns
					6.0V	31	43	54	65	ns
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay Time	Down/Up	Ripple Clock		2.0V	90	210	265	315	ns
					4.5V	30	42	53	63	ns
					6.0V	24	36	45	54	ns
t <sub>PLH</sub> , t <sub>PHL</sub>	Maximum Propagation Delay Time	Down/Up	Max/Min		2.0V	88	190	240	285	ns
					4.5V	30	38	48	57	ns
					6.0V	23	32	41	48	ns
t <sub>PHL</sub> , t <sub>PLH</sub>	Maximum Propagation Delay Time	Enable	Ripple Clock		2.0V	50	125	155	190	ns
					4.5V	18	25	31	38	ns
					6.0V	14	21	26	32	ns
t <sub>w</sub>	Minimum Clock, Load or Clear Input Pulse Width				2.0V	36	125	155	190	ns
					4.5V	12	25	31	38	ns
					6.0V	9	21	26	32	ns
t <sub>s</sub>	Minimum Setup Time	Data	Load		2.0V	50	100	125	150	ns
					4.5V	14	20	25	30	ns
					6.0V	10	17	21	26	ns
t <sub>H</sub>	Data Hold Time	Load	Data		2.0V	-16	25	30	40	ns
					4.5V	-3	5	6	8	ns
					6.0V	-2	5	6	7	ns
t <sub>s</sub>	Minimum Setup Time	Down/Up	Clock		2.0V	62	150	190	225	ns
					4.5V	18	30	38	48	ns
					6.0V	14	26	33	38	ns
t <sub>H</sub>	Minimum Hold Time	Clock	Down/Up		2.0V	-23	0	0	0	ns
					4.5V	-5	0	0	0	ns
					6.0V	-4	0	0	0	ns
t <sub>s</sub>	Minimum Setup Time	Enable	Clock		2.0V	28	100	125	150	ns
					4.5V	10	20	25	30	ns
					6.0V	7	17	21	26	ns
t <sub>H</sub>	Minimum Hold Time	Clock	Enable		2.0V	-11	0	0	0	ns
					4.5V	-5	0	0	0	ns
					6.0V	-3	0	0	0	ns
t <sub>rem</sub>	Minimum Removal Time	Load	Clock		2.0V	1	25	30	40	ns
					4.5V	1	5	6	8	ns
					6.0V	0	5	6	7	ns
t <sub>THL</sub> , t <sub>TLH</sub>	Maximum Output Rise and Fall Time				2.0V	30	75	95	110	s
					4.5V	10	15	19	22	ns
					6.0V	9	13	16	19	ns
t <sub>w</sub>	Minimum Load Pulse Width				2.0V	53	100	125	150	ns
					4.5V	15	20	25	30	ns
					6.0V	12	17	21	26	ns
C <sub>IN</sub>	Input Capacitance					5	10	10	10	pF
C <sub>PD</sub>	Power Dissipation Capacitance (Note 5)					35				pF

**Note 5:** C<sub>PD</sub> determines the no load dynamic power consumption, P<sub>D</sub> = C<sub>PD</sub> V<sub>CC</sub><sup>2</sup> f + I<sub>CC</sub> V<sub>CC</sub>, and the no load dynamic current consumption, I<sub>S</sub> = C<sub>PD</sub> V<sub>CC</sub> f + I<sub>CC</sub>.

# Logic Diagrams

## 'HC190 Decade Counters

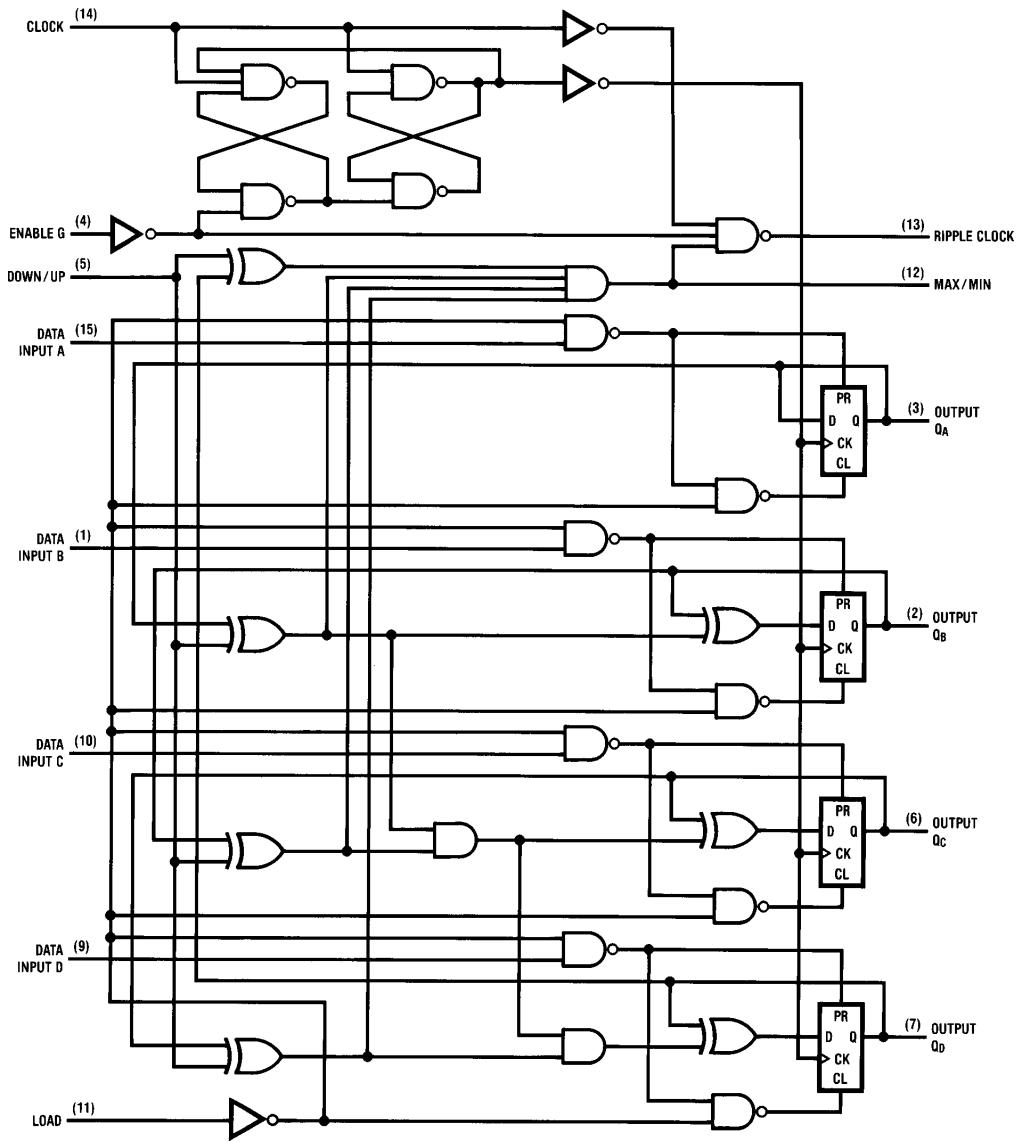


Pin (16) = V<sub>CC</sub>, Pin (8) = GND

TL/F/5322-2

# Logic Diagrams (Continued)

## 'HC191 Binary Counters

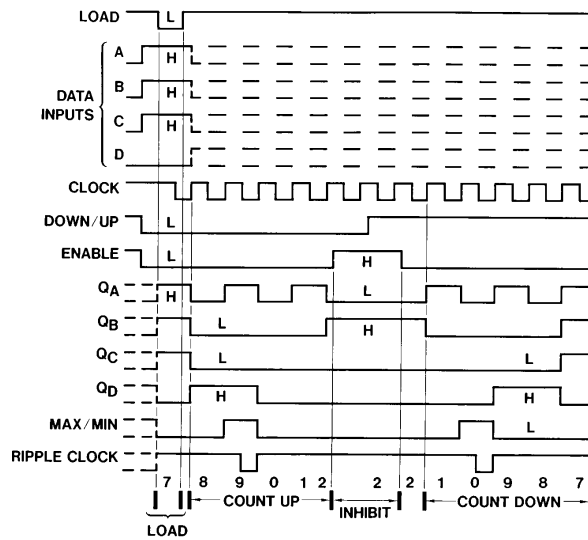


Pin (16) =  $V_{CC}$ , Pin (8) = GND

TL/F/5322-3

# Timing Diagrams

## 'HC190 Synchronous Decade Counters Typical Load, Count, and Inhibit Sequences

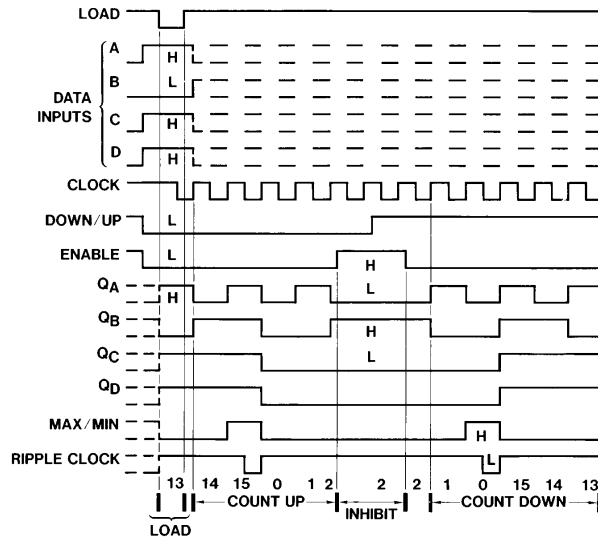


TL/F/5322-4

**Sequence:**

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

## 'HC191 Synchronous Binary Counters Typical Load, Count, and Inhibit Sequence

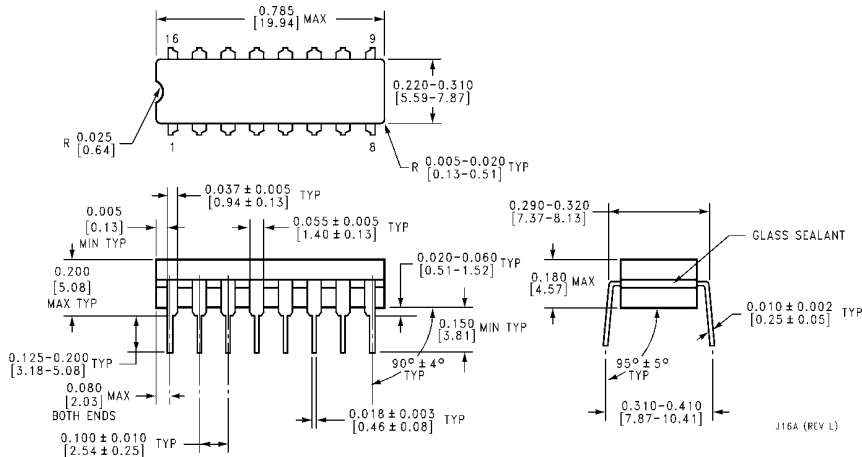


TL/F/5322-5

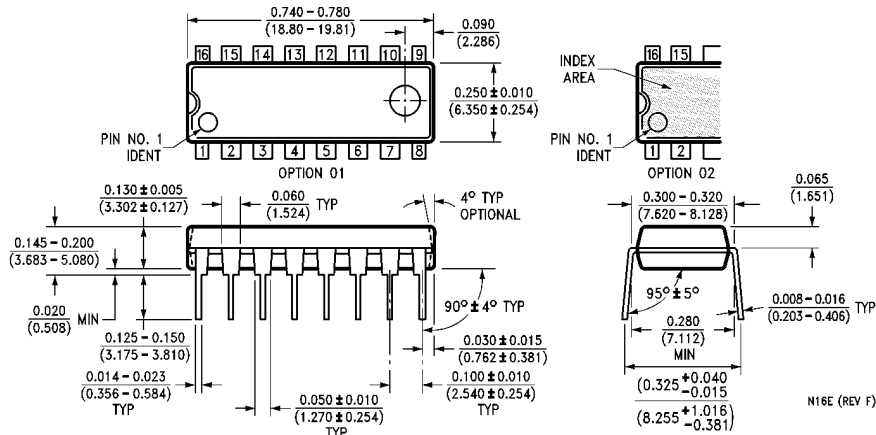
**Sequence:**

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

**Physical Dimensions** inches (millimeters)



**Order Number MM54HC190J, MM54HC191J, MM74HC190J, or MM74HC191J  
NS Package J16A**



**Order Number MM74HC190N or MM74HC191N  
NS Package N16E**

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