DATA SHEET

~~74F168~~*, 74F169

4-bit up/down binary synchronous counter

** Discontinued part. Please see the Discontinued Product List in Section 1, page 21.*

Product specification

IC15 Data Handbook

1996 Jan 05

Philips
Semiconductors

PHILIPS

4-bit up/down binary synchronous counter 74F169

FEATURES

- Synchronous counting and loading
- Up/Down counting
- Modulo 16 binary counter
- Two Count Enable inputs for n-bit cascading
- Positive edge-triggered clock
- Built-in carry look-ahead capability
- Presettable for programmable operation

DESCRIPTION

The 74F169 is a 4-bit synchronous, presettable Modulo 16 up/down counter featuring an internal carry look-ahead for applications in high-speed counting designs. Synchronous operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincident with each other when instructed by the Count Enable inputs and internal gating. This mode of operation eliminates the output spikes which are normally associated with asynchronous (ripple clock) counters. A buffered clock input triggers the flip-flops on the Low-to-High transition of the clock.

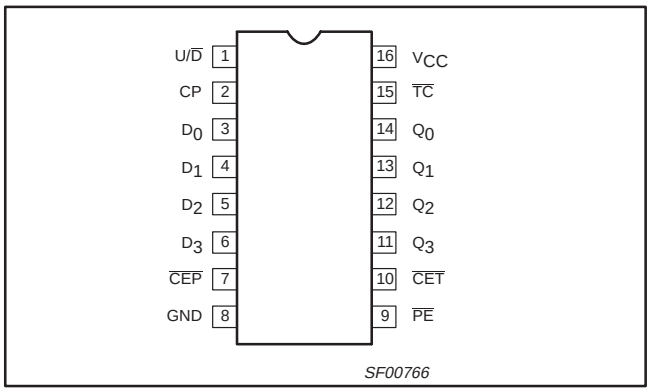
The counter is fully programmable; that is, the outputs may be preset to either level.

Presetting is synchronous with the clock and takes place regardless of the levels of the Count Enable inputs. A Low level on the Parallel Enable ($\overline{PE}$) input disables the counter and causes the data at the D_n input to be loaded into the counter on the next Low-to-High transition of the clock.

The direction of counting is controlled by the Up/Down (U/$\overline{D}$) input; a High will cause the count to increase, a Low will cause the count to decrease.

The carry look-ahead circuitry provides for n-bit synchronous applications without additional gating. Instrumental in accomplishing this function are two Count Enable inputs ($\overline{CET}$, $\overline{CEP}$) and a Terminal Count ($\overline{TC}$) output. Both Count Enable inputs must be Low to count. The $\overline{CET}$ input is fed forward to enable the $\overline{TC}$ output. The $\overline{TC}$ output thus enabled will produce a Low output pulse with a duration approximately equal to the High level portion of the Q_0 output. The Low level $\overline{TC}$ pulse is used to enable successive cascaded stages.

PIN CONFIGURATION



TYPE	TYPICAL f_{MAX}	TYPICAL SUPPLY CURRENT (TOTAL)
74F169	115MHz	35mA

ORDERING INFORMATION

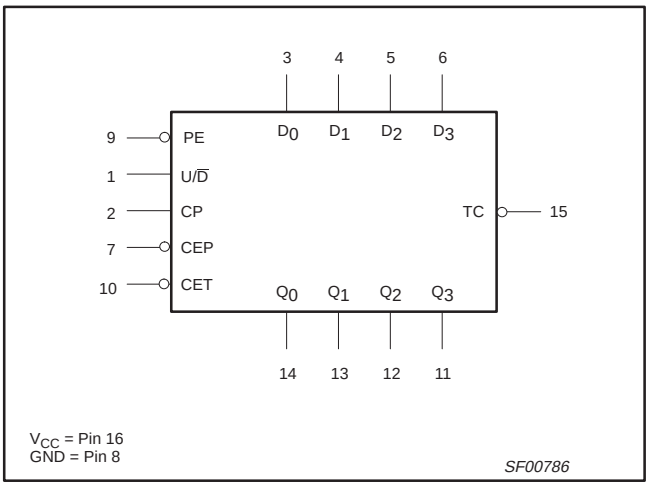
DESCRIPTION	ORDER CODE	PKG DWG #
	COMMERCIAL RANGE V_{CC} = 5V ±10%, T_{amb} = 0°C to +70°C	
16-pin plastic DIP	N74F169N	SOT38-4
16-pin plastic SO	N74F169D	SOT109-1

INPUT AND OUTPUT LOADING AND FAN-OUT TABLE

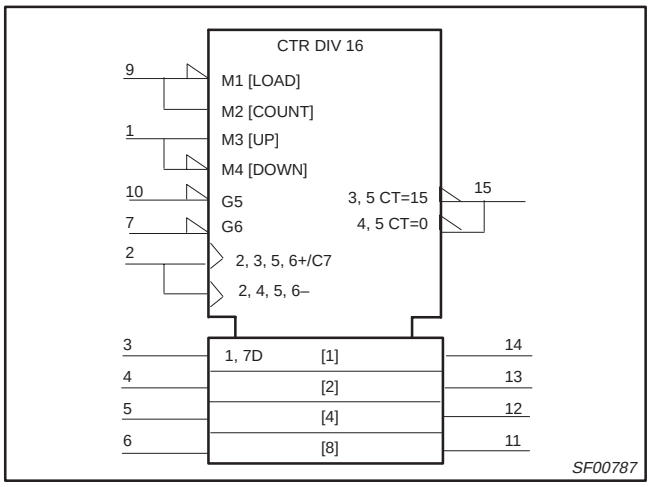
PINS	DESCRIPTION	74F(U.L.) HIGH/LOW	LOAD VALUE HIGH/LOW
D_0 - D_3	Parallel data inputs	1.0/1.0	20µA/0.6mA
$\overline{CEP}$	Count Enable parallel input (active Low)	1.0/1.0	20µA/0.6mA
$\overline{CET}$	Count Enable Trickle input (active Low)	1.0/2.0	20µA/1.2mA
CP	Clock input (active rising edge)	1.0/1.0	20µA/0.6mA
$\overline{PE}$	Parallel Enable input (active Low)	1.0/1.0	20µA/0.6mA
U/$\overline{D}$	Up/Down count control input	1.0/1.0	20µA/0.6mA
Q_0 - Q_3	Flip-flop outputs	50/33	1.0mA/20mA
$\overline{TC}$	Terminal count 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.

LOGIC SYMBOL



LOGIC SYMBOL (IEEE/IEC)



FUNCTIONAL DESCRIPTION

The 74F169 uses edge-triggered J-K-type flip-flops and have no constraints on changing the control or data input signals in either state of the clock. The only requirement is that the various inputs attain the desired state at least a setup time before the rising edge of the clock and remain valid for the recommended hold time thereafter. The parallel load operation takes precedence over the other operations, as indicated in the Mode Select Table. When $\overline{PE}$ is Low, the data on the D_0 - D_3 inputs enter the flip-flops on the next rising edge of the Clock. In order for counting to occur, both $\overline{CEP}$ and $\overline{CET}$ must be Low and $\overline{PE}$ must be High; the U/$\overline{D}$ input determines the direction of counting. The Terminal Count ($\overline{TC}$) output is normally High and goes Low, provided that $\overline{CET}$ is Low, when a counter reaches zero in the Count Down mode or reaches 15 in the Count Up mode. The $\overline{TC}$ output state is not a function of the Count Enable Parallel ($\overline{CEP}$) input level. Since the $\overline{TC}$ signal is derived by decoding the flip-flop states, there exists the possibility of decoding spikes on $\overline{TC}$. For this reason the use of $\overline{TC}$ as a clock signal is not recommended (see logic equations below).

1) Count Enable = $\overline{CEP}\cdot\overline{CET}\cdot\overline{PE}$

2) Up: $\overline{TC} = Q_0\cdot Q_3\cdot(U/\overline{D})\cdot\overline{CET}$

3) Down: $\overline{TC} = Q_0\cdot Q_1\cdot Q_2\cdot Q_3\cdot(U/\overline{D})\cdot\overline{CET}$

MODE SELECT — FUNCTION TABLE

INPUTS						OUTPUTS		OPERATING MODE
CP	U/$\overline{D}$	$\overline{CEP}$	$\overline{CET}$	$\overline{PE}$	D_n	Q_n	$\overline{TC}$	
↑	X	X	X	l	l	L	(1)	Parallel load (Dn→Qn)
↑	X	X	X	X	X	H	(1)	
↑	h	l	l	h	X	Count Up	(1)	Count Up (increment)
↑	l	l	l	h	X	Count Down	(1)	Count Down (decrement)
↑	X	h	X	h	X	q_n	(1)	Hold (do nothing)
↑	X	X	X	h	X	q_n	H	

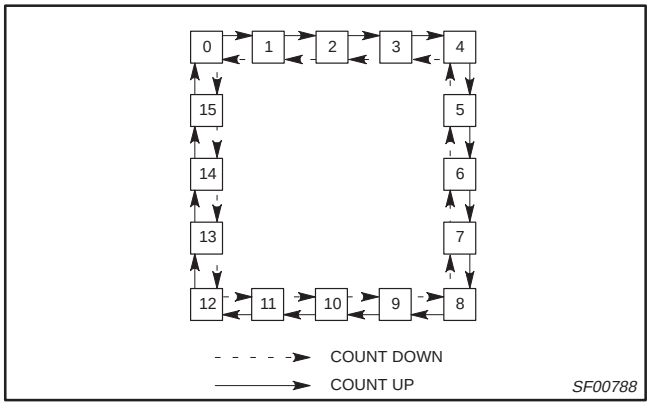
H = High voltage level steady state
h = High voltage level one setup time prior to the Low-to-High clock transition
L = Low voltage level steady state
l = Low voltage level one setup time prior to the Low-to-High clock transition
q = Lower case letters indicate the state of the referenced output prior to the Low-to-High clock transition
X = Don't care
↑ = Low-to-High clock transition
(1) = The $\overline{TC}$ is Low when $\overline{CET}$ is Low and the counter is at Terminal Count. Terminal Count Up is (HHHH) and Terminal Count Down is (LLLL).

MODE SELECT TABLE

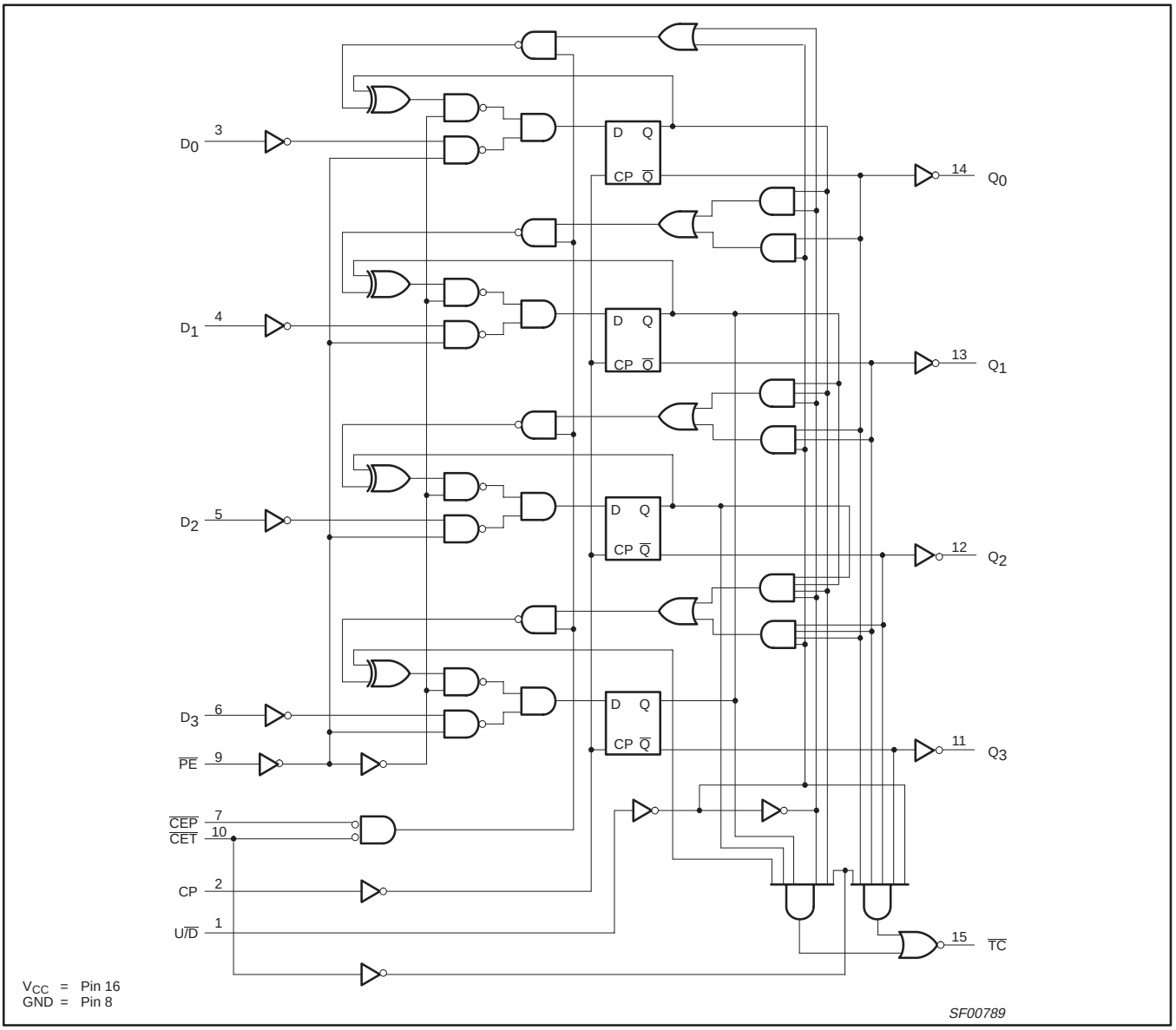
INPUTS				OPERATING MODE
$\overline{PE}$	$\overline{CEP}$	$\overline{CET}$	U/$\overline{D}$	
L	X	X	X	Load ($D_n \rightarrow Q_n$)
H	L	L	H	Count Up (Increment)
H	L	L	L	Count Down (Decrement)
H	H	X	X	No Change (Hold)
H	X	H	X	No Change (Hold)

H = High Voltage
L = Low Voltage Level
X = Don't care

STATE DIAGRAM



LOGIC DIAGRAM



APPLICATION

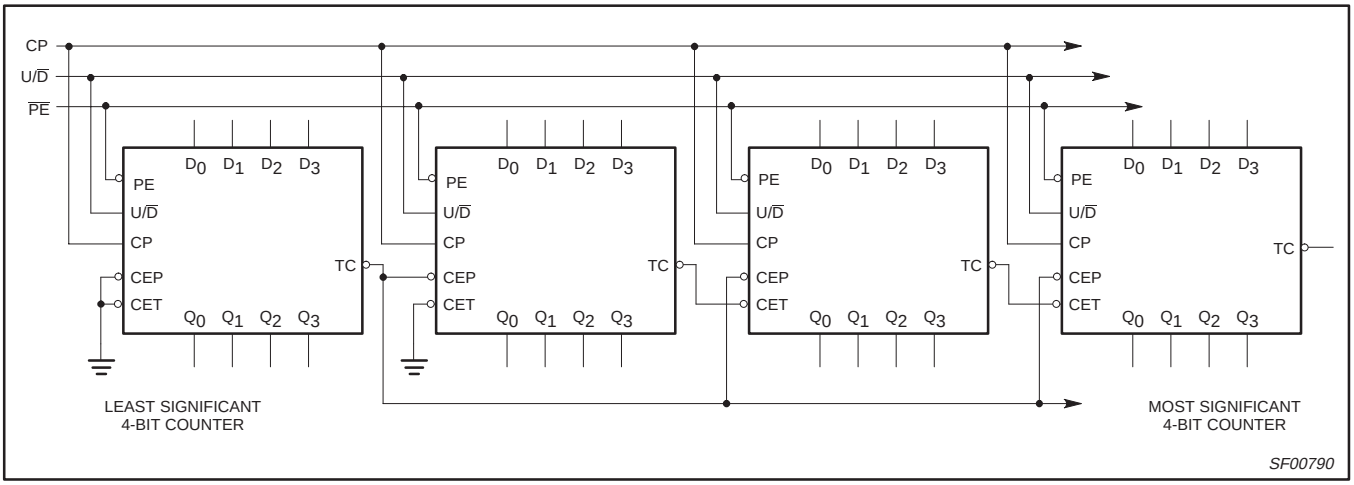


Figure 1. Synchronous Multistage Counting Scheme

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	–0.5 to +7.0	V
V_{IN}	Input voltage	–0.5 to +7.0	V
I_{IN}	Input current	–30 to +5	mA
V_{OUT}	Voltage applied to output in High output state	–0.5 to +V_{CC}	V
I_{OUT}	Current applied to output in Low output state	40	mA
T_{amb}	Operating free-air temperature range	0 to +70	°C
T_{STG}	Storage temperature	–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_{amb}	Operating free-air temperature range	0		70	°C

DC ELECTRICAL CHARACTERISTICS

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

SYMBOL	PARAMETER		TEST CONDITIONS[NO TAG]		LIMITS			UNIT
					MIN	TYP [NO TAG]	MAX	
V_{OH}	High-level output voltage		V_{CC} = MIN, V_{IL} = MAX, V_{IH} = MIN, I_{OH} = MAX	$\pm$10%V_{CC}	2.5			V
				$\pm$5%V_{CC}	2.7	3.4		V
V_{OL}	Low-level output voltage		V_{CC} = MIN, V_{IL} = MAX, V_{IH} = MIN, I_{OL} = MAX	$\pm$10%V_{CC}		0.35	0.50	V
				$\pm$5%V_{CC}		0.35	0.50	V
V_{IK}	Input clamp voltage		V_{CC} = MIN, I_I = I_{IK}			–0.73	–1.2	V
I_I	Input current at maximum input voltage		V_{CC} = MAX, V_I = 7.0V				100	µA
I_{IH}	High-level input current		V_{CC} = MAX, V_I = 2.7V				20	µA
I_{IL}	Low-level input current	$\overline{CET}$	V_{CC} = MAX, V_I = 0.5V				–1.2	mA
		Others	V_{CC} = MAX, V_I = 0.5V				–0.6	mA
I_{OS}	Short-circuit output current[NO TAG]		V_{CC} = MAX		–60		–150	mA
I_{CC}	Supply current (total)[4]		V_{CC} = MAX			35	52	mA

NOTES:

1. For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions for the applicable type.
2. All typical values are at V_{CC} = 5V, T_{amb} = 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. I_{CC} is measured after applying a momentary 4.5V, then ground to the clock input with all other inputs grounded and all outputs open.

AC ELECTRICAL CHARACTERISTICS

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS					UNIT
			T_{amb} = +25°C V_{CC} = +5V C_L = 50pF, R_L = 500Ω			T_{amb} = 0°C to +70°C V_{CC} = +5V ± 10% C_L = 50pF, R_L = 500Ω		
			MIN	TYP	MAX	MIN	MAX	
f_{MAX}	Maximum clock frequency	Waveform 1	100	115		90		MHz
t_{PLH} t_{PHL}	Propagation delay CP to Q_n ($\overline{PE}$, High or Low)	Waveform 1	3.0 4.0	6.5 9.0	8.5 11.5	3.0 4.0	9.5 13.0	ns ns
t_{PLH} t_{PHL}	Propagation delay CP to $\overline{TC}$	Waveform 1	5.5 4.0	12.0 8.5	15.5 11.0	5.5 4.0	17.0 12.5	ns ns
t_{PLH} t_{PHL}	Propagation delay $\overline{CET}$ to $\overline{TC}$	Waveform 2	2.5 2.5	4.5 6.0	6.0 8.0	2.5 2.5	7.0 9.0	ns ns
t_{PLH} t_{PHL}	Propagation delay U/$\overline{D}$ to $\overline{TC}$	Waveform 3	3.5 4.0	8.5 8.0	15.0 10.5	3.5 4.0	15.5 12.0	ns ns

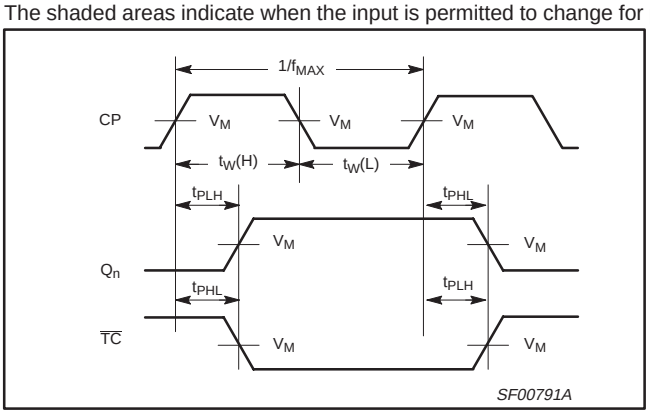
AC SETUP REQUIREMENTS

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS		LIMITS		UNIT
			T_{amb}= +25°C V_{CC} = +5.0V C_L = 50pF, R_L = 500Ω		T_{amb}= 0°C to +70°C V_{CC} = +5.0V ± 10% C_L = 50pF, R_L = 500Ω		
			MIN	TYP	MIN	MAX	
t_s(H) t_s(L)	Setup time, High or Low D_n to CP	Waveform 4	4.0 4.0		4.5 4.5		ns ns
t_h(H) t_h(L)	Hold time, High or Low D_n to CP	Waveform 4	3.0 3.0		3.5 3.5		ns ns
t_s(H) t_s(L)	Set-up time, High or Low $\overline{CEP}$ or $\overline{CET}$ to CP	Waveform 5	5.0 5.0		5.5 5.5		ns ns
t_h(H) t_h(L)	Hold time, High or Low $\overline{CEP}$ or $\overline{CET}$ to CP	Waveform 5	0 0		0 0		ns ns
t_s(H) t_s(L)	Set-up time, High or Low $\overline{PE}$ to CP	Waveform 4	8.0 8.0		9.0 9.0		ns ns
t_h(H) t_h(L)	Hold time, High or Low $\overline{PE}$ to CP	Waveform 4	0 0		0 0		ns ns
t_s(H) t_s(L)	Set-up time, High or Low U/$\overline{D}$ to CP	Waveform 6	11.0 7.0		12.5 8.0		ns ns
t_h(H) t_h(L)	Hold time, High or Low U/$\overline{D}$ to CP	Waveform 6	0 0		0 0		ns ns
t_w(H) t_w(L)	CP_U or CP_D pulse width, High or Low	Waveform 1	5.0 5.0		5.5 5.5		ns ns

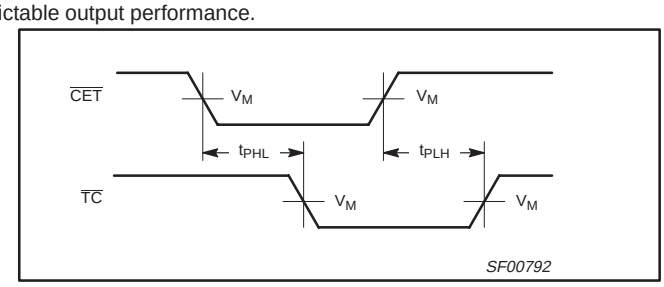
AC WAVEFORMS

For all waveforms, V_M = 1.5V

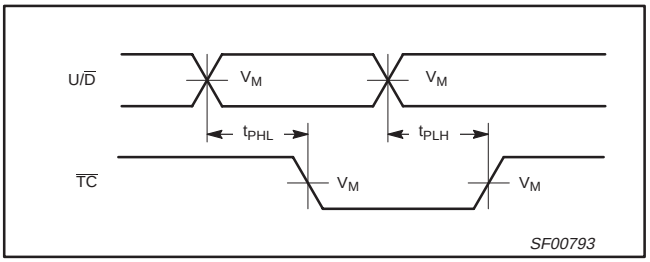
The shaded areas indicate when the input is permitted to change for predictable output performance.



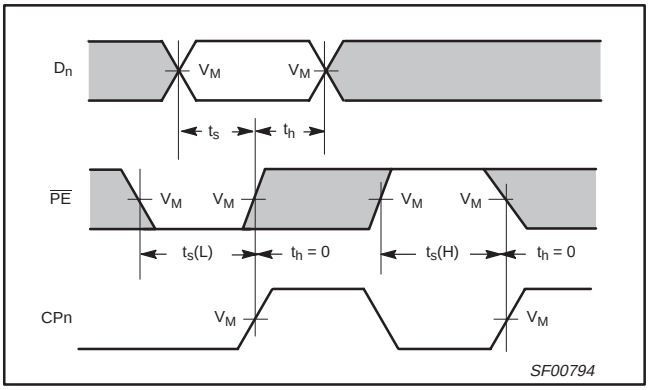
Waveform 1. Propagation Delay, Clock Input to Output, Clock Pulse Width, and Maximum Clock Frequency



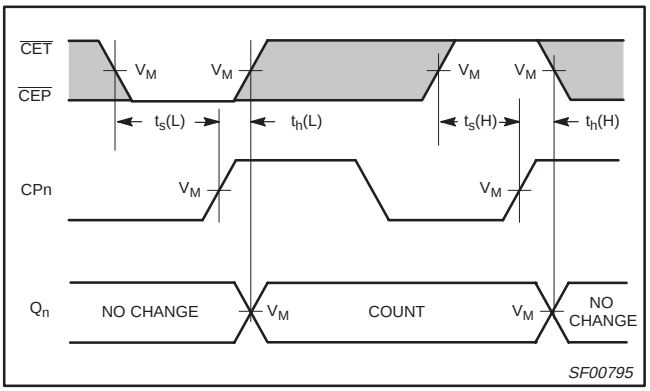
Waveform 2. Propagation Delays $\overline{CET}$ Input to Terminal Count Output



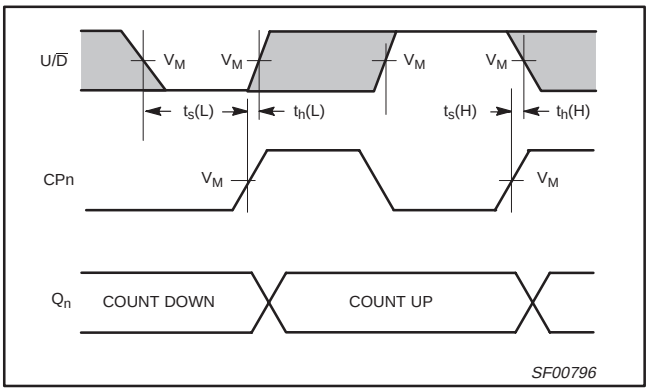
Waveform 3. Propagation Delay U/$\overline{D}$ Input to Terminal Count Output



Waveform 4. Parallel Data and Parallel Enable Setup and Hold Times

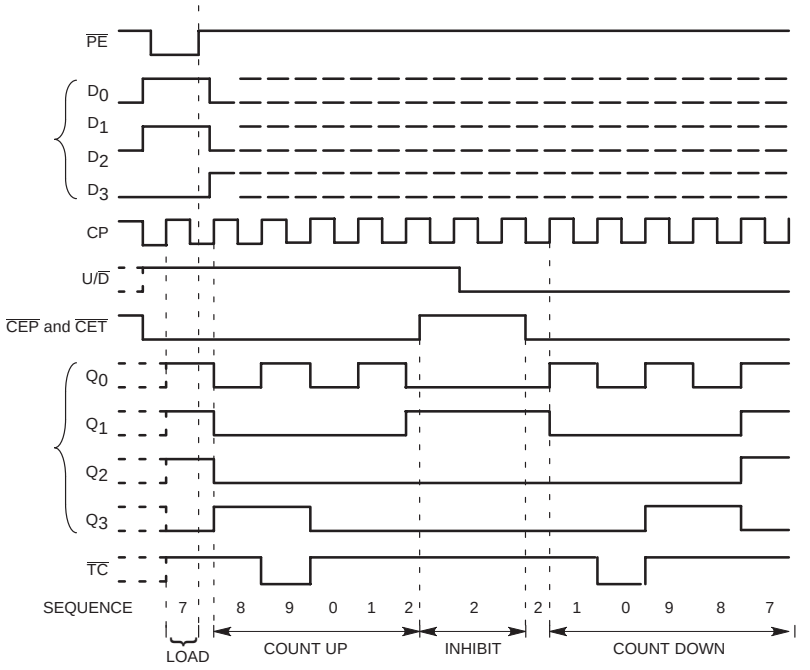


Waveform 5. Count Enable Setup and Hold Times



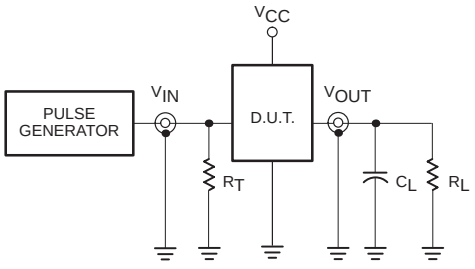
Waveform 6. Up/Down Control Setup and Hold Times

TIMING DIAGRAM (Typical Load, Count, and Inhibit Sequences)

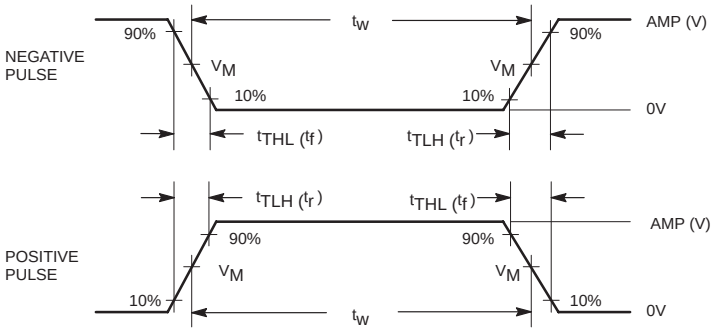


NOTES:
The operation of the 74F169 is similar to the Illustration above.
1. Load (preset) to BCD seven
2. Count up to eight, nine (maximum), zero, one, and two
3. Inhibit
4. Count down to one, zero (minimum), nine, eight, and seven

TEST CIRCUIT AND WAVEFORM



Test Circuit for Totem-Pole Outputs



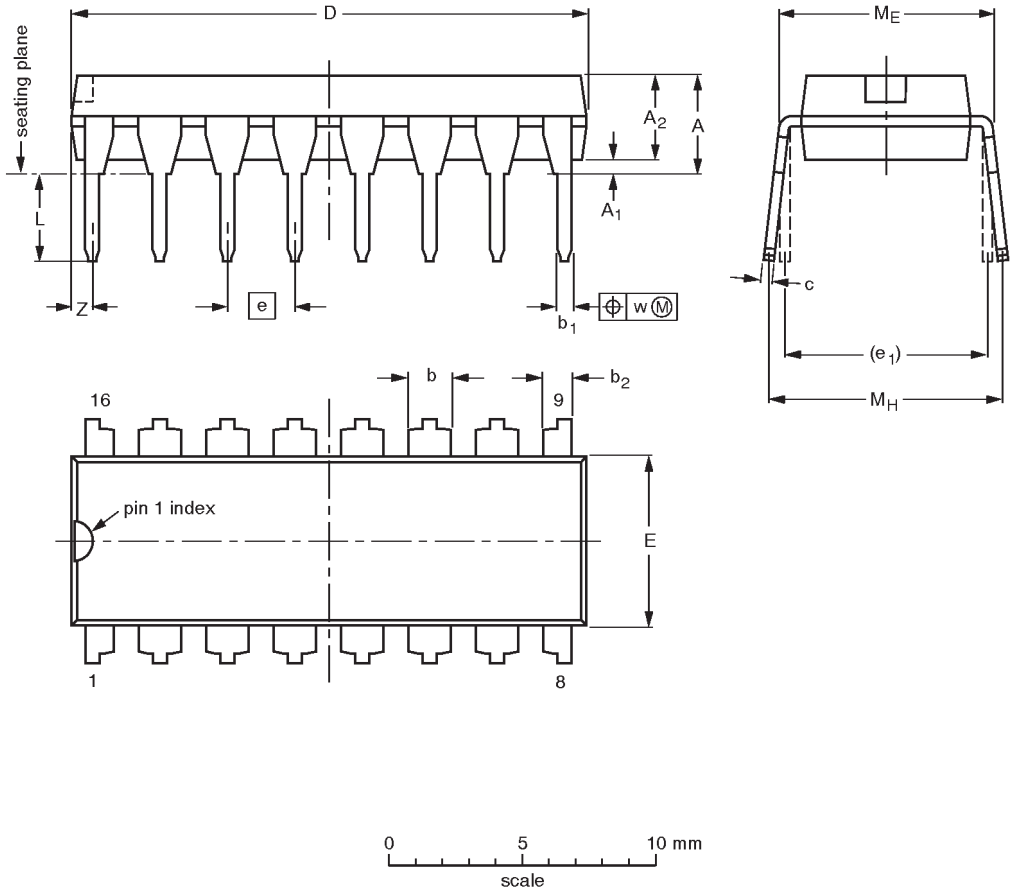
DEFINITIONS:
R_L = Load resistor;
see AC ELECTRICAL CHARACTERISTICS for value.
C_L = Load capacitance includes jig and probe capacitance;
see AC ELECTRICAL CHARACTERISTICS for value.
R_T = Termination resistance should be equal to Z_{OUT} of pulse generators.

Input Pulse Definition

family	INPUT PULSE REQUIREMENTS					
	amplitude	V_M	rep. rate	t_w	t_{TLH}	t_{THL}
74F	3.0V	1.5V	1MHz	500ns	2.5ns	2.5ns

SF00006

DIP16: plastic dual in-line package; 16 leads (300 mil) **SOT38-4**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1 min.	A_2 max.	b	b_1	b_2	c	D (1)	E (1)	e	e_1	L	M_E	M_H	w	Z (1) max.
mm	4.2	0.51	3.2	1.73 1.30	0.53 0.38	1.25 0.85	0.36 0.23	19.50 18.55	6.48 6.20	2.54	7.62	3.60 3.05	8.25 7.80	10.0 8.3	0.254	0.76
inches	0.17	0.020	0.13	0.068 0.051	0.021 0.015	0.049 0.033	0.014 0.009	0.77 0.73	0.26 0.24	0.10	0.30	0.14 0.12	0.32 0.31	0.39 0.33	0.01	0.030

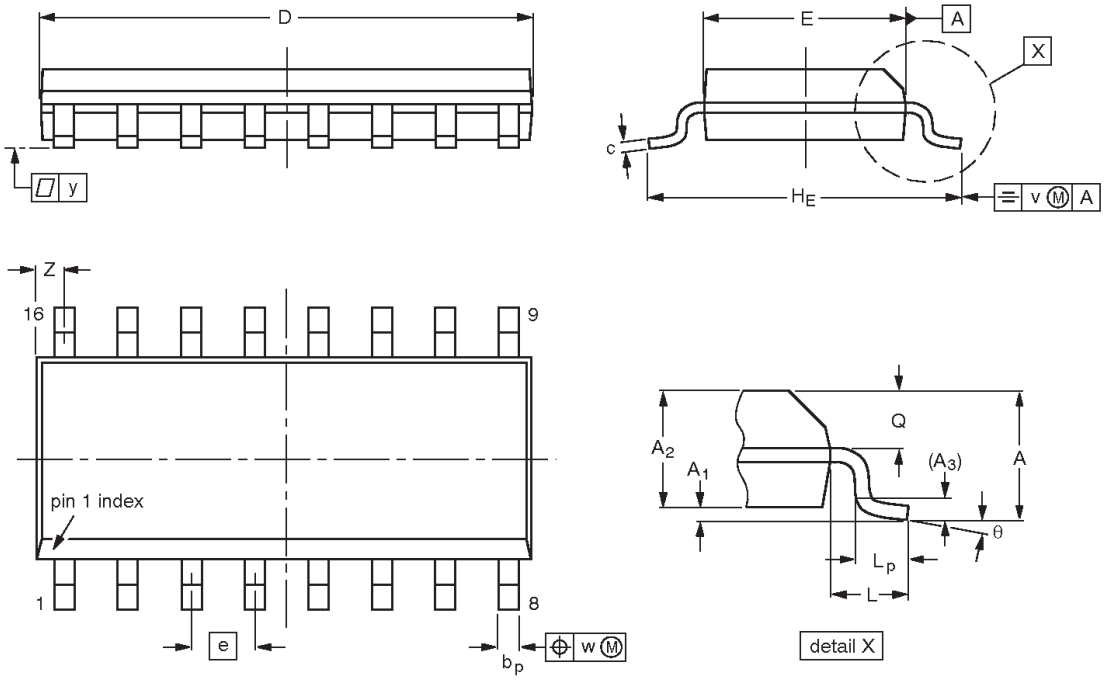
Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT38-4						~~92-11-17~~ 95-01-14

** Discontinued part. Please see the Discontinued Product List in Section 1, page 21.*

SO16: plastic small outline package; 16 leads; body width 3.9 mm **SOT109-1**



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

UNIT	A max.	A_1	A_2	A_3	b_p	c	$D^{(1)}$	$E^{(1)}$	e	H_E	L	L_p	Q	v	w	y	$Z^{(1)}$	θ
mm	1.75	0.25 0.10	1.45 1.25	0.25	0.49 0.36	0.25 0.19	10.0 9.8	4.0 3.8	1.27	6.2 5.8	1.05	1.0 0.4	0.7 0.6	0.25	0.25	0.1	0.7 0.3	8^o 0^o
inches	0.069	0.010 0.004	0.057 0.049	0.01	0.019 0.014	0.0100 0.0075	0.39 0.38	0.16 0.15	0.050	0.244 0.228	0.041	0.039 0.016	0.028 0.020	0.01	0.01	0.004	0.028 0.012	

Note

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

OUTLINE VERSION	REFERENCES				EUROPEAN PROJECTION	ISSUE DATE
	IEC	JEDEC	EIAJ			
SOT109-1	076E07S	MS-012AC				~~95-01-23~~ 97-05-22

** Discontinued part. Please see the Discontinued Product List in Section 1, page 21.*

DEFINITIONS

Data Sheet Identification	Product Status	Definition
Objective Specification	**Formative or in Design**	This data sheet contains the design target or goal specifications for product development. Specifications may change in any manner without notice.
Preliminary Specification	**Preproduction Product**	This data sheet contains preliminary data, and supplementary data will be published at a later date. Philips Semiconductors reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.
Product Specification	**Full Production**	This data sheet contains Final Specifications. Philips Semiconductors reserves the right to make changes at any time without notice, in order to improve design and supply the best possible product.

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(print code) Date of release: July 1994

Document order number: 9397-750-05087

** Discontinued part. Please see the Discontinued Product List in Section 1, page 21.*