

## 18-Bit Registered Transceivers

### Features

- Low power, pin-compatible replacement for LCX and LPT families
- 5V tolerant inputs and outputs
- 24 mA balanced drive outputs
- Power-off disable outputs permits live insertion
- Edge-rate control circuitry for reduced noise
- FCT-C speed at 4.6 ns
- Latch-up performance exceeds JEDEC standard no. 17
- ESD > 2000V per MIL-STD-883D, Method 3015
- Typical output skew < 250ps
- Industrial temperature range of -40°C to +85°C
- TSSOP (19.6-mil pitch) or SSOP (25-mil pitch)
- Typical  $V_{OLP}$  (ground bounce) performance exceeds Mil Std 883D
- $V_{CC} = 2.7V$  to 3.6V

#### CY74FCT163501 Features:

- **Balanced output drivers: 24 mA**
- **Reduced system switching noise**
- **Typical  $V_{OLP}$  (ground bounce) < 0.6V at  $V_{CC} = 3.3V$ ,  $T_A = 25^\circ C$**

#### CY74FCT163H501 Features:

- **Bus hold retains the last active state**
- **Devices with bus hold are not recommended for translating rail-to-rail CMOS signals to 3.3V logic levels**

- **Eliminates the need for external pull-up or pull-down resistors**

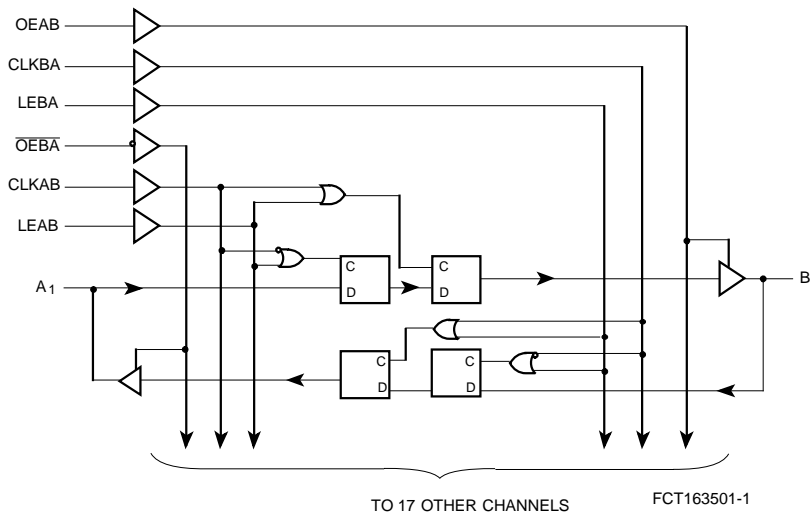
### Functional Description

These 18-bit universal bus transceivers can be operated in transparent, latched or clock modes by combining D-type latches and D-type flip-flops. Data flow in each direction is controlled by output enable (OEAB and  $\overline{OEBA}$ ), latch enable (LEAB and LEBA), and clock inputs (CLKAB and CLKBA). For A-to-B data flow, the device operates in transparent mode when LEAB is HIGH. When LEAB is LOW, the A data is latched if CLKAB is held at a HIGH or LOW logic level. If LEAB is LOW, the A bus data is stored in the latch/flip-flop on the LOW-to-HIGH transition of CLKAB. OEAB performs the output enable function on the B port. Data flow from B-to-A is similar to that of A-to-B and is controlled by  $\overline{OEBA}$ , LEBA, and CLKBA. The output buffers are designed with a power-off disable feature to allow live insertion of boards.

THE CY74FCT163501 has 24-mA balanced output drivers with current limiting resistors in the outputs. This reduces the need for external terminating resistors, as well as provides for minimal undershoot and reduced ground bounce. The CY74FCT163501 is ideal for driving transmission lines.

The CY74FCT163H501 is a 24-mA balanced output part, that has "bus hold" on the data inputs. The device retains the input's last state whenever the input goes to high impedance. This eliminates the need for pull-up/down resistors and prevents floating inputs.

### Functional Block Diagram; CY74FCT163501, CY74FCT163H501



### Pin Configuration SSOP/TSSOP Top View

OEAB	1	56	GND
LEAB	2	55	CLKAB
A <sub>1</sub>	3	54	B <sub>1</sub>
GND	4	53	GND
A <sub>2</sub>	5	52	B <sub>2</sub>
A <sub>3</sub>	6	51	B <sub>3</sub>
V <sub>CC</sub>	7	50	V <sub>CC</sub>
A <sub>4</sub>	8	49	B <sub>4</sub>
A <sub>5</sub>	9	48	B <sub>5</sub>
A <sub>6</sub>	10	47	B <sub>6</sub>
GND	11	46	GND
A <sub>7</sub>	12	45	B <sub>7</sub>
A <sub>8</sub>	13	44	B <sub>8</sub>
A <sub>9</sub>	14	43	B <sub>9</sub>
A <sub>10</sub>	15	42	B <sub>10</sub>
A <sub>11</sub>	16	41	B <sub>11</sub>
A <sub>12</sub>	17	40	B <sub>12</sub>
GND	18	39	GND
A <sub>13</sub>	19	38	B <sub>13</sub>
A <sub>14</sub>	20	37	B <sub>14</sub>
A <sub>15</sub>	21	36	B <sub>15</sub>
V <sub>CC</sub>	22	35	V <sub>CC</sub>
A <sub>16</sub>	23	34	B <sub>16</sub>
A <sub>17</sub>	24	33	B <sub>17</sub>
GND	25	32	GND
A <sub>18</sub>	26	31	B <sub>18</sub>
$\overline{OEBA}$	27	30	CLKBA
LEBA	28	29	GND

FCT163501-2

**Pin Description**

Name	Description
OEAB	A-to-B Output Enable Input
$\overline{OEBA}$	B-to-A Output Enable Input (Active LOW)
LEAB	A-to-B Latch Enable Input
LEBA	B-to-A Latch Enable Input
CLKAB	A-to-B Clock Input
CLKBA	B-to-A Clock Input
A	A-to-B Data Inputs or B-to-A Three-State Outputs <sup>[1]</sup>
B	B-to-A Data Inputs or A-to-B Three-State Outputs <sup>[1]</sup>

**Function Table<sup>[2, 3]</sup>**

Inputs				Outputs	
OEAB	LEAB	CLKAB	A	B	
L	X	X	X	Z	
H	H	X	L	L	
H	H	X	H	H	
H	L	┐	L	L	
H	L	┐	H	H	
H	L	L	X	B <sup>[4]</sup>	
H	L	H	X	B <sup>[5]</sup>	

- On the 74FCT163H501 these pins have bus hold.
- A-to-B data flow is shown. B-to-A data flow is similar but uses  $\overline{OEBA}$ , LEBA, and CLKBA.
- H = HIGH Voltage Level  
L = LOW Voltage Level  
X = Don't Care  
Z = High-impedance  
┐ = LOW-to-HIGH Transition
- Output level before the indicated steady-state input conditions were established.
- Output level before the indicated steady-state input conditions were established, provided that CLKAB was HIGH before LEAB went LOW.
- Operation beyond the limits set forth may impair the useful life of the device. Unless otherwise noted, these limits are over the operating free-air temperature range.
- Unused inputs must always be connected to an appropriate logic voltage level, preferably either  $V_{CC}$  or ground.

**Maximum Ratings<sup>[6, 7]</sup>**

(Above which the useful life may be impaired. For user guidelines, not tested.)

Storage Temperature ..... -55°C to +125°C

Ambient Temperature with

Power Applied ..... -55°C to +125°C

DC Input Voltage ..... -0.5V to +7.0V

DC Output Voltage ..... -0.5V to +7.0V

DC Output Current

(Maximum Sink Current/Pin) ..... -60 to +120 mA

Power Dissipation ..... 1.0W

Static Discharge Voltage..... >2001V  
(per MIL-STD-883, Method 3015)

**Operating Range**

Range	Ambient Temperature	$V_{CC}$
Industrial	-40°C to +85°C	2.7V to 3.6V

**Electrical Characteristics for Non Bus Hold Devices** Over the Operating Range  $V_{CC} = 2.7V$  to  $3.6V$ 

Parameter	Description	Test Conditions	Min.	Typ. <sup>[8]</sup>	Max.	Unit	
$V_{IH}$	Input HIGH Voltage	All Inputs	2.0		5.5	V	
$V_{IL}$	Input LOW Voltage				0.8	V	
$V_H$	Input Hysteresis <sup>[9]</sup>			100		mV	
$V_{IK}$	Input Clamp Diode Voltage	$V_{CC} = \text{Min.}, I_{IN} = -18 \text{ mA}$		-0.7	-1.2	V	
$I_{IH}$	Input HIGH Current	$V_{CC} = \text{Max.}, V_I = 5.5$			$\pm 1$	$\mu\text{A}$	
$I_{IL}$	Input LOW Current	$V_{CC} = \text{Max.}, V_I = \text{GND}$			$\pm 1$	$\mu\text{A}$	
$I_{OZH}$	High Impedance Output Current (Three-State Output pins)	$V_{CC} = \text{Max.}, V_{OUT} = 5.5V$			$\pm 1$	$\mu\text{A}$	
$I_{OZL}$	High Impedance Output Current (Three-State Output pins)	$V_{CC} = \text{Max.}, V_{OUT} = \text{GND}$			$\pm 1$	$\mu\text{A}$	
$I_{OS}$	Short Circuit Current <sup>[10]</sup>	$V_{CC} = \text{Max.}, V_{OUT} = \text{GND}$	-60	-135	-240	mA	
$I_{OFF}$	Power-Off Disable	$V_{CC} = 0V, V_{OUT} \leq 4.5V$			$\pm 100$	$\mu\text{A}$	
$I_{CC}$	Quiescent Power Supply Current	$V_{IN} \leq 0.2V,$ $V_{IN} \geq V_{CC} - 0.2V$		$V_{CC} = \text{Max.}$	0.1	10	$\mu\text{A}$
$\Delta I_{CC}$	Quiescent Power Supply Current (TTL inputs HIGH)	$V_{IN} = V_{CC} - 0.6V$ <sup>[11]</sup>		$V_{CC} = \text{Max.}$	2.0	30	$\mu\text{A}$

**Notes:**

8. Typical values are at  $V_{CC} = 3.3V, T_A = +25^\circ\text{C}$  ambient.
9. This parameter is specified but not tested.
10. Not more than one output should be shorted at a time. Duration of short should not exceed one second. The use of high-speed test apparatus and/or sample and hold techniques are preferable in order to minimize internal chip heating and more accurately reflect operational values. Otherwise prolonged shorting of a high output may raise the chip temperature well above normal and thereby cause invalid readings in other parametric tests. In any sequence of parameter tests,  $I_{OS}$  tests should be performed last.
11. Per TTL driven input ( $V_{IN} = 3.4V$ ); all other inputs at  $V_{CC}$  or GND.

**Electrical Characteristics For Bus Hold Devices** Over the Operating Range  $V_{CC}=2.7V$  to  $3.6V$ 

Parameter	Description	Test Conditions	Min.	Typ. <sup>[8]</sup>	Max.	Unit
$V_{IH}$	Input HIGH Voltage	All Inputs	2.0		$V_{CC}$	V
$V_{IL}$	Input LOW Voltage				0.8	V
$V_H$	Input Hysteresis <sup>[9]</sup>			100		mV
$V_{IK}$	Input Clamp Diode Voltage	$V_{CC}=\text{Min.}, I_{IN}=-18\text{ mA}$		-0.7	-1.2	V
$I_{IH}$	Input HIGH Current	$V_{CC}=\text{Max.}, V_I=V_{CC}$			$\pm 100$	$\mu\text{A}$
$I_{IL}$	Input LOW Current	$V_{CC}=\text{Max.}, V_I=\text{GND}$			$\pm 100$	$\mu\text{A}$
$I_{BBH}$ $I_{BBL}$	Bus Hold Sustain Current on Bus Hold Input <sup>[12]</sup>	$V_{CC}=\text{Min.}$ $V_I=2.0V$ $V_I=0.8V$	-50 +50			$\mu\text{A}$ $\mu\text{A}$
$I_{BHHO}$ $I_{BHLO}$	Bus Hold Overdrive Current on Bus Hold Input <sup>[12]</sup>	$V_{CC}=\text{Max.}, V_I=1.5V$			$\pm 500$	$\mu\text{A}$
$I_{OZH}$	High Impedance Output Current (Three-State Output pins)	$V_{CC}=\text{Max.}, V_{OUT}=V_{CC}$			$\pm 1$	$\mu\text{A}$
$I_{OZL}$	High Impedance Output Current (Three-State Output pins)	$V_{CC}=\text{Max.}, V_{OUT}=\text{GND}$			$\pm 1$	$\mu\text{A}$
$I_{OS}$	Short Circuit Current <sup>[10]</sup>	$V_{CC}=\text{Max.}, V_{OUT}=\text{GND}$	-60	-135	-240	mA
$I_{OFF}$	Power-Off Disable	$V_{CC}=0V, V_{OUT}\leq 4.5V$			$\pm 100$	$\mu\text{A}$
$I_{CC}$	Quiescent Power Supply Current	$V_{IN}\leq 0.2V,$ $V_{IN}\geq V_{CC}-0.2V$ $V_{CC}=\text{Max.}$			+40	$\mu\text{A}$
$\Delta I_{CC}$	Quiescent Power supply Current (TTL inputs HIGH)	$V_{IN}=V_{CC}-0.6V$ <sup>[11]</sup> $V_{CC}=\text{Max.}$			+350	$\mu\text{A}$

**Electrical Characteristics For Balanced Drive Devices** Over the Operating Range  $V_{CC}=2.7V$  to  $3.6V$ 

Parameter	Description	Test Conditions	Min.	Typ. <sup>[8]</sup>	Max.	Unit
$I_{ODL}$	Output LOW Dynamic Current <sup>[10]</sup>	$V_{CC}=3.3V, V_{IN}=V_{IH}$ or $V_{IL}, V_{OUT}=1.5V$	45		180	mA
$I_{ODH}$	Output HIGH Dynamic Current <sup>[10]</sup>	$V_{CC}=3.3V, V_{IN}=V_{IH}$ or $V_{IL}, V_{OUT}=1.5V$	-45		-180	mA
$V_{OH}$	Output HIGH Voltage	$V_{CC}=\text{Min.}, I_{OH}=-0.1\text{ mA}$	$V_{CC}-0.2$			V
		$V_{CC}=3.0V, I_{OH}=-8\text{ mA}$	2.4 <sup>[13]</sup>	3.0		V
		$V_{CC}=3.0V, I_{OH}=-24\text{ mA}$	2.0	3.0		V
$V_{OL}$	Output LOW Voltage	$V_{CC}=\text{Min.}, I_{OL}=0.1\text{ mA}$			0.2	V
		$V_{CC}=\text{Min.}, I_{OL}=24\text{ mA}$		0.3	0.55	

**Capacitance<sup>[9]</sup>** ( $T_A = +25^\circ\text{C}, f = 1.0\text{ MHz}$ )

Parameter	Description	Test Conditions	Typ. <sup>[8]</sup>	Max.	Unit
$C_{IN}$	Input Capacitance	$V_{IN} = 0V$	4.5	6.0	pF
$C_{OUT}$	Output Capacitance	$V_{OUT} = 0V$	5.5	8.0	pF

**Notes:**

12. Pins with bus hold are described in Pin Description.  
 13.  $V_{OH}=V_{CC}-0.6V$  at rated current.

**Power Supply Characteristics**

Sym.	Parameter	Test Conditions <sup>[14]</sup>		Min.	Typ. <sup>[8]</sup>	Max.	Unit
I <sub>CCD</sub>	Dynamic Power Supply Current <sup>[15]</sup>	V <sub>CC</sub> =Max., Outputs Open OEAB=OEBA=V <sub>CC</sub> or GND One Input Toggling, 50% Duty Cycle	V <sub>IN</sub> =V <sub>CC</sub> or V <sub>IN</sub> =GND	—	75	120	μA/ MHz
I <sub>C</sub>	Total Power Supply Current <sup>[16]</sup>	V <sub>CC</sub> =Max., Outputs Open f <sub>0</sub> = 10MHz (CLKAB) 50% Duty Cycle OEAB=OEBA=V <sub>CC</sub> LEAB = GND, One Bit Toggling f <sub>1</sub> = 5MHz, 50% Duty Cycle	V <sub>IN</sub> =V <sub>CC</sub> or V <sub>IN</sub> =GND	—	0.8	1.7	mA
			V <sub>IN</sub> =3.4V or V <sub>IN</sub> =GND	—	1.3	3.2	
		V <sub>CC</sub> =Max., Outputs Open f <sub>0</sub> = 10MHz (CLKAB) 50% Duty Cycle OEAB=OEBA=V <sub>CC</sub> LEAB=GND Eighteen Bits Toggling f <sub>1</sub> =2.5MHz, 50% Duty Cycle	V <sub>IN</sub> =V <sub>CC</sub> or V <sub>IN</sub> =GND	—	3.8	6.5 <sup>[17]</sup>	
			V <sub>IN</sub> =3.4V or V <sub>IN</sub> =GND	—	8.5	20.8 <sup>[17]</sup>	

**Notes:**

14. For conditions shown as Max. or Min., use appropriate value specified under Electrical Characteristics for the applicable device type.
15. This parameter is not directly testable, but is derived for use in Total Power Supply Current.
16.  $I_C = I_{\text{QUIESCENT}} + I_{\text{INPUTS}} + I_{\text{DYNAMIC}}$   
 $I_C = I_{CC} + \Delta I_{CC} D_H N_T + I_{CCD} (f_0/2 + f_1 N_1)$   
 $I_{CC}$  = Quiescent Current with CMOS input levels  
 $\Delta I_{CC}$  = Power Supply Current for a TTL HIGH input (V<sub>IN</sub>=3.4V)  
 $D_H$  = Duty Cycle for TTL inputs HIGH  
 $N_T$  = Number of TTL inputs at D<sub>H</sub>  
 $I_{CCD}$  = Dynamic Current caused by an input transition pair (HLH or LHL)  
 $f_0$  = Clock frequency for registered devices, otherwise zero  
 $f_1$  = Input signal frequency  
 $N_1$  = Number of inputs changing at f<sub>1</sub>  
 All currents are in milliamps and all frequencies are in megahertz.
17. Values for these conditions are examples of the I<sub>CC</sub> formula. These limits are specified but not tested.

**Switching Characteristics** Over the Operating Range  $V_{CC}=3.0V$  to  $3.6V$ <sup>[18]</sup>

Parameter	Description	CY74FCT163501C CY74FCT163H501C		Unit	Fig.No. <sup>[19]</sup>	
		Min.	Max.			
$f_{MAX}$	CLKAB or CLKBA frequency <sup>[9]</sup>	—	150	MHz	—	
$t_{PLH}$ $t_{PHL}$	Propagation Delay A to B or B to A	1.5	4.6	ns	1,3	
$t_{PLH}$ $t_{PHL}$	Propagation Delay LEBA to A, LEAB to B	1.5	5.3	ns	1,5	
$t_{PLH}$ $t_{PHL}$	Propagation Delay CLKBA to A, CLKAB to B	1.5	5.3	ns	1,5	
$t_{PZH}$ $t_{PZL}$	Output Enable Time OEBA to A, OEAB to B	1.5	5.6	ns	1,7,8	
$t_{PHZ}$ $t_{PLZ}$	Output Disable Time OEBA to A, OEAB to B	1.5	5.2	ns	1,7,8	
$t_{SU}$	Set-Up Time, HIGH or LOW A to CLKAB, B to CLKBA	3.0	—	ns	4	
$t_H$	Hold Time HIGH or LOW A to CLKAB, B to CLKBA	0	—	ns	4	
$t_{SU}$	Set-Up Time, HIGH or LOW A to LEAB, B to LEBA	Clock LOW	3.0	—	ns	4
		Clock HIGH	1.5	—	ns	4
$t_H$	Hold Time, HIGH or LOW, A to LEAB, B to LEBA	1.5	—	ns	4	
$t_W$	LEAB or LEBA Pulse Width HIGH <sup>[9]</sup>	3.0	—	ns	5	
$t_W$	CLKAB or CLKBA Pulse Width HIGH or LOW <sup>[9]</sup>	3.0	—	ns	5	
$t_{SK(O)}$	Output Skew <sup>[20]</sup>	—	0.5	ns	—	

**Notes:**

- 18. Minimum limits are specified, but not tested, on propagation delays.
- 19. See "Parameter Measurement Information" in the General Information section.
- 20. Skew between any two outputs of the same package switching in the same direction. This parameter ensured by design.

**Ordering Information CY74FCT163501T**

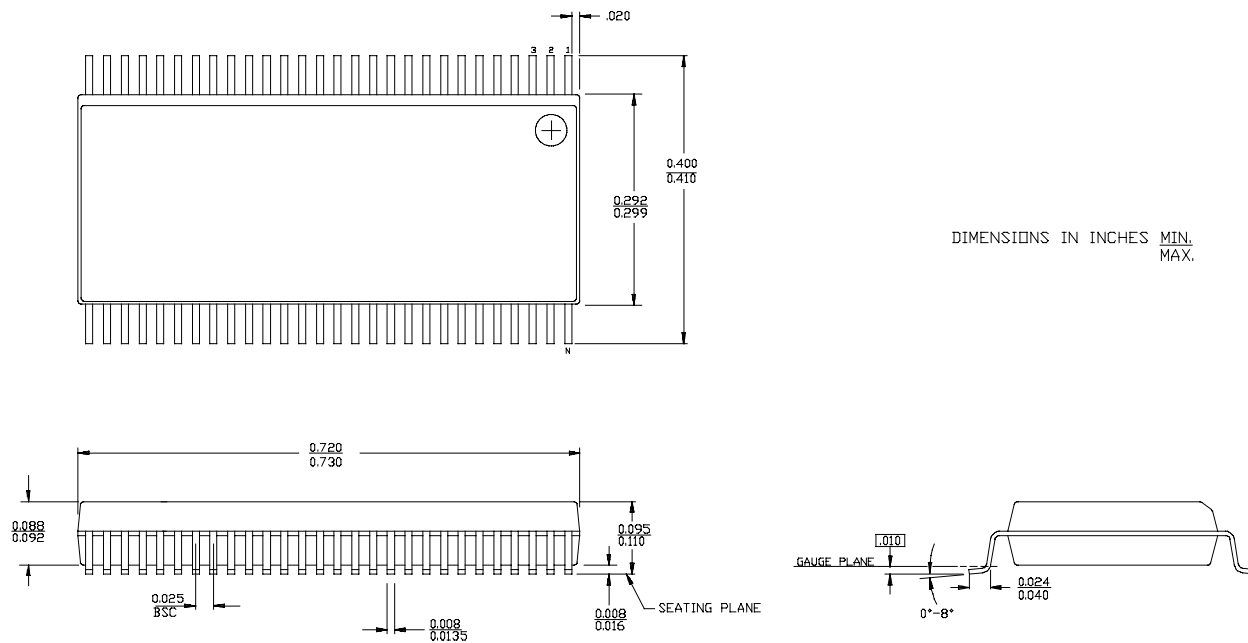
Speed (ns)	Ordering Code	Package Name	Package Type	Operating Range
4.6	CY74FCT163501CPACT	Z56	56-Lead (240-Mil) TSSOP	Industrial
	CY74FCT163501CPVC/PVCT	O56	56-Lead (300-Mil) SSOP	

**Ordering Information CY74FCT163H501T**

Speed (ns)	Ordering Code	Package Name	Package Type	Operating Range
4.6	74FCT163H501CPACT	Z56	56-Lead (240-Mil) TSSOP	Industrial
	CY74FCT163H501CPVC	O56	56-Lead (300-Mil) SSOP	
	74FCT163H501CPVCT	O56	56-Lead (300-Mil) SSOP	

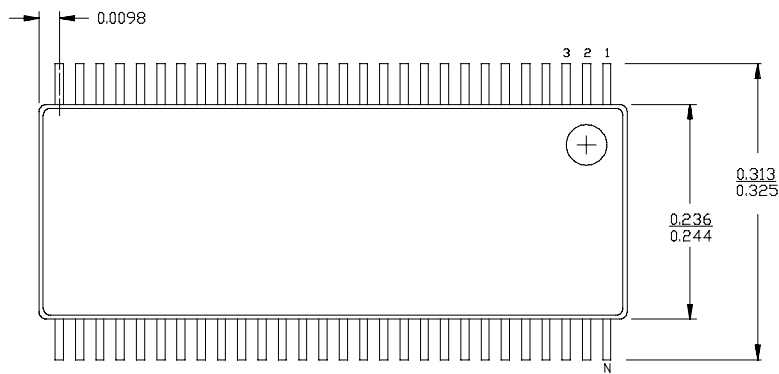
**Package Diagrams**

**56-Lead Shrunken Small Outline Package O56**

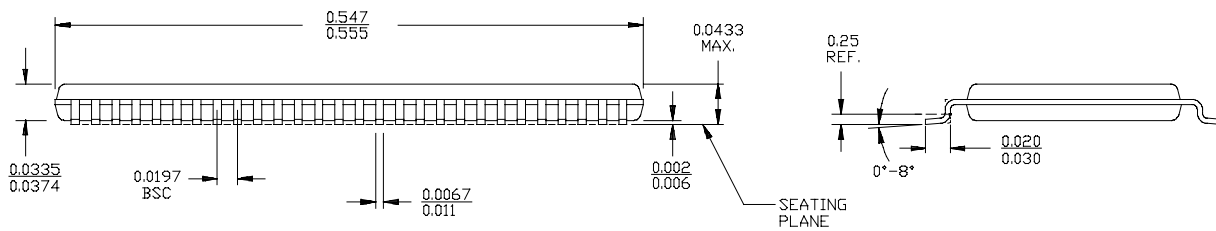


**Package Diagrams** (continued)

**56-Lead Thin Shrunken Small Outline Package Z56**



DIMENSIONS IN INCHES MIN.  
MAX.





**PACKAGING INFORMATION**

Orderable Device	Status <sup>(1)</sup>	Package Type	Package Drawing	Pins	Package Qty	Eco Plan <sup>(2)</sup>	Lead/Ball Finish	MSL Peak Temp <sup>(3)</sup>
74FCT163H501CPACT	OBSOLETE	TSSOP	DGG	56		TBD	Call TI	Call TI
74FCT163H501CPVCT	OBSOLETE	SSOP	DL	56		TBD	Call TI	Call TI
CY74FCT163501CPAC	OBSOLETE	TSSOP	DGG	56		TBD	Call TI	Call TI
CY74FCT163501CPACT	OBSOLETE	TSSOP	DGG	56		TBD	Call TI	Call TI
CY74FCT163501CPVC	OBSOLETE	SSOP	DL	56		TBD	Call TI	Call TI
CY74FCT163501CPVCT	OBSOLETE	SSOP	DL	56		TBD	Call TI	Call TI
CY74FCT163H501CPAC	OBSOLETE	TSSOP	DGG	56		TBD	Call TI	Call TI
CY74FCT163H501CPVC	OBSOLETE	SSOP	DL	56		TBD	Call TI	Call TI

<sup>(1)</sup> 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.

<sup>(2)</sup> Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS) 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.

**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)

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

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DL (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

48 PINS SHOWN



- NOTES: A. All linear dimensions are in inches (millimeters).  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).  
 D. Falls within JEDEC MO-118

DGG (R-PDSO-G\*\*)

PLASTIC SMALL-OUTLINE PACKAGE

48 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.  
 B. This drawing is subject to change without notice.  
 C. Body dimensions do not include mold protrusion not to exceed 0,15.  
 D. Falls within JEDEC MO-153

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