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

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

D, DB, OR N PACKAGE
(TOP VIEW)

$\overline{CLR}$	1	16	V_{CC}
CLK	2	15	RCO
A	3	14	Q_A
B	4	13	Q_B
C	5	12	Q_C
D	6	11	Q_D
ENP	7	10	ENT
GND	8	9	$\overline{LOAD}$

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 ($\overline{LOAD}$) 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 ($\overline{CLR}$) 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 $\overline{LOAD}$ 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.
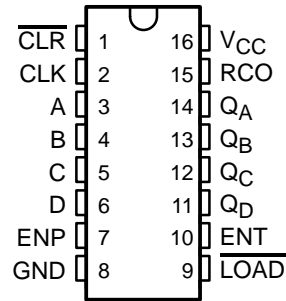
ORDERING INFORMATION

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.

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TEXAS INSTRUMENTS

state diagram

```
   0  →  1  →  2  →  3  →  4
   ↑                       ↓
  15                       5
   ↑                       ↓
  14                       6
   ↑                       ↓
  13                       7
   ↑                       ↓
  12  ← 11  ← 10  ←  9  ←  8
```
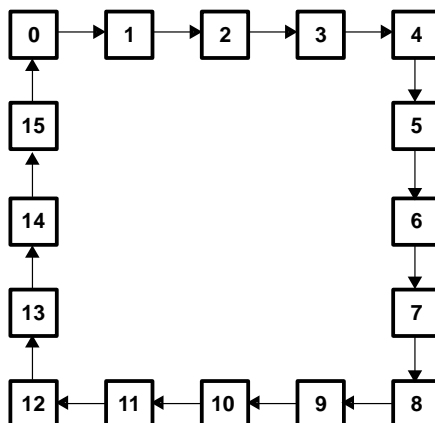
logic diagram (positive logic)
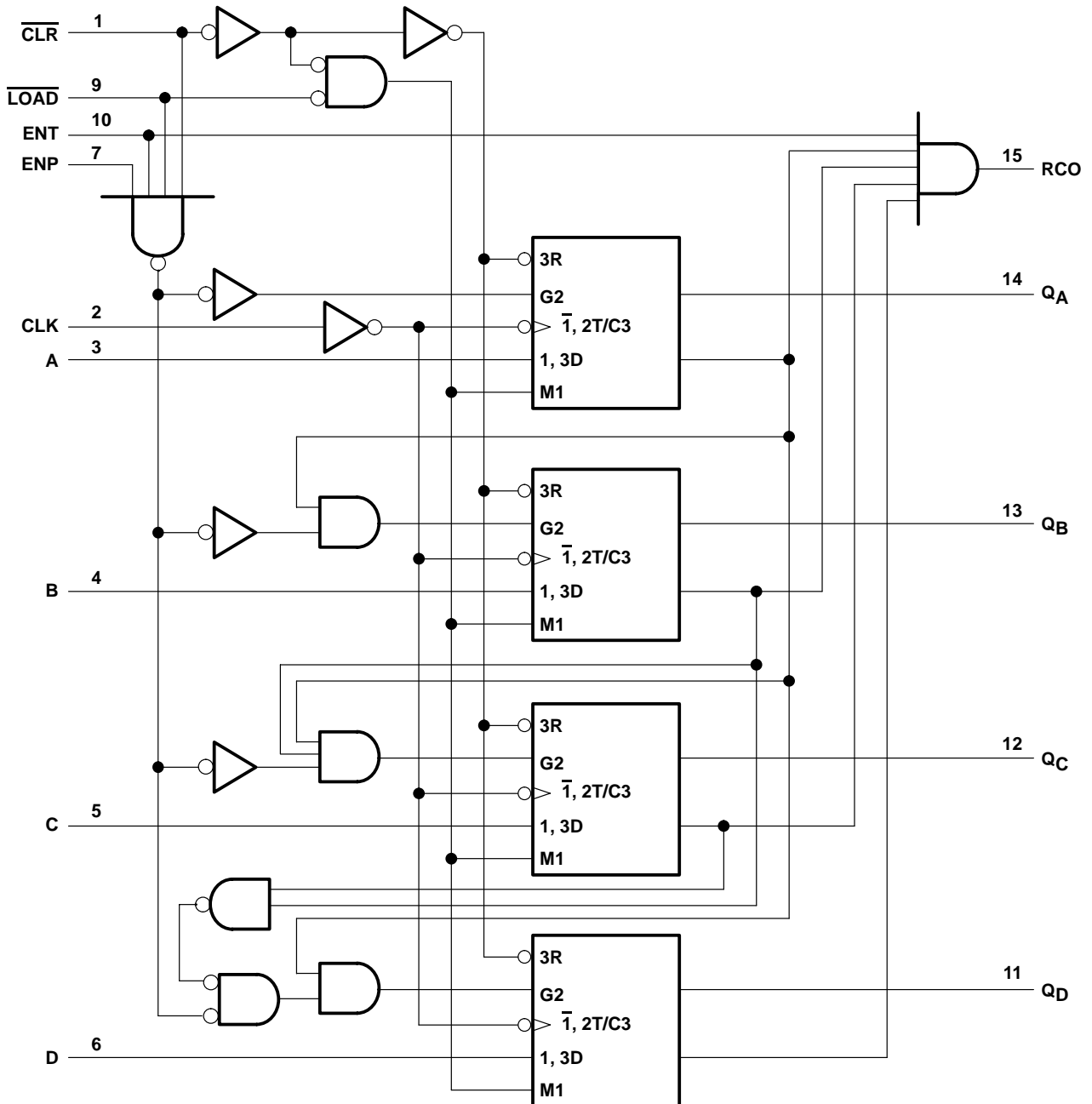
logic symbol, each flip-flop
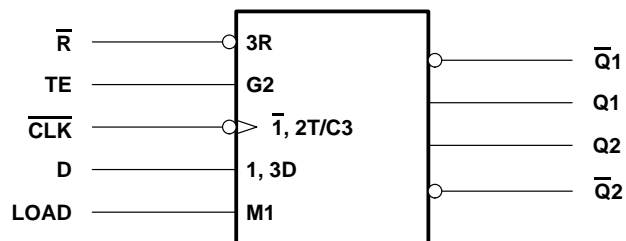
logic diagram, each flip-flop (positive logic)
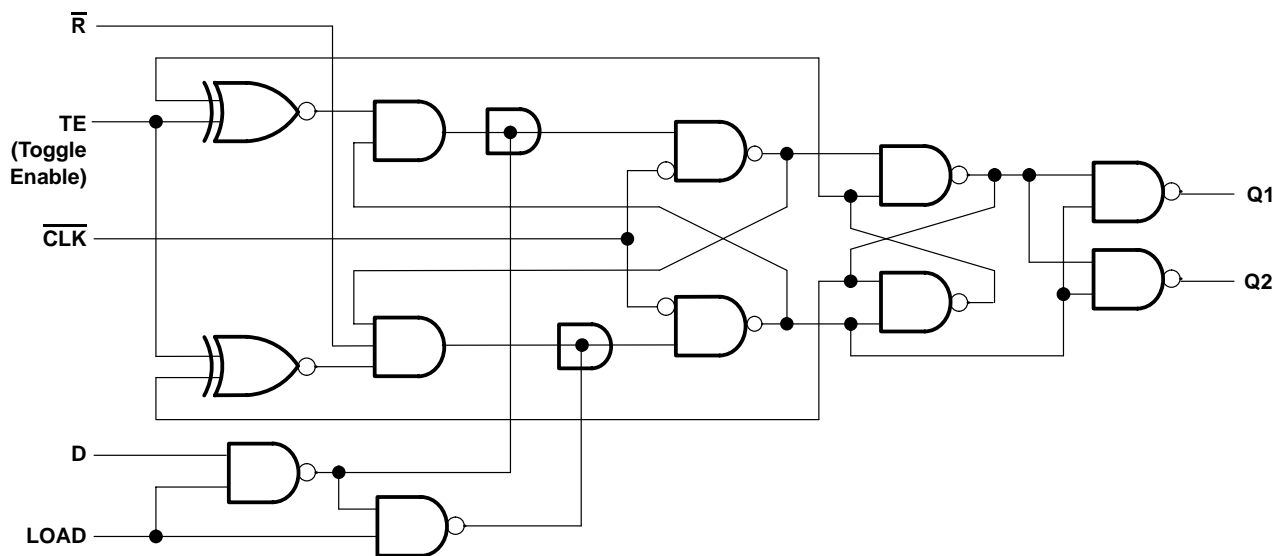
typical clear, preset, count, and inhibit sequences

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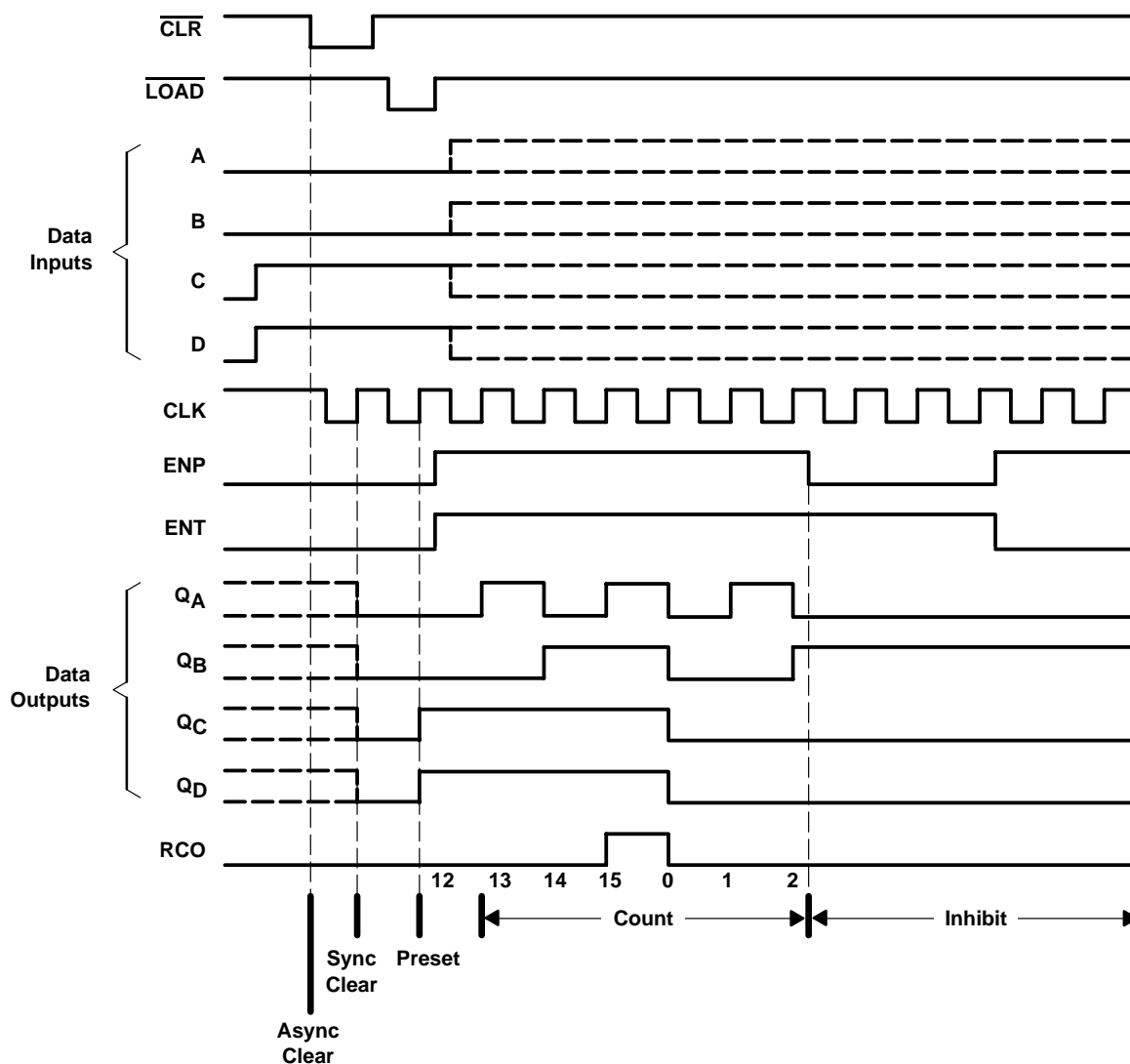
absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

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.

TEXAS INSTRUMENTS

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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		
		CLK (counting) 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		
		$\overline{LOAD}$ and $\overline{CLR}$ before CLK↑ Low	8.5		9.5		
		ENP and ENT before CLK↑ High	11		11.5		
		ENP and ENT before CLK↑ Low	5		5		
t_h	Hold time	Data after CLK↑ High or low	2		2		ns
		LOAD and CLR after CLK↑ High	2		2		
		LOAD and CLR after CLK↑ 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.
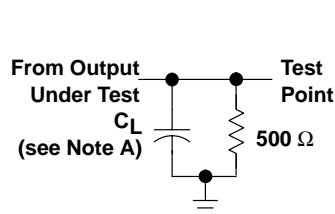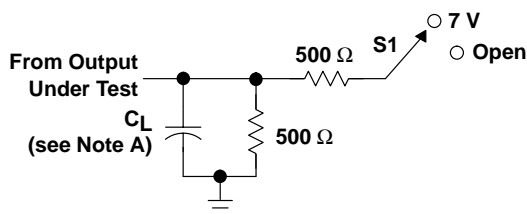NOTE 4: Load circuits and waveforms are shown in Figure 1.

PARAMETER MEASUREMENT INFORMATION

From Output Under Test
Test Point
C_L (see Note A)
500 Ω

LOAD CIRCUIT FOR TOTEM-POLE OUTPUTS

From Output Under Test
C_L (see Note A)
500 Ω
500 Ω
S1
7 V
Open

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

t_w
Input
1.5 V
1.5 V
3 V
0 V
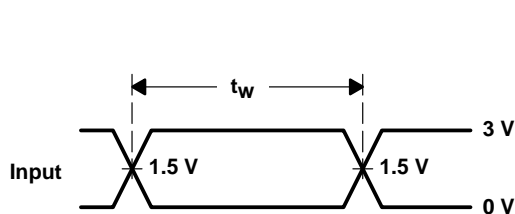
VOLTAGE WAVEFORMS PULSE DURATION

Timing Input
1.5 V
3 V
0 V
t_{su}
t_h
Data Input
1.5 V
1.5 V
3 V
0 V
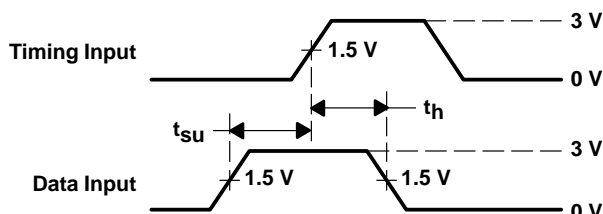
VOLTAGE WAVEFORMS SETUP AND HOLD TIMES

Input
1.5 V
1.5 V
3 V
0 V
t_{PLH}
t_{PHL}
In-Phase Output
1.5 V
1.5 V
V_{OH}
V_{OL}
t_{PHL}
t_{PLH}
Out-of-Phase Output
1.5 V
1.5 V
V_{OH}
V_{OL}
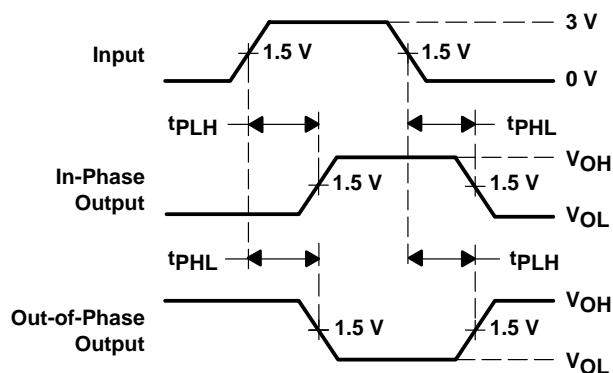
VOLTAGE WAVEFORMS PROPAGATION DELAY TIMES INVERTING AND NONINVERTING OUTPUTS

Output Control
1.5 V
1.5 V
3 V
0 V
t_{PZL}
t_{PLZ}
Output Waveform 1 S1 at 7 V (see Note B)
1.5 V
≈3.5 V
V_{OL} + 0.3 V
V_{OL}
t_{PZH}
t_{PHZ}
Output Waveform 2 S1 at GND (see Note B)
1.5 V
V_{OH}
V_{OH} − 0.3 V
≈0 V
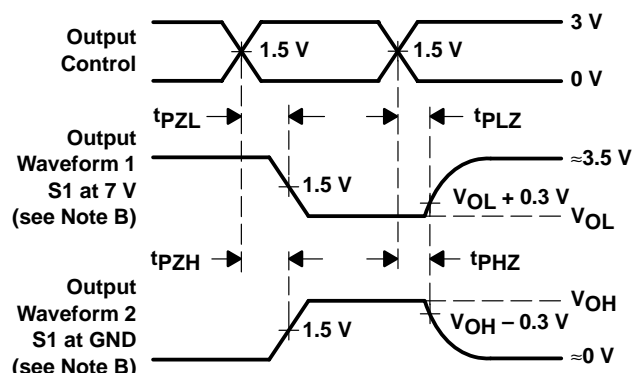
VOLTAGE WAVEFORMS ENABLE AND DISABLE TIMES LOW- AND HIGH-LEVEL ENABLING

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

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN74F163AD	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	F163A	Samples
SN74F163ADG4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	F163A	Samples
SN74F163ADR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	F163A	Samples
SN74F163AN	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	SN74F163AN	Samples
SN74F163AN3	OBSOLETE	PDIP	N	16		TBD	Call TI	Call TI	0 to 70		
SN74F163ANE4	ACTIVE	PDIP	N	16	25	Pb-Free (RoHS)	CU NIPDAU	N / A for Pkg Type	0 to 70	SN74F163AN	Samples
SN74F163ANSR	ACTIVE	SO	NS	16	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM	0 to 70	74F163A	Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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PACKAGE MATERIALS INFORMATION

TAPE AND REEL INFORMATION

REEL DIMENSIONS

TAPE DIMENSIONS

A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

TAPE AND REEL INFORMATION

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SN74F163ADR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1
SN74F163ANSR	SO	NS	16	2000	330.0	16.4	8.2	10.5	2.5	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS

*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74F163ADR	SOIC	D	16	2500	333.2	345.9	28.6
SN74F163ANSR	SO	NS	16	2000	367.0	367.0	38.0

N (R−PDIP−T**)　　　　　　PLASTIC DUAL−IN−LINE PACKAGE

16 PINS SHOWN

DIM ＼ PINS **	14	16	18	20
A MAX	0.775 (19,69)	0.775 (19,69)	0.920 (23,37)	1.060 (26,92)
A MIN	0.745 (18,92)	0.745 (18,92)	0.850 (21,59)	0.940 (23,88)
MS−001 VARIATION	AA	BB	AC	AD

0.260 (6,60) / 0.240 (6,10)

0.070 (1,78) / 0.045 (1,14)

0.045 (1,14) / 0.030 (0,76)

0.020 (0,51) MIN

0.200 (5,08) MAX

Seating Plane

0.125 (3,18) MIN

0.100 (2,54)

0.021 (0,53) / 0.015 (0,38)

⊕ | 0.010 (0,25) Ⓜ |

14/18 Pin Only
20 Pin vendor option

0.325 (8,26) / 0.300 (7,62)

0.015 (0,38)

Gauge Plane

0.010 (0,25) NOM

0.430 (10,92) MAX

4040049/E 12/2002

NOTES:　A.　All linear dimensions are in inches (millimeters).
　　　　　B.　This drawing is subject to change without notice.
　　　　　C.　Falls within JEDEC MS−001, except 18 and 20 pin minimum body length (Dim A).
　　　　　D.　The 20 pin end lead shoulder width is a vendor option, either half or full width.

D (R−PDSO−G16)   PLASTIC SMALL OUTLINE

0.394 (10,00)
0.386 (9,80)
⚠C

16   9

0.244 (6,20)
0.228 (5,80)

0.157 (4,00)
0.150 (3,80)   ⚠D

1   8

Pin 1
Index Area

0.050 (1,27)   0.020 (0,51)
                          0.012 (0,31)

⊕ 0.010 (0,25) Ⓜ

0.069 (1,75) Max

0.010 (0,25)
0.004 (0,10)

0.010 (0,25)
0.005 (0,13)

0.004 (0,10)

Gauge Plane

Seating Plane

0.010 (0,25)   0°−8°

0.050 (1,27)
0.016 (0,40)

4040047−6/M   06/11

NOTES: A.   All linear dimensions are in inches (millimeters).
         B.   This drawing is subject to change without notice.
        ⚠C   Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall
              not exceed 0.006 (0,15) each side.
        ⚠D   Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
         E.   Reference JEDEC MS−012 variation AC.

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D (R−PDSO−G16)   PLASTIC SMALL OUTLINE

Example Board Layout
(Note C)

Stencil Openings
(Note D)

←14x1,27

16x0,55

←14x1,27

5,40

16x1,50

5.40

Example
Non Soldermask Defined Pad

Example
Pad Geometry
(See Note C)

0,60

1,55

Example
Solder Mask Opening
(See Note E)

0,07

All Around
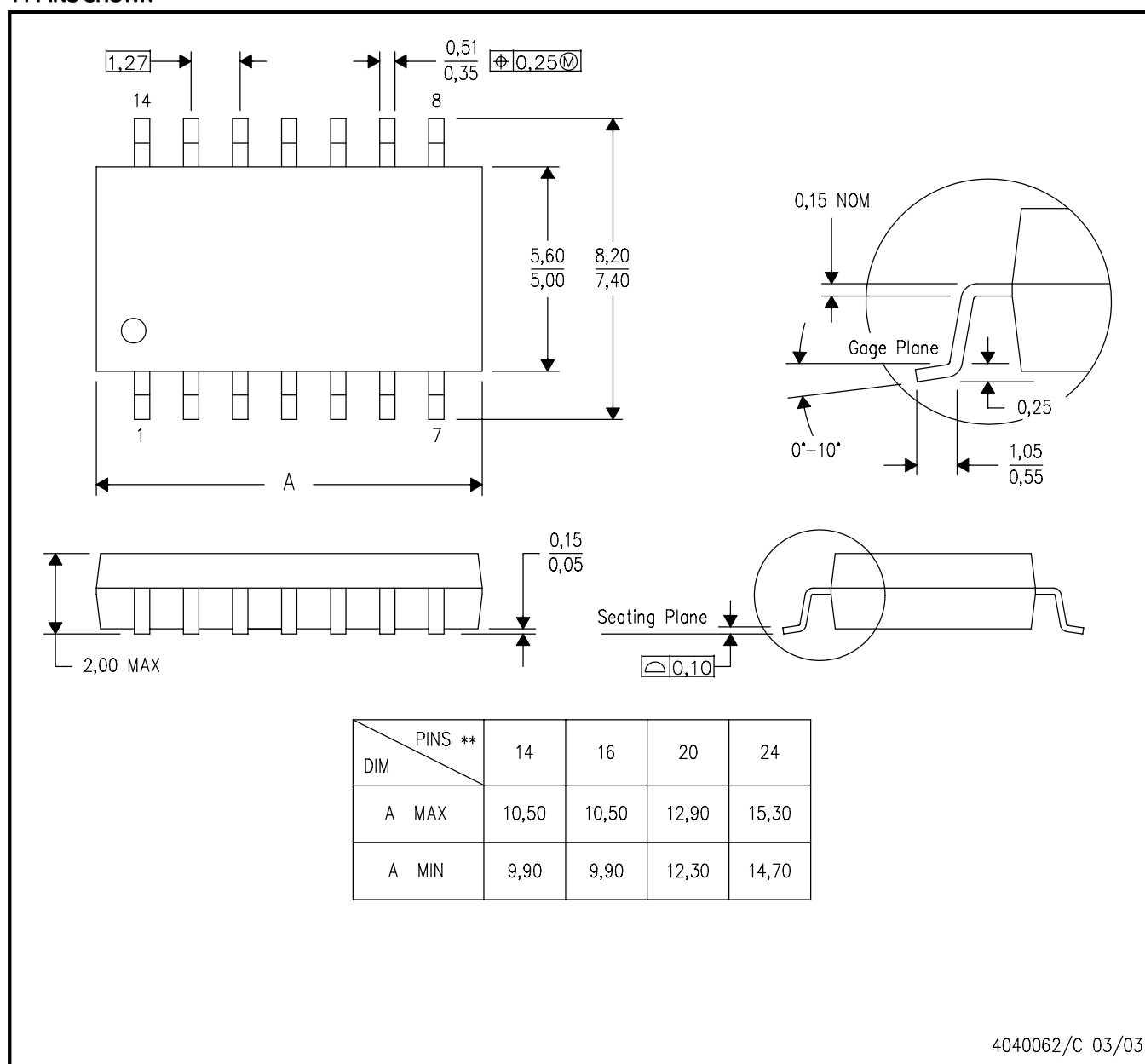
4211283−4/E 08/12

NOTES: A.   All linear dimensions are in millimeters.
          B.   This drawing is subject to change without notice.
          C.   Publication IPC−7351 is recommended for alternate designs.
          D.   Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should
               contact their board assembly site for stencil design recommendations. Refer to IPC−7525 for other stencil recommendations.
          E.   Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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MECHANICAL DATA

DIM \ PINS **	14	16	20	24
A MAX	10,50	10,50	12,90	15,30
A MIN	9,90	9,90	12,30	14,70

4040062/C 03/03

NOTES: A. All linear dimensions are in millimeters.
           B. This drawing is subject to change without notice.
           C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15.

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