Programmable logic sequencer (16 × 45 × 12)

PLS159A

DESCRIPTION

The PLS159A is a 3-State output, registered logic element combining AND/OR gate arrays with clocked J-K flip-flops. These J-K flip-flops are dynamically convertible to D-type via a "fold-back" inverting buffer and control gate F_C. It features 8 registered I/O outputs (F) in conjunction with 4 bidirectional I/O lines (B). These yield variable I/O gate and register configurations via control gates (D, L) ranging from 16 inputs to 12 outputs.

The AND/OR arrays consist of 32 logic AND gates, 13 control AND gates, and 21 OR gates with fusible link connections for programming I/O polarity and direction. All AND gates are linked to 4 inputs (I), bidirectional I/O lines (B), internal flip-flop outputs (Q), and Complement Array output ($\overline{C}$). The Complement Array consists of a NOR gate optionally linked to all AND gates for generating and propagating complementary AND terms.

On-chip T/C buffers couple either True (I, B, Q) or Complement ($\overline{I}$, $\overline{B}$, $\overline{Q}$, $\overline{C}$) input polarities to all AND gates, whose outputs can be optionally linked to all OR gates. Any of the 32 AND gates can drive bidirectional I/O lines (B), whose output polarity is individually programmable through a set of Ex-OR gates for implementing AND-OR or AND-NOR logic functions. Similarly, any of the 32 AND gates can drive the J-K inputs of all flip-flops. There are 4 AND gates for the Asynchronous Preset/Reset functions.

All flip-flops are positive edge-triggered and can be used as input, output or I/O (for interfacing with a bidirectional data bus) in conjunction with load control gates (L), steering inputs (I), (B), (Q) and programmable output select lines (E).

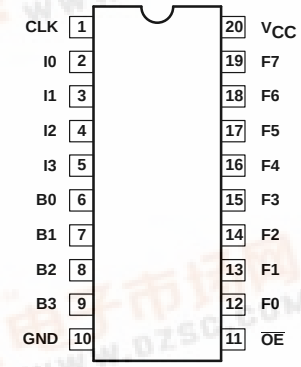
The PLS159A is field-programmable, enabling the user to quickly generate custom patterns using standard programming equipment.

FEATURES

- High-speed version of PLS159
- f_{MAX} = 18MHz
  - 25MHz clock rate
- Field-Programmable (Ni-Cr link)
- 4 dedicated inputs
- 13 control gates
- 32 AND gates
- 21 OR gates
- 45 product terms:
  - 32 logic terms
  - 13 control terms
- 4 bidirectional I/O lines
- 8 bidirectional registers
- J-K, T, or D-type flip-flops
- Power-on reset feature on all flip-flops (F_n = 1)
- Asynchronous Preset/Reset
- Complement Array
- Active-High or -Low outputs
- Programmable $\overline{OE}$ control
- Positive edge-triggered clock
- Input loading: –100µA (max.)
- Power dissipation: 750mW (typ.)
- TTL compatible
- 3-State outputs

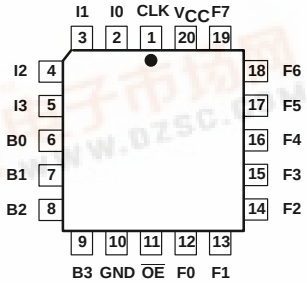
PIN CONFIGURATIONS

N Package



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

A Package



A = Plastic Leaded Chip Carrier

APPLICATIONS

- Random sequential logic
- Synchronous up/down counters
- Shift registers
- Bidirectional data buffers
- Timing function generators
- System controllers/synchronizers
- Priority encoder/registers

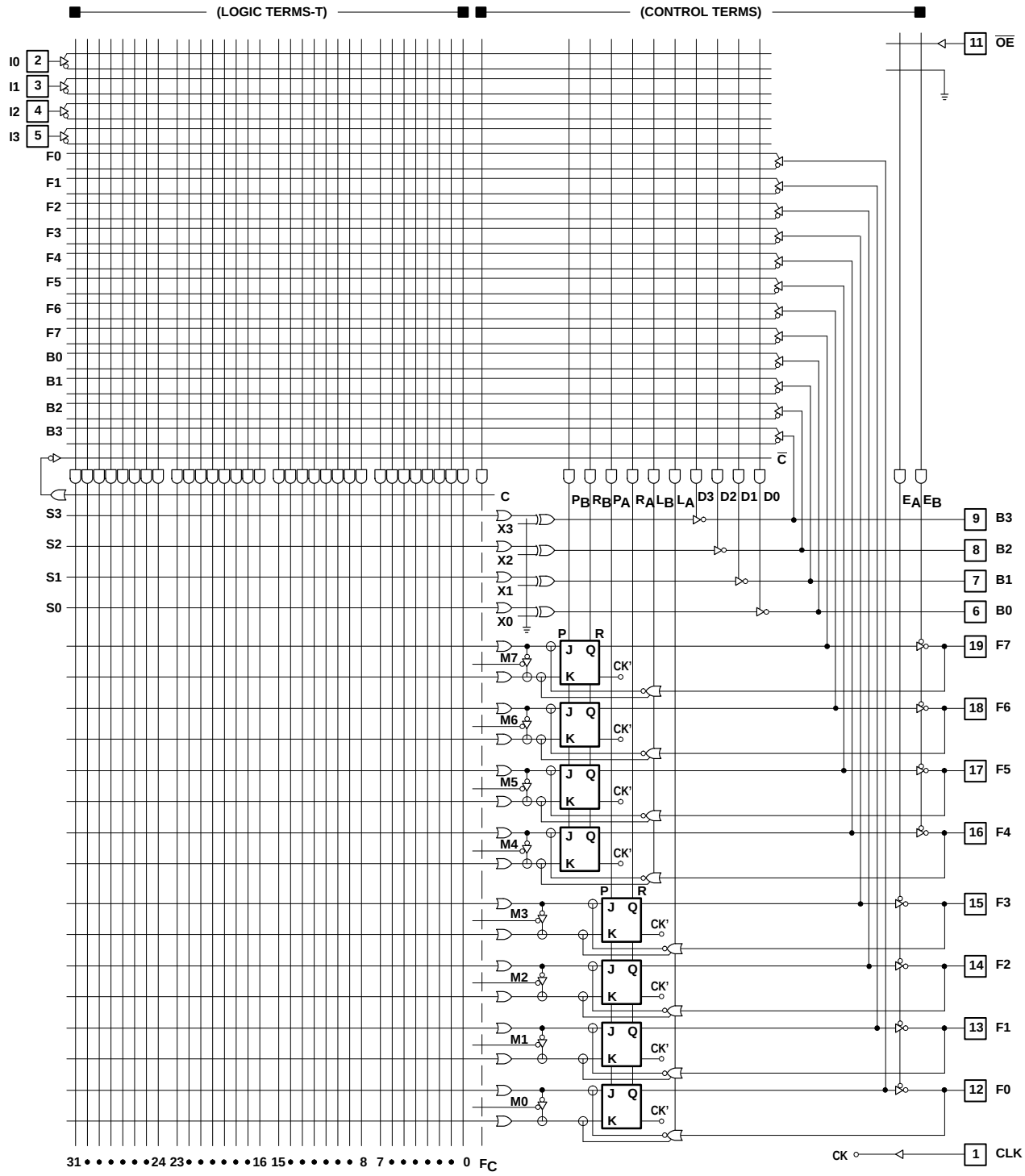
ORDERING INFORMATION

DESCRIPTION	ORDER CODE	DRAWING NUMBER
20-Pin Plastic Dual In-Line Package (300mil-wide)	PLS159AN	0408D
20-Pin Plastic Leaded Chip Carrier	PLS159AA	0400E

Programmable logic sequencer ($16 \times 45 \times 12$)

PLS159A

LOGIC DIAGRAM

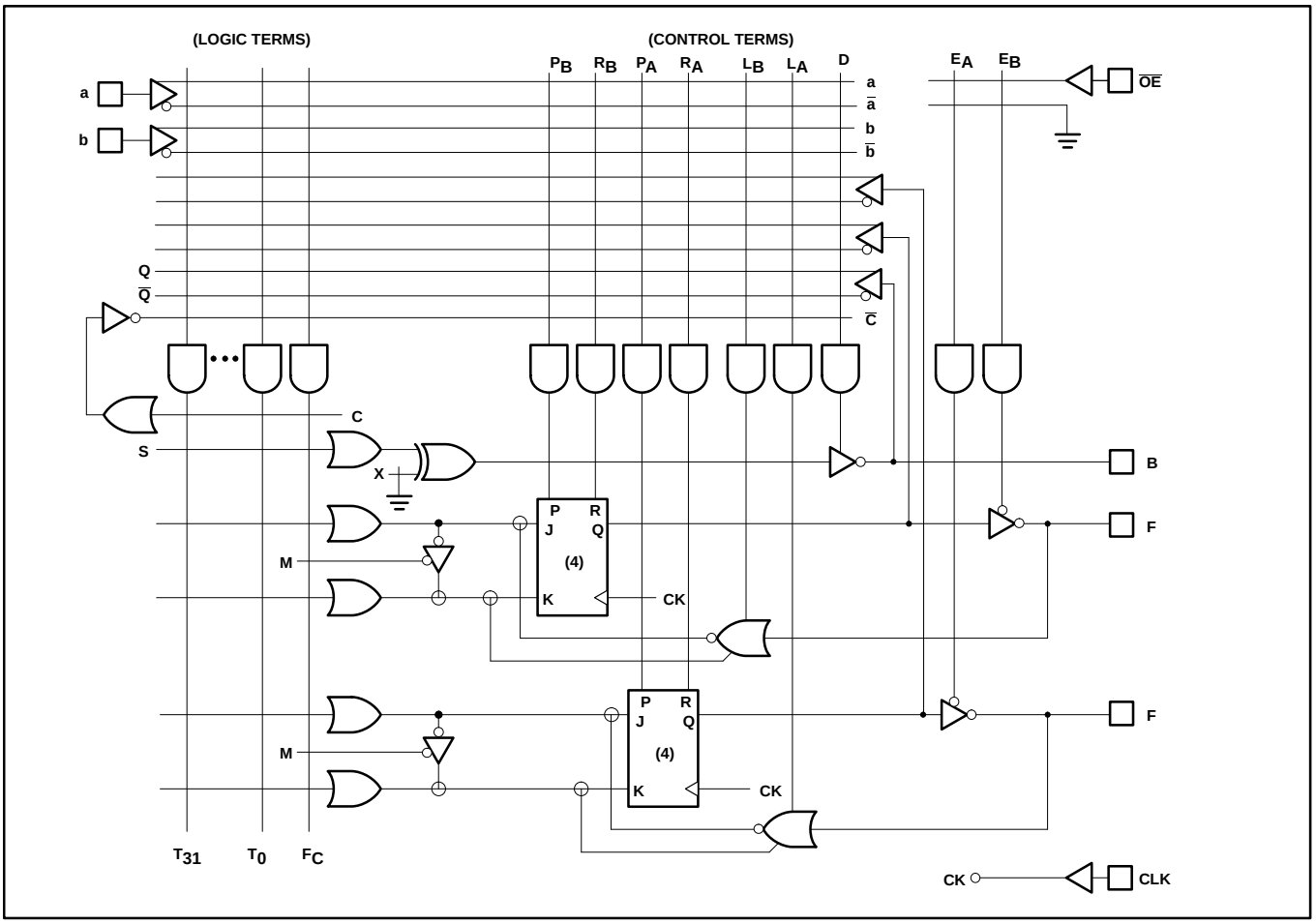


NOTES:
1. All OR gate inputs with a blown link float to logic “0”.
2. All other gates and control inputs with a blown link float to logic “1”.
3. ⊕ denotes WIRE-OR.
4. Programmable connection.

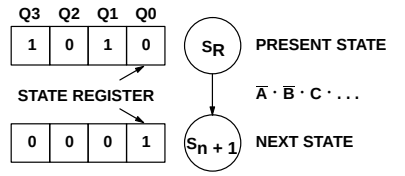
Programmable logic sequencer ($16 \times 45 \times 12$)

PLS159A

FUNCTIONAL DIAGRAM



LOGIC FUNCTION



$\overline{A} \cdot \overline{B} \cdot C \cdot \ldots$

SET Q_0: $J_0 = (Q_3 \cdot \overline{Q}_2 \cdot Q_1 \cdot \overline{Q}_0) \cdot \overline{A} \cdot \overline{B} \cdot C \ldots$
$K_0 = 0$

RESET Q_1: $J_1 = 0$
$K_1 = (Q_3 \cdot \overline{Q}_2 \cdot Q_1 \cdot \overline{Q}_0) \cdot \overline{A} \cdot \overline{B} \cdot C \ldots$

HOLD Q_2: $J_2 = 0$
$K_2 = 0$

TOGGLE Q_3: $J_3 = (Q_3 \cdot \overline{Q}_2 \cdot Q_1 \cdot \overline{Q}_0) \cdot \overline{A} \cdot \overline{B} \cdot C \ldots$
$K_3 = (Q_3 \cdot \overline{Q}_2 \cdot Q_1 \cdot \overline{Q}_0) \cdot \overline{A} \cdot \overline{B} \cdot C \ldots$

NOTE:
Similar logic functions are applicable for D and T mode flip-flops.

FLIP-FLOP TRUTH TABLE

$\overline{OE}$	L	CK	P	R	J	K	Q	F
H								Hi-Z
L	X	X	L	X	X	X	L	H
L	X	X	H	L	X	X	H	L
L	X	X	L	H	X	X	L	H
L	L	↑	L	L	L	L	Q	$\overline{Q}$
L	L	↑	L	L	L	H	L	H
L	L	↑	L	L	H	L	H	L
L	L	↑	L	L	H	H	$\overline{Q}$	Q
H	H	↑	L	L	L	H	L	H*
H	H	↑	L	L	H	L	H	L*
+10V	X	↑	X	X	L	H	L	H* *
	X	↑	X	X	H	L	H	L* *

NOTES:
1. Positive Logic:
   $J\text{-}K = T_0 + T_1 + T_2 \ldots\ldots\ldots\ldots T_{31}$
   $T_n = \overline{C} \cdot (I0 \cdot I1 \cdot I2 \ldots) \cdot (Q_0 \cdot Q_1 \ldots) \cdot (B0 \cdot B1 \cdot \ldots)$
2. ↑ denotes transition from Low to High level.
3. X = Don't care
4. * = Forced at F_n pin for loading the J-K flip-flop in the Input mode. The load control term, L_n must be enabled (HIGH) and the p-terms that are connected to the associated flip-flop must be forced LOW (disabled) during Preload.
5. At P = R = H, Q = H. The final state of Q depends on which is released first.
6. * * = Forced at F_n pin to load J-K flip-flop independent of program code (Diagnostic mode), 3-State B outputs.

Programmable logic sequencer ($16 \times 45 \times 12$) PLS159A

VIRGIN STATE

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

1. $\overline{OE}$ is always enabled.
2. Preset and Reset are always disabled.
3. All transition terms are disabled.
4. All flip-flops are in D-mode unless otherwise programmed to J-K only or J-K or D (controlled).
5. All B pins are inputs and all F pins are outputs unless otherwise programmed.

CAUTION: PLS159A PROGRAMMING ALGORITHM

The programming voltage required to program the PLS159A is higher (17.5V) than that required to program the PLS159 (14.5V). Consequently, the PLS159 programming algorithm will not program the PLS159A. Please exercise caution when accessing programmer device codes to insure that the correct algorithm is used.

THERMAL RATINGS

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

ABSOLUTE MAXIMUM RATINGS[1]

SYMBOL	PARAMETER	RATINGS		UNIT
		MIN	MAX	
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.

DC ELECTRICAL CHARACTERISTICS

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

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	V_{CC} = MIN, I_{IN} = –12mA		–0.8	–1.2	V
Output voltage[2]						
V_{OH}	High	V_{CC} = MIN, I_{OH} = –2mA	2.4			V
V_{OL}	Low	I_{OL} = 10mA		0.35	0.5	V
Input current						
I_{IH}	High	V_{CC} = MAX, V_{IN} = 5.5V		<1	80	µA
I_{IL}	Low	V_{IN} = 0.45V		–10	–100	µA
Output current						
$I_{O(OFF)}$	Hi-Z state[4, 7]	V_{CC} = MAX, V_{OUT} = 5.5V		1	80	µA
		V_{OUT} = 0.45V		–1	–140	µA
I_{OS}	Short circuit[3, 5]	V_{OUT} = 0V	–15		–70	mA
I_{CC}	V_{CC} supply current[6]	V_{CC} = MAX		150	190	mA
Capacitance						
C_{IN}	Input	V_{CC} = 5.0V, V_{IN} = 2.0V		8		pF
C_{OUT}	Output	V_{OUT} = 2.0V		15		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_{IH} applied to $\overline{OE}$.
5. Duration of short circuit should not exceed 1 second.
6. I_{CC} is measured with the $\overline{OE}$ input grounded, all other inputs at 4.5V and the outputs open.
7. Leakage values are a combination of input and output leakage.

Programmable logic sequencer ($16 \times 45 \times 12$)

PLS159A

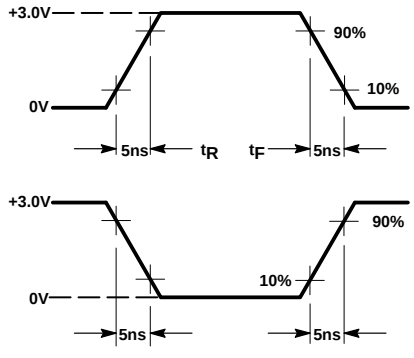
AC ELECTRICAL CHARACTERISTICS

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

SYMBOL	PARAMETER	FROM	TO	TEST CONDITION	LIMITS			UNIT
					MIN	TYP[1]	MAX	
Pulse width								
t_{CKH}	Clock[2] High	CK +	CK –	C_L = 30pF	20	15		ns
t_{CKL}	Clock Low	CK –	CK +	C_L = 30pF	20	15		ns
t_{CKP}	Period	CK +	CK +	C_L = 30pF	55	45		ns
t_{PRH}	Preset/Reset pulse	(I,B) –	(I,B) +	C_L = 30pF	35	30		ns
Setup time[5]								
t_{IS1}	Input	(I,B) ±	CK +	C_L = 30pF	35	30		ns
t_{IS2}	Input (through F_n)	F ±	CK +	C_L = 30pF	15	10		ns
t_{IS3}	Input (through Complement Array)[4]	(I,B) ±	CK +	C_L = 30pF	55	45		ns
Hold time								
t_{IH1}	Input	(I,B) ±	CK +	C_L = 30pF	0	–5		ns
t_{IH2}	Input (through F_n)	F ±	CK +	C_L = 30pF	15	10		ns
Propagation delay								
t_{CKO}	Clock	CK +	F ±	C_L = 30pF		15	20	ns
t_{OE1}	Output enable[3]	$\overline{OE}$ –	F –	C_L = 30pF		20	30	ns
t_{OD1}	Output disable[3]	$\overline{OE}$ +	F +	C_L = 5pF		20	30	ns
t_{PD}	Output	(I,B) ±	B ±	C_L = 30pF		25	35	ns
t_{OE2}	Output enable[3]	(I,B) +	B ±	C_L = 30pF		20	30	ns
t_{OD2}	Output disable[3]	(I,B) –	B +	C_L = 5pF		20	30	ns
t_{PRO}	Preset/Reset	(I,B) +	F ±	C_L = 30pF		35	45	ns
t_{PPR}	Power-on/preset	V_{CC} +	F –	C_L = 30pF		0	10	ns

NOTES:
1. All typical values are at V_{CC} = 5V, T_{amb} = +25°C.
2. To prevent spurious clocking, clock rise time (10% – 90%) ≤ 10ns.
3. 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.
4. When using the Complement Array t_{CKP} = 75ns (min).
5. Limits are guaranteed with 12 product terms maximum connected to each sum term line.

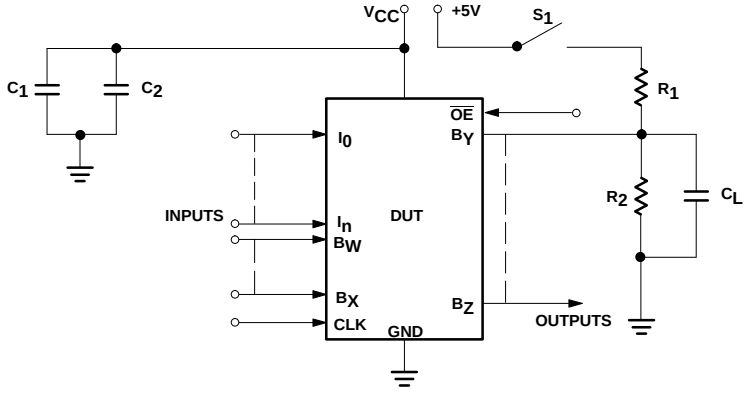
VOLTAGE WAVEFORMS



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

Input Pulses

TEST LOAD CIRCUIT

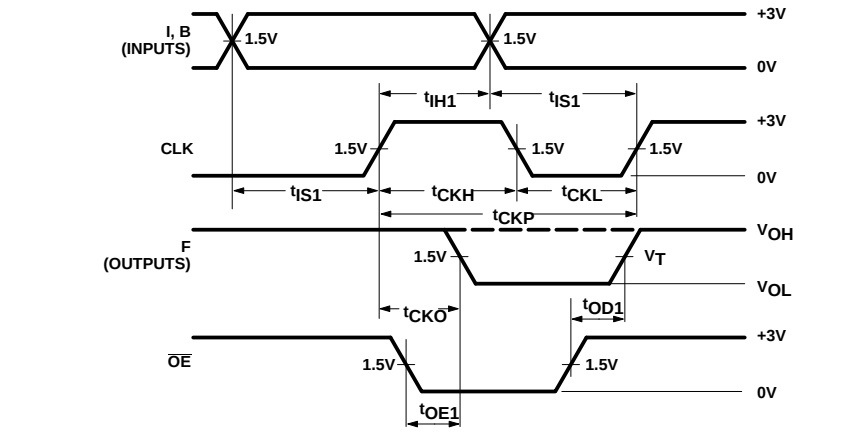


NOTE:
C_1 and C_2 are to bypass V_{CC} to GND.

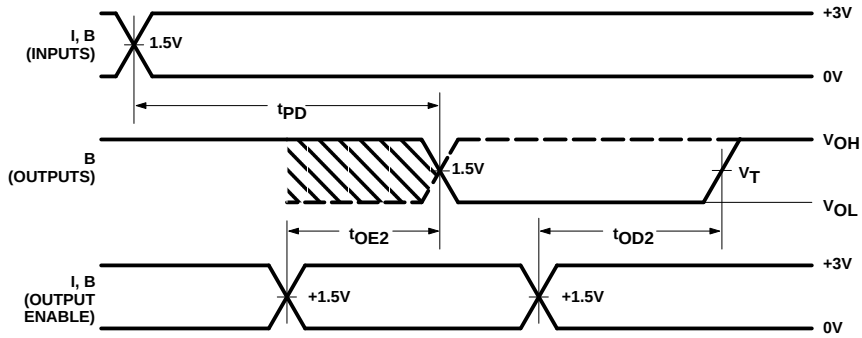
Programmable logic sequencer ($16 \times 45 \times 12$)

PLS159A

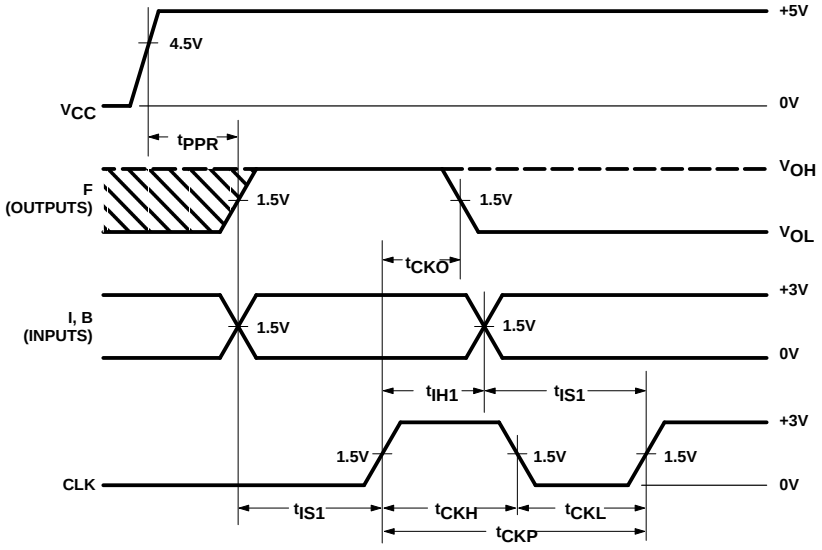
TIMING DIAGRAMS



Flip-Flop Outputs



Gate Outputs

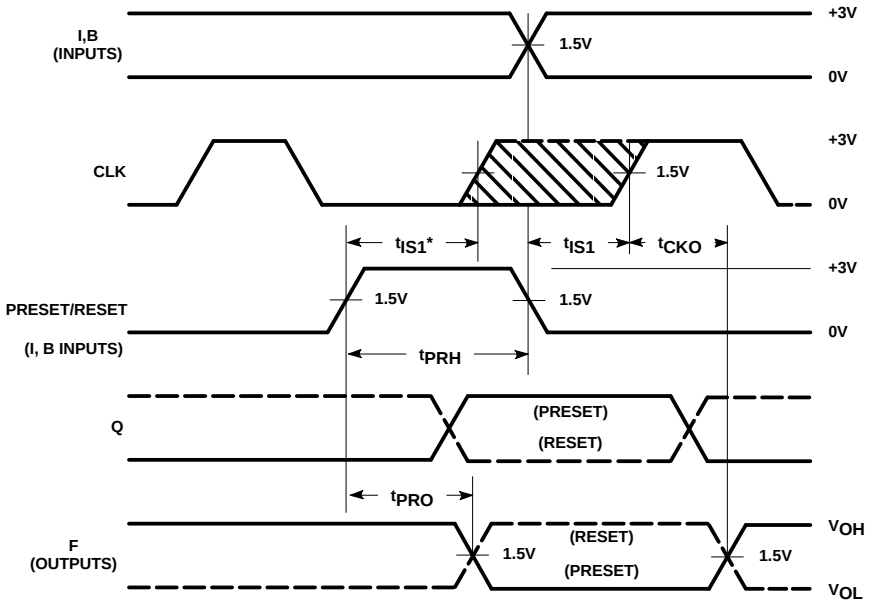


Power-On Reset

TIMING DEFINITIONS

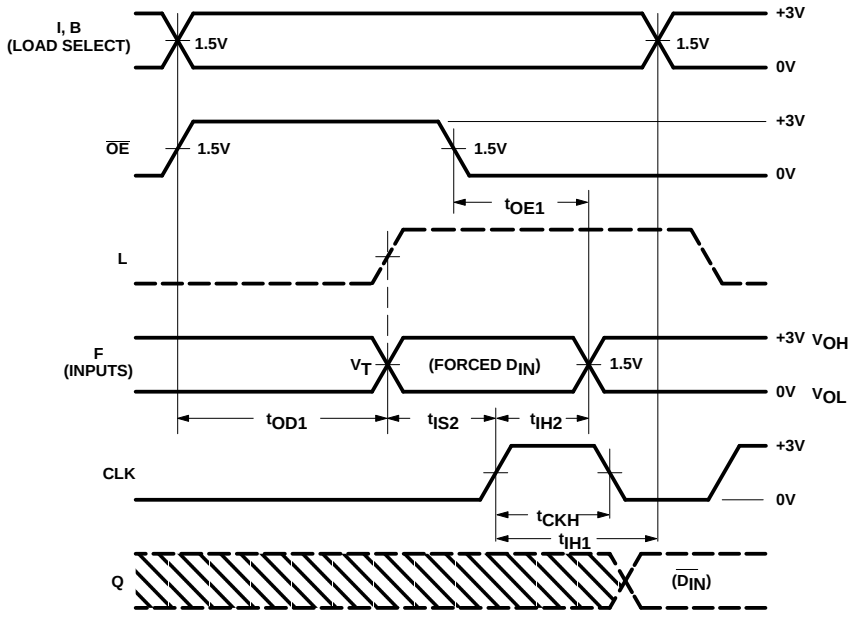
SYMBOL	PARAMETER
t_{CKH}	Width of input clock pulse.
t_{CKL}	Interval between clock pulses.
t_{CKP}	Clock period.
t_{PRH}	Width of preset input pulse.
t_{IS1}	Required delay between beginning of valid input and positive transition of clock.
t_{IS2}	Required delay between beginning of valid input forced at flip-flop output pins, and positive transition of clock.
t_{IH1}	Required delay between positive transition of clock and end of valid input data.
t_{IH2}	Required delay between positive transition of clock and end of valid input data forced at flip-flop output pins.
t_{CKO}	Delay between positive transition of clock and when outputs become valid (with $\overline{OE}$ Low).
t_{OE1}	Delay between beginning of Output Enable Low and when outputs become valid.
t_{OD1}	Delay between beginning of Output Enable High and when outputs are in the OFF-State.
t_{PPR}	Delay between V_{CC} (after power-on) and when flip-flop outputs become preset at “1” (internal Q outputs at “0”).
t_{PD}	Propagation delay between combinational inputs and outputs.
t_{OE2}	Delay between predefined Output Enable High, and when combinational outputs become valid.
t_{OD2}	Delay between predefined Output Enable Low and when combinational outputs are in the OFF-State.
t_{PRO}	Delay between positive transition of predefined Preset/Reset input, and when flip-flop outputs become valid.

TIMING DIAGRAMS (Continued)



* Preset and Reset functions override Clock. However, F outputs may glitch with the first positive Clock Edge if t_{IS1} cannot be guaranteed by the user.

Asynchronous Preset/Reset



Flip-Flop Input Mode

Programmable logic sequencer ($16 \times 45 \times 12$)

PLS159A

LOGIC PROGRAMMING

The PLS159A is fully supported by industry standard (JEDEC compatible) PLD CAD tools, including Philips Semiconductors' SNAP, Data I/O Corporation's ABEL™ and Logical Devices Inc.'s CUPL™ design software packages.

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

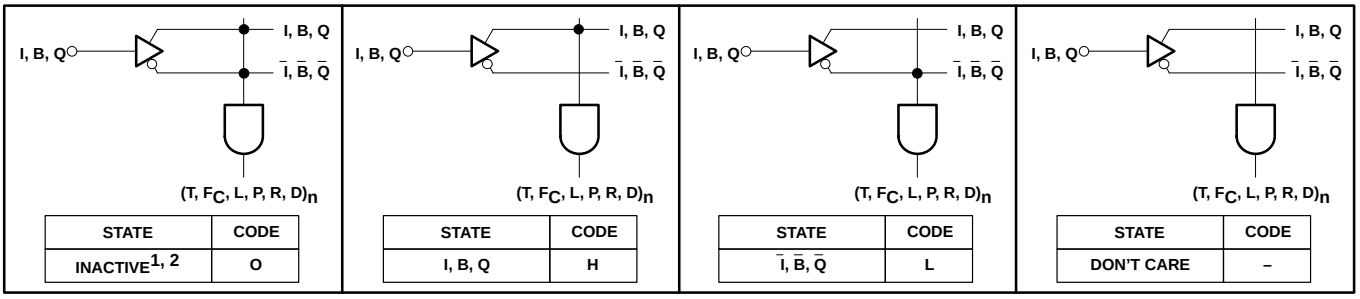
PLS159A logic designs can also be generated using the program table entry format detailed on the following pages. This program table entry format is supported by the Philips Semiconductors SNAP PLD design software package.

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.

"AND" ARRAY – (I), (B), (Qp)



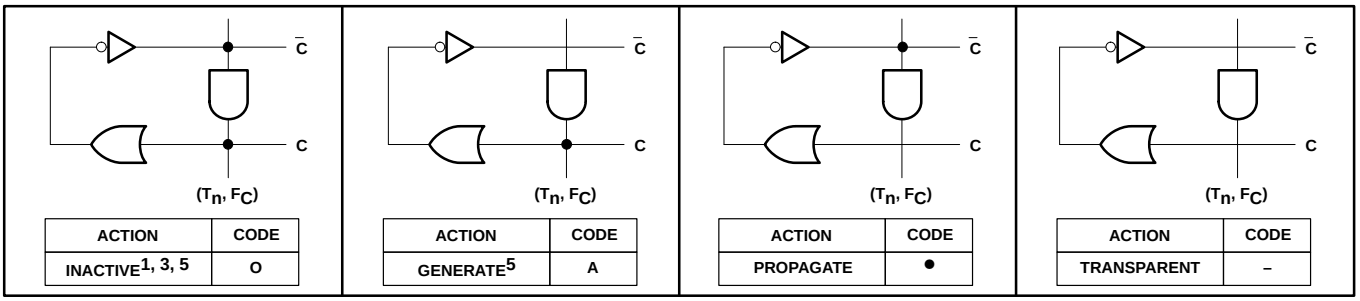
STATE	CODE
INACTIVE[1, 2]	O

STATE	CODE
I, B, Q	H

STATE	CODE
$\bar{I}, \bar{B}, \bar{Q}$	L

STATE	CODE
DON'T CARE	–

"COMPLEMENT" ARRAY – (C)



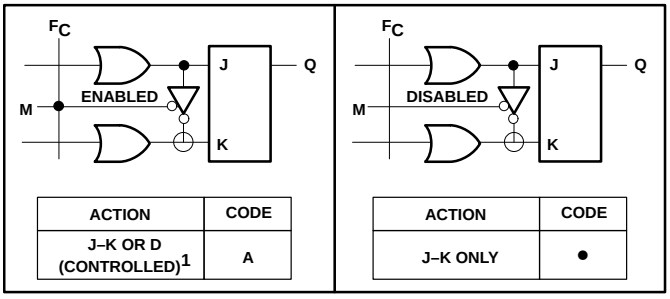
ACTION	CODE
INACTIVE[1, 3, 5]	O

ACTION	CODE
GENERATE[5]	A

ACTION	CODE
PROPAGATE	●

ACTION	CODE
TRANSPARENT	–

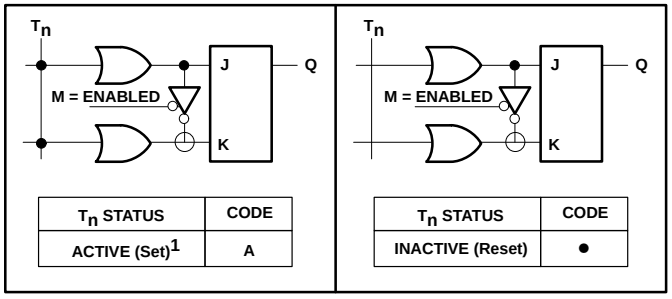
"OR" ARRAY – (F-F CONTROL MODE)



ACTION	CODE
J–K OR D (CONTROLLED)[1]	A

ACTION	CODE
J–K ONLY	●

"OR" ARRAY – (Q_n = D-Type)



T_n STATUS	CODE
ACTIVE (Set)[1]	A

T_n STATUS	CODE
INACTIVE (Reset)	●

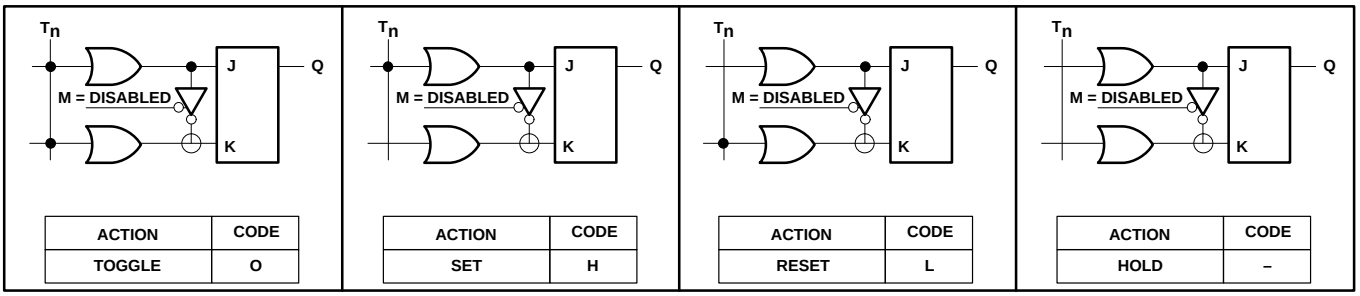
Notes on following page.

CAUTION:
THE PLS159A Programming Algorithm is different from the PLS159.

Programmable logic sequencer ($16 \times 45 \times 12$)

PLS159A

"OR" ARRAY – (Q_n = J-K Type)



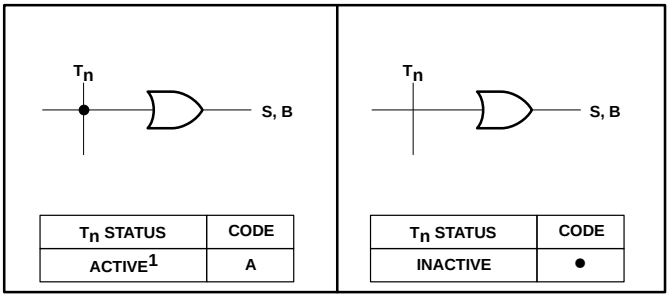
ACTION	CODE
TOGGLE	O

ACTION	CODE
SET	H

ACTION	CODE
RESET	L

ACTION	CODE
HOLD	–

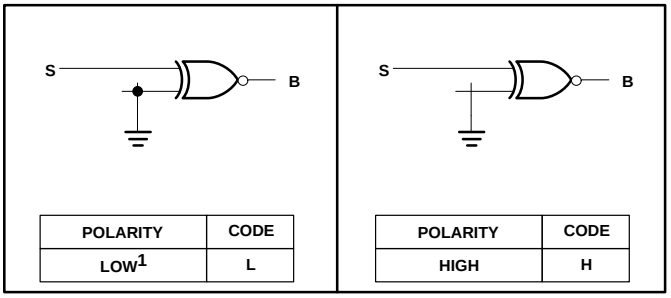
"OR" ARRAY – (S or B)



T_n STATUS	CODE
ACTIVE[1]	A

T_n STATUS	CODE
INACTIVE	•

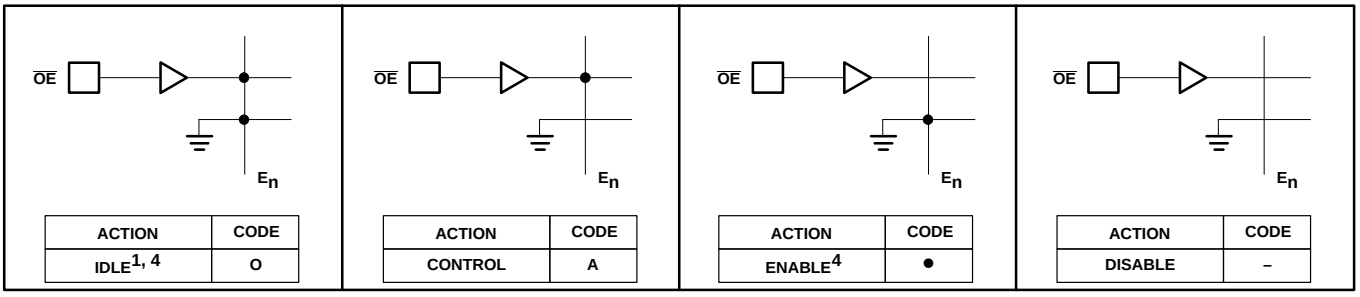
"EX-OR" ARRAY – (B)



POLARITY	CODE
LOW[1]	L

POLARITY	CODE
HIGH	H

"$\overline{OE}$" ARRAY – (E)



ACTION	CODE
IDLE[1, 4]	O

ACTION	CODE
CONTROL	A

ACTION	CODE
ENABLE[4]	•

ACTION	CODE
DISABLE	–

NOTES:
1. This is the initial unprogrammed state of all link pairs. It is normally associated with all unused (inactive) AND gates.
2. Any gate $(T, F_C, L, P, R, D)_n$ will be unconditionally inhibited if both of the I, B, or Q links are left intact.
3. To prevent oscillations, this state is not allowed for C link pairs coupled to active gates T_n, F_C.
4. E_n = O and E_n = • are logically equivalent states, since both cause F_n outputs to be unconditionally enabled.
5. These states are not allowed for control gates $(L, P, R, D)_n$ due to their lack of "OR" array links.

Programmable logic sequencer ($16 \times 45 \times 12$)

PLS159A

PROGRAM TABLE

AND		OR		CONTROL	
INACTIVE	O	ACTIVE	A	J/K	•
I, B, Q	H	INACTIVE	•	J/K or D (controlled)	A
$\overline{I}$, $\overline{B}$, $\overline{Q}$	L				
DON'T CARE	–				

I, B(I), Q(P)

P, R, B(O) (Q = D)

F/F MODE

IDLE	O
CONTROL	A
ENABLE	•
DISABLE	–

$E_{A, B}$

INACTIVE	O
GENERATE	A
PROPAGATE	•
TRANSPARENT	–

C

TOGGLE	O
SET	H
RESET	L
HOLD	–

(Q = J/K)

HIGH	H
LOW	L

(POL)

NOTES

1. The device is shipped with all links intact. Thus a background of entries corresponding to states of virgin links exists in the table, shown BLANK for clarity.
2. Program unused C, I, B, and Q bits in the AND array as (–). Program unused Q, B, P, and R bits in the OR array as (–) or (A), as applicable.
3. Unused Terms can be left blank.
4. Q (P) and Q (N) are respectively the present and next states of flip-flops Q.

F/F MODE	E_B	E_A	POLARITY

THIS PORTION TO BE COMPLETED BY SIGNETICS

CF (XXXX)_____

CUSTOMER SYMBOLIZED PART #_____

DATE RECEIVED_____

COMMENTS_____

CUSTOMER NAME_____

PURCHASE ORDER #_____

PHILIPS DEVICE #_____

TOTAL NUMBER OF PARTS_____

PROGRAM TABLE #_____ REV_____ DATE_____

TERM	AND C	AND I 3	AND I 2	AND I 1	AND I 0	AND B(I) 3	AND B(I) 2	AND B(I) 1	AND B(I) 0	AND Q(P) 7	AND Q(P) 6	AND Q(P) 5	AND Q(P) 4	AND Q(P) 3	AND Q(P) 2	AND Q(P) 1	AND Q(P) 0	(OR) Q(N) 7	(OR) Q(N) 6	(OR) Q(N) 5	(OR) Q(N) 4	(OR) Q(N) 3	(OR) Q(N) 2	(OR) Q(N) 1	(OR) Q(N) 0	(OR) B(O) 3	(OR) B(O) 2	(OR) B(O) 1	(OR) B(O) 0
0																													
1																													
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30																													
31																													
F_C																													
P_B																													
R_B																													
L_B																													
P_A																													
R_A																													
L_A																													
D3																													
D2																													
D1																													
D0																													
PIN		5	4	3	2	9	8	7	6	19	18	17	16	15	14	13	12												

Programmable logic sequencer ($16 \times 45 \times 12$) PLS159A

SNAP RESOURCE SUMMARY DESIGNATIONS