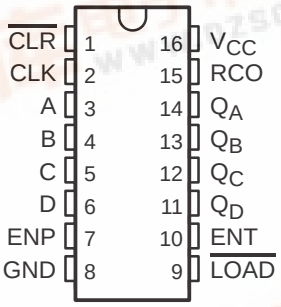
SN54ALS161B, SN54ALS162B, SN54ALS163B, SN54AS161, SN54AS163
SN74ALS161B, SN74ALS163B, SN74AS161, SN74AS163
SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS

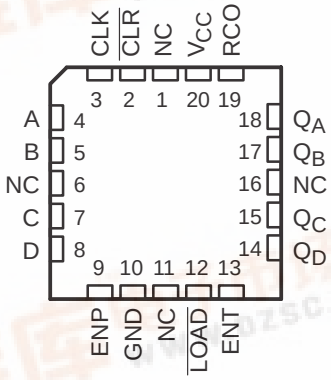
SDAS276 – DECEMBER 1994

- **Internal Look-Ahead Circuitry for Fast Counting**
- **Carry Output for n-Bit Cascading**
- **Synchronous Counting**
- **Synchronously Programmable**
- **Package Options Include Plastic Small-Outline (D) Packages, Ceramic Chip Carriers (FK), and Standard Plastic (N) and Ceramic (J) 300-mil DIPs**

SN54ALS161B, SN54ALS162B, SN54ALS163B, SN54AS161, SN54AS163 . . . J PACKAGE
SN74ALS161B, SN74ALS163B, SN74AS161, SN74AS163 . . . D OR N PACKAGE
(TOP VIEW)



SN54ALS161B, SN54ALS162B, SN54ALS163B, SN54AS161, SN54AS163 . . . FK PACKAGE
(TOP VIEW)



NC – No internal connection

description

These synchronous, presettable, 4-bit decade and binary counters feature an internal carry look-ahead circuitry for application in high-speed counting designs. The SN54ALS162B is a 4-bit decade counter. The ′ALS161B, ′ALS163B, ′AS161, and ′AS163 are 4-bit binary counters. Synchronous operation is provided by having all flip-flops clocked simultaneously so that the outputs change coincidentally with each other when instructed by the count-enable (ENP, ENT) inputs and internal gating. This mode of operation eliminates the output counting spikes normally associated with asynchronous (ripple-clock) counters. A buffered clock (CLK) input triggers the four flip-flops on the rising (positive-going) edge of the clock input waveform.

These counters are fully programmable; they may be preset to any number between 0 and 9 or 15. Because presetting is synchronous, setting up a low 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 the enable inputs.

The clear function for the ′ALS161B and ′AS161 is asynchronous. A low level at the clear ($\overline{\text{CLR}}$) input sets all four of the flip-flop outputs low, regardless of the levels of the CLK, $\overline{\text{LOAD}}$, or enable inputs. The clear function for the SN54ALS162B, ′ALS163B, and ′AS163 is synchronous, and a low level at $\overline{\text{CLR}}$ sets all four of the flip-flop outputs low after the next clock pulse, regardless of the levels of the enable inputs. 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 $\overline{\text{CLR}}$ 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. ENP and ENT inputs and a ripple-carry (RCO) output are instrumental in accomplishing this function. Both ENP and ENT must be high to count, and ENT is fed forward to enable RCO. RCO, thus enabled, produces a high-level pulse while the count is maximum (9 or 15 with Q_A high). The high-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.

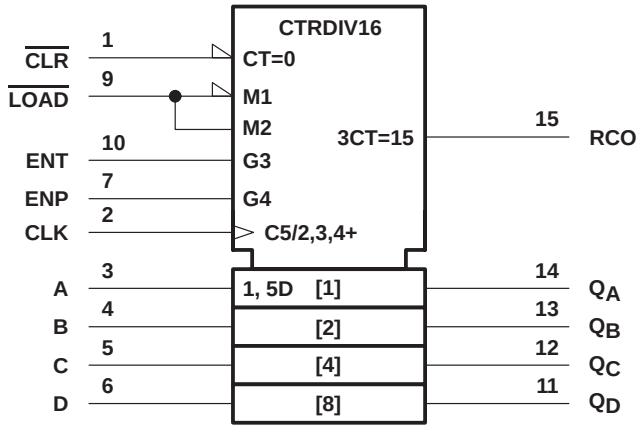
description (continued)

These counters feature a fully independent clock circuit. Changes at control inputs (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 stable setup and hold times.

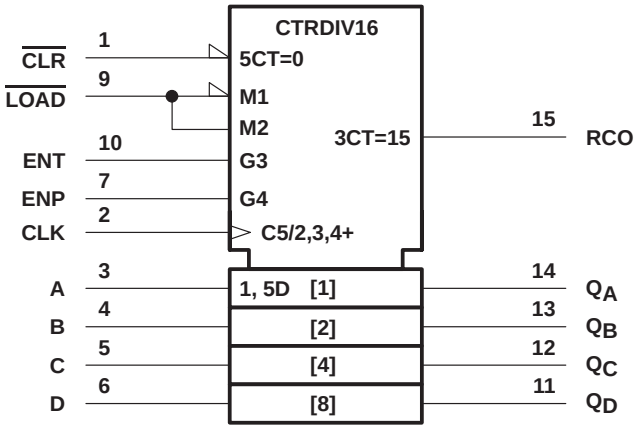
The SN54ALS161B, SN54ALS162B, SN54ALS163B, SN54AS161, and SN54AS163 are characterized for operation over the full military temperature range of –55°C to 125°C. The SN74ALS161B, SN74ALS163B, SN74AS161, and SN74AS163 are characterized for operation from 0°C to 70°C.

logic symbols†

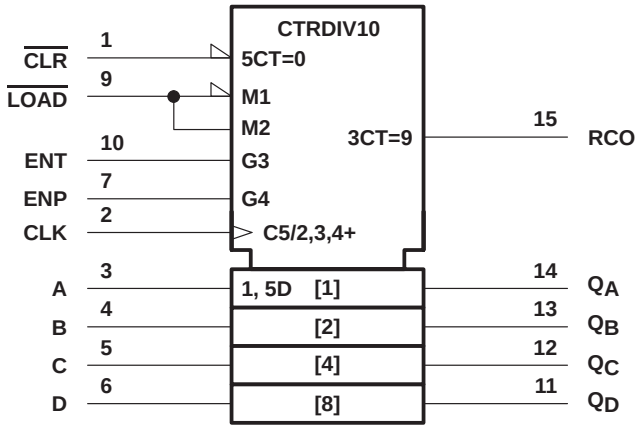
′ALS161B AND ′AS161 BINARY COUNTERS
WITH DIRECT CLEAR



′ALS163B AND ′AS163 BINARY COUNTERS
WITH SYNCHRONOUS CLEAR

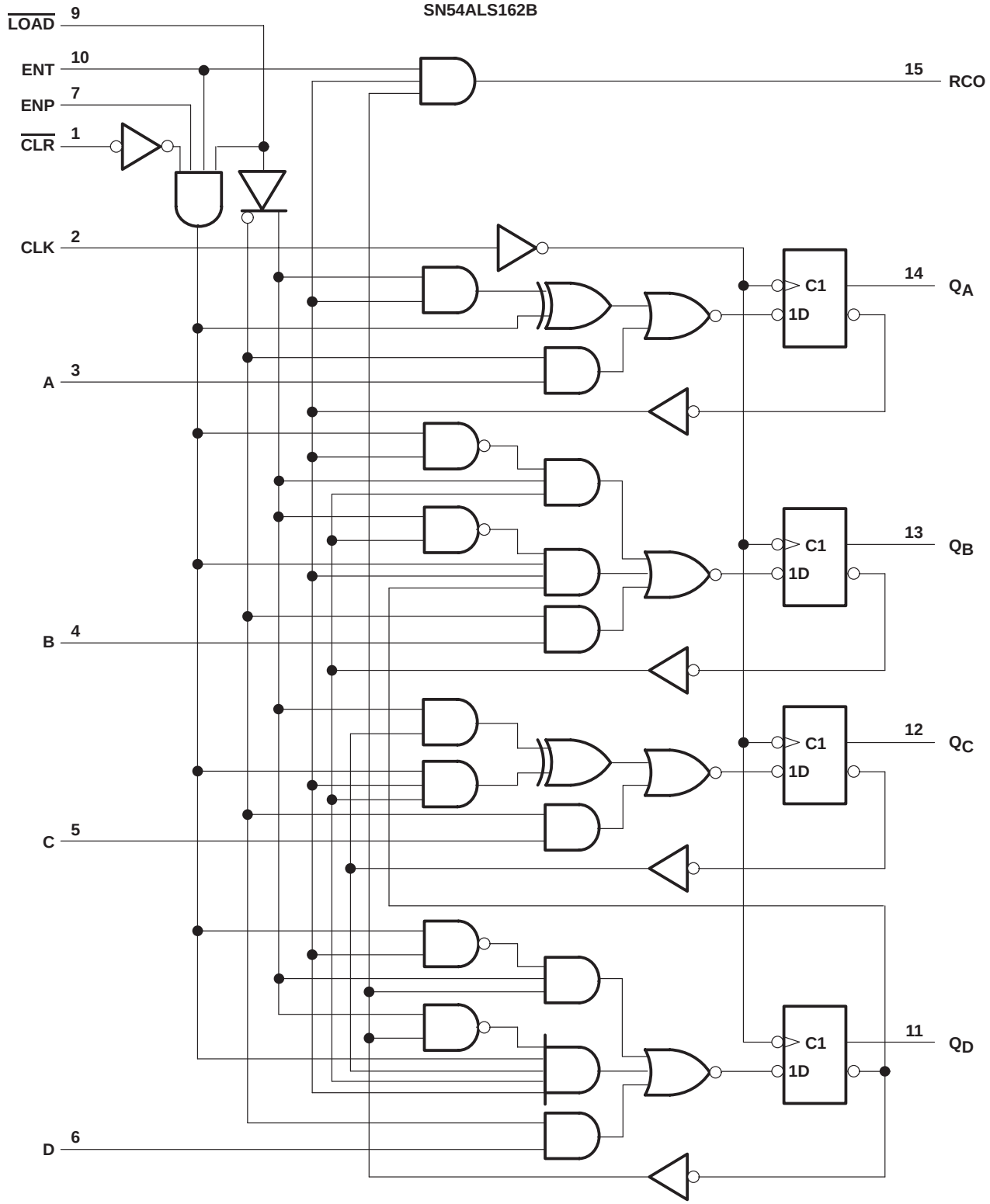


SN54ALS162B DECADE COUNTER
WITH SYNCHRONOUS CLEAR



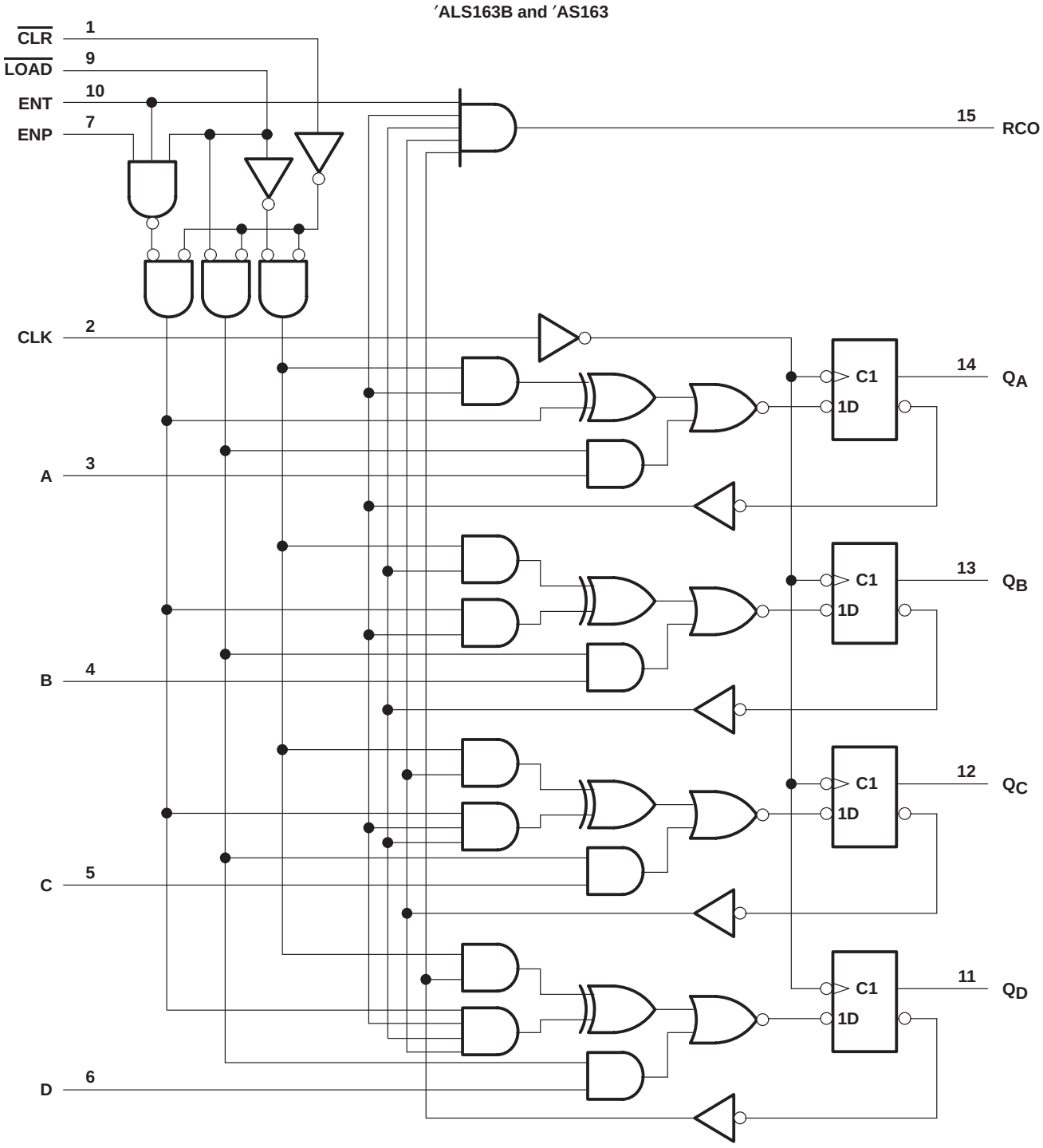
† These symbols are in accordance with ANSI/IEEE Std 91-1984 and IEC Publication 617-12.
Pin numbers shown are for the D, J, and N packages.

logic diagram (positive logic)



Pin numbers shown are for the J package.

logic diagram (positive logic)



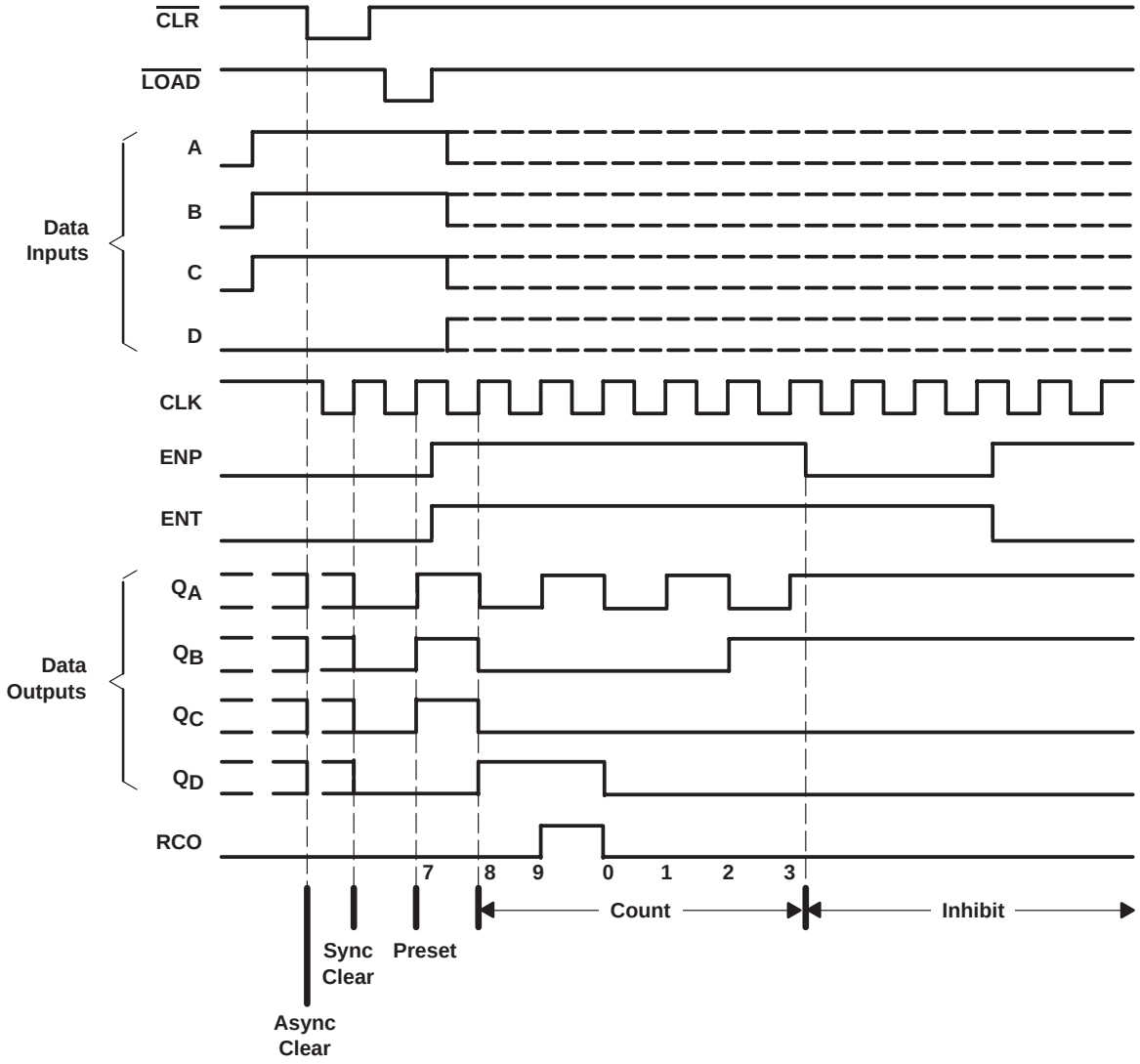
Pin numbers shown are for the D, J, and N packages.
′ALS161B and ′AS161 synchronous binary counters are similar; however, $\overline{\text{CLR}}$ is asynchronous.

typical clear, preset, count, and inhibit sequences

SN54ALS162B

The following sequence is illustrated below:

1. Clear outputs to zero (SN54ALS162B is synchronous)
2. Preset to BCD 7
3. Count to 8, 9, 0, 1, 2, and 3
4. Inhibit

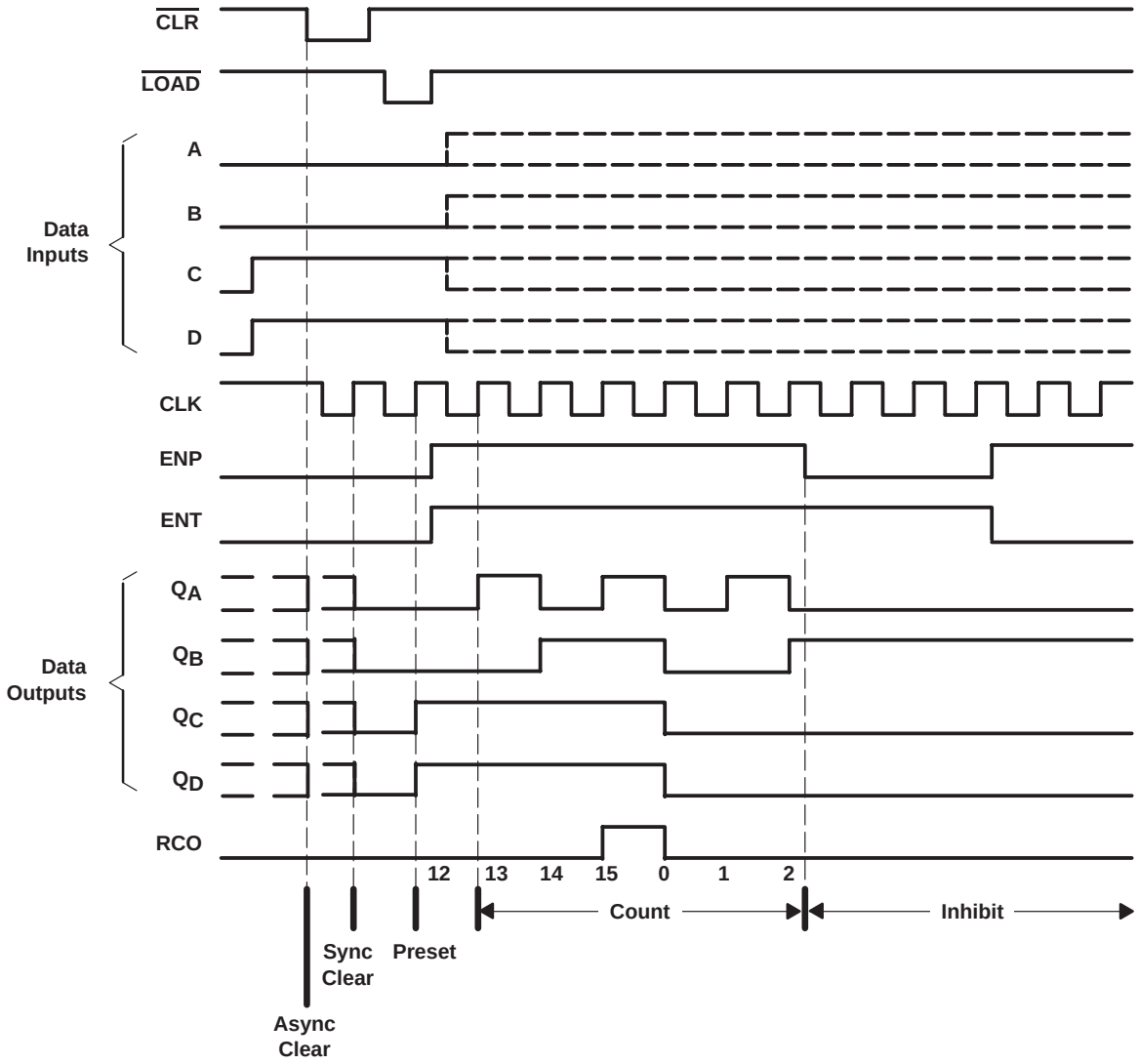


typical clear, preset, count, and inhibit sequences

′ALS161B, ′AS161, ′ALS163B, and ′AS163

The following sequence is illustrated below:

1. Clear outputs to zero (′ALS161B and ′AS161 are asynchronous; ′ALS163B and ′AS163 are synchronous.)
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, V_{CC} . . . . . 7 V
Input voltage, V_I . . . . . 7 V
Operating free-air temperature range, T_A: SN54ALS161B, SN54ALS162B, SN54ALS163B . . . . . –55°C to 125°C
SN74ALS161B, SN74ALS163B . . . . . 0°C to 70°C
Storage temperature range . . . . . –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.

recommended operating conditions

				SN54ALS161B SN54ALS162B SN54ALS163B			SN74ALS161B SN74ALS163B			UNIT
				MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage			4.5	5	5.5	4.5	5	5.5	V
V_{IH}	High-level input voltage			2			2			V
V_{IL}	Low-level input voltage					0.7			0.8	V
I_{OH}	High-level output current					–0.4			–0.4	mA
I_{OL}	Low-level output current					4			8	mA
f_{clock}	Clock frequency			0		22	0		40	MHz
t_w	Pulse duration	$\overline{CLR}$ high or low		20			12.5			ns
		′ALS161B	$\overline{CLR}$ low	20			15			
t_{su}	Setup time before CLK↑	A, B, C, D		50			15			ns
		$\overline{LOAD}$		20			15			
		′ALS161B	ENP, ENT	25			15			
		SN54ALS162B, ′ALS163B		20			15			
		′ALS161B	$\overline{CLR}$ inactive	10			10			
		SN54ALS162B, ′ALS163B	$\overline{CLR}$ low	20			15			
			$\overline{CLR}$ high	20			10			
t_h	Hold time, all synchronous inputs after CLK↑			0			0			ns
T_A	Operating free-air temperature			–55		125	0		70	°C

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

PARAMETER	TEST CONDITIONS		SN54ALS161B SN54ALS162B SN54ALS163B			SN74ALS161B SN74ALS163B			UNIT
			MIN	TYP†	MAX	MIN	TYP†	MAX	
V_{IK}	V_{CC} = 4.5 V,	I_I = –18 mA			–1.5			–1.5	V
V_{OH}	V_{CC} = 4.5 V to 5.5 V,	I_{OH} = –0.4 mA	V_{CC} –2			V_{CC} –2			V
V_{OL}	V_{CC} = 4.5 V	I_{OL} = 4 mA		0.25	0.4		0.25	0.4	V
		I_{OL} = 8 mA					0.35	0.5	
I_I	V_{CC} = 5.5 V,	V_I = 7 V			0.1			0.1	mA
I_{IH}	V_{CC} = 5.5 V,	V_I = 2.7 V			20			20	µA
I_{IL}	V_{CC} = 5.5 V,	V_I = 0.4 V			–0.2			–0.2	mA
I_O‡	V_{CC} = 5.5 V,	V_O = 2.25 V	–20		–112	–30		–112	mA
I_{CC}	V_{CC} = 5.5 V			12	21		12	21	mA

† All typical values are at V_{CC} = 5 V, T_A = 25°C.
‡ The output conditions have been chosen to produce a current that closely approximates one half of the true short-circuit output current, I_{OS}.

switching characteristics (see Figure 3)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CC} = 4.5 V to 5.5 V, C_L = 50 pF, R_L = 500 Ω, T_A = MIN to MAX§				UNIT
			SN54ALS161B		SN74ALS161B		
			MIN	MAX	MIN	MAX	
f_{max}			22		40		MHz
t_{PLH}	CLK	RCO	5	34	5	20	ns
t_{PHL}			5	27	5	20	
t_{PLH}	CLK	Any Q	4	19	4	15	ns
t_{PHL}			6	25	6	20	
t_{PLH}	ENT	RCO	3	18	3	13	ns
t_{PHL}			3	17	3	13	
t_{PHL}	$\overline{CLR}$	Any Q	8	27	8	24	ns
		RCO	11	32	11	23	

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

switching characteristics (see Figure 3)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CC} = 4.5 V to 5.5 V, C_L = 50 pF, R_L = 500 Ω, T_A = MIN to MAX†				UNIT
			SN54ALS162B SN54ALS163B		SN74ALS163B		
			MIN	MAX	MIN	MAX	
f_{max}			35		40		MHz
t_{PLH}	CLK	RCO	5	25	5	20	ns
t_{PHL}			5	25	5	20	
t_{PLH}	CLK	Any Q	4	18	4	15	ns
t_{PHL}			6	25	6	20	
t_{PLH}	ENT	RCO	3	16	3	13	ns
t_{PHL}			3	16	3	13	

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

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

Supply voltage, V_{CC} . . . . . 7 V
Input voltage, V_I . . . . . 7 V
Operating free-air temperature range, T_A: SN54AS161, SN54AS163 . . . . . −55°C to 125°C
SN74AS161, SN74AS163 . . . . . 0°C to 70°C
Storage temperature range . . . . . −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.

recommended operating conditions

				SN54AS161 SN54AS163			SN74AS161 SN74AS163			UNIT
				MIN	NOM	MAX	MIN	NOM	MAX	
V_{CC}	Supply voltage			4.5	5	5.5	4.5	5	5.5	V
V_{IH}	High-level input voltage			2			2			V
V_{IL}	Low-level input voltage					0.8			0.8	V
I_{OH}	High-level output current					−2			−2	mA
I_{OL}	Low-level output current					20			20	mA
f_{clock}*	Clock frequency			0		65	0		75	MHz
t_w*	Pulse duration	$\overline{CLR}$ high or low		7.7			6.7			ns
		′AS161	$\overline{CLR}$ low	10			8			
t_{su}*	Setup time before CLK↑	A, B, C, D		10			8			ns
		$\overline{LOAD}$		10			8			
		ENP, ENT		10			8			
		′AS161	$\overline{CLR}$ inactive	10			8			
		′AS163	$\overline{CLR}$ low	14			12			
			$\overline{CLR}$ high (inactive)	10			9			
t_h*	Hold time, all synchronous inputs after CLK↑			2			0			ns
T_A	Operating free-air temperature			−55		125	0		70	°C

* On products compliant to MIL-STD-883, Class B, this parameter is based on characterization data but is not production tested.

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

PARAMETER		TEST CONDITIONS		SN54AS161 SN54AS163			SN74AS161 SN74AS163			UNIT
				MIN	TYP†	MAX	MIN	TYP†	MAX	
V_{IK}		V_{CC} = 4.5 V,	I_I = –18 mA			–1.2			–1.2	V
V_{OH}		V_{CC} = 4.5 V to 5.5 V,	I_{OH} = –2 mA	V_{CC} –2			V_{CC} –2			V
V_{OL}		V_{CC} = 4.5 V,	I_{OL} = 20 mA		0.25	0.5		0.25	0.5	V
I_I	$\overline{LOAD}$	V_{CC} = 5.5 V,	V_I = 7 V			0.3			0.3	mA
	ENT					0.2			0.2	
	All others					0.1			0.1	
I_{IH}	$\overline{LOAD}$	V_{CC} = 5.5 V,	V_I = 2.7 V			60			60	µA
	ENT					40			40	
	All others					20			20	
I_{IL}	$\overline{LOAD}$	V_{CC} = 5.5 V,	V_I = 0.4 V			–1.5			–1.5	mA
	ENT					–1			–1	
	All others					–0.5			–0.5	
I_O‡		V_{CC} = 5.5 V,	V_O = 2.25 V	–30		–112	–30		–112	mA
I_{CC}		V_{CC} = 5.5 V			35	53		35	53	mA

† All typical values are at V_{CC} = 5 V, T_A = 25°C.
‡ The output conditions have been chosen to produce a current that closely approximates one half of the true short-circuit output current, I_{OS}.

switching characteristics (see Figure 3)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CC} = 4.5 V to 5.5 V, C_L = 50 pF, R_L = 500 Ω, T_A = MIN to MAX§				UNIT
			SN54AS161		SN74AS161		
			MIN	MAX	MIN	MAX	
f_{max}*			65		75		MHz
t_{PLH}	CLK	RCO (with $\overline{LOAD}$ high)	1	8.5	1	8	ns
		RCO (with $\overline{LOAD}$ low)	3	17.5	3	16.5	
t_{PHL}		RCO	2	14	2	12.5	
t_{PLH}	CLK	Any Q	1	7.5	1	7	ns
t_{PHL}			2	14	2	13	
t_{PLH}	ENT	RCO	1.5	10	1.5	9	ns
t_{PHL}			1	9.5	1	8.5	
t_{PHL}	$\overline{CLR}$	Any Q	2	14	2	13	ns
		RCO	2	14	2	12.5	

* On products compliant to MIL-STD-883, Class B, this parameter is based on characterization data but is not production tested.
§ For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

switching characteristics (see Figure 3)

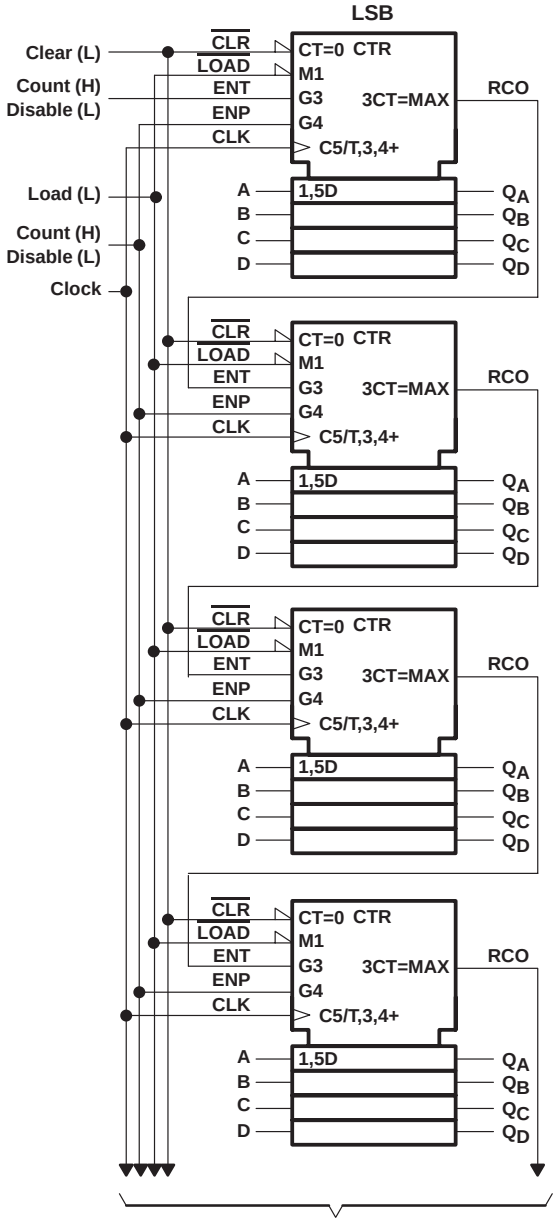
PARAMETER	FROM (INPUT)	TO (OUTPUT)	V_{CC} = 4.5 V to 5.5 V, C_L = 50 pF, R_L = 500 Ω, T_A = MIN to MAX†				UNIT
			SN54AS163		SN74AS163		
			MIN	MAX	MIN	MAX	
f_{max}*			65		75		MHz
t_{PLH}	CLK	RCO (with $\overline{\text{LOAD}}$ high)	1	8.5	1	8	ns
		RCO (with $\overline{\text{LOAD}}$ low)	3	17.5	3	16.5	
t_{PHL}		RCO	2	14	2	12.5	
t_{PLH}	CLK	Any Q	1	7.5	1	7	ns
t_{PHL}			2	14	2	13	
t_{PLH}	ENT	RCO	1.5	10	1.5	9	ns
t_{PHL}			1	9.5	1	8.5	

* On products compliant to MIL-STD-883, Class B, this parameter is based on characterization data but is not production tested.
† For conditions shown as MIN or MAX, use the appropriate value specified under recommended operating conditions.

APPLICATION INFORMATION

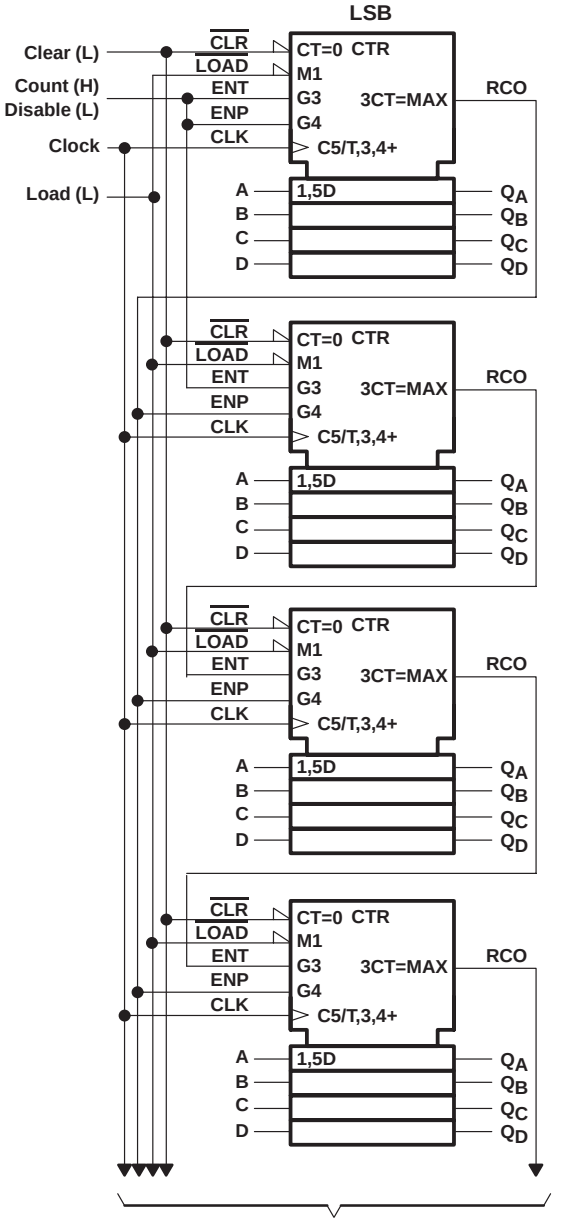
n-bit synchronous counters

This application demonstrates how the ripple-mode carry circuit (see Figure 1) and the carry-look-ahead circuit (see Figure 2) can be used to implement a high-speed n-bit counter. The SN54ALS162B counts in BCD. The ′ALS161B, ′AS161, ′ALS163B, and ′AS163 count in binary. When additional stages are added, the f_{max} decreases in Figure 1, but remains unchanged in Figure 2.



$f_{max} = 1/(\text{CLK to RCO } t_{PLH}) + (\text{ENT to RCO } t_{PLH})\ (N - 2) + (\text{ENT } t_{su})$

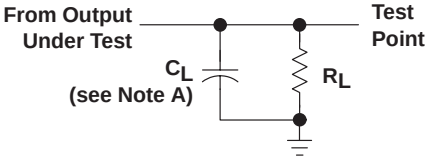
Figure 1. Ripple-Mode Carry Circuit



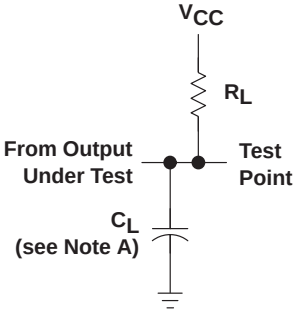
$f_{max} = 1/(\text{CLK to RCO } t_{PLH}) + (\text{ENP } t_{su})$

Figure 2. Carry-Look-Ahead Circuit

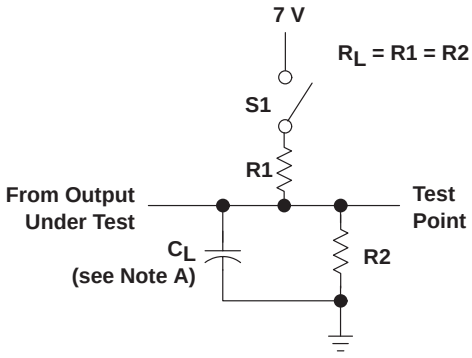
PARAMETER MEASUREMENT INFORMATION
SERIES 54ALS/74ALS AND 54AS/74AS DEVICES



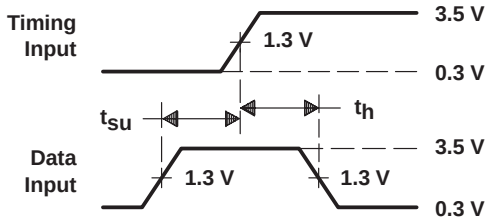
LOAD CIRCUIT FOR
BI-STATE
TOTEM-POLE OUTPUTS



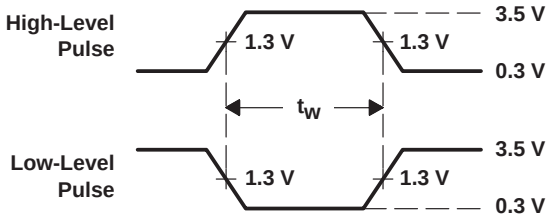
LOAD CIRCUIT
FOR OPEN-COLLECTOR OUTPUTS



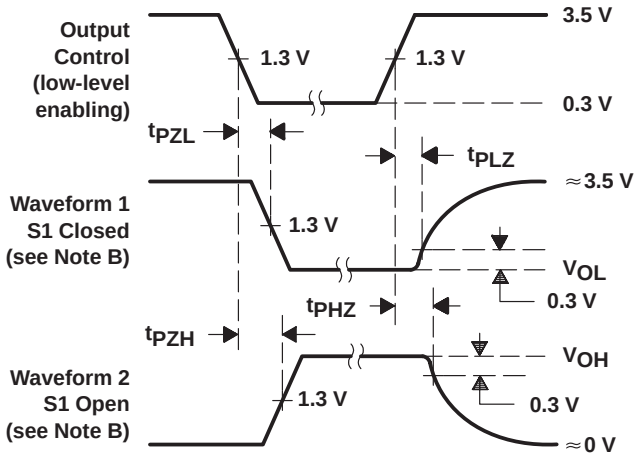
LOAD CIRCUIT
FOR 3-STATE OUTPUTS



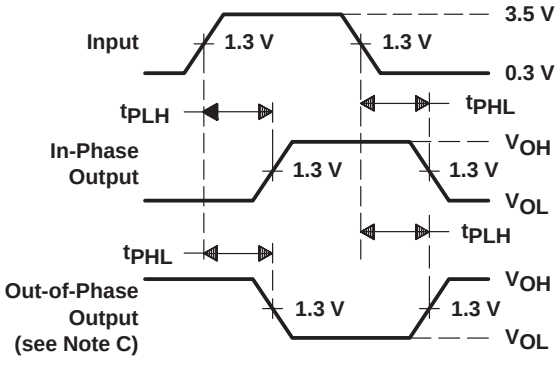
VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES



VOLTAGE WAVEFORMS
PULSE DURATIONS



VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES, 3-STATE OUTPUTS



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES

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. When measuring propagation delay items of 3-state outputs, switch S1 is open.
D. All input pulses have the following characteristics: PRR ≤ 1 MHz, $t_r = t_f$ = 2 ns, duty cycle = 50%.
E. The outputs are measured one at a time with one transition per measurement.

Figure 3. Load Circuits and Voltage Waveforms

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