

BCD UP/DOWN COUNTER

FEATURES

- Output capability: standard
- I_{CC} category: MSI

GENERAL DESCRIPTION

The 74HC/HCT4510 are high-speed Si-gate CMOS devices and are pin compatible with the "4510" of the "4000B" series. They are specified in compliance with JEDEC standard no. 7A.

The 74HC/HCT4510 are edge-triggered synchronous up/down BCD counters with a clock input (CP), an up/down count control input (UP/DN), an active LOW count enable input (CE), an asynchronous active HIGH parallel load input (PL), four parallel inputs (D₀ to D₃), four parallel outputs (Q₀ to Q₃), an active LOW terminal count output (TC), and an overriding asynchronous master reset input (MR).

Information on D₀ to D₃ is loaded into the counter while PL is HIGH, independent of all other input conditions except the MR input, which must be LOW. With PL LOW, the counter changes on the LOW-to-HIGH transition of CP if CE is LOW. UP/DN determines the direction of the count, HIGH for counting up, LOW for counting down. When counting up, TC is LOW when Q₀ and Q₃ are HIGH and CE is LOW. When counting down, TC is LOW when Q₀ to Q₃ and CE are LOW. A HIGH on MR resets the counter (Q₀ to Q₃ = LOW) independent of all other input conditions.

Logic equation for terminal count:

$$\overline{TC} = \overline{CE} \cdot \{ (\overline{UP/DN}) \cdot Q_0 \cdot Q_3 + (\overline{UP/DN}) \cdot \overline{Q_0} \cdot \overline{Q_1} \cdot \overline{Q_2} \cdot \overline{Q_3} \}$$

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC	HCT	
t _{PHL} / t _{PLH}	propagation delay CP to Q _n	C _L = 15 pF V _{CC} = 5 V	21	23	ns
f _{max}	maximum clock frequency		57	58	MHz
C _I	input capacitance		3.5	3.5	pF
C _{PD}	power dissipation capacitance per package	notes 1 and 2	50	53	pF

GND = 0 V; T_{amb} = 25 °C; t_r = t_f = 6 ns

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW):

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

f_i = input frequency in MHz C_L = output load capacitance in pF
f_o = output frequency in MHz V_{CC} = supply voltage in V
Σ (C_L × V_{CC}² × f_o) = sum of outputs

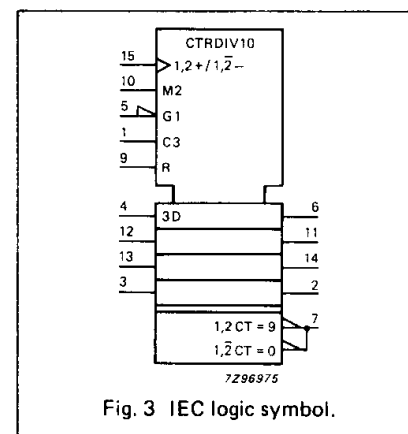
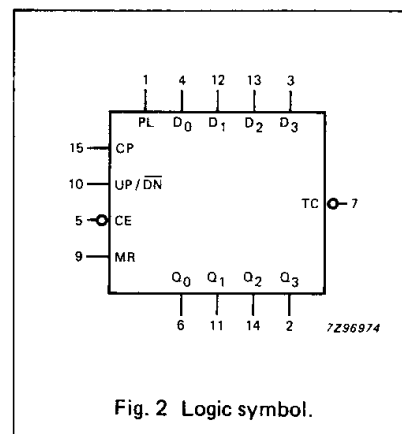
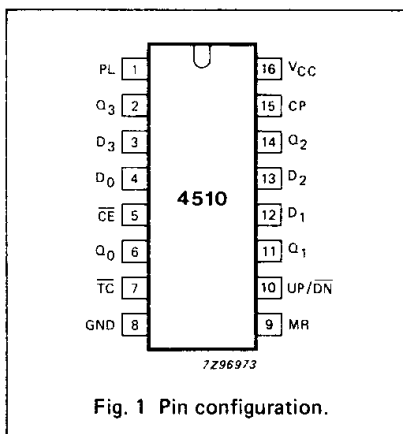
2. For HC the condition is V_I = GND to V_{CC}
For HCT the condition is V_I = GND to V_{CC} - 1.5 V

PACKAGE OUTLINES

16-lead DIL; plastic (SOT38Z).
16-lead mini-pack; plastic (SO16; SOT109A).

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION
1	PL	parallel load input (active HIGH)
4, 12, 13, 3	D ₀ to D ₃	parallel inputs
5	CE	count enable input (active LOW)
6, 11, 14, 2	Q ₀ to Q ₃	parallel outputs
7	TC	terminal count output (active LOW)
8	GND	ground (0 V)
9	MR	asynchronous master reset input (active HIGH)
10	UP/DN	up/down control input
15	CP	clock input (LOW-to-HIGH, edge-triggered)
16	V _{CC}	positive supply voltage



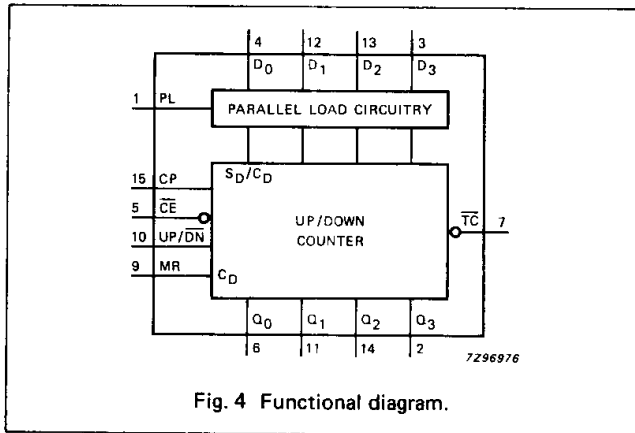


Fig. 4 Functional diagram.

FUNCTION TABLE

MR	PL	UP/DN	CE	CP	MODE
L	H	X	X	X	parallel load
L	L	X	H	X	no change
L	L	L	L	↑	count down
L	L	H	L	↑	count up
H	X	X	X	X	reset

H = HIGH voltage level
L = LOW voltage level
X = don't care
↑ = LOW-to-HIGH clock transition

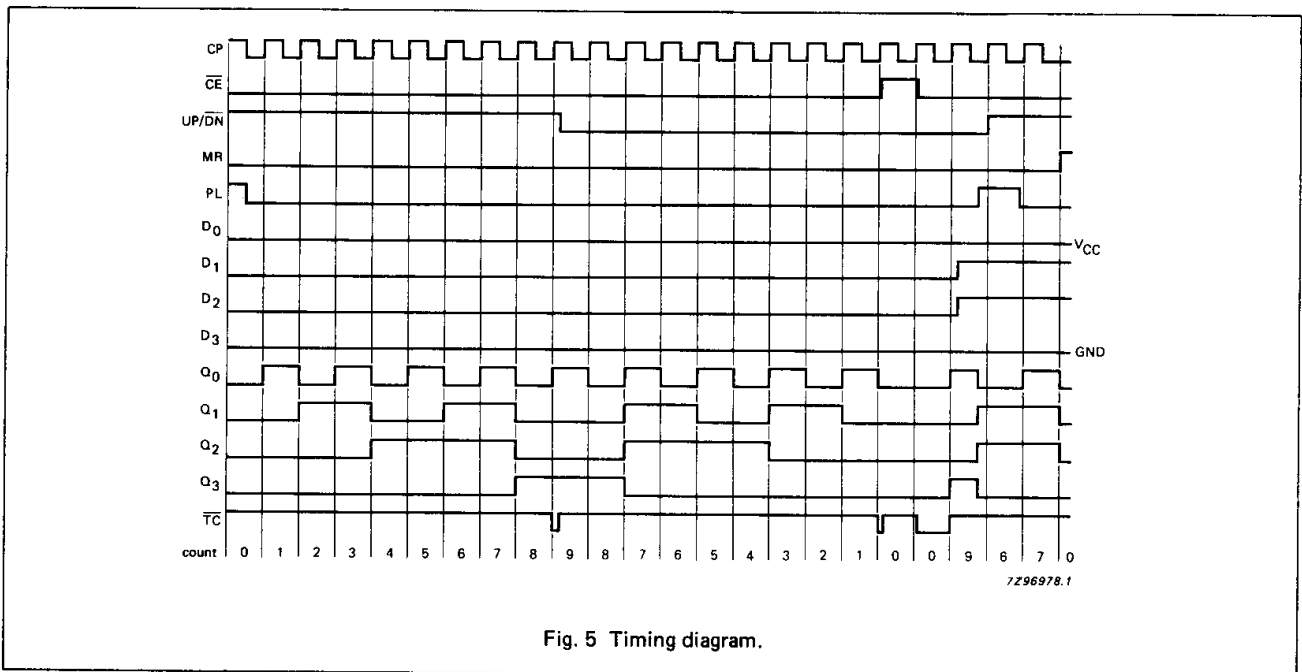


Fig. 5 Timing diagram.

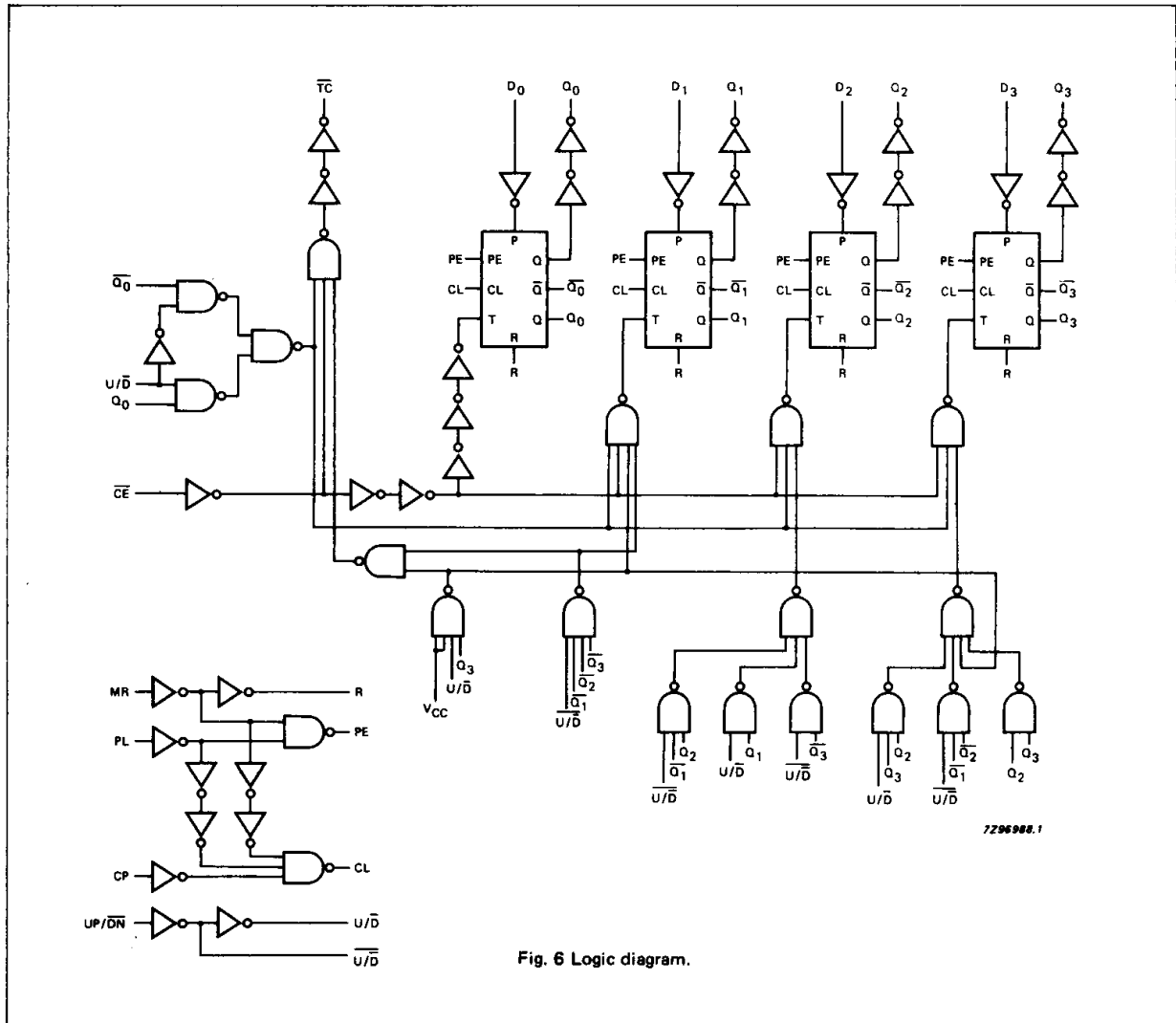


Fig. 6 Logic diagram.

DC CHARACTERISTICS FOR 74HC

For the DC characteristics see chapter "HCMOS family characteristics", section "Family specifications".

Output capability: standard
I_{CC} category: MSI

AC CHARACTERISTICS FOR 74HC

GND = 0 V; t_r = t_f = 6 ns; C_L = 50 pF

SYMBOL	PARAMETER	T _{amb} (°C)						UNIT	TEST CONDITIONS		
		74HC							V _{CC} V	WAVEFORMS	
		+25			-40 to +85		-40 to +125				
		min.	typ.	max.	min.	max.	min.				max.
t _{PHL} / t _{PLH}	propagation delay CP to Q _n		69 25 20	220 44 37		275 55 47		330 66 56	ns	2.0 4.5 6.0	Fig. 7
t _{PHL}	propagation delay MR to Q _n		63 23 18	210 42 36		265 53 45		315 63 54	ns	2.0 4.5 6.0	Fig. 10
t _{PLH} / t _{PHL}	propagation delay PL to Q _n		77 28 22	250 50 43		315 63 54		375 75 64	ns	2.0 4.5 6.0	Fig. 9
t _{PHL} / t _{PLH}	propagation delay CP to \overline{TC}		74 27 22	260 52 44		325 65 55		395 78 66	ns	2.0 4.5 6.0	Fig. 7
t _{PHL} / t _{PLH}	propagation delay \overline{CE} to \overline{TC}		36 13 10	125 25 21		155 31 26		190 38 32	ns	2.0 4.5 6.0	Fig. 8
t _{PLH}	propagation delay MR to \overline{TC}		69 25 20	235 47 40		295 59 50		355 71 60	ns	2.0 4.5 6.0	Fig. 10
t _{PHL} / t _{PLH}	propagation delay PL to \overline{TC}		91 33 26	300 60 51		375 75 64		450 90 77	ns	2.0 4.5 6.0	Fig. 9
t _{THL} / t _{TLH}	output transition time		19 7 6	75 15 13		95 19 16		110 22 19	ns	2.0 4.5 6.0	Fig. 9
t _W	pulse width CP, \overline{CE} HIGH or LOW	80 16 14	25 9 7		100 20 17		120 24 20		ns	2.0 4.5 6.0	Fig. 7
t _W	parallel load pulse width HIGH	80 16 14	22 8 7		100 20 17		120 24 20		ns	2.0 4.5 6.0	Fig. 10
t _W	master reset pulse width HIGH	100 20 17	19 7 6		125 25 21		150 30 26		ns	2.0 4.5 6.0	Fig. 10
t _{rem}	removal time MR to CP	80 16 14	28 10 8		100 20 17		120 24 20		ns	2.0 4.5 6.0	Fig. 10
t _{rem}	removal time PL to CP	80 16 14	14 5 4		100 20 17		120 24 20		ns	2.0 4.5 6.0	Fig. 10

SYMBOL	PARAMETER	T _{amb} (°C)						UNIT	TEST CONDITIONS		
		74HC							V _{CC} V	WAVEFORMS	
		+25			-40 to +85		-40 to +125				
		min.	typ.	max.	min.	max.	min.				max.
t _{su}	set-up time UP/DN to CP	100 20 17	30 11 9		125 25 21		150 30 26		ns	2.0 4.5 6.0	Fig. 8
t _{su}	set-up time \overline{CE} to CP	100 20 17	19 7 6		125 25 21		150 30 26		ns	2.0 4.5 6.0	Fig. 8
t _{su}	set-up time D _n to PL	100 20 17	17 6 5		125 25 21		150 30 26		ns	2.0 4.5 6.0	Fig. 11
t _h	hold time \overline{CE} to CP	5 5 5	0 0 0		5 5 5		5 5 5		ns	2.0 4.5 6.0	Fig. 8
t _h	hold time D _n to PL	3 3 3	-6 -2 -2		3 3 3		3 3 3		ns	2.0 4.5 6.0	Fig. 11
t _h	hold time UP/DN to CP	0 0 0	-19 -7 -6		0 0 0		0 0 0		ns	2.0 4.5 6.0	Fig. 8
f _{max}	maximum clock pulse frequency	6.0 30 35	17 52 62		4.8 24 28		4.0 20 24		MHz	2.0 4.5 6.0	Fig. 7

DC CHARACTERISTICS FOR 74HCT

For the DC characteristics see chapter "HCMOS family characteristics", section "Family specifications".

Output capability: standard

I_{CC} category: MSI

Note to HCT types

The value of additional quiescent supply current (ΔI_{CC}) for a unit load of 1 is given in the family specifications.

To determine ΔI_{CC} per input, multiply this value by the unit load coefficient shown in the table below.

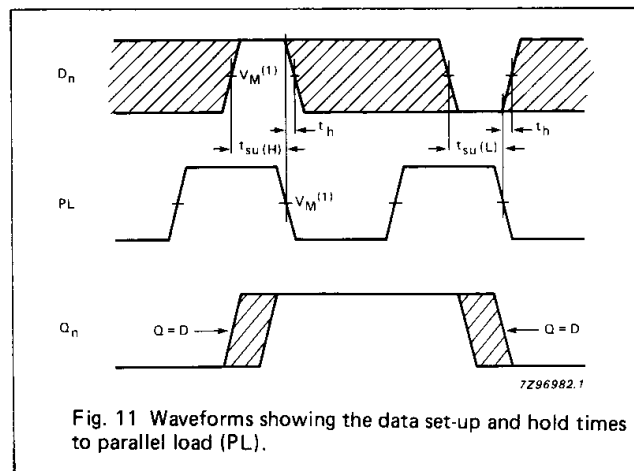
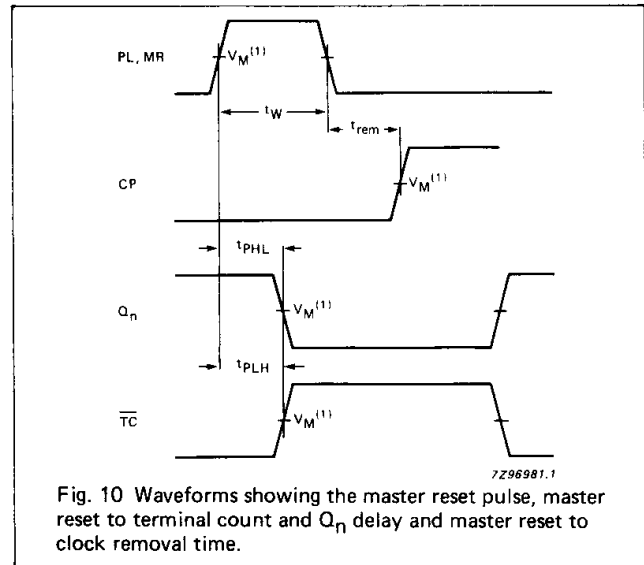
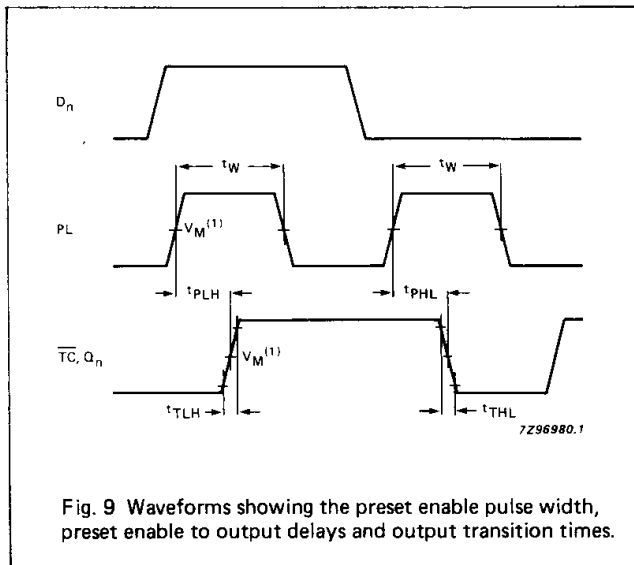
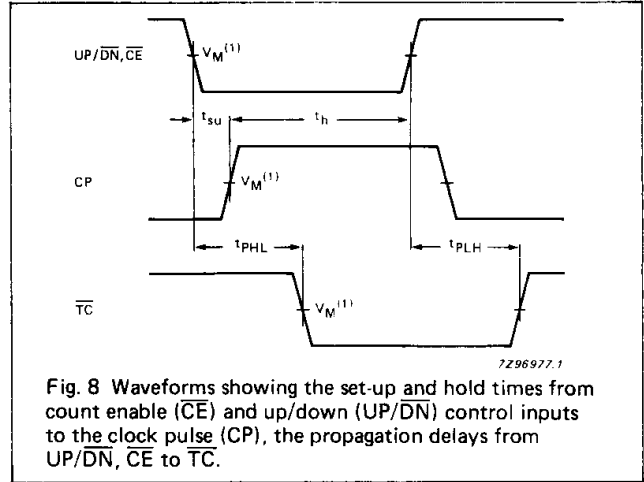
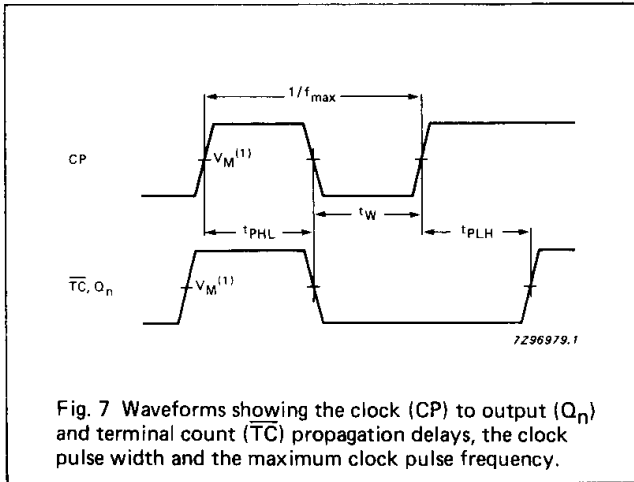
INPUT	UNIT LOAD COEFFICIENT
D _n	0.75
PL, \overline{CE}	1.00
UP/DN	1.00
CP	1.25
MR	1.50

AC CHARACTERISTICS FOR 74HCT

GND = 0 V; $t_r = t_f = 6$ ns; $C_L = 50$ pF

SYMBOL	PARAMETER	T_{amb} (°C)						UNIT	TEST CONDITIONS		
		74HCT							V_{CC} V	WAVEFORMS	
		+25			-40 to +85		-40 to +125				
		min.	typ.	max.	min.	max.	min.				max.
t_{PHL}/t_{PLH}	propagation delay CP to Q_n		27	50		63		75	ns	4.5	Fig. 7
t_{PHL}	propagation delay MR to Q_n		25	42		53		63	ns	4.5	Fig. 10
t_{PLH}/t_{PHL}	propagation delay PL to Q_n		28	53		66		80	ns	4.5	Fig. 9
t_{PHL}/t_{PLH}	propagation delay CP to TC		29	58		73		87	ns	4.5	Fig. 7
t_{PHL}/t_{PLH}	propagation delay CE to TC		17	31		39		47	ns	4.5	Fig. 8
t_{PLH}	propagation delay MR to TC		31	50		63		75	ns	4.5	Fig. 10
t_{PHL}/t_{PLH}	propagation delay PL to TC		35	68		85		102	ns	4.5	Fig. 10
t_{THL}/t_{TLH}	output transition time		7	15		19		22	ns	4.5	Fig. 9
t_w	pulse width CP, \overline{CE} HIGH or LOW	16	9		20		24		ns	4.5	Fig. 7
t_w	parallel load pulse width HIGH	16	6		20		24		ns	4.5	Fig. 10
t_w	master reset pulse width HIGH	20	4		25		30		ns	4.5	Fig. 10
t_{rem}	removal time MR to CP	23	13		29		35		ns	4.5	Fig. 10
t_{rem}	removal time PL to CP	17	10		21		26		ns	4.5	Fig. 10
t_{su}	set-up time UP/ \overline{DN} to CP	20	12		25		30		ns	4.5	Fig. 8
t_{su}	set-up time \overline{CE} to CP	20	6		25		30		ns	4.5	Fig. 8
t_{su}	set-up time D_n to PL	20	6		25		30		ns	4.5	Fig. 11
t_h	hold time \overline{CE} to CP	5	0		5		5		ns	4.5	Fig. 8
t_h	hold time D_n to PL	5	0		5		5		ns	4.5	Fig. 11
t_h	hold time UP/ \overline{DN} to CP	0	-5		0		0		ns	4.5	Fig. 8
f_{max}	maximum clock pulse frequency	30	53		24		20		MHz	4.5	Fig. 7

AC WAVEFORMS



Note to AC waveforms

- (1) HC : $V_M = 50\%$; $V_I = GND$ to V_{CC} .
- HCT: $V_M = 1.3V$; $V_I = GND$ to $3V$.

APPLICATION INFORMATION

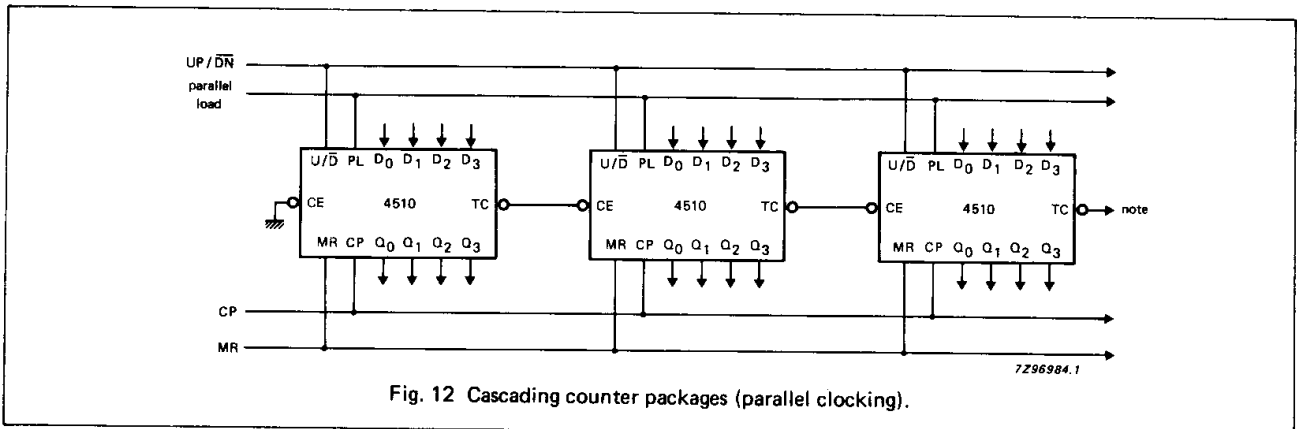


Fig. 12 Cascading counter packages (parallel clocking).

Note to Fig. 12

Terminal count (\overline{TC}) lines at the 2nd, 3rd, etc. stages may have a negative-going glitch pulse resulting from differential delays of different 4510s. These negative-going glitches do not affect proper 4510 operation. However, if the terminal count signals are used to trigger other edge sensitive logic devices, such as flip-flops or counters, the terminal count signals should be gated with the clock signal using a 2-input OR gate such as HC/HCT32.

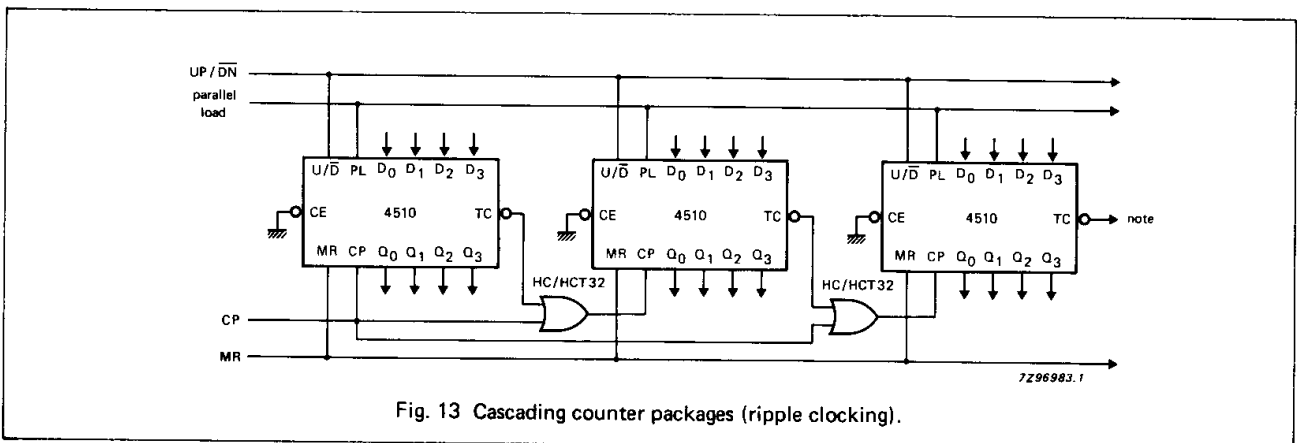
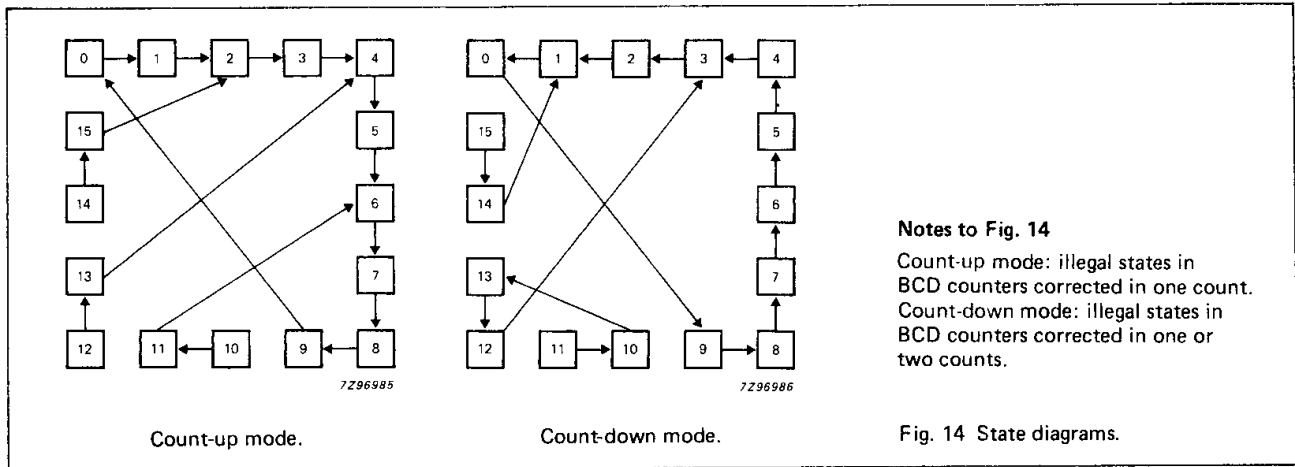


Fig. 13 Cascading counter packages (ripple clocking).

Note to Fig. 13

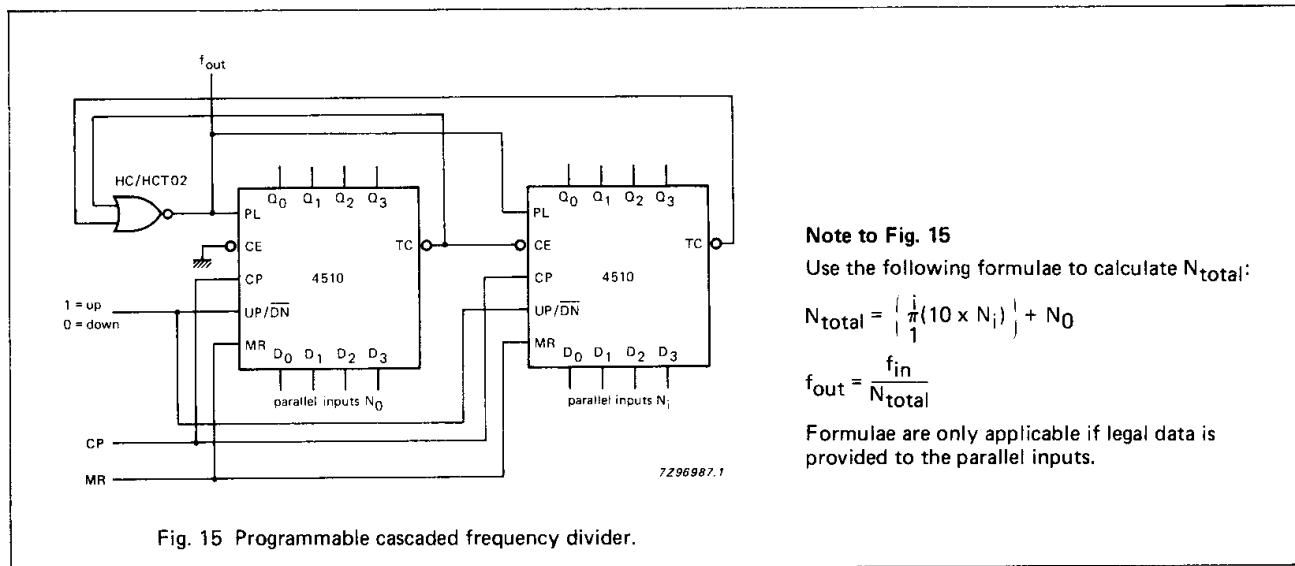
Ripple clocking mode: the UP/\overline{DN} control can be changed at any count. The only restriction on changing the UP/\overline{DN} control is that the clock input to the first counting stage must be HIGH. For cascading counters operating in a fixed up-count or \overline{DN} -count mode, the OR gates are not required between stages and \overline{TC} is connected directly to the CP input of the next stage with \overline{CE} grounded.



Notes to Fig. 14

Count-up mode: illegal states in BCD counters corrected in one count.
Count-down mode: illegal states in BCD counters corrected in one or two counts.

Fig. 14 State diagrams.



Note to Fig. 15

Use the following formulae to calculate N_{total} :

$$N_{total} = \left(\prod_{i=1}^n (10 \times N_i) \right) + N_0$$

$$f_{out} = \frac{f_{in}}{N_{total}}$$

Formulae are only applicable if legal data is provided to the parallel inputs.

parallel inputs				count-up n	count-down n
D ₃	D ₂	D ₁	D ₀		
0	0	0	0	9	*
0	0	0	1	8	1
0	0	1	0	7	2
0	0	1	1	6	3
0	1	0	0	5	4
0	1	0	1	4	5
0	1	1	0	3	6
0	1	1	1	2	7
1	0	0	0	1	8
1	0	0	1	*	9

* no count; f_{out} is HIGH