

## General Description

The SN74HC/HCT192 is a synchronous BCD up/down counter. Separate up/down clocks, CPU and CPD respectively, simplify operation. The outputs change state synchronously with the LOW-to-HIGH transition of either clock input. If the CPU clock is pulsed while CPD is held HIGH, the device will count up. If the CPD clock is pulsed while CPU is held HIGH, the device will count down. Only one clock input can be held HIGH at any time to guarantee predictable behavior. The device can be cleared at any time by the asynchronous master reset input (MR); it may also be loaded in parallel by activating the asynchronous parallel load input ( $P\bar{L}$ ).

The terminal count up ( $T\bar{C}U$ ) and terminal count down ( $T\bar{C}D$ ) outputs are normally HIGH. When the circuit has reached the maximum count state of 15, the next HIGH-to-LOW transition of CPU will cause  $T\bar{C}U$  to go LOW.  $T\bar{C}U$  will stay LOW until CPU goes HIGH again, duplicating the count up clock. Likewise, the  $T\bar{C}D$  output will go LOW when the circuit is in the zero state and the CPD goes LOW. The terminal count outputs can be used as the clock input signals to the next higher order circuit in a multistage counter, since they duplicate the clock waveforms. Multistage counters will not be fully synchronous, since there is a slight delay time difference added for each stage that is added.

The counter may be preset by the asynchronous parallel load capability of the circuit. Information present on the parallel data inputs (D0 to D3) is loaded into the counter and appears on the outputs (Q0 to Q3) regardless of the conditions of the clock inputs when the parallel load ( $P\bar{L}$ ) input is LOW. A HIGH level on the master reset (MR) input will disable the parallel load gates, override both clock inputs and set all outputs (Q0 to Q3) LOW. If one of the clock inputs is LOW during and after a reset or load operation, the next LOW-to-HIGH transition of that clock will be interpreted as a legitimate signal and will be counted. Inputs include clamp diodes. This enables the use of current limiting resistors to interface inputs to voltages in excess of  $V_{CC}$ .

## Features

- Input levels:  
For SN74HC192: CMOS level  
For SN74HCT192: TTL level
- Synchronous reversible counting
- Asynchronous parallel load
- Asynchronous reset
- Expandable without external logic
- Specified from -40°C to +85°C
- Packaging information: DIP16/SOP16/TSSOP16

**ORDERING INFORMATION**

DEVICE	Package Type	MARKING	Packing	Packing QTY
SN74HC192N	DIP-16	74HC192N	Tube	1000/Box
SN74HC192DTR	SOP-16	74HC192	Tape	2500/Reel
SN74HCT192DTR	SOP-16	74HCT192	Tape	2500/Reel
SN74HCT192TDTR	TSSOP-16	74HCT192	Tape	3000/Reel

**Block Diagram And Pin Description**

**Block Diagram**

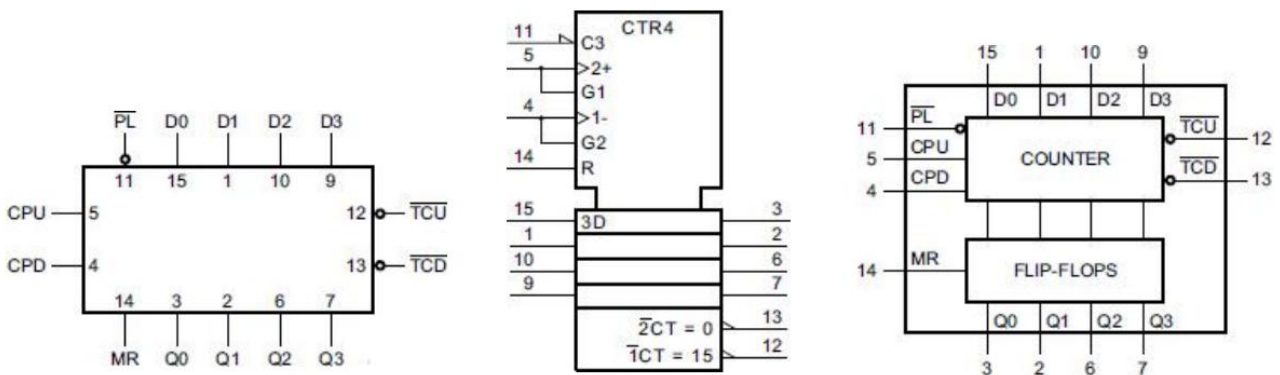


Figure 1. Logic symbol

Figure 2. IEC Logic symbol

Figure 3. Functional diagram

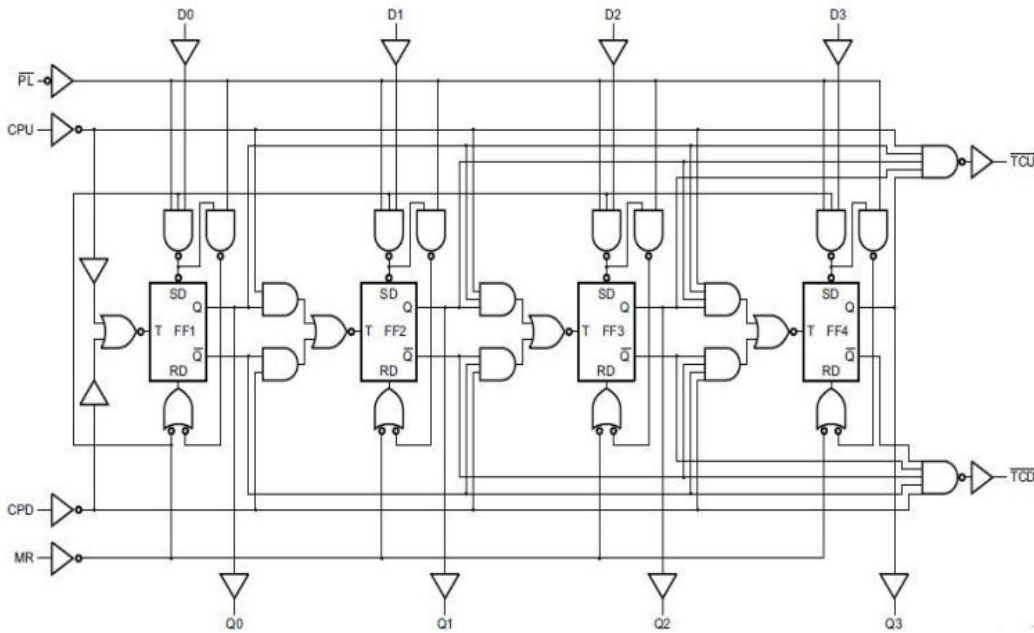


Figure 4. Logic diagram

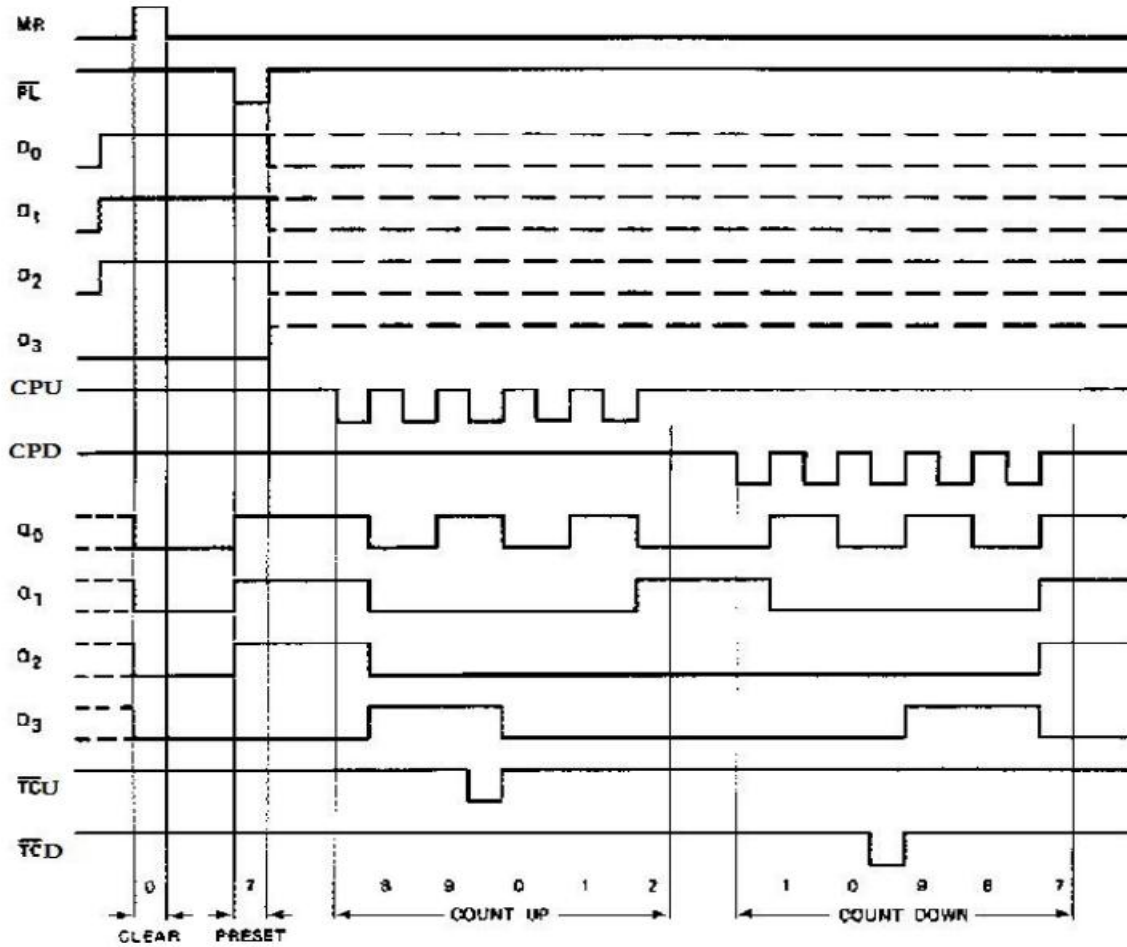
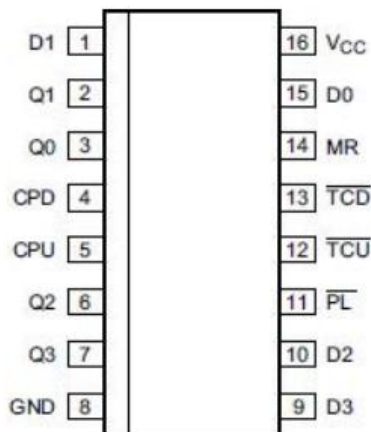


Figure 5. Typical clear, load and count sequence

### Pin Configurations



Pin Description

Pin No.	Pin Name	Description
1	D1	data input 1
2	Q1	flip-flop output 1
3	Q0	flip-flop output 0
4	CPD	count down clock input
5	CPU	count up clock input
6	Q2	flip-flop output 2
7	Q3	flip-flop output 3
8	GND	ground(0V)
9	D3	data input 3
10	D2	data input 2
11	$\overline{P\bar{L}}$	asynchronous parallel load input(active LOW)
12	$\overline{T\bar{C}U}$	terminal count up (carry)output(active LOW)
13	$\overline{T\bar{C}D}$	terminal count down (borrow)output(active LOW)
14	MR	asynchronous master reset input(active HIGH)
15	D0	data input 0
16	V <sub>CC</sub>	supply voltage

Note: CPD, CPU is LOW-to-HIGH, edge triggered.

Function Table

Operating mode	Input								Output					
	MR	$\overline{P\bar{L}}$	CPU	CPD	D0	D1	D2	D3	Q0	Q1	Q2	Q3	$\overline{T\bar{C}U}$	$\overline{T\bar{C}D}$
reset (clear)	H	X	X	L	X	X	X	X	L	I	L	L	H	L
	H	X	X	H	X	X	X	X	I	L	L	L	H	H
parallel load	L	L	X	L	L	L	L	L	L	L	L	L	H	L
	L	L	X	H	L	L	L	L	L	I	L	L	H	H
	L	L	L	X	H	X	X	H	Q <sub>n</sub> =D <sub>n</sub>			L	H	
	L	L	H	X	H	X	X	H	Q <sub>n</sub> =D <sub>n</sub>			H	H	
count up	L	H	↑	H	X	X	X	X	count up			H	H	
count down	L	H	H	↑	X	X	X	X	count down			H	H	

Note:

[1] H=HIGH voltage level; L=LOW voltage level; X=don't care; ↑=LOW-to-HIGH transition.

[2]  $\overline{T\bar{C}U}$ =CPU at terminal count up (HLLH).

[3]  $\overline{T\bar{C}D}$ =CPD at terminal count down (LLLL).

## Electrical Parameter

**Absolute Maximum Ratings** (Voltages are referenced to GND (ground=0V), unless otherwise specified.)

Parameter	Symbol	Conditions	Min.	Max.	Unit
supply voltage	$V_{CC}$	-	-0.5	+7.0	V
input clamping current	$I_{IK}$	$V_I < -0.5V$ or $V_I > V_{CC}+0.5V$	-	$\pm 20$	mA
output clamping current	$I_{OK}$	$V_O < -0.5V$ or $V_O > V_{CC}+0.5V$	-	$\pm 20$	mA
output current	$I_O$	$V_O = -0.5V$ to $(V_{CC}+0.5V)$	-	$\pm 25$	mA
supply current	$I_{CC}$	-	-	50	mA
ground current	$I_{GND}$	-	-	-50	mA
storage temperature	$T_{stg}$	-	-65	+150	°C
total power dissipation	$P_{tot}$	-	-	500	mW
soldering temperature	$T_L$	10s	DIP	245	°C
			SOP	250	

Note:

- [1] For DIP16 packages: above 70°C the value of  $P_{tot}$  derates linearly with 12mW/K.
- [2] For SOP16 packages: above 70°C the value of  $P_{tot}$  derates linearly with 8mW/K.
- [3] For (T)SSOP16 packages: above 60°C the value of  $P_{tot}$  derates linearly with 5.5mW/K.

## Recommended Operating Conditions

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	
<b>SN74HC192</b>							
supply voltage	$V_{CC}$	-	2.0	5.0	6.0	V	
input voltage	$V_I$	-	0	-	$V_{CC}$	V	
output voltage	$V_O$	-	0	-	$V_{CC}$	V	
input transition rise and fall rate	$\Delta t/\Delta V$	-	$V_{CC}=2.0V$	-	-	625	ns/V
			$V_{CC}=4.5V$	-	1.67	139	ns/V
			$V_{CC}=6.0V$	-	-	83	ns/V
ambient temperature	$T_{amb}$	-	-40	-	+85	°C	
<b>SN74HCT192</b>							
supply voltage	$V_{CC}$	-	4.5	5.0	5.5	V	
input voltage	$V_I$	-	0	-	$V_{CC}$	V	
output voltage	$V_O$	-	0	-	$V_{CC}$	V	
input transition rise and fall rate	$\Delta t/\Delta V$	-	$V_{CC}=2.0V$	-	-	-	ns/V
			$V_{CC}=4.5V$	-	1.67	139	ns/V
			$V_{CC}=6.0V$	-	-	-	ns/V
ambient temperature	$T_{amb}$	-	-40	-	+85	°C	

**Electrical Characteristics**

DC Characteristics 1 (Tamb=25°C, voltages are referenced to GND (ground=0V), unless otherwise specified.)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	
<b>SN74HC192</b>							
HIGH-level input voltage	V <sub>IH</sub>	V <sub>CC</sub> =2.0V	1.5	1.2	-	V	
		V <sub>CC</sub> =4.5V	3.15	2.4	-	V	
		V <sub>CC</sub> =6.0V	4.2	3.2	-	V	
LOW-level input voltage	V <sub>IL</sub>	V <sub>CC</sub> =2.0V	-	0.8	0.5	V	
		V <sub>CC</sub> =4.5V	-	2.1	1.35	V	
		V <sub>CC</sub> =6.0V	-	2.8	1.8	V	
HIGH-level output voltage	V <sub>OH</sub>	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub>	I <sub>O</sub> =-20uA; V <sub>CC</sub> =2.0V	1.9	2.0	-	V
			I <sub>O</sub> =-20uA; V <sub>CC</sub> =4.5V	4.4	4.5	-	V
			I <sub>O</sub> =-20uA; V <sub>CC</sub> =6.0V	5.9	6.0	-	V
			I <sub>O</sub> =-4.0mA; V <sub>CC</sub> =4.5V	3.98	4.32	-	V
			I <sub>O</sub> =-5.2mA; V <sub>CC</sub> =6.0V	5.48	5.81	-	V
LOW-level output voltage	V <sub>OL</sub>	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub>	I <sub>O</sub> =20uA; V <sub>CC</sub> =2.0V	-	0	0.1	V
			I <sub>O</sub> =20uA; V <sub>CC</sub> =4.5V	-	0	0.1	V
			I <sub>O</sub> =20uA; V <sub>CC</sub> =6.0V	-	0	0.1	V
			I <sub>O</sub> =4.0mA; V <sub>CC</sub> =4.5V	-	0.15	0.26	V
			I <sub>O</sub> =5.2mA; V <sub>CC</sub> =6.0V	-	0.16	0.26	V
input leakage current	I <sub>I</sub>	V <sub>I</sub> =V <sub>CC</sub> or GND; V <sub>CC</sub> =6.0V	-	-	±0.1	μA	
supply current	I <sub>CC</sub>	V <sub>I</sub> =V <sub>CC</sub> or GND; I <sub>O</sub> =0A; V <sub>CC</sub> =6.0V	-	-	8.0	μA	
input apacitance	C <sub>I</sub>	-	-	3.5	-	pF	
<b>SN74HCT192</b>							
HIGH-level input voltage	V <sub>IH</sub>	V <sub>CC</sub> =4.5V to 5.5V	2.0	1.6	-	V	
LOW-level input voltage	V <sub>IL</sub>	V <sub>CC</sub> =4.5V to 5.5V	-	1.2	0.8	V	
HIGH-level output voltage	V <sub>OH</sub>	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub> V <sub>CC</sub> =4.5V	I <sub>O</sub> =-20uA	4.4	4.5	-	V
			I <sub>O</sub> =-4.0uA	3.98	4.32	-	V
LOW-level output voltage	V <sub>OL</sub>	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub> V <sub>CC</sub> =4.5V	I <sub>O</sub> =20uA	-	0	0.1	V
			I <sub>O</sub> =4.0uA	-	0.15	0.26	V
input leakage current	I <sub>I</sub>	V <sub>I</sub> =V <sub>CC</sub> or GND; V <sub>CC</sub> =5.5V	-	-	±0.1	μA	
supply current	I <sub>CC</sub>	V <sub>I</sub> =V <sub>CC</sub> or GND; I <sub>O</sub> =0A; V <sub>CC</sub> =5.5V	-	-	8.0	μA	
Additional Supply currend	ΔI <sub>CC</sub>	per input pin; V <sub>I</sub> =V <sub>CC</sub> -2.1V; other inputs at V <sub>CC</sub> or GND; I <sub>O</sub> =0V; V <sub>CC</sub> =4.5V to 5.5V	pin Dn	-	35	126	μA
			pins CPU, CPD	-	140	504	μA
			pin P <sub>L</sub>	-	65	234	μA
			pin MR	-	105	378	μA
input apacitance	C <sub>I</sub>	-	-	3.5	-	pF	

DC Characteristics 2

(Tamb=-40°C to +85°C, voltages are referenced to GND (ground=0V), unless otherwise specified.)

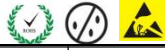
Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	
<b>SN74HC192</b>							
HIGH-level input voltage	V <sub>IH</sub>	V <sub>CC</sub> =2.0V	1.5	-	-	V	
		V <sub>CC</sub> =4.5V	3.15	-	-	V	
		V <sub>CC</sub> =6.0V	4.2	-	-	V	
LOW-level input voltage	V <sub>IL</sub>	V <sub>CC</sub> =2.0V	-	-	0.5	V	
		V <sub>CC</sub> =4.5V	-	-	1.35	V	
		V <sub>CC</sub> =6.0V	-	-	1.8	V	
HIGH-level output voltage	V <sub>OH</sub>	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub>	I <sub>O</sub> =-20uA;V <sub>CC</sub> =2.0V	1.9	-	-	V
			I <sub>O</sub> =-20uA;V <sub>CC</sub> =4.5V	4.4	-	-	V
			I <sub>O</sub> =-20uA;V <sub>CC</sub> =6.0V	5.9	-	-	V
			I <sub>O</sub> =-4.0mA;V <sub>CC</sub> =4.5V	3.84	-	-	V
			I <sub>O</sub> =-5.2mA;V <sub>CC</sub> =6.0V	5.34	-	-	V
LOW-level output voltage	V <sub>OL</sub>	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub>	I <sub>O</sub> =20uA;V <sub>CC</sub> =2.0V	-	-	0.1	V
			I <sub>O</sub> =20uA;V <sub>CC</sub> =4.5V	-	-	0.1	V
			I <sub>O</sub> =20uA;V <sub>CC</sub> =6.0V	-	-	0.1	V
			I <sub>O</sub> =4.0mA;V <sub>CC</sub> =4.5V	-	-	0.33	V
			I <sub>O</sub> =5.2mA;V <sub>CC</sub> =6.0V	-	-	0.33	V
input leakage current	I <sub>I</sub>	V <sub>I</sub> =V <sub>CC</sub> or GND;V <sub>CC</sub> =6.0V	-	-	±0.1	μA	
supply current	I <sub>CC</sub>	V <sub>I</sub> =V <sub>CC</sub> or GND;I <sub>O</sub> =0A;V <sub>CC</sub> =6.0V	-	-	80	μA	
input apacitance	C <sub>I</sub>	-	-	-	-	pF	
<b>SN74HCT192</b>							
HIGH-level input voltage	V <sub>IH</sub>	V <sub>CC</sub> =4.5V to 5.5V	2.0	-	-	V	
LOW-level input voltage	V <sub>IL</sub>	V <sub>CC</sub> =4.5V to 5.5V	-	-	0.8	V	
HIGH-level output voltage	V <sub>OH</sub>	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub> V <sub>CC</sub> =4.5V	I <sub>O</sub> =-20uA	4.4	-	-	V
			I <sub>O</sub> =-4.0uA	3.84	-	-	V
LOW-level output voltage	V <sub>OL</sub>	V <sub>I</sub> =V <sub>IH</sub> or V <sub>IL</sub> V <sub>CC</sub> =4.5V	I <sub>O</sub> =20uA	-	-	0.1	V
			I <sub>O</sub> =4.0uA	-	-	0.33	V
input leakage current	I <sub>I</sub>	V <sub>I</sub> =V <sub>CC</sub> or GND;V <sub>CC</sub> =5.5V	-	-	±1.0	μA	
supply current	I <sub>CC</sub>	V <sub>I</sub> =V <sub>CC</sub> or GND;I <sub>O</sub> =0A;V <sub>CC</sub> =5.5V	-	-	80	μA	
Additional Supply currend	ΔI <sub>CC</sub>	per input pin; V <sub>I</sub> =V <sub>CC</sub> -2.1V; other inputs at V <sub>CC</sub> or GND;I <sub>O</sub> =0V; V <sub>CC</sub> =4.5V to 5.5V	pin Dn	-	-	157.5	μA
			pins CPU,CPD	-	-	630	μA
			pin P <sub>L</sub>	-	-	292.5	μA
			pin MR	-	-	472.5	μA
input apacitance	C <sub>I</sub>	-	-	-	-	pF	

AC Characteristics 1 (Tamb=25°C, GND=0V, tr=tr=6ns, CL=50pF, unless otherwise specified.)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit			
<b>SN74HC192</b>									
Propagation delay	t <sub>pd</sub>	CPU, CPD to Qn; see Figure7	V <sub>CC</sub> =2.0V	-	66	215	ns		
			V <sub>CC</sub> =4.5V	-	23	43	ns		
			V <sub>CC</sub> =5.0V; CL=15pF	-	24	-	ns		
			V <sub>CC</sub> =6.0V	-	19	37	ns		
		CPU to T <sub>CU</sub> ; see Figure8	V <sub>CC</sub> =2.0V	-	33	125	ns		
			V <sub>CC</sub> =4.5V	-	12	25	ns		
			V <sub>CC</sub> =6.0V	-	10	21	ns		
		CPU to T <sub>CD</sub> ; see Figure8	V <sub>CC</sub> =2.0V	-	39	125	ns		
			V <sub>CC</sub> =4.5V	-	14	25	ns		
			V <sub>CC</sub> =6.0V	-	11	21	ns		
		P <sub>L</sub> to Qn; see Figure9	V <sub>CC</sub> =2.0V	-	69	215	ns		
			V <sub>CC</sub> =4.5V	-	25	43	ns		
			V <sub>CC</sub> =6.0V	-	20	37	ns		
		MR to Qn; see Figure10	V <sub>CC</sub> =2.0V	-	63	200	ns		
			V <sub>CC</sub> =4.5V	-	23	40	ns		
			V <sub>CC</sub> =6.0V	-	18	34	ns		
		Dn to Qn; see Figure9	V <sub>CC</sub> =2.0V	-	91	275	ns		
			V <sub>CC</sub> =4.5V	-	33	55	ns		
			V <sub>CC</sub> =6.0V	-	26	47	ns		
		P <sub>L</sub> to T <sub>CU</sub> ; P <sub>L</sub> to T <sub>CD</sub> ; see Figure12	V <sub>CC</sub> =2.0V	-	102	315	ns		
			V <sub>CC</sub> =4.5V	-	37	63	ns		
			V <sub>CC</sub> =6.0V	-	30	54	ns		
		MR to T <sub>CU</sub> ; MR to T <sub>CD</sub> ; see Figure12	V <sub>CC</sub> =2.0V	-	96	285	ns		
			V <sub>CC</sub> =4.5V	-	35	57	ns		
			V <sub>CC</sub> =6.0V	-	28	48	ns		
		Dn to T <sub>CU</sub> ; Dn to T <sub>CD</sub> ; see Figure12	V <sub>CC</sub> =2.0V	-	83	290	ns		
			V <sub>CC</sub> =4.5V	-	30	58	ns		
			V <sub>CC</sub> =6.0V	-	24	49	ns		
		transition time	t <sub>t</sub>	see Figure10	V <sub>CC</sub> =2.0V	-	19	75	ns
					V <sub>CC</sub> =4.5V	-	7	15	ns
V <sub>CC</sub> =6.0V	-				6	13	ns		
pulse width	t <sub>w</sub>	up clock pulse width HIGH or LOW; see Figure7	V <sub>CC</sub> =2.0V	120	39	-	ns		
			V <sub>CC</sub> =4.5V	24	14	-	ns		
			V <sub>CC</sub> =6.0V	20	11	-	ns		
		down clock pulse width HIGH or LOW; see Figure7	V <sub>CC</sub> =2.0V	140	50	-	ns		
			V <sub>CC</sub> =4.5V	28	18	-	ns		
			V <sub>CC</sub> =6.0V	24	14	-	ns		



		master reset pulse width HIGH; see Figure10	V <sub>CC</sub> =2.0V	80	22	-	ns
			V <sub>CC</sub> =4.5V	16	8	-	ns
			V <sub>CC</sub> =6.0V	14	6	-	ns
		parallel load pulse width LOW; see Figure9	V <sub>CC</sub> =2.0V	80	22	-	ns
			V <sub>CC</sub> =4.5V	16	8	-	ns
			V <sub>CC</sub> =6.0V	14	6	-	ns
Recovery time	t <sub>rec</sub>	P $\bar{L}$ to CPU,CPD; see Figure9	V <sub>CC</sub> =2.0V	50	3	-	ns
			V <sub>CC</sub> =4.5V	10	1	-	ns
			V <sub>CC</sub> =6.0V	9	1	-	ns
		MR to CPU,CPD; see Figure10	V <sub>CC</sub> =2.0V	50	0	-	ns
			V <sub>CC</sub> =4.5V	10	0	-	ns
			V <sub>CC</sub> =6.0V	9	0	-	ns
Set-up time	t <sub>su</sub>	Dn to P $\bar{L}$ ; see Figure11;note: CPU=CPD=HIGH	V <sub>CC</sub> =2.0V	80	22	-	ns
			V <sub>CC</sub> =4.5V	16	8	-	ns
			V <sub>CC</sub> =6.0V	14	6	-	ns
Hold time	t <sub>h</sub>	Dn to P $\bar{L}$ see Figure11	V <sub>CC</sub> =2.0V	0	-14	-	ns
			V <sub>CC</sub> =4.5V	0	-5	-	ns
			V <sub>CC</sub> =6.0V	0	-4	-	ns
		CPU to CPD, CPD to CPU; see Figure13	V <sub>CC</sub> =2.0V	80	19	-	ns
			V <sub>CC</sub> =4.5V	16	7	-	ns
			V <sub>CC</sub> =6.0V	14	6	-	ns
Maximum frequency	f <sub>MAX</sub>	CPU,CPD; see Figure8	V <sub>CC</sub> =2.0V	4.0	12	-	MHz
			V <sub>CC</sub> =4.5V	20	36	-	MHz
			V <sub>CC</sub> =5.0V;CL=15pF	-	40	-	MHz
			V <sub>CC</sub> =6.0V	24	43	-	MHz
power dissipation capacitance	C <sub>PD</sub>	V <sub>I</sub> =GND to V <sub>CC</sub>	-	24	-	pF	
<b>SN74HCT192</b>							
Propagation delay	t <sub>pd</sub>	CPU,CPD to Q <sub>n</sub> ; see Figure7	V <sub>CC</sub> =4.5V	-	23	43	ns
			V <sub>CC</sub> =5.0V;C <sub>L</sub> =15pF	-	20	-	ns
		CPU to T $\bar{C}U$ ; see Figure8	V <sub>CC</sub> =4.5V	-	16	30	ns
		CPU to T $\bar{C}D$ ; see Figure8	V <sub>CC</sub> =4.5V	-	17	30	ns
		P $\bar{L}$ to Q <sub>n</sub> ; see Figure9	V <sub>CC</sub> =4.5V	-	28	46	ns
		MR to Q <sub>n</sub> ; see Figure10	V <sub>CC</sub> =4.5V	-	24	40	ns
		Dn to Q <sub>n</sub> ; see Figure9	V <sub>CC</sub> =4.5V	-	36	62	ns
P $\bar{L}$ to T $\bar{C}U$ ; P $\bar{L}$ to T $\bar{C}D$ ;	V <sub>CC</sub> =4.5V	-	36	64	ns		



		see Figure12					
		MR to $\overline{T\bar{C}U}$ ; MR to $\overline{T\bar{C}D}$ ; see Figure12	$V_{CC}=4.5V$	-	36	64	ns
		Dn to $\overline{T\bar{C}U}$ ; Dn to $\overline{T\bar{C}D}$ ; see Figure12	$V_{CC}=4.5V$	-	33	58	ns
transition time	$t_t$	$V_{CC}=4.5V$ ; see Figure10		-	7	15	ns
pulse width	$t_w$	$V_{CC}=4.5V$	up down clock pulse width HIGH or LOW; see Figure7	25	14	-	ns
			master reset pulse width HIGH; see Figure10	16	6	-	ns
			parallel load pulse width LOW; see Figure9	20	10	-	ns
Recovery time	$t_{rec}$	$V_{CC}=4.5V$	$\overline{P\bar{L}}$ to CPU,CPD; see Figure9	10	1	-	ns
			MR to CPU,CPD; see Figure10	10	2	-	ns
Set-up time	$t_{su}$	Dn to $\overline{P\bar{L}}$ ; see Figure11; Note: CPU=CPD=HIGH; $V_{CC}=4.5V$		16	8	-	ns
Hold time	$t_h$	$V_{CC}=4.5V$	Dn to $\overline{P\bar{L}}$ see Figure11	0	-6	-	ns
			CPU to CPD, CPD to CPU; see Figure13	20	9	-	ns
Maximum frequency	$f_{MAX}$	CPU,CPD; see Figure7	$V_{CC}=4.5V$	20	41	-	MHz
			$V_{CC}=5.0V$ ; $C_L=15pF$	-	45	-	MHz
power dissipation capacitance	$C_{PD}$	$V_I=GND$ to $V_{CC}-1.5V$		-	28	-	pF

Note:

[1]  $t_{pd}$  is the same as  $t_{PLH}$  and  $t_{PHL}$ .

[2]  $t_t$  is the same as  $t_{THL}$  and  $t_{TLH}$ .

[3]  $C_{PD}$  is used to determine the dynamic power dissipation ( $P_D$  in uW).

$$P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \sum (C_L \times V_{CC}^2 \times f_o) \text{ where:}$$

$f_i$  = input frequency in MHz;

$f_o$  = output frequency in MHz;

$C_L$  = output load capacitance in pF;

$V_{CC}$  = supply voltage in V;

$N$  = number of inputs switching;

$\sum (C_L \times V_{CC}^2 \times f)$  = sum of outputs.

AC Characteristics 2 (Tamb=-40°C to +85°C, GND =0V, tr=tr=6ns, CL=50pF, unless otherwise specified.)

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit	
<b>SN74HC192</b>							
Propagation delay	t <sub>pd</sub>	CPU, CPD to Qn; see Figure7	V <sub>CC</sub> =2.0V	-	-	270	ns
			V <sub>CC</sub> =4.5V	-	-	54	ns
			V <sub>CC</sub> =5.0V; CL=15pF	-	-	-	ns
		CPU to T <sub>CU</sub> ; see Figure8	V <sub>CC</sub> =2.0V	-	-	155	ns
			V <sub>CC</sub> =4.5V	-	-	31	ns
			V <sub>CC</sub> =6.0V	-	-	26	ns
		CPU to T <sub>CD</sub> ; see Figure8	V <sub>CC</sub> =2.0V	-	-	155	ns
			V <sub>CC</sub> =4.5V	-	-	31	ns
			V <sub>CC</sub> =6.0V	-	-	26	ns
		P <sub>L</sub> to Qn; see Figure9	V <sub>CC</sub> =2.0V	-	-	270	ns
			V <sub>CC</sub> =4.5V	-	-	54	ns
			V <sub>CC</sub> =6.0V	-	-	46	ns
		MR to Qn; see Figure10	V <sub>CC</sub> =2.0V	-	-	25	ns
			V <sub>CC</sub> =4.5V	-	-	50	ns
			V <sub>CC</sub> =6.0V	-	-	43	ns
		Dn to Qn; see Figure9	V <sub>CC</sub> =2.0V	-	-	345	ns
			V <sub>CC</sub> =4.5V	-	-	69	ns
			V <sub>CC</sub> =6.0V	-	-	59	ns
		P <sub>L</sub> to T <sub>CU</sub> ; P <sub>L</sub> to T <sub>CD</sub> ; see Figure12	V <sub>CC</sub> =2.0V	-	-	395	ns
			V <sub>CC</sub> =4.5V	-	-	79	ns
			V <sub>CC</sub> =6.0V	-	-	67	ns
		MR to T <sub>CU</sub> ; MR to T <sub>CD</sub> ; see Figure12	V <sub>CC</sub> =2.0V	-	-	355	ns
			V <sub>CC</sub> =4.5V	-	-	71	ns
			V <sub>CC</sub> =6.0V	-	-	60	ns
Dn to T <sub>CU</sub> ; Dn to T <sub>CD</sub> ; see Figure12	V <sub>CC</sub> =2.0V	-	-	365	ns		
	V <sub>CC</sub> =4.5V	-	-	73	ns		
	V <sub>CC</sub> =6.0V	-	-	62	ns		
transition time	t <sub>t</sub>	see Figure10	V <sub>CC</sub> =2.0V	-	-	95	ns
			V <sub>CC</sub> =4.5V	-	-	19	ns
			V <sub>CC</sub> =6.0V	-	-	16	ns
pulse width	t <sub>w</sub>	up clock pulse width HIGH or LOW; see Figure7	V <sub>CC</sub> =2.0V	150	-	-	ns
			V <sub>CC</sub> =4.5V	30	-	-	ns
			V <sub>CC</sub> =6.0V	26	-	-	ns
		down clock pulse width HIGH or LOW; see Figure7	V <sub>CC</sub> =2.0V	175	-	-	ns
			V <sub>CC</sub> =4.5V	35	-	-	ns
			V <sub>CC</sub> =6.0V	30	-	-	ns



		master reset pulse width HIGH; see Figure10	$V_{CC}=2.0V$	100	-	-	ns
			$V_{CC}=4.5V$	20	-	-	ns
			$V_{CC}=6.0V$	17	-	-	ns
		parallel load pulse width LOW; see Figure9	$V_{CC}=2.0V$	100	-	-	ns
			$V_{CC}=4.5V$	20	-	-	ns
			$V_{CC}=6.0V$	17	-	-	ns
Recovery time	$t_{rec}$	$P\bar{L}$ to CPU,CPD; see Figure9	$V_{CC}=2.0V$	65	-	-	ns
			$V_{CC}=4.5V$	13	-	-	ns
			$V_{CC}=6.0V$	11	-	-	ns
		MR to CPU,CPD; see Figure10	$V_{CC}=2.0V$	65	-	-	ns
			$V_{CC}=4.5V$	13	-	-	ns
			$V_{CC}=6.0V$	11	-	-	ns
Set-up time	$t_{su}$	Dn to $P\bar{L}$ ; see Figure11;note: CPU=CPD=HIGH	$V_{CC}=2.0V$	100	-	-	ns
			$V_{CC}=4.5V$	20	-	-	ns
			$V_{CC}=6.0V$	17	-	-	ns
Hold time	$t_h$	Dn to $P\bar{L}$ see Figure11	$V_{CC}=2.0V$	0	-	-	ns
			$V_{CC}=4.5V$	0	-	-	ns
			$V_{CC}=6.0V$	0	-	-	ns
		CPU to CPD, CPD to CPU; see Figure13	$V_{CC}=2.0V$	100	-	-	ns
			$V_{CC}=4.5V$	20	-	-	ns
			$V_{CC}=6.0V$	17	-	-	ns
Maximum frequency	$f_{MAX}$	CPU,CPD; see Figure8	$V_{CC}=2.0V$	3.2	-	-	MHz
			$V_{CC}=4.5V$	16	-	-	MHz
			$V_{CC}=5.0V;C_L=15pF$	-	-	-	MHz
			$V_{CC}=6.0V$	19	-	-	MHz
power dissipation capacitance	$C_{PD}$	$V_I=GND$ to $V_{CC}$	-	-	-	pF	
<b>SN74HCT192</b>							
Propagation delay	$t_{pd}$	CPU,CPD to Qn; see Figure7	$V_{CC}=4.5V$	-	-	54	ns
			$V_{CC}=5.0V;C_L=15pF$	-	-	-	ns
		CPU to $T\bar{C}U$ ; see Figure8	$V_{CC}=4.5V$	-	-	38	ns
		CPU to $T\bar{C}D$ ; see Figure8	$V_{CC}=4.5V$	-	-	38	ns
		$P\bar{L}$ to Qn; see Figure9	$V_{CC}=4.5V$	-	-	58	ns
		MR to Qn; see Figure10	$V_{CC}=4.5V$	-	-	50	ns
		Dn to Qn; see Figure9	$V_{CC}=4.5V$	-	-	78	ns
		$P\bar{L}$ to $T\bar{C}U$ ; $P\bar{L}$ to $T\bar{C}D$ ;	$V_{CC}=4.5V$	-	-	80	ns



		see Figure12					
		MR to $\overline{T\bar{C}U}$ ; MR to $\overline{T\bar{C}D}$ ; see Figure12	$V_{CC}=4.5V$	-	-	80	ns
		Dn to $\overline{T\bar{C}U}$ ; Dn to $\overline{T\bar{C}D}$ ; see Figure12	$V_{CC}=4.5V$	-	-	73	ns
transition time	$t_t$	$V_{CC}=4.5V$ ; see Figure10		-	-	19	ns
pulse width	$t_w$	$V_{CC}=4.5V$	up down clock pulse width HIGH or LOW; see Figure7	31	-	-	ns
			master reset pulse width HIGH; see Figure10	20	-	-	ns
			parallel load pulse width LOW; see Figure9	25	-	-	ns
Recovery time	$t_{rec}$	$V_{CC}=4.5V$	$\overline{P\bar{L}}$ to CPU,CPD; see Figure9	13	-	-	ns
			MR to CPU,CPD; see Figure10	13	-	-	ns
Set-up time	$t_{su}$	Dn to $\overline{P\bar{L}}$ ; see Figure11; Note:CPU=CPD=HIGH; $V_{CC}=4.5V$		20	-	-	ns
Hold time	$t_h$	$V_{CC}=4.5V$	Dn to $\overline{P\bar{L}}$ see Figure11	0	-	-	ns
			CPU to CPD,CPD to CPU; see Figure13	25	-	-	ns
Maximum frequency	$f_{MAX}$	CPU,CPD; see Figure7	$V_{CC}=4.5V$	16	-	-	MHz
			$V_{CC}=5.0V$ ; $C_L=15pF$	-	-	-	MHz
power dissipation capacitance	$C_{PD}$	$V_I=GND$ to $V_{CC}-1.5V$		-	-	-	pF

Note:

[1]  $t_{pd}$  is the same as  $t_{PLH}$  and  $t_{PHL}$ .

[2]  $t_t$  is the same as  $t_{THL}$  and  $t_{TLH}$ .

[3]  $C_{PD}$  is used to determine the dynamic power dissipation ( $P_D$  in uW).

$P_D=C_{PD} \times V_{CC}^2 \times f_i + \sum (C_L \times V_{CC}^2 \times f_o)$  where:

$f_i$ =input frequency in MHz;

$f_o$ =output frequency in MHz;

$C_L$ =output load capacitance in pF;

$V_{CC}$ =supply voltage in V;

$\sum (C_L \times V_{CC}^2 \times f_o)$ =sum of outputs.

## Testing Circuit

### AC Testing Circuit

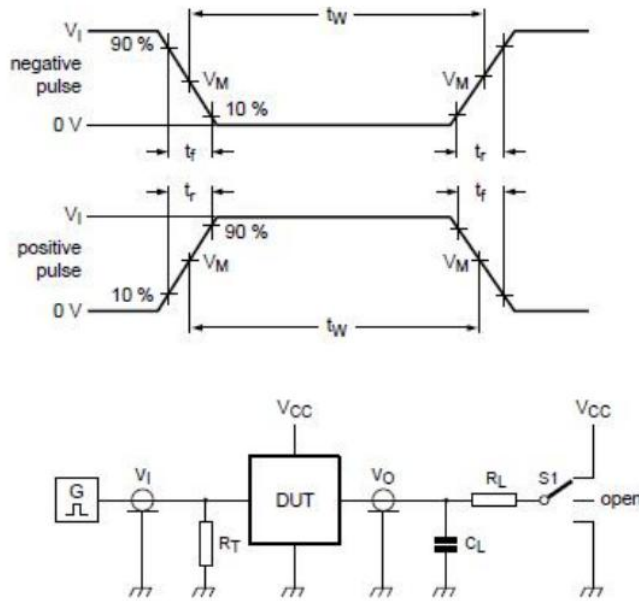


Figure 6. Test circuit for measuring switching times

Definitions for test circuit:

$C_L$ =Load capacitance including jig and probe capacitance.

$R_T$ =Termination resistance should be equal to the output impedance  $Z_o$  of the pulse generator.

$R_L$ =Load resistance

S1=Test selection switch

### AC Testing Waveforms

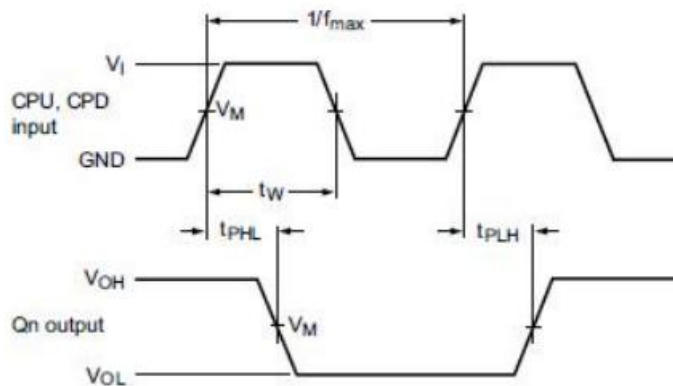


Figure 7. The clock (CPU, CPD) to output (Qn) propagation delays, the clock pulse width, and the maximum clock pulse frequency

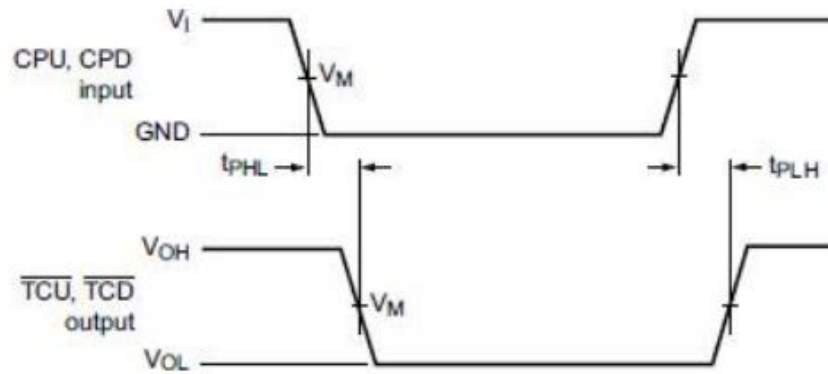


Figure 8. The clock (CPU, CPD) to terminal count output ( $\overline{TCU}$ ,  $\overline{TCD}$ ) propagation delays

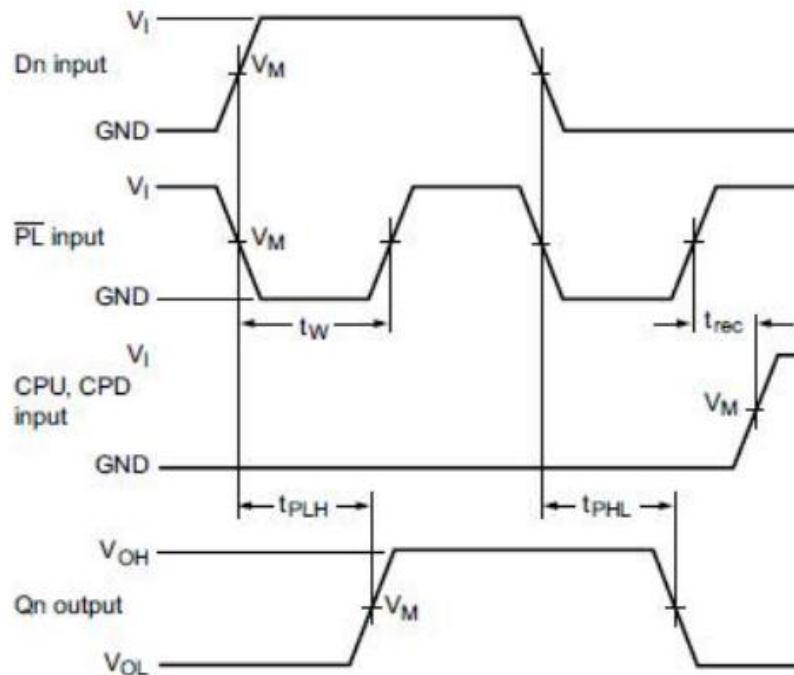


Figure 9. The parallel load input ( $\overline{PL}$ ) and data ( $D_n$ ) to  $Q_n$  output propagation delays and  $\overline{PL}$  removal time to clock input (CPU, CPD)

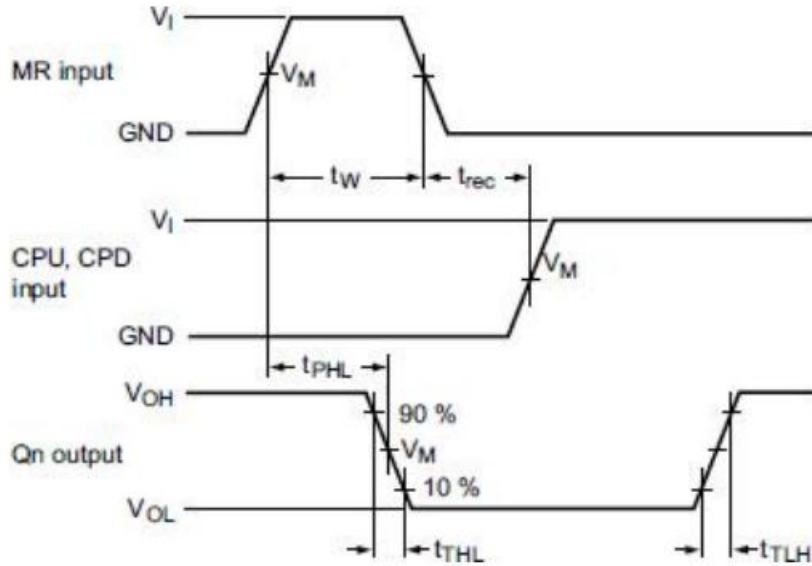


Figure 10. The master reset input (MR) pulse width, MR to Qn propagation delays, MR to CPU, CPD removal time and output transition times

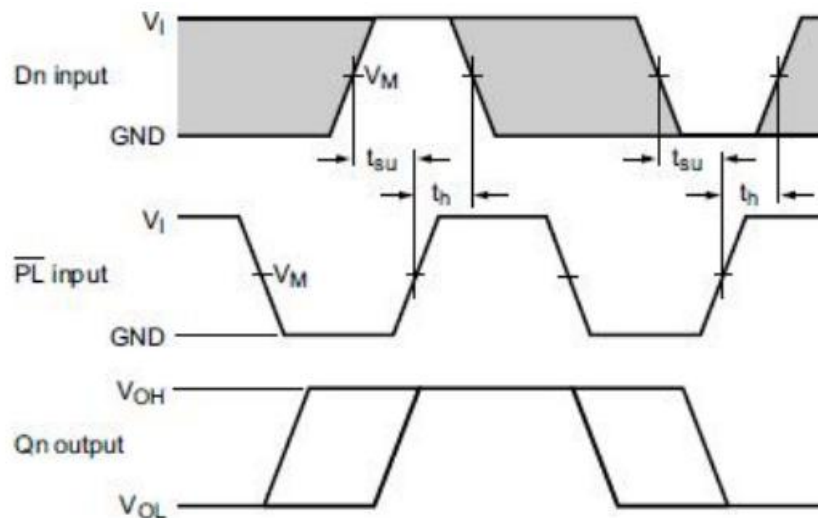


Figure 11. The data input (Dn) to parallel load input ( $\overline{PL}$ ) set-up and hold times



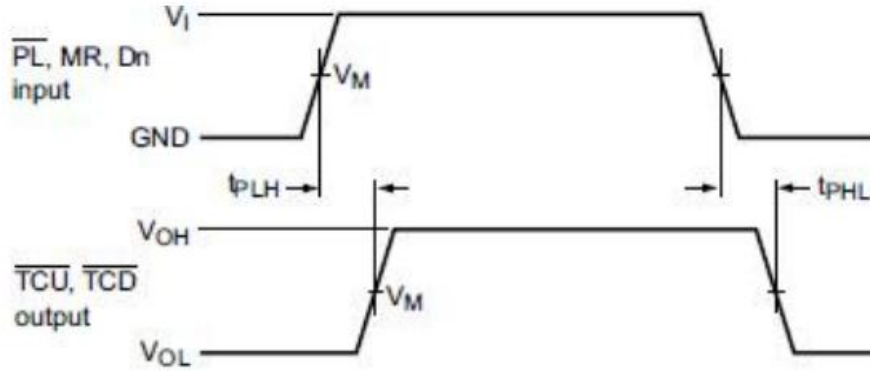


Figure 12. The data input (Dn), parallel load input ( $\overline{PL}$ ) and the master reset input (MR) to the terminal count outputs ( $\overline{TCU}$ ,  $\overline{TCD}$ ) propagation delays

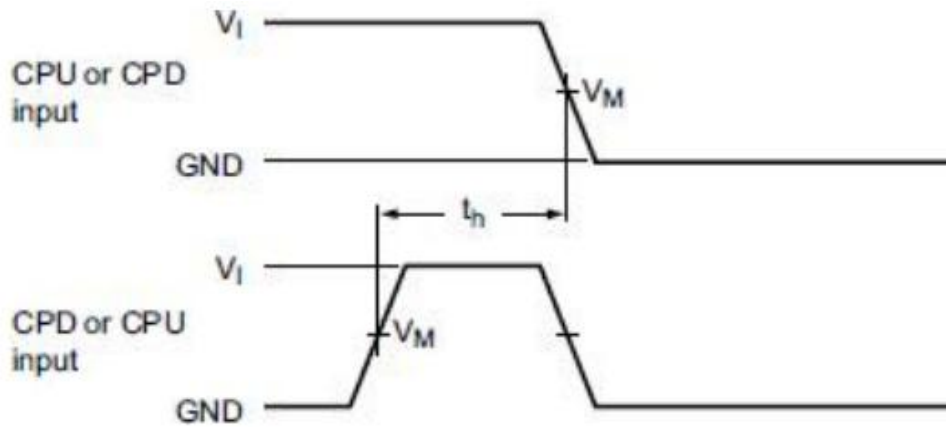


Figure 13. The CPU to CPD or CPD to CPU hold times



Measurement Points

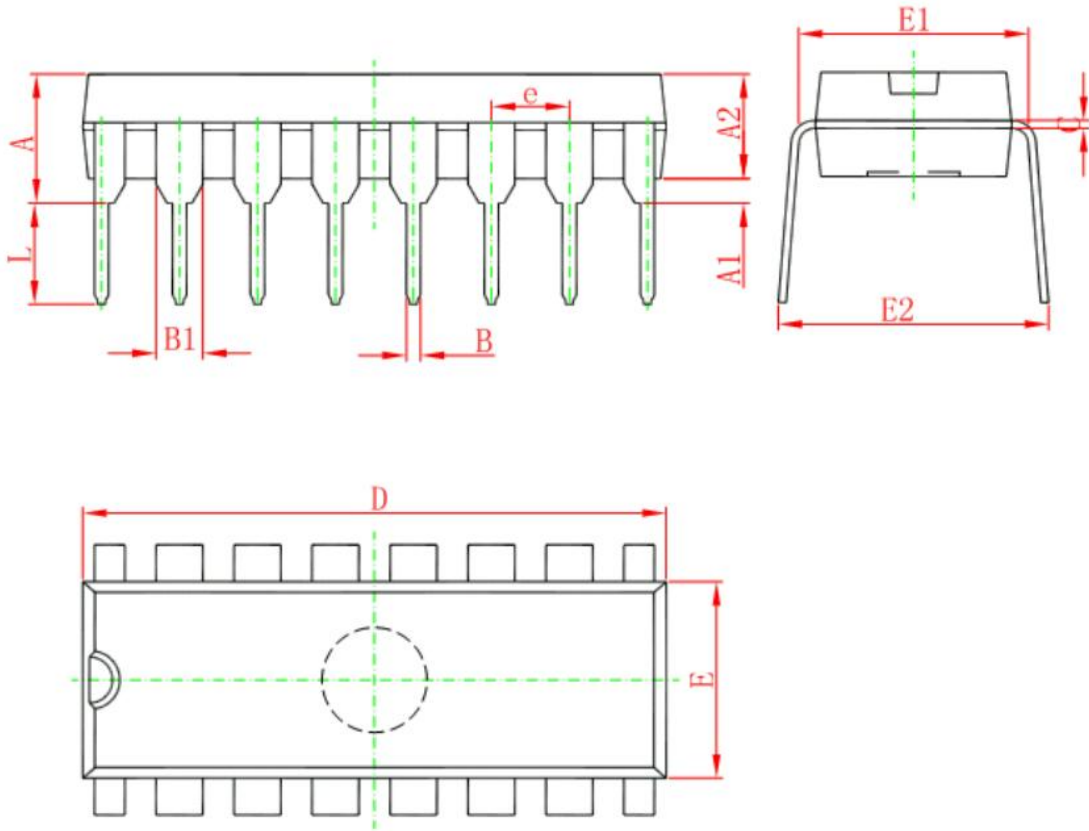
Type	Input		Output
	$V_I$	$V_M$	$V_M$
SN74HC192	GND to $V_{CC}$	$0.5 \times V_{CC}$	$0.5 \times V_{CC}$
SN74HCT192	GND to 3V	1.3V	1.3V

Test Data

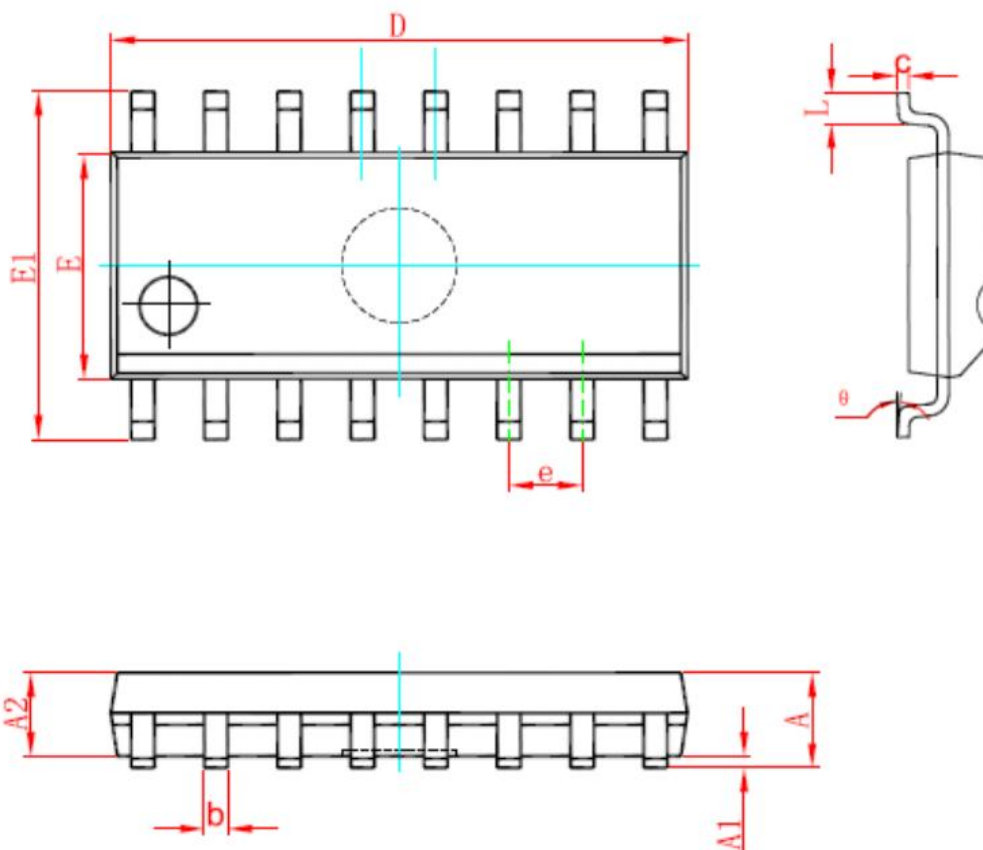
Type	Input		Load		S1 position
	$V_I$	$t_r, t_f$	$C_L$	$R_L$	$t_{PHL}, t_{PLH}$
SN74HC192	$V_{CC}$	6.0ns	15pF, 50pF	1K $\Omega$	open
SN74HCT192	3.0V	6.0ns	15pF, 50pF	1K $\Omega$	open

Package Information

DIP16

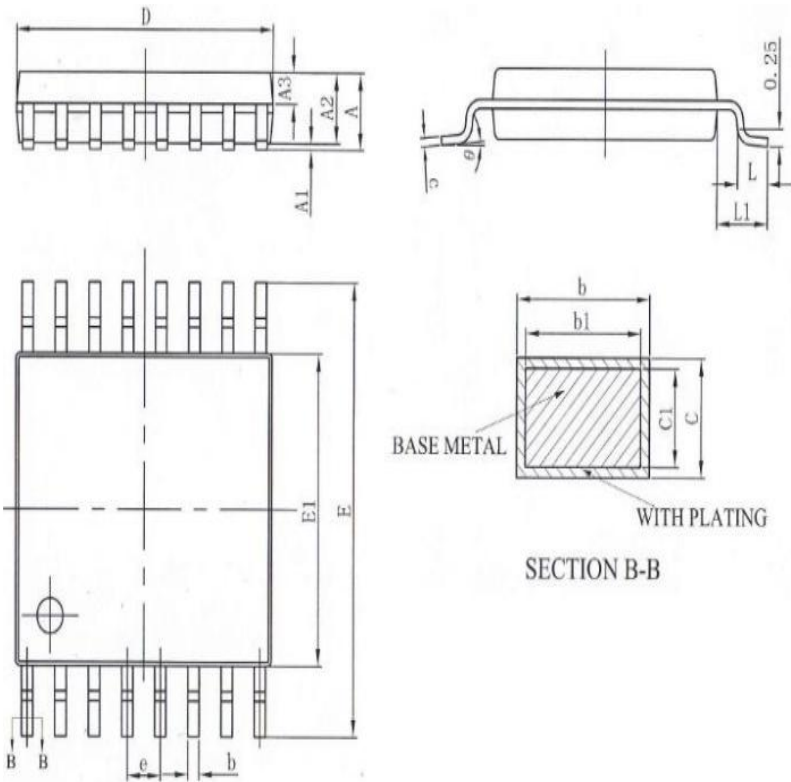


Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	4.310	0.146	0.170
A1	0.510		0.020	
A2	3.200	3.600	0.126	0.142
B	0.380	0.570	0.015	0.022
B1	1.524(BSC)		0.060(BSC)	
C	0.204	0.360	0.008	0.014
D	18.800	19.200	0.740	0.756
E	6.200	6.600	0.244	0.260
E1	7.320	7.920	0.288	0.312
e	2.540(BSC)		0.100(BSC)	
L	3.000	3.600	0.118	0.142
E2	8.400	9.000	0.331	0.354



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
C	0.170	0.250	0.007	0.010
D	9.800	10.200	0.386	0.402
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

TSSOP16



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	-	-	1.20
A1	0.05	-	0.15
A2	0.90	1.00	1.05
A3	0.39	0.44	0.49
b	0.20	-	0.28
b1	0.19	0.22	0.25
c	0.13	-	0.17
c1	0.12	0.13	0.14
D	4.90	5.00	5.10
E	6.20	6.40	6.60
E1	4.30	4.40	4.50
e	0.65BSC		
L	0.45	0.60	0.75
L1	1.00BSC		
$\theta$	0	-	8°

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