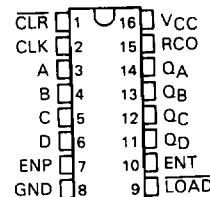


# TYPES SN54ALS160A THRU SN54ALS163A, SN54AS160 THRU SN54AS163 SN74ALS160A THRU SN74ALS163A, SN74AS160 THRU SN74AS163 SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS

D2661, APRIL 1982—REVISED DECEMBER 1983

- Internal Look-Ahead for Fast Counting
- Carry Output for n-Bit Cascading
- Synchronous Counting
- Synchronously Programmable
- Package Options Include Both Plastic and Ceramic Chip Carriers in Addition to Plastic and Ceramic DIPs
- Dependable Texas Instruments Quality and Reliability

SN54ALS', SN54AS' . . . J PACKAGE  
SN74ALS', SN74AS' . . . N PACKAGE  
(TOP VIEW)



## description

These synchronous, presettable counters feature an internal carry look-ahead for application in high-speed counting designs. The 'ALS160A, 'ALS162A, 'AS160, and 'AS162 are decade counters, and the 'ALS161A, 'ALS163A, 'AS161, and 'AS163 are 4-bit binary counters. 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 inputs and internal gating. This mode of operation eliminates the output counting spikes that are normally associated with asynchronous (ripple clock) counters. A buffered clock input triggers the four flip-flops on the rising (positive-going) edge of the clock input waveform.

These counters are fully programmable; that is, the outputs may be preset to either level. As presetting is synchronous, setting up a low level at the 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 'ALS160A, 'ALS161A, 'AS160, and 'AS161 is asynchronous and a low level at the clear input sets all four of the flip-flop outputs low regardless of the levels of the clock, load, or enable inputs.

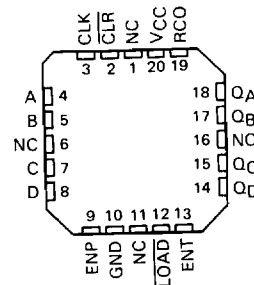
The clear function for the 'ALS162A, 'ALS163A, 'AS162, and 'AS163 is synchronous and a low level at the clear input sets all four of the flip-flop outputs low after the next clock pulse, regardless of the levels of the enable inputs. This synchronous clear allows the count length to be modified easily as decoding the maximum count desired can be accomplished with one external NAND gate. The gate output 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. Instrumental in accomplishing this function are two count-enable inputs and a ripple carry output. Both count-enable inputs (ENP and ENT) must be high to count, and ENT is fed forward to enable the ripple carry output. The ripple carry output (RCO) thus enabled will produce a high-level pulse while the count is maximum (9 or 15 with QA high). This high-level overflow ripple carry pulse can be used to enable successive cascaded stages. Transitions at the ENP or ENT are allowed regardless of the level of the clock input.

These counters feature a fully independent clock circuit. Changes at control inputs (ENP, ENT, or LOAD) that will 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) will be dictated solely by the conditions meeting the stable setup and hold times.

The SN54ALS160A through SN54ALS163A and SN54AS160 through SN54AS163 are characterized for operation over the full military temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$ . The SN74ALS160A through SN74ALS163A and SN74AS160 through SN74AS163 are characterized for operation from  $0^{\circ}\text{C}$  to  $70^{\circ}\text{C}$ .

SN54ALS', SN54AS' . . . FH PACKAGE  
SN74ALS', SN74AS' . . . FN PACKAGE  
(TOP VIEW)



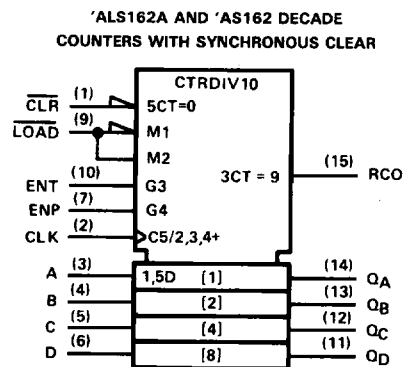
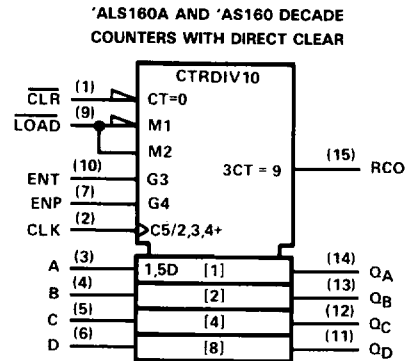
NC—No internal connection

2

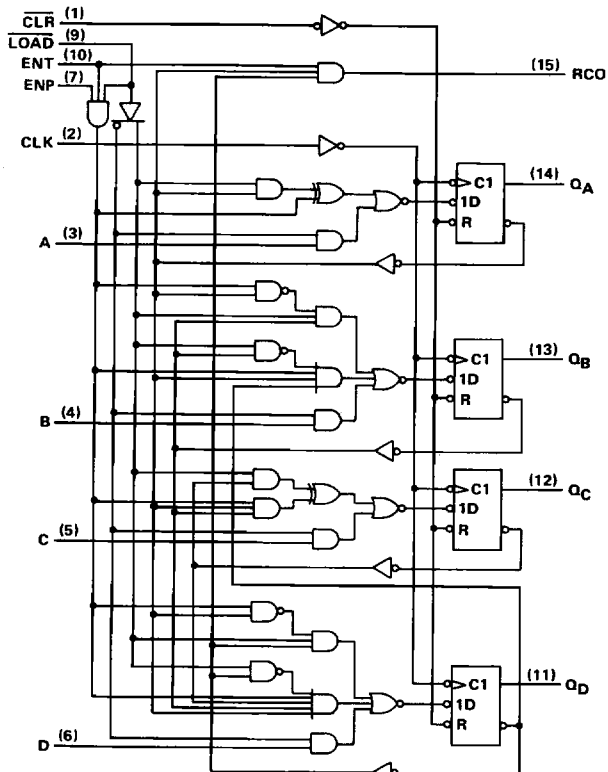
ALS AND AS CIRCUITS

**TYPES SN54ALS160A, SN54ALS162A, SN54AS160, SN54AS162  
SN74ALS160A, SN74ALS162A, SN74AS160, SN74AS162  
SYNCHRONOUS 4-BIT DECADE COUNTERS**

**logic symbols**



**'ALS160A and 'AS160 logic diagram (positive logic)**

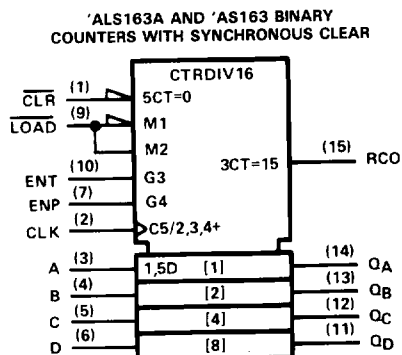
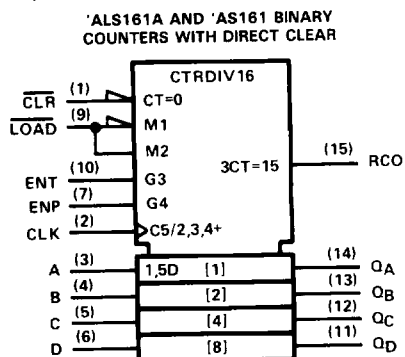


'ALS162A and 'AS162 decade counters are similar; however the clear is synchronous as shown for the 'ALS163A and 'AS163 binary counters.

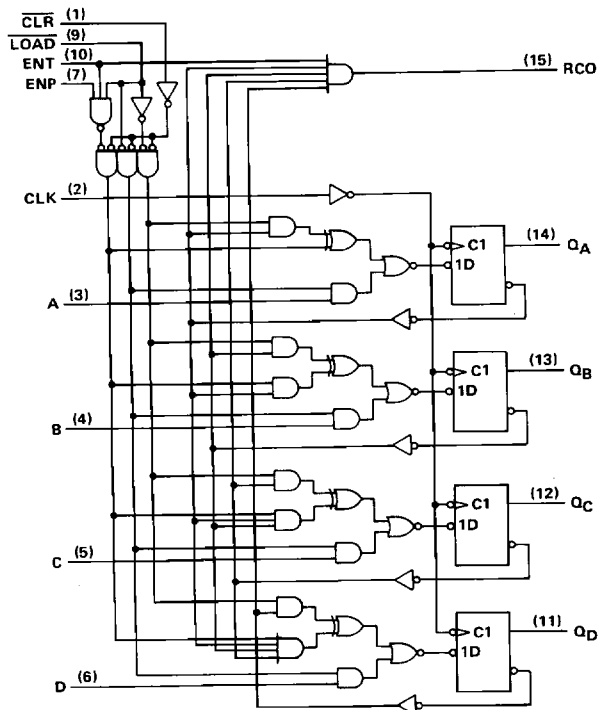
Pin numbers shown are for J and N packages.

**TYPES SN54ALS161A, SN54ALS163A, SN54AS161, SN54AS163  
SN74ALS161A, SN74ALS163A, SN74AS161, SN74AS163  
SYNCHRONOUS 4-BIT DECADE COUNTERS**

**logic symbols**



**'ALS163A and 'AS163 logic diagram (positive logic)**



'ALS161A and 'AS161 synchronous binary counters are similar; however the clear is asynchronous as shown for the 'ALS160A and 'AS160 decade counters.

Pin numbers shown are for J and N packages.

**2**

**ALS AND AS CIRCUITS**

**TYPES SN54ALS160A, SN54ALS162A, SN54AS160, SN54AS162  
SN74ALS160A, SN74ALS162A, SN74AS160, SN74AS162  
SYNCHRONOUS 4-BIT BINARY COUNTERS**

typical clear, preset, count, and inhibit sequences

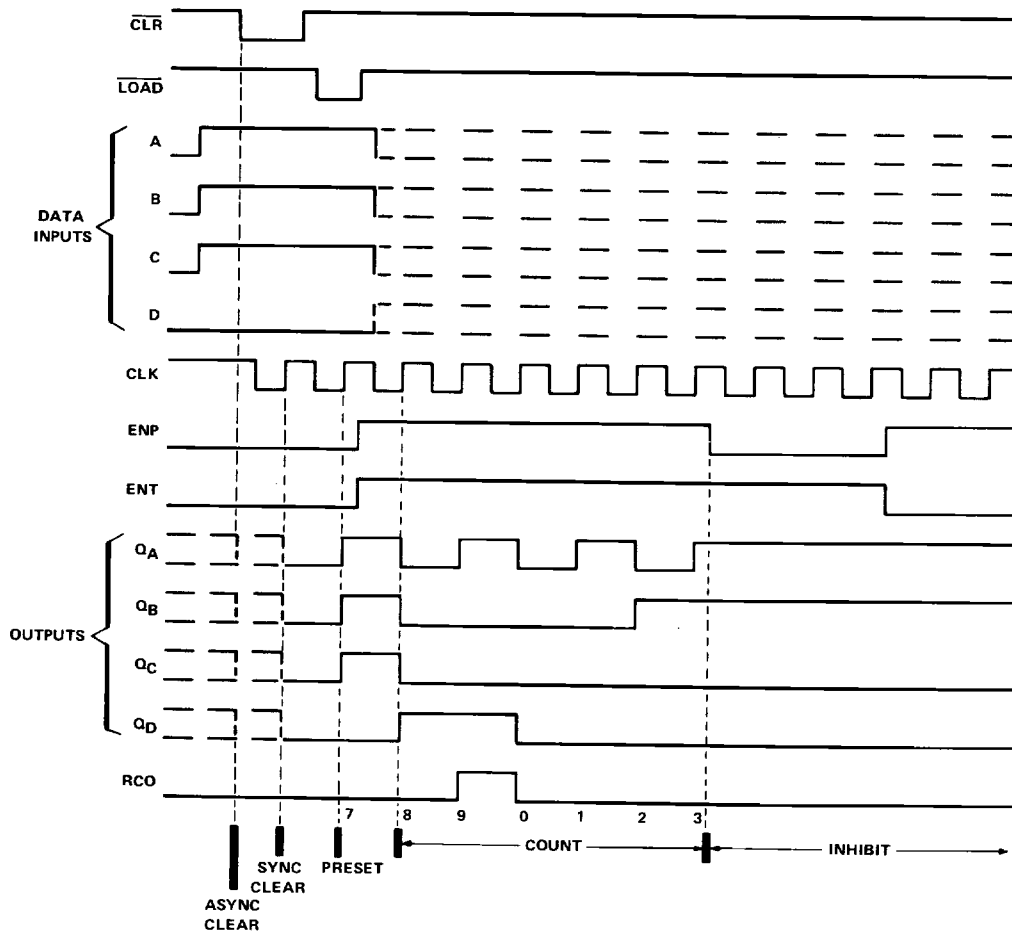
'ALS160A, 'AS160, 'ALS162A, 'AS162

Illustrated below is the following sequence:

1. Clear outputs to zero ('ALS160A and 'AS160 are asynchronous; 'ALS162A and 'AS162 are synchronous)
2. Preset to BCD seven
3. Count to eight, nine, zero, one, two, and three
4. Inhibit

2

ALS AND AS CIRCUITS



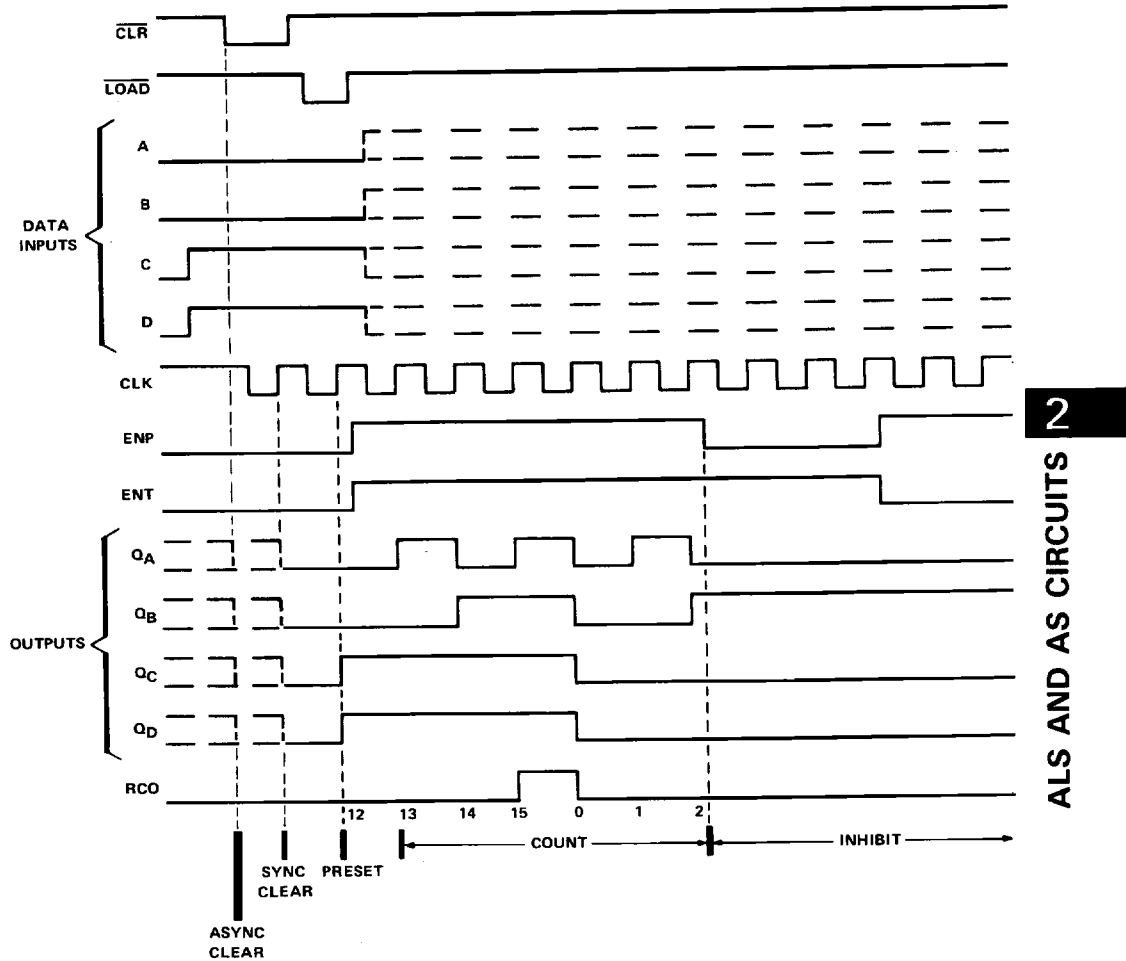
**TYPES SN54ALS161A, SN54ALS163A, SN54AS161, SN54AS163  
SN74ALS161A, SN74ALS163A, SN74AS161, SN74AS163  
SYNCHRONOUS 4-BIT DECADE COUNTERS**

typical clear, preset, count, and inhibit sequences

'ALS161A, 'AS161, 'ALS163A, 'AS163

Illustrated below is the following sequence:

1. Clear outputs to zero ('ALS161A and 'AS161 are asynchronous; 'ALS163A and 'AS163 are synchronous)
2. Preset to binary twelve
3. Count to thirteen, fourteen, fifteen, zero, one, and two
4. Inhibit



**TYPES SN54ALS160A THRU SN54ALS163A  
SN74ALS160A THRU SN74ALS163A  
SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS**

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

Supply voltage, $V_{CC}$	7 V
Input voltage	7 V
Operating free-air temperature range: SN54ALS160A thru SN54ALS163A	-55°C to 125°C
SN74ALS160A thru SN74ALS163A	0°C to 70°C
Storage temperature range	-65°C to 150°C

**recommended operating conditions**

		SN54ALS160A THRU SN54ALS163A			SN74ALS160A THRU SN74ALS163A			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			-0.4			-0.4	mA
$I_{OL}$	Low-level output current			4			8	mA
$f_{clock}$	Clock frequency	0		25	0		30	MHz
$t_w$	Pulse duration	CLK high or low			16.5			ns
		'ALS160A, 'ALS161A, CLR low			20			
		A, B, C, D			15			
		LOAD			15			
$t_{su}$	Setup time before CLK†	ENP, ENT		'ALS160A, 'ALS161A	25		20	ns
				'ALS162A, 'ALS163A	30		25	
		'ALS160A, 'ALS161A		CLR inactive	10		10	
				CLR low	20		15	
				CLR high (inactive)	10		10	
$t_h$	Hold time, all synchronous inputs after CLK†	0			0			ns
$T_A$	Operating free-air temperature	-55			125			°C

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

PARAMETER		TEST CONDITIONS		SN54ALS160A THRU SN54ALS163A			SN74ALS160A THRU SN74ALS163A			UNIT
				MIN	TYP†	MAX	MIN	TYP†	MAX	
$V_{IK}$		$V_{CC} = 4.5 \text{ V}$ , $I_I = -18 \text{ mA}$		-1.5			-1.5			V
$V_{OH}$		$V_{CC} = 4.5 \text{ V to } 5.5 \text{ V}$ , $I_{OH} = -0.4 \text{ mA}$		$V_{CC} - 2$			$V_{CC} - 2$			V
$V_{OL}$		$V_{CC} = 4.5 \text{ V}$ , $I_{OL} = 4 \text{ mA}$		0.25			0.25			V
		$V_{CC} = 4.5 \text{ V}$ , $I_{OL} = 8 \text{ mA}$					0.35			
$I_I$	LOAD, CLK or ENT	$V_{CC} = 5.5 \text{ V}$ , $V_I = 7 \text{ V}$		0.2			0.2			mA
	All other			0.1			0.1			
$I_{IH}$	LOAD, CLK or ENT	$V_{CC} = 5.5 \text{ V}$ , $V_I = 2.7 \text{ V}$		40			40			μA
	All other			20			20			
$I_{IL}$		$V_{CC} = 5.5 \text{ V}$ , $V_I = 0.4 \text{ V}$		-0.2			-0.2			mA
$I_{O}^{\dagger}$	RCO	$V_{CC} = 5.5 \text{ V}$ , $V_O = 2.25 \text{ V}$		-15	-70	-15	-70			mA
	Q			-30	-112	-30	-112			
$I_{CC}$		$V_{CC} = 5.5 \text{ V}$		12			12			mA

†All typical values are at  $V_{CC} = 5 \text{ V}$ ,  $T_A = 25^\circ\text{C}$ .

†The output conditions have been chosen to produce a current that closely approximates one half of the true short-circuit output current,  $I_{OS}$ .

**TYPES SN54ALS160A THRU SN54ALS163A  
SN74ALS160A THRU SN74ALS163A  
SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS**

'ALS160A, 'ALS161A switching characteristics (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub> = 4.5 V to 5.5 V, C <sub>L</sub> = 50 pF, R <sub>L</sub> = 500 Ω, T <sub>A</sub> = MIN to MAX				UNIT
			SN54ALS160A SN54ALS161A		SN74ALS160A SN74ALS161A		
			MIN	MAX	MIN	MAX	
f <sub>max</sub>			25		30		MHz
t <sub>PLH</sub>	CLK	RCO	8	30	8	26	ns
t <sub>PHL</sub>			7	25	7	23	
t <sub>PLH</sub>	CLK	Any Q	4	18	4	15	ns
t <sub>PHL</sub>			6	20	6	17	
t <sub>PLH</sub>	ENT	RCO	3	16	3	13	ns
t <sub>PHL</sub>			3	16	3	13	
t <sub>PHL</sub>	CLR	Any Q	8	27	8	24	ns
t <sub>PHL</sub>	CLR	RCO	11	31	11	28	ns

'ALS162A, 'ALS163A switching characteristics (see Note 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub> = 4.5 V to 5.5 V, C <sub>L</sub> = 50 pF, R <sub>L</sub> = 500 Ω, T <sub>A</sub> = MIN to MAX				UNIT
			SN54ALS162A SN54ALS163A		SN74ALS162A SN74ALS163A		
			MIN	MAX	MIN	MAX	
t <sub>max</sub>			25		30		MHz
t <sub>PLH</sub>	CLK	RCO	8	30	8	26	ns
t <sub>PHL</sub>			7	25	7	23	
t <sub>PLH</sub>	CLK	Any Q	4	18	4	15	ns
t <sub>PHL</sub>			6	20	6	17	
t <sub>PLH</sub>	ENT	RCO	3	20	3	17	ns
t <sub>PHL</sub>			3	16	3	13	

NOTE 1: For load circuit and voltage waveforms, see page 1-12.

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ALS AND AS CIRCUITS

**TYPES SN54AS160 THRU SN54AS163  
SN74AS160 THRU SN74AS163  
SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS**

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

Supply voltage, $V_{CC}$	7 V
Input voltage	7 V
Operating free-air temperature range: SN54AS160 thru SN54AS163	-55°C to 125°C
SN74AS160 thru SN74AS163	0°C to 70°C
Storage temperature range	-65°C to 150°C

**recommended operating conditions**

			SN54AS160 THRU SN54AS163			SN74AS160 THRU 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								MHz
$t_w$	Pulse duration	CLK high or low							ns
$t_{su}$	Setup time before CLK $\uparrow$	'AS160, 'AS161 CLR low							ns
		A, B, C, D							
		LOAD							
		ENP, ENT							
		'AS160, 'AS161 CLR inactive							
$t_h$	Hold time, all synchronous inputs after CLK $\uparrow$	'AS162, 'AS163 CLR low							ns
		'AS162, 'AS163 CLR high (inactive)							
$T_A$	Operating free-air temperature		-55		125	0		70	°C

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

PARAMETER	TEST CONDITIONS	SN54AS160 THRU SN54AS163			SN74AS160 THRU SN74AS163			UNIT
		MIN	TYP <sup>†</sup>	MAX	MIN	TYP <sup>†</sup>	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
$I_I$	$V_{CC} = 5.5$ V, $V_I = 7$ V			0.1			0.1	mA
$I_{IH}$	$V_{CC} = 5.5$ V, $V_I = 2.7$ V			20			20	$\mu$ A
$I_{IL}$	LOAD, ENT			-1			-1	mA
	All other			-0.5			-0.5	
$I_O^{\ddagger}$	$V_{CC} = 5.5$ V, $V_O = 2.25$ V	-30		-112	-30		-112	mA
$I_{CC}$	$V_{CC} = 5.5$ V		40			40		mA

<sup>†</sup>All typical values are at  $V_{CC} = 5$  V,  $T_A = 25^\circ\text{C}$ .

<sup>‡</sup>The output conditions have been chosen to produce a current that closely approximates one half of the true short-circuit output current,  $I_{OS}$ .

Additional information on these products can be obtained from the factory as it becomes available.

**PRODUCT PREVIEW**

2-144 This page contains information on a product under development. Texas Instruments reserves the right to change or discontinue this product without notice.

**TEXAS  
INSTRUMENTS**

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128:



**TYPES SN54AS160 THRU SN54AS163  
SN74AS160 THRU SN74AS163  
SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS**

**'AS160, 'AS161 switching characteristics (see Note 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	V <sub>CC</sub> = 4.5 V to 5.5 V, C <sub>L</sub> = 50 pF, R <sub>L</sub> = 500 Ω, T <sub>A</sub> = MIN to MAX						UNIT
			SN54AS160 SN54AS161			SN74AS160 SN74AS161			
			MIN	TYP <sup>†</sup>	MAX	MIN	TYP <sup>†</sup>	MAX	
f <sub>max</sub>									MHz
t <sub>PLH</sub>	CLK	RCO		7			7		ns
t <sub>PHL</sub>		RCO (with <u>LOAD</u> high)		6			6		
t <sub>PHL</sub>		RCO (with <u>LOAD</u> low)		10			10		
t <sub>PLH</sub>	CLK	Any Q		5			5		ns
t <sub>PHL</sub>				6			6		
t <sub>PLH</sub>	ENT	RCO		3			3		ns
t <sub>PHL</sub>				4			4		
t <sub>PHL</sub>	<u>CLR</u>	Any Q		7			7		ns

**'AS162, 'AS163 switching characteristics (see Note 1)**

PARAMETER	FROM (INPUT)	TO (OUTPUT)	VCC = 4.5 V to 5.5 V, CL = 50 pF, RL = 500 Ω, TA = MIN to MAX						UNIT
			SN54AS162 SN54AS163			SN74AS162 SN74AS163			
			MIN	TYP†	MAX	MIN	TYP†	MAX	
fmax									MHz
tPLH	CLK	RCO		7			7		ns
tPHL		RCO (with LOAD high)		6			6		
tPHL		RCO (with LOAD low)		10			10		
tPLH	CLK	Any Q		5			5		ns
tPHL				6			6		
tPLH	ENT	RCO		3			3		ns
tPHL				4			4		
tPHL	CLR	Any Q		7			7		

<sup>†</sup>All typical values are at  $V_{CC} = 5 \text{ V}, T_A = 25^\circ\text{C}.$

NOTE 1: For load circuit and voltage waveforms, see page 1-12.

Additional information on these products can be obtained from the factory as it becomes available.

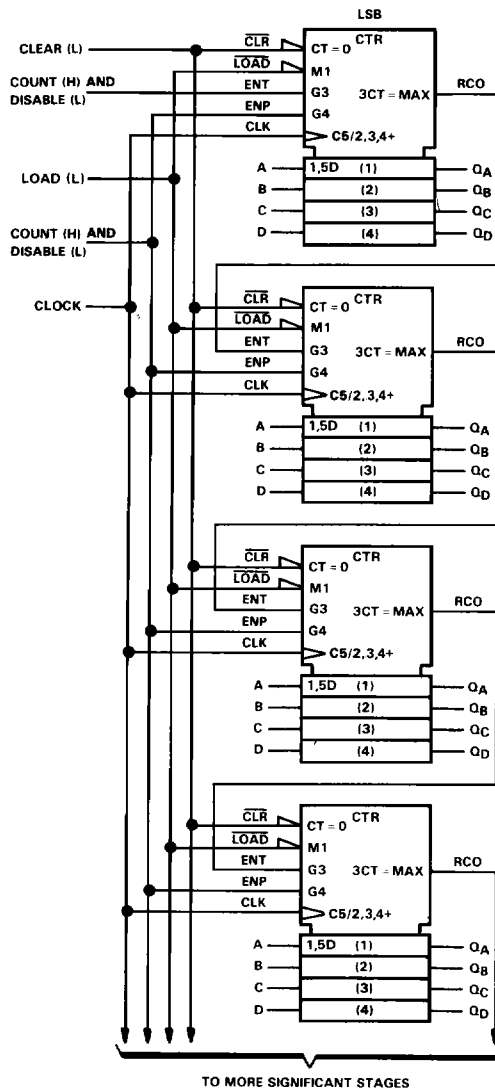
**2  
ALS AND AS CIRCUITS**

**TYPES SN54ALS160A THRU SN54ALS163A, SN54AS160 THRU SN54AS163  
SN74ALS160A THRU SN74ALS163A, SN74AS160 THRU SN74AS163  
SYNCHRONOUS 4-BIT DECADE AND BINARY COUNTERS**

**TYPICAL APPLICATION DATA**

**N-BIT SYNCHRONOUS COUNTERS**

This application demonstrates how the look-ahead carry circuit can be used to implement a high-speed n-bit counter. The 'ALS160A, 'AS160, 'ALS162A, and 'AS162 will count in BCD and the 'ALS161A, 'AS161, 'ALS163A and 'AS163 will count in binary. Virtually any count mode (modulo-N,  $N_1$ -to- $N_2$ ,  $N_1$ -to-maximum) can be used with this fast look-ahead circuit.



2  
ALS AND AS CIRCUITS