Programmable logic sequencers (14 × 48 × 6)

PLS167/A

DESCRIPTION

The PLS167 and PLS167A are bipolar, Programmable Logic State machines of the Mealy type. The Programmable Logic Sequencers (PLS) contain logic AND/OR gate arrays with user programmable connections which control the inputs of on-chip State and Output Registers. These consist respectively of 8 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 14 external inputs, I0-13, with 8 internal inputs, P0-7, fed back from the State Register to form up to 48 transition terms (AND terms). In addition, P0 and P1 of the internal State Register are brought off-chip to allow extending the Output Register to 6 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 Low-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 are listed in the Ordering Information Table.

FEATURES

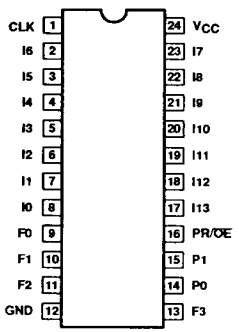
- PLS167
  - f_{MAX} = 13.9MHz
  - 20MHz clock rate
- PLS167A
  - f_{MAX} = 20MHz
  - 25MHz clock rate
- Field-Programmable (Ni-Cr link)
- 14 True/Complement buffered inputs
- 48 programmable AND gates
- 25 programmable OR gates
- 8-bit State Register
- 2-bit shared State/Output Register
- 4-bit Output Register
- Transition Complement Array
- Programmable Asynchronous Preset/Output Enable
- Positive edge-triggered 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 (typ.)
- TTL compatible
- 3-State outputs
- Single +5V supply

APPLICATIONS

- Interface protocols
- Sequence detectors
- Peripheral controllers
- Timing generators
- Sequential circuits
- Security locking systems

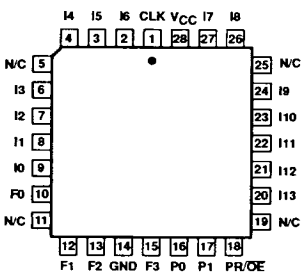
PIN CONFIGURATIONS

N Package



N = Plastic Dual In-Line Package (300mil-wide)

A Package



A = Plastic Leaded Chip Carrier

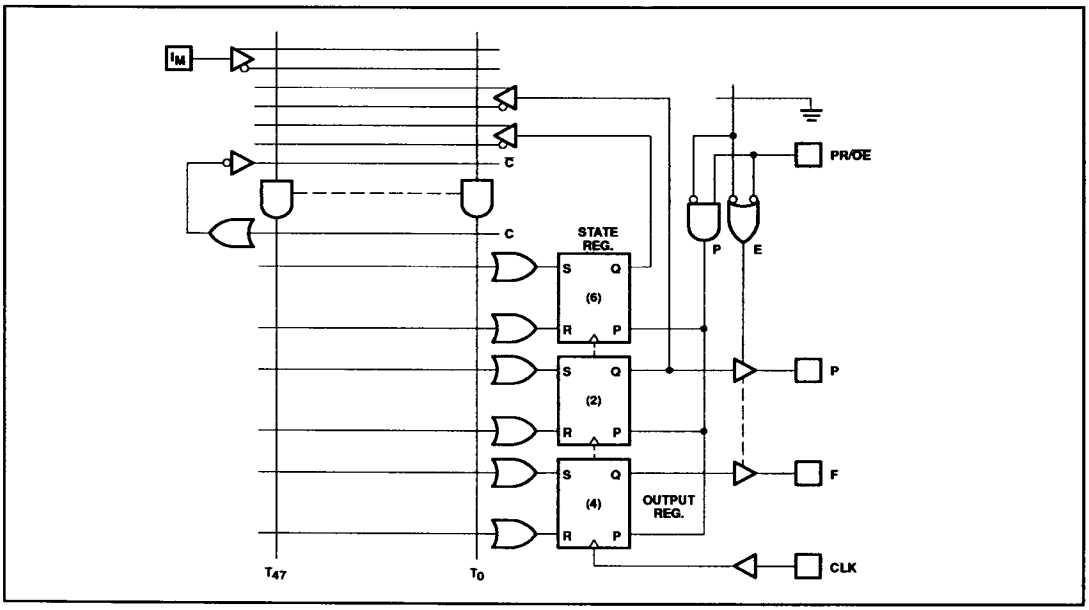
ORDERING INFORMATION

DESCRIPTION	ORDER CODE	DRAWING NUMBER
24-Pin Plastic Dual In-Line Package (300mil-wide)	PLS167N, PLS167AN	0410D
28-Pin Plastic Leaded Chip Carrier	PLS167A, PLS167AA	0401F

Programmable logic sequencers (14 × 48 × 6)

PLS167/A

FUNCTIONAL DIAGRAM



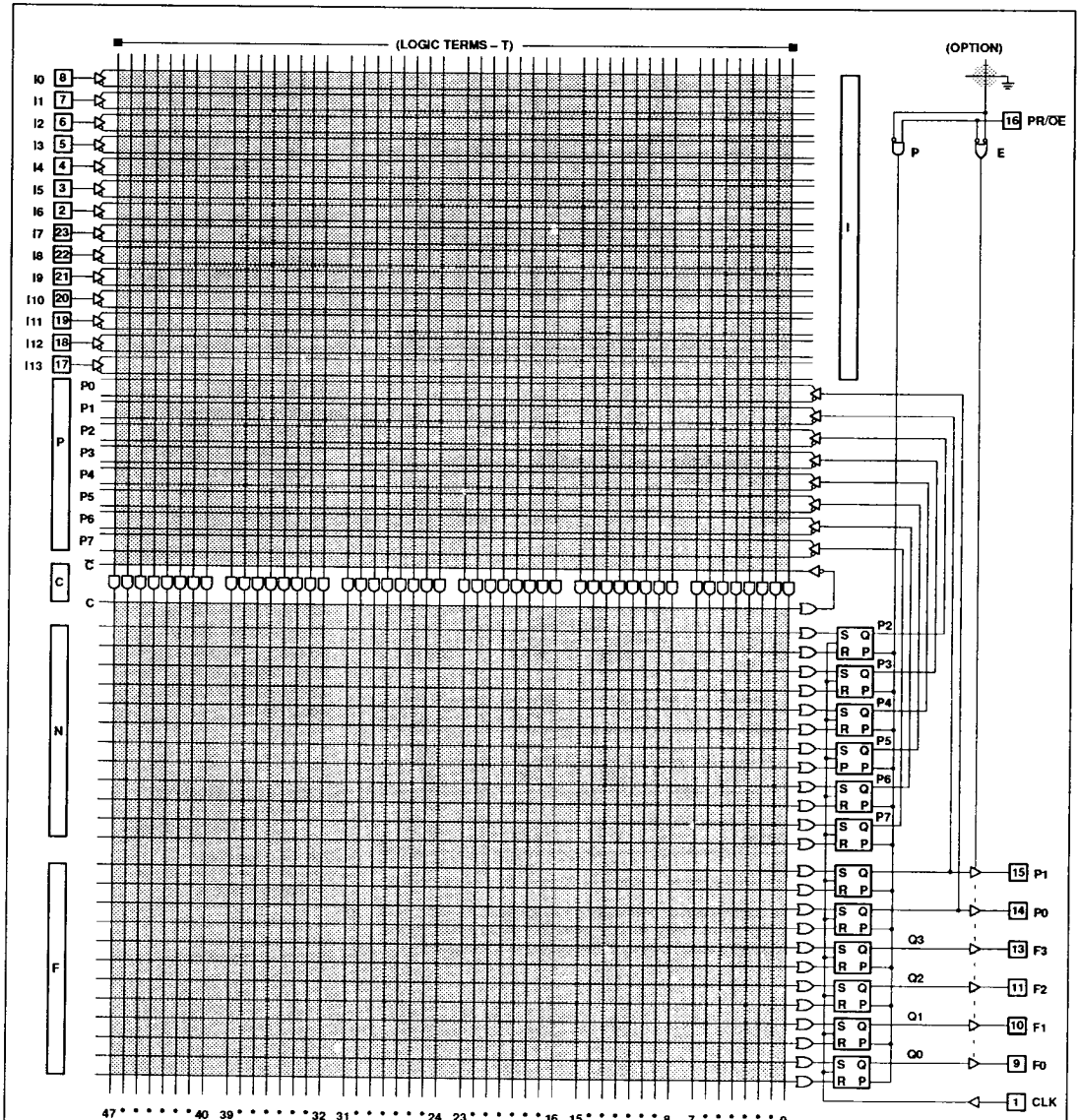
PIN DESCRIPTION

PIN NO.	SYMBOL	NAME AND FUNCTION	POLARITY
1	CLK	**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 17 – 23	I1 – I13	**Logic Inputs:** The 13 external inputs to the AND array used to program jump conditions between machine states, as determined by a given logic sequence.	Active-High/Low
8	I0	**Logic/Diagnostic Input:** A 14th external logic input to the AND array, as above, when exercised with standard TTL levels. When I0 is held at +10V, device outputs F0 – 3 and P0 – 1 reflect the contents of State Register bits P2 – 7 (see Diagnostic Output Mode diagram). The contents of flip-flops P0 – 1 and F0 – 3 remain unaltered.	Active-High/Low
9 – 11 13	F0 – 3	**Logic/Diagnostic Outputs:** Four device outputs which normally reflect the contents of Output Register bits Q_{0-3}, when enabled. When I0 is held at +10V, F0 – 3 = (P2 – 5).	Active-High
14 – 15	P0 – 1	**Logic/Diagnostic Outputs:** Two register bits with shared function as least Significant State Register bits, or most significant Output Register bits. When I_0 is held at +10V, P0 – 1 = (P6 – 7).	Active-High
16	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 P0 – 7 and F0 – 3 are High. Normal clocking resumes with the first full clock pulse following a High-to-Low clock transition, after Preset goes Low.	Active-High (H)
		• **$\overline{\text{Output Enable}}$:** Provides an Output Enable function to all output buffers.	Active-Low (L)

Programmable logic sequencers ($14 \times 48 \times 6$)

PLS167/A

LOGIC DIAGRAM



NOTES:
1. All AND gate inputs with a blown link float to a logic "1".
2. All OR gate inputs with a blown fuse float to logic "0".
3. ▒ Programmable connection.

Programmable logic sequencers (14 × 48 × 6)

PLS167/A

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	

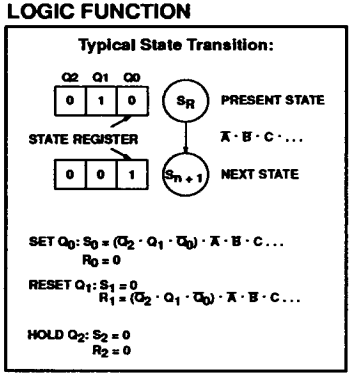
NOTES:
1. Positive Logic:
   $S/R = T_0 + T_1 + T_2 + \ldots T_{47}$
   $T_n = C(I0\ I1\ I2 \ldots)\ (P0\ P1 \ldots P7)$
2. Either Preset (Active-High) or $\overline{\text{Output Enable}}$ (Active-Low) are available, but not both. The desired function is a user-programmable option.
3. ↑ denotes transition from Low-to-High level.
4. R = S = High is an illegal input condition.
5. * = H or L or +10V.
6. X = Don't Care (≤5.5V)

ABSOLUTE MAXIMUM RATINGS[1]

SYMBOL	PARAMETER	RATINGS MIN	RATINGS MAX	UNIT
V_{CC}	Supply voltage		+7	V_{DC}
V_{IN}	Input voltage		+5.5	V_{DC}
V_{OUT}	Output voltage		+5.5	V_{DC}
I_{IN}	Input currents	–30	+30	mA
I_{OUT}	Output currents		+100	mA
T_{amb}	Operating temperature range	0	+75	°C
T_{stg}	Storage temperature range	–65	+150	°C

NOTES:
1. Stresses above those listed may cause malfunction or permanent damage to the device. This is a stress rating only. Functional operation at these or any other condition above those indicated in the operational and programming specification of the device is not implied.

LOGIC FUNCTION



VIRGIN STATE

The 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 Semiconductors qualified programming equipment.

THERMAL RATINGS

TEMPERATURE	
Maximum junction	150°C
Maximum ambient	75°C
Allowable thermal rise ambient to junction	75°C

DC ELECTRICAL CHARACTERISTICS

$0°C \leq T_{amb} \leq +75°C$, $4.75V \leq V_{CC} \leq 5.25V$

SYMBOL	PARAMETER	TEST CONDITION	LIMITS			UNIT
			MIN	TYP[1]	MAX	
Input voltage[2]						
V_{IH}	High	V_{CC} = MAX	2.0			V
V_{IL}	Low	V_{CC} = MIN			0.8	V
V_{IC}	Clamp[3]	V_{CC} = MIN, I_{IN} = −12mA		−0.8	−1.2	V
Output voltage[2]						
V_{OH}	High[4]	V_{CC} = MIN I_{OH} = −2mA	2.4			V
V_{OL}	Low[5]	I_{OL} = 9.6mA		0.35	0.45	V
Input current						
I_{IH}	High	V_{IN} = 5.5V		<1	80	μA
I_{IL}	Low	V_{IN} = 0.45V		−10	−100	μA
I_{IL}	Low (CK input)	V_{IN} = 0.45V		−50	−250	μA
Output current						
$I_{O(OFF)}$	Hi-Z state[5, 6]	V_{CC} = MAX V_{OUT} = 5.5V		1	40	μA
		V_{OUT} = 0.45V		−1	−40	μA
I_{OS}	Short circuit[3, 7]	V_{OUT} = 0V	−15		−70	mA
I_{CC}	V_{CC} supply current[8]	V_{CC} = MAX		120	180	mA
Capacitance[6]						
C_{IN}	Input	V_{CC} = 5.0V V_{IN} = 2.0V		8		pF
C_{OUT}	Output	V_{OUT} = 2.0V		10		pF

NOTES:

1. All typical values are at V_{CC} = 5V, T_{amb} = +25°C.
2. All voltage values are with respect to network ground terminal.
3. Test one at a time.
4. Measured with V_{IL} applied to $\overline{OE}$ and a logic high stored, or with V_{IH} applied to PR.
5. 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 supplied through a resistor to V_{CC}.
6. Measured with V_{IH} applied to PR/$\overline{OE}$.
7. Duration of short circuit should not exceed 1 second.
8. I_{CC} is measured with the PR/$\overline{OE}$ input grounded, all other inputs at 4.5V and the outputs open.

Programmable logic sequencers (14 × 48 × 6)

PLS167/A

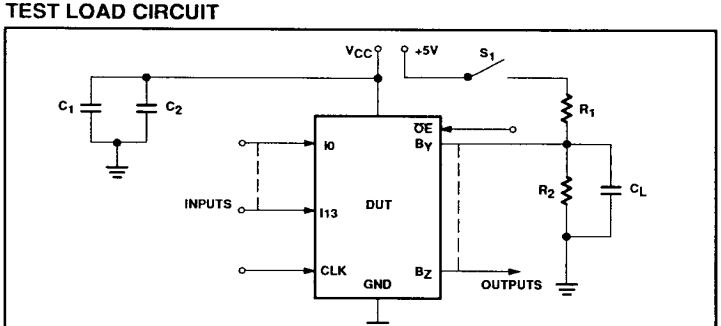
AC ELECTRICAL CHARACTERISTICS

$R_1 = 470\Omega$, $R_2 = 1k\Omega$, $C_L = 30pF$, $0°C \le T_{amb} \le +75°C$, $4.75°CV \le V_{CC} \le 5.25V$

SYMBOL	PARAMETER	FROM	TO	LIMITS						UNIT
				PLS167			PLS167A			
				MIN	TYP[1]	MAX	MIN	TYP[1]	MAX	
Pulse width[3]										
t_{CKH}	Clock[2] High	CK +	CK –	25	15		20	15		ns
t_{CKL}	Clock Low	CK –	CK +	25	15		20	15		ns
t_{CKP}	Clock Period	CK +	CK +	50	30		40	30		ns
t_{PRH}	Preset pulse	PR +	PR –	25	15		25	15		ns
Setup time[3]										
$t_{IS1}A$	Input	Input ±	CK +	60			40			ns
$t_{IS1}B$	Input	Input ±	CK +	50			30			ns
$t_{IS1}C$	Input	Input ±	CK +	42			N/A			ns
$t_{IS2}A$	Input (through Complement Array)	Input ±	CK +	90			70			ns
$t_{IS2}B$	Input (through Complement Array)	Input	CK +	80			60			ns
$t_{IS2}C$	Input (through Complement Array)	Input	CK +	72			N/A			ns
t_{VS}	Power-on preset	V_{CC} +	CK –	0	–10		0	–10		ns
t_{PRS}	Preset	PR –	CK –	0	–10		0	–10		ns
Hold time										
t_{IH}	Input	CK +	Input ±	5	–10		5	–5		ns
Propagation delay										
t_{CKO}	Clock	CK +	Output ±		15	30		15	20	ns
t_{OE}	Output enable[4]	OE –	Output –		20	30		20	30	ns
t_{OD}	Output disable[4]	OE +	Output +		20	30		20	30	ns
t_{PR}	Preset	PR +	Output +		18	30		18	30	ns
t_{PPR}	Power-on preset	V_{CC} +	Output +		0	10		0	10	ns
Frequency of operation[3]										
$f_{MAX}C$	Without Complement Array			13.9			20.0			MHz
$f_{MAX}C$	With Complement Array			9.8			12.5			MHz

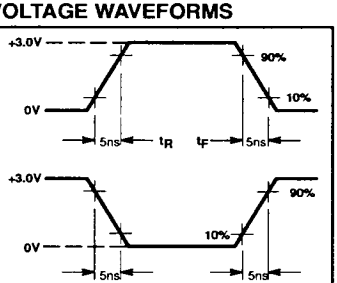
NOTES:
1. All typical values are at $V_{CC} = 5V$, $T_{amb} = +25°C$.
2. To prevent spurious clocking, clock rise time (10% – 90%) ≤ 30ns.
3. See "Speed vs. OR Loading" diagrams.
4. For 3-State output; output enable times are tested with $C_L = 30pF$ to the 1.5V level, and S_1 is open for high-impedance to High tests and closed for high-impedance to Low tests. Output disable times are tested with $C_L = 5pF$. High-to-High impedance tests are made to an output voltage of $V_T = (V_{OH} - 0.5V)$ with S_1 open, and Low-to-High impedance tests are made to the $V_T = (V_{OL} + 0.5V)$ level with S_1 closed.

TEST LOAD CIRCUIT



NOTE:
C_1 and C_2 are to bypass V_{CC} to GND.

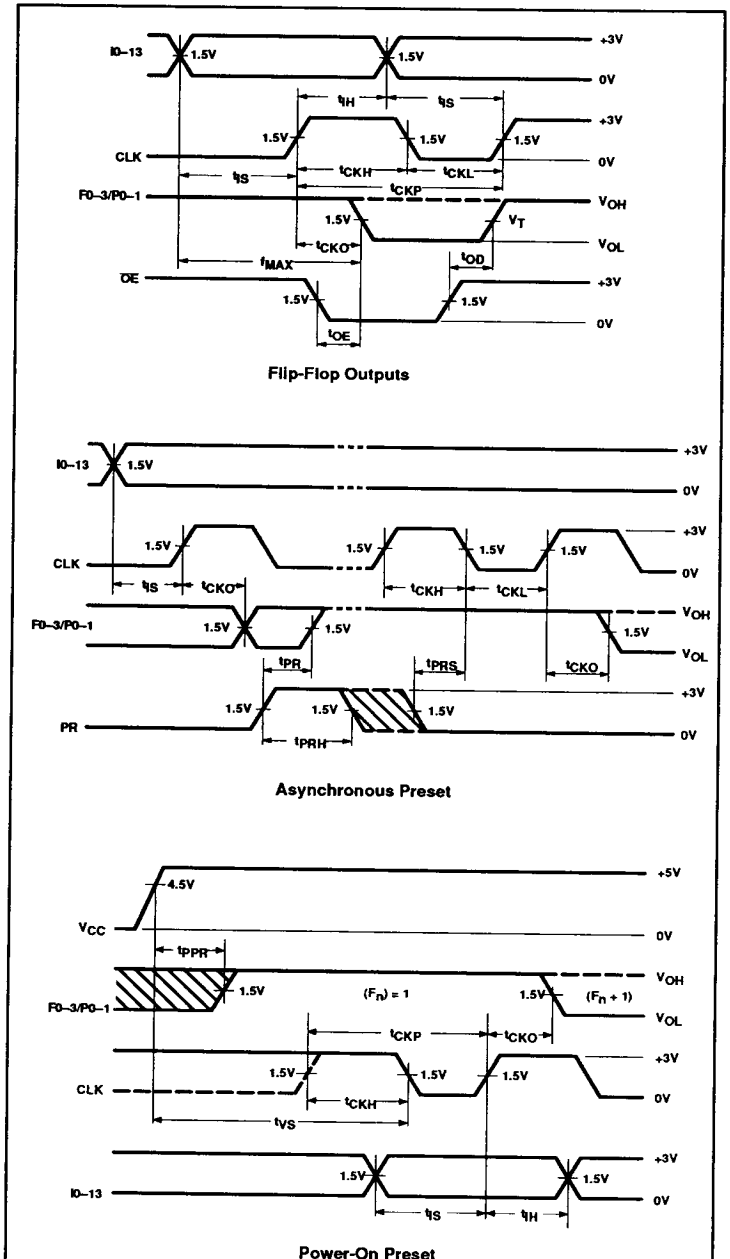
VOLTAGE WAVEFORMS



MEASUREMENTS:
All circuit delays are measured at the +1.5V level of inputs and outputs, unless otherwise specified.

Input Pulses

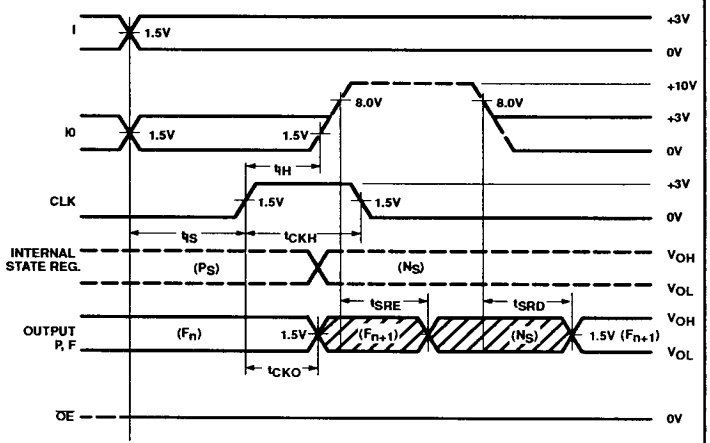
TIMING DIAGRAMS



TIMING DEFINITIONS

SYMBOL	PARAMETER
t_{CKH}	Width of input clock pulse.
t_{CKL}	Interval between clock pulses.
t_{CKP}	Minimum guaranteed clock period.
t_{IS1}	Required delay between beginning of valid input and positive transition of clock.
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_{SRE}	Delay between input I_0 transition to Diagnostic mode and when the outputs reflect the contents of the State Register.
t_{SRD}	Delay between input I_0 transition to Logic mode and when the outputs reflect the contents of the Output Register.
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}	Minimum guaranteed operating frequency.

TIMING DIAGRAMS (Continued)



Diagnostic Output Mode

SPEED VS. "OR" LOADING

The maximum frequency at which the PLS can be clocked while operating in *sequential mode* is given by:

$$(1/f_{MAX}) = t_{CY} = t_{IS} + t_{CKO}$$

This frequency depends on the number of transition terms T_n used. Having all 48 terms connected in the AND array does not appreciably impact performance; but the number of terms connected to each OR line affects t_{IS}, due to capacitive loading. The effect of this loading can be seen in Figure 1, showing the variation of t_{IS1} with the number of terms connected per OR.

The PLS167 AC electrical characteristics contain three limits for the parameters t_{IS1} and t_{IS2} (refer to Figure 1). The first, t_{IS1A} is guaranteed for a device with 48 terms connected to any OR line. t_{IS1B} is guaranteed for a device with 32 terms connected to any OR line. And t_{IS1C} is guranteed for a device with 24 terms conntected to any OR line.

The three other entries in the AC table, t_{IS2} A, B, and C are corresponding 48, 32, and 24 term limits when using the on-chip Complement Array.

The PLS167A AC electrical characteristics contain two limits for the parameters t_{IS1} and t_{IS2} (refer to Figure 2). The first, t_{IS1A} is guaranteed for a device with 24 terms connected to any OR line. t_{IS1B} is guaranteed for a device with 16 terms connected to any OR line.

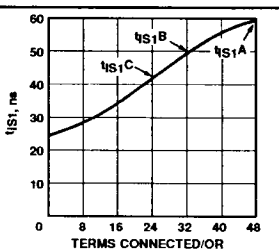


Figure 1. PLS167 t_{IS1} vs. Terms/OR Connected

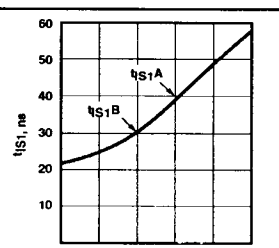


Figure 2. PLS167A t_{IS1} vs. Terms/OR Connected

The two other entries in the AC table, t_{IS2} A and B are corresponding 24 and 16 term limits when using the on-chip Complement Array.

The worst case of t_{IS} for a given application can be determined by identifying the OR line with the maximum number of T_n connections. This can be done by referring to the interconnect pattern in the PLS logic diagram, typically illustrated in Figure 3, or by counting the maximum number of "H" *or* "L" entries in one of the columns of the device Program Table.

This number plotted on the curve in Figure 1 or Figure 2 will yield the worst case t_{IS} and, by implication, the maximum clocking frequency for reliable operation.

Note that for maximum speed all UNUSED transition terms should be disconnected from the OR array.

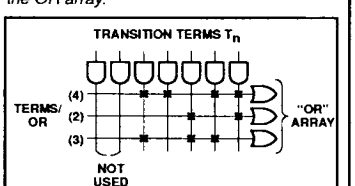


Figure 3. Typical OR Array Interconnect Pattern

Programmable logic sequencers (14 × 48 × 6)

PLS167/A

LOGIC PROGRAMMING

The PLS167/A devices are fully supported by industry standard (JEDEC compatible) PLD CAD tools, including Philips Semiconductors' SNAP design software package. ABEL™ CUPL™ and PALASM® 90 design software packages also support the PLS167/A architecture.

All packages allow Boolean and state equation entry formats. SNAP, ABEL and CUPL also accept, as input, schematic capture format.

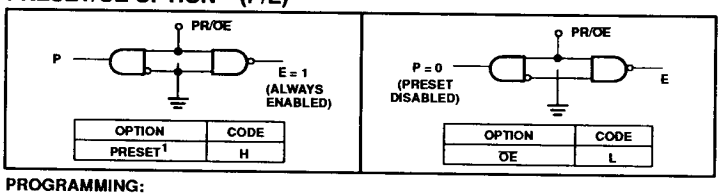
PLS167/A logic designs can also be generated using the program table entry format detailed on the following pages. This program table entry format is supported by the Philips Semiconductors SNAP PLD design software package.

To implement the desired logic functions, the state of each logic variable from logic equations (I, B, O, P, etc.) is assigned a symbol. The symbols for TRUE, COMPLEMENT, INACTIVE, PRESET, etc., are defined below.

PROGRAMMING AND SOFTWARE SUPPORT

Refer to Section 9 *(Development Software)* and Section 10 *(Third-party Programmer/ Software Support)* of this data handbook for additional information.

PRESET/$\overline{OE}$ OPTION – (P/E)



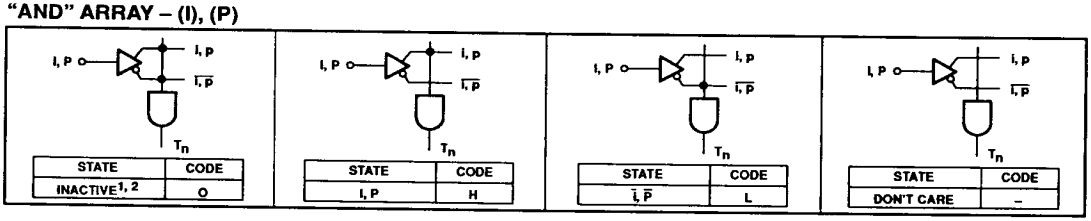
OPTION	CODE
PRESET[1]	H

OPTION	CODE
$\overline{OE}$	L

PROGRAMMING:

The PS167/A 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)



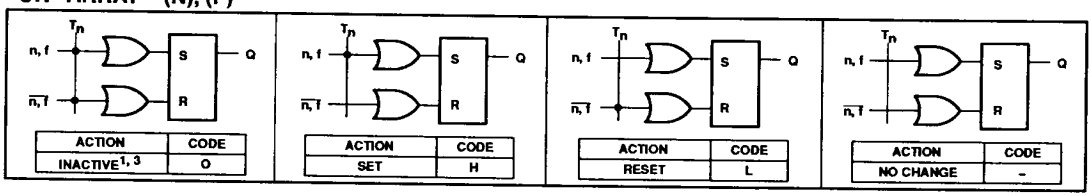
STATE	CODE
INACTIVE[1, 2]	O

STATE	CODE
I, P	H

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

STATE	CODE
DON'T CARE	–

"OR" ARRAY – (N), (F)



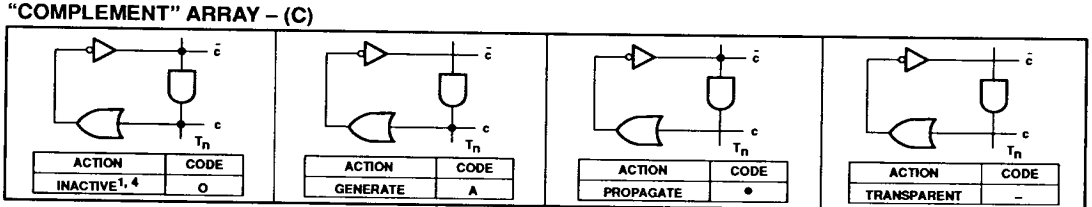
ACTION	CODE
INACTIVE[1, 3]	O

ACTION	CODE
SET	H

ACTION	CODE
RESET	L

ACTION	CODE
NO CHANGE	–

"COMPLEMENT" ARRAY – (C)



ACTION	CODE
INACTIVE[1, 4]	O

ACTION	CODE
GENERATE	A

ACTION	CODE
PROPAGATE	•

ACTION	CODE
TRANSPARENT	–

NOTES:

1. This is the initial unprogrammed state of all links.
2. Any gate T_n will be unconditionally inhibited if both the true and complement of any input (I, P) are left intact.
3. 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).
4. To prevent oscillations, this state is not allowed for C link pairs coupled to active gates T_n.

Programmable logic sequencers (14 × 48 × 6)

PLS167/A

PROGRAM TABLE

CUSTOMER NAME_____
PURCHASE ORDER #_____
PHILIPS DEVICE # CF (XXXX)
CUSTOMER SYMBOLIZED PART #_____
TOTAL NUMBER OF PARTS_____
PROGRAM TABLE_____
REV_____
DATE_____

PROGRAM TABLE ENTRIES

AND			OR		
INACTIVE	0	C_n	INACTIVE	0	N_s, Fr
GENERATE	A		SET	H	
PROPAGATE	•		RESET	L	
TRANSPARENT	—		NO CHANGE	—	
INACTIVE	0	I_m, P_s	OPTION		
I, P	H		PRESET	H	P/E
$\overline{I}$, $\overline{P}$	L		$\overline{OE}$	L	
DON'T CARE	—				

TERM	C_n	AND: INPUT (I_m) 13 12 11 10 9 8 7 6 5 4 3 2 1 0	AND: PRESENT STATE (P_s) 7 6 5 4 3 2 1 0	REMARKS	OPTION (P/E) OR: NEXT STATE (N_s) 7 6 5 4 3 2 1 0	OUTPUT (Fr) 3 2 1 0
0						
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
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39						
40						
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42						
43						
44						
45						
46						
47						
PIN NO.		17 18 19 20 21 22 23 2 3 4 5 6 7 8			15 14	13 11 10 9
VARIABLE NAME						

NOTES:

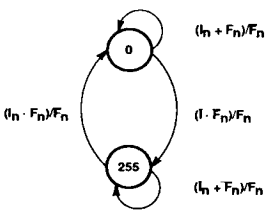
1. The device is shipped with all links initially intact. Thus, a background of "0" for all Terms, and an "H" for the P/E option, exists in the table, shown BLANK instead for clarity.
2. Unused C_n, I_m, and P_s bits are normally programmed Don't Care (–).
3. Unused Transition Terms can be left blank for future code modification, or programmed as (–) for maximum speed.
4. Letters in variable fields are used as identifiers by logic type programmers.

TEST ARRAY

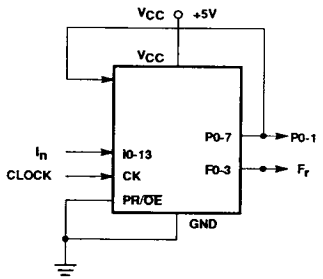
The PLS may be subjected to AC and DC parametric tests prior to programming via an on-chip test array.

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

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



State Diagram



PLS Under Test

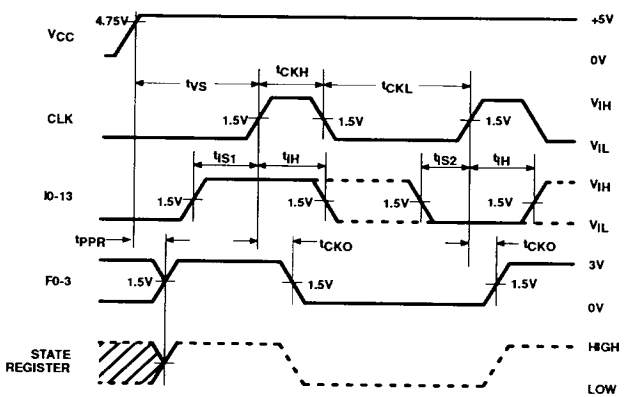
TERM	C	AND INPUT (Im) 13	12	11	10	9	8	7	6	5	4	3	2	1	0	PRESENT STATE (Ps) 7	6	5	4	3	2	1	0
48	A	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
49	•	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L

OPTION (P/E)	H
OR	

NEXT STATE (Ns) 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
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 Signetic's qualified programming equipment.



Test Circuit Timing Diagram

TERM	C	AND INPUT (Im) 13	12	11	10	9	8	7	6	5	4	3	2	1	0	PRESENT STATE (Ps) 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) 7	6	5	4	3	2	1	0	OUTPUT (Fr) 5	4	3	2	1	0
–	–	–	–	–	–	–	–	–	–	–	–	–	–
–	–	–	–	–	–	–	–	–	–	–	–	–	–

Test Array Deleted

SNAP RESOURCE SUMMARY DESIGNATIONS