Signetics

54F193
Counter

Synchronous Presettable 4-Bit Binary Down Counter

Product Specification

Military FAST Products

FEATURES

- **Synchronous reversible 4-bit binary counting**
- **Asynchronous parallel load**
- **Asynchronous reset (clear)**
- **Expandable without external logic**

DESCRIPTION

The 54F193 is a 4-bit synchronous up/down counter in the binary mode. Separate up/down clocks, CP_U and CP_D respectively, simplify operation. The outputs change state synchronously with the Low-to-High transition of either Clock input. If the CP_U clock is pulsed while CP_D is held High, the device will count up ... if CP_D is pulsed while CP_U is held High, the device will count down. Only one Clock input can be held High at any time, or erroneous operation will result. The device can be cleared at any time by the asynchronous reset pin — it may also be loaded in parallel by activating the asynchronous parallel load pin.

ORDERING INFORMATION

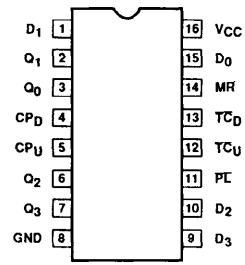
DESCRIPTION	ORDER CODE
Ceramic DIP	54F193/BEA
Ceramic Flat Pack	54F193/BFA
20-Pin Ceramic LLCC	54F193/B2A

INPUT AND OUTPUT LOADING AND FAN-OUT TABLE

PINS	DESCRIPTION	54F(U.L.) HIGH/LOW	LOAD VALUE HIGH/LOW
CP_U	Count up clock input (active rising edge)	1.0/2.0	20µA/1.2mA
CP_D	Count down clock input (active rising edge)	1.0/2.0	20µA/1.2mA
MR	Asynchronous master reset input (active High)	1.0/1.0	20µA/0.6mA
$\overline{PL}$	Asynchronous parallel load input (active Low)	1.0/1.0	20µA/0.6mA
D_0 - D_3	Parallel data inputs	1.0/1.0	20µA/0.6mA
Q_0 - Q_3	Flip-flop outputs	50/33	1.0mA/20mA
$\overline{TC}_D$	Terminal count down (borrow) output (active Low)	50/33	1.0mA/20mA
$\overline{TC}_U$	Terminal count up (carry) output (active Low)	50/33	1.0mA/20mA

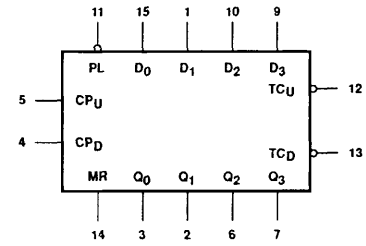
NOTE: One (1.0) FAST Unit Load (U.L.) is defined as: 20µA in the High state and 0.6mA in the Low state.

PIN CONFIGURATION



For LLCC pin assignments, see JEDEC Standard No. 2

LOGIC SYMBOL



VCC = Pin 16
GND = Pin 8

For LLCC pin assignments, see JEDEC Standard No. 2

Counter | 54F193

Inside the device are four master-slave JK flip-flops with the necessary steering logic to provide the asynchronous reset, load, and synchronous count up and count down functions.

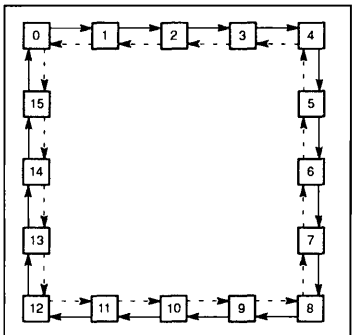
Each flip-flop contains JK feedback from slave to master, such that a Low-to-High transition on the CP_D input will decrease the count by one, while a similar transition on the CP_U input will advance the count by one.

One clock should be held High while counting with the other, because the circuit will either count by twos or not at all, depending on the state of the first flip-flop, which cannot toggle as long as either Clock input is Low. Applications requiring reversible operation must make the reversing decision while the activating clock is High to avoid erroneous counts.

The Terminal Count Up ($\overline{TC}_U$) and Terminal Count Down ($\overline{TC}_D$) outputs are normally High. When the circuit has reached the maximum count state of 15, the next High-to-Low transition of CP_U will cause $\overline{TC}_U$ to go Low. $\overline{TC}_U$ will stay Low until CP_U goes High again, duplicating the count up clock, although delayed by two gate delays. Likewise, the $\overline{TC}_D$ output will go Low when the circuit is in the zero state and the CP_D goes Low. The $\overline{TC}$ 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 two-gate 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 (D_0 - D_3) is loaded into the counter and appears on the outputs regardless of the conditions of the Clock inputs when the Parallel Load ($\overline{PL}$) 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 Q outputs 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.

STATE DIAGRAM

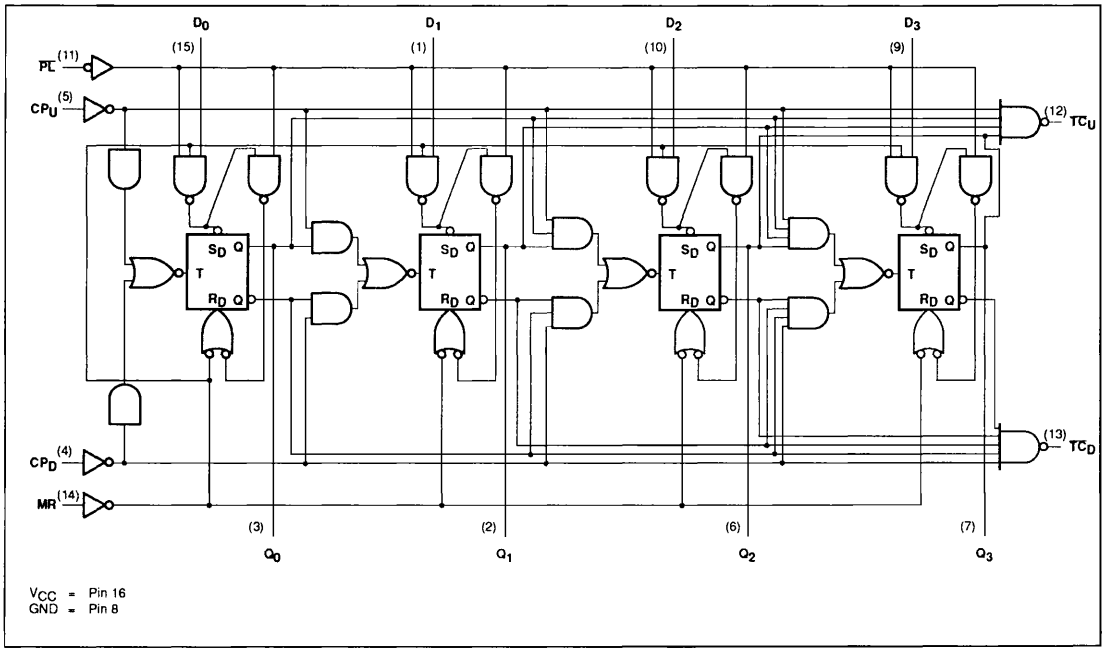


$\overline{TC}_U = Q_0 \cdot Q_1 \cdot Q_2 \cdot Q_3 \cdot \overline{CP}_U$

$\overline{TC}_D = \overline{Q}_0 \cdot \overline{Q}_1 \cdot \overline{Q}_2 \cdot \overline{Q}_3 \cdot \overline{CP}_D$

Logic Equations for Terminal Count

LOGIC DIAGRAM



MODE SELECT — FUNCTION TABLE

OPERATING MODE	INPUTS								OUTPUTS					
	$\overline{MR}$	$\overline{PL}$	CP_U	CP_D	D_0	D_1	D_2	D_3	Q_0	Q_1	Q_2	Q_3	$\overline{TC_U}$	$\overline{TC_D}$
Reset (clear)	H	X	X	L	X	X	X	X	L	L	L	L	H	L
	H	X	X	H	X	X	X	X	L	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	L	L	L	H	H
	L	L	L	X	H	H	H	H	H	H	H	H	L	H
	L	L	H	X	H	H	H	H	H	H	H	H	H	H
Count up	L	H	↑	H	X	X	X	X	Count up				$H^{(1)}$	H
Count down	L	H	H	↑	X	X	X	X	Count down				H	$H^{(2)}$

H = High voltage level
L = Low voltage level
X = Don't care
↑ = Low-to-High clock transition

NOTES:
1. TC_U = CP_U at terminal count up (HHHH).
2. TC_D = CP_D at terminal count down (LLLL).

ABSOLUTE MAXIMUM RATINGS

(Operation beyond the limits set forth in this table may impair the useful life of the device. Unless otherwise noted these limits are over the operating free-air temperature range.)

SYMBOL	PARAMETER	RATING	UNIT
V_{CC}	Supply voltage range	-0.5 to +7.0	V
V_I	Input voltage range	-0.5 to +7.0	V
I_I	Input current range	-30 to +5.0	mA
V_O	Voltage applied to output in High output state range	-0.5 to +V_{CC}	V
I_O	Current applied to output in Low output state	40	mA
T_{STG}	Storage temperature range	-65 to +150	°C

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	LIMITS			UNIT
		Min	Nom	Max	
V_{CC}	Supply voltage	4.5	5.0	5.5	V
V_{IH}	High-level input voltage	2.0			V
V_{IL}	Low-level input voltage			0.8	V
I_{IK}	Input clamp current			-18	mA
I_{OH}	High-level output current			-1	mA
I_{OL}	Low-level output current			20	mA
T_A	Operating free-air temperature range	-55		+125	°C

DC ELECTRICAL CHARACTERISTICS (Over recommended operating free-air temperature range unless otherwise noted.)

SYMBOL	PARAMETER	TEST CONDITIONS[1]		LIMITS			UNIT
				Min	Typ[2]	Max	
V_{OH}	High-level output voltage	V_{CC} = Min, V_{IL} = Max, I_{OH} = Max, V_{IH} = Min		2.5			V
V_{OL}	Low-level output voltage	V_{CC} = Min, V_{IL} = Max, I_{OL} = Max, V_{IH} = Min			.35	.5	V
V_{IK}	Input clamp voltage	V_{CC} = Min, I_I = I_{IK}			-0.73	-1.2	V
I_{IH2}	Input current at maximum input voltage	V_{CC} = Max, V_I = 7.0V				100	µA
I_{IH1}	High-level input current	V_{CC} = Max, V_I = 2.7V			1	20	µA
I_{IL}	Low-level input current	V_{CC} = Max, V_I = 0.5V	CP_U, CP_D			-1.8	mA
			Other inputs		-0.4	-0.6	mA
I_{OS}	Short-circuit output current[3]	V_{CC} = Max		-60		-150	mA
I_{CC}	Supply current[4] (total)	V_{CC} = Max			32	50	mA

AC ELECTRICAL CHARACTERISTICS (When measured in accordance with the procedures outlined in Signetics LOGIC App Note 202 "Testing and Specifying FAST Logic.")

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS					UNIT
			T_A = +25°C, V_{CC} = +5.0V, C_L = 50pF, R_L = 500Ω			T_A = -55°C to +125°C, V_{CC} = +5.0V ± 10%, C_L = 50pF, R_L = 500Ω		
			Min	Typ	Max	Min	Max	
f_{MAX}	Maximum clock frequency	Waveform 1	100	125		90		MHz
t_{PLH} t_{PHL}	Propagation delay CP_U or CP_D to $\overline{TC_U}$ or $\overline{TC_D}$	Waveform 2	2.5 3.0	5.5 5.0	8.5 8.0	2.5 3.0	9.0 9.0	ns ns
t_{PLH} t_{PHL}	Propagation delay CP_U or CP_D to Q_n	Waveform 1	2.5 5.0	5.5 8.5	8.5 12.0	3.0 6.0	9.0 13.0	ns ns
t_{PLH} t_{PHL}	Propagation delay D_n to Q_n	Waveform 4	2.0 6.0	4.0 9.5	7.0 13.5	1.5 6.0	7.5 15.0	ns ns
t_{PLH} t_{PHL}	Propagation delay $\overline{PL}$ to Q_n	Waveform 3	4.5 5.5	6.5 8.5	10.0 12.0	4.0 5.0	11.0 13.0	ns ns
t_{PHL}	Propagation delay MR to Q_n	Waveform 5	5.0	7.5	11.0	5.5	12.5	ns
t_{PLH}	Propagation delay MR to $\overline{TC_U}$	Waveform 5	6.0	8.5	12.0	5.5	12.5	ns
t_{PHL}	Propagation delay MR to $\overline{TC_D}$	Waveform 5	5.0	7.5	11.0	5.0	11.0	ns
t_{PLH} t_{PHL}	Propagation delay $\overline{PL}$ to $\overline{TC_U}$ or $\overline{TC_D}$	Waveform 3	6.0 6.0	9.5 9.0	13.5 12.0	6.0 6.0	15.0 13.0	ns ns
t_{PLH} t_{PHL}	Propagation delay D_n to $\overline{TC_U}$ or $\overline{TC_D}$	Waveform 4	5.5 4.5	9.0 8.5	13.0 12.5	5.0 4.5	14.0 13.5	ns ns

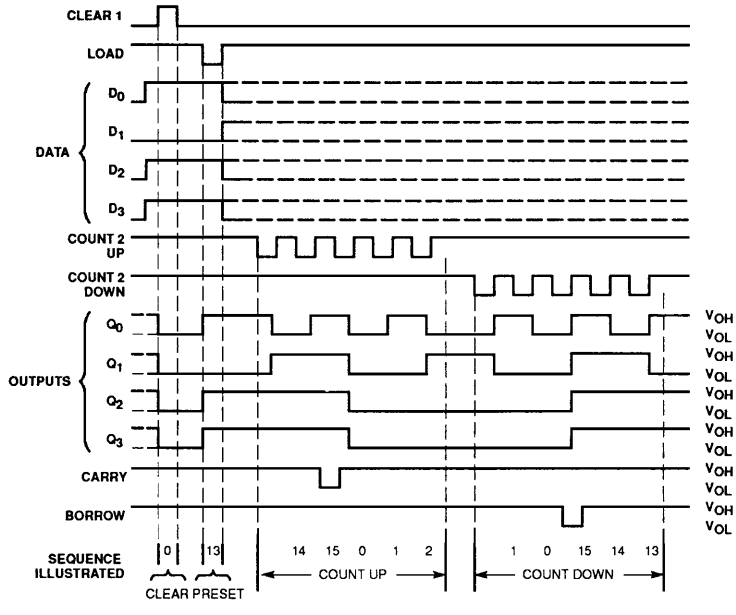
AC SETUP REQUIREMENTS

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS					UNIT
			T_A = +25°C V_{CC} = +5.0V C_L = 50pF, R_L = 500Ω			T_A = -55°C to +125°C V_{CC} = +5.0V ± 10% C_L = 50pF, R_L = 500Ω		
			Min	Typ	Max	Min	Max	
$t_s(H)$ $t_s(L)$	Setup time, High or Low D_n to $\overline{PL}$	Waveform 6	4.5 4.5			5.0 5.0		ns ns
$t_h(H)$ $t_h(L)$	Hold time, High or Low D_n to $\overline{PL}$	Waveform 6	2.0 2.0			2.0 2.0		ns ns
$t_w(L)$	$\overline{PL}$ Pulse width Low	Waveform 1	6.0			6.0		ns
$t_w(H)$ $t_w(L)$	CP_U or CP_D Pulse width High or Low	Waveform 1	3.5 5.0			3.5 5.0		ns ns
$t_w(L)$	CP_U or CP_D Pulse width Low (Change of direction)	Waveform 1	10.0			10.0		ns
$t_w(H)$	MR Pulse width High	Waveform 5	6.0			6.0		ns
t_{rec}	Recovery time, $\overline{PL}$ to CP_U or CP_D	Waveform 3	6.0			8.0		ns
t_{rec}	Recovery time MR to CP_U or CP_D	Waveform 5	4.0			4.0		ns

NOTES:

1. For conditions shown as Min or Max, use the appropriate value specified under recommended operating conditions for the applicable type and function table for operating mode.
2. All typical values are at V_{CC} = 5V, T_A = 25°C.
3. Not more than one output should be shorted at a time. For testing I_{OS}, the use of high-speed test apparatus and/or sample-and-hold techniques are preferable in order to minimize internal heating and more accurately reflect operational values. Otherwise, prolonged shorting of a High output may raise the chip temperature well above normal and thereby cause invalid readings in other parameter tests. In any sequence of parameter tests, I_{OS} tests should be performed last.
4. Measure I_{CCH} with parallel load and Master Reset inputs grounded, all other inputs at 4.5V and all outputs open.

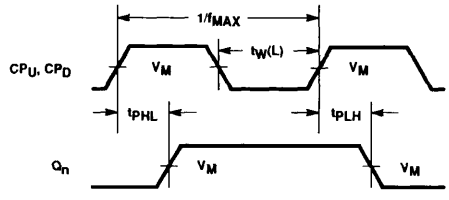
FUNCTIONAL WAVEFORM (Typical clear, load, and count sequences)



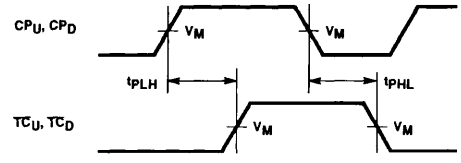
NOTES:
1. Clear overrides load, data, and count inputs.
2. When counting up, count-down input must be High; when counting down, count-up input must be High.

Binary Counter

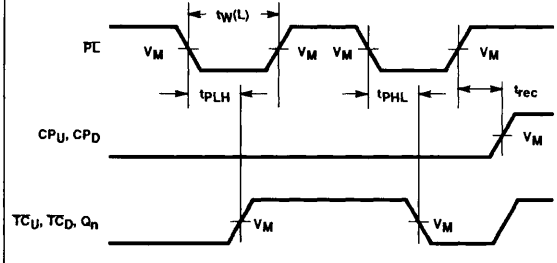
AC WAVEFORMS



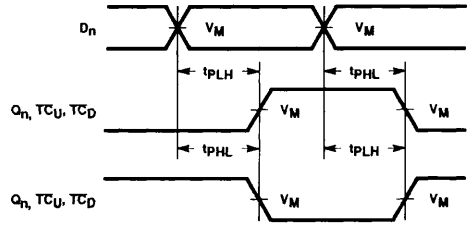
Waveform 1. Propagation Delay, Clock Input to Output, Clock Width and Maximum Clock



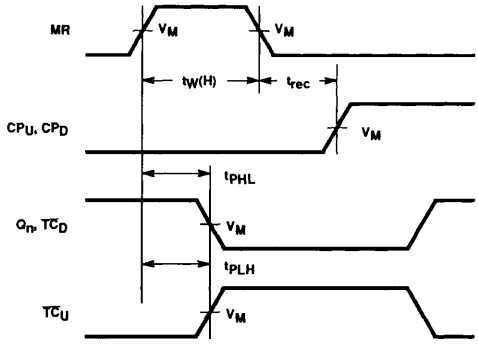
Waveform 2. Propagation Delay, Clock Pulse to Terminal Count



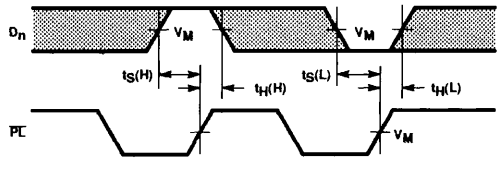
Waveform 3. Parallel Load Pulse Width, Parallel Load to Output Delays, and Parallel Load to Clock Recovery Time



Waveform 4. Propagation Delay, Data to Flip-Flop Outputs, Terminal Count Up and Down Outputs



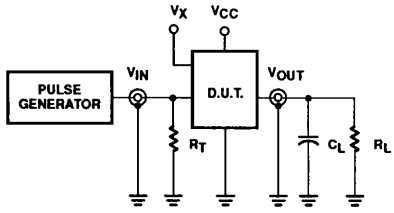
Waveform 5. Master Reset Pulse Width, Master Reset to Output Delay and Master Reset to Clock Recovery



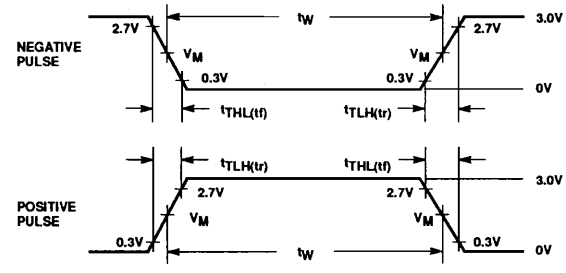
Waveform 6. Setup Time and Hold Time for D_n to $\overline{PL}$

$V_M = 1.5V$

TEST CIRCUIT AND WAVEFORMS



Test Circuit for Totem-Pole Outputs



Input Pulse Definition

DEFINITIONS:

R_L = Load Resistor; see AC Characteristics for value.
C_L = Load capacitance includes jig and probe capacitance; see AC Characteristics for value.
R_T = Termination resistance should be equal to Z_{OUT} of pulse generators.
V_X = Unclocked pins must be held at: ≤0.8V; ≥2.7V or open per FunctionTable.

INPUT PULSE CHARACTERISTICS				
Family	**Rep. Rate**	**Pulse Width**	**t_{TLH}**	**t_{THL}**
54F	1MHz	500ns	≤2.5ns	≤2.5ns