DATA SHEET

PLS168
Field programmable logic sequencer (12 x 48 x 8)

Product specification

1995 Jan 5

Military and Special Products Data Handbook

Philips Semiconductors

PHILIPS

Field programmable logic sequencer (12 x 48 x 8) PLS168

FEATURES

- Field-programmable (Ni-Cr link)
- 12 True/Complement buffered inputs
- 48 programmable AND gates
- 29 programmable OR gates
- 10-bit state register
- 4-bit shared state/output register
- 4-bit output register
- Transition complement array
- Programmable asynchronous preset/output enable
- Positive edge-trigger clock
- Power-on preset to logic "1" of all registers
- Automatic logic "HOLD" state via S/R flip-flops
- On-chip test array
- Power: 600mW
- TTL compatible
- 3-State outputs
- Single +5V supply
- 300mil-wide 24-pin DIP

APPLICATIONS

- Interface protocols
- Sequence detectors
- Peripheral controllers
- Timing generators
- Sequential circuits
- Elevator controllers
- Security locking systems
- Counters
- Shift registers

DESCRIPTION

The PLS168 is a bipolar, programmable state machine of the Mealy type. It contains logic AND-OR gate arrays with user programmable connections which control the inputs of on-chip state and output registers. These consist respectively of 10 Q_p, and 4 Q_f edge-triggered, clocked S/R flip-flops, with an asynchronous preset option.

All flip-flops are unconditionally preset to "1" during power turn-on.

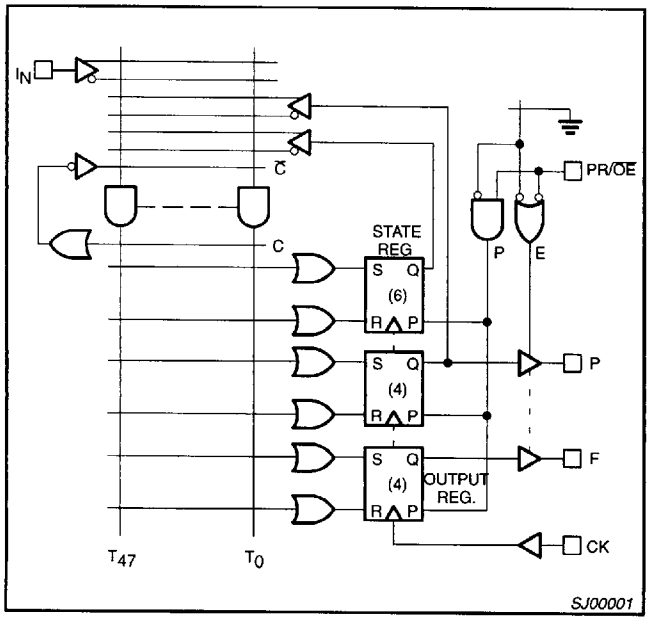
The AND array combines 12 external inputs, I_{0-11}, with 10 internal inputs, P_{0-9}, fed back from the State register to form up to 48 transition terms (AND terms). In addition, P_0-P_3 of the internal state register are brought off-chip to allow extending the output register to 8 bits, if so desired.

All transition terms can include True, False, or Don't Care states of the controlling variables, and are merged in the OR array to issue next-state and next-output commands to their respective registers on the log to high transition of the Clock pulse.

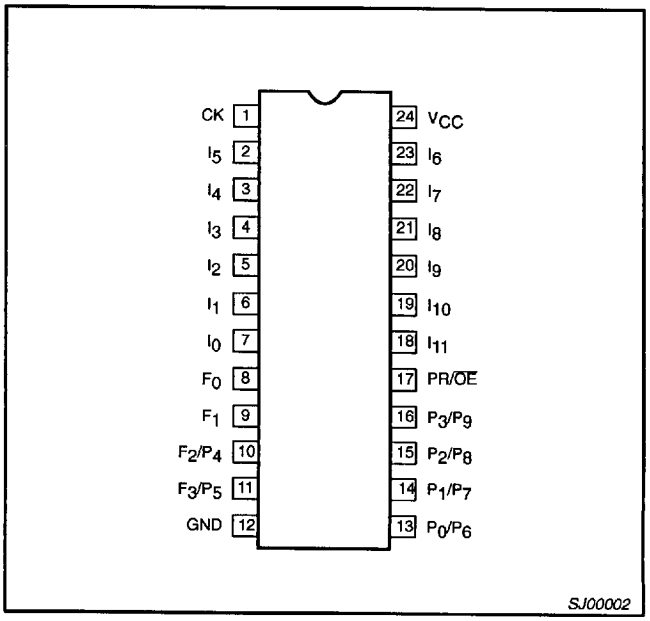
Both True and Complement transition terms can be generated by optional use of the internal variable (C) from the complement array. Also, if desired, the Preset input can be converted to output-enable function, as an additional user programmable option.

Order codes for this device are listed in the Ordering Information table.

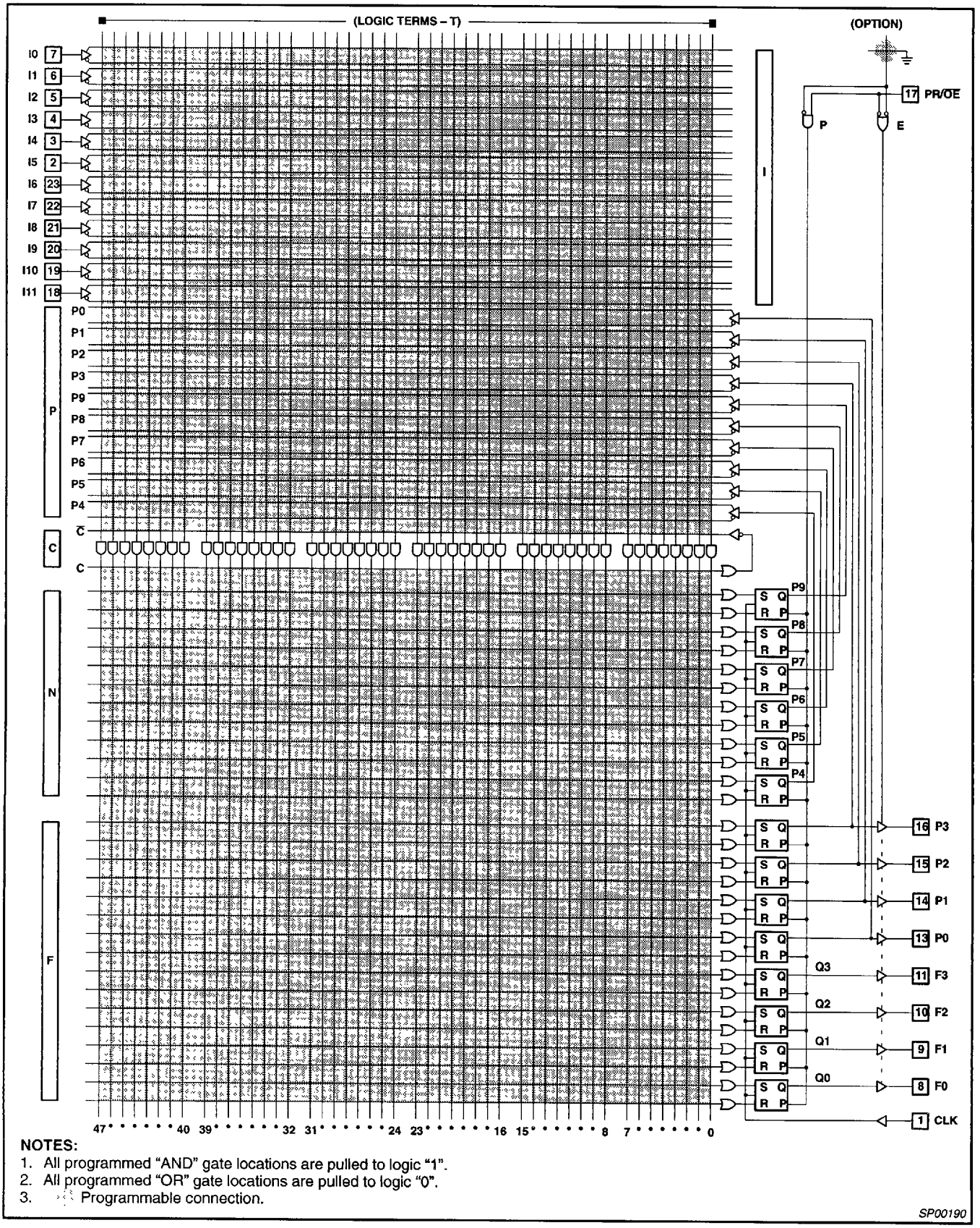
FUNCTIONAL DIAGRAM



PIN CONFIGURATION



FPLS LOGIC DIAGRAM



NOTES:

1. All programmed "AND" gate locations are pulled to logic "1".
2. All programmed "OR" gate locations are pulled to logic "0".
3. × Programmable connection.

SP00190

ORDERING INFORMATION

DESCRIPTION	ORDER CODE
24-Pin Ceramic DIP 300mil-wide	PLS168/BLA

PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION	POLARITY
1	CK	**Clock:** The Clock input to the state and output registers. A Low-to-High transition on this line is necessary to update the contents of both registers.	Active-High
2 - 7 18 - 23	I_{1-11}	**Logic Inputs:** The 11 external inputs to the AND array used to program jump conditions between machine states, as determined by a given logic sequence.	Active-High/Low
7	I_0	**Logic/Diagnostic Input:** A 12th external logic input to the AND array, as above, when exercised with standard TTL levels. When I_0 is held at +10V, device outputs F_{2-3} and P_{0-3} reflect the contents of state register bits P_{4-9} (see Diagnostic Output Mode diagram on page 7). The contents of flip-flops P_{0-1} and F_{0-3} remain unaltered.	Active-High/Low
13 - 16	P_{0-3}	**Logic/Diagnostic Outputs:** Four device outputs which normally reflect the contents of state register bits P_{0-3}. When I_0 is held at +10V these pins reflect (P_6 - P_9).	Active-High
10 - 11	F_2 - F_3	**Logic/Diagnostic Outputs:** Two register bits (F_2 - F_3) which normally reflect output register bits (Q_2 - Q_3). When I_0 is held at +10V these pins reflect (P_4 - P_5).	Active-High
17	PR/$\overline{OE}$	**Preset or $\overline{\text{Output Enable}}$ Input:** A user programmable function: • **Preset:** Provides an asynchronous preset to logic "1" of all state and output register bits. Preset overrides Clock, and when held High, clocking is inhibited and P_{0-9} and F_{0-3} are High. Normal clocking resumes with the first full clock pulse following a High-to-Low clock transition, after Preset goes Low. • **$\overline{\text{Output Enable}}$:** Provides an Output Enable function to all output buffers.	Active-High (H) Active-Low (L)
8, 9	F_0 - F_1	**Logic Output:** Two device outputs which reflect output registers Q_0 - Q_1. When I_0 is held at +10V F_0 - F_1 = Logic "1".	

ABSOLUTE MAXIMUM RATINGS[1]

SYMBOL	PARAMETER	RATING		UNIT
		Min	Max	
V_{CC}	Supply voltage		+ 7	V_{DC}
V_I	Input voltage		+10.0	V_{DC}
V_O	Output voltage		+5.5	V_{DC}
I_I	Input currents	-30	+30	mA
I_O	Output currents		+100	mA
T_A	Operating Temperature range	-55	+125	°C
T_{STG}	Storage Temperature range	-65	+150	°C

DC ELECTRICAL CHARACTERISTICS $-55°C \leq T_A \leq +125°C$, $4.5V \leq V_{CC} \leq 5.5V$

SYMBOL	PARAMETER[3]	TEST CONDITIONS[3]	LIMITS[3]			UNIT
			Min	Typ[2]	Max	
Input Voltage						
V_{IH}	High	$V_{CC} = 5.5V$	2			V
V_{IL}	Low	$V_{CC} = 4.5V$			0.8	V
V_{IK}	Clamp[4]	$V_{CC} = 4.5V$, $I_I = -18mA$		-0.8	-1.2	V
Output Voltage						
		$V_{CC} = 4.5V$				
V_{OH}	High[5]	$I_{OH} = -2mA$	2.4			V
V_{OL}	Low[6]	$I_{OL} = 9.6mA$		0.35	0.5	V
Input Current						
		$V_{CC} = 5.5V$				
I_{IH}	High	$V_I = 5.5V$		<1	50	µA
I_{IL}	Low	$V_I = 0.45V$		-10	-150	µA
I_{IL}	Low (CK input)	$V_I = 0.45V$		-50	-350	µA
Output Current						
		$V_{CC} = 5.5V$				
$I_{O(OFF)}$	Hi-Z state[7]	$V_{CC} = 5.5V$		1	60	µA
		$V_O = 0.45V$		-1	-60	µA
I_{OS}	Short circuit[4,8]	$V_O = 0V$	-15		-85	mA
I_{CC}	V_{CC} supply current[9]	$V_{CC} = 5.5V$		120	185	mA
Capacitance[7, 10]						
		$V_{CC} = 5.0V$				
C_{IN}	Input	$V_I = 2.0V$		8	10	pF
C_{OUT}	Output	$V_O = 2.0V$		10	13	pF

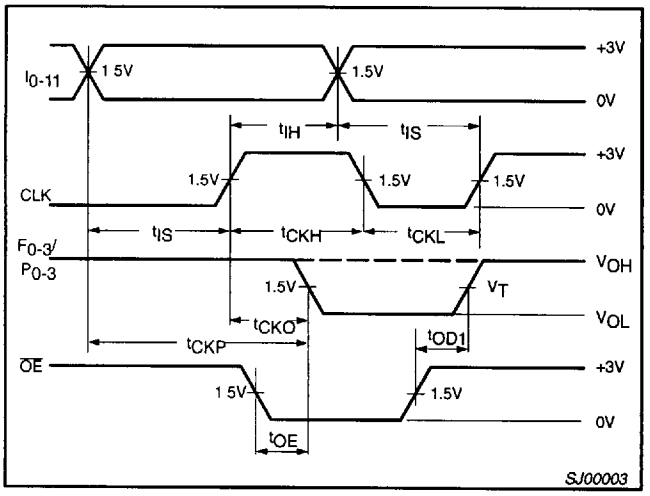
AC ELECTRICAL CHARACTERISTICS $-55°C \le T_A \le +125°C$, $4.5V \le V_{CC} \le 5.5V$

SYMBOL	PARAMETER	TO	FROM	LIMITS			UNIT
				Min	Typ[2]	Max	
Pulse Width							
t_{CKH}	Clock High[11]	CK–	CK+	40	15		ns
t_{CKL}	Clock Low	CK+	CK–	40	15		ns
t_{CKP1}	Period (w/o C-array)	CK+	CK+	95	40		ns
t_{CKP2}	Period (w/C-array)[10]	CK+	CK+	135	60		ns
t_{PRH}	Preset pulse	PR+	PR-	40	15		ns
Setup Time							
t_{IS1}	Input[13]	CK+	Input ±	60			ns
t_{IS2}	Input (through Complement array)[12, 13]	CK+	Input ±	100			ns
t_{VS}	Power-on preset[10]	CK–	V_{CC}+	5	–10		ns
t_{PRS}	Preset[10]	CK–	PR–	5	–10		ns
Hold Time							
t_{IH}	Input[10]	Input ±	CK+	10	-10		ns
Propagation Delay							
t_{CKO}	Clock	Output ±	CK+		15	35	ns
t_{OE}	Output Enable[12]	Output–	OE–		20	40	ns
t_{OD}	Output Disable[12]	Output+	OE+		20	40	ns
t_{PR}	Preset	Output+	PR+		18	45	ns
t_{PPR}	Power-on preset	Output+	V_{CC}+		0	20	ns
Frequency of Operation							
f_{MAX}	w/o C-array					10.5	MHz
$f_{MAX}{}^{C}$	w/C-array[10]					7.4	MHz

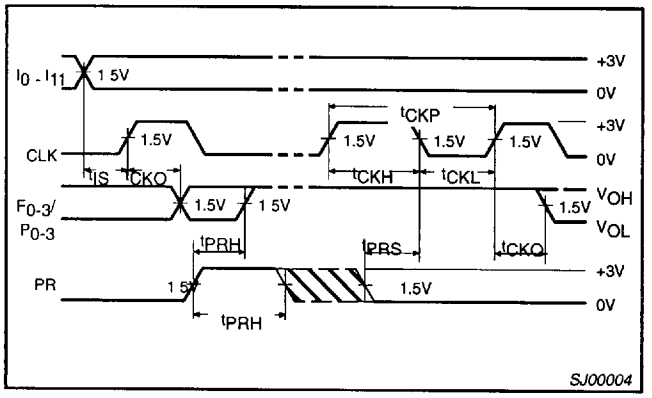
NOTES:

1. Stresses above those listed under "Absolute Maximum Ratings" may cause malfunction or permanent damage to the device. This is a stress rating only. Functional operation at these or any other conditions above those indicated in the operational and programming specification of the device is not implied.
2. All typical values are at $V_{CC} = 5V$, $T_A = +25°C$.
3. All voltage values are with respect to network ground terminal.
4. Test one at a time.
5. Measured with V_{IL} applied to $\overline{OE}$ and a logic High stored, or with V_{IH} applied to PR.
6. Measured with a programmed logic condition for which the output is at a Low logic level, and V_{IL} applied to PR/$\overline{OE}$ Output sink current is applied through a resistor to V_{CC}.
7. Measured with V_{IH} applied to PR/$\overline{OE}$.
8. Duration of short circuit should not exceed 1 second.
9. I_{CC} is measured with the PR/$\overline{OE}$ input grounded, all other inputs at 4.5V, ant the outputs open.
10. Guaranteed, but not tested.
11. To prevent spurious clocking, clock rise time (10% - 90%) ≤ 30ns.
12. Not testable on unprogrammed devices.
13. Set up time must be increased with increased number of product terms programmed. Time shown is with two product terms programmed.

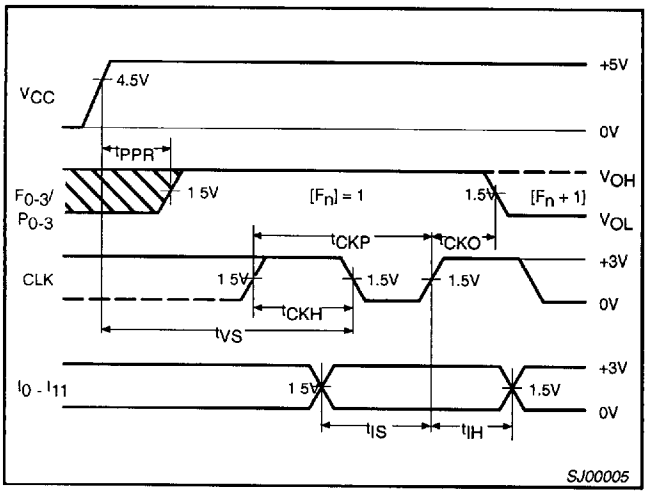
TIMING DIAGRAMS



Sequential Mode



Asynchronous mode

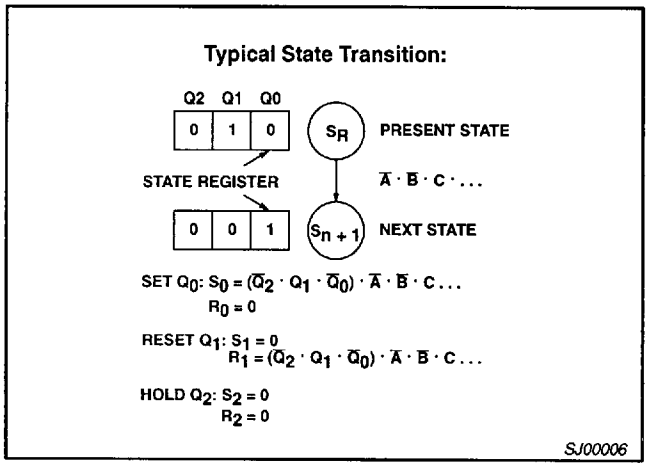


Power-On Preset

TIMING DEFINITIONS

SYMBOL	PARAMETER
t_{CKH}	Width of input clock pulse.
t_{CKL}	Interval between clock pulses.
t_{CKP1}	Clock period - when not using Complement Array.
t_{IS1}	Required delay between beginning of valid input and positive transition of clock.
t_{CKP2}	Clock period - when using Complement Array.
t_{IS2}	Required delay between beginning of valid input and positive transition of clock, when using optional Complement array (two passes necessary through the AND array).
t_{VS}	Required delay between V_{CC} (after power-on) and negative transition of clock preceding first reliable clock pulse.
t_{PRS}	Required delay between negative transition of asynchronous Preset and negative transition of clock preceding first reliable clock pulse.
t_{IH}	Required delay between positive transition of clock and end of valid input data.
t_{CKO}	Delay between positive transition of clock and when Outputs become valid (with PR/$\overline{OE}$ Low).
t_{OE}	Delay between beginning of Output Enable Low and when Outputs become valid.
t_{OD}	Delay between beginning of Output Enable High and when Outputs are in the OFF-State.
t_{PR}	Delay between positive transition of Preset and when Outputs become valid at "1".
t_{PPR}	Delay between V_{CC} (after power-on) and when Outputs become preset at "1".
t_{PRH}	Width of preset input pulse.
f_{MAX}	Maximum clock frequency.

LOGIC FUNCTION



VIRGIN STATE

A factory shipped virgin device contains all fusible links intact, such that:

1. PR/$\overline{OE}$ option is set to PR. Thus, all outputs will be at "1", as preset by initial power-up procedure.
2. All transition terms are disabled (0).
3. All S/R flip-flop inputs are disabled (0).
4. The device can be clocked via a Test Array pre-programmed with a standard test pattern.

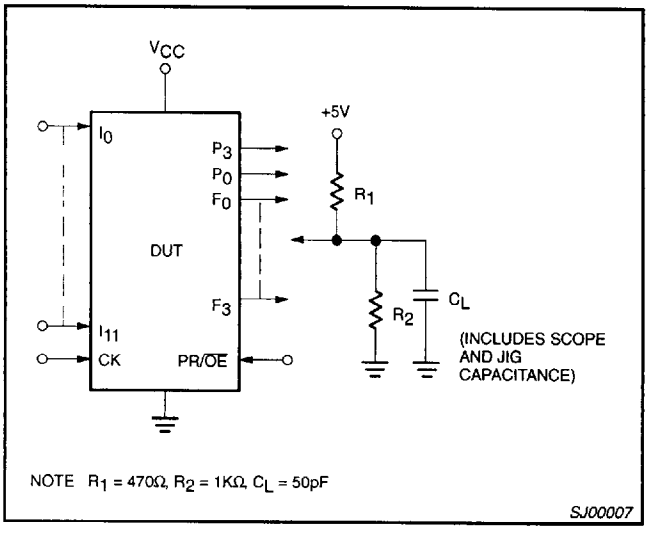
NOTE: The Test Array pattern must be deleted before incorporating a user program. This is accomplished automatically by any Philips qualified programming equipment.

TRUTH TABLE[1, 2, 3, 4, 5, 6]

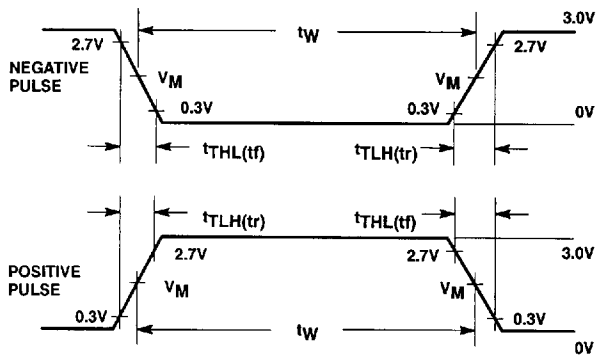
V_{CC}	OPTION PR	OPTION $\overline{OE}$	I_0	CK	S	R	$Q_{P/F}$	F
+5V	H		•	X	X	X	H	H
	L		+10V	X	X	X	Q_n	$(Q_P)_n$
	L		X	X	X	X	Q_n	$(Q_F)_n$
		H	•	X	X	X	Q_n	Hi-Z
		L	+10V	X	X	X	Q_n	$(Q_P)_n$
		L	X	X	X	X	Q_n	$(Q_F)_n$
		L	X	↑	L	L	Q_n	$(Q_F)_n$
		L	X	↑	L	H	L	L
		L	X	↑	H	L	H	H
		L	X	↑	H	H	IND.	IND.
↑	X	X	X	X	X	X	H	

NOTES:
1. Positive Logic $S/R = T_0 + T_1 + T_2 + \ldots + T_{47}$; $T_n = C(I_0\, I_1\, I_2 \ldots)\,(P_0\, P_1 \ldots P_5)$
2. Either Preset (Active-High) or Output Enable (active-Low) are available, but not both. The desired function is a user programmable option.
3. ↑ denotes transition from Low to High level.
4. R = S = High is an illegal input condition
5. • = H/L/+10V.
6. X = Don't Care (≤ 5.5V)

TEST LOAD CIRCUITS



VOLTAGE WAVEFORMS



Input Pulse Definitions

INPUT PULSE CHARACTERISTICS				
V_M	Rep. Rate	Pulse Width	t_{TLH}	t_{THL}
1.5V	1MHz	500ns	≤5ns	≤5ns

SJ00008

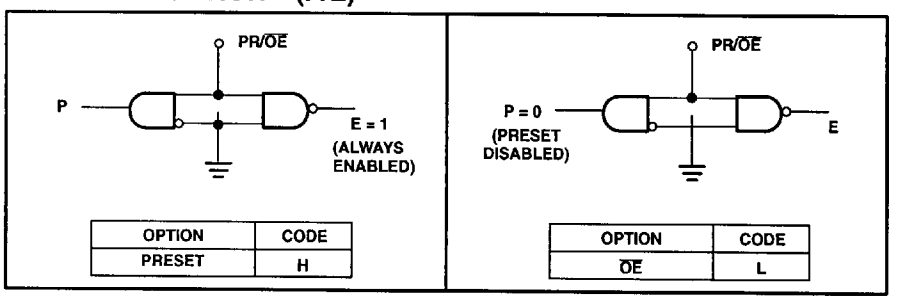
LOGIC PROGRAMMING

The FPLS can be programmed by means of Logic programming equipment.

With Logic programming, the AND/OR gate input connections necessary to implement the desired logic function are coded directly from the State Diagram using the Program Table on the following page.

In this table, the logic state or action of control variables C, I, P, N and F, associated with each Transition term T_n is assigned a symbol which results in the proper fusing pattern of corresponding link pairs, defined as follows:

PRESET/$\overline{OE}$ OPTION – (P/E)



OPTION	CODE
PRESET	H

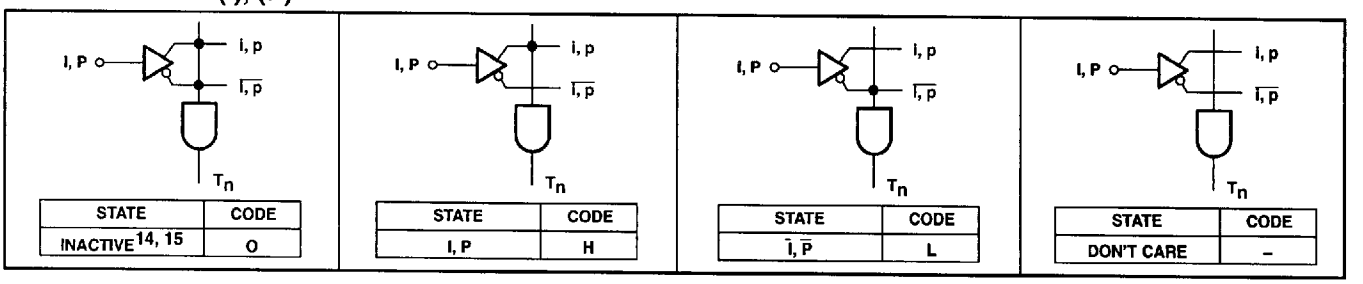
OPTION	CODE
$\overline{OE}$	L

SJ000009

PROGRAMMING:

The PS168 has a power-up preset feature. This feature insures that the device will power-up in a known state with all register elements (state and output register) at logic High (H). When programming the device it is important to realize this is the initial state of the device. You *must* provide a next state jump if you do not wish to use all Highs (H) as the present state.

"AND" ARRAY – (I), (P)



STATE	CODE
INACTIVE[14, 15]	O

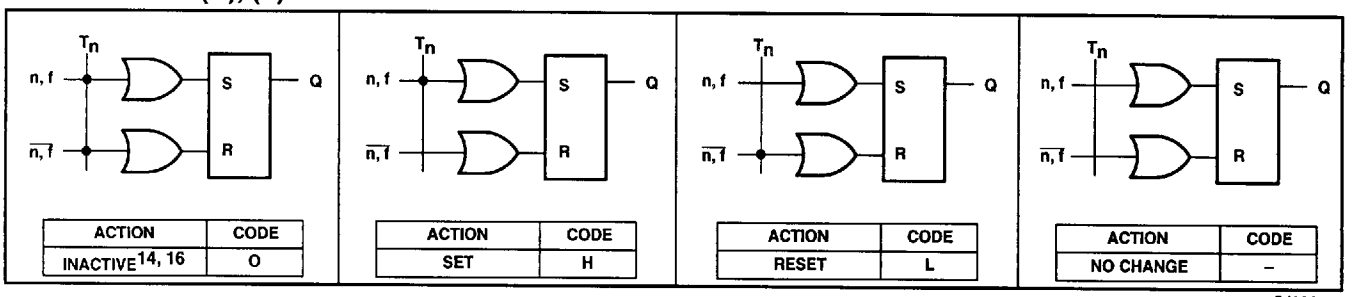
STATE	CODE
I, P	H

STATE	CODE
$\overline{I}$, $\overline{P}$	L

STATE	CODE
DON'T CARE	–

SJ00010

"OR" ARRAY – (N), (F)



ACTION	CODE
INACTIVE[14, 16]	O

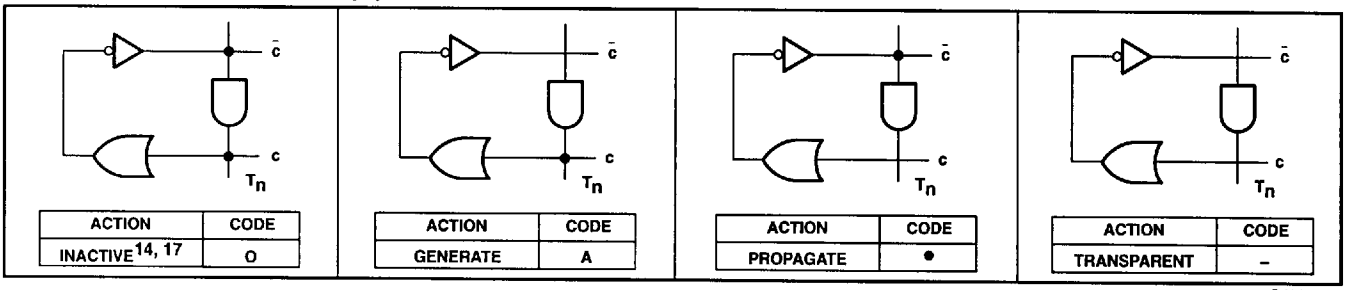
ACTION	CODE
SET	H

ACTION	CODE
RESET	L

ACTION	CODE
NO CHANGE	–

SJ00011

"COMPLEMENT" ARRAY – (C)



ACTION	CODE
INACTIVE[14, 17]	O

ACTION	CODE
GENERATE	A

ACTION	CODE
PROPAGATE	•

ACTION	CODE
TRANSPARENT	–

SJ00012

NOTES:

14. This is the initial unprogrammed state of all link pairs. It is normally associated with all unused (inactive) AND gates T_n.
15. Any gate T_n will be unconditionally inhibited if any one of its I or P link pairs are left intact.
16. To prevent simultaneous Set and Reset flip-flop commands, this state is not allowed for N and F link pairs coupled to active gates T_n (see flip-flop truth tables).
17. To prevent oscillations, this state is not allowed for C link pairs coupled to active gates T_n.

FPLS PROGRAM TABLE PLS168

CUSTOMER NAME _____

PURCHASE ORDER # _____

PHILIPS DEVICE # CF (XXXX) _____

CUSTOMER SYMBOLIZED PART # _____

TOTAL NUMBER OF PARTS _____

PROGRAM TABLE _____

REV _____

DATE _____

PROGRAM TABLE ENTRIES

AND

INACTIVE	0
GENERATE	A
PROPAGATE	•
TRANSPARENT	—

C_n

INACTIVE	0
I, P	H
$\overline{I}$, $\overline{P}$	L
DON'T CARE	—

I_m, P_S

OR

INACTIVE	0
SET	H
RESET	L
NO CHANGE	—

Ns, Fr

OPTION

PRESET	H
$\overline{OE}$	L

P/E

TERM	C_n	AND: INPUT (I_m) 11 10 9 8 7 6 5 4 3 2 1 0	AND: PRESENT STATE (P_S) 9 8 7 6 5 4 3 2 1 0	REMARKS	OPTION (P/E) OR: NEXT STATE (Ns) 9 8 7 6 5 4 3 2 1 0	OUTPUT (Fr) 3 2 1 0
0						
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PIN NO.	18	19	20	21	22	23	2	3	4	5	6	7	16	15	14	13	11	10	9	8
VARIABLE NAME																				

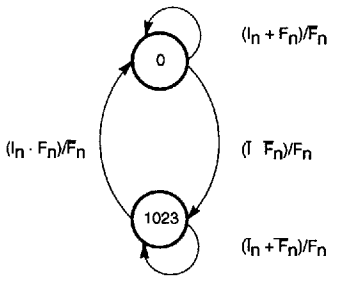
SP00195

TEST ARRAY

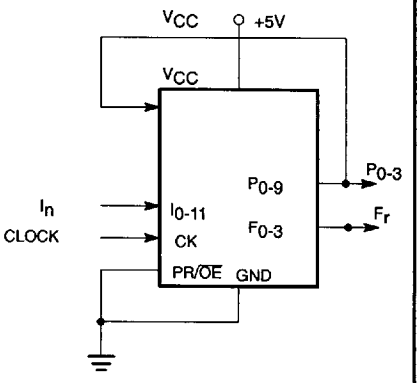
The FPLS may be subjected to AC and DC parametric tests prior to programming via an on-chip test array.

The array consists of test transition terms 48 and 49, factory programmed as shown below.

Testing is accomplished by clocking the FPLS and applying the proper input sequence to $I_{0\text{-}13}$ as shown in the test circuit timing diagram.



State Diagram



FPLS Under Test

TEST ARRAY PROGRAM

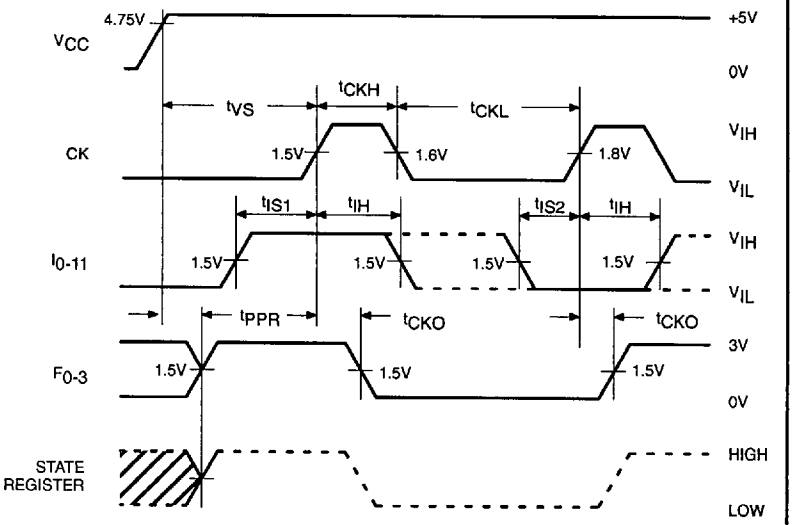
TERM	Cn	AND: INPUT (Im) 11	10	9	8	7	6	5	4	3	2	1	0	PRESENT STATE (Ps) 9	8	7	6	5	4	3	2	1	0
48	A	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
49	•	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

OPTION (P/E)	H
OR	

NEXT STATE (Ns) 9	8	7	6	5	4	3	2	1	0	OUTPUT (Fr) 3	2	1	0
L	L	L	L	L	L	L	L	L	L	L	L	L	L
H	H	H	H	H	H	H	H	H	H	H	H	H	H

Test Array Program

Both terms 48 and 49 must be deleted during user programming to avoid interfering with the desired logic function. This is accomplished automatically by any Philips qualified programming equipment.



Test Circuit Timing Diagram

TEST ARRAY DELETED

TERM	Cn	AND: INPUT (Im) 11	10	9	8	7	6	5	4	3	2	1	0	PRESENT STATE (Ps) 9	8	7	6	5	4	3	2	1	0
48	—	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
49	•	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

OPTION (P/E)	H
OR	

NEXT STATE (Ns) 9	8	7	6	5	4	3	2	1	0	OUTPUT (Fr) 3	2	1	0
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—

Test Array Deleted

SJ00013