74LS147

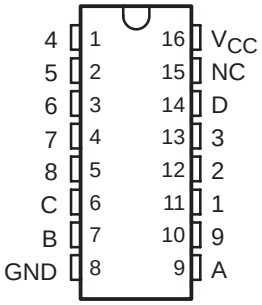
- **Encode 10-Line Decimal to 4-Line BCD**
- **Applications Include:**
  - **Keyboard Encoding**
  - **Range Selection**

74LS148

- **Encode 8 Data Lines to 3-Line Binary (Octal)**
- **Applications Include:**
  - **n-Bit Encoding**
  - **Code Converters and Generators**

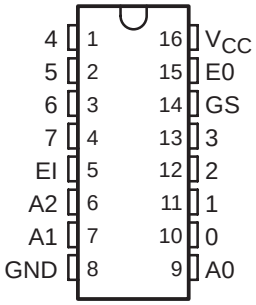
74LS147

(TOP VIEW)



74LS148

(TOP VIEW)



TYPE	TYPICAL DATA DELAY	TYPICAL POWER DISSIPATION
’147	10 ns	225 mW
’148	10 ns	190 mW
’LS147	15 ns	60 mW
’LS148	15 ns	60 mW

description/ordering information

These TTL encoders feature priority decoding of the inputs to ensure that only the highest-order data line is encoded. The 74LS147 devices encode nine data lines to four-line (8-4-2-1) BCD. The implied decimal zero condition requires no input condition, as zero is encoded when all nine data lines are at a high logic level. The ’148 and ’LS148 devices encode eight data lines to three-line (4-2-1) binary (octal). Cascading circuitry (enable input EI and enable output EO) has been provided to allow octal expansion without the need for external circuitry. For all types, data inputs and outputs are active at the low logic level. All inputs are buffered to represent one normalized Series 54/74 or 54/74LS load, respectively.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	PDIP − N	Tube	74LS148	74LS148
	SOIC − D	Tube	74LS148	74LS148
		Tape and reel	74LS148	
	SOP − NS	Tape and reel	74LS148	74LS148

FUNCTION TABLE − 74LS147

INPUTS									OUTPUTS			
1	2	3	4	5	6	7	8	9	D	C	B	A
H	H	H	H	H	H	H	H	H	H	H	H	H
X	X	X	X	X	X	X	X	L	L	H	H	L
X	X	X	X	X	X	X	L	H	L	H	H	H
X	X	X	X	X	X	L	H	H	H	L	L	L
X	X	X	X	X	L	H	H	H	H	L	L	H
X	X	X	X	L	H	H	H	H	H	L	H	L
X	X	X	L	H	H	H	H	H	H	L	H	H
X	X	L	H	H	H	H	H	H	H	H	L	L
X	L	H	H	H	H	H	H	H	H	H	L	H
L	H	H	H	H	H	H	H	H	H	H	H	L

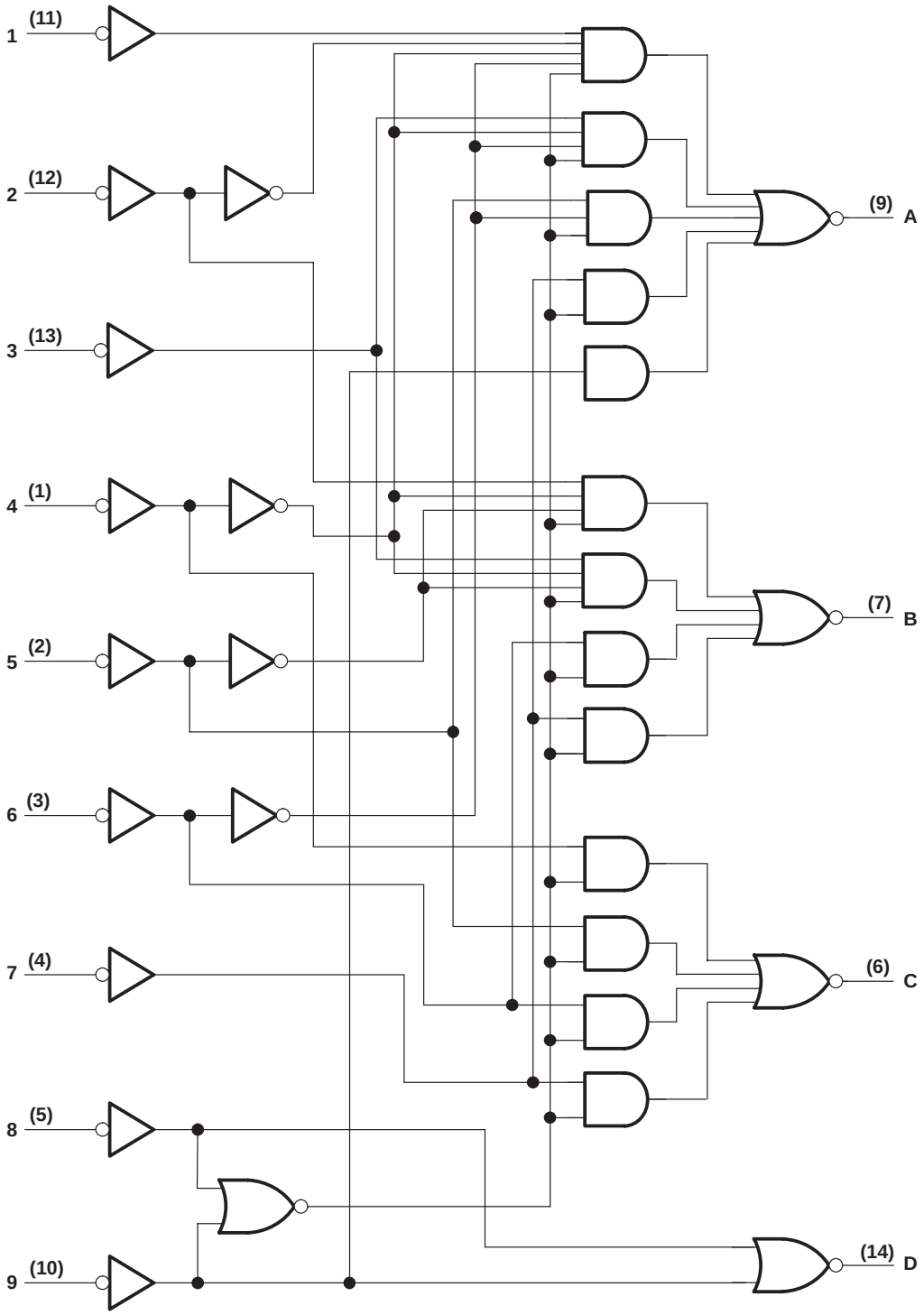
H = high logic level, L = low logic level, X = irrelevant

FUNCTION TABLE − 74LS148

INPUTS									OUTPUTS				
EI	0	1	2	3	4	5	6	7	A2	A1	A0	GS	EO
H	X	X	X	X	X	X	X	X	H	H	H	H	H
L	H	H	H	H	H	H	H	H	H	H	H	H	L
L	X	X	X	X	X	X	X	L	L	L	L	L	H
L	X	X	X	X	X	X	L	H	L	L	H	L	H
L	X	X	X	X	X	L	H	H	L	H	L	L	H
L	X	X	X	X	L	H	H	H	L	H	H	L	H
L	X	X	X	L	H	H	H	H	H	L	L	L	H
L	X	X	L	H	H	H	H	H	H	L	H	L	H
L	X	L	H	H	H	H	H	H	H	H	L	L	H
L	L	H	H	H	H	H	H	H	H	H	H	L	H

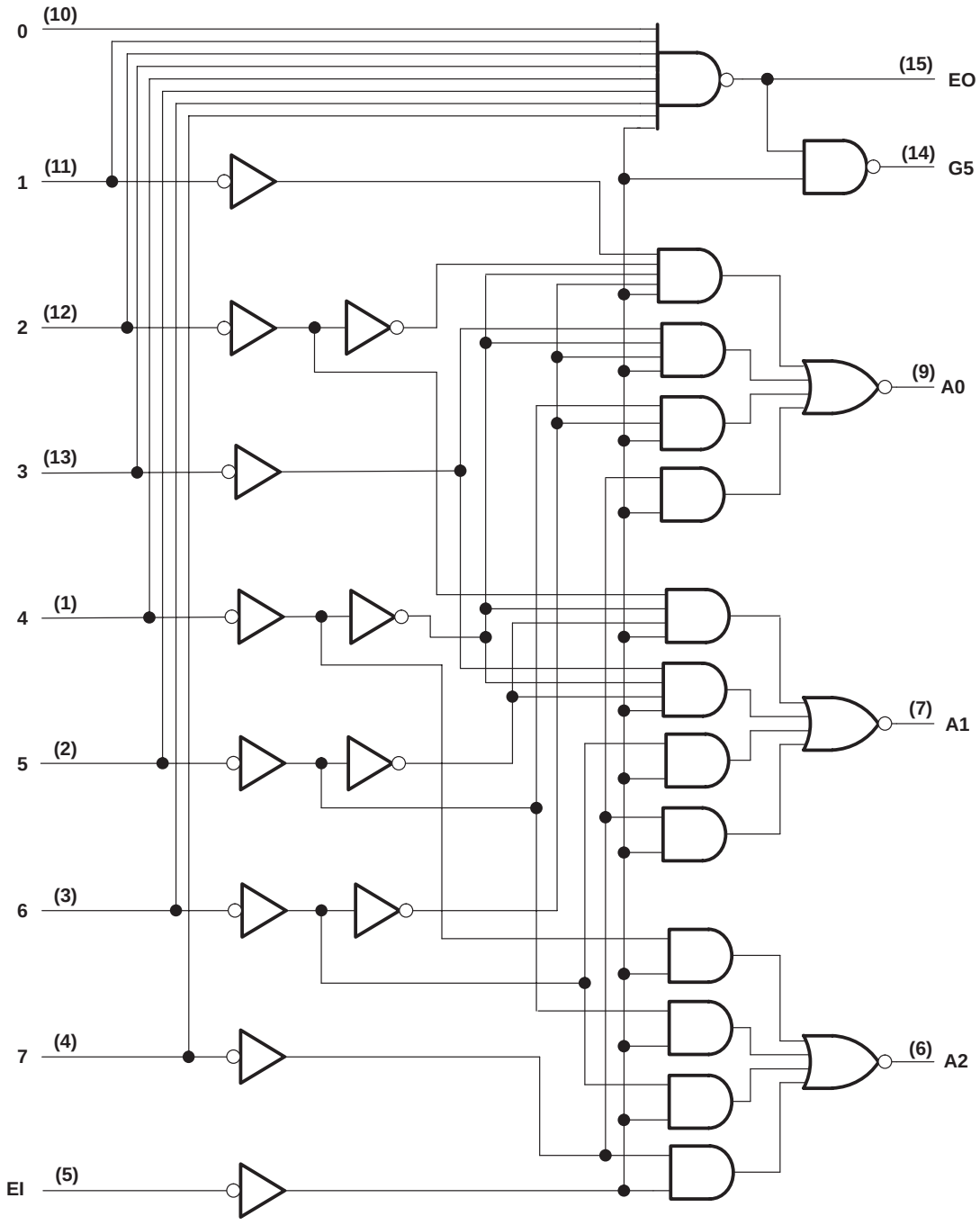
H = high logic level, L = low logic level, X = irrelevant

74LS147 logic diagram (positive logic)



Pin numbers shown are for D, J, N, and W packages.

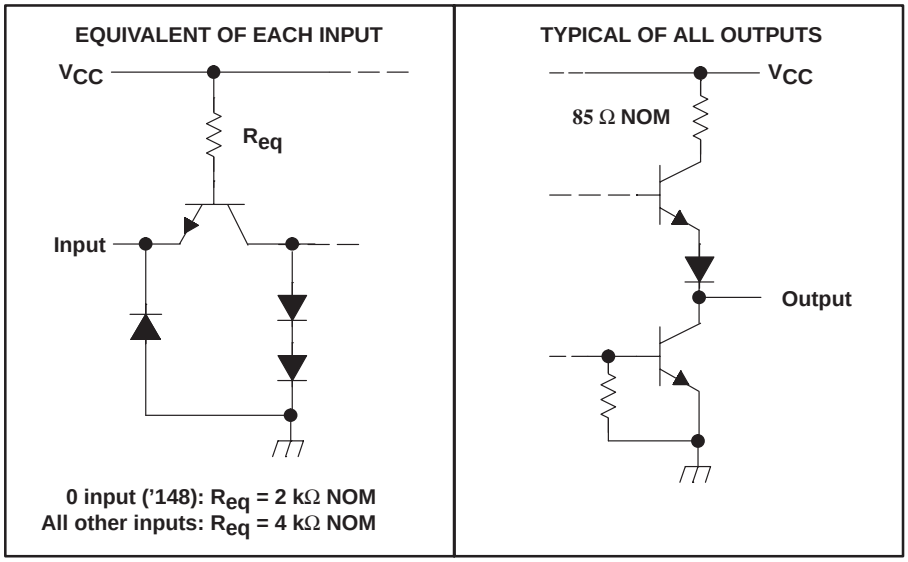
74LS148 logic diagram (positive logic)



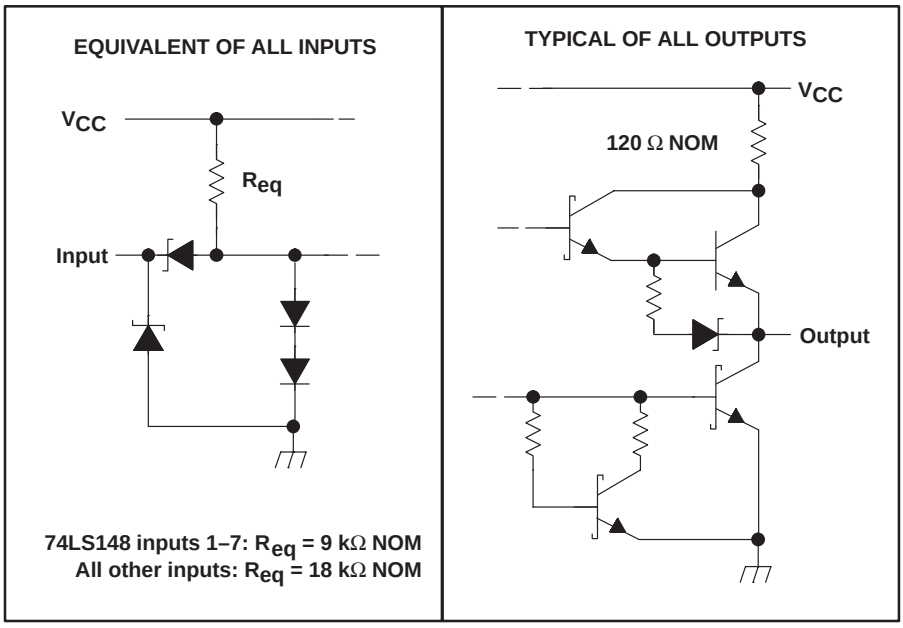
Pin numbers shown are for D, J, N, NS, and W packages.

schematics of inputs and outputs

74LS148/74LS148



'LS147, 'LS148



absolute maximum ratings over operating free-air temperature (unless otherwise noted)†

Supply voltage, V_{CC} (see Note 1) . . . . . 7 V
Input voltage, V_I :74LS147,74LS148 . . . . . 5.5 V
74LS147,74LS148 . . . . . 7 V
Inter-emitter voltage: ’148 only (see Note 2) . . . . . 5.5 V
Package thermal impedance θ_{JA} (see Note 3): D package . . . . . 73°C/W
N package . . . . . 67°C/W
NS package . . . . . 64°C/W
Storage temperature range, T_{stg} . . . . . −65°C to 150°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTES: 1. Voltage values, except inter-emitter voltage, are with respect to the network ground terminal.
2. This is the voltage between two emitters of a multiple-emitter transistor. For 74LS148 circuits, this rating applies between any two of the eight data lines, 0 through 7.
3. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions (see Note 4)

		74LS			74LS			74LS			74LS			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage	4.5	5	5.5	4.75	5	5.25	4.5	5	5.5	4.75	5	5.25	V
I_{OH}	High-level output current			−800			−800			−400			−400	μA
I_{OL}	Low-level output current			16			16			4			8	mA
T_A	Operating free-air temperature	−55		125	0		70	−55		125	0		70	°C

NOTE 4: All unused inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER			TEST CONDITIONS†		74LS147			74LS148			UNIT
					MIN	TYP‡	MAX	MIN	TYP‡	MAX	
V_{IH}	High-level input voltage				2			2			V
V_{IL}	Low-level input voltage						0.8			0.8	V
V_{IK}	Input clamp voltage		V_{CC} = MIN,	I_I = −12 mA			−1.5			−1.5	V
V_{OH}	High-level output voltage		V_{CC} = MIN, V_{IL} = 0.8 V,	V_{IH} = 2 V, I_{OH} = −800 µA	2.4	3.3		2.4	3.3		V
V_{OL}	Low-level output voltage		V_{CC} = MIN, V_{IL} = 0.8 V,	V_{IH} = 2 V, I_{OL} = 16 mA		0.2	0.4		0.2	0.4	V
I_I	Input current at maximum input voltage		V_{CC} = MIN,	V_I = 5.5 V			1			1	mA
I_{IH}	High-level input current	0 input	V_{CC} = MAX,	V_I = 2.4 V						40	µA
		Any input except 0					40			80	
I_{IL}	Low-level input current	0 input	V_{CC} = MAX,	V_I = 0.4 V						−1.6	mA
		Any input except 0					−1.6			−3.2	
I_{OS}	Short-circuit output current§		V_{CC} = MAX		−35		−85	−35		−85	mA
I_{CC}	Supply current		V_{CC} = MAX (See Note 5)	Condition 1		50	70		40	60	mA
				Condition 2		42	62		35	55	

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡ All typical values are at V_{CC} = 5 V, T_A = 25°C.
§ Not more than one output should be shorted at a time.
NOTE 5: For 74LS147, I_{CC} (Condition 1) is measured with input 7 grounded, other inputs and outputs open; I_{CC} (Condition 2) is measured with all inputs and outputs open. For 74LS148 I_{CC} (Condition 1) is measured with inputs 7 and EI grounded, other inputs and outputs open; I_{CC} (Condition 2) is measured with all inputs and outputs open.

74LS147 switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	WAVEFORM	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH}	Any	Any	In-phase output	C_L = 15 pF, R_L = 400 Ω		9	14	ns
t_{PHL}						7	11	
t_{PLH}	Any	Any	Out-of-phase output			13	19	ns
t_{PHL}						12	19	

74LS148 switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Figure 1)

PARAMETER†	FROM (INPUT)	TO (OUTPUT)	WAVEFORM	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH}	1–7	A0, A1, or A2	In-phase output	C_L = 15 pF, R_L = 400 Ω		10	15	ns
t_{PHL}						9	14	
t_{PLH}	1–7	A0, A1, or A2	Out-of-phase output			13	19	ns
t_{PHL}						12	19	
t_{PLH}	0–7	EO	Out-of-phase output			6	10	ns
t_{PHL}						14	25	
t_{PLH}	0–7	GS	In-phase output			18	30	ns
t_{PHL}						14	25	
t_{PLH}	EI	A0, A1, or A2	In-phase output			10	15	ns
t_{PHL}						10	15	
t_{PLH}	EI	GS	In-phase output			8	12	ns
t_{PHL}						10	15	
t_{PLH}	EI	EO	In-phase output			10	15	ns
t_{PHL}						17	30	

† t_{PLH} = propagation delay time, low-to-high-level output.
t_{PHL} = propagation delay time, high-to-low-level output.

electrical characteristics over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER			TEST CONDITIONS†		74LS MIN	74LS TYP‡	74LS MAX	74LS MIN	74LS TYP‡	74LS MAX	UNIT
V_{IH}	High-level input voltage				2			2			V
V_{IL}	Low-level input voltage						0.7			0.8	V
V_{IK}	Input clamp voltage		V_{CC} = MIN,	I_I = −18 mA			−1.5			−1.5	V
V_{OH}	High-level output voltage		V_{CC} = MIN, V_{IL} = 0.8 V,	V_{IH} = 2 V, I_{OH} = −400 µA	2.5	3.4		2.7	3.4		V
V_{OL}	Low-level output voltage		V_{CC} = MIN, V_{IH} = 2 V, V_{IL} = V_{IL} MAX	I_{OL} = 4 mA		0.25	0.4		0.25	0.4	V
				I_{OL} = 8 mA					0.35	0.5	
I_I	Input current at maximum input voltage	74LS148 inputs 1–7	V_{CC} = MAX,	V_I = 7 V			0.2			0.2	mA
		All other inputs					0.1			0.1	
I_{IH}	High-level input current	74LS148 inputs 1–7	V_{CC} = MAX,	V_I = 2.7 V			40			40	µA
		All other inputs					20			20	
I_{IL}	Low-level input current	74LS148 inputs 1–7	V_{CC} = MAX,	V_I = 0.4 V			−0.8			−0.8	mA
		All other inputs					−0.4			−0.4	
I_{OS}	Short-circuit output current§		V_{CC} = MAX		−20		−100	−20		−100	mA
I_{CC}	Supply current		V_{CC} = MAX (See Note 6)	Condition 1		12	20		12	20	mA
				Condition 2		10	17		10	17	

† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.
‡ All typical values are at V_{CC} = 5 V, T_A = 25°C.
§ Not more than one output should be shorted at a time.
NOTE 6: For 74LS147, I_{CC} (Condition 1) is measured with input 7 grounded, other inputs and outputs open; I_{CC} (Condition 2) is measured with all inputs and outputs open. For 74LS148, I_{CC} (Condition 1) is measured with inputs 7 and EI grounded, other inputs and outputs open; I_{CC} (Condition 2) is measured with all inputs and outputs open.

74LS147 switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Figure 2)

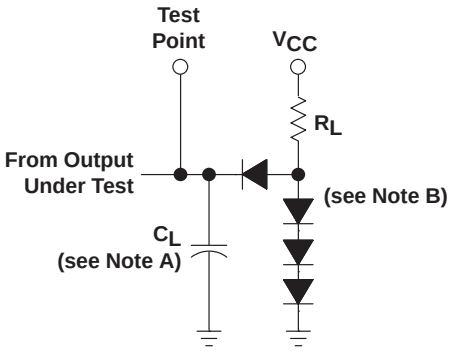
PARAMETER	FROM (INPUT)	TO (OUTPUT)	WAVEFORM	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH}	Any	Any	In-phase output	C_L = 15 pF, R_L = 2 kΩ		12	18	ns
t_{PHL}						12	18	
t_{PLH}	Any	Any	Out-of-phase output			21	33	ns
t_{PHL}						15	23	

74LS148 switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Figure 2)

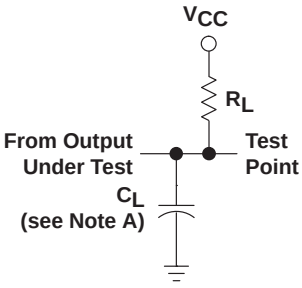
PARAMETER†	FROM (INPUT)	TO (OUTPUT)	WAVEFORM	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH}	1–7	A0, A1, or A2	In-phase output	C_L = 15 pF, R_L = 2 kΩ		14	18	ns
t_{PHL}						15	25	
t_{PLH}	1–7	A0, A1, or A2	Out-of-phase output			20	36	ns
t_{PHL}						16	29	
t_{PLH}	0–7	EO	Out-of-phase output			7	18	ns
t_{PHL}						25	40	
t_{PLH}	0–7	GS	In-phase output			35	55	ns
t_{PHL}						9	21	
t_{PLH}	EI	A0, A1, or A2	In-phase output			16	25	ns
t_{PHL}						12	25	
t_{PLH}	EI	GS	In-phase output			12	17	ns
t_{PHL}						14	36	
t_{PLH}	EI	EO	In-phase output			12	21	ns
t_{PHL}						23	35	

† t_{PLH} = propagation delay time, low-to-high-level output
t_{PHL} = propagation delay time, high-to-low-level output

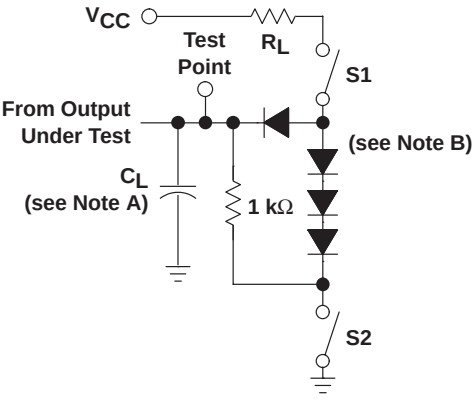
PARAMETER MEASUREMENT INFORMATION
SERIES 54/74 DEVICES



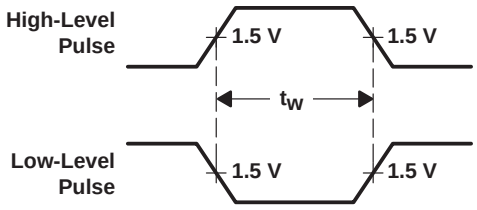
LOAD CIRCUIT
FOR 2-STATE TOTEM-POLE OUTPUTS



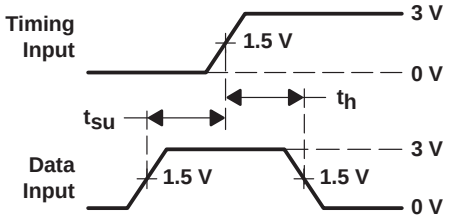
LOAD CIRCUIT
FOR OPEN-COLLECTOR OUTPUTS



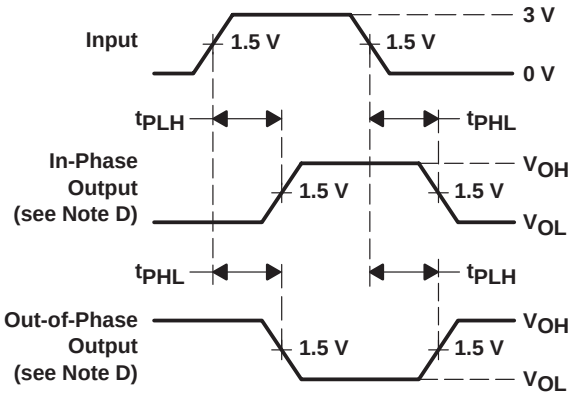
LOAD CIRCUIT
FOR 3-STATE OUTPUTS



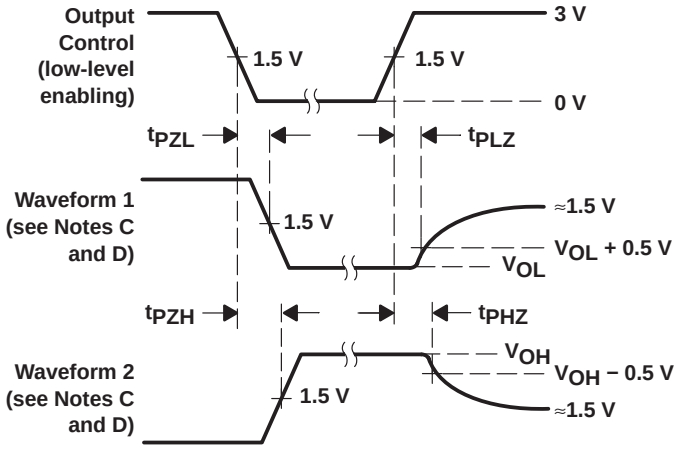
VOLTAGE WAVEFORMS
PULSE DURATIONS



VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES

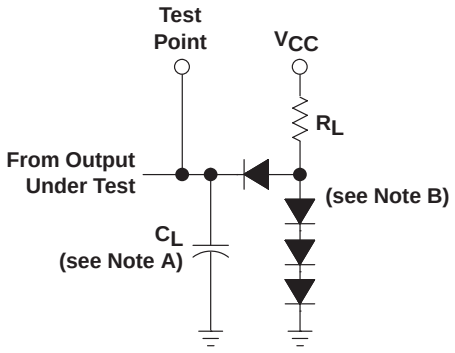


VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES, 3-STATE OUTPUTS

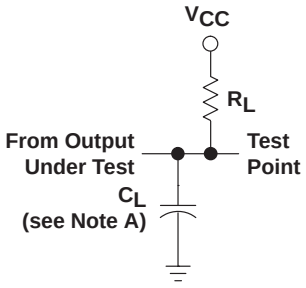
NOTES: A. C_L includes probe and jig capacitance.
B. All diodes are 1N3064 or equivalent.
C. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.
D. S1 and S2 are closed for t_{PLH}, t_{PHL}, t_{PHZ}, and t_{PLZ}; S1 is open, and S2 is closed for t_{PZH}; S1 is closed, and S2 is open for t_{PZL}.
E. All input pulses are supplied by generators having the following characteristics: PRR ≤ 1 MHz, $Z_O \approx 50\ \Omega$; t_r and $t_f \leq 7$ ns for Series 54/74 devices and t_r and $t_f \leq 2.5$ ns for Series 74LS devices.
F. The outputs are measured one at a time, with one input transition per measurement.

Figure 1. Load Circuits and Voltage Waveforms

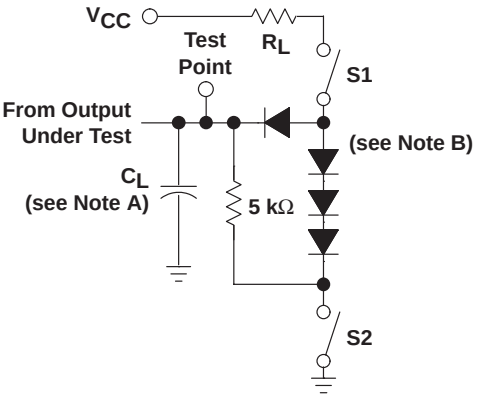
PARAMETER MEASUREMENT INFORMATION
SERIES 74LS DEVICES



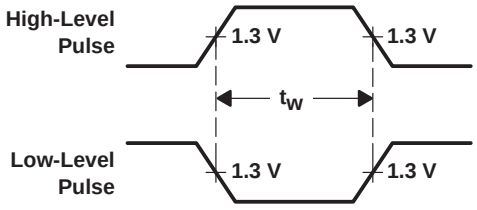
LOAD CIRCUIT
FOR 2-STATE TOTEM-POLE OUTPUTS



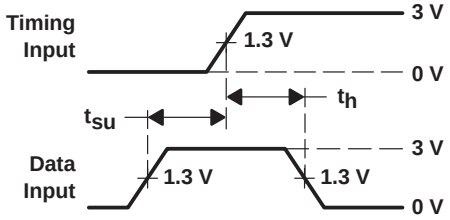
LOAD CIRCUIT
FOR OPEN-COLLECTOR OUTPUTS



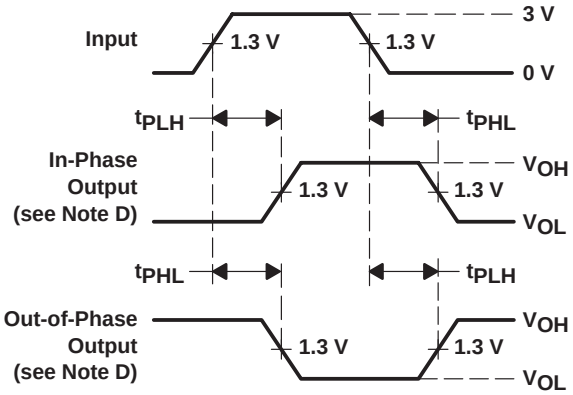
LOAD CIRCUIT
FOR 3-STATE OUTPUTS



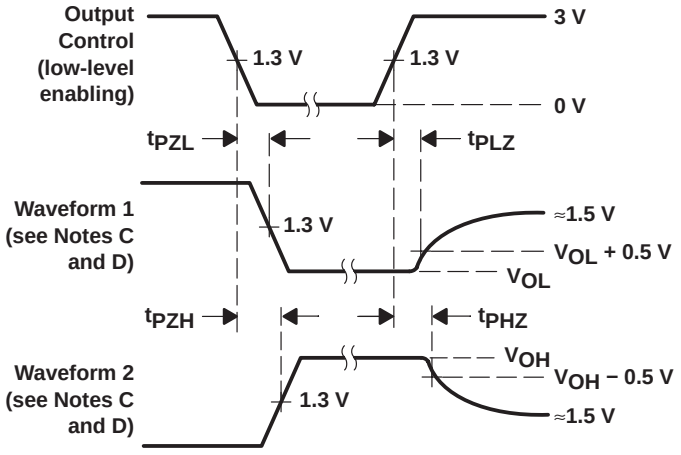
VOLTAGE WAVEFORMS
PULSE DURATIONS



VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES

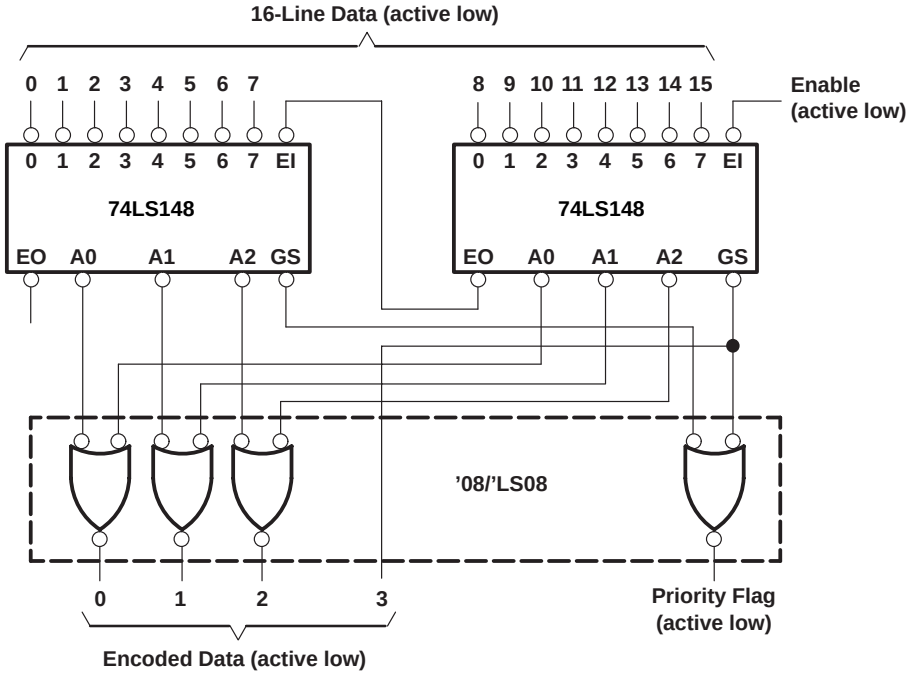


VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES, 3-STATE OUTPUTS

NOTES: A. C_L includes probe and jig capacitance.
B. All diodes are 1N3064 or equivalent.
C. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.
D. S1 and S2 are closed for t_{PLH}, t_{PHL}, t_{PHZ}, and t_{PLZ}; S1 is open, and S2 is closed for t_{PZH}; S1 is closed, and S2 is open for t_{PZL}.
E. Phase relationships between inputs and outputs have been chosen arbitrarily for these examples.
F. All input pulses are supplied by generators having the following characteristics: PRR ≤ 1 MHz, $Z_O \approx 50\ \Omega$, $t_r \le 1.5$ ns, $t_f \le 2.6$ ns.
G. The outputs are measured one at a time, with one input transition per measurement.

Figure 2. Load Circuits and Voltage Waveforms

APPLICATION INFORMATION



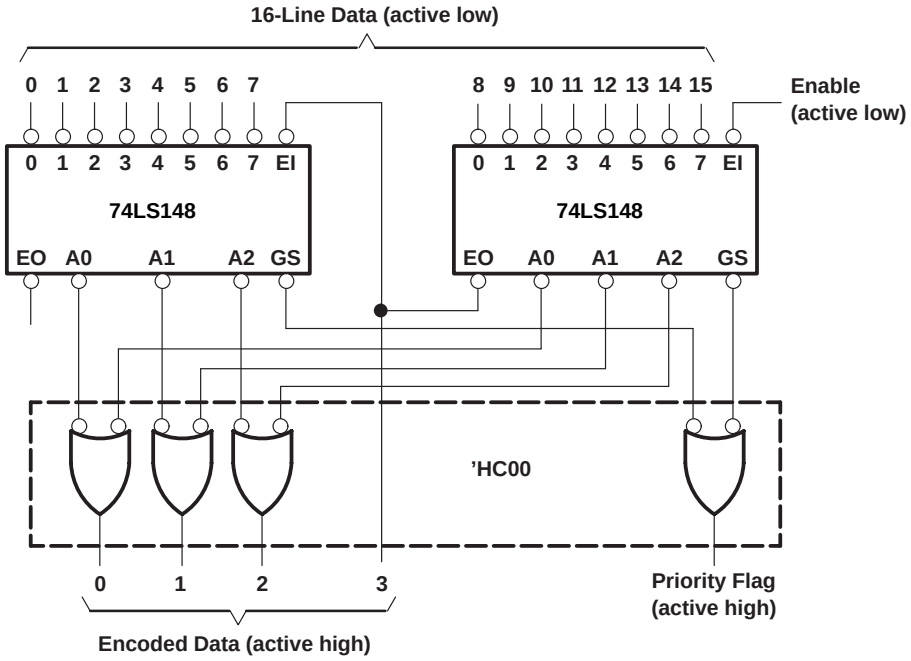


Figure 3. Priority Encoder for 16 Bits

Because the 74LS147 and 74LS148 devices are combinational logic circuits, wrong addresses can appear during input transients. Moreover, for the 74LS148 devices, a change from high to low at EI can cause a transient low on GS when all inputs are high. This must be considered when strobing the outputs.