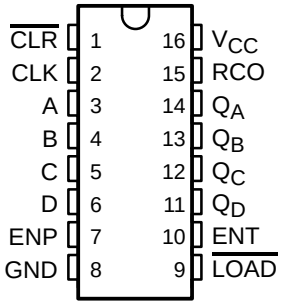
SDFS088A – MARCH 1987 – REVISED AUGUST 2001

- **Internal Look-Ahead Circuitry for Fast Counting**
- **Carry Output for N-Bit Cascading**
- **Fully Synchronous Operation for Counting**

D, DB, OR N PACKAGE
(TOP VIEW)



description

This synchronous, presettable, 4-bit binary counter has internal carry look-ahead circuitry for use in high-speed counting designs. Synchronous operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincident with each other when so instructed by the count-enable (ENP, ENT) inputs and internal gating. This mode of operation eliminates the output counting spikes that normally are associated with asynchronous (ripple-clock) counters. However, counting spikes can occur on the ripple-carry (RCO) output. A buffered clock (CLK) input triggers the four flip-flops on the rising (positive-going) edge of CLK.

This counter is fully programmable. That is, it can be preset to any number between 0 and 15. Because presetting is synchronous, a low logic level at the load ($\overline{\text{LOAD}}$) input disables the counter and causes the outputs to agree with the setup data after the next clock pulse, regardless of the levels of ENP and ENT.

The clear function is synchronous, and a low logic level at the clear ($\overline{\text{CLR}}$) input sets all four of the flip-flop outputs to low after the next low-to-high transition of the clock, regardless of the levels of ENP and ENT. This synchronous clear allows the count length to be modified easily by decoding the Q outputs for the maximum count desired. The active-low output of the gate used for decoding is connected to the clear input to synchronously clear the counter to 0000 (LLLL).

The carry look-ahead circuitry provides for cascading counters for n-bit synchronous applications, without additional gating. This function is implemented by the ENP and ENT inputs and an RCO output. Both ENP and ENT must be high to count, and ENT is fed forward to enable RCO. RCO, thus enabled, produces a high-logic-level pulse while the count is 15 (HHHH). The high-logic-level overflow ripple-carry pulse can be used to enable successive cascaded stages. Transitions at ENP or ENT are allowed, regardless of the level of CLK.

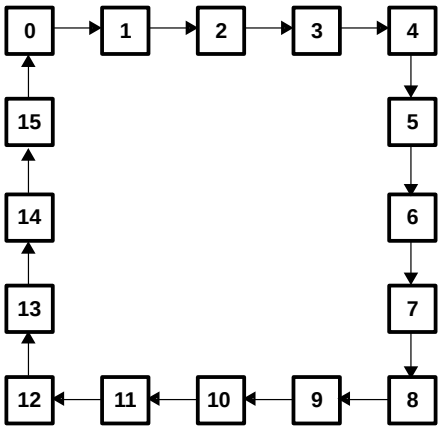
The SN74F163A features a fully independent clock circuit. Changes at ENP, ENT, or $\overline{\text{LOAD}}$ that modify the operating mode have no effect on the contents of the counter until clocking occurs. The function of the counter (whether enabled, disabled, loading, or counting) is dictated solely by the conditions meeting the setup and hold times.

ORDERING INFORMATION

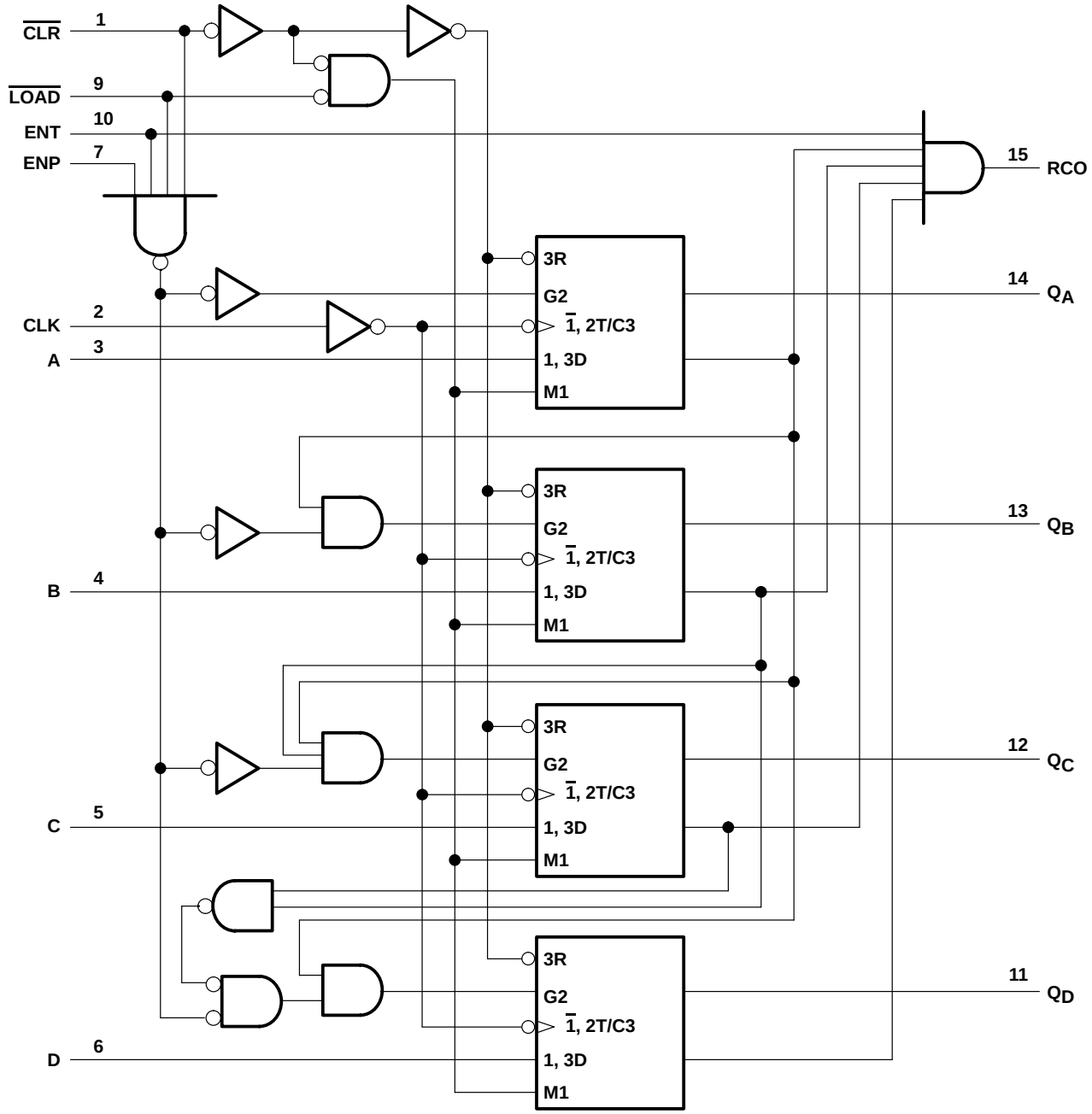
T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	PDIP – N	Tube	SN74F163AN	SN74F163AN
	SOIC – D	Tube	SN74F163AD	F163A
		Tape and reel	SN74F163ADR	
	SSOP – DB	Tape and reel	SN74F163ADBR	F163A

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

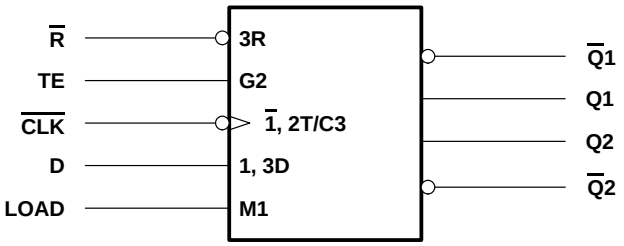
state diagram



logic diagram (positive logic)



logic symbol, each flip-flop



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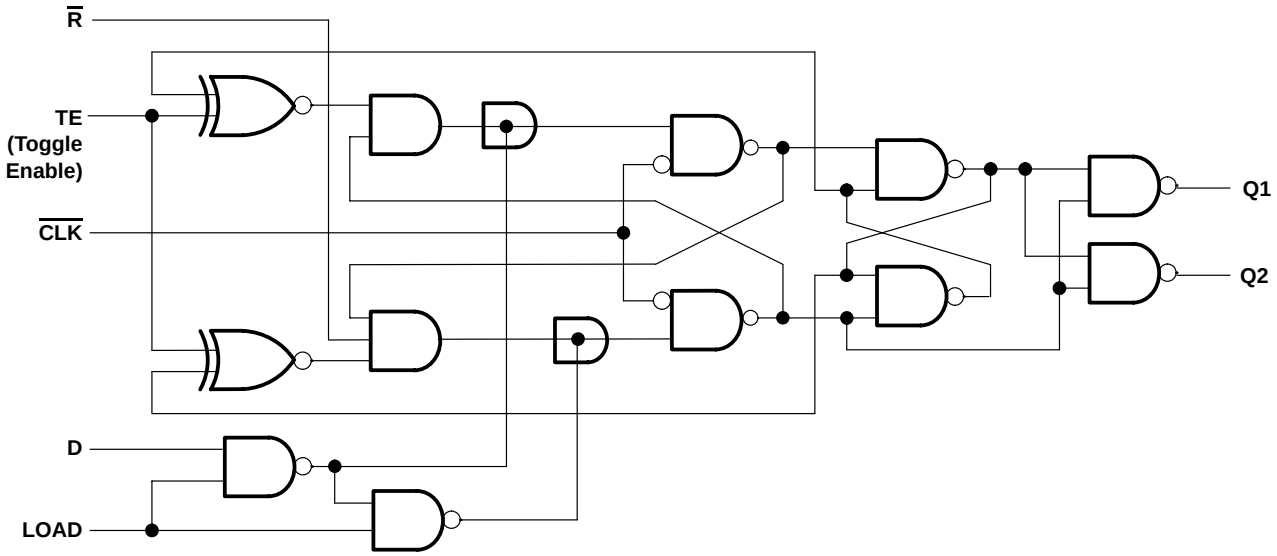
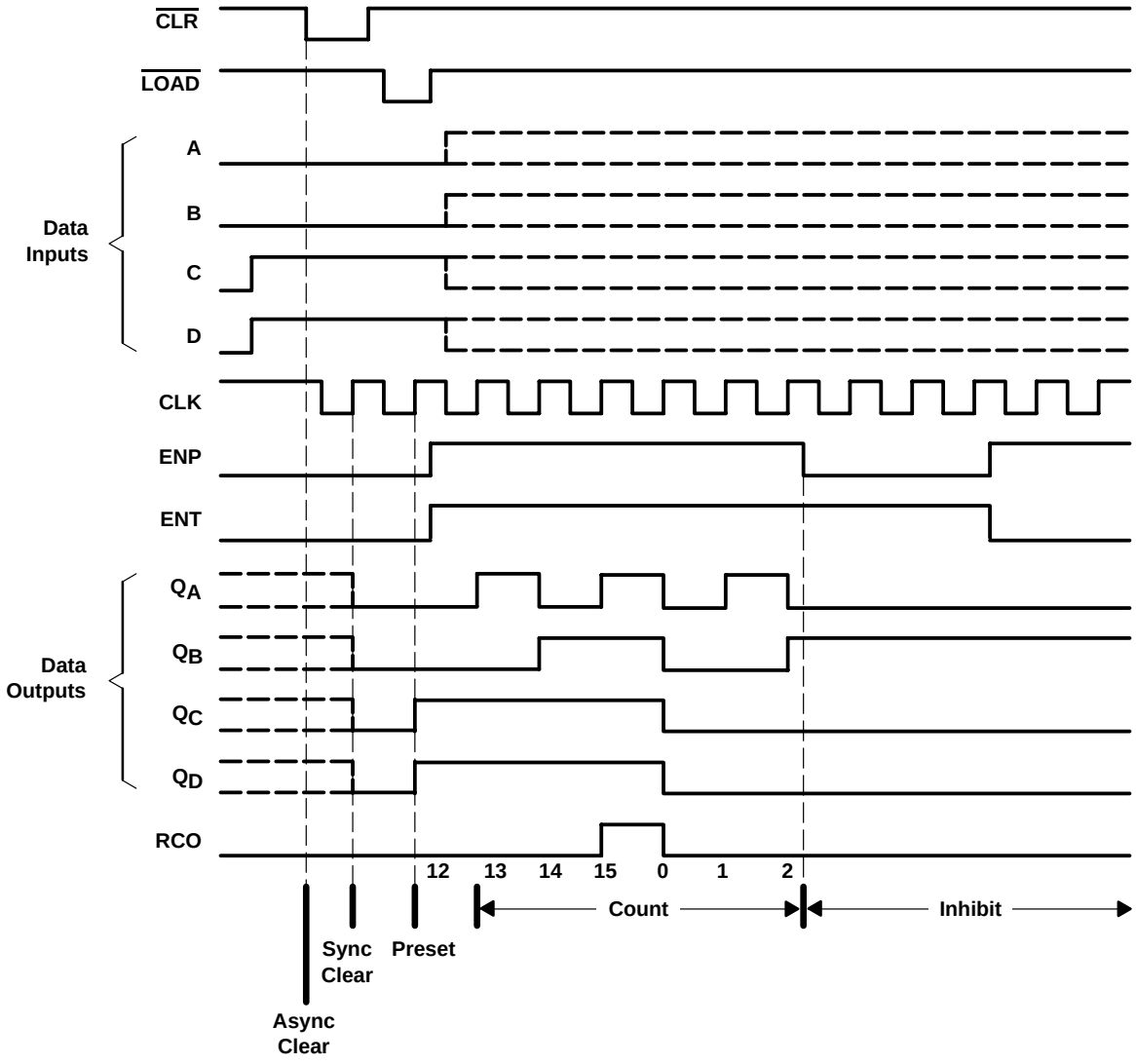


typical clear, preset, count, and inhibit sequences

The following timing sequence is illustrated below:

1. Clear outputs to zero
2. Preset to binary 12
3. Count to 13, 14, 15, 0, 1, and 2
4. Inhibit



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

Supply voltage range, V_{CC} . . . . . –0.5 V to 7 V
Input voltage range, V_I (see Note 1) . . . . . –1.2 V to 7 V
Input current range . . . . . –30 mA to 5 mA
Voltage range applied to any output in the high state . . . . . –0.5 V to V_{CC}
Current into any output in the low state . . . . . 40 mA
Package thermal impedance, θ_{JA} (see Note 2): D package . . . . . 73°C/W
DB package . . . . . 82°C/W
N package . . . . . 67°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. The input voltage ratings may be exceeded provided the input current ratings are observed.
2. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions (see Note 3)

		MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	4.5	5	5.5	V
V_{IH}	High-level input voltage	2			V
V_{IL}	Low-level input voltage			0.8	V
I_{IK}	Input clamp current			–18	mA
I_{OH}	High-level output current			–1	mA
I_{OL}	Low-level output current			20	mA
T_A	Operating free-air temperature	0		70	°C

NOTE 3: 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		MIN	TYP‡	MAX	UNIT
V_{IK}		V_{CC} = 4.5 V,	I_I = –18 mA			–1.2	V
V_{OH}		V_{CC} = 4.5 V,	I_{OH} = – 1 mA	2.5	3.4		V
		V_{CC} = 4.75 V,	I_{OH} = – 1 mA	2.7			
V_{OL}		V_{CC} = 4.5 V,	I_{OL} = 20 mA		0.3	0.5	V
I_I		V_{CC} = 5.5 V,	V_I = 7 V			0.1	mA
I_{IH}		V_{CC} = 5.5 V,	V_I = 2.7 V			20	µA
I_{IL}	ENP, CLK, A, B, C, D	V_{CC} = 5.5 V,	V_I = 0.5 V			– 0.6	mA
	ENT, $\overline{\text{LOAD}}$					– 1.2	
	$\overline{\text{CLR}}$					– 1.2	
I_{OS}§		V_{CC} = 5.5 V,	V_O = 0	–60		–150	mA
I_{CC}		V_{CC} = 5.5 V			37	55	mA

‡ All typical values are at V_{CC} = 5 V, T_A = 25°C.
§ Not more than one output should be shorted at a time, and the duration of the short circuit should not exceed one second.

timing requirements over recommended ranges of supply voltage and operating free-air temperature (unless otherwise noted)

				V_{CC} = 5 V, T_A = 25°C		MIN	MAX	UNIT
				MIN	MAX			
f_{clock}	Clock frequency			0	100	0	90	MHz
t_w	Pulse duration	CLK high or low (loading)		5		5		ns
		CLK (counting)	High	4		4		
			Low	6		7		
t_{su}	Setup time	Data before CLK↑	High or low	5		5		ns
		$\overline{LOAD}$ and $\overline{CLR}$ before CLK↑	High	11		11.5		
			Low	8.5		9.5		
		ENP and ENT before CLK↑	High	11		11.5		
			Low	5		5		
t_h	Hold time	Data after CLK↑	High or low	2		2		ns
		LOAD and CLR after CLK↑	High	2		2		
			Low	0		0		
		ENP and ENT after CLK↑	High or low	0		0		

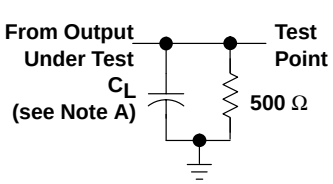
switching characteristics (see Note 4)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CC} = 5 V, C_L = 50 PF, R_L = 500 Ω, T_A = 25°C			V_{CC} = 4.5 V TO 5.5 V, C_L = 50 PF, R_L = 500 Ω, T_A = MIN TO MAX†		UNIT
			MIN	TYP	MAX	MIN	MAX	
f_{max}			100	120		90		MHz
t_{PLH}	CLK ($\overline{LOAD}$ high)	Any Q	2.7	5.1	7.5	2.7	8.5	ns
t_{PHL}			2.7	7.1	10	2.7	11	
t_{PLH}	CLK (LOAD low)	Any Q	3.2	5.6	8.5	3.2	9.5	ns
t_{PHL}			3.2	5.6	8.5	3.2	9.5	
t_{PLH}	CLK	RCO	4.2	9.6	14	4.2	15	ns
t_{PHL}			4.2	9.6	14	4.2	15	
t_{PLH}	ENT	RCO	1.7	4.1	7.5	1.7	8.5	ns
t_{PHL}			1.7	4.1	7.5	1.7	8.5	

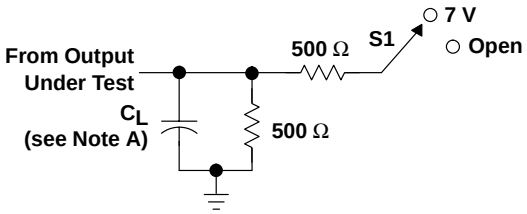
† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

NOTE 4: Load circuits and waveforms are shown in Figure 1.

PARAMETER MEASUREMENT INFORMATION

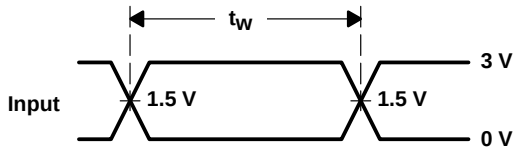


LOAD CIRCUIT FOR
TOTEM-POLE OUTPUTS

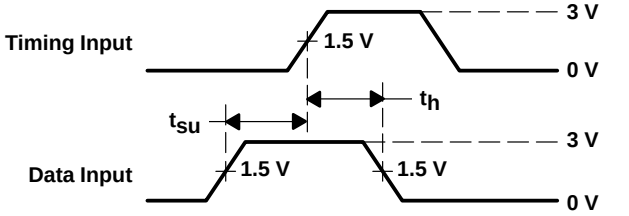


LOAD CIRCUIT FOR
3-STATE AND OPEN-DRAIN OUTPUTS

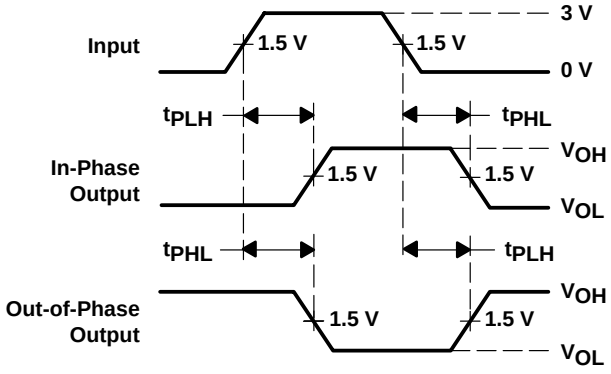
TEST	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	7 V
t_{PHZ}/t_{PZH}	Open
Open Collector	7 V



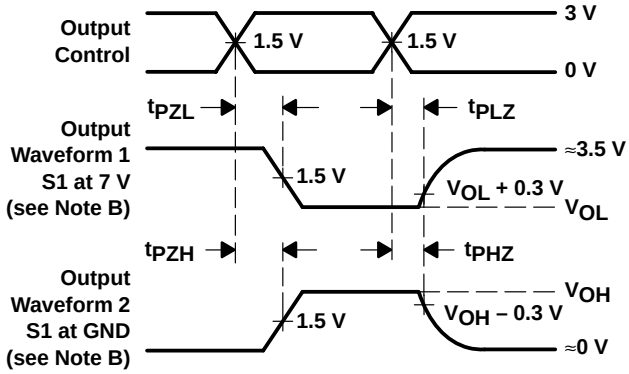
VOLTAGE WAVEFORMS
PULSE DURATION



VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES
INVERTING AND NONINVERTING OUTPUTS



VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES
LOW- AND HIGH-LEVEL ENABLING

NOTES: A. C_L includes probe and jig capacitance.
B. 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.
C. All input pulses are supplied by generators having the following characteristics: PRR ≤ 1 MHz, Z_O = 50 Ω, t_r ≤ 2.5 ns, t_f ≤ 2.5 ns, duty cycle = 50%.
D. The outputs are measured one at a time with one input transition per measurement.

Figure 1. Load Circuit and Voltage Waveforms

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