

**PAL devices**  
**16L8, 16R8, 16R6, 16R4**

**PLUS16R8D/-7 SERIES**

**FEATURES**

- Ultra high-speed
  - $t_{PD} = 7.5ns$  and  $f_{MAX} = 74MHz$  for the PLUS16R8-7 Series
  - $t_{PD} = 10ns$  and  $f_{MAX} = 60 MHz$  for the PLUS16R8D Series
- 100% functionally and pin-for-pin compatible with industry standard 20-pin PAL<sup>®</sup> ICs
- Power-up reset function to enhance state machine design and testability
- Design support provided via SNAP and other CAD tools for Series 20 PAL devices
- Field-programmable on industry standard programmers
- Security fuse
- Individual 3-State control of all outputs

**DESCRIPTION**

The Philips Semiconductors PLUS16XX family consists of ultra high-speed 7.5ns and 10ns versions of Series 20 PAL devices.

The PLUS16XX family is 100% functional and pin-compatible with the 16L8, 16R8, 16R6, and 16R4 Series devices.

The sum of products (AND-OR) architecture is comprised of 64 programmable AND gates and 8 fixed OR gates. Multiple bidirectional pins provide variable input/output pin ratios. Individual 3-State control of all outputs and registers with feedback (R8, R6, R4) is also provided. Proprietary designs can be protected by programming the security fuse.

The PLUS16R8, R6, and R4 have D-type flip-flops which are loaded on the Low-to-High transition of the clock input.

In order to facilitate state machine design and testing, a power-up reset function has been incorporated into these devices to reset all

internal registers to Active-Low after a specific period of time.

The Philips Semiconductors State-of-the-Art oxide isolation Bipolar fabrication process is employed to achieve high-performance operation.

The PLUS16XX family of devices are field programmable, enabling the user to quickly generate custom patterns using standard programming equipment. See the programmer chart for qualified programmers.

The SNAP software package from Philips Semiconductors supports easy design entry for the PLUS16XX series as well as other PLD devices from Philips Semiconductors. The PLUS16XX series are also supported by other standard CAD tools for PAL-type devices.

Order codes are listed in the Ordering Information table.

DEVICE NUMBER	DEDICATED INPUTS	COMBINATORIAL OUTPUTS	REGISTERED OUTPUTS
PLUS16L8	10	8 (6 I/O)	0
PLUS16R8	8	0	8
PLUS16R6	8	2 I/O	6
PLUS16R4	8	4 I/O	4

**ORDERING INFORMATION**

DESCRIPTION	ORDER CODE	DRAWING NUMBER
20-Pin Plastic Dual-In-Line 300mil-wide	PLUS16R8DN PLUS16R6DN PLUS16R4DN PLUS16L8DN PLUS16R8-7N PLUS16R6-7N PLUS16R4-7N PLUS16L8-7N	0408B
20-Pin Plastic Leaded Chip Carrier (PLCC)	PLUS16R8DA PLUS16R6DA PLUS16R4DA PLUS16L8DA PLUS16R8-7A PLUS16R6-7A PLUS16R4-7A PLUS16L8-7A	0400E

**NOTE:**

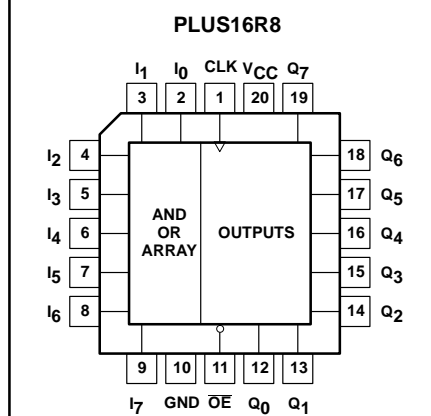
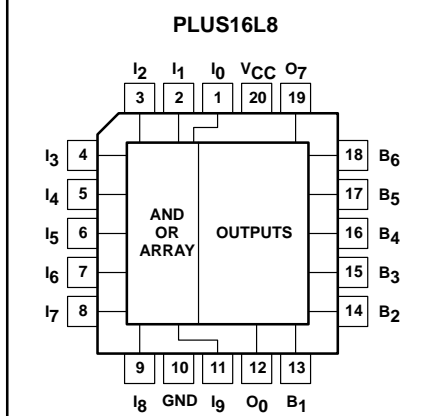
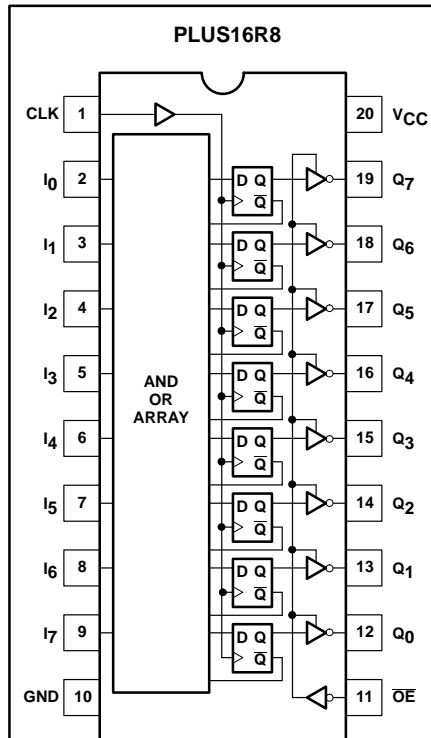
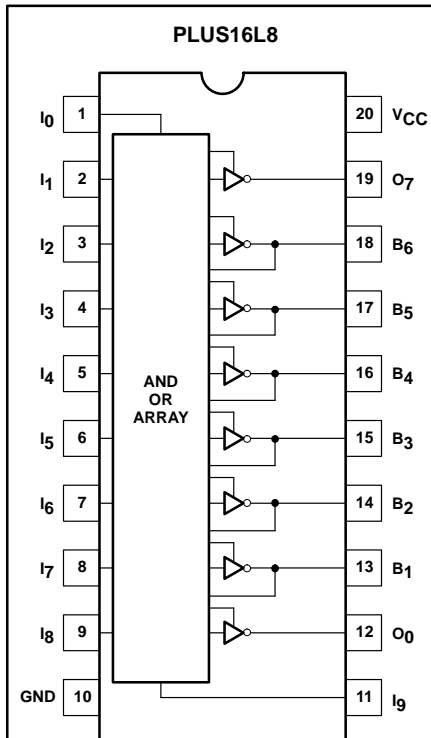
The PLUS16XX series of devices are also processed to military requirements for operation over the military temperature range. For specifications and ordering information, consult the Philips Semiconductors Military Data Book.



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**PIN CONFIGURATIONS**



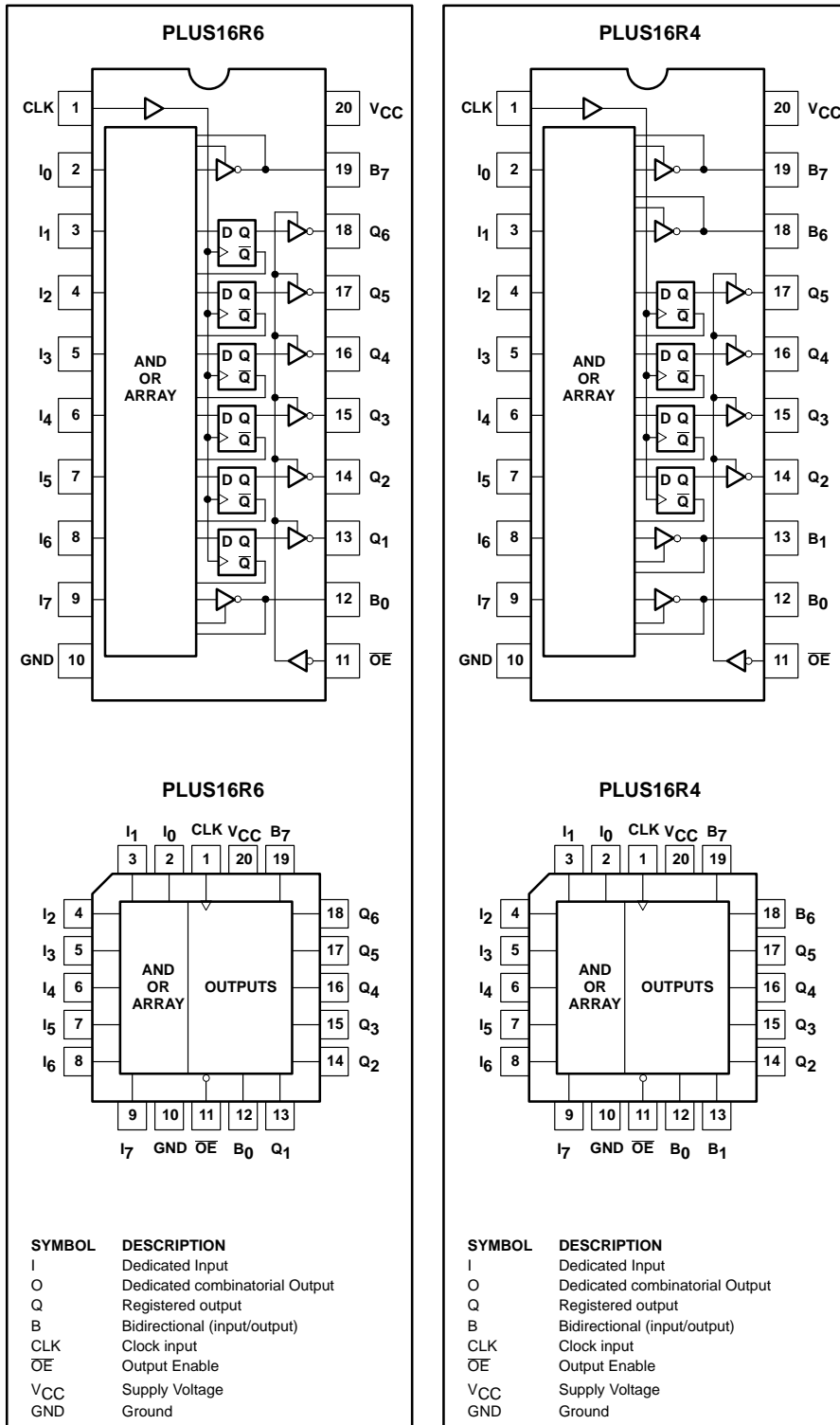
SYMBOL	DESCRIPTION
I	Dedicated Input
O	Dedicated combinatorial Output
Q	Registered output
B	Bidirectional (input/output)
CLK	Clock input
OE	Output Enable
V <sub>CC</sub>	Supply Voltage
GND	Ground

SYMBOL	DESCRIPTION
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**PLUS16R8D/-7 SERIES**

**PIN CONFIGURATIONS**

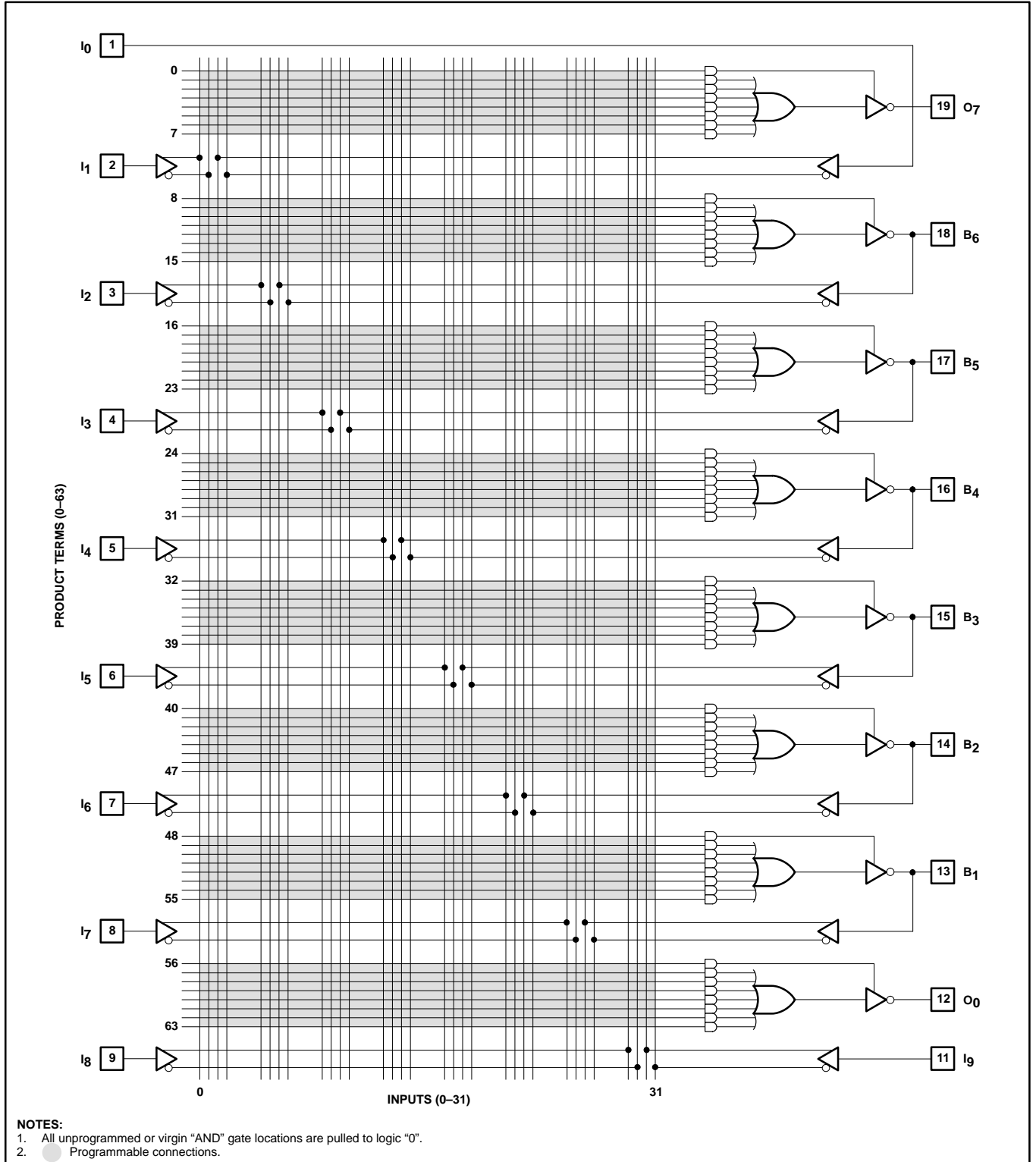


PAL devices  
16L8, 16R8, 16R6, 16R4

PLUS16R8D/-7 SERIES

LOGIC DIAGRAM

PLUS16L8

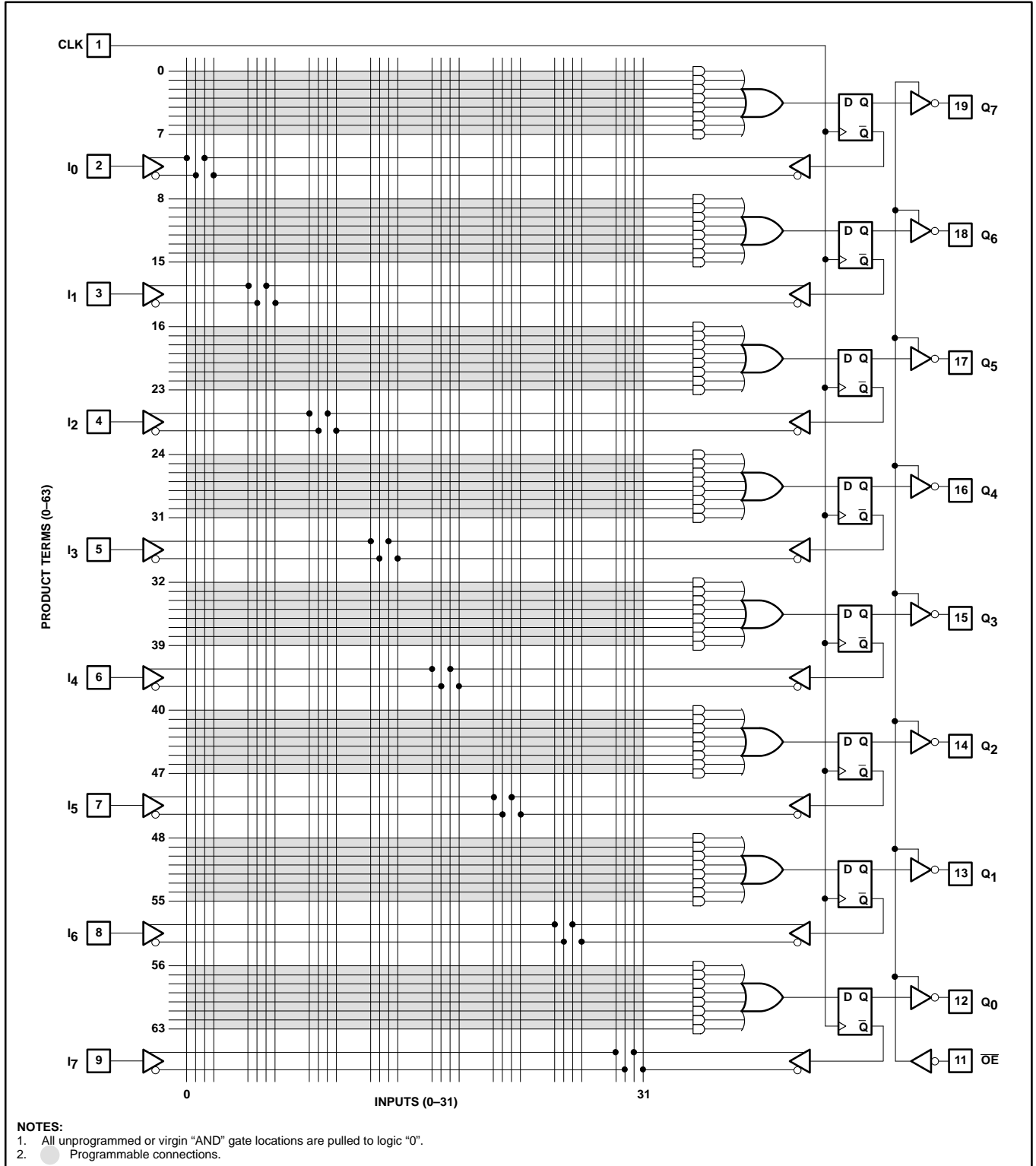


PAL devices  
16L8, 16R8, 16R6, 16R4

PLUS16R8D/-7 SERIES

LOGIC DIAGRAM

PLUS16R8

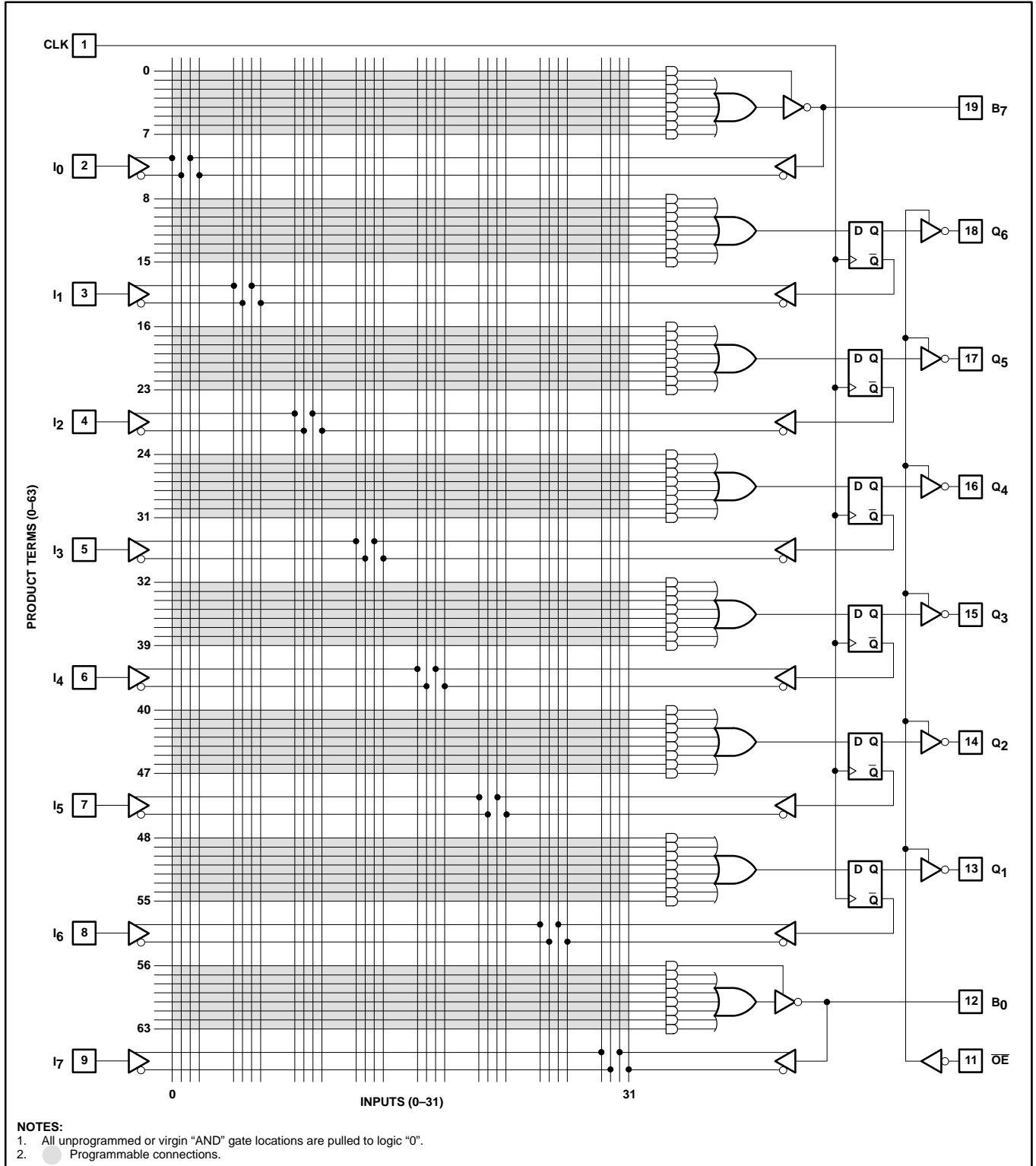


PAL devices  
16L8, 16R8, 16R6, 16R4

PLUS16R8D/-7 SERIES

LOGIC DIAGRAM

PLUS16R6

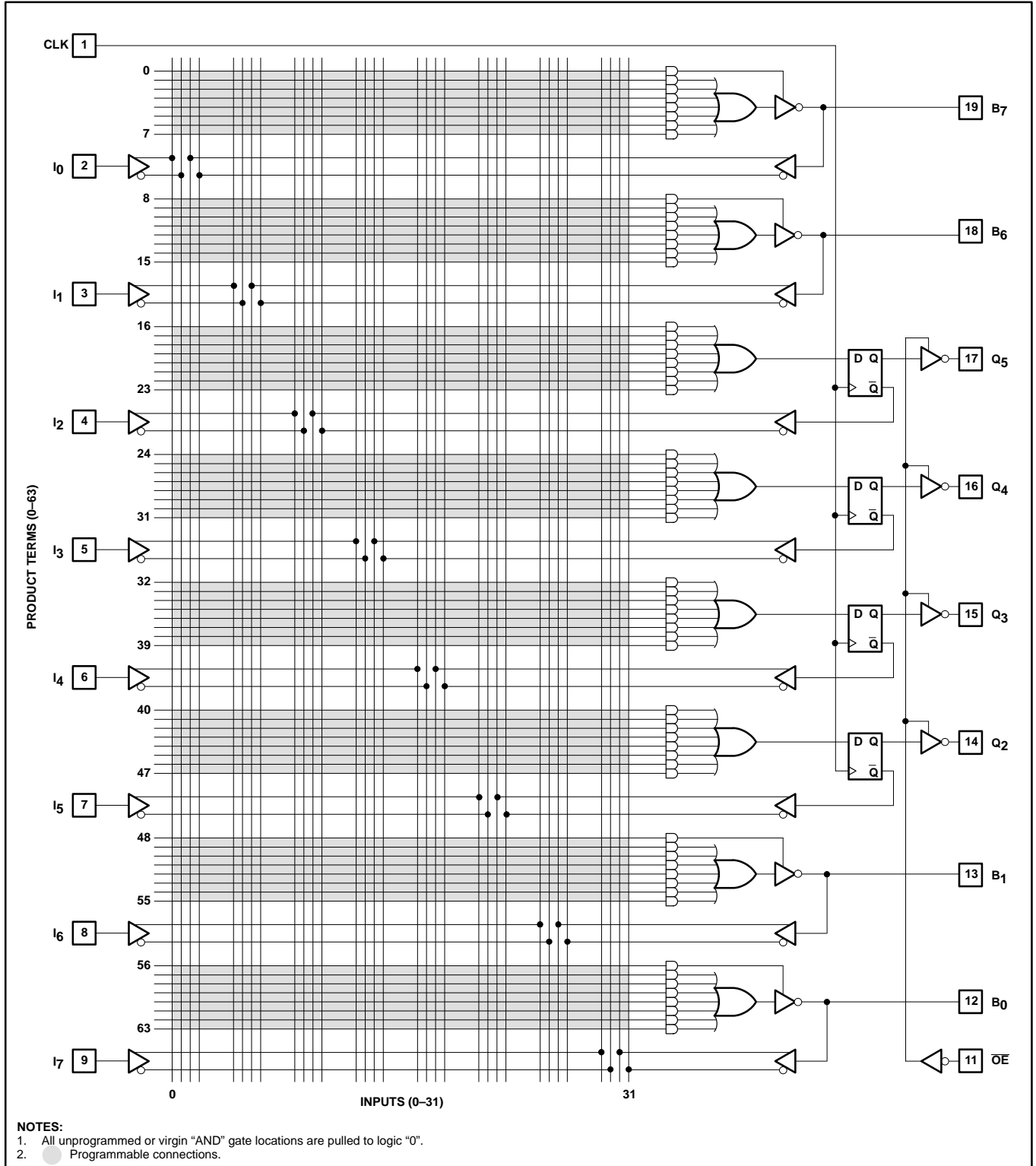


PAL devices  
16L8, 16R8, 16R6, 16R4

PLUS16R8D/-7 SERIES

LOGIC DIAGRAM

PLUS16R4



# PAL devices

## 16L8, 16R8, 16R6, 16R4

# PLUS16R8D/-7 SERIES

### FUNCTIONAL DESCRIPTIONS

The PLUS16XX series utilizes the familiar sum-of-products implementation consisting of a programmable AND array and a fixed OR array. These devices are capable of replacing an equivalent of four or more SSI/MSI integrated circuits to reduce package count and board area occupancy, consequently improving reliability and design cycle over Standard Cell or gate array options. By programming the security fuse, proprietary designs can be protected from duplication.

The PLUS16XX series consists of four PAL-type devices. Depending on the particular device type, there are a variable number of combinatorial and registered outputs available to the designer. The PLUS16L8 is a combinatorial part with 8 user configurable outputs (6 bidirectional), while the other three devices, PLUS16R8, PLUS16R6, PLUS16R4, have respectively 8, 6, and 4 output registers.

### 3-State Outputs

The PLUS16XX series devices also feature 3-State output buffers on each output pin which can be programmed for individual control of all outputs. The registered outputs (Qn) are controlled by an external input (/OE), and the combinatorial outputs (On, Bn)

use a product term to control the enable function.

### Programmable Bidirectional Pins

The PLUS16XX products feature variable Input/Output ratios. In addition to 8 dedicated inputs, each combinatorial output pin of the registered devices can be individually programmed as an input or output. The PLUS16L8 provides 10 dedicated inputs and 6 Bidirectional I/O lines that can be individually configured as inputs or outputs.

### Output Registers

The PLUS16R8 has 8 output registers, the 16R6 has 6, and the 16R4 has 4. Each output register is a D-type flip-flop which is loaded on the Low-to-High transition of the clock input. These output registers are capable of feeding the outputs of the registers back into the array to facilitate design of synchronous state machines.

### Power-up Reset

By resetting all flip-flops to a logic Low, as the power is turned on, the PLUS16R8, R6, R4 enhance state machine design and initialization capability.

### Software Support

Like other Programmable Logic Devices from Philips Semiconductors, the PLUS16XX

series are supported by SLICE, the PC-based software development tool from Philips Semiconductors. The PLUS16XX family of devices are also supported by standard CAD tools for PAL devices, including ABEL and CUPL.

SLICE is available free of charge to qualified users.

### Logic Programming

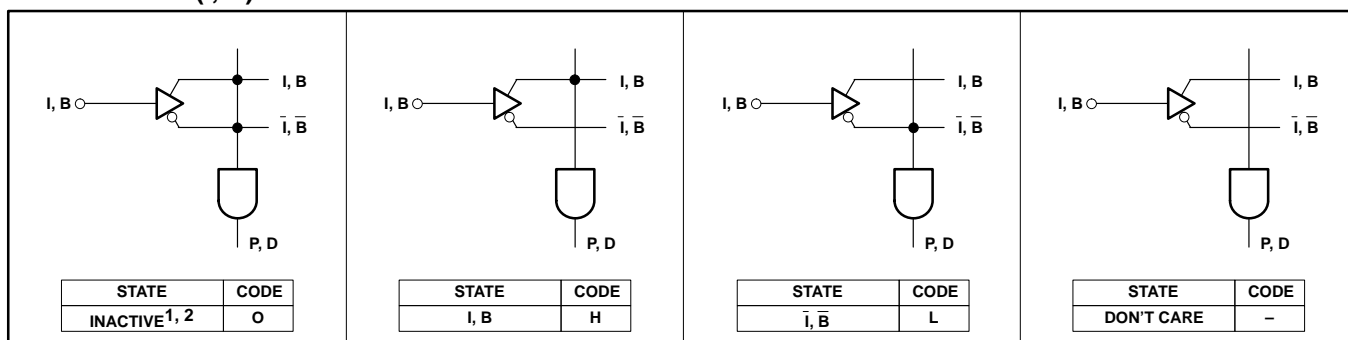
The PLUS16XX series is fully supported by industry standard (JEDEC compatible) PLD CAD tools, including Philips Semiconductors SNAP design software package. ABEL™ CUPL™ and PALASM® 90 design software packages also support the PLUS16XX architecture.

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

### Programming/Software Support

Ref to Section 9 (*Development Software*) and Section 10. (*Third-Party Programmer/Software Support*) of the PLD data handbook for additional information.

### AND ARRAY – (I, B)



### VIRGIN STATE

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

1. All outputs are at "H" polarity.
2. All P<sub>n</sub> terms are disabled.
3. All P<sub>n</sub> terms are active on all outputs.

ABEL is a trademark of Data I/O Corp.  
 CUPL is a trademark of Logical Devices, Inc.  
 PALASM is a registered trademark of AMD Corp.



**PAL devices**  
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**PLUS16R8D/-7 SERIES**

**ABSOLUTE MAXIMUM RATINGS<sup>1</sup>**

SYMBOL	PARAMETER	RATINGS		UNIT
		MIN	MAX	
V <sub>CC</sub>	Supply voltage	-0.5	+7	V <sub>DC</sub>
V <sub>IN</sub>	Input voltage	-1.2	+8.0	V <sub>DC</sub>
V <sub>OUT</sub>	Output voltage	-0.5	V <sub>CC</sub> + 0.5V	V <sub>DC</sub>
I <sub>IN</sub>	Input currents	-30	+30	mA
I <sub>OUT</sub>	Output currents		+100	mA
T <sub>stg</sub>	Storage temperature range	-65	+150	°C

**NOTE:**

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.

**OPERATING RANGES**

SYMBOL	PARAMETER	RATINGS		UNIT
		MIN	MAX	
V <sub>CC</sub>	Supply voltage	+4.75	+5.25	V <sub>DC</sub>
T <sub>amb</sub>	Operating free-air temperature	0	+75	°C

**THERMAL RATINGS**

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

PAL devices  
16L8, 16R8, 16R6, 16R4

## PLUS16R8D/-7 SERIES

**DC ELECTRICAL CHARACTERISTICS**
 $0^{\circ}\text{C} \leq T_{\text{amb}} \leq +75^{\circ}\text{C}, 4.75 \leq V_{\text{CC}} \leq 5.25\text{V}$ 

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN	TYP <sup>1</sup>	MAX	
<b>Input voltage<sup>2</sup></b>						
$V_{\text{IL}}$	Low	$V_{\text{CC}} = \text{MIN}$			0.8	V
$V_{\text{IH}}$	High	$V_{\text{CC}} = \text{MAX}$	2.0			V
$V_{\text{IC}}$	Clamp	$V_{\text{CC}} = \text{MIN}, I_{\text{IN}} = -18\text{mA}$		-0.8	-1.5	V
<b>Output voltage</b>						
$V_{\text{OL}}$	Low	$V_{\text{CC}} = \text{MIN}, V_{\text{IN}} = V_{\text{IH}} \text{ or } V_{\text{IL}}$ $I_{\text{OL}} = 24\text{mA}$			0.5	V
$V_{\text{OH}}$	High	$I_{\text{OH}} = -3.2 \text{ mA}$	2.4			V
<b>Input current</b>						
$I_{\text{IL}}$	Low <sup>3</sup>	$V_{\text{CC}} = \text{MAX}$ $V_{\text{IN}} = 0.40\text{V}$			-250	$\mu\text{A}$
$I_{\text{IH}}$	High <sup>3</sup>	$V_{\text{IN}} = 2.7\text{V}$			25	$\mu\text{A}$
$I_{\text{I}}$	Maximum input current	$V_{\text{IN}} = V_{\text{CC}} = V_{\text{CCMAX}}$			100	$\mu\text{A}$
<b>Output current</b>						
$I_{\text{OZH}}$	Output leakage	$V_{\text{CC}} = \text{MAX}$ $V_{\text{OUT}} = 2.7\text{V}$			100	$\mu\text{A}$
$I_{\text{OZL}}$	Output leakage	$V_{\text{OUT}} = 0.4\text{V}$			-100	$\mu\text{A}$
$I_{\text{OS}}$	Short circuit <sup>4, 5</sup>	$V_{\text{OUT}} = 0\text{V}$	-30		-90	mA
$I_{\text{CC}}$	$V_{\text{CC}}$ supply current	$V_{\text{CC}} = \text{MAX}$		160	180	mA
<b>Capacitance<sup>6</sup></b>						
$C_{\text{IN}}$	Input	$V_{\text{CC}} = 5\text{V}$ $V_{\text{OUT}} = 2.0\text{V}$		8		pF
$C_{\text{B}}$	I/O (B)	$V_{\text{OUT}} = 2\text{V}, f = 1\text{MHz}$		8		pF

**NOTES:**

- All typical values are at  $V_{\text{CC}} = 5\text{V}, T_{\text{amb}} = +25^{\circ}\text{C}$ .
- All voltage values are with respect to network ground terminal.
- Leakage current for bidirectional pins is the worst case of  $I_{\text{IL}}$  and  $I_{\text{OZL}}$  or  $I_{\text{IH}}$  and  $I_{\text{OZH}}$ .
- Test one at a time.
- Duration of short circuit should not exceed 1 second.
- These parameters are not 100% tested but periodically sampled.

PAL devices  
16L8, 16R8, 16R6, 16R4

## PLUS16R8D/-7 SERIES

**AC ELECTRICAL CHARACTERISTICS**
 $R_1 = 200\Omega$ ,  $R_2 = 390\Omega$ ,  $0^\circ\text{C} \leq T_{\text{amb}} \leq +75^\circ\text{C}$ ,  $4.75 \leq V_{\text{CC}} \leq 5.25\text{V}$ 

SYMBOL	PARAMETER	FROM	TO	LIMITS					UNIT
				-7			D		
				MIN <sup>1</sup>	TYP	MAX	MIN <sup>1</sup>	MAX	
<b>Pulse Width</b>									
$t_{\text{CKH}}$	Clock High	CK+	CK-	5			7		ns
$t_{\text{CKL}}$	Clock Low	CK-	CK+	5			7		ns
$t_{\text{CKP}}$	Period	CK+	CK+	10			14		ns
<b>Setup &amp; Hold time</b>									
$t_{\text{IS}}$	Input	Input or feedback	CK+	7			9		ns
$t_{\text{IH}}$	Input	CK+	Input or feedback	0			0		ns
<b>Propagation delay</b>									
$t_{\text{CKO}}$	Clock	CK±	Q±	3		6.5	3	7.5	ns
$t_{\text{CKF}}$	Clock <sup>3</sup>	CK±	$\bar{Q}$			3		6.5	ns
$t_{\text{PD}}$	Output (16L8, R6, R4) <sup>2</sup>	I, B	Output	3		7.5	3	10	ns
$t_{\text{OE1}}$	Output enable <sup>4</sup>	$\bar{OE}$	Output enable	3		8	3	10	ns
$t_{\text{OE2}}$	Output enable <sup>4,5</sup>	I	Output enable	3		10	3	10	ns
$t_{\text{OD1}}$	Output disable <sup>4</sup>	$\bar{OE}$	Output disable	3		8	3	10	ns
$t_{\text{OD2}}$	Output disable <sup>4,5</sup>	I	Output disable	3		10	3	10	ns
$t_{\text{SKW}}$	Output	Q	Q			1		1	ns
$t_{\text{PPR}}$	Power-Up Reset	V <sub>CC+</sub>	Q+			10		10	ns
<b>Frequency (16R8, R6, R4)</b>									
$f_{\text{MAX}}$	No feedback $1/(t_{\text{CKL}} + t_{\text{CKH}})^6$				100		71.4		MHz
	Internal feedback $1/(t_{\text{IS}} + t_{\text{CKF}})^6$				90		64.5		MHz
	External feedback $1/(t_{\text{IS}} + t_{\text{CKO}})^6$				74		60.6		MHz

\* For definitions of the terms, please refer to the Timing/Frequency Definitions tables.

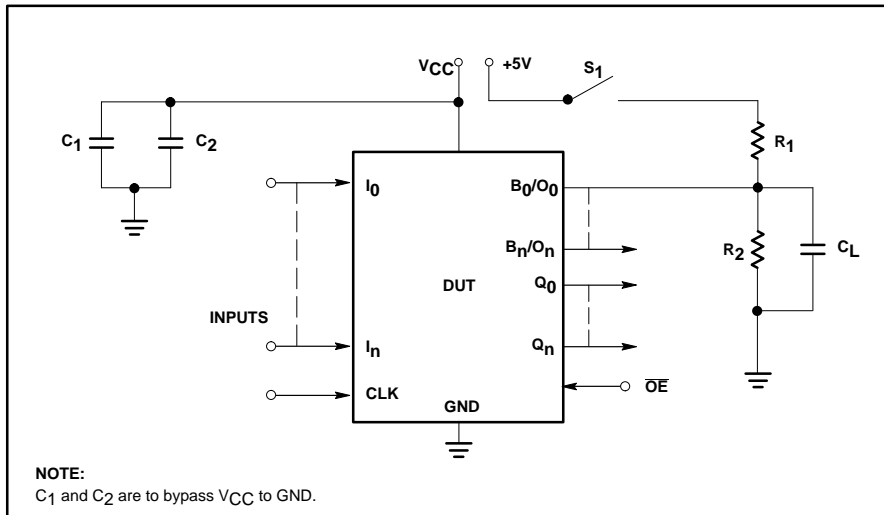
**NOTES:**

- CL = 0pF while measuring minimum output delays.
- $t_{\text{PD}}$  test conditions: CL = 50pF (with jig and scope capacitance),  $V_{\text{IH}} = 3\text{V}$ ,  $V_{\text{IL}} = 0\text{V}$ ,  $V_{\text{OH}} = V_{\text{OL}} = 1.5\text{V}$ .
- $t_{\text{CKF}}$  was calculated from measured Internal  $f_{\text{MAX}}$ .
- For 3-State output; output enable times are tested with  $C_L = 50\text{pF}$  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  $C_L = 5\text{pF}$ . High-to-High impedance tests are made to an output voltage of  $V_T = (V_{\text{OH}} - 0.5\text{V})$  with  $S_1$  open, and Low-to-High impedance tests are made to the  $V_T = (V_{\text{OL}} + 0.5\text{V})$  level with  $S_1$  closed.
- Same function as  $t_{\text{OE1}}$  and  $t_{\text{OD1}}$ , with the difference of using product term control.
- Not 100% tested, but calculated at initial characterization and at any time a modification in design takes place which may affect the frequency.

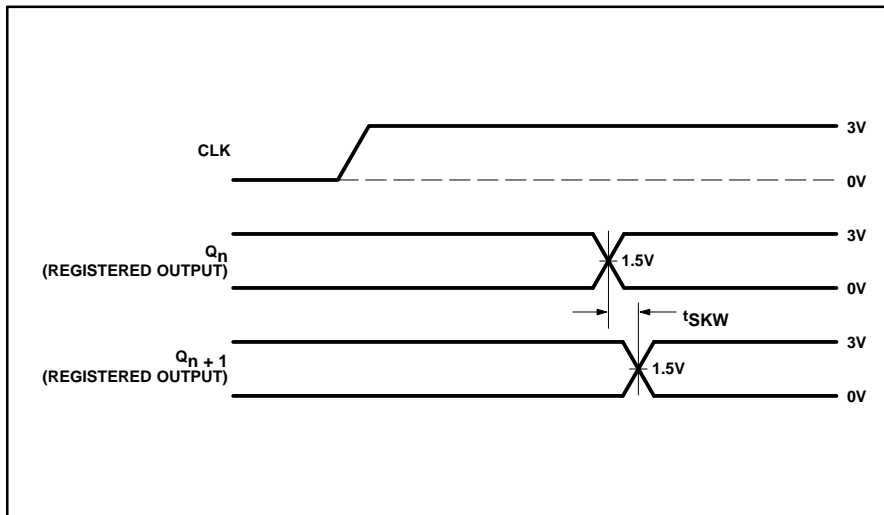
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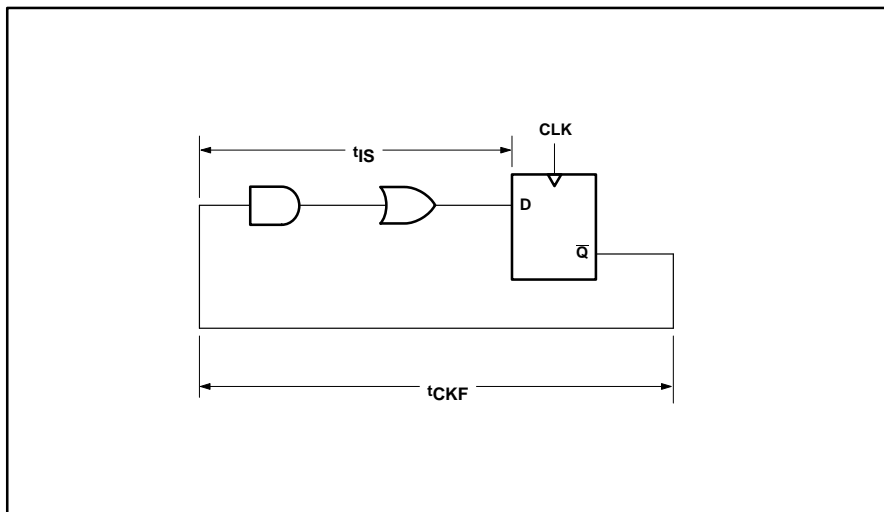
**TEST LOAD CIRCUIT**



**OUTPUT REGISTER SKEW**



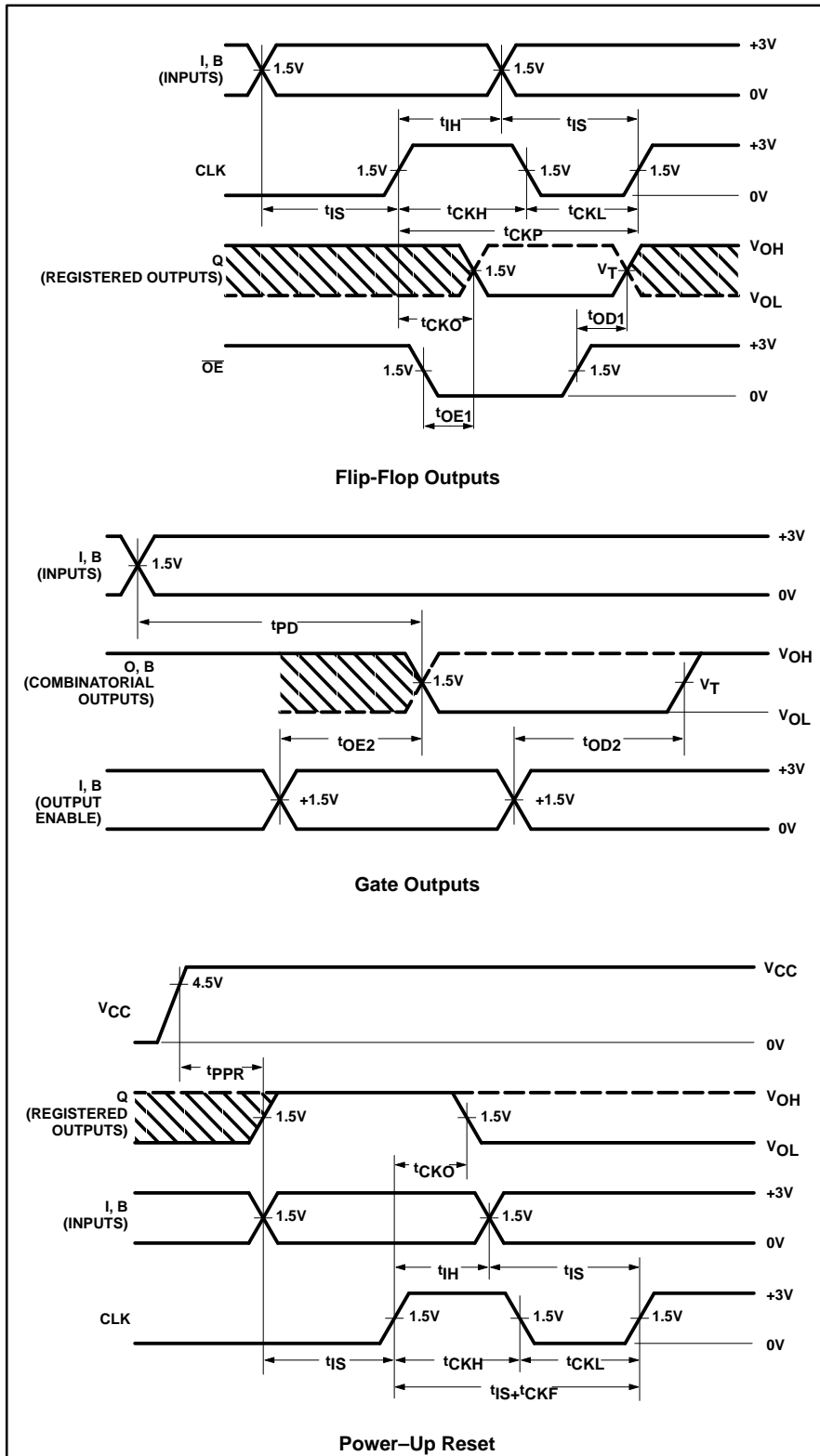
**CLOCK TO FEEDBACK PATH**



PAL devices  
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PLUS16R8D/-7 SERIES

TIMING DIAGRAMS<sup>1, 2</sup>



TIMING DEFINITIONS

SYMBOL	PARAMETER
$t_{CKH}$	Width of input clock pulse.
$t_{CKL}$	Interval between clock pulses.
$t_{CKP}$	Clock period.
$t_{IS}$	Required delay between beginning of valid input and positive transition of clock.
$t_{IH}$	Required delay between positive transition of clock and end of valid input data.
$t_{CKF}$	Delay between positive transition of clock and when internal $\bar{Q}$ output of flip-flop becomes valid.
$t_{CKO}$	Delay between positive transition of clock and when outputs become valid (with $\bar{OE}$ 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.
$t_{OE2}$	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.
$t_{PPR}$	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.

FREQUENCY DEFINITIONS

$f_{MAX}$	<p><b>No feedback:</b> Determined by the minimum clock period, <math>1/(t_{CKL} + t_{CKH})</math>.</p> <p><b>Internal feedback:</b> Determined by the internal delay from flip-flop outputs through the internal feedback and array to the flip-flop inputs, <math>1/(t_{IS} + t_{CKF})</math>.</p> <p><b>External feedback:</b> Determined by clock-to-output delay and input setup time, <math>1/(t_{IS} + t_{CKO})</math>.</p>
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NOTES:

1. Input pulse amplitude is 0V to 3V.
2. Input rise and fall times are 2.5ns.

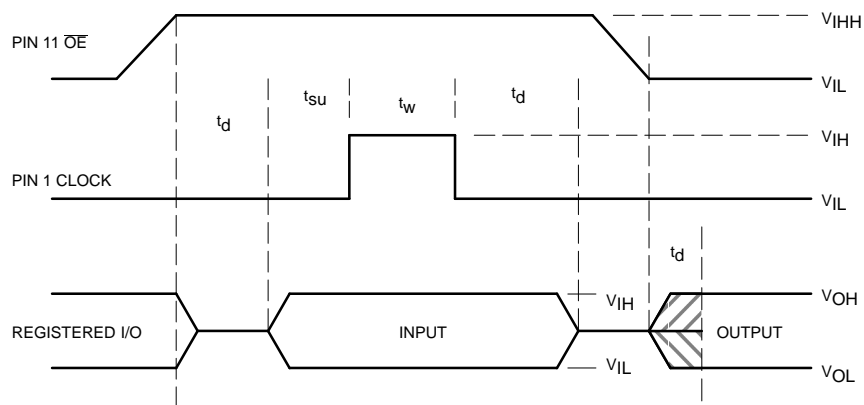
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**OUTPUT REGISTER PRELOAD**

The output registers can be preloaded to any desired state during device testing. This permits any state to be tested without having to step through the entire state-machine sequence. Each register is preloaded individually by following the steps given below.

- Step 1. With  $V_{CC}$  at 5V and Pin 1 at  $V_{IL}$ , raise Pin 11 to  $V_{IHH}$ .
- Step 2. Apply either  $V_{IL}$  or  $V_{IH}$  to the output corresponding to the register to be preloaded.
- Step 3. Pulse Pin 1, clocking in preload data.
- Step 4. Remove output voltage, then lower Pin 11 to  $V_{IL}$ . Preload can be verified by observing the voltage level at the output pin.



NOTE:  $t_d = t_{su} = t_w = 100\text{ns to } 1000\text{ns}$ .  
 $V_{IHH} = 10.25\text{V to } 10.75\text{V}$ .  
 Pin number references for DIP package.

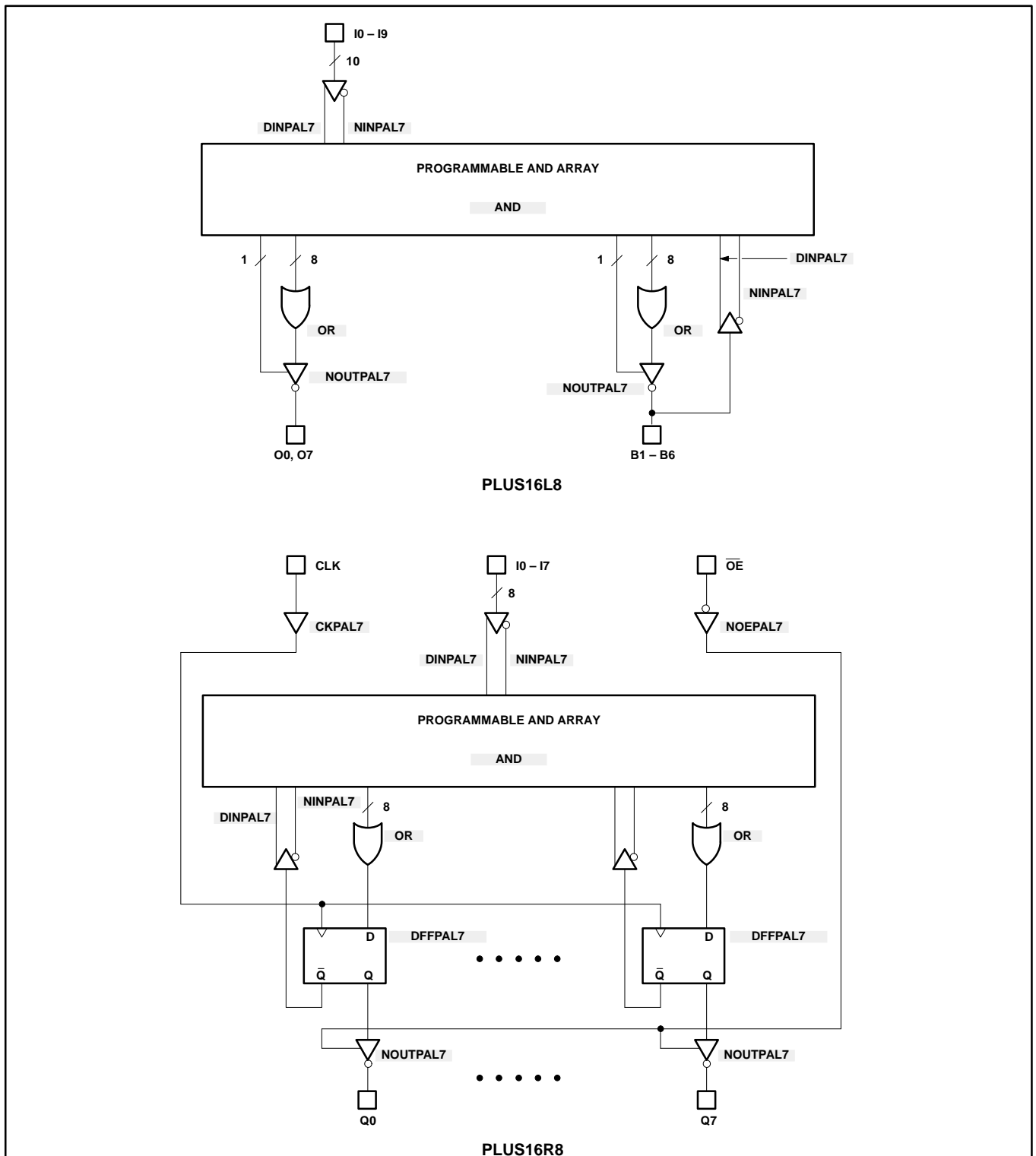
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**PLUS16R8D/-7 SERIES**

**PROGRAMMING/SOFTWARE**

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

**SNAP RESOURCE SUMMARY DESIGNATIONS**



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**PLUS16R8D/-7 SERIES**

**SNAP RESOURCE SUMMARY DESIGNATIONS (Continued)**

