

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



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

- 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 logic to high transition of the Clock pulse.

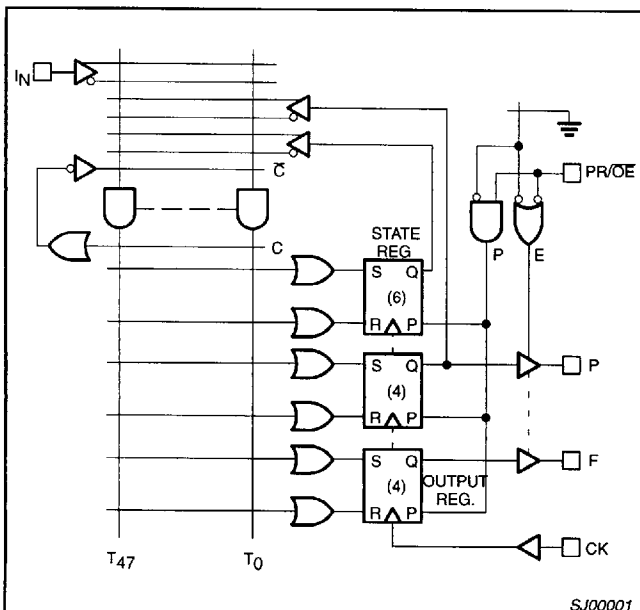
Both True and Complement transition terms can be generated by optional use of the internal variable (C) from the complement array. Also, if desired, the Preset input can be converted to output-enable function, as an additional user programmable option.

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

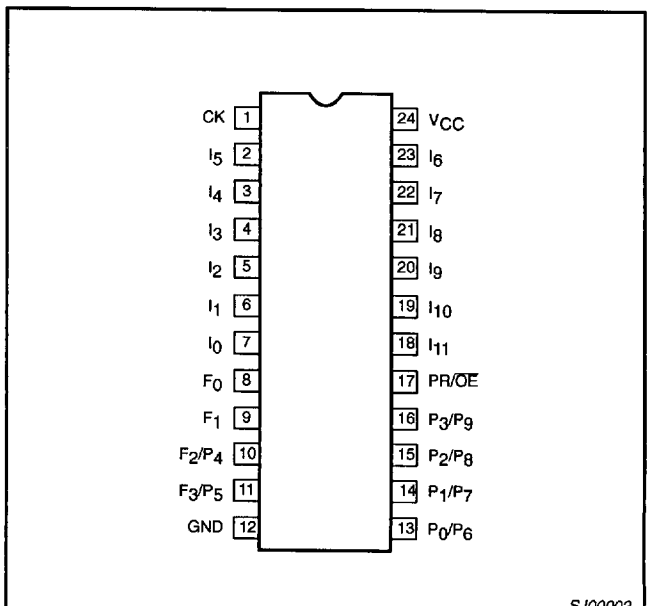
APPLICATIONS

- Interface protocols
- Sequence detectors
- Peripheral controllers

FUNCTIONAL DIAGRAM



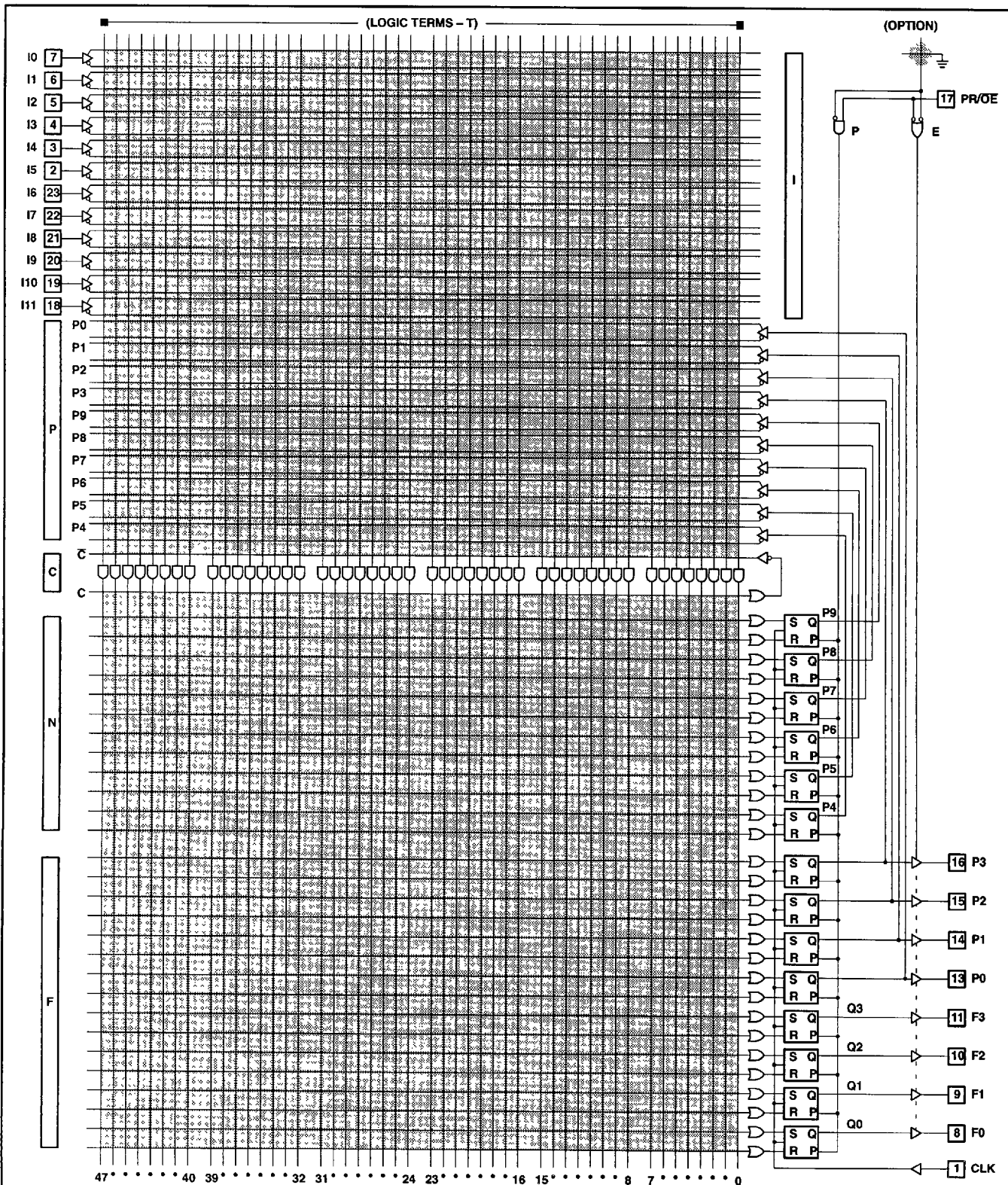
PIN CONFIGURATION



Field programmable logic sequencer (12 x 48 x 8)

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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.

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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 - I 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 - F ₃ and P ₀ - F ₃ reflect the contents of state register bits P ₄ - F ₉ (see Diagnostic Output Mode diagram on page 7). The contents of flip-flops P ₀ - F ₁ and F ₀ - F ₃ remain unaltered.	Active-High/Low
13 - 16	P ₀ - F ₃	Logic/Diagnostic Outputs: Four device outputs which normally reflect the contents of state register bits P ₀ - F 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/OE	Preset or Output Enable Input: A user programmable function: <ul style="list-style-type: none"> 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 P₀ - F₉ and F₀ - F₃ are High. Normal clocking resumes with the first full clock pulse following a High-to-Low clock transition, after Preset goes Low. Output Enable: Provides an Output Enable function to all output buffers. 	Active-High (H)
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".	Active-Low (L)

ABSOLUTE MAXIMUM RATINGS¹

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

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

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

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AC ELECTRICAL CHARACTERISTICS $-55^{\circ}\text{C} \leq T_A \leq +125^{\circ}\text{C}$, $4.5\text{V} \leq V_{\text{CC}} \leq 5.5\text{V}$

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

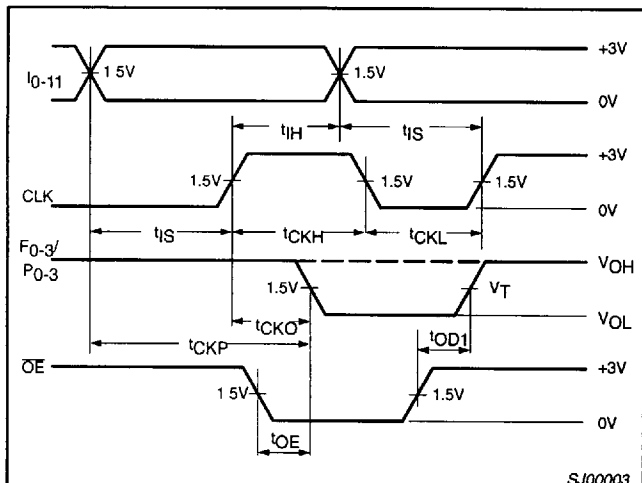
NOTES:

- 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.
- All typical values are at $V_{\text{CC}} = 5\text{V}$, $T_A = +25^{\circ}\text{C}$.
- All voltage values are with respect to network ground terminal.
- Test one at a time.
- Measured with V_{IL} applied to $\overline{\text{OE}}$ and a logic High stored, or with V_{IH} applied to PR.
- Measured with a programmed logic condition for which the output is at a Low logic level, and V_{IL} applied to PR/ $\overline{\text{OE}}$ Output sink current is applied through a resistor to V_{CC} .
- Measured with V_{IH} applied to PR/ $\overline{\text{OE}}$.
- Duration of short circuit should not exceed 1 second.
- I_{CC} is measured with the PR/ $\overline{\text{OE}}$ input grounded, all other inputs at 4.5V, and the outputs open.
- Guaranteed, but not tested.
- To prevent spurious clocking, clock rise time (10% - 90%) $\leq 30\text{ns}$.
- Not testable on unprogrammed devices.
- Set up time must be increased with increased number of product terms programmed. Time shown is with two product terms programmed.

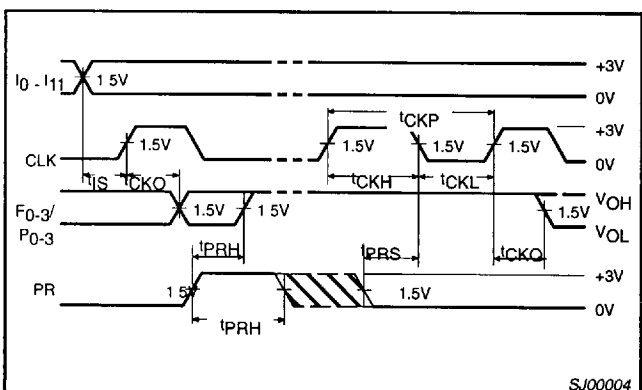
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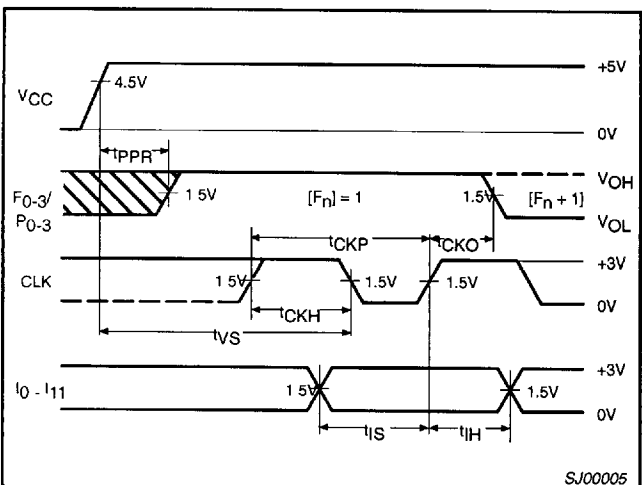
TIMING DIAGRAMS



Sequential Mode



Asynchronous mode



Power-On Preset

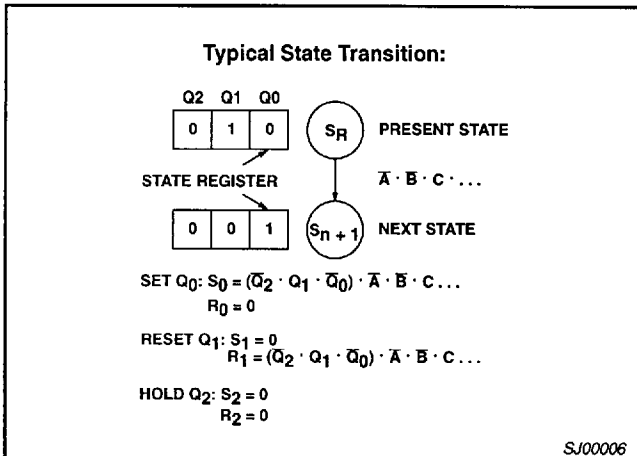
TIMING DEFINITIONS

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/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.

Field programmable logic sequencer (12 x 48 x 8)

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LOGIC FUNCTION



VIRGIN STATE

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

1. PR/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.

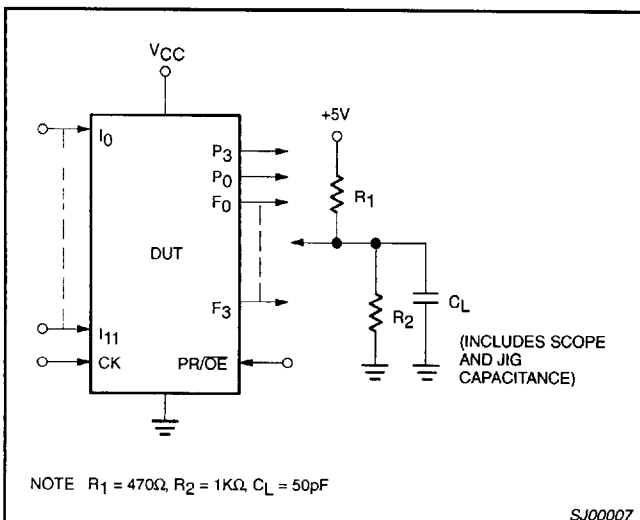
TRUTH TABLE 1, 2, 3, 4, 5, 6

V _{CC}	OPTION		I ₀	CK	S	R	Q _{P/F}	F
	PR	OE						
+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	X	L	H	L	L
		L	X	X	H	L	H	H
		L	X	X	H	H	IND.	IND.
↑	X	X	X	X	X	X	H	

NOTES:

- 1 Positive Logic $S/R = T_0 + T_1 + T_2 + \dots + T_{47}$
 $T_n = C(I_0 I_1 I_2 \dots) (P_0 P_1 \dots P_5)$
- 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 ($\leq 5.5V$)

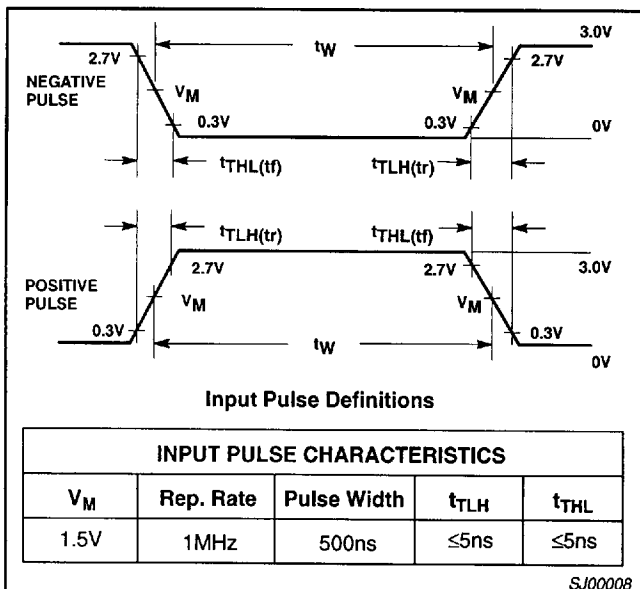
TEST LOAD CIRCUITS



Field programmable logic sequencer (12 x 48 x 8)

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VOLTAGE WAVEFORMS



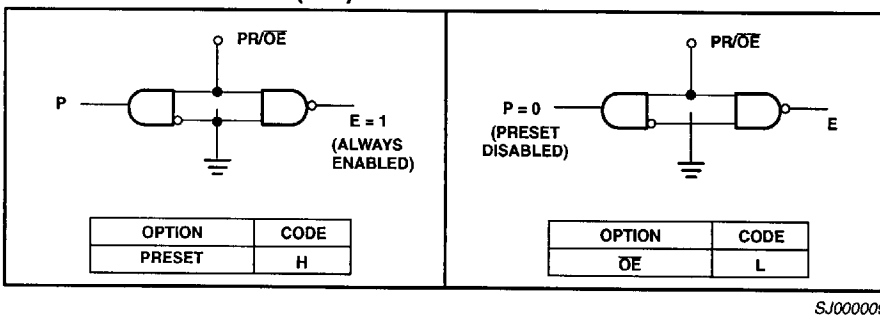
LOGIC PROGRAMMING

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/ØE OPTION - (P/E)

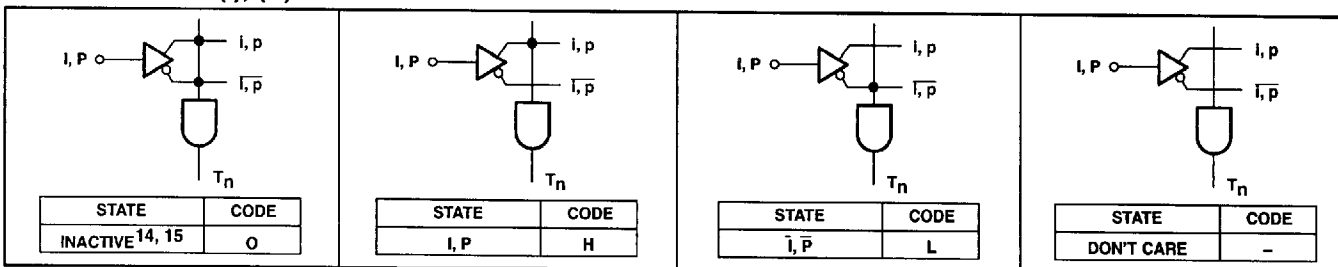


PROGRAMMING:

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.

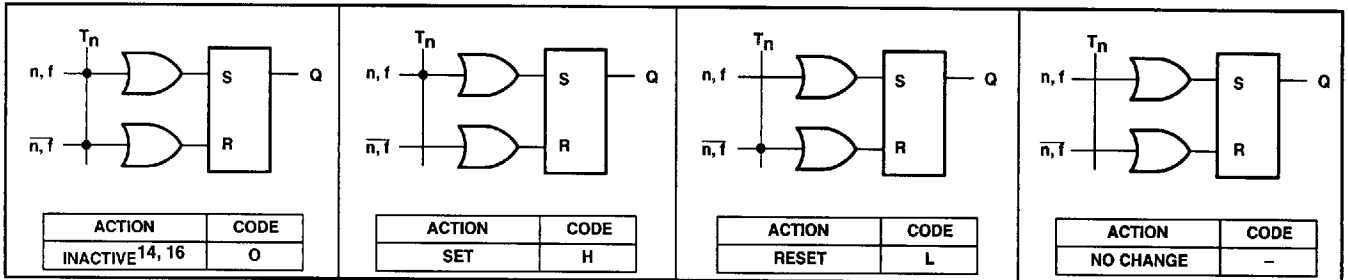
"AND" ARRAY - (I), (P)



Field programmable logic sequencer (12 x 48 x 8)

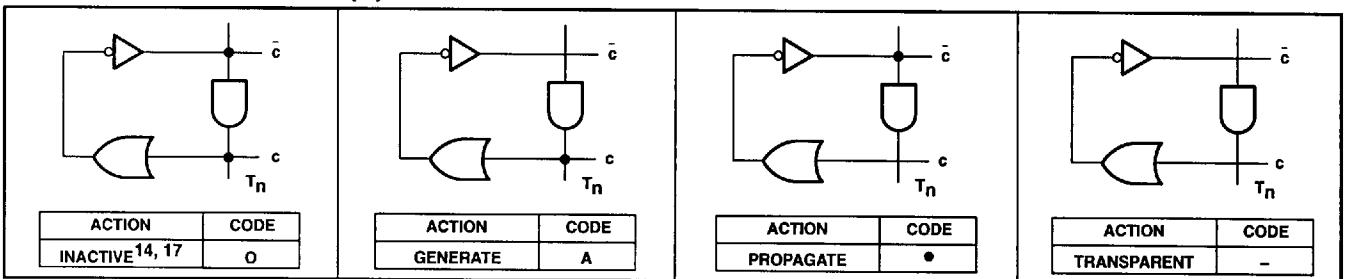
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“OR” ARRAY – (N), (F)



SJ00011

“COMPLEMENT” ARRAY – (C)



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 .

Field programmable logic sequencer (12 x 48 x 8)

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FPLS PROGRAM TABLE PLS168

PROGRAM TABLE ENTRIES

CUSTOMER NAME _____ PURCHASE ORDER # _____ PHILIPS DEVICE # _____ CF (XXXX) CUSTOMER SYMBOLIZED PART # _____ TOTAL NUMBER OF PARTS _____ PROGRAM TABLE _____ REV _____ DATE _____	AND <table border="1" style="width:100%; border-collapse: collapse;"> <tr><td>INACTIVE</td><td>0</td></tr> <tr><td>GENERATE</td><td>A</td></tr> <tr><td>PROPAGATE</td><td>.</td></tr> <tr><td>TRANSPARENT</td><td>—</td></tr> </table> <table border="1" style="width:100%; border-collapse: collapse;"> <tr><td>INACTIVE</td><td>0</td></tr> <tr><td>I, P</td><td>H</td></tr> <tr><td>I, P</td><td>L</td></tr> <tr><td>DON'T CARE</td><td>—</td></tr> </table>	INACTIVE	0	GENERATE	A	PROPAGATE	.	TRANSPARENT	—	INACTIVE	0	I, P	H	I, P	L	DON'T CARE	—	OR <table border="1" style="width:100%; border-collapse: collapse;"> <tr><td>INACTIVE</td><td>0</td></tr> <tr><td>SET</td><td>H</td></tr> <tr><td>RESET</td><td>L</td></tr> <tr><td>NO CHANGE</td><td>—</td></tr> </table> OPTION <table border="1" style="width:100%; border-collapse: collapse;"> <tr><td>PRESET</td><td>H</td></tr> <tr><td>OE</td><td>L</td></tr> </table>	INACTIVE	0	SET	H	RESET	L	NO CHANGE	—	PRESET	H	OE	L
INACTIVE	0																													
GENERATE	A																													
PROPAGATE	.																													
TRANSPARENT	—																													
INACTIVE	0																													
I, P	H																													
I, P	L																													
DON'T CARE	—																													
INACTIVE	0																													
SET	H																													
RESET	L																													
NO CHANGE	—																													
PRESET	H																													
OE	L																													

TERM	C _n	AND										REMARKS	OPTION (P/E)																
		INPUT (I _m)											NEXT STATE (N _s)																
		11	10	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0	3	2	1	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

Field programmable logic sequencer (12 x 48 x 8)

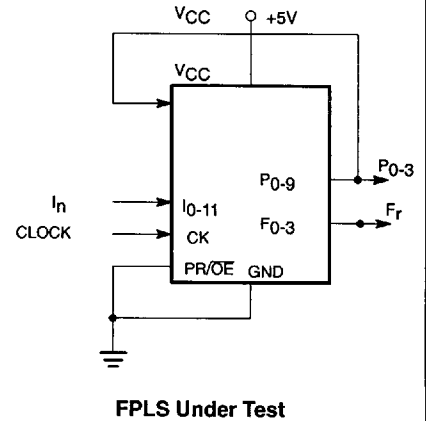
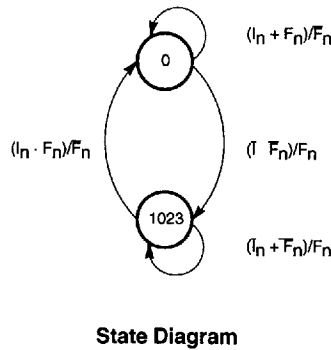
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TEST ARRAY

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 I₀₋₁₃ as shown in the test circuit timing diagram.

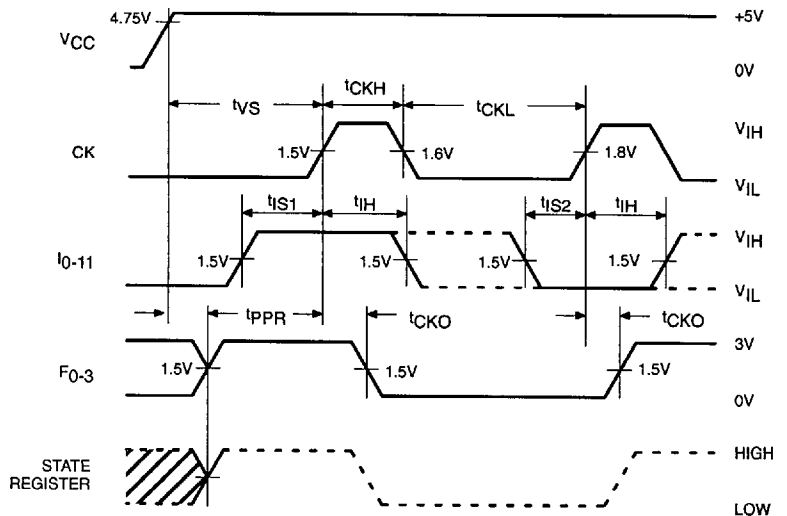


TEST ARRAY PROGRAM

TERM	AND																OR																OPTION (P/E)	H	
	C _n	INPUT (I _m)												PRESENT STATE (P _s)				NEXT STATE (N _s)								OUTPUT (F _r)									
		1	1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2			1
48	A	H	H	H	H	H	H	H	H	H	H	H	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	L	L	L	L	L	L	L	L	L	L	L	L

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	AND																OR																OPTION (P/E)	H
	C _n	INPUT (I _m)												PRESENT STATE (P _s)				NEXT STATE (N _s)								OUTPUT (F _r)								
		1	1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2	1	0	9	8	7	6	5	4	3	2		
48	—	H	H	H	H	H	H	H	H	H	H	H	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	L	L	L	L	L	L	L	L	L	L	L

Test Array Deleted

SJ00013