National Semiconductor

Programmable Array Logic (PAL®) 20-Pin Small PAL Family

General Description

The 20-pin Small PAL family contains nine popular PAL architectures. The devices in the Small PAL family draw only 90 mA maximum supply current for standard power versions, and as little as 45 mA for Series A2 as compared to 180 mA in the 20-pin Medium PAL devices. These devices offer speeds as fast as 25 ns maximum propagation delay. National Semiconductor's Schottky TTL process with titanium tungsten fusible links provides high-speed user-programmable replacements for conventional SSI/MSI logic with significant chip-count reduction.

Programmable logic devices provide convenient solutions for a wide variety of application-specific functions, including random logic, custom decoders, state machines, etc. By programming fusible links to configure AND/OR gate connections, the system designer can implement custom logic as convenient sum-of-products Boolean functions. System prototyping and design iterations can be performed quickly using these off-the-shelf products. A large variety of programming units and software makes design development and functional testing of PAL devices quick and easy.

The Small PAL logic array has between 10 and 16 complementary input pairs and up to 8 combinatorial outputs generated by a single programmable AND-gate array with fixed OR-gate connections. The Small PAL family offers a variety of input/output combinations as shown in the Device Types table below. Security fuses can be programmed to prevent direct copying of proprietary logic patterns.

Features

- As fast as 25 ns maximum propagation delay
- User-programmable replacement for TTL logic
- Large variety of JEDEC-compatible programming equipment available
- Fully supported by National PLAN™ development software
- Security fuse prevents direct copying of logic patterns

Device Types

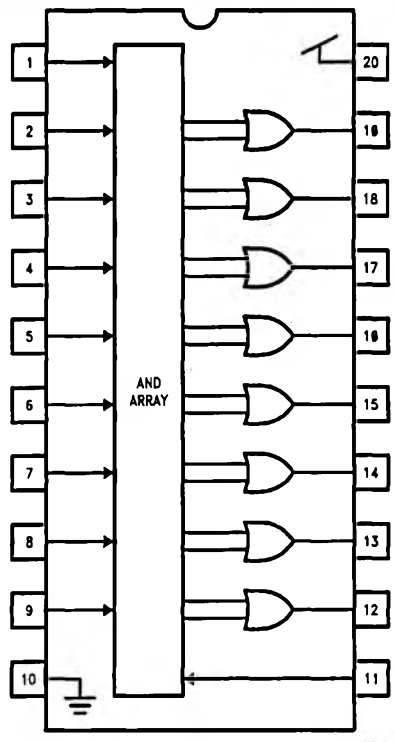
Device Type	Dedicated Inputs	Combinatorial Outputs
PAL10H8/PAL10L8	10	8
PAL12H6/PAL12L6	12	6
PAL14H4/PAL14L4	14	4
PAL16H2/PAL16L2	16	2
PAL16C1	16	1 Pair

Speed/Power Versions

Series	Example	Commercial		Military	
		t_{PD}	I_{CC}	t_{PD}	I_{CC}
Standard	PAL10H8	35 ns	90 mA	45 ns	90 mA
A	PAL10H8A	25 ns*	90 mA	30 ns*	90 mA
A2	PAL10H8A2	35 ns*	45 mA	45 ns	45 mA

*Except PAL16C1A t_{PD} = 30 ns Commercial, 35 ns Military.
PAL16C1A2 t_{PD} = 40 ns Commercial.

Block Diagram—PAL10H8



TL/L/9995–1

Standard Series (PAL10H8, PAL12H6, PAL14H4, PAL16H2, PAL10L8, PAL12L6, PAL14L4, PAL16L2, PAL16C1)

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage (V_{CC}) (Note 2)	−0.5 to +7.0V
Input Voltage (Notes 2 and 3)	−1.5 to +5.5V
Off-State Output Voltage (Note 2)	−1.5 to +5.5V
Input Current (Note 2)	−30.0 mA to +5.0 mA
Output Current (I_{OL})	+100 mA
Storage Temperature	−65°C to +150°C
Ambient Temperature with Power Applied	−65°C to +125°C
Junction Temperature	−65°C to +150°C

Recommended Operating Conditions

Symbol	Parameter	Military			Commercial			Units
		Min	Nom	Max	Min	Nom	Max	
V_{CC}	Supply Voltage	4.5	5	5.5	4.75	5	5.25	V
T_A	Operating Free-Air Temperature	−55			0		75	°C
T_C	Operating Care Temperature			125				°C

Electrical Characteristics Over Recommended Operating Conditions (Note 4)

Symbol	Parameter	Test Conditions			Min	Typ	Max	Units
V_{IL}	Low Level Input Voltage (Note 5)						0.8	V
V_{IH}	High Level Input Voltage (Note 5)				2			V
V_{IC}	Input Clamp Voltage	V_{CC} = Min, I = −18 mA				−0.8	−1.5	V
I_{IL}	Low Level Input Current	V_{CC} = Max, V_I = 0.4V				−0.02	−0.25	mA
I_{IH}	High Level Input Current	V_{CC} = Max, V_I = 2.4V					25	μA
I_I	Maximum Input Current	V_{CC} = Max, V_I = 5.5V					1	mA
V_{OL}	Low Level Output Voltage	V_{CC} = Min	I_{OL} = 8 mA			0.3	0.5	V
V_{OH}	High Level Output Voltage	V_{CC} = Min	I_{OH} = −2 mA	MIL	2.4	2.9		V
			I_{OH} = −3.2 mA	COM				
I_{OS}	Output Short-Circuit Current (Note 6)	V_{CC} = 5V, V_O = 0V			−30	−70	−130	mA
I_{CC}	Supply Current	V_{CC} = Max, Outputs Open				55	90	mA

Note 1: Absolute maximum ratings are those values beyond which the device may be permanently damaged. Proper operation is not guaranteed outside the specified recommended operating conditions.

Note 2: Some device pins may be raised above these limits during programming operations according to the applicable specification.

Note 3: It is recommended that precautions be taken to minimize electrostatic discharge when handling and testing this product. Pins 1 and 11 are connected directly to the security fuses, and the security fuses may be damaged preventing subsequent programming and verification operations.

Note 4: All typical values are for V_{CC} = 5.0V and T_A = 25°C.

Note 5: These are absolute voltages with respect to the ground pin on the device and include all overshoots due to system and/or tester noise. Do not attempt to test these values without suitable equipment.

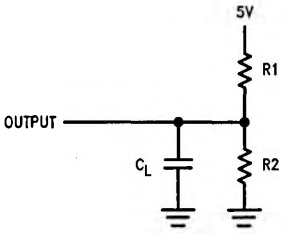
Note 6: To avoid Invalid readings in other parameter tests, it is preferable to conduct the I_{OS} test last. To minimize internal heating, only one output should be shorted at a time with a maximum duration of 1.0 second each. Prolonged shorting of a high output may raise the chip temperature above normal and permanent damage may result.

Standard Series (PAL10H8, PAL12H6, PAL14H4, PAL16H2, PAL10L8, PAL12L6, PAL14L4, PAL16L2, PAL16C1)
(Continued)

Switching Characteristics Over Recommended Operating Conditions

Symbol	Parameter	Test Conditions	Military			Commercial			Units
			Min	Typ	Max	Min	Typ	Max	
t_{PD}	Input to Output	C_L = 50 pF		25	45		25	35	ns

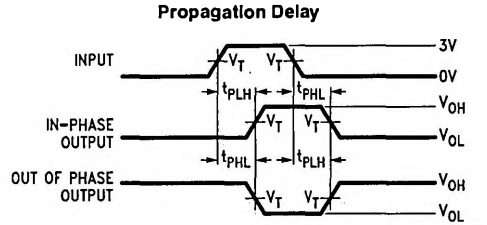
Test Load



MIL/COM
R1 = 560
R2 = 1.1K

TL/L/9995-2

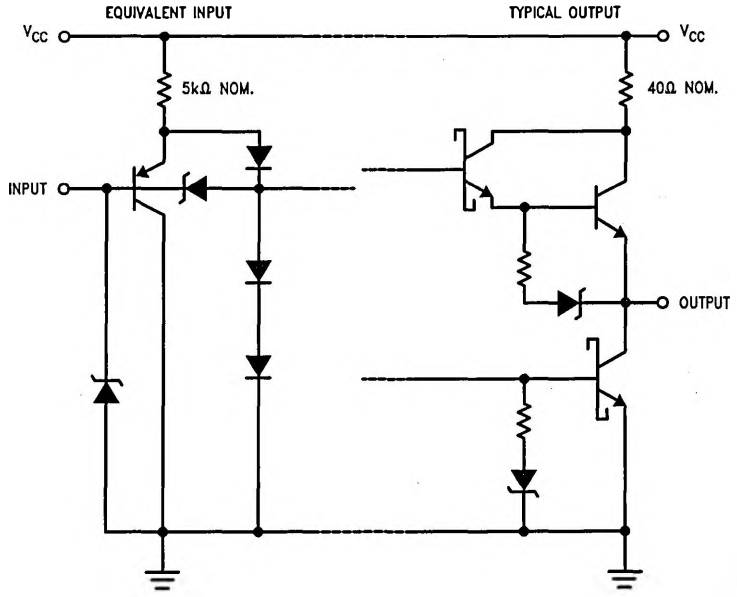
Test Waveform



TL/L/9995-3

Notes:
V_T = 1.5V
C_L includes probe and jig capacitance.
In the examples above, the phase relationships between inputs and outputs have been chosen arbitrarily.

Schematic of Inputs and Outputs



TL/L/9995-4

Series A (PAL10H8A, PAL12H6A, PAL14H4A, PAL16H2A, PAL10L8A, PAL12L6A, PAL14L4A, PAL16L2A, PAL16C1A)

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage (V_{CC}) (Note 2)	−0.5 to +7.0V
Input Voltage (Notes 2 and 3)	−1.5 to +5.5V
Off-State Output Voltage (Note 2)	−1.5 to +5.5V
Input Current (Note 2)	−30.0 mA to +5.0 mA
Output Current (I_{OL})	+100 mA
Storage Temperature	−65°C to +150°C
Ambient Temperature with Power Applied	−65°C to +125°C
Junction Temperature	−65°C to +150°C

Recommended Operating Conditions

Symbol	Parameter	Military			Commercial			Units
		Min	Nom	Max	Min	Nom	Max	
V_{CC}	Supply Voltage	4.5	5	5.5	4.75	5	5.25	V
T_A	Operating Free-Air Temperature	−55			0		75	°C
T_C	Operating Case Temperature			125				°C

Electrical Characteristics Over Recommended Operating Conditions (Note 4)

Symbol	Parameter	Test Conditions			Min	Typ	Max	Units
V_{IL}	Low Level Input Voltage (Note 5)						0.8	V
V_{IH}	High Level Input Voltage (Note 5)				2			V
V_{IC}	Input Clamp Voltage	V_{CC} = Min, I = −18 mA				−0.8	−1.5	V
I_{IL}	Low Level Input Current	V_{CC} = Max, V_I = 0.4V				−0.02	−0.25	mA
I_{IH}	High Level Input Current	V_{CC} = Max, V_I = 2.4V					25	μA
I_I	Maximum Input Current	V_{CC} = Max, V_I = 5.5V					1	mA
V_{OL}	Low Level Output Voltage	V_{CC} = Min	I_{OL} = 8 mA			0.3	0.5	V
V_{OH}	High Level Output Voltage	V_{CC} = Min	I_{OH} = −2 mA	MIL	2.4	2.9		V
			I_{OH} = −3.2 mA	COM				
I_{OS}	Output Short-Circuit Current (Note 6)	V_{CC} = 5V, V_O = 0V			−30	−70	−130	mA
I_{CC}	Supply Current	V_{CC} = Max, Outputs Open				55	90	mA

Note 1: Absolute maximum ratings are those values beyond which the device may be permanently damaged. Proper operation is not guaranteed outside the specified recommended operating conditions.

Note 2: Some device pins may be raised above these limits during programming operations according to the applicable specification.

Note 3: It is recommended that precautions be taken to minimize electrostatic discharge when handling and testing this product. Pins 1 and 11 are connected directly to the security fuses, and the security fuses may be damaged preventing subsequent programming and verification operations.

Note 4: All typical values are for V_{CC} = 5.0V and T_A = 25°C.

Note 5: These are absolute voltages with respect to the ground pin on the device and include all overshoots due to system and/or tester noise. Do not attempt to test these values without suitable equipment.

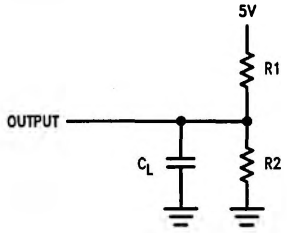
Note 6: To avoid Invalid readings in other parameter tests, it is preferable to conduct the I_{OS} test last. To minimize internal heating, only one output should be shorted at a time with a maximum duration of 1.0 second each. Prolonged shorting of a high output may raise the chip temperature above normal and permanent damage may result.

Series A (PAL10H8A, PAL12H6A, PAL14H4A, PAL16H2A, PAL10L8A, PAL12L6A, PAL14L4A, PAL16L2A, PAL16C1A) (Continued)

Switching Characteristics Over Recommended Operating Conditions

Symbol	Parameter	Test Conditions		Military			Commercial			Units
				Min	Typ	Max	Min	Typ	Max	
t_{PD}	Input to Output	C_L = 50 pF	Except 16C1A		15	30		15	25	ns
			16C1A			35			30	ns

Test Load

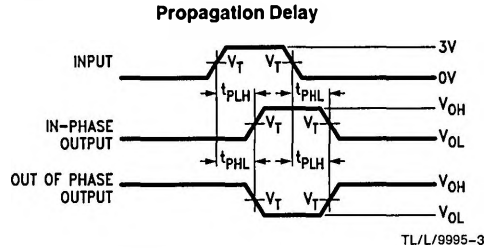


MIL/COM

R1 = 560
R2 = 1.1K

TL/L/9995-2

Test Waveform



TL/L/9995-3

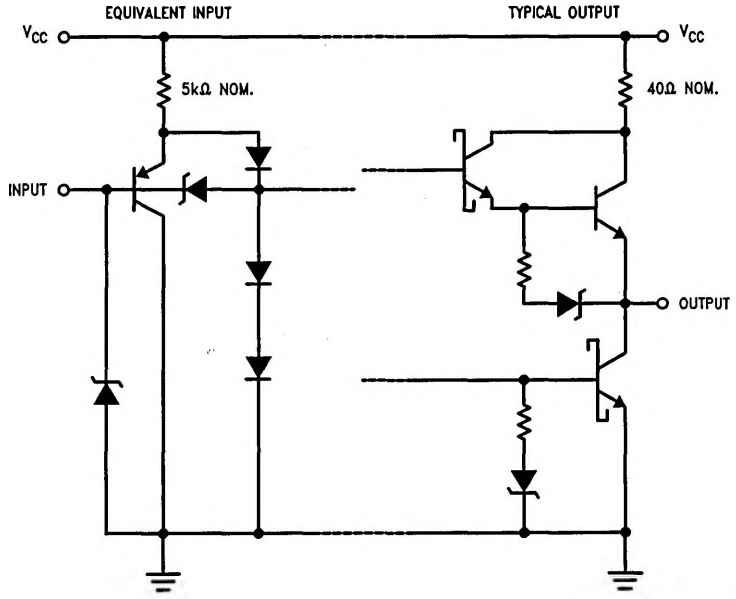
Notes:

V_T = 1.5V

C_L includes probe and jig capacitance.

In the examples above, the phase relationships between inputs and outputs have been chosen arbitrarily.

Schematic of Inputs and Outputs



TL/L/9995-4

Series A2 (PAL10H8A2, PAL12H6A2, PAL14H4A2, PAL16H2A2, PAL10L8A2, PAL12L6A2, PAL14L4A2, PAL16L2A2, PAL16C1A2)

Absolute Maximum Ratings (Note 1)

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Supply Voltage (V_{CC}) (Note 2)	−0.5 to +7.0V
Input Voltage (Notes 2 and 3)	−1.5 to +5.5V
Off-State Output Voltage (Note 2)	−1.5 to +5.5V
Input Current (Note 2)	−30.0 mA to +5.0 mA
Output Current (I_{OL})	+100 mA
Storage Temperature	−65°C to +150°C
Ambient Temperature with Power Applied	−65°C to +125°C
Junction Temperature	−65°C to +150°C

Recommended Operating Conditions

Symbol	Parameter	Military			Commercial			Units
		Min	Nom	Max	Min	Nom	Max	
V_{CC}	Supply Voltage	4.5	5	5.5	4.75	5	5.25	V
T_A	Operating Free-Air Temperature	−55			0		75	°C
T_C	Operating Case Temperature			125				°C

Electrical Characteristics Over Recommended Operating Conditions (Note 4)

Symbol	Parameter	Test Conditions			Min	Typ	Max	Units
V_{IL}	Low Level Input Voltage (Note 5)						0.8	V
V_{IH}	High Level Input Voltage (Note 5)				2			V
V_{IC}	Input Clamp Voltage	V_{CC} = Min, I = −18 mA				−0.8	−1.5	V
I_{IL}	Low Level Input Current	V_{CC} = Max, V_I = 0.4V				−0.02	−0.25	mA
I_{IH}	High Level Input Current	V_{CC} = Max, V_I = 2.4V					25	μA
I_I	Maximum Input Current	V_{CC} = Max, V_I = 5.5V					1	mA
V_{OL}	Low Level Output Voltage	V_{CC} = Min	I_{OL} = 8 mA			0.3	0.5	V
V_{OH}	High Level Output Voltage	V_{CC} = Min	I_{OH} = −2 mA	MIL	2.4	2.9		V
			I_{OH} = −3.2 mA	COM				
I_{OS}	Output Short-Circuit Current (Note 6)	V_{CC} = 5V, V_O = 0V			−30	−70	−130	mA
I_{CC}	Supply Current	V_{CC} = Max, Outputs Open				28	45	mA

Note 1: Absolute maximum ratings are those values beyond which the device may be permanently damaged. Proper operation is not guaranteed outside the specified recommended operating conditions.

Note 2: Some device pins may be raised above these limits during programming operations according to the applicable specification.

Note 3: It is recommended that precautions be taken to minimize electrostatic discharge when handling and testing this product. Pins 1 and 11 are connected directly to the security fuses, and the security fuses may be damaged preventing subsequent programming and verification operations.

Note 4: All typical values are for V_{CC} = 5.0V and T_A = 25°C.

Note 5: These are absolute voltages with respect to the ground pin on the device and include all overshoots due to system and/or tester noise. Do not attempt to test these values without suitable equipment.

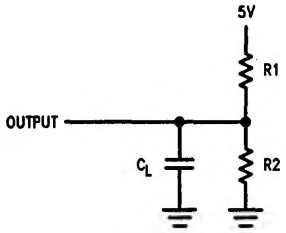
Note 6: To avoid invalid readings in other parameter tests, it is preferable to conduct the I_{OS} test last. To minimize internal heating, only one output should be shorted at a time with a maximum duration of 1.0 second each. Prolonged shorting of a high output may raise the chip temperature above normal and permanent damage may result.

Series A2 (PAL10H8A2, PAL12H6A2, PAL14H4A2, PAL16H2A2, PAL10L8A2, PAL12L6A2, PAL14L4A2, PAL16L2A2, PAL16C1A2) (Continued)

Switching Characteristics Over Recommended Operating Conditions

Symbol	Parameter	Test Conditions		Military			Commercial			Units
				Min	Typ	Max	Min	Typ	Max	
t_{PD}	Input to Output	C_L = 50 pF	Except 16C1A2		25	45		25	35	ns
			16C1A2			45			40	ns

Test Load



MIL/COM

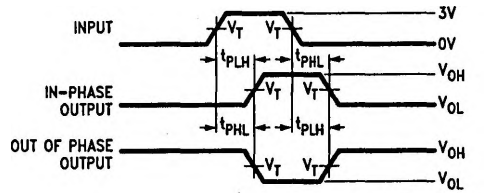
R1 = 560

R2 = 1.1K

TL/L/9995-2

Test Waveform

Propagation Delay



TL/L/9995-3

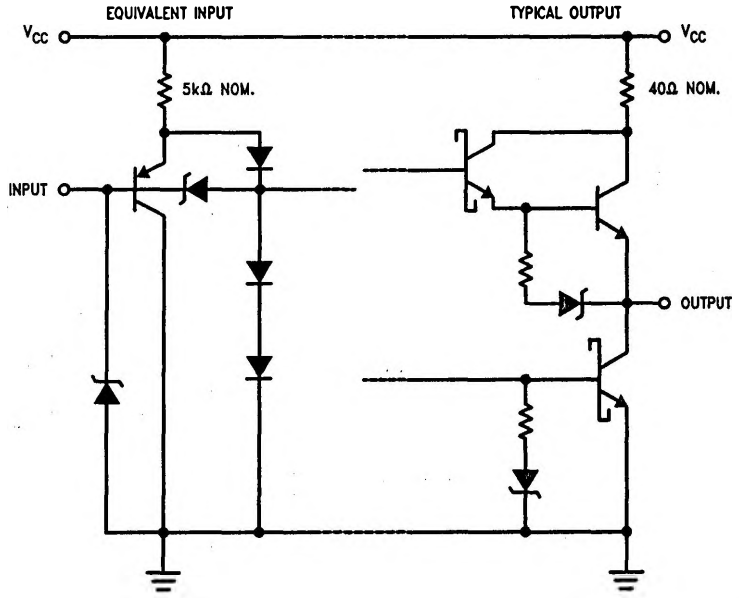
Notes:

V_T = 1.5V

C_L includes probe and jig capacitance.

In the examples above, the phase relationships between inputs and outputs have been chosen arbitrarily.

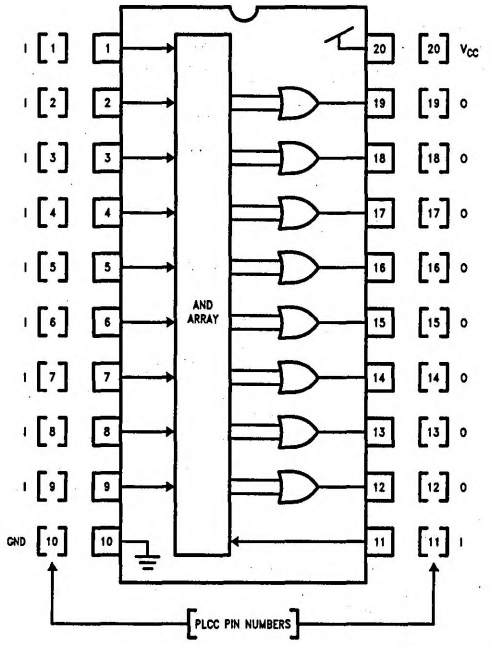
Schematic of Inputs and Outputs



TL/L/9995-4

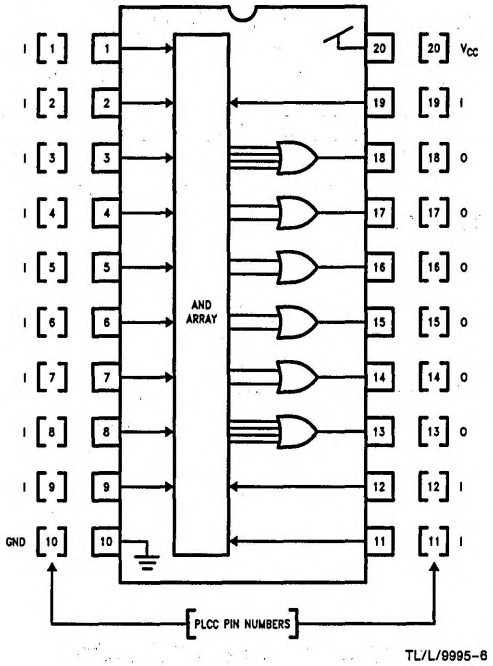
20-Pin Small PAL Family Block Diagrams—DIP Connections

PAL10H8



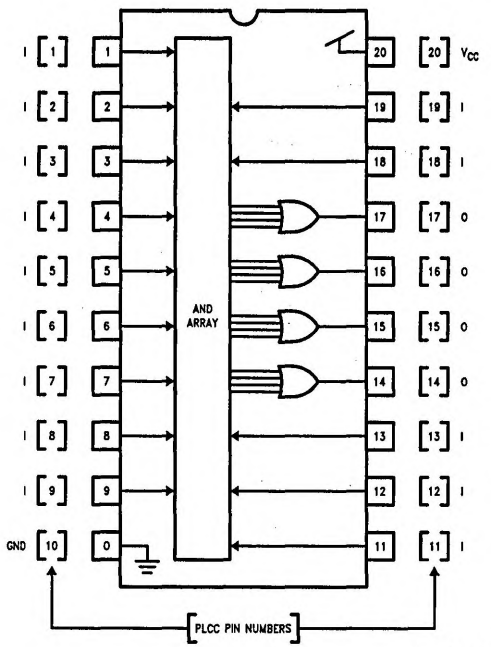
TL/L/9995-5

PAL12H6



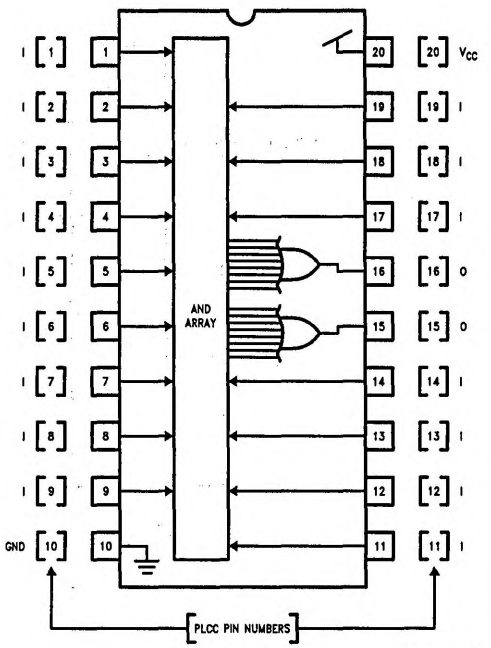
TL/L/9995-6

PAL14H4



TL/L/9995-7

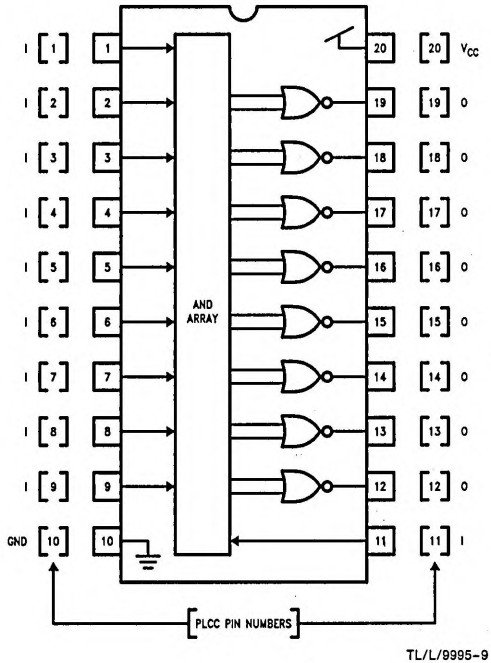
PAL16H2



TL/L/9995-8

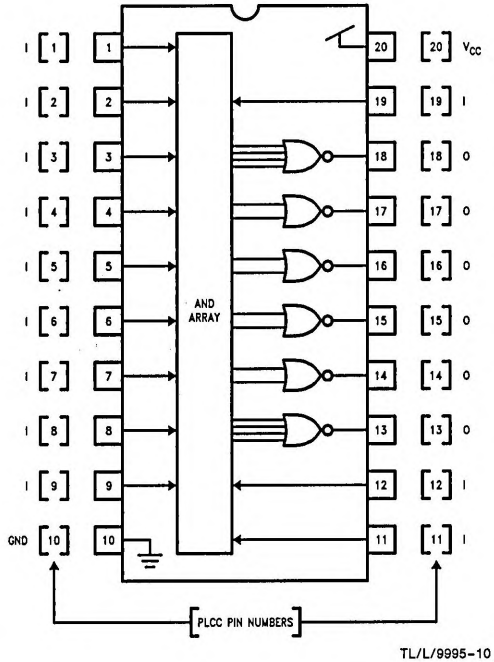
20-Pin Small PAL Family Block Diagrams—DIP Connections (Continued)

PAL10L8



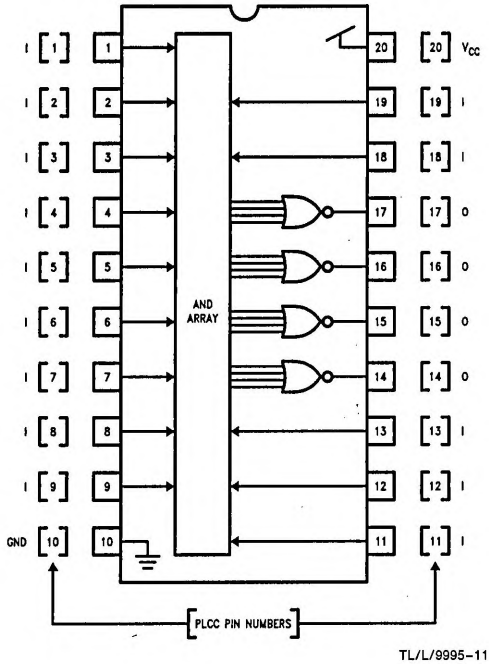
TL/L/9995-9

PAL12L6



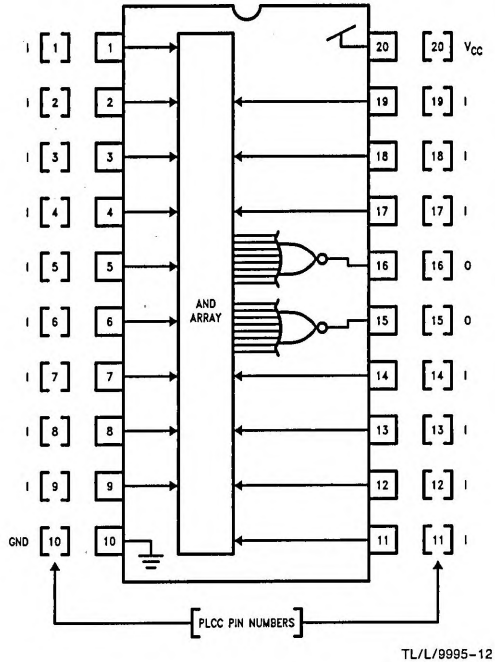
TL/L/9995-10

PAL14L4



TL/L/9995-11

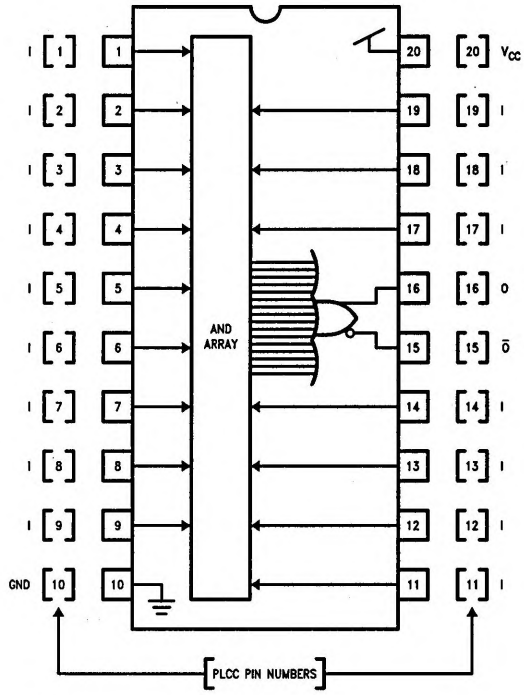
PAL16L2



TL/L/9995-12

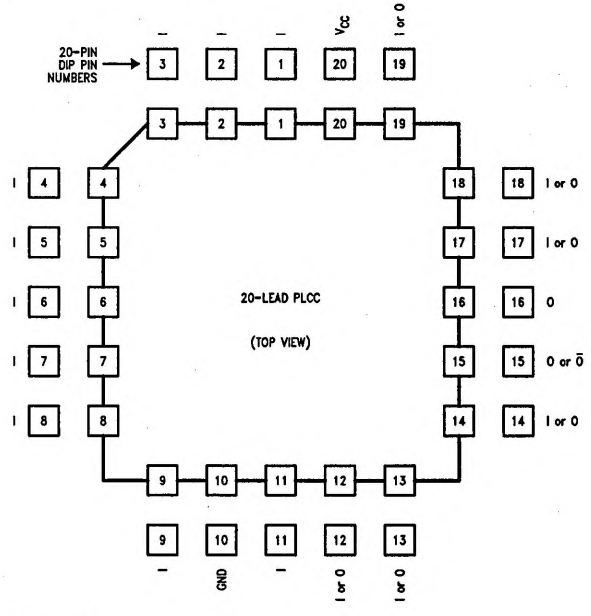
20-Pin Small PAL Family Block Diagrams—DIP Connections (Continued)

PAL16C1



TL/L/9995–13

20-Lead PLCC Connection Conversion Diagram*



TL/L/9995–14

*Series-A parts are not available in this package.

Functional Description

The 20-pin Small PAL logic arrays consist of between 10 and 16 complementary input lines and 16 product-term lines with a programmable fuse link at each intersection (up to 512 fuses). The family consists of nine device types with different numbers of combinatorial outputs. The 20-pin Small PAL Family Block Diagrams show the number of product terms allocated to each output for each device. All product terms allocated to each output connect into an OR-gate to produce the sum-of-products output logic function.

An unprogrammed (intact) fuse establishes a connection between an input line (true or complement phase of an array input signal) and a product term; programming the fuse removes the connection. A product term is satisfied (logically true) while all of the input lines connected to it (via unprogrammed fuses) are in the high logic state. Therefore, if both the true and complement of at least one array input is left connected to a product line, that product term is always held in the low logic state (which is the state of all product terms in an unprogrammed device). Conversely, if all fuses on a product term were programmed, the product term and the resulting logic function would be held in the high state.

As with any TTL logic circuits, unused inputs to a PAL device should be connected to ground, V_{OL}, V_{OH}, or resistively to V_{CC}. However, switching any input not connected to a product term or logic function has no effect on its output logic state.

Security Fuse

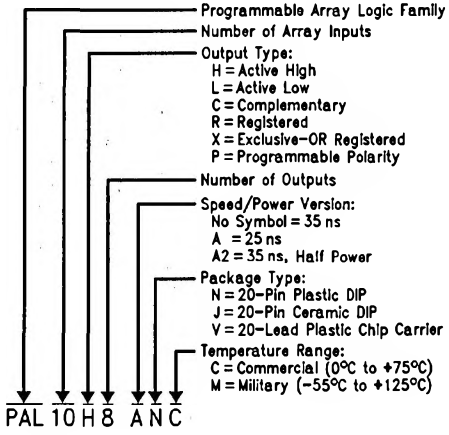
Security fuses are provided on all National PAL devices which, when programmed, inhibit any further programming or verifying operations. This feature prevents direct copying of proprietary logic patterns. The security fuses should be programmed only after programming and verifying all other device fuses.

Design Development Support

A variety of software tools and programming hardware is available to support the development of designs using PAL products. Typical software packages accept Boolean logic equations to define desired functions. Most are available to run on personal computers and generate JEDEC-compatible "fuse maps". The industry-standard JEDEC format ensures that the resulting fuse-map files can be down-loaded into a variety of programming equipment. Many software packages and programming units support a wide variety of programmable logic products as well. The PLAN™ software package from National Semiconductor supports all programmable logic products available from National and is fully JEDEC-compatible. PLAN software also provides automatic device selection based on the designer's Boolean logic equations.

Detailed logic diagrams showing all JEDEC fuse-map addresses for the 20-pin Small PAL family are provided for direct map editing and diagnostic purposes. Contact your local National Semiconductor sales representative or distributor for a list of current software and programming support tools available for these devices. Contact the National Semiconductor Programmable Device Support Department if detailed specifications of PAL programming algorithms are needed.

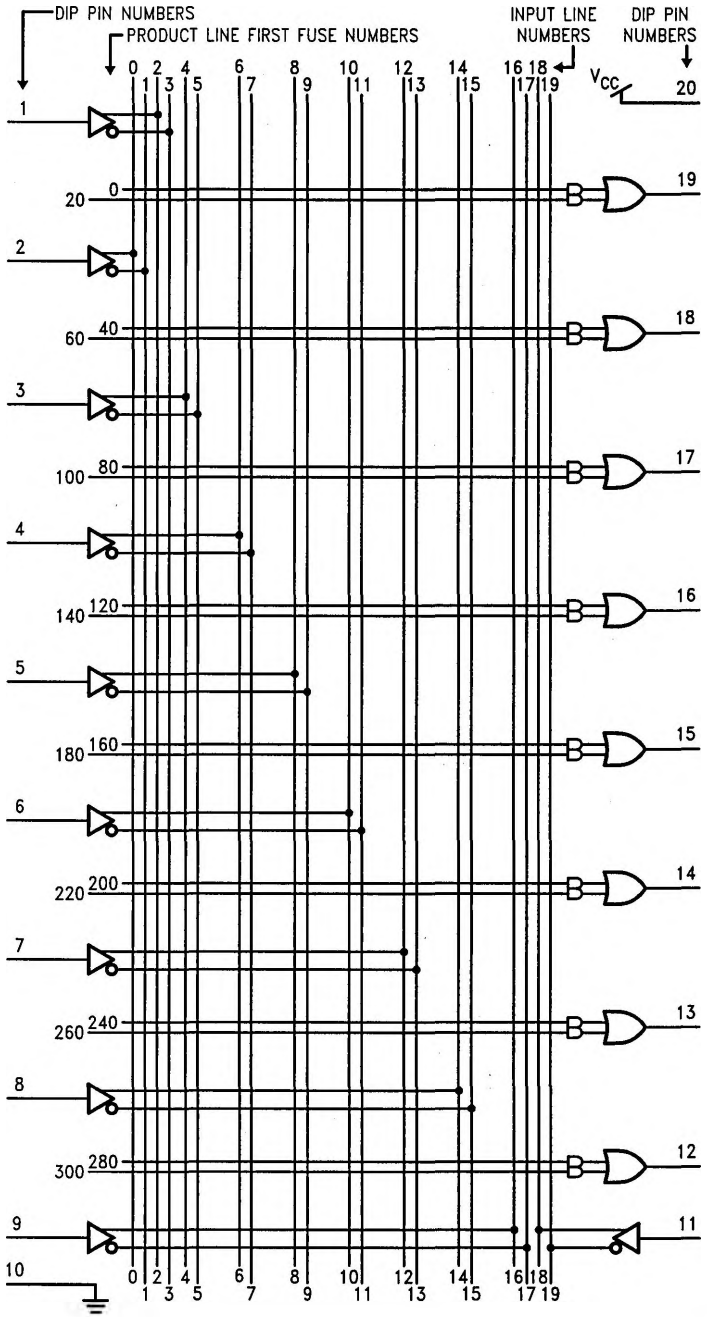
Ordering Information



TL/L/9995–15

*Series-A is not available in the V-package.

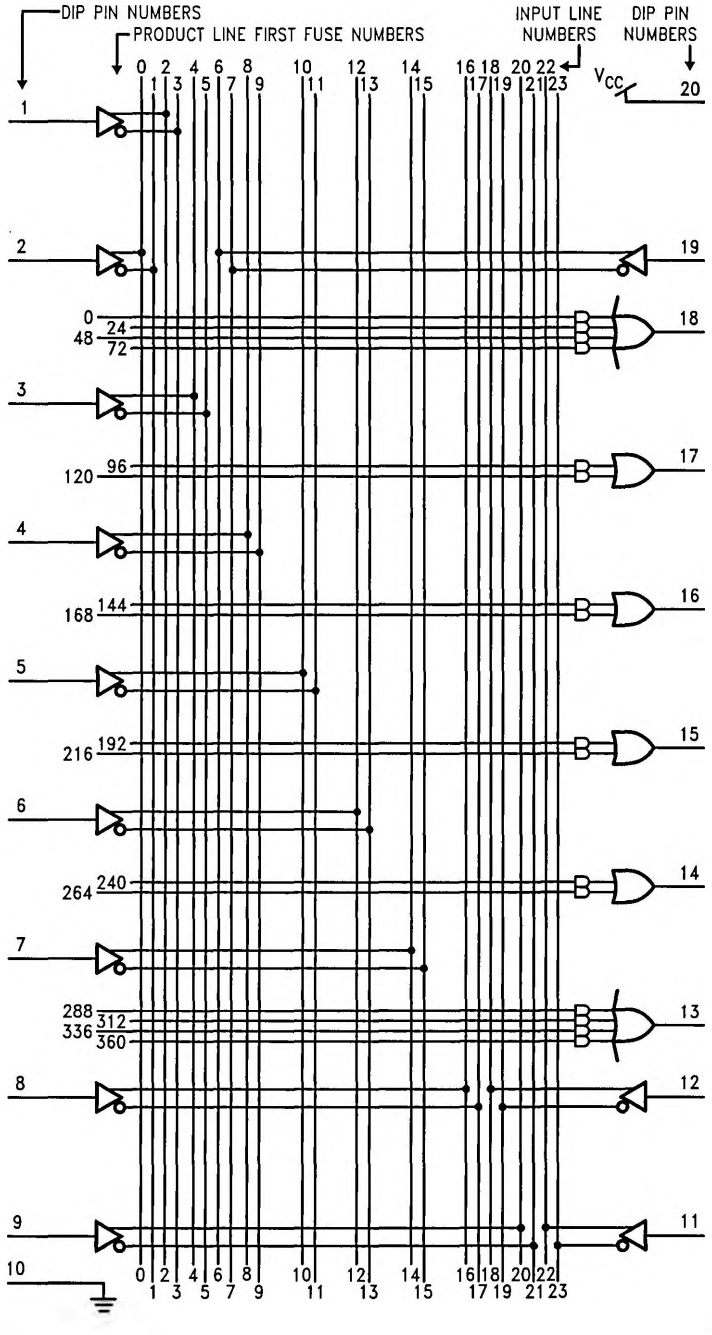
Logic Diagram PAL10H8



TL/L/9995-16

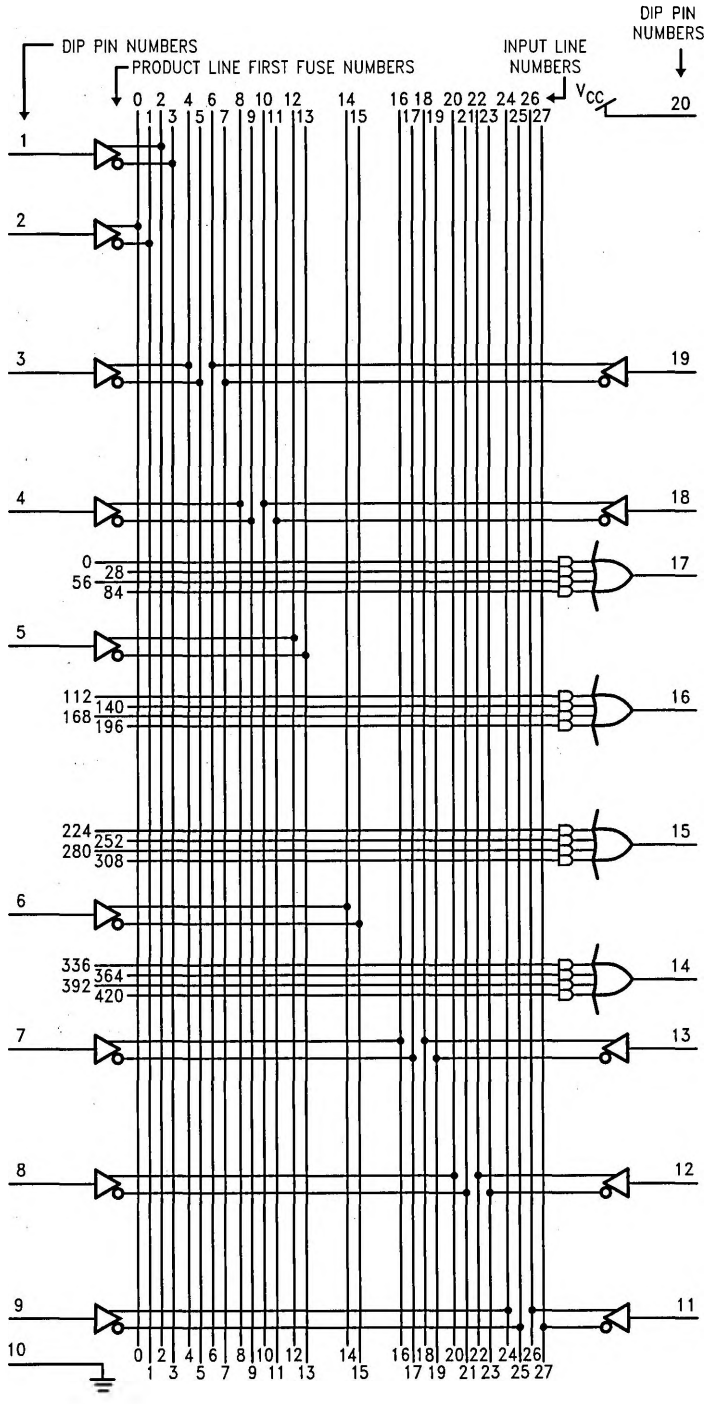
Note: JEDEC Logic Array Fuse Number = Product Line First Fuse Number + Input Line Number.

Logic Diagram PAL12H6



Note: JEDEC Logic Array Fuse Number = Product Line First Fuse Number + Input Line Number.

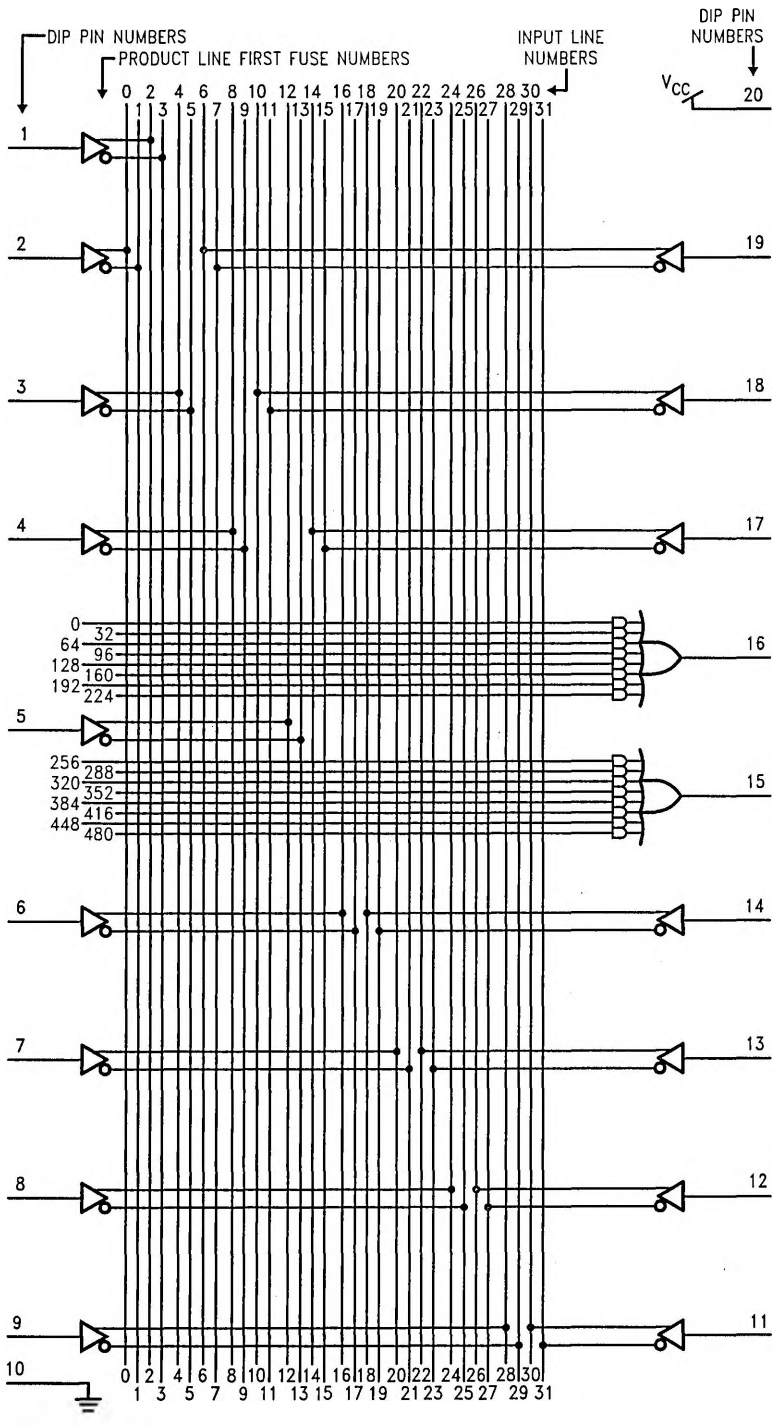
Logic Diagram PAL14H4



TL/L/9995–18

Note: JEDEC Logic Array Fuse Number = Product Line First Fuse Number + Input Line Number.

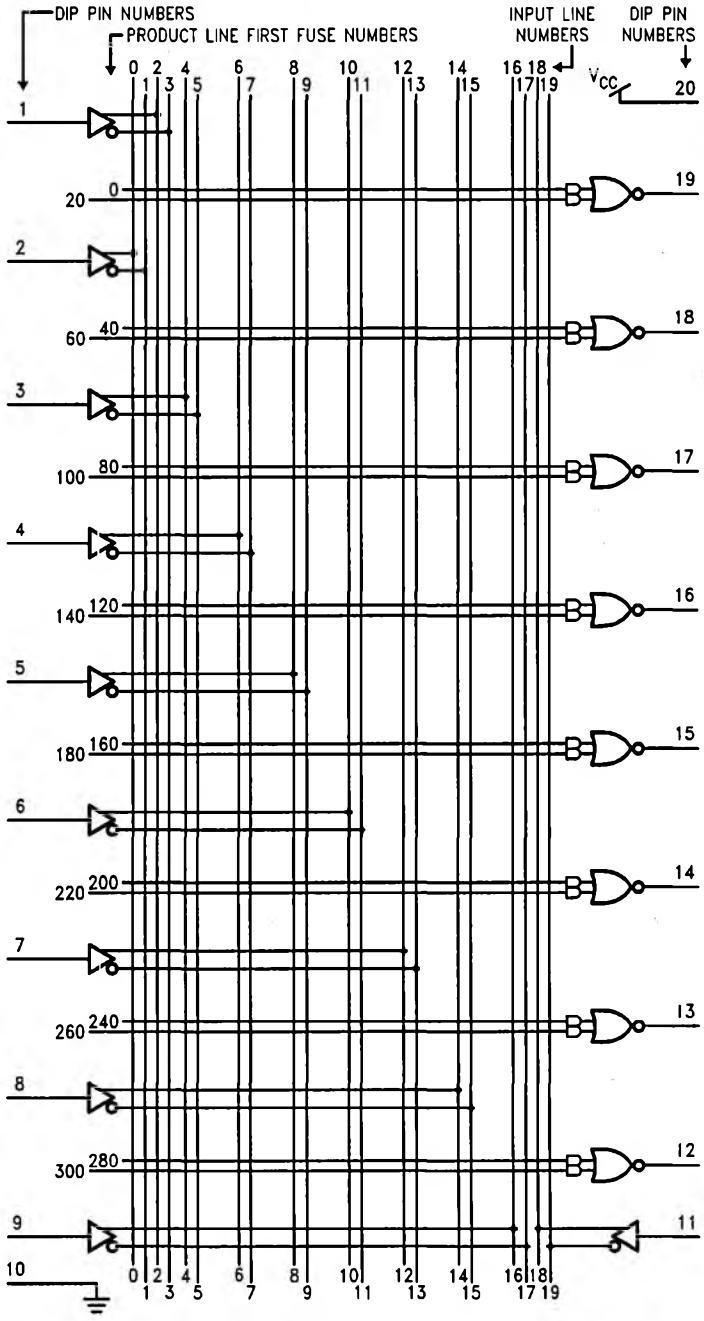
Logic Diagram PAL16H2



TL/L/9995-19

Note: JEDEC Logic Array Fuse Number = Product Line First Fuse Number + Input Line Number.

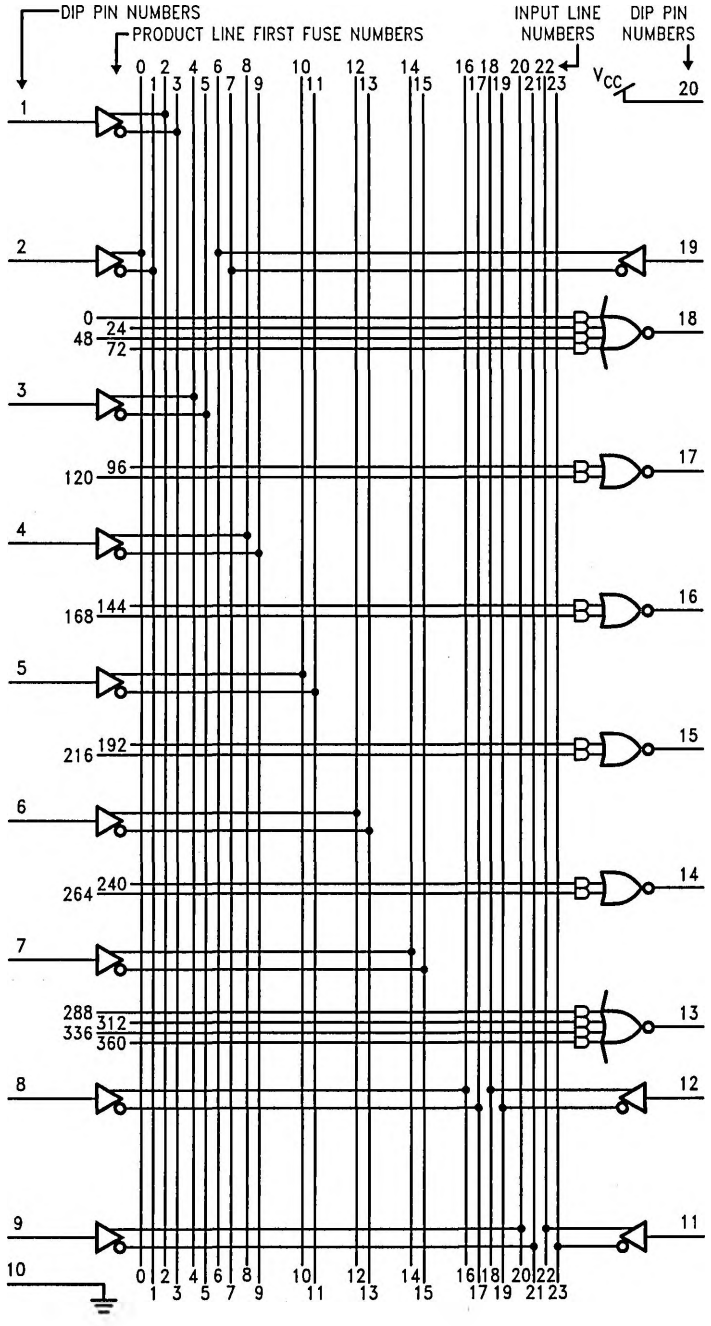
Logic Diagram PAL10L8



TL/L/9995-20

Note: JEDEC Logic Array Fuse Number = Product Line First Fuse Number + Input Line Number.

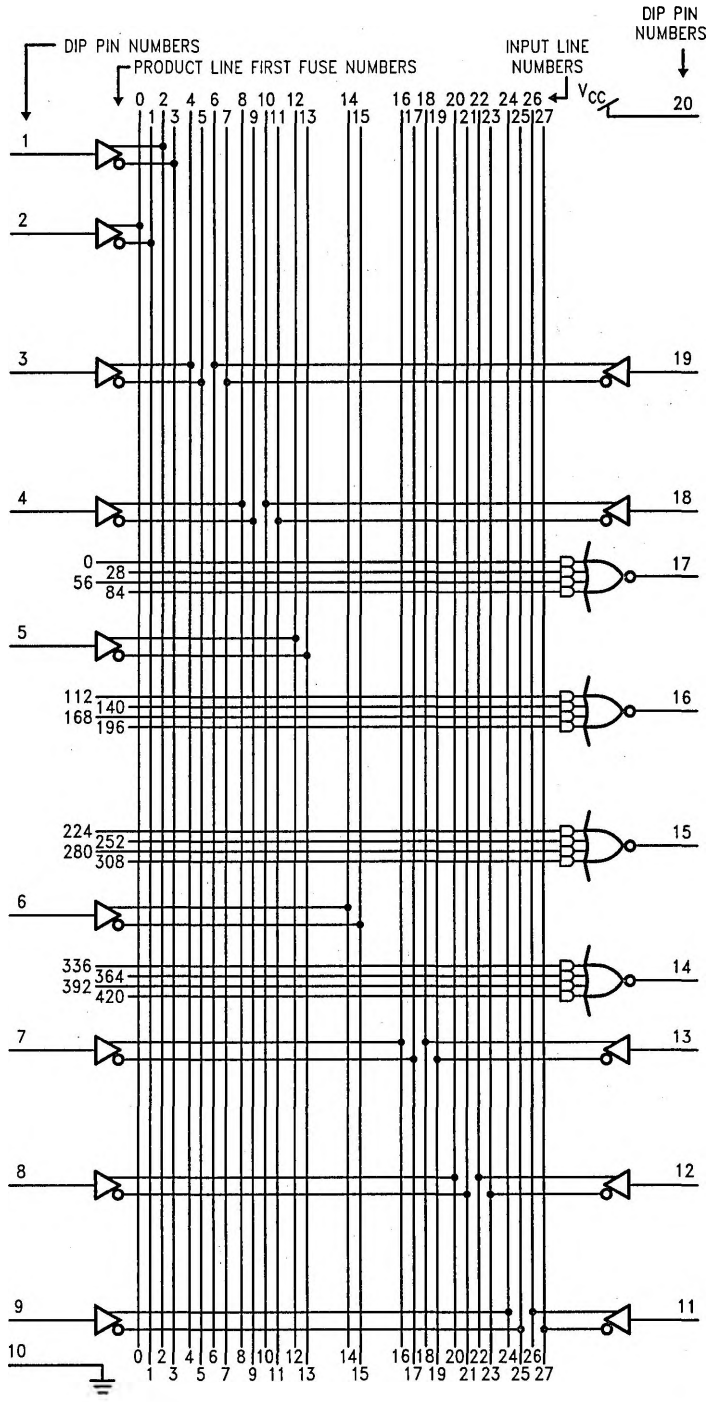
Logic Diagram PAL12L6



TL/L/9995–21

Note: JEDEC Logic Array Fuse Number = Product Line First Fuse Number + Input Line Number.

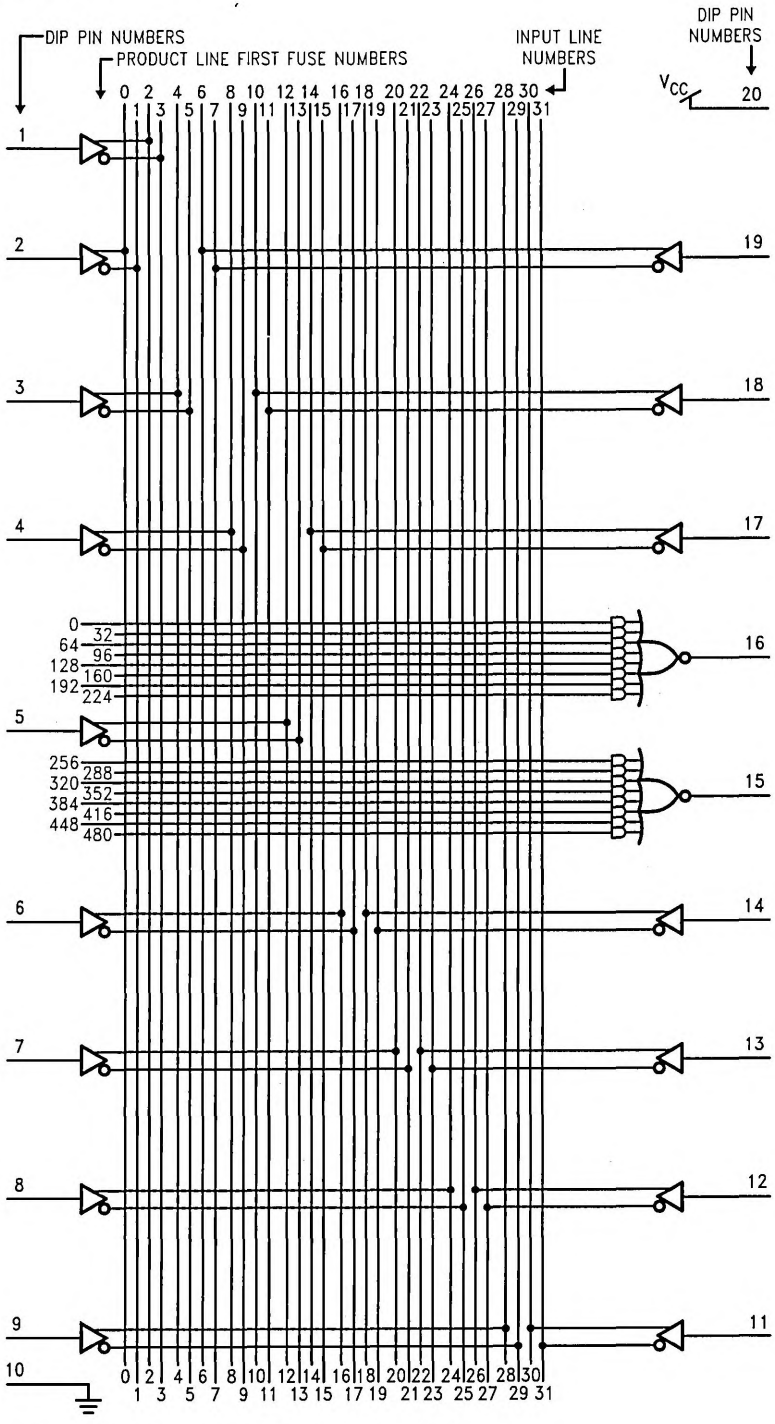
Logic Diagram PAL14L4



TL/L/9995–22

Note: JEDEC Logic Array Fuse Number = Product Line First Fuse Number + Input Line Number.

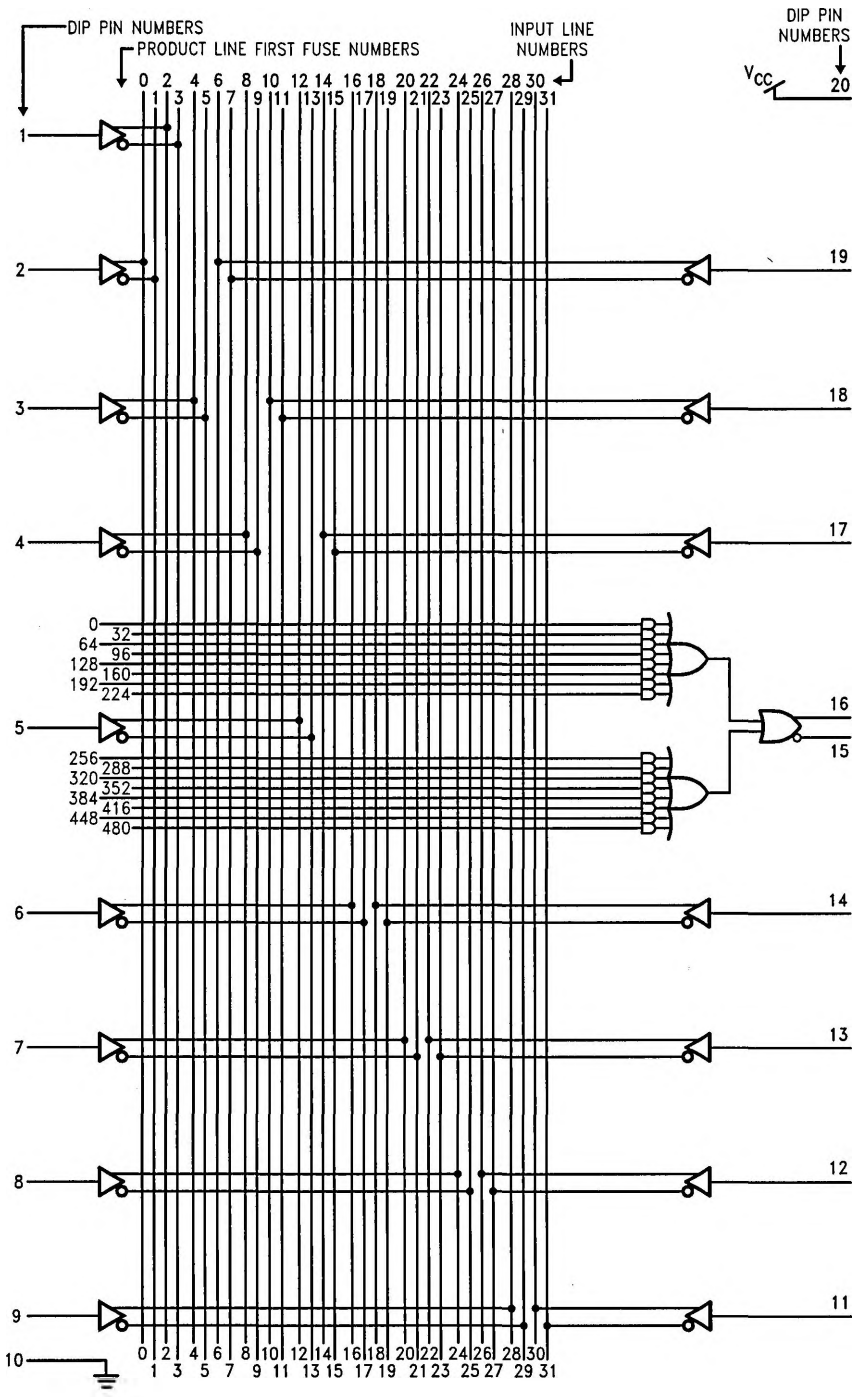
Logic Diagram PAL16L2



TL/L/9995–23

Note: JEDEC Logic Array Fuse Number = Product Line First Fuse Number + Input Line Number.

Logic Diagram PAL16C1



TL/L/9995-24

Note: JEDEC Logic Array Fuse Number = Product Line First Fuse Number + Input Line Number.