CD74HC192, CD74HC193, CD74HCT193

High Speed CMOS Logic
Presettable Synchronous 4-Bit Up/Down Counters

Features

- **Synchronous Counting and Asynchronous Loading**

- **Two Outputs for N-Bit Cascading**

- **Look-Ahead Carry for High-Speed Counting**

- **Fanout (Over Temperature Range)**
  - **Standard Outputs . . . . 10 LSTTL Loads**
  - **Bus Driver Outputs . . . . 15 LSTTL Loads**

- **Wide Operating Temperature Range . . . -55°C to 125°C**

- **Balanced Propagation Delay and Transition Times**

- **Significant Power Reduction Compared to LSTTL Logic ICs**

- **HC Types**
  - **2V to 6V Operation**
  - **High Noise Immunity: N_{IL} = 30%, N_{IH} = 30% of V_{CC} at V_{CC} = 5V**

- **HCT Types**
  - **4.5V to 5.5V Operation**
  - **Direct LSTTL Input Logic Compatibility, V_{IL}= 0.8V (Max), V_{IH} = 2V (Min)**
  - **CMOS Input Compatibility, $I_I \leq 1\mu A$ at V_{OL}, V_{OH}**

Pinout

CD74HC192, CD74HC193, CD74HCT193
(PDIP, SOIC)
TOP VIEW

|			
P1	1	16	V$_{CC}$
Q1	2	15	P0
Q0	3	14	MR
CPD	4	13	TCD
CPU	5	12	TCU
Q2	6	11	$\overline{PL}$
Q3	7	10	P2
GND	8	9	P3

Description

The Harris CD74HC192, CD74HC193 and CD74HCT193 are asynchronously presettable BCD Decade and Binary Up/Down synchronous counters, respectively.

Presetting the counter to the number on the preset data inputs (P0-P3) is accomplished by a LOW asynchronous parallel load input ($\overline{PL}$). The counter is incremented on the low-to-high transition of the Clock-Up input (and a high level on the Clock-Down input) and decremented on the low to high transition of the Clock-Down input (and a high level on the Clock-up input). A high level on the MR input overrides any other input to clear the counter to its zero state. The Terminal Count up (carry) goes low half a clock period before the zero count is reached and returns to a high level at the zero count. The Terminal Count Down (borrow) in the count down mode likewise goes low half a clock period before the maximum count (9 in the 192 and 15 in the 193) and returns to high at the maximum count. Cascading is effected by connecting the carry and borrow outputs of a less significant counter to the Clock-Up and CLock-Down inputs, respectively, of the next most significant counter.

If a decade counter is present to an illegal state or assumes an illegal state when power is applied, it will return to the normal sequence in one count as shown in state diagram.

Ordering Information

PART NUMBER	TEMP. RANGE (^{o}C)	PACKAGE	PKG. NO.
CD74HC192E	-55 to 125	16 Ld PDIP	E16.3
CD74HC193E	-55 to 125	16 Ld PDIP	E16.3
CD74HCT193E	-55 to 125	16 Ld PDIP	E16.3
CD74HCT193M	-55 to 125	16 Ld SOIC	M16.15

NOTES:

1. When ordering, use the entire part number. Add the suffix 96 to obtain the variant in the tape and reel.

2. Wafer or die for this part number is available which meets all electrical specifications. Please contact your local sales office or Harris customer service for ordering information.

File Number **1674.1**

Functional Diagram

BCD/BINARY
PRESET

P0 P1 P2 P3

15   1   10   9

$\overline{\text{ASYN.}}$
$\overline{\text{PARALLEL}}$
$\overline{\text{LOAD}}$ $\overline{\text{PL}}$ 11
$\overline{\text{ENABLE}}$

MASTER   14
RESET

CLOCK UP   5

CLOCK DOWN   4

3   Q_0
2   Q_1 BCD (192)
6   Q_2 BINARY (193)
7   Q_3 OUTPUTS

12   $\overline{\text{TERMINAL}}$
     $\overline{\text{COUNT UP}}$
13   $\overline{\text{TERMINAL}}$
     $\overline{\text{COUNT DOWN}}$
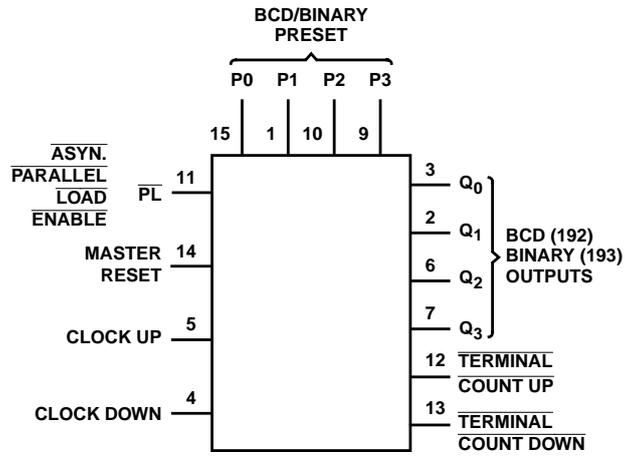
TRUTH TABLE

CLOCK UP	CLOCK DOWN	RESET	PARALLEL LOAD	FUNCTION
↑	H	L	H	Count Up
H	↑	L	H	Count Down
X	X	H	X	Reset
X	X	L	L	Load Preset Inputs

NOTE: H = High Voltage Level, L = Low Voltage Level, X = Don't Care, ↑ = Transition from Low to High Level

CD74HC192, CD74HC193, CD74HCT193

Absolute Maximum Ratings

DC Supply Voltage, V_{CC} . . . . -0.5V to 7V
DC Input Diode Current, I_{IK}
   For V_I < -0.5V or V_I > V_{CC} + 0.5V. . . . . ±20mA
DC Output Diode Current, I_{OK}
   For V_O < -0.5V or V_O > V_{CC} + 0.5V . . . . ±20mA
DC Output Source or Sink Current per Output Pin, I_O
   For V_O > -0.5V or V_O < V_{CC} + 0.5V . . . . ±25mA
DC V_{CC} or Ground Current, I_{CC} or I_{GND} . . . . ±50mA

Operating Conditions

Temperature Range (T_A) . . . . -55°C to 125°C
Supply Voltage Range, V_{CC}
   HC Types . . . . .2V to 6V
   HCT Types . . . . .4.5V to 5.5V
DC Input or Output Voltage, V_I, V_O . . . . 0V to V_{CC}
Input Rise and Fall Time
   2V . . . . 1000ns (Max)
   4.5V. . . . . 500ns (Max)
   6V . . . . 400ns (Max)

Thermal Information

Thermal Resistance (Typical, Note 3) θ_{JA} (°C/W)
   PDIP Package   90
   SOIC Package.   160
Maximum Junction Temperature . . . . .150°C
Maximum Storage Temperature Range . . . .-65°C to 150°C
Maximum Lead Temperature (Soldering 10s) . . . . .300°C
   (SOIC - Lead Tips Only)

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTE:

3. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.

DC Electrical Specifications

PARAMETER	SYMBOL	TEST CONDITIONS			25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
		V_I (V)	I_O (mA)	V_{CC} (V)	MIN	TYP	MAX	MIN	MAX	MIN	MAX	
HC TYPES												
High Level Input Voltage	V_{IH}	-	-	2	1.5	-	-	1.5	-	1.5	-	V
				4.5	3.15	-	-	3.15	-	3.15	-	V
				6	4.2	-	-	4.2	-	4.2	-	V
Low Level Input Voltage	V_{IL}	-	-	2	-	-	0.5	-	0.5	-	0.5	V
				4.5	-	-	1.35	-	1.35	-	1.35	V
				6	-	-	1.8	-	1.8	-	1.8	V
High Level Output Voltage CMOS Loads	V_{OH}	V_{IH} or V_{IL}	-0.02	2	1.9	-	-	1.9	-	1.9	-	V
			-0.02	4.5	4.4	-	-	4.4	-	4.4	-	V
			-0.02	6	5.9	-	-	5.9	-	5.9	-	V
High Level Output Voltage TTL Loads			-4	4.5	3.98	-	-	3.84	-	3.7	-	V
			-5.2	6	5.48	-	-	5.34	-	5.2	-	V
Low Level Output Voltage CMOS Loads	V_{OL}	V_{IH} or V_{IL}	0.02	2	-	-	0.1	-	0.1	-	0.1	V
			0.02	4.5	-	-	0.1	-	0.1	-	0.1	V
			0.02	6	-	-	0.1	-	0.1	-	0.1	V
Low Level Output Voltage TTL Loads			4	4.5	-	-	0.26	-	0.33	-	0.4	V
			5.2	6	-	-	0.26	-	0.33	-	0.4	V
Input Leakage Current	I_I	V_{CC} or GND	-	6	-	-	±0.1	-	±1	-	±1	μA
Quiescent Device Current	I_{CC}	V_{CC} or GND	0	6	-	-	8	-	80	-	160	μA

DC Electrical Specifications   (Continued)

PARAMETER	SYMBOL	TEST CONDITIONS			25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
		V_I (V)	I_O (mA)	V_{CC} (V)	MIN	TYP	MAX	MIN	MAX	MIN	MAX	
HCT TYPES												
High Level Input Voltage	V_{IH}	-	-	4.5 to 5.5	2	-	-	2	-	2	-	V
Low Level Input Voltage	V_{IL}	-	-	4.5 to 5.5	-	-	0.8	-	0.8	-	0.8	V
High Level Output Voltage CMOS Loads	V_{OH}	V_{IH} or V_{IL}	-	4.5	4.4	-	-	4.4	-	4.4	-	V
High Level Output Voltage TTL Loads			-	4.5	3.98	-	-	3.84	-	3.7	-	V
Low Level Output Voltage CMOS Loads	V_{OL}	V_{IH} or V_{IL}	-	4.5	-	-	0.1	-	0.1	-	0.1	V
Low Level Output Voltage TTL Loads			-	4.5	-	-	0.26	-	0.33	-	0.4	V
Input Leakage Current	I_I	V_{CC} to GND	-	5.5	-	-	±0.1	-	±1	-	±1	µA
Quiescent Device Current	I_{CC}	V_{CC} or GND	-	5.5	-	-	8	-	80	-	160	µA
Additional Quiescent Device Current Per Input Pin: 1 Unit Load (Note 4)	ΔI_{CC}	V_{CC} -2.1	-	4.5 to 5.5	-	100	360	-	450	-	490	µA

NOTE:

4. For dual-supply systems theoretical worst case (V_I = 2.4V, V_{CC} = 5.5V) specification is 1.8mA.

HCT Input Loading Table

INPUT	UNIT LOADS
P0-P3	0.4
MR	1.45
$\overline{PL}$	0.85
CPU, CPD	1.45

NOTE: Unit Load is ΔI_{CC} limit specified in DC Electrical Specifications table, e.g. 360µA max at 25°C.

Prerequisite For Switching Specifications

PARAMETER	SYMBOL	V$_{CC}$ (V)	25°C MIN	25°C TYP	25°C MAX	-40°C TO 85°C MIN	-40°C TO 85°C MAX	-55°C TO 125°C MIN	-55°C TO 125°C MAX	UNITS
HC TYPES										
Pulse Width	t$_W$	2	115	-	-	145	-	175	-	ns
CPU, CPD		4.5	23	-	-	29	-	35	-	ns
192		6	20	-	-	25	-	30	-	ns
	t$_W$	2	100	-	-	125	-	150	-	ns
CPU, CPD		4.5	20	-	-	25	-	30	-	ns
193		6	17	-	-	21	-	26	-	ns
$\overline{PL}$	t$_W$	2	80	-	-	100	-	120	-	ns
		4.5	16	-	-	20	-	24	-	ns
		6	14	-	-	17	-	20	-	ns
MR	t$_W$	2	100	-	-	125	-	150	-	ns
		4.5	20	-	-	25	-	30	-	ns
		6	17	-	-	21	-	26	-	ns
Set-up Time	t$_{SU}$	2	80	-	-	100	-	120	-	ns
Pn to $\overline{PL}$		4.5	16	-	-	20	-	24	-	ns
		6	14	-	-	17	-	20	-	ns
Hold Time	t$_H$	2	0	-	-	0	-	0	-	ns
Pn to $\overline{PL}$		4.5	0	-	-	0	-	0	-	ns
		6	0	-	-	0	-	0	-	ns
Hold Time	t$_H$	2	80	-	-	100	-	120	-	ns
CPD to CPU or		4.5	16	-	-	20	-	24	-	ns
CPU to CPD		6	14	-	-	17	-	20	-	ns
Recovery Time	t$_{REC}$	2	80	-	-	100	-	120	-	ns
$\overline{PL}$ to CPU, CPD		4.5	16	-	-	20	-	24	-	ns
		6	14	-	-	17	-	20	-	ns
MR to CPU, CPD	t$_{REC}$	2	5	-	-	5	-	5	-	ns
		4.5	5	-	-	5	-	5	-	ns
		6	5	-	-	5	-	5	-	ns
Maximum Frequency	f$_{MAX}$	2	5	-	-	4	-	3	-	MHz
CPU, CPD		4.5	22	-	-	18	-	15	-	MHz
192		6	24	-	-	21	-	18	-	MHz
	f$_{MAX}$	2	5	-	-	4	-	3	-	MHz
CPU, CPD		4.5	25	-	-	20	-	17	-	MHz
193		6	29	-	-	24	-	20	-	MHz
HCT TYPES										
Pulse Width	t$_W$	2	-	-	-	-	-	-	-	ns
CPU, CPD		4.5	23	-	-	29	-	35	-	ns
192		6	-	-	-	-	-	-	-	ns
CPU, CPD	t$_W$	2	-	-	-	-	-	-	-	ns
193		4.5	23	-	-	29	-	35	-	ns
		6	-	-	-	-	-	-	-	ns

Prerequisite For Switching Specifications (Continued)

PARAMETER	SYMBOL	V_{CC} (V)	25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
			MIN	TYP	MAX	MIN	MAX	MIN	MAX	
$\overline{PL}$	t_W	2	-	-	-	-	-	-	-	ns
		4.5	16	-	-	20	-	24	-	ns
		6	-	-	-	-	-	-	-	ns
MR	t_W	2	-	-	-	-	-	-	-	ns
		4.5	20	-	-	25	-	30	-	ns
		6	-	-	-	-	-	-	-	ns
Set-up Time	t_{SU}	2	-	-	-	-	-	-	-	ns
Pn to $\overline{PL}$		4.5	15	-	-	19	-	22	-	ns
		6	-	-	-	-	-	-	-	ns
Hold Time	t_H	2	-	-	-	-	-	-	-	ns
Pn to $\overline{PL}$		4.5	0	-	-	0	-	0	-	ns
		6	-	-	-	-	-	-	-	ns
Hold Time	t_H	2	-	-	-	-	-	-	-	ns
CPD to CPU or		4.5	16	-	-	20	-	24	-	ns
CPU to CPD		6	-	-	-	-	-	-	-	ns
Recovery Time	t_{REC}	2	-	-	-	-	-	-	-	ns
$\overline{PL}$ to CPU, CPD		4.5	15	-	-	19	-	22	-	ns
		6	-	-	-	-	-	-	-	ns
MR to CPU, CPD	t_{REC}	2	-	-	-	-	-	-	-	ns
		4.5	5	-	-	5	-	5	-	ns
		6	-	-	-	-	-	-	-	ns
Maximum Frequency	f_{MAX}	2	-	-	-	-	-	-	-	MHz
CPU, CPD		4.5	22	-	-	18	-	15	-	MHz
192		6	-	-	-	-	-	-	-	MHz
CPU, CPD	f_{MAX}	2	-	-	-	-	-	-	-	MHz
193		4.5	22	-	-	18	-	15	-	MHz
		6	-	-	-	-	-	-	-	MHz

Switching Specifications Input t_r, t_f = 6ns

PARAMETER	SYMBOL	TEST CONDITIONS	V_{CC} (V)	25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
HC TYPES											
Propagation Delay	t_{PLH}, t_{PHL}	C_L = 50pF	2	-	-	125	-	155	-	190	ns
CPU to $\overline{TCU}$		C_L = 50pF	4.5	-	-	25	-	31	-	38	ns
		C_L = 15pF	5	-	10	-	-	-	-	-	ns
		C_L = 50pF	6	-		21	-	26	-	32	ns
CPD to $\overline{TCD}$	t_{PLH}, t_{PHL}	C_L = 50pF	2	-	-	125	-	155	-	190	ns
		C_L = 50pF	4.5	-	-	25	-	31	-	38	ns
		C_L = 15pF	5	-	10	-	-	-	-	-	ns
		C_L = 50pF	6	-	-	21	-	26	-	32	ns
CPU to Q_n	t_{PLH}, t_{PHL}	C_L = 50pF	2	-	-	220	-	270	-	325	ns
		C_L = 50pF	4.5	-	-	43	-	54	-	65	ns
		C_L = 15pF	5	-	18	-	-	-	-	-	ns
		C_L = 50pF	6	-	-	37	-	46	-	55	ns

Switching Specifications Input t_r, t_f = 6ns **(Continued)**

PARAMETER	SYMBOL	TEST CONDITIONS	V_{CC} (V)	25°C			-40°C TO 85°C		-55°C TO 125°C		UNITS
				MIN	TYP	MAX	MIN	MAX	MIN	MAX	
CPD to Q_n	t_{PLH}, t_{PHL}	C_L = 50pF	2	-	-	220	-	270	-	325	ns
		C_L = 50pF	4.5	-	-	43	-	54	-	65	ns
		C_L = 15pF	5	-	18	-	-	-	-		ns
		C_L = 50pF	6	-	-	37	-	46	-	55	ns
$\overline{PL}$ to Q_n	t_{PLH}, t_{PHL}	C_L = 50pF	2	-	-	220	-	275	-	330	ns
		C_L = 50pF	4.5	-	-	44	-	55	-	66	ns
		C_L = 15pF	5	-	18	-	-	-	-	-	ns
		C_L = 50pF	6	-	-	37	-	47	-	56	ns
MR to Q_n	t_{PHL}	C_L = 50pF	2	-	-	200	-	250	-	300	ns
		C_L = 50pF	4.5	-	-	40	-	50	-	60	ns
		C_L = 15pF	5	-	17	-	-	-	-	-	ns
		C_L = 50pF	6	-	-	34	-	43	-	51	ns
Transition Time Q, TCU, TCD	t_{TLH}, t_{THL}	C_L = 50pF	2	-	-	75	-	95	-	110	ns
			4.5	-	-	15	-	19	-	22	ns
			6	-	-	13	-	16	-	19	ns
Input Capacitance	C_{IN}	C_L = 50pF	-	-	-	10	-	10	-	10	pF
Power Dissipation Capacitance	C_{PD}	C_L = 15pF	5	-	40	-	-	-	-	-	pF
HCT TYPES											
Propagation Delay CPU to $\overline{TCU}$	t_{PLH}, t_{PHL}	C_L = 50pF	4.5	-	-	27	-	34	-	41	ns
		C_L = 15pF	5	-	11	-	-	-	-	-	ns
CPU to $\overline{TCD}$	t_{PLH}, t_{PHL}	C_L = 50pF	4.5	-	-	27	-	34	-	41	ns
		C_L = 15pF	5	-	11	-	-	-	-	-	ns
CPU to Q_n	t_{PLH}, t_{PHL}	C_L = 50pF	4.5	-	-	40	-	50	-	60	ns
		C_L = 15pF	5	-	17	-	-	-	-	-	ns
CPD to Q_n	t_{PLH}, t_{PHL}	C_L = 50pF	4.5	-	-	40	-	50	-	60	ns
		C_L = 15pF	5	-	17	-	-	-	-	-	ns
$\overline{PL}$ to Q_n	t_{PLH}, t_{PHL}	C_L = 50pF	4.5	-	-	46	-	58	-	69	ns
		C_L = 15pF	5	-	21	-	-	-	-	-	ns
MR to Q_n	t_{PHL}	C_L = 50pF	4.5	-	-	43	-	54	-	65	ns
		C_L = 15pF	5	-	18	-	-	-	-	-	ns
Transition Time Q, TCU, TCD	t_{TLH}, t_{THL}	C_L = 50pF	4.5	-	-	15	-	19	-	22	ns
Input Capacitance	C_{IN}	C_L = 50pF	-	-	-	10	-	10	-	10	pF
Power Dissipation Capacitance	C_{PD}	C_L = 15pF	5	-	50	-	-	-	-	-	pF

NOTES:

5. C_{PD} is used to determine the dynamic power consumption, per gate.

6. $P_D = V_{CC}^2 f_i + \Sigma (C_L V_{CC}^2)$ where f_i = Input Frequency, C_L = Output Load Capacitance, V_{CC} = Supply Voltage.

## CD74HC192, CD74HC193, CD74HCT193

Test Circuits and Waveforms

MASTER RESET

ASYNCHRONOUS PARALLEL LOAD

PRESET DATA
- P0
- P1
- P2
- P3

SEQUENCES:
1. RESET OUTPUTS TO ZERO.
2. LOAD (PRESET) TO BCD SEVEN.
3. COUNT UP TO EIGHT, NINE, TERMINAL COUNT UP, ZERO, ONE AND TWO.
4. COUNT DOWN TO ONE, ZERO, TERMINAL COUNT DOWN, NINE, EIGHT AND SEVEN.

CLOCK UP

CLOCK DOWN

OUTPUTS
- Q_0
- Q_1
- Q_2
- Q_3

TERMINAL COUNT UP

TERMINAL COUNT DOWN

| 0 | 7 | 8 9 0 1 2 | 1 0 9 8 7 |

| RESET | PRESET | ◄— COUNT UP —► | ◄— COUNT DOWN —► |
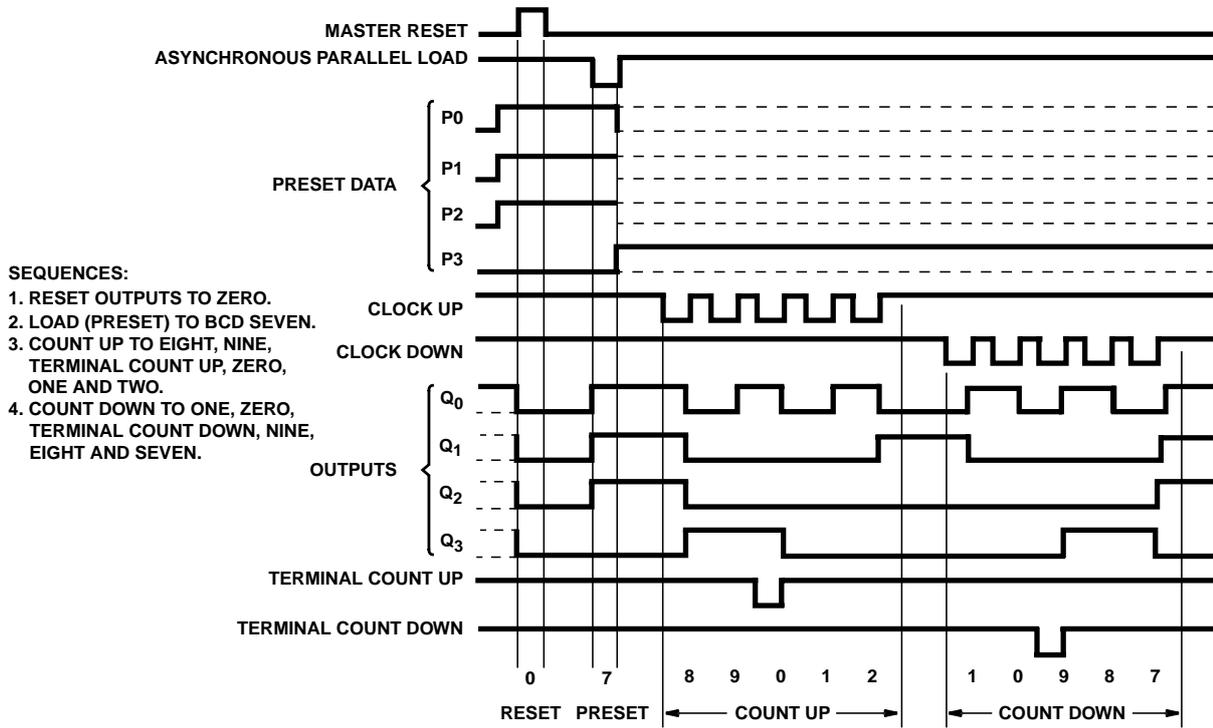
FIGURE 1. CD74HC192 SYNCHRONOUS DECADE COUNTERS, TYPICAL RESET, PRESET AND COUNT SEQUENCES

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Test Circuits and Waveforms (Continued)

MASTER RESET
ASYNCHRONOUS PARALLEL LOAD

PRESET DATA
- P0
- P1
- P2
- P3

SEQUENCES:
1. RESET OUTPUTS TO ZERO.
2. LOAD (PRESET) TO BINARY THIRTEEN.
3. COUNT UP TO FOURTEEN, FIFTEEN, TERMINAL COUNT UP, ZERO, ONE AND TWO.
4. COUNT DOWN TO ONE, ZERO, TERMINAL COUNT DOWN, FIFTEEN, FOURTEEN AND THIRTEEN.

CLOCK UP
CLOCK DOWN

OUTPUTS
- Q_0
- Q_1
- Q_2
- Q_3

TERMINAL COUNT UP
TERMINAL COUNT DOWN

0   13   14   15   0   1   2   1   0   15   14   13
RESET   PRESET |← COUNT UP →| |← COUNT DOWN →|

NOTES:

1. Master reset overrides load data and clock inputs.

2. When counting up, clock-down input must be high.
   When counting down, clock-up input must be high.

FIGURE 2. CD74HC193 SYNCHRONOUS BINARY COUNTERS, TYPICAL RESET, PRESET AND COUNT SEQUENCES

CPU OR CPD   INPUT LEVEL
$1/f_{MAX}$
V_S V_S V_S
t_W
t_{PHL} t_{PLH}
Q_n V_S V_S
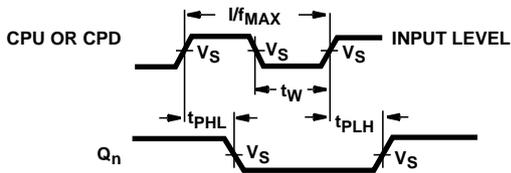
FIGURE 3. CLOCK TO OUTPUT DELAYS AND CLOCK PULSE WIDTH

CPU OR CPD   INPUT LEVEL
V_S V_S
t_{PHL} t_{PLH}
$\overline{TCU}$ OR $\overline{TCD}$ V_S V_S
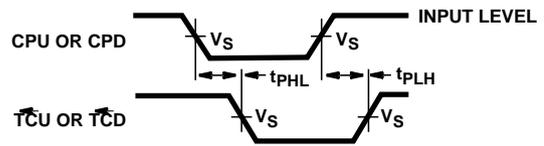
FIGURE 4. CLOCK TO TERMINAL COUNT DELAYS

Pn   INPUT LEVEL
t_W t_W
$\overline{PL}$ V_S V_S V_S V_S INPUT LEVEL
CPU OR CPD t_{REC} V_S INPUT LEVEL
t_{PLH} t_{PHL}
Q_n V_S V_S
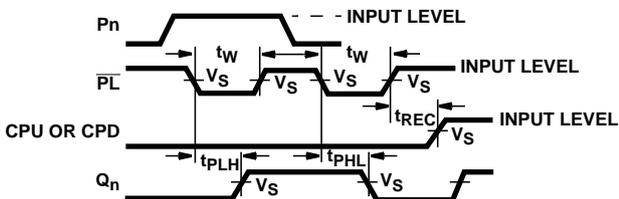
FIGURE 5. PARALLEL LOAD PULSE WIDTH, PARALLEL LOAD TO OUTPUT DELAYS, AND PARALLEL LOAD TO CLOCK RECOVERY TIME

MR V_S V_S INPUT LEVEL
t_W t_{REC}
CPU OR CPD V_S
t_{PHL}
Q_n V_S INPUT LEVEL
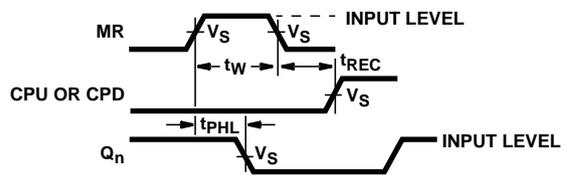
FIGURE 6. MASTER RESET PULSE WIDTH, MASTER RESET TO OUTPUT DELAY AND MASTER RESET TO CLOCK RECOVERY TIME

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Test Circuits and Waveforms (Continued)
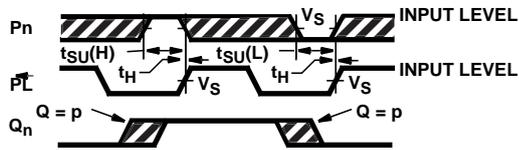
**FIGURE 7. SET-UP AND HOLD TIMES DATA TO PARALLEL LOAD (PL)**
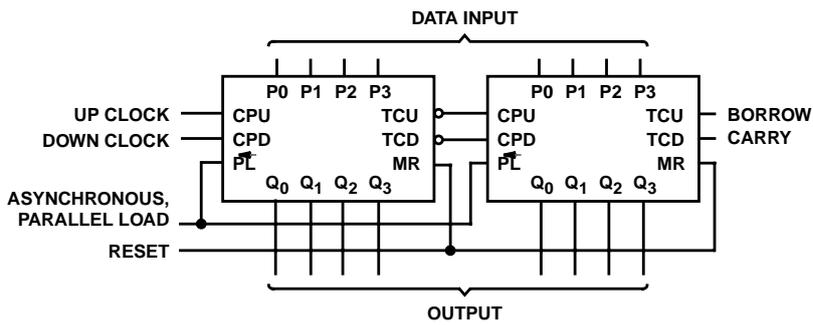
FIGURE 8. CASCADED UP/DOWN COUNTER WITH PARALLEL LOAD

COUNT UP

COUNT DOWN
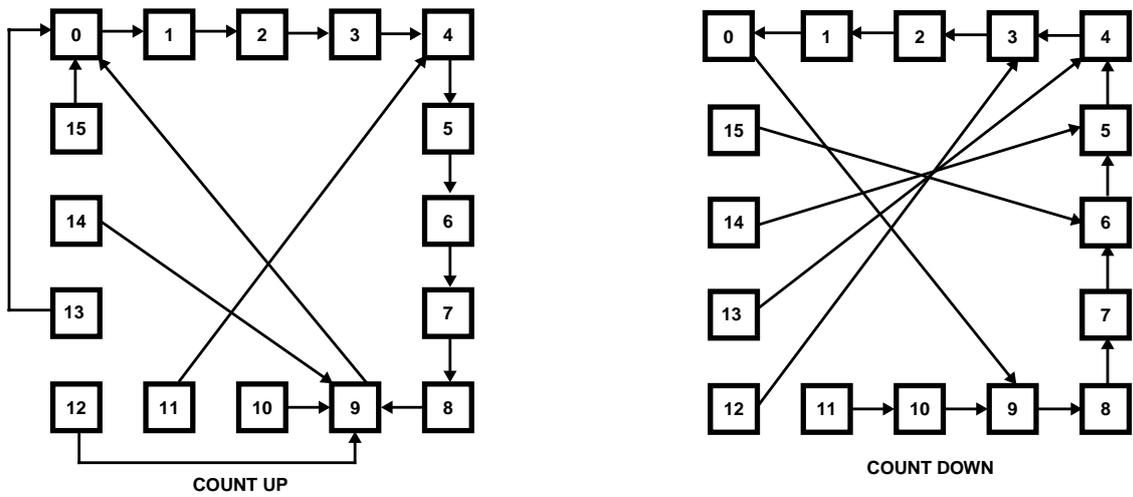
NOTE: Illegal states in BCD counters corrected in one count.   NOTE: Illegal states in BCD counters corrected in one or two counts.

FIGURE 9. CD74HC192, CD74HCT193 STATE DIAGRAMS

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