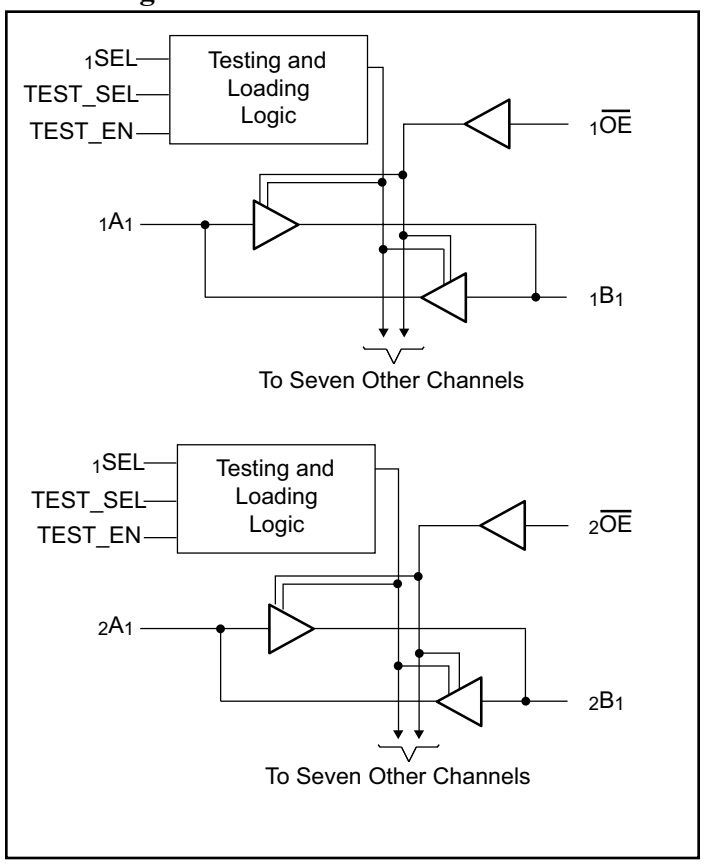
1.5V to 3.3V Universal Bi-directional Level Shifter with Automatic Direction Control & Advanced Package Solution

Features

- Designed for low voltage operation: 1.4V to 3.6V
- Universal bidirectional level shifting with automatic direction control
- Fast bus speeds up to 160 Mbps
- I_{OFF} supports partial Power-Down mode operation
- Drive Capability 12mA
- Independent translation of each bit
- Each supply rail is configurable over supply range
- ESD Protection exceeds JESD22
  – 2000V Human Body Model (A114-B)
  – 200V Machine Model (A115-A)
- Latch-up performance exceeds 100mA per JESD 78
- Industrial operation at –40°C to +85°C
- Packaging (Pb-free & Green):
  – 45 lead TFBGA (NL)

Block Diagram



Description

Pericom Semiconductor's PI4ULS3V16M is a 16-bit (dual-octal) non-inverting bus transceiver with two separate supply rails. A port (V_{CCA}) and B port (V_{CCB}) are set to operate at 1.4V to 3.6V. This arrangement permits universal bidirectional translation of differential signal levels over the voltage ranges.

PI4ULS3V16M is designed for asynchronous communication between data buses. Data is transmitted from the A bus to the B bus, or vice versa, without direction control. All A_X, and B_X are tri-stated when data is coming from both directions at the same time. The output-enable ($\overline{OE}$) input is used to disable outputs so buses are isolated.

The control pins, SEL, TEST_EN and TEST_SEL are supplied by V_{CCB}.

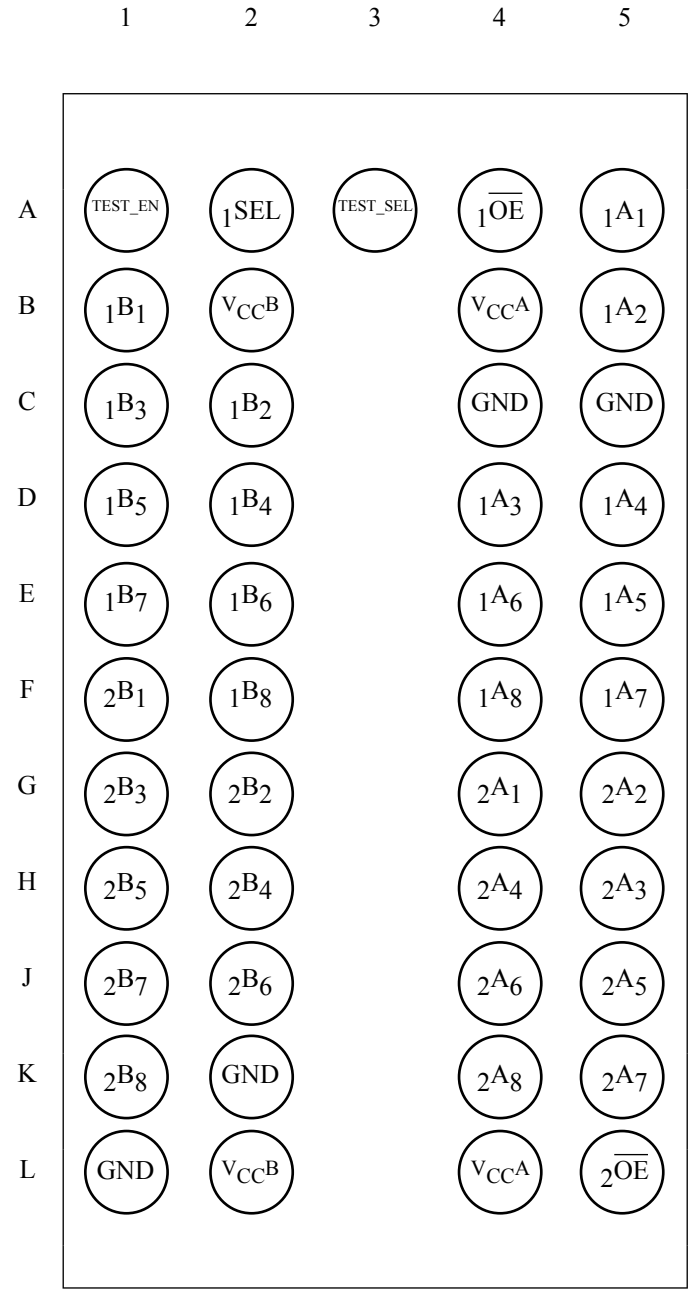
The device is fully specified for partial power-down applications using I_{OFF}. The I_{OFF} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down.

To ensure the high-impedance state during power-up or power-down, the output-enable ($\overline{OE}$) input should be tied to V_{CC} through a pullup resistor. The minimum value of the resistor is determined by the current-sinking capability of the driver.

Applications

- Voltage Translation
- Bus Relay
- Mobile Terminals

Pin Configuration



Maximum Ratings

(Absolute maximum ratings over operating free-air temperature range, unless otherwise noted)

Supply voltage range: V_{CCA} ..... –0.5V to 4.6V
V_{CCB} ..... –0.5V to 4.6V
Input voltage range, V_I (1) Control Inputs ..... –0.5V to 4.6V
Voltage Range applied to any I/O pins in the high-impedance or Power-Off state, V_{IO} (1) :
A Port ..... –0.5V to 4.6V
B Port ..... –0.5V to 4.6V
Voltage Range applied to any I/O pins in the High or Low state V_{IO} (1, 2): A Port ..... –0.5V to V_{CCA} +0.5V
B Port ..... –0.5V to V_{CCB} +0.5V

Input clamp current, I_{IK} (V_I <0) ..... –50mA
Output clamp current, I_{OK} (V_O <0) ..... –50mA
Continuous output current, I_O ..... ±20mA
Continuous current through V_{CCA}, V_{CCB} or GND ..... ±100mA
Package thermal impedance, 0_{JA} (3):
A package ..... 82°C/W
ZF package ..... 33°C/W
Storage temperature range, T_{STG} ..... –65°C to 150°C

Note:
1. The input negative voltage and output voltage ratings may be exceeded if the input and output current ratings are observed.
2. This value is limited to 3.6V maximum.
3. The package thermal impedance is calculated in accordance with JESD 51.
4. Stresses greater than those listed under MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

Pin Description

Pin Name	Description
$_X\overline{OE}$	3-State Output Enable Inputs (Active LOW)
$_X$SEL	Outputs Loading Selection
$_XA_X$	Side A Inputs/Outputs
$_XB_X$	Side B Inputs/Outputs
TEST_EN	Enable Test Mode
TEST_SEL	Test Mode Selection
GND	Ground
V_{CCA}, V_{CCB}	Power

Truth Table(1)

Inputs		Outputs Loading(2)	Operation
$_x\overline{OE}$	$_1$SEL		
L	L	31pF ≤ C_L ≤ 50pF	Bus B data to Bus A, or Bus A data to Bus B
L	H	21pF ≤ C_L ≤ 30pF	
H	X		Z (Isolation)

Notes:
1. H = HIGH Signal Level
   L = LOW Signal Level
   X = Don't Care or Irrelevant
   Z = High Impedence
2. Refer to Figure 1 for Output Loading Chart

Test Mode

TEST_EN	TEST_SEL	Condition
L	X	Normal Operation
H	L	TEST MODE A → B
H	H	TEST MODE B → A

Recommended Operating Conditions(1, 2, 3)

Parameter	Description		V_{CCI}	Min.	Max.	Units
V_{CCA}, V_{CCB}	Supply Voltage			1.1	3.6	V
V_{IH}	High-Level Input Voltage	I/O pins	1.1V to 1.95V	0.65 x V_{CCI}		
			2.3V to 2.7V	1.7		
			2.7V to 3.6V	2		
V_{IL}	Low-Level Input Voltage	I/O pins	1.1V to 1.95V		0.35 x V_{CCI}	
			2.3V to 2.7V		0.7	
			2.7V to 3.6V		0.8	
V_{IHB}	High-Level Input Voltage	Control Inputs ($\overline{OE}$ and SEL)	1.1V to 1.95V	0.65 x V_{CCB}		
			2.3V to 2.7V	1.7		
			2.7V to 3.6V	2		
V_{ILB}	Low-Level Input Voltage	Control Inputs ($\overline{OE}$ and SEL)	1.1V to 1.95V		0.35 x V_{CCB}	
			2.3V to 2.7V		0.7	
			2.7V to 3.6V		0.8	
V_I	Input Voltage	I/O pins and Control Inputs		0	3.6	
V_O	Output Voltage	I/O pins and Control Inputs		0	3.6	
I_{OH}	High-Level Output Current	I/O pins	V_{CCO} = 1.1V		-3	mA
			V_{CCO} = 1.4V		-5	
			V_{CCO} = 1.65V		-8	
			V_{CCO} = 2.3V		-9	
			V_{CCO} = 3.0V		-12	
I_{OL}	Low-Level Output Current	I/O pins	V_{CCO} = 1.1V		3	
			V_{CCO} = 1.4V		5	
			V_{CCO} = 1.65V		8	
			V_{CCO} = 2.3V		9	
			V_{CCO} = 3.0V		12	
$\Delta t/\Delta V$	Input Transition rise or fall rate				10	V/ns
T_A	Operating Free-Air Temperature			-40	85	°C

Notes:
1. V_{CCI} is the V_{CC} associated with the data input port.
2. V_{CO} is the V_{CC} associated with the date output port.
3. To ensure proper device operation, all unused device inputs must be held at V_{CCI} or GND.

Electrical Characteristics for (Over recommended free-air temperature range, unless otherwise noted.)(7)

Parameter	Description	Test Conditions	V_{CCA}/V_{CCB}	Min.	Typ. (1)	Max.	Units
V_{OH}	High-Level Output Voltage	I_{OH} = -100µA	1.1V to 3.6V	V_{CCO} - 0.1V			V
		I_{OH} = -2mA	1.1V	0.8			
		I_{OH} = -4mA	1.4V	1			
		I_{OH} = -7mA	1.65V	1.2			
		I_{OH} = -9mA	2.3V	1.8			
		I_{OH} = -12mA	3.0V	2.4			
V_{OL}	Low-Level Output Voltage	I_{OL} = 100µA	1.1V to 3.6V			0.2	
		I_{OL} = 2mA	1.1V			0.3	
		I_{OL} = 4mA	1.4V			0.4	
		I_{OL} = 7mA	1.65V			0.4	
		I_{OL} = 9mA	2.3V			0.4	
		I_{OL} = 12mA	3.0V			0.4	
I_{CC}	Quiescent Supply Current	$V_I = V_{CCI}$ or GND, I_O = 0	1.1V to 3.6V			10	µA
I_I	Control Inputs (OE and SEL)	$V_I = V_{CCB}$ or GND	1.1V to 3.6V			±5	
I_{OZ}(6)	3-State Output Current	$V_O = V_{CCO}$ or GND	1.1V to 3.6V			±10	
I_{OFF}	Power-off Leakage Current	V_I or V_O = 0 to 3.6V	0V			±10	
C_{IN}	Control Input Capacitance	$V_I = V_{CCB}$ or GND			3		pF
C_{IO}	I/O Capacitance	$V_O = V_{CCA/B}$ or GND			5		

Notes:
1. All typical values are at T_A = 25°C.
2. The High-level minimum sustaining current that the bus-hold circuit can source at V_{IH} min. I_{BHH} is measured after raising V_{IN} to V_{CCA} and then lowering it to V_{IH} min.
3. The Low-level minimum sustaining current that the bus-hold circuit can sink at V_{IL} max. I_{BHL} is measured after lowering V_{IN} to GND and then raising it to V_{IL} Max.
4. An external driver must sink as least I_{BHLO} to switch this node from High to Low.
5. An external driver must source at least I_{BHHO} to switch this node from Low to High.
6. For I/O ports, the parrameter I_{OZ} includes the input leakage current.
7. Parameters are specified under test mode conditions.

Timing Characteristics for V_{CCA} = 1.5V ±0.1V

(Over recommended free-air temperature range, unless otherwise noted.)

Parameter	From (Input)	To (Output)	V_{CCB} = 1.5V ±0.1V		V_{CCB} = 1.8V ±0.15V		V_{CCB} = 2.5V ±0.2V		V_{CCB} = 3.3V ±0.3V		Units
			Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
t_{PD}	A	B	1.0	7.0	1.0	6.5	1.0	6.0	1.0	5.0	ns
	B	A	1.0	7.0	1.0	6.5	1.0	6.0	1.0	5.5	
$t_{SK(a)}$(1)				0.3		0.3		0.3		0.3	
$t_{SK(b)}$(1)				0.25		0.25		0.25		0.25	
f_{max}(2)	Maximum Frequency		40		60		80		80		MHz

Timing Characteristics for V_{CCA} = 1.8V ±0.15V

(Over recommended free-air temperature range, unless otherwise noted.)

Parameter	From (Input)	To (Output)	V_{CCB} = 1.5V ±0.1V		V_{CCB} = 1.8V ±0.15V		V_{CCB} = 2.5V ±0.2V		V_{CCB} = 3.3V ±0.3V		Units
			Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
t_{PD}	A	B	1.0	7.0	0.5	6.0	0.5	5.5	0.5	5.0	ns
	B	A	1.0	6.0	0.5	6.0	0.5	5.5	0.5	5.0	
$t_{SK(a)}$(1)				0.25		0.25		0.25		0.25	
$t_{SK(b)}$(1)				0.2		0.2		0.2		0.2	
f_{MAX}(2)	Maximum Frequency		40		60		80		80		MHz

Timing Characteristics for V_{CCA} = 2.5V ±0.2V

(Over recommended free-air temperature range, unless otherwise noted.)

Parameter	From (Input)	To (Output)	V_{CCB} = 1.5V ±0.1V		V_{CCB} = 1.8V ±0.15V		V_{CCB} = 2.5V ±0.2V		V_{CCB} = 3.3V ±0.3V		Units
			Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
t_{PD}	A	B	1.0	6.0	0.5	5.5	0.5	5.0	0.5	4.5	ns
	B	A	1.0	6.0	0.5	5.5	0.5	5.0	0.5	4.5	
$t_{SK(a)}$(1)				0.25		0.25		0.25		0.25	
$t_{SK(b)}$(1)				0.2		0.2		0.2		0.2	
f_{max}(2)	Maximum Frequency		40		60		80		80		MHz

Notes:

1. This is the skew between any two outputs of the same package, and switching in the same direction. For $t_{SK(a)}$, Output 1 and Output 2 are any two outputs. For $t_{SK(b)}$, Output 1 and Output 2 are in the same bank. These parameters are warranted but not production tested.
2. Refer to Truth Table for Frequency Selections.
3. This parameter is specified under test mode conditions.

Timing Characteristics for V_{CCA} = 3.0V ±0.3V

(Over recommended free-air temperature range, unless otherwise noted.)

Parameter	From (Input)	To (Output)	V_{CCB} = 1.5V ±0.1V		V_{CCB} = 1.8V ±0.15V		V_{CCB} = 2.5V ±0.2V		V_{CCB} = 3.3V ±0.3V		Units
			Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
t_{PD}	A	B	1.0	6.0	0.5	5.0	0.5	4.5	0.5	4.0	ns
	B	A	1.0	5.5	0.05	5.0	0.5	4.5	0.5	4.0	
$t_{SK(a)}$ (1)				0.25		0.25		0.25		0.25	
$t_{SK(b)}$ (1)				0.2		0.2		0.2		0.2	
f_{max} (2)	Maximum Frequency		40		60		80		80		MHz

Notes:
1. This is the skew between any two outputs of the same package, and switching in the same direction. For $t_{SK(a)}$, Output 1 and Output 2 are any two outputs. For $t_{SK(b)}$, Output 1 and Output 2 are in the same bank. These parameters are warranted but not poroduction tested.
2. Refer to Truth Table for Frequency Selections.
3. This parameter is specified under test mode conditions.

Operating Characteristics (V_{CCA} and V_{CCB} = 2.5V, T_A = 25°C)

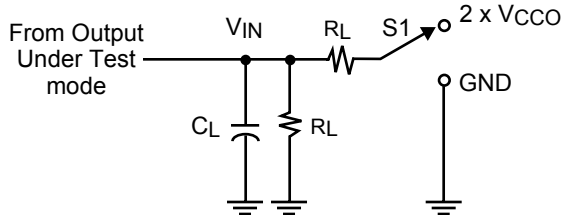
Parameter			Test Conditions	Typ.	Units
Cpd (1) (V_{CCA})	Power Dissipation Capacitance A to B	Outputs Enabled	C_L = 0 f = 10 MHz	13	pF
		Outputs Disabled		28	
	Power Dissipation Capacitance B to A	Outputs Enabled		17	
		Outputs Disabled		30	
Cpd (1) (V_{CCB})	Power Dissipation Capacitance A to B	Outputs Enabled	C_L = 0 f = 10 MHz	17	pF
		Outputs Disabled		32	
	Power Dissipation Capacitance B to A	Outputs Enabled		13	
		Outputs Disabled		28	

Notes:
1. This parameter is specified under test mode conditions.

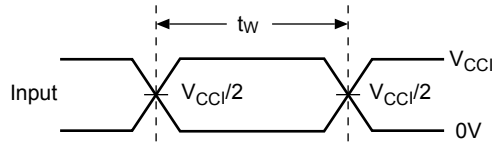
Parameter Measurement Information

V_{CCA}/V_{CCB}	C_L	R_L
1.1V ~ 1.6V	10pF	2kΩ
1.8V ±0.15V	20pF	1kΩ
2.5V ±0.2V	30pF	500Ω
3.3V ±0.3V	50pF	500Ω

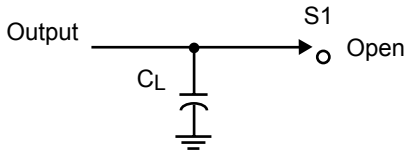
Test	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	2X V_{CCO}
t_{PHZ}/t_{PZH}	GND



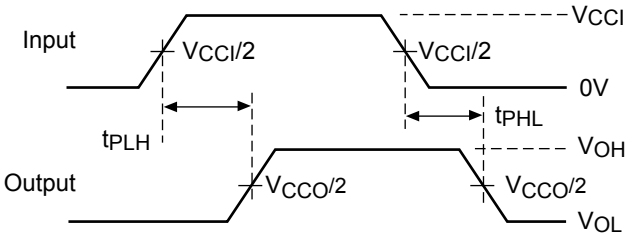
Test Circuit for t_{DIS} / t_{EN}



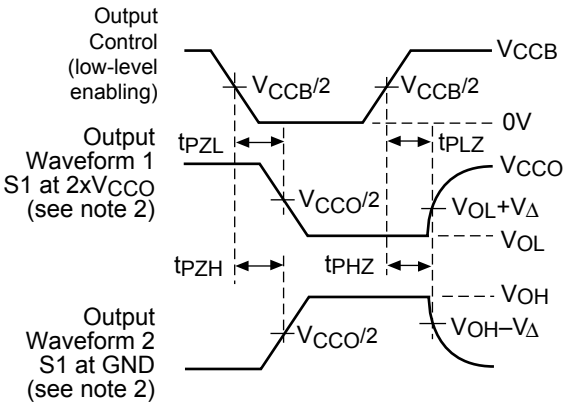
Voltage Waveforms
Enable and Disable Times



Test Circuit for t_{pd} / t_{sk}



Voltage Waveforms
Propagation Delay Times

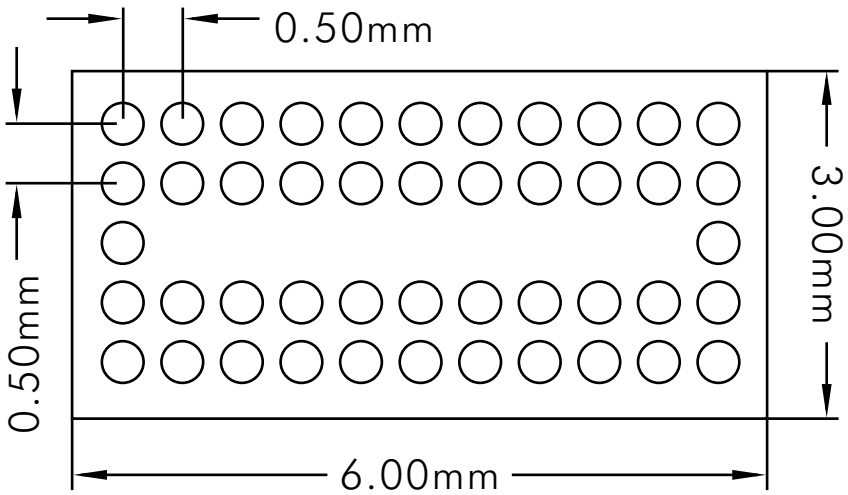


Voltage Waveforms
Enable and Disable Times

Figure 1. Load Circuit and Voltage Waveforms

Notes:
1. C_L includes probe and jig capacitance.
2. 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.
3. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10Mz, Z_O = 50Ω, tr ≤ 2.5ns, tf ≤ 2.5ns.
4. The outputs are measured one at a time with one transition per measurement.
5. t_{PLZ} and t_{PHZ} are the same as t_{DIS}.
6. t_{PZL} and t_{PZH} are the same as t_{EN}.
7. t_{PLH} and t_{PHL} are the same as t_{PD}.
8. V_{CCI} defines the input port (V_{CCA} or V_{CCB}).
9. V_{CCO} defines the output port (V_{CCA} or V_{CCB}).

Packaging Mechanical: 45-lead TBGA



Ordering Information

Ordering Code	Packaging Code	Package Description
PI4ULS3V16NLE	NL	Pb-free and Green 45-ball TFBGA

Notes:

1. Thermal characteristics can be found on the company web site at www.pericom.com/packaging/
2. Number of Transistors = TBD